Rosa Lasaponara
Nicola Masini
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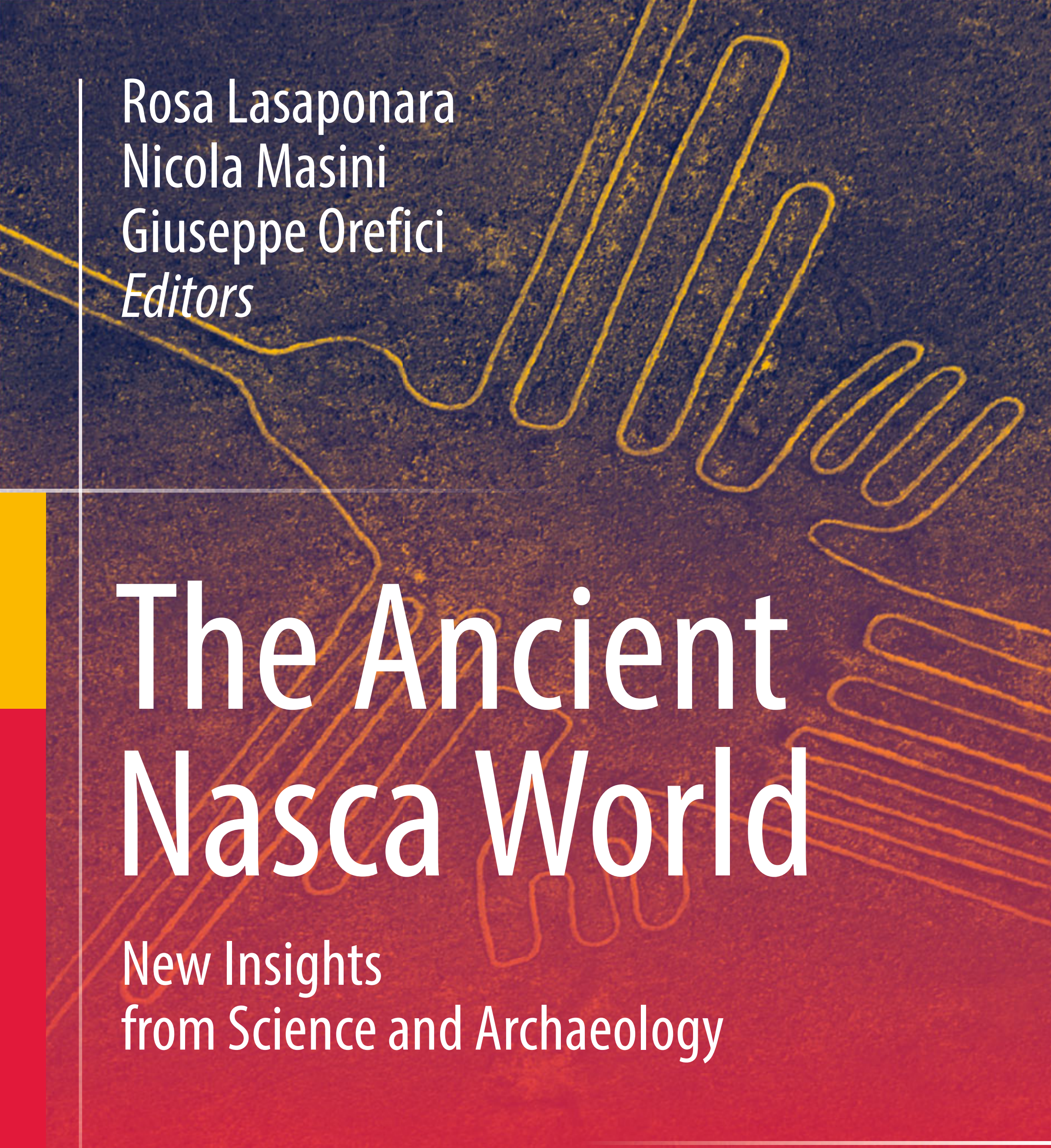
Editors



The Ancient Nasca World

New Insights from Science and Archaeology

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Cover Illustration: Nasca geoglyph depicting a hummingbird in the Pampa of Nasca Archaeological Reserve Area, District of El Ingenio, Nasca Province, Ica Region. (*Photo* Nicola Masini)

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Foreword I

This is an important, extraordinary and useful book for many reasons. As the reader might expect, a book that provides a description of fieldwork and findings that began in 1982 at an archaeological area of global renown, the Nasca area of the Ica region in Peru, will reward the reader generously with a very comprehensive presentation of information and insights. We are dealing here, after all, with an enormous breadth of material that has been documented first hand. A parallel might be drawn to research that rests upon the examination of primary archival written documents versus a survey of secondary documents, yet even this would not do this work justice. Here we have the primary analysis of material evidence that was gathered and analyzed by the team of authors themselves. This is an example of what archaeology can bring to the accumulation of human knowledge: the interpretation of *material evidence* by those who know it and have removed it from the context in which it was found. This is what only archaeology can offer the world. By discharging their responsibility to analyze and publish what they have excavated, the authors in this volume have satisfied what should be the prime directive for all archaeologists: publish what you excavate. Given the range of excavations and other research carried out, this is especially worthy of admiration and congratulations.

Yet there is more. The authors have managed to push the boundaries of archaeological research in a direction that holds enormous promise. They have, by doing so, thrown down a challenge to all archaeologists to do the same. The term *landscape archaeology* is not new, of course, but this book shows how it should be done. The authors use remote sensing technologies not only to discover sites and features, but even more so to explore the ongoing dialectic between collective human behavior and the environment. This approach will surely render the information gained from archaeological research not only more complete but also much more relevant to the environmental, social, and political issues that we face today.

The use of archaeogeophysical research by the scholars who have prepared this book has enabled a profoundly landscape-oriented approach to the surveys (including rock art) and excavations (from burials to dwellings and temples and ceremonial structures, including evidence of human sacrifice dating back to 4200 BCE) that began in 1982 and the intense excavation and anastylosis that has been done at Cahuachi since 2002. The extent to which aerial and satellite remote sensing have been used to accomplish this may well be unprecedented in a book of this scope. As such, it should be seen as a benchmark in archaeological scholarship.

In accomplishing this feat, the editors of this book have leveraged the effort invested in their research in the most admirable of ways. They have provided training in the use of aerial and satellite imagery through workshops and conferences that draw upon their Nasca work, as well as at other of their research areas and in other places in the world. This is timely because the treasure trove of remotely sensed imagery collected from satellite and aerial platforms that are now available online, grows every day. Let other archaeologists use the doorway that this book has opened to explore a new world of rapidly expanding research possibilities.

Mauro Marsili

Foreword II

Several decades ago, as a young student of Mediterranean archaeology, I used to consult in my school library publications of archaeologists of the nineteenth and early twentieth centuries. I looked with admiration and incredulity at the impressive number of volumes of reports, in which results of several campaigns of excavations in Greece, Egypt, or the Middle East were presented, such as the reports of the French mission (École française d'Athènes) in Delos (Greece), related to investigations carried out since 1873 and continuing to date. What tenacity and deep dedication these scholars possessed, who devoted several decades of their lives to research into one site, such as Claude Schaeffer who devoted 40 years of life (1929–1969) to study Ugarit in Syria.

I had never expected to find similar cases in Andean archaeology, before arriving in Cahuachi and meeting Giuseppe Orefici, who since 1982 has directed 33 campaigns of excavations—so, probably constituting the longest episode of uninterrupted work in Andean archaeology.

This volume summarizes more than just three decades of archaeological research, interdisciplinary investigations ranging from the botanical research by Luigi Piacenza to the anthropological studies by Andrea Drusini. Besides them, we have the results of investigations carried out since 2007 by the ITACA Mission of Italian CNR, directed by Nicola Masini, including scholarly experts in remote sensing, archaeogeophysics, geology, diagnostics, and photogrammetry. The interdisciplinary investigations led by Nicola Masini and Rosa Lasaponara have been conducted to provide information for the further detection of buried remains, the study of geoglyphs and puquios, the analysis of ceramics, and the evaluation and monitoring of archaeological looting and vandalism.

What has motivated all these specialists is definitely the scientific interest and charm of Cahuachi, with its long history, huge size, and fascinating complexity. No less important is the personality of Giuseppe Orefici who has been, during the recent past decades, to coordinate dozens of specialists and students, offering them the opportunity to develop their own research topics. I personally and my colleagues are proud to have had the opportunity to work in Cahuachi[1]: in fact, the contribution of one of us (Anna Gruszczynska-Ziolkowska) is included in this publication. The importance of this volume resides in the wide panorama of various different perspectives into the remains of the Nasca culture, with its monumental architecture, mysterious geoglyphs, irrigation systems, polychrome ceramic, textiles, and musical instruments.

Reading this book, it is fascinating for the richness and variety of its contents and investigation methods which will further enhance our knowledge of Nasca culture.

The amount of data collected with the use of advanced technologies and scientific approaches is overwhelming and yet more decades will be needed to fully analyze and publish them.

Probably Cahuachi will become the Délos or Ugarit of Andean archaeology: I wish this to the Nasca Project, its scholars, and its director.

Mariusz S. Ziółkowski

[1]Mariusz S. Ziółkowski refers to the mission of the Centre for Precolombian Studies of University of Warsaw which cooperated with Proyecto Nasca for a number of investigations, among which is the musicological studies of the Nasca (see Chap. 17 by Gruszczynska-Ziolkowska).

Foreword III

"The Ancient Nasca World: New Insights from Science and Archaeology" collects the innovative results of the Italian research in Peru carried out by the archaeological mission Proyecto Nasca, directed by Giuseppe Orefici, and the Italian Mission of Heritage Conservation and Archaeo-Geophysics in Peru (ITACA) directed by Nicola Masini of CNR, active in Nasca 1982–2007, respectively.

The volume edited by Rosa Lasaponara, Nicola Masini, and Giuseppe Orefici is the original result of the synergy between two realities of Italian research and the dialogue between various disciplines, such as archaeology, anthropology, remote sensing, geophysics, and diagnostics, in order to respond to the numerous questions posed by the history of human beings in relation to the environment and to the physical evidence that has been left in legacy and that we recognize as cultural heritage.

It seems that the Nasca civilization, with its mysteries and questions that have long been posed to scholars from countries all over the world, is the ideal ground for interdisciplinary research and to create a bridge between humanities and physical scientific disciplines.

Archaeology and science, also through digital technologies, are increasingly interconnected in order to know, interpret, and actualize the contributions of the various civilizations and to raise awareness of our origins, as well as to develop a vision of the future by learning from the past.

Nasca and the ceremonial center of Cahuachi are two emblematic case studies that help us to understand how humans has been able to exploit, with intelligence and an intimate and mystic relationship with nature, the few resources that the environment and the climate of one of the most arid places in the world, the Atacama desert, granted them.

The great pyramids of Cahuachi, built by exploiting the hills of the Nasca drainage, marked by floods, and the intelligent filtration systems to retrieve subterranean water, are only some of the most significant examples of this ability that the Nasca have demonstrated to adapt to their desert environment.

In this way, they created oases where agriculture flourished, built villages, erected pyramids, and drew geoglyphs in order to celebrate their intimate relationship with the gods and to express a vision of the world which the authors of the chapters of this volume have been able to outline in the various artistic expressions (architecture, ceramics, music, textile) and with the most innovative methods of scientific analysis.

Douglas C. Comer

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Chapter 1
Thirty Years of Investigations in Nasca: From Proyecto Nasca to the ITACA Mission

Giuseppe Orefici, Nicola Masini and Rosa Lasaponara

Abstract The Nasca Project, which can be considered the longest-running archaeological mission in Peru, came into being in 1982. The project, sponsored by the Centro Italiano Studi e Ricerche Archeologiche Precolombiane (CISRAP) in Brescia, was conducted uninterruptedly in the Nasca area of the Ica region in Peru from 1982 to 2014, thanks to a bilateral agreement between the Permanent Director of the Mission, Giuseppe Orefici, and the Peruvian *Ministerio de Cultura* (formerly the *Instituto Nacional de Cultura*). It is part of the Peru–Italy Cultural Agreement, and is renewed periodically thanks to an agreement between the presidents of the two republics. The research program, still ongoing, is dedicated to archaeological excavations in various areas, as well as to the iconographic analysis of Nasca (culture) and the study of rock art. The first twenty years of research activity were devoted to the study of several archaeological sites, including San Jose, Pueblo Viejo, Cahuachi, Huayurí, Santa Clara, Atarco, Quemado, Usaka, Jumana, and Estaquería. Since 1984, the excavation of the ceremonial center of Cahuachi occupied much of the time spent on research, this being the world's largest ceremonial center built with adobe. Since 2002, in combination with artchaeological excavation, the Nasca Project began the rehabilitation and partial restoration of the monumental structures of Cahuachi, focusing on Zone A. The excavations in large

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areas has also enabled us to discover most of the existing buildings in the ceremonial center and the relationship between them. Since 2008, the research has been conducted in collaboration with the Mission ITACA of CNR, directed by Nicola Masini, that, with integrated investigations based on geophysics and remote sensing, has played a decisive role in for the management of excavation planning. In some cases, archaeo-geophysical research has enabled the discovery of several structures, tombs, and ritual offerings.

Keywords Proyecto Nasca · ITACA mission · Nasca archaeology · Archaeo-geophysics · Remote sensing · Cahuachi · Pueblo Viejo · Estaquería

1.1 Introduction

The Nasca Project, which can be considered the longest-running archaeological mission in Peru, came into being in 1982. The project, sponsored by the Centro Italiano Studi e Ricerche Archeologiche Precolombiane (CISRAP) in Brescia, was conducted uninterruptedly in the Nasca area of the Ica region in Peru from 1982 to 2014, thanks to a bilateral agreement between the Permanent Director of the Mission, Giuseppe Orefici, and the Peruvian *Ministerio de Cultura*. It is part of the Peru–Italy Cultural Agreement, and is renewed periodically thanks to an agreement between the Presidents of the two republics.

Research in the Nasca area includes fact-finding activities in the territory, based on a systematic study of cultural material associated with the ancient settlements visible on the surface. The detailed study-phase involves stratigraphic excavations as part of a long-term plan for a multi-disciplinary study of the findings, but also the eventual valorization of the monuments for the future socio-economic development of the area, especially with a view to fostering tourism. Alongside the archaeological research carried out in the area, the project aims to analyze the region's rock art. There are very important sites located in the various valleys, so studies and systematic research have been under way since 1982 to compare the various finds and to determine a chronological range to support archaeological study. The major sites investigated include Chichitara in the province of Palpa, while, in the Nasca region, work has been done in Pongo Grande and San Marcos (Valle del Río Aja), as well as in Quebrada de Majuelos, in the Las Trancas Valle, the Río Grande, and in the Valleys of Santa Cruz and Ingenio. In 2014 and 2015, studies were carried out on the petroglyphs at Huancor in an area near the city of Chincha; this is an important site dating from a period between the second millennium BCE and the first centuries of the Common Era (Figs. 1.1, 1.2 and 1.3).

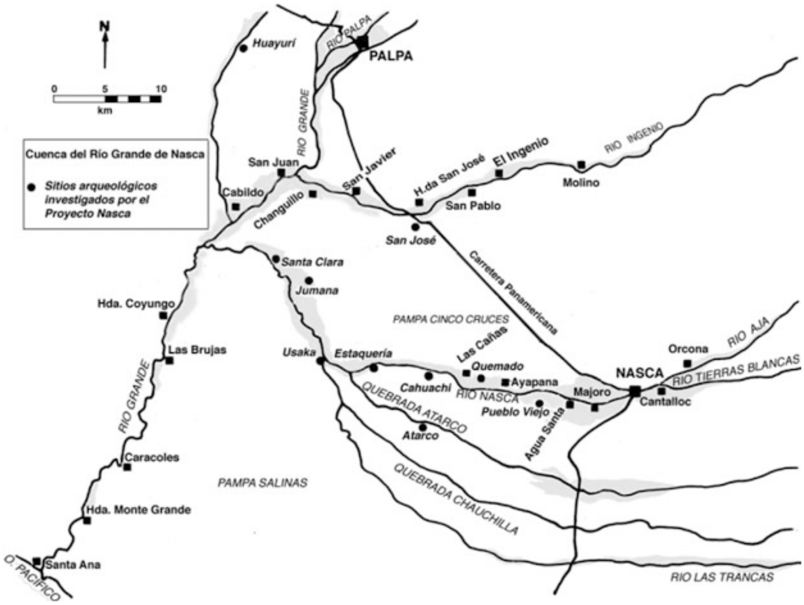

Fig. 1.1 Map with the location of the archaeological sites investigated by Proyecto Nasca (Drawing by Elvina Pieri)

Fig. 1.2 Chichitara (rock 17): petroglyph depicting a feline figure, associated with solar symbols and camelids (Photo by Giuseppe Orefici)

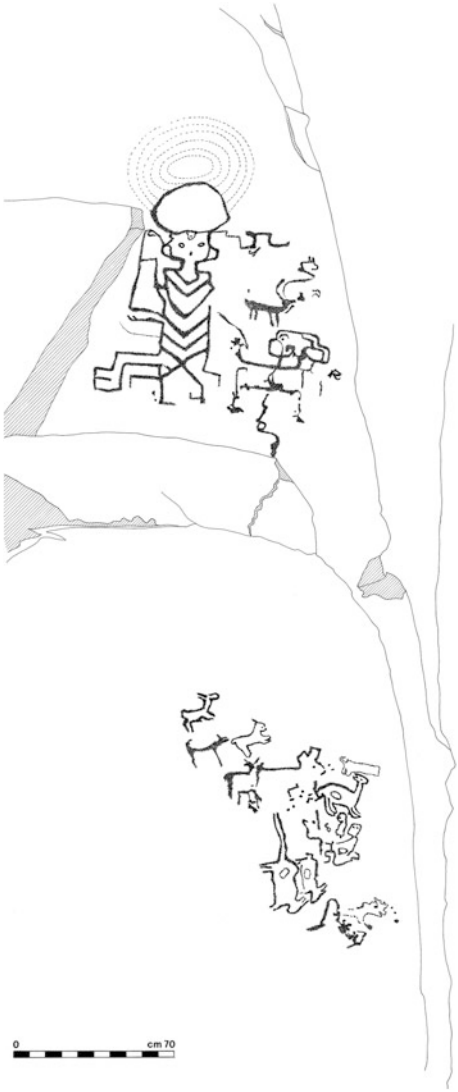

Fig. 1.3 San Marcos, rock 12. Large petroglyph depicting a divinity with halo associated with zoomorphic motifs including a stylized feline. At the *bottom* there are images of Andean female camelids with fetuses in their wombs (Drawing by Delia Perini)

1.2 Objectives and Results of the Research

The on-going research program has made use of the data collected over a period spanning from 1982 to the present at the sites of San José (1982), Pueblo Viejo (1983–1988), and Cahuachi (1984–2014), which is the largest adobe ceremonial center in the world, covering an area of 24 km^2. Data from Estaquería (1997–2002) and Huayurí (1984–1985), a small town located on the western side of the valley of the Río Santa Cruz, near Palpa have also been used in the project (Figs. 1.4, 1.5 and 1.6).

Fig. 1.4 Pueblo Viejo, Sector X3. Terracing system of transitional period Paracas–Nasca (Photo by Giuseppe Orefici)

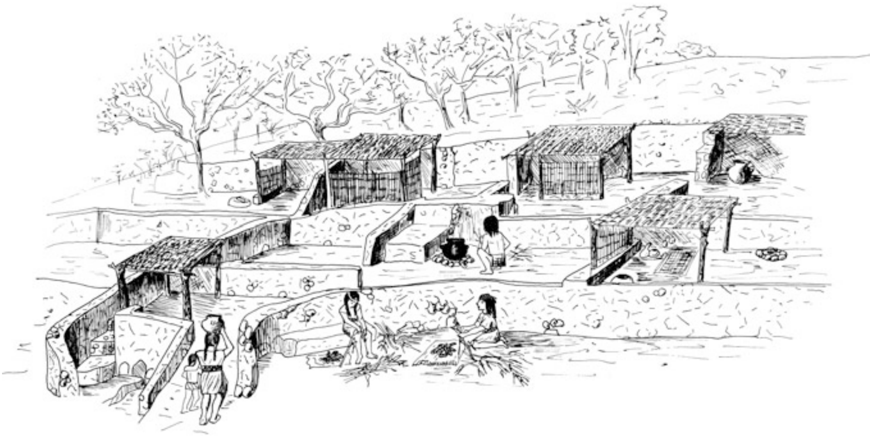

Fig. 1.5 Pueblo Viejo. Hypothetical reconstruction of Sector X3. (Drawing by Elvina Pieri)

The *Proyecto Nasca* aims to obtain as much data as possible concerning the real social and political-economic organization of Nasca (society). In the first phase (1982), the project set out to establish the relationship between the main inhabited sites, the great ceremonial centre at Cahuachi, and the Pampa geoglyphs, also

Fig. 1.6 Pueblo Viejo, Sector X3. Large polychrome pot (olla) decorated with figures of fishes (Photo by Giuseppe Orefici)

aiming to produce a register and a survey of the rock art sites in the secondary valleys. This first phase focused on the study of burial systems in the San José necropolis and the dwellings and temple structures in the area dating from the Early Intermediate and subsequent periods. Of particular note among the more important constructions is a large rectangular Middle Horizon temple.

The main results obtained in the next phase (1983–1988) include the discovery of a series of Paracas–Nasca dwellings in Pueblo Viejo and a considerable wealth of information on the early population of the valley from a study of bone remains found in the necropolis. In addition, five phases (with sub-phases) of architectural remodelling were identified at the Cahuachi site. Lastly, the possibility arose of proposing a new and more accurate pottery seriation) based on the stratigraphic position of the finds. At the same time, a systematic study of the architectural structures of the Pueblo Viejo and Cahuachi was undertaken with a view to subsequently comparing them with other similar finds in the various valleys influenced by the development of Nasca culture). Among the most important elements emerging from analysis of the buildings are the numerous construction materials found and their diversified uses.

A project was set up in 1988 to valorize a part of the excavations as a tourist attraction. At the Cahuachi site, it was also possible to start drawing up a record of a number of ceremonial offerings in order to classify them by type and to understand the significance of the surviving objects that either formed an integral part of the religious center or were sometimes left as offerings in the temples and other sacred enclosures. As mentioned above, in 1984 and 1985, the Nasca Project developed a research and archaeological excavation program in the *Ciudad Perdida* (lost town) of Huayurí, an urban center in the Middle Horizon and, above all, in the Late Intermediate Period, later destroyed in a conflagration. It has been possible to establish the layout of the city and the building types. The center of the valley was densely built up with clusters of buildings stretching up to the heights (the city had a population of 8000–12,000 inhabitants), with storage wells for food supplies and water. Using the data relating to the use of the city center and the fact that the buildings were burned, it was possible to find a large number of artefacts and remains under the thick layer of ash produced by the fire, which preserved intact the last moments of life in the city.

From 1986 to 1988, the research focused solely on Pueblo Viejo and Cahuachi, during which time important conservation work and redevelopment of the sites was carried out (including warning signs, paths for visitors, three houses for the guardians, and fencing works). In this phase, the research took on a specifically multidisciplinary character, and the scientific staff of the mission were joined by numerous Italian and other foreign specialists. This made it possible to analyze the sites and materials not only from the archaeological point of view, but also in terms of the architectural, botanical, anthropological/physical, geological, archaeo-astronomical, archaeo-zoological, and archaeo-musicological profiles, among others. A temple was discovered in the course of these excavations at Cahuachi. Its façade was decorated with a terraced geometrical frieze, symmetrical and in mirror-image, constituting the only example of ornament in bas-relief in the entire region. A Preceramic settlement was found dating back to 4282 BCE, thus pre-dating the Nasca temple.

In 1989, a study was done of the various archaeological sites along the Nasca valley, including Atarco, where various areas of the necropolis were excavated. They belonged to different historical periods, especially Early Nasca and Middle Horizon. In Jumana, it was possible to determine the extent of a large burial area from the Middle Nasca phase and the Recent Intermediate Period. Usaca was an extremely interesting excavation, especially due to the cemeteries from various periods, but also because of the presence of temple structures, now completely destroyed, including an Late Nasca terraced structure in adobe, which was more than 60 m wide. Quemado was undoubtedly one of the sites richest in very ancient material, consisting of tapered adobe walls datable to 500 BCE. Dwellings and temples of varying sizes were excavated here. During the religious expansion of Cahuachi, these were put to new use as warehouses. The location of this residential center, located in the middle of the riverbed, was of considerable importance during the development of Nasca (culture), especially in the earliest period, and was later reused as a necropolis during the Middle Horizon. Only a very small part the Santa Clara site was excavated: the surface was strewn with looted remains from a vast graveyard from the Recent Intermediate Period, but the existing cemeteries lower down, in close proximity to the dwellings, provided important data on burials from intermediate phases of Nasca (culture).

1.3 Cahuachi

Since late 1989, the project has focused its research on Cahuachi in order to study in greater detail the use of the various temple areas and the original urban layout. Moreover, the discovery of much earlier architectural structures (1700 BCE) than those in the urban context dating from the Paracas–Nasca (400 BC–550 CE) has suggested some new hypotheses concerning the continuity of use of the site and the importance that it may have had as a religious center over the millennia. As of 1990, a five-year program was set up to plan in detail the work to be carried out at the ceremonial centre.

In 1994, the excavations at Cahuachi were extended to cover not only the central temple complexes, enclosed within large walls (Zone A), but also the westernmost sector, (Zone B), where an offering/sacrifice was found consisting of 64 Andean camelids (llamas) in a single ceremonial enclosure (Fig. 1.7).

The burial was carried out during the Fourth Architectural Phase in Cahuachi: it included two offerings in the form of human heads along with the camelids, as well as figures accompanying the animals. A group of 27 large pottery *antaras* (pan-pipes) was found in the same sector (Y13). They had been purposefully broken in the aftermath of an earthquake and heavy rainfall which had damaged the buildings. The musical instruments had been placed in a crack in the floor, which had formed after an earthquake of gigantic proportions had affected most of the temples in Cahuachi (Fig. 1.8). The instruments have been reconstructed and now form a collection that is invaluable in interpreting the structure, sounds, and meaning of

Fig. 1.7 Cahuachi, Sector Y13 - Enclosure 1. Ritual burial of Andean camelids, part of a multiple offering/sacrifice (Photo by Giuseppe Orefici)

Fig. 1.8 Cahuachi, Sector Y13. Ritual sacrifice of a group of 27 polychrome panpipes (Photo by Giuseppe Orefici)

Nasca music [see Chap. 17 by Gruszczyńska-Ziółkowska (2016)]. After the *antaras* had been buried, the surface of the temple was covered with fill, and a camelid was placed over the clay seal as an offering; it was positioned and oriented in the same way as those found in the lower enclosure. In 1996, fabrics of incomparable value were found in an olla placed in a temple complex named Y15, and these have been studied by specialists Mary Frame and Maria Bastiand. The fabrics consisted of a ceremonial net, bordered in three-dimensional embroidery, a large piece of fabric consisting of a simple cotton sheet with embroidered corners in relief, and a mantle composed of two large, simple cotton sheets joined by a central strip with three-dimensional embroidery, which included more than two hundred human figures dancing on both sides of a procession of embroidered deities walking down the middle.

1.4 Estaquería

In order to understand the cultural dynamics within the valley between 400–550 CE, simultaneous excavations were conducted from 1997 to 2002 in Cahuachi (Fig. 1.9) and Estaquería (a site 4 km to the west) which assumed a dominant role after the abandonment of the ancient theocratic capital and its decline, becoming the

Fig. 1.9 Aerial view of archaeological excavations of Great Pyramid of Cahuachi (Photo by Giuseppe Orefici)

most important Late Nasca ceremonial center. During excavations, a u-shaped temple was found measuring more than 60 m across. It was located in front of an ample square, and it clearly once had floor decorations consisting of various colored-clay figures of birds. This building belonged to the western sector of Cahuachi and had also been used in the Middle Nasca (period) (350–550 CE) after the other temple complexes of Cahuachi had been abandoned. At the same time, a more recent late Nasca temple (550–650 CE) was found, containing a significant number of offerings, along with a group of Middle Nasca tombs in the form of small temples measuring about 3 × 3 m. In the same place, known as Cahuachi Zone C, a large necropolis was discovered with tombs from the latter stages of the Nasca (culture) and the early presence of Wari in the valley. Among the most important elements highlighted by the excavation in Estaquería are those found in an open trench to the west of the remains of the Wari temple located above an artificial : the descending forms consisted of step-like platforms dug into the natural clay, with very substantial Paracas–Nasca remains, including jars of considerable size and offerings belonging to the early phases of Nasca culture. In the same period, it was also possible to study and carry out archaeological excavations within the Wari structure located on the above-mentioned artificial platform (Fig. 1.10). The temple building, with its large huarango (*Prosopis pallida*) posts, which were originally placed there to withstand the weight of a large roof, was only partially finished, and

Fig. 1.10 Aerial view of Sector Y22 in Estaquería (Templo de Las Estacas) with piles of the bearing structure of an ancient roofing system (Photo by Giuseppe Orefici)

the flooring was also not completed. Within the buildings connected to the main patio, Recent Nasca tombs were found with sacrificial characters from the time of the Middle Horizon.

The most important repository of fabric from the Early Intermediate Period (68 bundles containing groups of painted and embroidered cloth) was discovered during the 1998 excavation of the Cahuachi Y16 complex, including many complete ceremonial robes. These findings are still being studied by the Mission Director and specialists Mary Frame (see Chap. 18 by Frame 2016) and Maria Bastiand and in the Nasca CISRAP laboratories. The same iconographic subject was repeated in a number of these large painted fabrics, suggesting that it had to do with a shared mythology recounted through the scenes represented on the ceremonial robes. The presence of repeated iconographic elements in fabrics made by different people and using different colors led to the conclusion that they were representations of myths, widely known in the collective knowledge of the Nasca.

1.5 Strategies and Technologies for the Conservation and Enhancement of the Ceremonial Center of Cahuachi

From 2002, a new phase in the project began, with archaeological excavation, conservation, and restoration of temples running in parallel. The area, where most of the activities intended to valorize buildings have been carried out, is on the North and East façades of the Gran Pirámide, including the squares and related precincts. Since 2005, it has also been possible to work in the complex named *Templo del Escalonado* in Sector Y2, which is almost perfectly preserved and has friezes in bas-relief along the perimeter walls. This is the only example of Paracas–Nasca monumental architecture, and it had already been excavated and covered over as a precautionary measure in 1987 and 1988. At the same time, conservation and reinforcement work was done on the adjacent *Pirámide Naranja*, which can be considered one of the most emblematic complexes on account of its intrinsic significance. It contained some extraordinary offerings, especially those found in the tomb of a little girl from a high-ranking family, complete with funeral trappings which included a nose decoration (*nariguera*) in gilded silver, numerous necklaces of varying size in semi-precious stones, and an ornate *spondylus* shell along with ritual-offering pottery, animals, and some two-color, woven basket work. The most recent excavations in this area have made it possible to establish that this architectural group, which includes the *Templo del Escalonado* and other buildings to the northwest and was examined for the first time in 1986, extended to form a further complex. This complex was named the *Pirámide Naranja*, where very important finds have been made, either associated with burials or at some point left as ritual offerings. The architectural features of this area date from a difficult time in the life of Cahuachi, which coincides with the ideological crisis that occurred in

Architectural Phase IV before it was abandoned. The oldest structures, including steps, corridors, passageways, and doors, were concealed and filled over with materials that mostly had belonged to the earliest periods. The various remodellings were accompanied by offerings of items belonging to the distant past and associated with animal, vegetable, textile, and ceramic, and sometimes human sacrifice. This stage of construction is clearly recognizable not only in terms of its particularly distinctive features, but also because of the abundance and quality of the materials offered. Among the most important findings associated with the *Pirámide Naranja,* and of particular note, is the group of 66 pieces of intact pottery and several gourds (*Lagenaria* sp.) carved and painted with resinous pigment, similar to the pottery belonging to the late Paracas. It is a unique example in the world since it exemplifies the use of a very refined technique for decorating the exterior of vegetal vessels with the addition of inorganic pigments of mineral origin together with metallic elements.

Research has been going on since 2008 in collaboration with the CNR-ITACA Mission which, using integrated geophysical survey and remote sensing, has played a key role as a support to decision making and the planning of excavation work (Masini et al. 2009). In some cases, archaeo-geophysical research has made it possible to locate buried archaeological sites and remains (Fig. 1.11). Of all these, especially worthy of note are some ritual offerings found in *Templo del Escalonado* and *Pirámide Naranja* (Lasaponara et al. 2011), a vast settlement buried in the bed of the Río Nasca, which has not yet been excavated, and in the Templo Sur, where work has been under way since 2012, in excavations within the remains of the buildings.

The detection of the buried settlement, located less than 2 km NW of Cahuachi, was achieved by means of satellite imagery with indirect validation based on geomagnetic prospecting and infrared thermography. The discovery opened new perspectives to archaeological research in Nasca territory and, in particular, in Cahuachi (Fig. 1.12) (Orefici 2009).

Templo Sur is a monumental construction closely connected with the eastern façade of the Gran Pirámide. It is a step pyramid with seven platforms, and its longer side faces the valley to the north. Comparing the size of the walls, especially the width of the outer walls, it can be stated that no other excavated area in Cahuachi has contained a structure with walls more than 2.5 m thick. Only in Templo Sur have measurements greater than 3-meters wide been found, apart from a cluster of walls one against the other on the west side of the temple, which reaches a thickness of almost 13 m. Among the peculiarities of the buildings, of particular note is the presence of a large quantity of walls in quincha composed of wattle joined by ropes made of vegetal material and covered in clay and raw earth before being whitewashed at a later date. These buildings were built during Cahuachi Architectural Phase IV, when many buildings were destroyed as a result of a violent earthquake. Repeated flooding had devastating consequences. It therefore became necessary to reconstruct the facilities in haste, so that the priestly class could not be accused of being unable to control natural events due to the anger or negative judgment of the gods. Among the materials found in the excavation of the *Templo Sur*

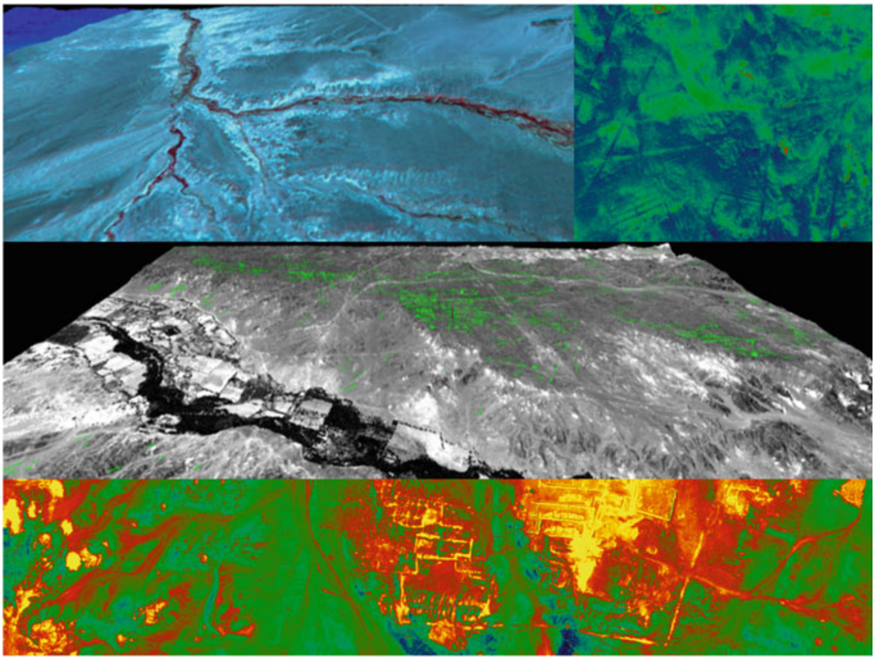

Fig. 1.11 Satellite remote sensing has been used for various applications and studies such as detection of archaeological features in Cahuachi, the reconnaissance and mapping of geoglyphs in Pampa de Atarco, the study of paleo-environment and the ancient aqueducts, and the monitoring of archaeological looting

buildings and the annexed ceremonial precincts, of particular note are a sizeable number of large ceremonial jars, a few tombs with offerings, and especially a completely ransacked cemetery, which belongs to the transition between Cahuachi Architecture phases II and III.

There are some still complete structures at the top of *Templo Sur*, with walls more than 5 meters high surrounding the upper platforms on the four sides of the building. The platforms of the building had parallel rows of columns covering the area, which contributed to the great volume of the built-up area. The platforms were divided inside by walls in *quincha*, which formed distinct rooms where various activities were carried out, especially ceremonies. The remains of a large collapsed roof were found in the SW corner of the building, which provided the opportunity to analyze the construction system of the shell. A special feature of the *Templo Sur* not found in the other buildings in Cahuachi was the presence of many small ovens showing signs of sporadic use as they were possibly utilised for offerings in Architectural Phase IV of the ceremonial center.

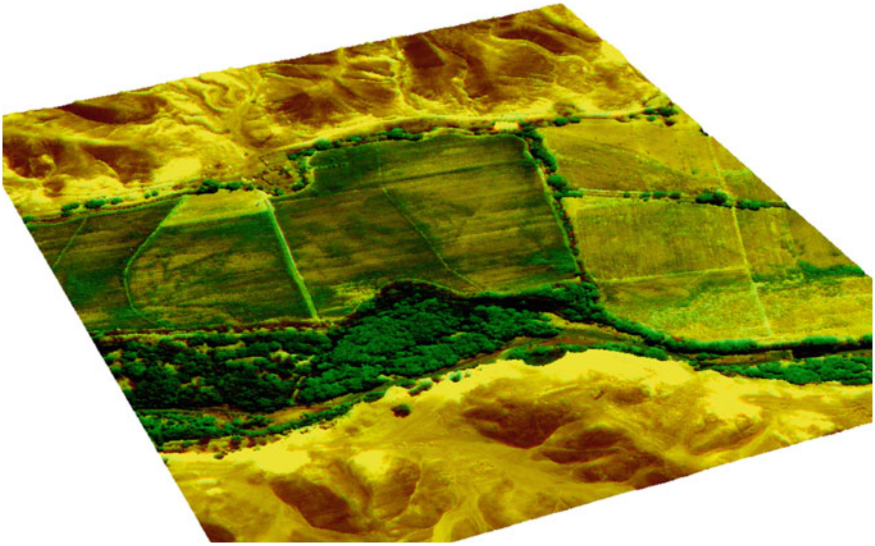

Fig. 1.12 3D QuickBird image of the Nasca riverbed. The processing of the satellite image (acquired in March 2005) revealed the presence of crop-marks referable to a large buried settlement

The western side of the temple construction was certainly of great importance, given its connection with the complex known as the *Gran Templo*. It is hoped that during the archaeological excavations over the coming years, it will be possible to obtain all the information on the side access to the temple and any of its connections to possible smaller buildings on the west side. No traces of color have been found on the walls, as they mostly date from Cahuachi Stage IV, a time of rapid and partial remodelling of the buildings that had been largely destroyed by flooding and earthquake. The evidence of the alluvial material deposited in the south-western corner of the temple clearly shows that rain and sediment resulted in many of the buildings being partially buried during Cahuachi architectural Phase IV. The traces of this collapse, which mostly affected the surface of the Templo Sur, clearly show how the path of the surface runoff came from the neighboring valleys in the opposite direction to the slope of the Río Nasca.

A geological study of the area has also made it possible to confirm the two main and most likely factors behind the abandonment and decline of the great ceremonial center: an earthquake of unprecedented violence combined with a catastrophic flood. During the excavation of the perimeter wall of Cahuachi Zone A, two different instances of floods were identified, one immediately before and one after its construction. Knowing the date of the buildings, it was possible to establish the date of these phenomena at between 350 and 400 CE. It became clear that, in the final abandonment phase, all the Cahuachi temple areas were the scenes of a series of rituals with animal and occasionally human sacrifices, in addition to offerings of ceremonial materials (including a large quantity of musical instruments). The priestly ruling elite implemented a plan of destruction on an enormous scale, and their main target was the theocratic capital itself. After the ceremonial complex, the wooden posts of most of the temples were burned, thus annihilating centuries of the history of a civilization which had come into being with all the hallmarks of one that would renew itself cyclically, as well as one having a real perception of the passage of time.

However, the Nasca Project has also been able to reconstruct the aftermath of this stage, because the clay foundations of the new edifices were placed on top of the still glowing ancient temple ruins, with traces of burning marking the lower parts due to the heat of the embers below. This confirms that temporary constructions were being erected in order to carry out offertory activities or further sacrifices during the last stages of the fire. Later, the pyramid complexes were covered with fill from the remains of the ceremonial center, and they were given a terraced appearance, concealing the older construction. The final act, at huge economic and human cost, was to seal the structures with a layer of clay of varying thickness, thus turning Cahuachi into an eternal monument.

The project has excavated more than 180 areas (EXP) located in 24 different temple complexes (Y) in the ceremonial center, establishing, as stated above, the existence of five architectural phases and a number of sub-stages controlled by means of a stratigraphic sequence proven by more than 80 radiocarbon datings. Currently, thanks to a greater knowledge of Cahuachi urban design, the project is embarking on further analysis of the activities that have been carried out in the various areas of the site. At the same time, it is seeking to define in greater detail the dynamics of the events that preceded abandonment, including the posthumous activities of other administrative or religious centers, up until around 550 CE, before the conquest of the territory by the Wari).

1.6 Collaboration with the ITACA Mission

With the contribution of ITACA–Mission, directed by Nicola Masini, the archaeological research in Nasca enlarged the horizon of investigation to include the study of filtration galleries and the analysis and mapping of geoglyphs in Pampa de Atarco [Fig. 1.11; see Chap. 22 by Lasaponara et al. (2016b)].

Three years of investigations enabled us to provide new information on the presence of unknown *puquios* in the valleys of Río Nasca, Río Taruga, and Río Las Trancas, as well as to characterize the groundwater table by using geoelectrical prospecting. The use and the processing of very-high- and high-resolution satellite

Fig. 1.13 Geological investigations conducted in Cahuachi and in the Nasca drainage basin

imagery enables us to obtain very detailed maps of the aqueducts as well as to study the hydraulic regime of the Nasca drainage basin[1].

In Pampa de Atarco, CNR investigations have been focused on the study of the spatial and functional relationships between the geoglyphs and the pyramids of Cahuachi.[2]

Moreover, recent advances in the geological knowledge of Cahuachi have been achieved. In particular, the conglomerate at the top of the succession at Piramide Sur and Gran Piramide was not deposited by an extraordinary flood that followed the catastrophic El Niño event of the 10th century, as hypothesized in the literature. Rather, according Delle Rose (2016, see Chap. 3), it represents the progradation of an alluvial fan and must be related to the stratigraphic transition (Upper Pliocene—Lower Pleistocene) toward the Cañete Formation which is exposed outside of the area of Cahuachi (Fig. 1.13).

[1]For additional detail, see Chap. 13 by Lasaponara et al. (2016a).

[2]For additional detail, see Chap. 12 by Masini et al. (2016a).

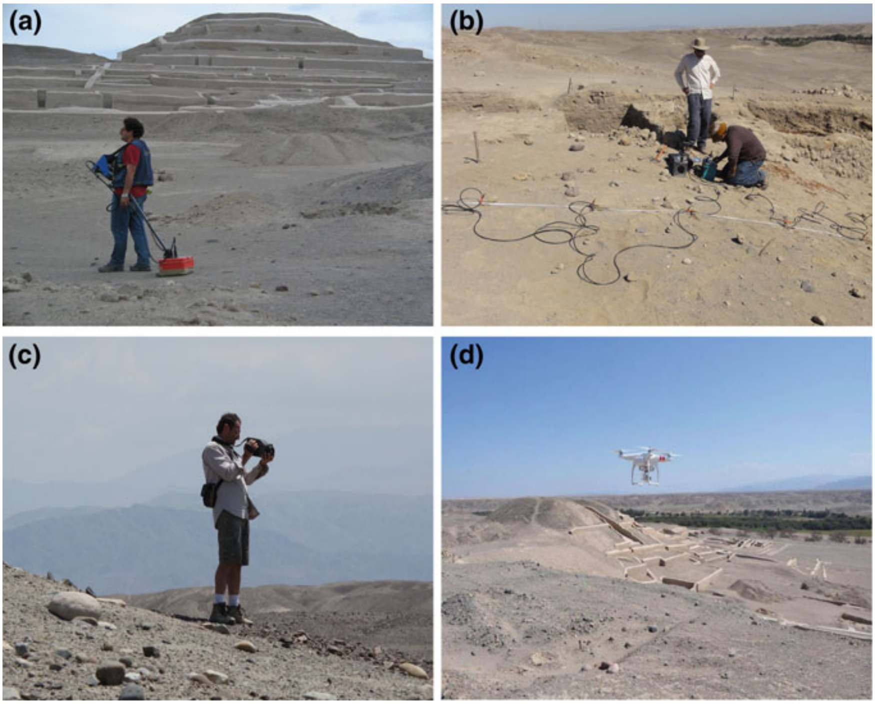

Fig. 1.14 Various methods and techniques used for investigating and mapping buried and shallow archaeological remains in Cahuachi and in Nasca territory, such as **a** georadar, **b** electrical resistivity tomography, **c** magnetometry, infrared thermography, and **d** aerial prospection by ultra-light aircrafts and UAVs

Finally, the synergic cooperation between the archaeologists of Proyecto Nasca and the researchers of ITACA Mission enabled us to experience and develop new scientific methodologies and technologies for various applications, such as: (1) the detection of buried earthen walls, by means of geophysics, geomatics,[3] satellite remote sensing (Masini et al. 2016b), Unmanned Air Vehicle (UAV) and Synthetic Aperture Radar[4]; (2) the diagnostics for the conservation of adobe; (3) the compositional and mineralogical analysis of pigments of Nasca ceramic (Pappalardo et al. 2016), and finally (4) the monitoring and the study of archaeological looting and vandalism in the Nasca Lines (Figs. 1.14 and 1.15; see Chaps. 24 and 25).

[3]See Chap. 23 by Bitelli and Mandanici (2016).

[4]See Chap. 21 by Cigna and Tapete (2016).

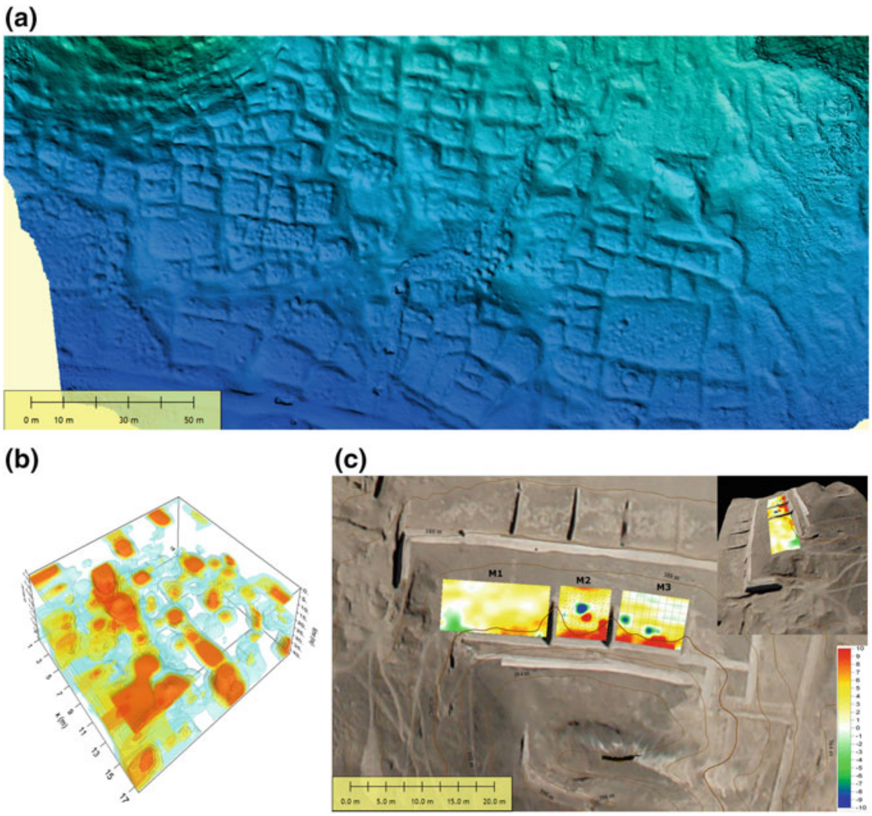

Fig. 1.15 The integrated use and interpretation of the results from remote sensing and geophysical investigations enabled obtaining new information of cultural interest in the subsoil of Cahuachi and of other investigated sites. The figure shows: **a** the digital elevation model of a settlement in Taruga, resulting from the processing of images taken from UAV, **b** the 3D representation of georadar investigations in Piramide Surd in Cahuachi, and **c** geomagnetic mapping of the top of Gran Piramide in Cahuachi

Acknowledgments The DEM in Fig. 1.15a has been acquired and processed by Antonio Pecci of CNR/IBAM. The georadar data have been acquired by Enzo Rizzo and Luigi Capozzoli (CNR/IMAA). The acquisition and processing of geomagnetic data showed in Fig. 1.15c have been made by Enzo Rizzo. The 3d representation (Fig. 1.15b) of georadar data has been performed by Giovanni Leucci (CNR/IBAM).

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Chapter 2
The Nasca Area and Its Environment

Giuseppe Orefici and Josué Lancho Rojas

Abstract The environment in which the Nasca Culture developed is the valley of the Río Grande de Nasca and its tributaries. The area is a hyper-arid desert with river oases which made possible the development of one of the most important cultural expressions of the south coast. Along the entire Peruvian coastline, the effect of the Humboldt Current causes the lack of rain on the coast, because of the strong winds that remove the hot water from the surface, altering the natural thermal balance between the ocean and the continent. The wealth of marine life and the ability to best use the river valleys for agricultural purposes determined the reasons why there were continual settlements along the coast near the waterways. Human presence in the valley of the Río Grande was linked to its progressive capacity to adapt to this type of climate, environment and ecosystem while basing their subsistence in accord with the available resources for hunting, gathering, and supplies connected with marine products. The seasonal characteristics of the different existing ecosystems in the coastal areas and river oases were the elements that contributed to the creation of permanent and seasonal settlements.

Keywords Río Nasca · Hydrography · Hydrology · Ecology · Climate · Marine and land resources

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2.1 The Río Grande de Nasca Drainage Basin

The current territory of the Nasca area fits into the hollow of the *Río Grande de Nasca*, which abounds in river systems. Most of these are tributaries of the Río Grande that forms the core of the hydrological system. The watercourses are largely torrential, and the water resources and their extent depend on the amount of rainfall in the mountains on the plateau during the austral summer (Fig. 2.1).

2.1.1 Hydrological Resources and Water Regime

The aquifer of the Río Grande consists of important deposits dating from the Tertiary and Quaternary periods and lies on an important impermeable base made up of metamorphic, sedimentary, and intrusive rocks. It is estimated that the maximum thickness of the aquifer is approximately 500 m. The mountains in the area belong to the oldest formations in the Andes and are part of the Western Maritime Cordillera, which runs parallel to the desert coastline, with altitudes ranging from 900 to 1200 m above sea level. This unit consists of Precambrian and Palæozoic rocks, with widths ranging 15–50 km.[1]

The rocks in this formation are volcanic and sedimentary, dating from between the Jurassic and the Tertiary, while the intrusive rocks are from the Cretaceous and Tertiary periods, originating from alluvial, marine, fluvial, and wind action during the Quaternary, as can be seen from the present accumulations. According to Dollfus (1965), Tricart et al. (1969), Grodzicki et al. (1989) and Grodzicki (1994), the stratigraphy of the rivers enables us to recognize three periods of fluvial sedimentation in the Quaternary that led to the formation of four terraces. There is also marked erosion and subsidence to the north, off the Paracas Peninsula, where the Ballestas, Independencia, and Chincha Islands are located. Areas of depression can be noted even in the most southern parts, in the proximity of the mountains of Tunga and in the Central Plateau of Marcona, where there are also traces of deep-sea crevices with very important stratified deposits of fossil shells.

In the area between the river basin of the Nasca Río Grande and the Acarí site, the sea gradually reaches a great depth, which, about five-kilometers distance from the coast, abruptly falls in a vertical drop of 5000 m, taking the form of a circular depression. We can observe the same situation near the coast between Cañete and Paracas, where there is another very deep, rounded depression. A rock formation rises between the two underwater anomalies and extends onto the land, where it is known as Loma de Ica. In the desert and mountainous areas, like Ica and Nasca, the continual use of water by the early inhabitants constantly created the greatest problem due to the almost total lack of rainfall (5 ml/year) and the fact that there is

[1]See the Chap. 3 “The Geology of Cahuachi” by M. Delle Rose (2016).

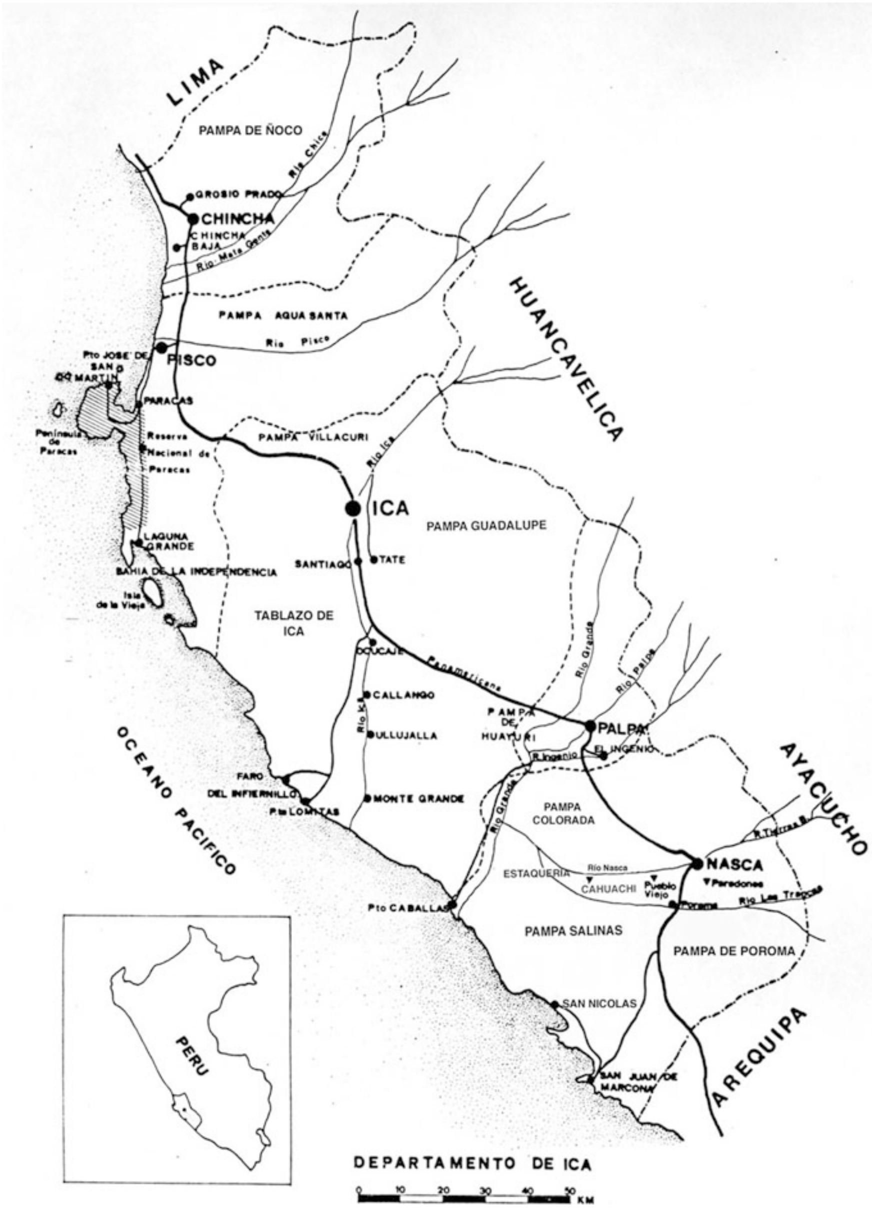

Fig. 2.1 Map of Ica Region (Drawing by Elvina Pieri)

much more subterranean water than can be found on the surface. Currently, around 80% of the water used in the Ica and Nasca valleys comes from wells. Millions of cubic meters are extracted annually from underground, but the size of the water table is unknown.

The hydrogeological resources are invariably related to the porosity and permeability of the geological matter. The rocky ground shows very low levels of porosity and permeability, so its ability to amass and redistribute water depends on its degree of fracturing. When there are deposits on the surface, its porosity and the permeability are associated solely with the empty interconnected spaces. The only way to exploit subterranean water is to make use of the alluvial deposits enclosed in the valleys. Among the best known, the most extensive and the ones offering the most potential, are in the lower basin of the Río Grande and in the alluvial cones of Río Acarí and the Río Yauca: these coincide with the morpho-structural unit known as the Ica-Nasca depression (Fig. 2.2).

Higher than 4000 m above sea level, in the highlands of Huancavelica, rainfall reaches 1000 mm per year, but only 15–25% of the rainfall flows on the surface: a portion evaporates and the rest seeps into the ground to form underground aquifers, whose size and capacity are unknown. This volume of water may flow from the higher area to the sea, using an escape route formed by a system of interconnected faults and fractures, which would allow it to make contact with the alluvial base of each valley and then reach the coast. Several deposits of igneous–hydrothermal origin may be found in the region, with copper, lead, zinc, and silver in the form of sulphurous concretions. Furthermore, in the provinces of Nasca and Ocoña, there are important deposits of native gold. On the South Coast, the genesis and mineralization of deposits are characterized by the presence of copper and gold deposits located in the batholith of the coastline and are identified on the map as the Nasca-Ocoña metallogenetic gold-bearing area. At the top of the Western Maritime Cordilleras, there are also seam deposits of metasomatic copper and silver.

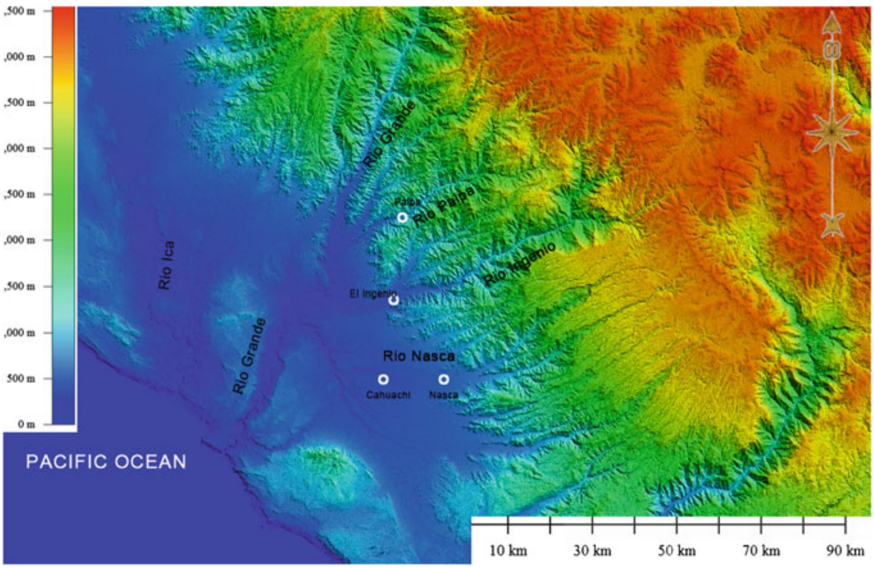

Fig. 2.2 DEM from Shuttle Radar Topography Mission: detail of Ica Region including the Río Grande and Río Ica drainage basins

The entire 3080 km of Peruvian coast is very arid land, crossed by around fifty rivers with very low water flows, descending from the western side of the mountain range. The Nasca region, with its plains, mountains and coasts, is one of the most challenging regions for human settlement (Figs. 2.3 and 2.4).

Fig. 2.3 Majuelos: deep furrow in the sandy soil left by the occasional alluvial deposits in the desert land of Nasca (Photo by Giuseppe Orefici)

Fig. 2.4 The sparse vegetation survives due to underground water and moisture derived from the large strong temperature variations between day and night (Photo by Giuseppe Orefici)

The only possibility of subsistence, as in the rest of the desert coast, comes from some river oases, where abundant natural vegetation grows and the soil is more fertile, thanks to the humus-rich debris that are brought by the rivers during the summer floods (Figs. 2.5 and 2.6). The desert climate has a wide temperature range and considerable variation in relative humidity between night and day, especially during the winter months. Temperature measurements oscillate between 5 °C during the night and 32–40 °C during the day, while the relative humidity varies from 97–100 to 20–30% (ONERN 1971; Skibinski 1991). The scarcity of rain [2.2 mm (ONERN 1971)] and the above-mentioned geographical and geological characteristics bring about a unique ecosystem that, according to palaeoclimatic studies, must not have been very different in the past.

2.1.2 *Ecology and Different Ecosystems. Effects of the Humboldt Current*

It is also important to add that, in the coastal area in question, beyond the desert area, there are different ecosystems that depend on multiple factors which are as much environmental as exogenous (Fig. 2.7). Here we refer to the coastal

Fig. 2.5 Nasca river valley in the area of Cahuachi. The green zone area contrasts with the clay and sandy soil where the buried temples of the ceremonial center can be found (Photo by Giuseppe Orefici)

Fig. 2.6 Río Ingenio valley. Typical landscape of river oases where vegetation grows and is maintained due to the constant presence of water in the river (Photo by Giuseppe Orefici)

ecosystem up to 500–800 m above sea level, *Chala*, without taking into consideration the area between 500–800 m and 2000 m above sea level (called *Yunga seca*), with sporadic rainfall of around 150 mm per year (Pulgar Vidal 1987). Among the factors specific to the desert climate, we can mention wind erosion,

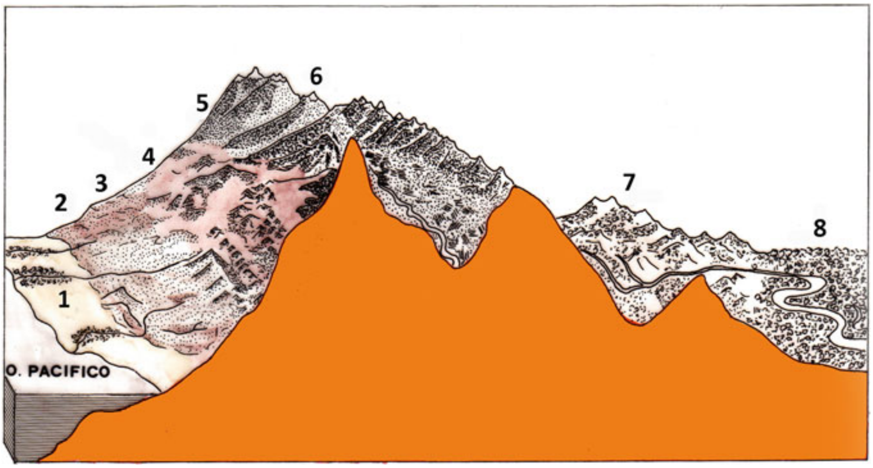

Fig. 2.7 Geographic pattern of the eight regions of Peru according Pulgar Vidal (1987) (Drawing by Elvina Pieri). Their Spanish or Quechua names are: Costa or Chala (*1*), Yunga marítima (*2*), Quechua (*3*), Suni or Jalca (*4*), Puna (*5*), Cordillera or Janca (*6*), Selva Alta or Rurarupa (*7*), and Selva baja or Omagua (*8*)

especially in the months between August and October, as winds blow very strongly, sometimes lasting three or four days in a row, and paralyzing all human activities outdoors. This phenomenon is commonly known by the name of *Paraca*.

Another factor that has a decisive influence is the system of sea currents flowing parallel to the entire coastline. The most important of these is the Humboldt Current or Peruvian Current, a constant flow of cold water that forms off the coast of Chile, Peru, and Ecuador due to the action of the wind, dragging away the warm surface water, thus altering the natural thermal balance between the ocean and the continental mainland. The result is that the water cools by 5–10 °C below what it otherwise would be, a phenomenon that occurs as far north as the equator. This natural phenomenon was discovered and documented in 1800 by the German naturalist and explorer Alexander von Humboldt, who measured the temperature of the sea in the southeast area of the Pacific Ocean, off the coast of Callao (Peru). The Humboldt Current flows from south to north along 4000 km of coastline and does not form a single stream, but is divided into a coastal branch and an ocean branch, to a depth of between 30 and 400 m, respectively. Hence, it is referred to as the Humboldt Current system. It is one of the most biologically productive phenomena in the Pacific, primarily because of the presence of areas of resurgent sea water or surfacing produced by the action of the wind, causing the displacement of extensive surface water, and creating spaces which are filled by the water rising from a depth fluctuating from between 150 and 300 m, which is lower in temperature and richer in oxygen. The cold water contains nitrates and phosphates from the seabed, essential substances for the growth and maintenance of life throughout the food chain that feeds all the species of ocean animals, from microorganisms to larger fish. This means that the Peruvian sea is one of the richest in the world in terms of the abundance of fish, creating an irreplaceable source of food for birds and marine mammals, as well as a steady source of income for the fisheries sector. This cold current is the main cause of the heavy mist and stratified fog that condense along the Peruvian coast, often producing very fine rain known as the *garua*, which benefits and sustains the Lomas area (von Ellenberg 1959; Pulgar Vidal 1987). During the winter, the Cordillera Mountains closest to the sea are covered in vegetation, able to spread thanks to the humidity held by the terrain, despite the scarce rainfall in this arid zone. It is a very peculiar phenomenon well known to the ancient inhabitants of the valleys of Peru and Nasca, who used the vegetation that developed in this ecosystem (Orefici and Drusini 2003). Nevertheless, abnormal events periodically occur when the Humboldt Current is unable to emerge because the north winds push the warm waters from the Gulf of Guayaquil (Ecuador) to the south, leading to the formation of a warm current, known as *El Niño*, which replaces the natural cold current. This phenomenon, which continues while the action of the equatorial current lasts, causes an increase in surface water temperature of between 6 and 10 °C, causing torrential rains, floods, and alterations in the marine habitat; it also brings with it tropical fish and causes a decrease in the plankton typical of cooler currents, bringing catastrophe for the survival of wildlife and fishing in the coastal areas.

In the drainage basin of Río Grande de Nasca, there are signs of more dramatic alluvial phenomena that caused alterations in the morphology of the land in ancient times, even affecting structural damage to the buildings of the ancient settlements, as became clear from the archaeological excavations of the Nasca Project at the Cahuachi ceremonial center (Orefici 1989, 1990; Orefici and Drusini 2003; Grodzicki 1989, 1990, 1994). It is possible that these changes had to do with phenomena connected with El *Niño* called Super ENSO or Mega Niño (Mörner 1986, 1992; Orefici and Drusini 2003). In particular cases, the coastal rain may depend on masses of very warm air from the Amazon Cyclone if it manages to surpass the natural barrier of the Andes.

This area, despite being characterized by a desolate appearance and a habitat that appears unfavorable to any kind of life, has a fairly varied natural vegetation, as well as animal life that has adapted to the coastal ecosystem. Currently, agricultural crops have increased significantly, as has the indiscriminate felling of trees, especially due to the growing demand for charcoal for restaurants. Even the intensive use of groundwater resources and grazing have caused profound changes and irreversible damage in the valleys, dramatically altering the natural ecological balance. At present, we are unable to determine with certainty the reconstruction of the palaeoclimate of this habitat, but some studies (Cardich 1977; Lynch 1982; Dollfus and Lavallée 1973; Dollfus 1981; Rick 1980) have established a subdivision of the main climatic phases in the territory. One of the main sources is the documented evidence for the presence of continental ice, which enables us to go back in time almost one hundred and fifty thousand years (Lories et al. 1985; Thompson 1993 for the palaeoclimatic fluctuations over the last millennium). Other archaeological data regarding phenomena capable of damaging the cultural remains of the coast, such as the effects of *El Niño*, are still being studied in order to understand the relationship between the environment and human presence. Comparing the stratigraphy of various sites in order to determine the real cause of these events, it was possible to develop experimental models to build upon in order to ascertain the chronology of the more dramatic phenomena (Macharé and Ortlieb 1993).

2.1.3 Marine and Land Resources

Human presence in the valley of the Río Grande in Nasca was closely linked to their gradual capacity to adapt to this type of ecosystem and was based on subsistence activities in line with available resources.

A major source of food supply was undoubtedly the coastal strip closer to the ocean, rich in marine life and easy to reach by moving along the river valleys to their mouths. Thanks to the Humboldt Current, the maritime area of the Nasca territory is most certainly among the richest in marine wildlife on the planet. The complexity of the food chain characterizing this system includes various levels, starting from the abundant zooplankton and phytoplankton and ending with their exploitation by fish, marine mammals, and birds, and consequently also by humans. Among the birds found on the coast, there are large numbers of pelicans, gulls, cormorants, flamingos, gannets, and many other species. Many of these form huge colonies on the rocky coast or on the islands near the mainland, where they deposit thick layers of guano, which has been used since ancient times as a fertilizer and for trade purposes.

The huge amount of fish, crustaceans, and molluscs found here is an enormous food resource and formed the staple diet of the ancient mussel pickers and coastal fishermen. Among the most common species, both now and in Pre-Colombian times, are sardines (*Sardinops sagax*), anchovies (*Engraulis ringens*), *silver smelt* (*Odontesthes regia*), Pacific bonito (*Sarda chiliensis*), mackerel (*Scomberomorus maculatus*), some sciaenidi such as *lomas and cocos* (*Sciaena deliciosa and Paralonchurus peruanus*), corvinas (*Cilus gilberti*), *palm ruff* (*Seriolella violacea*), grey mullet, tuna, and others. An alternative source of protein was provided by the large variety of marine molluscs, whose remains were amply identified in the archaeological excavations conducted by the Nasca Project at the Cahuachi ceremonial centre and in other sites with dwellings where its influence was felt. The most common were varieties of mussels (*Choromytilus chorus* and *Choromytilus ater*), pectinidae (*Pecten purpuratus*), tellinidae and clams (*Mesodesma donacium* and *Mulinia edulis*), as well as numerous snails (*Thais* sp., *Tegula atra*, *Trophon peruvianus*, etc.) and echinoderms, including sea urchins (*Loxechinus albus*). There are also numerous types of shellfish such as the purple crab (*Platyxanthus orbigny*) and the MuyMuy (*Emerita analoga*). The analysis and recording of fish remains, carried out during various archaeological projects along the coast, have revealed the presence and use of various species of fish and shellfish beginning from the Preceramic

Period. Thus it has been possible to demonstrate the importance of the presence of marine produce left as offerings as part of temple ceremonies. Freshwater streams are the habitat of the changallo shrimp (*Cryphiops caementarius*), abundantly documented in Nasca textile and ceramic images and of which numerous remains were found in Cahuachi. Today, because of overfishing, these crustaceans are significantly fewer in number and can be consumed only thanks to the many farms situated along the rivers, especially in the areas most distant from the sources.

The variety of coastal fauna is also seen in the number of mammals that feed on marine resources, including two species of carnivorous pinnipeds of the otariid family, commonly known as sea lions, including the South American sea lion (*Otaria flavescens*, formerly *byronia*) and the South American fur seal (*Arctocephalus australis*), who live along the rocky coast and on the beach; there is also a small saltwater coypu (*Lontra felina*) or *chungungo*, also known as the sea cat. The Peruvian waters have numerous species of cetaceans, including several varieties of whales and dolphins, the largest of which is the orca marina (*Orcinus orca*), depicted as one of the main gods of the Nasca Paracas pantheon.

As was noted before, the desert territory where the Nasca culture developed has different ecosystems, including areas defined as river oases. It is necessary to distinguish between them on the basis of characteristics and morphology, resulting in three different environmental classifications:

1. oases caused by water from water tables or *puquiales*, at sources of various types and sizes (Schreiber and Lancho Rojas 1995; Lasaponara and Masini 2012; see also Chap. 13 by Lasaponara et al. (2016));
2. river oases occupying both sides of the rivers perpendicular to the coast and making up the cultivated areas most widely used throughout the Peruvian coastal desert areas;
3. nebulo genetic oases, arising from the concentration of moisture contained in the fog and falling to the ground which cause the phenomenon known as *lomas*.

The fluvial oases provided the determining factor favoring the first human groups in the Early Preceramic Period who considered them as sites for seasonal exploitation of resources or permanent settlement. The ancient hunter-gatherers migrated into the river valleys during specific seasons, following the wildlife as it moved towards the coast. The river oases therefore constituted an important geographical environment where they could settle for certain periods. Together with the *lomas*, the river valleys provided an important reserve of wild plants, seeds and tubers. During the Pre-Hispanic period, this type of initial socio-economic activity was supplemented by hunting and, perhaps, some incipient forms of agriculture.

Although there is currently scarce land fauna, in Pre-Columbian times, the coast was well-populated with cervids (*Odoicoleus virginianus*), guanacos (*Lama guanicoe*), and foxes (*Duscicyon* sp.), as well as felines like *Felis colocolo*, an endemic species also known as the Andean cat and/or *pajonales*. At present, numerous bird species dwell in the huarango forests (*Prosopis pallida*), including hummingbirds, *vencejos*, *chaucatos* (*Mimos longicaudatus*), swallows, *huerequeques* (*Burhinus superciliaris*), green parrots. There are also large numbers of falcons and owls, which feed primarily on rodents, insects, and reptiles, in addition to condors at particular times of the year when they come down from the mountains to the coastal areas in search of food.

In ancient times, as is well documented by archaeological research, there were already many domestic species such as the llama (*Lama glama*), the alpaca (*Vicugna pacos*), the guinea pig (*Cavia porcellus*, *Cavia cutleri*), the dog (*Canis familiaris*), and possibly a few birds such as the duck. The presence of dogs in Peru is well documented, both in iconography and in ceramics: dog remains have been found in tombs in Paracas, Nasca, Moche, and other archaeological contexts. After the Spanish conquest, the fauna in the area included almost all the species introduced by the Europeans, and the Andean camelids are mainly bred in the *Sierra* today. Spontaneous endemic trees and shrubs grow at the oases: there are large huarango forests (*Prosopis pallida*), *espinos* (*Acacia macracantha*), willows (*Salix chilensis*), *Peruvian pepper* (*Schinus molle*), *pájarobobo* (*Tessaria integrifolia*), *paloverde* (*Cercidium praecox*), *mata burro* (*Parkinsonia aculeata*), and others.

As humans began to settle, this was possibly the most suitable habitat for some temperate plants to adapt to the environment, even in very ancient times. The types of edible species found here depend on the agricultural development of the valleys: they are numerous and include the most ancient cultivated plant species from the early stages of the cultural development of the area introduced after their domestication. The best known are those used for sustenance, including the cucurbitaceae (*Cucurbita maxima*, *Cucurbita moschata*, *Cucurbita ficifolia*, which could be eaten as well as used for practical purposes such as the *Lagenaria siceraria*), maize (*Zea mays*), various legumes such as *pallar* (*Phaseulus lunatus*), beans (*Phaseulus vulgaris*), canavalia (*Canavalia plagiosperma*), peanuts (*Arachis hipogaea*), and all varieties of peppers (*Capsicum* sp.). Of the edible tubers and roots, in addition to the potato (*Solanum tuberosum*) originally from the Andes, we can mention the camote or sweet potato (*Ipomoea batatas*), the manioca (*Manihot esculenta* or *utilisima*), the *achira* or arrowroot (*Canna edulis*) and the *jíquima* (*Pachyrhizus tuberosus*) whose rhizome is used for food.

Other plants were used industrially or for other practical purposes, e.g., cotton (*Gossypium barbadense*), the *caña brava* (*Gynerium sagittatum*) and the *totora* (*Typha dominguensis*), scirpus (*Scirpus* sp.), and *sedge* (*Cyperus laevigatus*), while *carrizo* or common reed (*Phragmites communis*) was used to make mats of woven vegetable baskets, the roofs of buildings, and utensils. Among the endemic fruit trees were the *lúcumo* (*Pouteria* sp.), whose fruit or kernels are very frequently found at the excavations of the Cahuachi ceremonial centre, the pacae (*Inga feuillei*), used for its wood and seeds, and the *chirimoyo* (*Annona cherimola*). Other plant species used include one of the cactus family, the prickly pear (*Opuntia ficus-indica*), whose presence is documented in native patterns from about 9000 ACE. In addition to being a source of fruit, this plant was very important for breeding a parasitic insect, the cochineal (*Dactylopius coccus*) whose body contains a haemolymph based on carminic acid, a natural red pigment used to dye fabrics and currently adopted as a colorant in food, cosmetics, and pharmaceuticals.

2.2 Subsistence Economy and the Dynamics of Settlements in Coastal Southern Peru

In these environmental conditions, the first human groups had to adopt a number of strategies to control the natural produce, thus adapting to a completely different ecosystem, leading to a new order in the structural relationships between the various social categories and the creation of an economic basis founded on food production.

During the transitional period corresponding to the final stage of the last Pleistocene ice age (c. 10,000 BCE), prehistoric Peruvian man had to adapt to sequential climate changes, as well as to various changes in the morphology of the ground, which altered his habitat and reduced the varieties of plants and animal resources available. At the same time, the gradual thaw following the end of the Ice Age allowed bands of hunters to move to areas, which, up to then, had been beyond their reach, such as the *Puna* and the grasslands on the plateau, rich in fauna and various plants, exploiting them for a very long period of time. These groups of hunters who fed on deer and camelids, smaller animals, and the fruits of wild plants, which they gathered as they went, camped near lagoons, springs, or rivers, where they were more likely to run into the local fauna. In the Preceramic Period, there was already evidence of long-term occupation of some of the sites with these features, so it is impossible to hypothesize an on-going nomadic existence, because this does not correspond to reality. There were certainly periods of transhumance, depending on the rainy season or seasonal movements of herds of animals, and many human activities were tied in with the rhythms of nature.

The vertical morphology of the Andes and the close relationship between the climate and the topography enabled the population access to a variety of ecosystems at higher altitudes, despite the relatively short distances. This clearly explains the efficiency of transhumance in its various forms, based on seasonal circulation from the bottom of the valley's western slope to the plateau and back, as well as human adaptation to the fluvial oases of the Pacific side. This then was an important time in the creation of the conditions that led to the gradual domestication of plants and animals. The availability of abundant fauna and a constant supply of vegetation, along with the possibility of staying in the same region for a long period of time and an increasing knowledge of environmental resources, meant that the first agricultural practices could develop, and flocks of gregarious animals such as camels could be brought together so as to tame them and develop the rudiments of farming. The hunter-gatherer thus assimilated the knowledge necessary to practice an early form of agriculture at a very early date, since the plants growing on the plateau appeared around 8000 BCE and on the coast from 6000 BCE onwards. This form of socio-economic innovation brought about new models of experimentation to make use of the resources, which began to be increasingly independent of periods of short-term meteorological or climatic change. Gradual limitation or reduction of natural food reserves brought about a profound change within the societies that would develop later.

This was not a homogeneous stage in the Central Andes due to the fluctuations in the climate and the environment that led to significant changes in the availability of the natural resources, greatly influencing the stability of early human occupation, with a marked impact on subsistence models. In the transition from the Pleistocene to the Holocene, in areas with marginal water and food, the rapid environmental transformation was the main cause of changes in the way of life of the hunter-gatherer, increasing volatility in the way he made use of resources. Moving to areas with less environmental stress and the acquisition of new production methods were phenomena conducive to an increase in population in the coastal desert areas, in parallel with a new form of agricultural experimentation: these factors favored greater autonomy despite the diminished reserves of natural foodstuffs.

From the current palaeo-climatological evidence relating to the Mid-Holocene, we know that the effects of the melting ice, which lasted until 6000–5500 BCE, brought about a so-called *climatic optimum* or *thermal optimum*, meaning a phase in which the temperature stabilized with an increase in rainfall and humidity in the northern area. Unfortunately, quite unlike other areas, there are no specific studies on the extent of this phenomenon along the coast, although it can be assumed that the same process took place (Unkel et al. 2006), as is evident from what is known from palynological, sedimentological, and stratigraphic data which provide information on the sedimentary deposits and their composition. There are also cultural and historical data from studies of maritime settlements from the Terminal Pleistocene (De France and Umire Álvarez 2004). Analysis of the results of the Proyecto Quebrada Tacahuay, 1997–2001, which provided evidence of catastrophic flooding caused by El Niño sealing the remains of the first cultural level dating back to around 8700 BCE, shows a later reoccupation of the site, albeit on a smaller scale, due to the presence of mollusc remains. Among the most interesting findings are stone tools, remnants of stone processing, items showing the preparation of food in certain hearths [see also Sandweiss (2003)].

There is sufficient information about the oldest prehistoric sites located in the plateau to construct a reliable chronology for the various archaeological stations in the High Lands (Cardich 1974, 1980; Mercer and Palacios 1977; Lynch 1980, 1982, 1983; Dollfus and Lavallée 1973; Dollfus 1981; Rick 1980; MacNeish 1972, 1981).

The contemporaneous existence of human groups in the coastal area has been analyzed, especially along the North Coast. Chauchat's studies prove the existence of an ancient culture such as the one known as Paijanian, which developed in the period of transition from Pleistocene to Holocene and gave rise to a very well-documented lithic tradition found in many places on the coast, supplying knowledge of technological development and the socio-economic model achieved, in addition to forms of adaptation to the territory, the environment, and the existing natural resources. For Chauchat (1982, 1992), Paijan man developed between 6600 and 4000 BCE and lived at a time when the sea level was rising sharply, in the midst of a serious environmental crisis, which saw gradual desertification of the coastal strip and the consequent reduction of wildlife resources. Currently, there is evidence of the submersion of the entire current central-north coastal strip, until around the fifth millennium BCE. For Richardson (1981), only four sites avoided submersion: Vegas in Ecuador; Amotape–Sichesin Peru, dated 11200–6000 BCE, Cupisnique, in the Valley of Chicama, dated 9800–7000 BCE, and Las Conchas, in Chile, dating from 9600–9400 BC. Applying his analysis to the South Coast, Richardson concluded that the dividing line between land and sea before the ice withdrew must have been between 10 and 30 km inland from the coast, and this would also explain the presence of large deposits of prehistoric shells that have been identified 10–15 km inland from the current shoreline, while others were submerged and are therefore no longer accessible.

Studies conducted by the Proyecto Nasca in the Río Grande valley, including the Río Nasca, Río Atarco, and neighboring valleys examined erosion and accumulation during the Quaternary Period, enabling the identification of four terraces. On the Pacheco site, on the oldest terrace, 12 sedimentation processes can be observed. By dating the second sedimentary layer, it was possible to fix the date at 10,600 ± 800 BP (Grodzicki 1994). Moreover, based on the presence of saline layers formed by evaporation, underlying the sediments from dissolved mudflow caused by ancient climatic anomalies, it was possible to confirm a desert climate existed at that time. It could thus be imagined that the ancient inhabitants of the area had to face significant problems arising from the scarcity of water, in addition to the relationship with the vegetation and wild products, and sources of animal protein. They therefore had to combine the need for procuring raw materials for subsistence with their preservation and storage in times of scarcity, a need to develop systems for adaptation to the territory and the increasingly common system of herding that naturally also provided for the conservation of dairy products and animal protein. The cultivation of the land was later adapted to times of sowing and harvesting, as well as subsistence during seasonal periods of dry soil. This evolution in terms of adaptation was therefore the first step towards the formation of new types of complex, agro-pottery-based societies, adequately prepared to deal with the conditions of arid and desert land.

It is not possible to define models able to explain the whole process of plant domestication in the Andes, but it must be considered that the experience gained by human beings in contact with various ecosystems over thousands of years in the territory, and the needs arising from fluctuations between abundance or scarcity in the availability of resources, were the driving force in the development of the first forms of agriculture. The oldest dated presence of crops growing on the plateau are chilli, beans, *pacae*, and the *lúcumo*, along with other species of minor importance already domesticated by 8000 BCE, and the pumpkin and the *Pallar* or Lima bean, between 8000 and 6000 BCE. Maize was already used around 6000 BCE and the cultivation of other food crops spread later. The potato is not easily datable due to its widespread use, although the importance of this tuber in the Andean diet meant that it was one of the main items on the list of plants used for food. The remains found in the Central Plateau cannot be dated properly, so its earliest use cannot be ascertained with any precision.

On the coast, the documented appearance of cultivated plants indicates a later date: there is evidence of the presence of the Lagenaria genus between 6000 BCE and 4200 BCE, such as maize, *pacae*, the peanut, manioca, chilli pepper, the *guayabo*, the *lúcumo*, the *achira*, and cotton, to name just some of the species of edible and industrial use. Cotton (*Gossypium barbadensis*) appeared on the coast around 2500 BCE introducing a radical change in the use of technologies applied to fibers for the manufacture of fabrics.

In the Nasca valleys, this cultural phase is poorly represented, which is mainly due to the shortage of studies and analysis related to this chronological period, while there is significant evidence in ancient sites along the coast that already show features of village life, confirming the abandonment of, or at least a reduction in, the use of seasonal camps. The first to cultivate probably made use of hotter and more humid ecosystems, such as the bottoms of the valleys, the *lomas*, or the lowland areas, where the silt deposited by the seasonal floods on the river margins formed fertile ground for germination. Nevertheless, this is mere hypothesis, although it is very likely that the people who lived in the Nasca geographical area, including the coastline, had to adopt special strategies to supplement their diet so as not to depend only on sustenance from the sea.

The terminology used here to establish the chronology of the sites of the coast in the central-south, is mainly based on the classification used by scholars for what is referred to as the Archaic Period, i.e., until the introduction of pottery. The Archaic Period began around 8000 BCE and ended approximately 1800 BCE, when the cultural period also called Formative began. It is broken down into Early Archaic (8000–6000 BCE), Middle Archaic (6000–3000 BCE) and Late Archaic (3000–1800/1500 BCE). These dates may vary depending on the interpretations of archaeologists based on their research (Lumbreras 1969; Shadi Solis 1995). Other archaeologists (Lanning 1967; Rowe 1967; Rowe and Menzel 1967; Ravines 1970) use the term Preceramic, dividing it into six eras or five periods, otherwise (Chu Barrera 2008) into Early, Middle, and Late Preceramic, a dating that will be used also in this text.

The earliest evidence of human activity in the Southern Coastal area was found in sites offering varied food resources that required a great knowledge of the surrounding environment on the part of those who exploited it. The only way to understand the degree of development reached by the people using this land and to know whether their survival strategies were similar is by comparison with other settlements of the same period, recorded and analyzed archaeologically. Until now, the only known site is Ilo, called Ring or Anillo (Richardson III et al. 1990) on the South Coast that can be dated as Early Preceramic. It reveals a society specializing in the exploitation of marine resources which followed an economic model already well-established along the coast. It dates from between 10575 ± 105 to 7415 ± 65 BP.

Along the central and southern Peruvian coast, among the Middle Preceramic settlements are those of Paloma (Río Chilca), dated by F. Engel between 5200 BCE and 2800 BCE, with groups of circular, ovoid, and quadrangular dwellings, built with structures supported by trunks and roofs with plant fibers. The inhabitants practiced complex forms of ancestor worship (Engel 1980; Benver 1982, 1984) and stored their food in warehouses. Another important site was Casavilca (named after its discoverer), called Boca del Río Ica by F. Engel, dating from 5570 to 3500 BCE (Engel 1957a: 57–62), together with the Salinas de Otuma. At the mouth of the Río Grande de Nasca, there is a site called Santa Ana, with traces of continuous occupation, where Engel (1963) reports the discovery of marine mammals, sea turtles, fish, molluscs, crustaceans, birds, and unidentified terrestrial mammals among the materials found, as well as cucurbits and beans, with no further specification (Fig. 2.8a, b). During his research along the Nasca coast, archaeologist W. D. Strong analyzed some shell deposits from the San Nicolás sites in the bay of the same name.

He identified three different occupations from the same period, all from 4000 BCE. In his report, Strong (1957) describes the finds, which included remains of sea urchins, shells of various shellfish, ash, coals, bones of birds and sea lions, and the remains of work in stone, as well as scrapers, chisels, bits, blades, and black and red obsidian microliths (Fig. 2.9). During his research, Strong also unearthed residues of woven plant fiber and a little botanical produce, briefly mentioning the remains of only pumpkin and corn. Geological analysis highlighted eight different lines of beach, a natural rocky dam encrusted with freshwater algae, which must probably

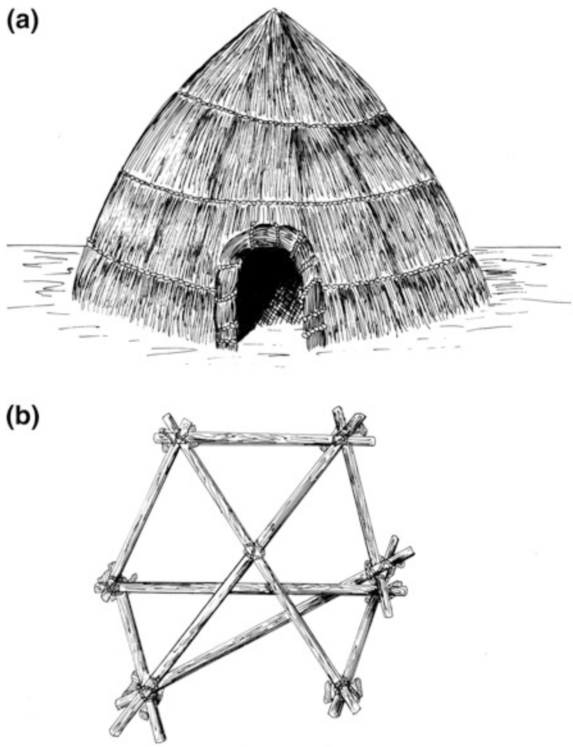

Fig. 2.8 **a** Hypothetical reconstruction of a hut in Chilca (Engel 1966). **b** Diagram of the supporting structure of a house in Santa Ana, at the mouth of the Río Grande of Nasca (Engel 1987)

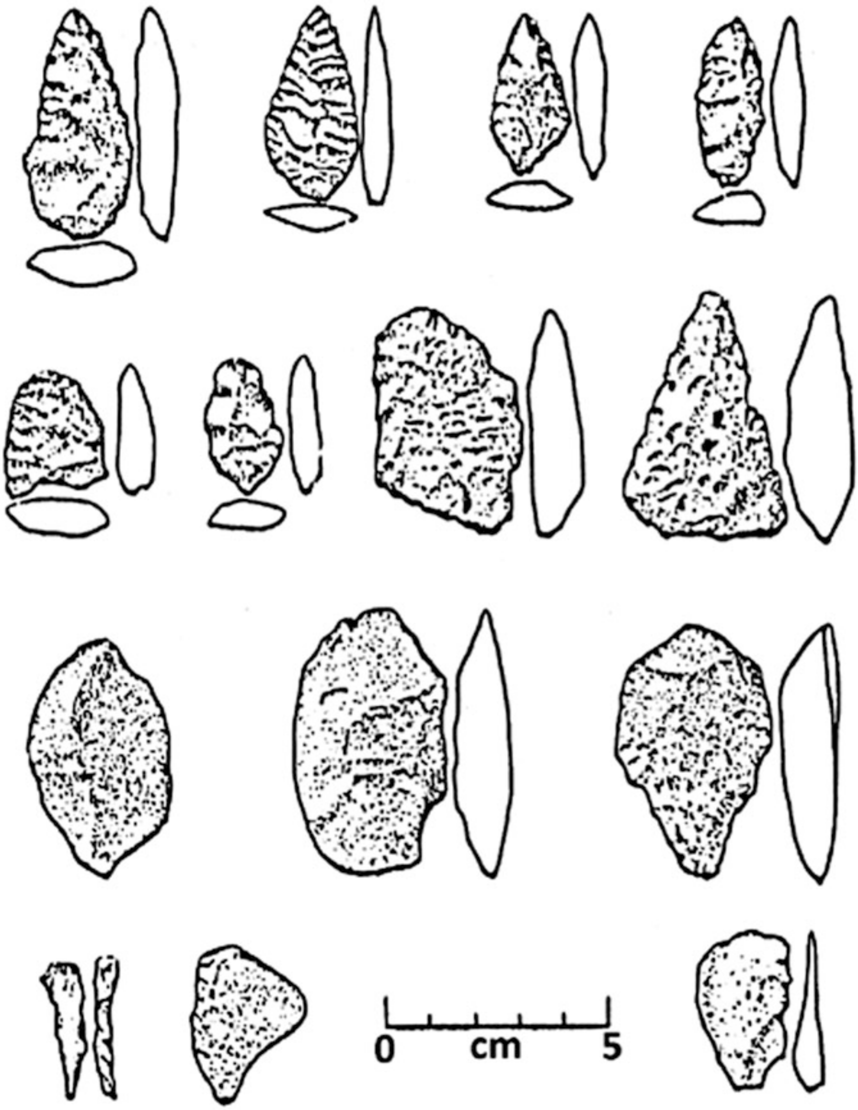

Fig. 2.9 Stone tools found by W.D. Strong in San Nicolás III (Strong 1957)

have once closed off a lagoon or a dry canal. Other deposits from the same period were found in Lomas and Chaviña, south of Nasca, in the department of Arequipa, but for the moment they do not have enough data to include them in an accurate chronological framework.

Further north, on the Paracas Peninsula, Engel analyzed numerous settlements and pre-agricultural and Preceramic sites at Cabezas Largas and Santo Domingo dating from approximately 4000 BCE. [Some of Engel's datings have been criticized and revised. On this subject see Velarde (2002)]. During the 1988 campaign, in the Gran Pirámide 2 at Cahuachi (CAH88Y10EXP37), the Nasca Project found a small structure associated with a burial, as well as lithic, mollusc, and plant material, whose antiquity, as evidenced by the various calibrated C14 datings, gave an average result of around 4200 BCE. All of these sites belong chronologically to a period of occupation of the coastal areas by human groups whose economy was based on marine or mixed resources.

Scarce as it may be, the archaeological documentation for the area is very interesting on account of the information that it offers concerning the dietary habits of the inhabitants of the coastal settlements and helps to establish the economic model on which they were based.

Most of the artefacts found in the deposits on the early sites are associated with fishing, as evidenced by the presence of hooks made from bone and shell, nets made from plant fibers (mainly *cattail* and bulrush, as cotton was not yet in use), stone weights, floating gourds, and pointed harpoons (Fig. 2.10). This indicates a specialist knowledge of fishing for very diverse fauna, which includes not only harvesting shellfish or catching fish, but also hunting sea lions and possibly certain types of cetaceans. The discovery of the skeleton remains of these species in refuse dumps, and archaeological evidence of their use in the manufacture of small pieces of armour, are proof of their use, as is the constant use of pinnipeds or cetaceans for food and in tool manufacture. Of course, a diet based only on produce from the sea had to be supplemented by terrestrial hunting and taking advantage of the presence of wild vegetation as well cultivated plant material.

As mentioned earlier, many settlements were situated by the *lomas*, and others were located in the river terraces along to the coast, or in places protected by marine terraces. Analysis of the sites where research has been conducted, especially by Engel, leads to the hypothesis that the number of residents per village did not exceed 50 to 60. The remains of dwellings Engel found in Santa Ana had a skeleton structure made up of poles in willow (*Salix humboldtiana*), onto which the walls and the roof were lashed. This was probably made of rushes or reeds, like the *carrizo* (Fig. 2.10).

It is very difficult to reconstruct the way of life of these ancient societies with their fairly homogeneous cultural base, even if they had different food resources and were located in different ecosystems. In all probability, an atomized socio-economic model was formed, centered on independent families acting with no centralized authority, but coming together in times of collective necessity. In any case, their activities were family or clan-centered, mainly exploiting the resources or assets needed by small groups.

Despite these limitations, this production system, which lacked any kind of economic stratification, came to be able to process a large number of cultivated plants and, over a period of time that is difficult to establish for each cultural area, introduced more complex social organization, until a time when agriculture became

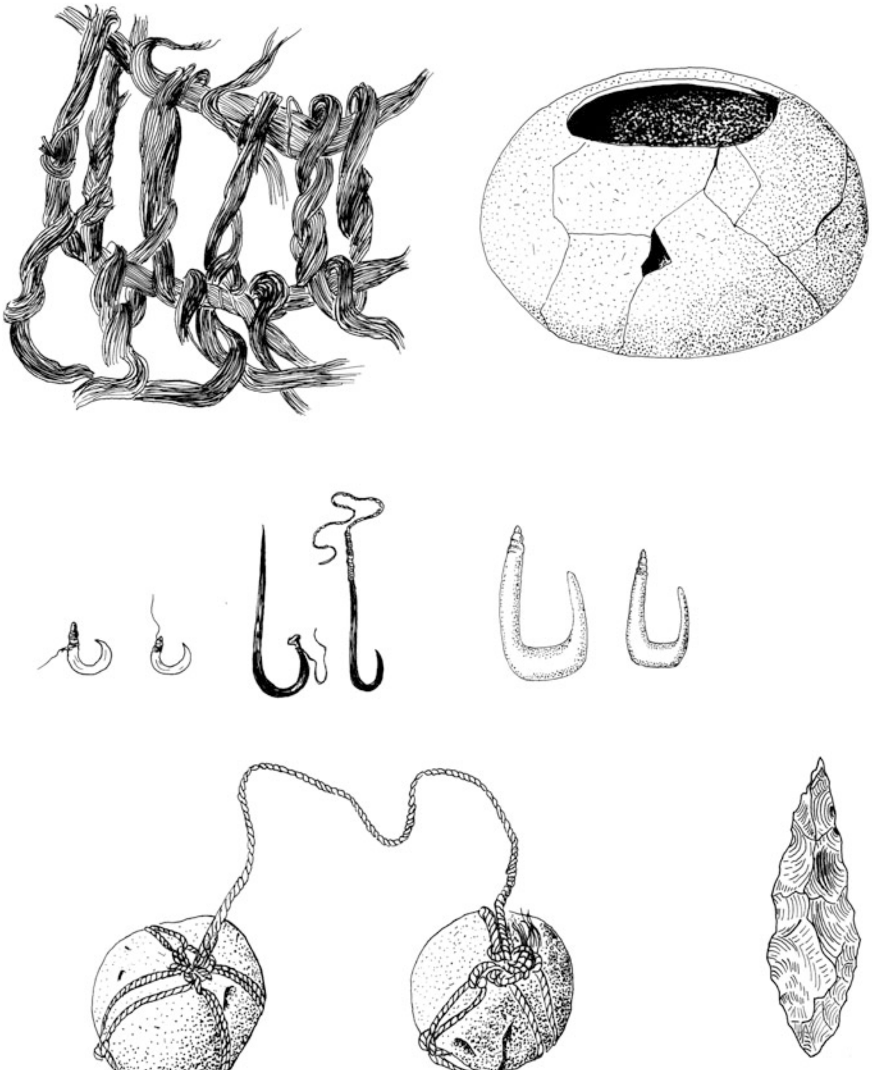

Fig. 2.10 Instruments and tools used in fishing, including a fragment of a net of plant fiber, a container of *Lagenaria* sp., hooks made from shell, bone and thorns of *huarango*, weights, and a tip of harpoon (Drawing by Dolores Venturi)

the main source of sustenance. However, the continual exchanges of non-food products, such as obsidian, show the importance of communication and trade between different ecological niches, as indicated by the presence of this material at San Nicolás and the older structure found at Cahuachi, cited previously.

During the third millennium BCE, there was a gradual transformation accompanying the development of agriculture and a radical change in settlement patterns.

2.2.1 *The Emergence of Complex Society in the Late Preceramic Period*

The transition period culminates in sedentarization, as well as the parallel development of agricultural techniques, irrigation, and water use. The earlier model of the dispersed village or seasonal camp gradually gave way to a new type of agglutinated settlement, with the dwellings arranged in a concentrated pattern, with strong autarkic characteristics and a marked trend towards more extended and self-sufficient models of urban development. These characteristics facilitated population growth and led to new standards in terms of the organization of society and production systems. It is a settlement model that considers the concentration of villages in the areas as more favorable, with priority of choice going to the territories of the lower river valleys, where it is easier to make the best use of the oncoming floods with their contribution of fertilizing silt. These settlements were usually located near the sacred sites or ceremonial centers that arose at the end of the third millennium BCE. The organization was community-based, under the control of incipient forms of theocratic government.

At this stage of development, between the Middle and Late Preceramic, albeit with different modes of application, the coast was already being cultivated with well-known traditional plants. The first irrigation systems and water-control methods were improved, and there were numerous goods and artefacts that circulated even in distant territories through bartering systems. Around 2500 BCE, the extensive use of cotton enabled the development of very important technological innovations, such as increased textile weaving using specialist techniques which developed before those of ceramic work.

With the use of cotton fibers, fishing techniques also changed, as it was possible to make larger nets, leading to larger catches. Only later on, on the Paracas Peninsula and in the Nasca area, during the Early Horizon, called the Middle Formative by some archaeologists (Lumbreras 1969; Kaulicke 1994), weaving techniques reached levels of perfection and beauty unmatched elsewhere in the world in terms of both the refinement of the yarn and the variety of techniques used, as well as the inimitable colors. Around 2200–2000 BCE, the evolutionary process accelerated and coincided with increased urbanization throughout the country, higher levels of specialization in food production, and, at the same time, an early social hierarchy. Increased availability of goods also led to a surplus in production that enabled society to maintain an elite dedicated to the management of joint activities, the manufacture of highly specialized products in the fields of ceramics and textiles, and the implementation/enforcement of shared regulations which involved the population in the construction of monumental buildings such as El Paraiso, Aspero, Las Haldas, and Asia. In the valley of the Río Grande de Nasca, as along the rest of the South Coast, there is no clear evidence of this transition, if we exclude some dating in the deeper stratigraphy of a building at Cahuachi (Y13EXP 49) which, however, offers significant data on the presence of ceremonial architecture of the era. What is lacking is the comprehensive research on most of the

Fig. 2.11 Aerial view of Río Nasca valley: detail including the riverbed and the ceremonial center of Cahuachi (Photo by Giuseppe Orefici)

coastal valleys needed to clarify the obscure points of this vital stage of development, especially if we relate it to the earliest ceramic production in the area, around 1800–1500 BCE (Fig. 2.11).

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Chapter 3
The Geology of Cahuachi

Marco Delle Rose

Abstract The geological setting of Cahuachi was determined by means of a detailed field survey. However, the stratigraphic knowledge achieved during the previous two decades fundamentally framed the survey within the broader regional context. The bedrock of Cahuachi is built up by a succession of conglomerates, sandy-siltstones, and mudstones belonging to the uppermost stratigraphic level of the Changuillo Formation. The conglomerate at the top of the succession at Piramide Sur and Gran Piramide was not deposited by an extraordinary flood that followed the catastrophic El Niño event of the X century, as hypothesized in the literature. This conglomerate, instead, represents the progradation of an alluvial fan and must be assigned to the stratigraphic transition (Upper Pliocene–Lower Pleistocene) toward the Canete Formation that is exposed outside the Cahuachi area. The geology of the ceremonial center entails some hazards, such as seismic and hydrogeological ones, of varying degrees of danger. Consequently, heavy precipitation and strong earthquakes may have occasionally damaged the settlement as shown by archaeological investigations.

Keywords Stratigraphy · Geomorphology · Geological hazards · Paleo-climatology

3.1 Introduction

The environmental features of every location have always influenced both the choice of sites and the development of human settlements. Nevertheless, changes over time can have made significant transformations, or even led to the fall, of organized societies. In this chapter, the physical and geological contexts of the

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territory surrounding Cahuachi are initially summarized. The threatening geological hazards are also considered. This basic knowledge is essential to frame, as well as to interpret, the stratigraphic and morphological elements gathered by means of a field survey performed in December 2012 at Cahuachi.

3.2 Physical Framework

Climates and environments of southern Peru (14–18°S) are due to two spatially-oriented physical gradients. The variation of altitude acts as an east-west control factor, from the Pacific Ocean shore to the Amazon jungle, whereas atmospheric dynamics determines landscape variations along the south-north axis. The first gradient produces a succession of natural zones labelled by means of terms of the *Quechua* language (Pulgar Vidal 1987). These zones show very different environmental conditions, ranging from inland snow-capped peaks to extremely dry coastal plains. Cahuachi, together with the *pampas* of Nasca (*pampa* means "level ground" in the *Quechua* language), belong to the hyper-arid *chala* zone which runs from the coast to the hills belt of the Andean Precordillera (up to 500 m above sea level). Such a desert region results from the SE Pacific anticyclone and the cold Humboldt Current coming from the Antarctic Sea since both inhibit the rainfall (Caviedes and Fik 1992).[1] The degree of aridity as well as the average impact of El Niño events vary along the aforementioned south-north gradient (Sandweiss and Richardson 2008).

The *chala zone* is crossed by a number of river systems, flowing from the Andes to the Pacific, and each of them has its own regime, varying from ephemeral to seasonal (Fig. 3.1). These streams alone support both biological life and human settlements, like the "ghost town" of Cahuachi and the present Nasca (Mächtle and Eitel 2013). Cahuachi spread mainly on the south of the Nasca River, at a mean elevation of 365 m above sea level. It extends over about 24 km^2, including the riverbed and some mounds on the north side of the river (Masini et al. 2012). The annual precipitation is usually less than 20 mm even if some heavy, brief rain episodes, having extra-regional origin, occasionally occur. Moreover, the site is subject to intense north-eastward winds that can cause sandstorms. The mean annual temperature is about 21.5 °C (Oficina Nacional de Evaluación de Recursos Natural 1971).

The physical conditions of the air masses clearly reflect the climate and meteorological features. The stable atmosphere of south Peru reduces convection, while the Pacific moisture is trapped close to the coast. During the austral summer, Amazonian air masses normally cause rainfall over the Altiplano. Moreover, the El Niño-Southern Oscillation determines the substantial inter-annual variation of summer precipitation (Webb et al. 2011). In the Andean highlands, the warm El

[1]See Chap. 2 by Orefici and Lancho Rojas.

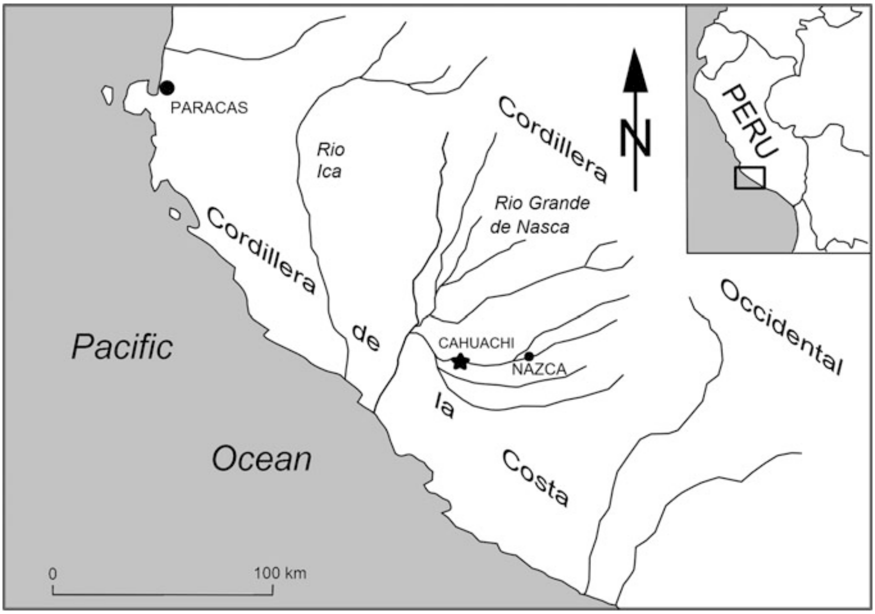

Fig. 3.1 Geographic scheme

Niño produces drier conditions, while the cool La Niña wetter conditions, which can in turn lead to flooding along the river catchments. The coastal precipitation, instead, increases during El Niño years, again raising the flood hazard. However, on the *pampas* of Nasca, the vegetation is absent, except in the alluvial valleys and on the tops of some hills where seasonal grasses may grow. Therefore, the zone surrounding Cahuachi is ecologically classified as a “pre-mountain desert formation” or a “sub-tropical desiccated desert” (Oficina Nacional de Evaluación de Recursos Natural 1971). Today, it belongs to one of driest regions on Earth. Moreover, in relation to the effects induced by climate change, the *pampas* around Cahachi must be classified labelled as a highly sensitive environment. Such features are congruent, on the other hand, with the outlying position of the *pampas* with respect to the Chilean Atacama Desert (Clarke 2006).

The catchment basin of the Río Grande de Nasca extends between the Cordillera Occidental and the Pacific coast (Fig. 3.1). Nine streams flow into the main river bed which, in turn, crosses a narrow valley traversing the Cordillera de la Costa and finally flows into the sea. The pattern of this drainage system is due to the uplift, throughout geological times (see below), of the Cordillera de la Costa which prevented direct outflows. The annual discharge of the northern tributaries is higher than the southern ones, because of differences in both the catchment surface and the permeability of the ground. Southern tributaries, among these the Nasca river, are fed by seasonal Andean rainfall flowing downhill until the water reaches the alluvial deposits of the valleys. The high permeability of alluvium initially reduces their flow rate and then, usually below 800 m in the middle valleys, causes the disappearance of the runoff in most years. The points where rivers drop below the surface varies seasonally and annually. Finally, rivers re-emerge at the passage to the lower valleys, at around 400 m.a.s.l. Currently, five years out of seven on average the middle valleys of the southern tributaries of the Río Grande are totally devoid of surface water (Schreiber and Lancho Rojas 1995; Lasaponara and Masini 2012). In the middle valleys of Nasca's southern tributaries, during periods of drought and normally in the dry season (the austral summer), the phreatic surface of the alluvial aquifer can be too deep to be tapped readily by traditional wells. Based on a recent hydrogeological study, in the surrounding of Cahuachi, the phreatic surface ranges 5–10 m under the ground and exhibits considerable seasonal variations, as well as changes of the annual average level (Intendencias de Recursos Naturales 2007, pp. 95–103; Autoridad Nacional de Agua 2009).

Physical features of the territory where Cahuachi lies, have changed several times during the previous millennia. Since the Upper Pleistocene, alternating phases of increasing and decreasing moisture transport across the Andes led to the shift of the vegetation belts and the deserts. During the periods of increasing moisture transport, instead of the hyper-arid desert, a semi-desert *Matorral* was established, as is geologically documented (Mächtle et al. 2010). Periods of geo-ecological fragility were predominately triggered by climatic changes, which induced just as many oscillations of the desert margin. Around 11.5 ka, increasing Andean precipitations led progressively to a persistent grassland ecosystem that, in turn, has determined the formation of both soils and aeolian deposits. About 4.2 ka, the establishment of the modern ENSO atmospheric conditions caused decreasing precipitation, which changed the landscape features. The grassland disappeared, the desert expanded, and arid conditions took effect. Successively, the environmental changes can be significantly inferred by the geomorphological activity (Mächtle and Eitel 2013). Fine-grained alluvial deposits, indicating stable conditions, were diffusely accumulated between 2.8 and 1.3 ka. Moreover, based on biostratigraphic and palynological data, Schittek et al. (2011) highlighted that between 1.8 and 1.3 ka, on the western Andes of south Peru, a stable interval relatively humid existed, "which coincides with the florescence of the Nasca culture". According to these authors: "an abrupt turnover occurs at 1.3 ka, which coincides with the collapse of the Nasca society". In any event, geomorphological activity increased throughout the successive centuries, as indicated by alluvial down-cutting. Up to about 0.8 ka, the lack of river flow is interpreted as due to renewed hyper-arid conditions [warm Medieval Climate Anomaly (Graham et al. 2007)]. Finally, a further transition to a more fragile environment should be indicated by the river activity as well as the occurrence of debris flows. This moister and hydrologically unstable period lasted up to the Little Ice Age (Mächtle and Eitel 2013).

3.3 Regional Geological Framework

Southern Peru, together with Bolivia and northern Argentina, belong to geological province named Central Sector of the Central Andes (Ramos 1999). Two main morpho-structural units constitute the upper lithosphere: the Dominio Costero (the so called *foreland*) and the Dominio Andino (the so called *foredeep*). The former, in turn, is composed by three sub-units: Cordillera de la Costa, Llanuras costeras, Depresión de Ica-Nasca (Fig. 3.2). The Dominio Costero and the Fruente Andino (the more external sub-units of the Dominio Andino) have a pre-Tertiary basement composed of sedimentary, igneous, and metamorphic rocks. They form, as a whole, the so-called Conca Pisco Oriental (Montoya et al. 1994; León et al. 2008).

The Cordillera de la Costa, a discontinuous series of hills which are a few hundred meters tall and arranged according to a SE-NW alignment, form a sea buttress up to the Paracas Peninsula. The orogenesis of such a ridge began during the Cretaceous and continued to cause tectonic activity until the Quaternary. Its eastern border with the Llanuras costeras is usually not very distinct from the morphological point of view. A structural platform of flat hills, ranging from 250 to 700 m.a.s.l., forms the Llanuras costeras. Over the basement lies a Cenozoic succession (up to 850 m thick), which has been strongly eroded during the Quaternary to form the characteristic features of the *pampas*. Eolian deposits, such us dunes and residual pebbles, frequently cover the Tertiary succession. A regional tectonic structure, the Fault of Cerrillos, separates the Llanuras costeras from the Depresión de Ica-Nasca (Figs. 3.2 and 3.3).

This fault made possible differential uplift movements between the aforementioned sub-units over the Quaternary and presently constitutes an important active seismogenic structure (Teves 1975; Macharé and Ortlieb 1992). The Depresión de Ica-Nasca presents the shape of the lowered crustal blocks named “graben”. Its average altitude is about of 450 m.a.s.l. Such a planar tectonic depression is detached by the Fruente Andino by means of a complex strongly deformed block that is, in extent, several kilometers wide. However, on the surface, evidence of the tectonic thrusts appears not particularly evident. Where field structures are well exposed, the main tectonic discontinuities can be defined, as the in the case of the Fault of Viscas which runs SE of Palpa (León et al. 2008). The landscape features change abruptly passing through the Fruente Andino, which is composed of sedimentary and volcanic-clastic rocks of the Jurassic and Cretaceous, where deep ravines cut into high peaks and alluvial fans lie at the piedmont belt.

The flat landscapes of both the Llanuras costeras and the Depresión de Ica-Nasca are primarily due to the sub-horizontal setting of the sedimentary Cenozoic succession. Both the Pisco and Changuillo Formations form the larger part of the geological substratum underlying the superficial covers (Newell 1956; Dávila 1989; Báez Gómez 2006). The former essentially consists of diatomitic claystones and siltstones with intercalation of sandstones and conglomerates (Miocene in age). The Pliocenic Changuillo Formation is mainly built up by silty-claystones, mudstones, sandstones, and also by conglomerates at the uppermost stratigraphic level.

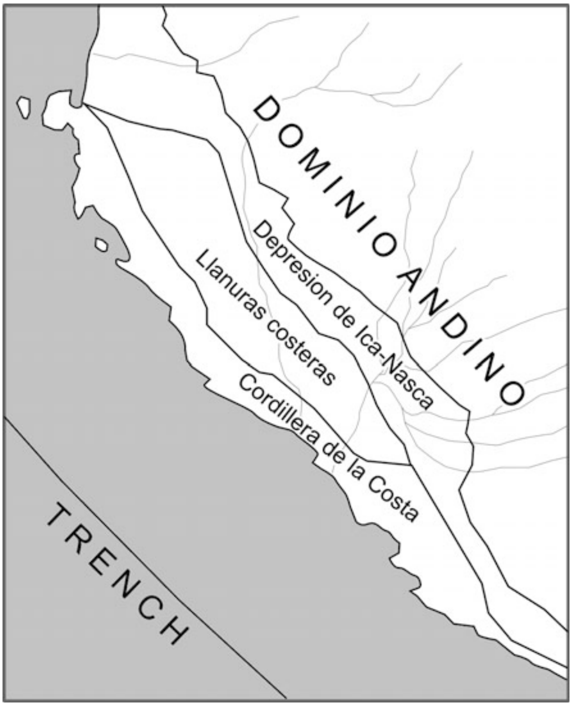

Fig. 3.2 Tectonic-morphological scheme (modified from León et al. 2008)

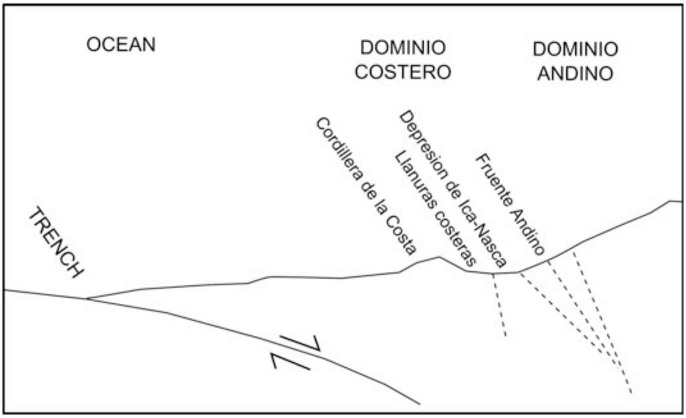

Fig. 3.3 Lithospheric cross-section scheme

Throughout the Pleistocene, south-west Peru progressively emerged out the sea to be shaped by exogenous processes. The Dominio Costero evolved from a marginal sea (in relation to the South American continent) to the present coastal plain, on the seaward barred by the ridge of the coastal Cordillera. The uplift of the Andes led to abundant supplies of conglomerates which formed numerous alluvial fans. Several planation surfaces and sequences of stream terraces were formed within the Dominio Costero. At the same time, the catchment basin of the Río Grande also developed. Phases of valley cutting into the bedrock had alternated with phases of valley filling of alluvial sediments. The latter now constitute some aquifers where groundwater can be drawn. From the foot of the Fronte Andino to the Depression of Ica-Nasca and between the towns of Palpa and Nasca, two main planation surfaces are present. Such morphological landforms are the preserved remnants of extensive alluvial fans built up mainly by volcanic clasts and quartzite cobbles painted by desert varnish. The highest of them has an altitude of about 410 m.a.s.l., whereas the lowest of about 385 m.a.s.l. For the latter, a final Middle Pleistocene age (i.e., 200 ka) was determined by cosmogenic analysis (Hall et al. 2008). After the genesis of this surface of planation, the *pampas* of Nasca could finally evolve toward the present (cf. Orefici and Lancho Rojas, 2016), passing through changing environmental conditions such as those arising from the last ice age.

3.4 Geological Hazards

The geological framework of the studied area entails some geological hazards. As regards the seismicity, this area is located in one of the zones with the highest earthquake activity of the Earth (Castillo Aedo and Alva Hurtado 1993; Chlieh et al. 2011). In detail, there are two tectonic mechanisms generating seismic shocks. One is related to the convergence of the Nasca and South-America tectonic plates. The other is due to superficial crustal deformation inside the Dominio Costero and Dominio Andino. The South- American Pacific coast marks the boundary between the aforementioned plates where, according to the theory of plate tectonics, the oceanic crust beneath the South Pacific descends into the continental crust of South America (James 1971; Kulm et al. 1981). The convergence causes the uplift of the Andes as well as both volcanic and seismic activities (Fig. 3.3). Slips along the dipping interface between the two plates generate earthquakes, some of which can also produce, in turn, tsunami. Inside the continental domains, the crustal deformation displaces the sides of regional faults and, so, generate shallow earthquakes.

The hydrogeological hazards threatening the Cahuachi area involve both debris flow activity and flooding. Debris flows usually occur as streams of viscous muddy water containing rock materials and pebbles, traditionally named *huaycos*. In the main, they are related to the occurrence of rainfall higher than particular thresholds. In the South Peruvian desert, such debris flows are usually triggered by rain events above a few tens of millimetres and lasting at least three hours. Where the larger *huaycos* move before reaching the riverbeds, induced overflowing could occur. At Cahuachi, as well as around the ceremonial center, some relatively small debris flow deposits are present (Fig. 3.4). The zones more exposed to flooding near the ceremonial center are clearly those closer to the riverbed.

Fig. 3.4 Ground features at South of *Piramide* or *Templo Sur*. The bedrock underlies a lag pebbly deposit (material winnowed by wind), while along the sides of the mounds eluviums are present. Debris-flow deposits are located in the small incised rills

It must be noted that floods in the Atacama Desert are usually associated with El Niño, even if the relationship is actually more complex. Moreover, the relationship between the occurrence of strong rainfall episodes able to produce debris flows in south Peru and ENSO conditions is weaker than the connection observed in the adjacent coastal area of northern Chile (Ortlieb and Vargas 2003). The winter precipitation causes floods within the Coastal Cordillera, where the impact of extra-tropical depressions is felt, and the relation with El Niño is clear. In contrast, at the Llanuras costera floods are largely due to exogenous precipitation associated with La Niña (Houston 2006). In Palaeoclimatology, the first inference of this finding entails careful assessment of the source of Quaternary flood deposits before correlations with either El Niño or La Niña events. In any case, along the valley of the Río Ica (Fig. 3.1). Beresford-Jones et al. (2009) recognized an alluvial deposit formed as a consequence of the occurrence of a catastrophic El Niño event and which "can be dated approximately to the end of the Early Intermediate" period.

As regards human safety and the protection of settlements and goods from inundations, the environmental vulnerabilities can determine, on a case by case basis, notable differences in the amount of damage suffered. The statement of Silverman (1993) regarding the consequences of a heavy rain occurring in the January of 1985 on the Andean Cordillera appears particularly significant. Two tributaries of the Río Grande, namely "the Aja and Tierras Blancas rivers, simultaneously charged to overflowing and on the same night broke through the embankments protecting the town of Nasca, disastrously flooding the city and causing much loss of property". Rain continued for several days and "downstream at Cahuachi river swept away many hectares" of fields (Silverman 1993; pp. 3–8). Actually, the town of Nasca is affected by flooding and the effects on houses and infrastructures are amplified by their high levels of exposure, as deducible by episodes occurring in recent years. Nevertheless, several researchers have highlighted the risks of the archaeological heritage of Nasca due to flooding and debris-flow activity (Lefort et al. 2004; Ruescas et al. 2010; Cigna et al. 2013). Archaeological evidence confirm the susceptibility to such hazards. Precisely at Cahuachi, some debris flows that have left "profound marks in the structures" belonging to the Fourth Phase (350–400 AD) were revealed as well as the destructive effects of an earthquake (Masini et al. 2009, 2012). Moreover, the ceremonial site diffusely shows "the effects of water erosion. The site surface is marked by gullies created by water action from infrequent strong rains; many of the mounds […] show erosion channels caused by rainwater" (Silverman 1993). Orefici (2012) refers to the recognition of two different hydrogeological instability episodes triggered by equally many, presumably intense, precipitations, which occurred respectively at about 400 AD and 450 AD as inferred by the dating of the archaeological structures damaged. As a ritual of abandonment of the site "besides the covering of the structures with earth, a series of offerings was performed […] where a structural fault was produced" by the seismic wave (Sánchez Borjas 2010).

3.5 Field Survey

Cahuachi consists of a number of smoothed mounds capped by gravels mixed with finer clastic materials. Such small hills form the core of pyramids and temples. Despite the absence of soils and plants on both the flanks of Nasca River, outcrops are rare of the geological substratum, which is, in fact, extensively covered by recent continental deposits and adobe constructions. During the 2012 archaeological excavation work, the geological substratum beneath the Piramide Sur was temporarily exposed (Fig. 3.5).

Stratigraphic observations and measurements were performed together with sampling of the strata. The lower part of the stratigraphic column was measured inside a cylindrical underground storage, excavated into the bedrock and located at the "Monticolo 2" (Fig. 3.6). The whole succession has a sub-horizontal attitude and presents four joints systems arranged according to angles of about 45° one from the other. The planes of such discontinuities of tectonic origin (uplift) are nearly vertical. Three main lithologies were recognized: conglomerates, sandy-siltstones, and mudstones. Conglomerates prevail in the lower half of the column, while mudstones are more abundant in the upper one. The top is formed by a conglomerate of about 1.8 m in thickness and an abrupt undulated lower surface. The stratification is plane-parallel with the exception of some lenticular bodies and a few undulated lithological boundaries. Moreover, cross lamination is exhibited by the

Fig. 3.5 The bedrock beneath the mound of the *Piramide Sur* was temporarily exposed along an archaeological excavation on December 2012

thickest sandy-siltstone (Fig. 3.6). Conglomerates present imbrications of the pebbles and erosive basal contacts, and load casts may have occurred within the underlying soft strata. They have homogeneous sandy-muddy matrix. Pebbles generally show degrees of sphericity from low to middle degrees. Probable mud cracks and uncertain flasser bedding (the restricted exposure impeded complete observations) seem present around 6–7 m above the base of the succession.

Starting from the above described bedrock exposures, geological mapping of an area of about ten-kilometers square has been performed (Fig. 3.7). The outcrops of the bedrock found within such an area are built up by the same lithologies observed below the Piramide Sur of Cahuachi. These exposures are normally small in size (a few meters square) and present strata with a sub-horizontal attitude; the largest outcrops are located along the escarpments at the north side of the Río Nasca where mudstones prevail. The recent continental deposits that cover the bedrock are constituted of: alluviums, eluviums, and aeolian sediments. The alluvial deposits of the Río Nasca valley around Cahuachi can be distinguished in: sediments of the present riverbed; a first terrace elevated up to the edge, about 3 m above the present riverbed; and a second terrace up to the edge. no more than 10 m above the present riverbed. Sedimentological observations of such deposits were made at the *puquio* of Ocongalla, which is located about 13 km east of the ceremonial centre (Fig. 3.8).

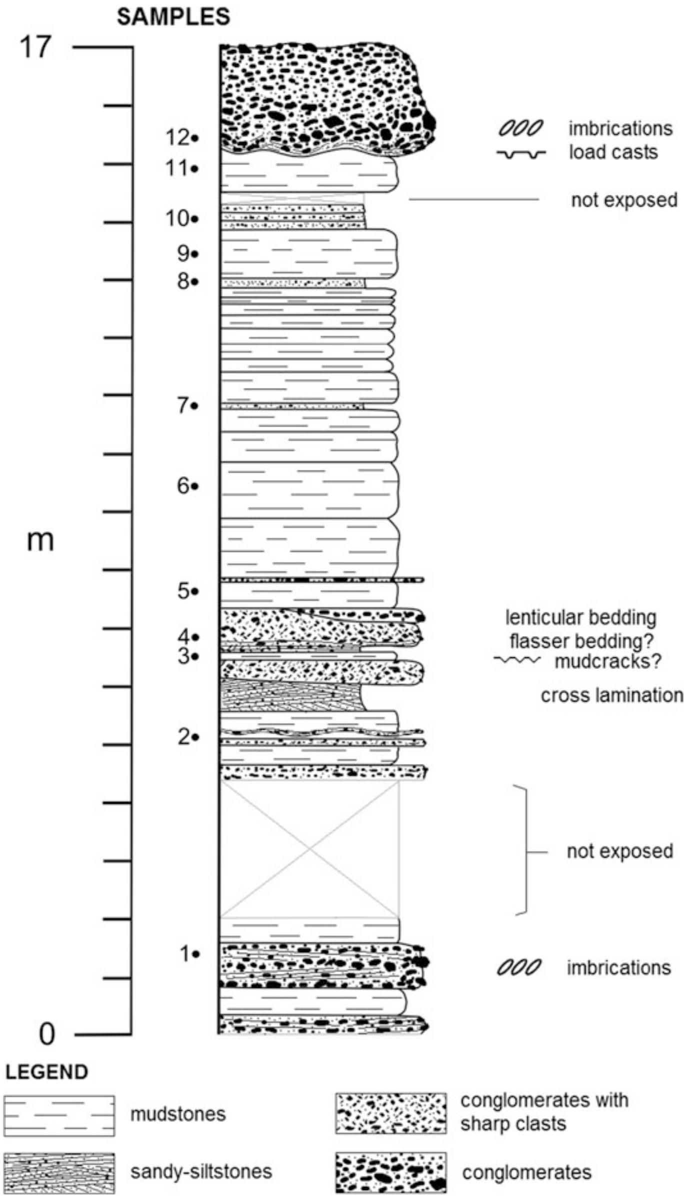

Fig. 3.6 The measured stratigraphic section

Along the trenches of this ancient aqueduct, alluvial deposits of the second terrace are well exposed. The facies observed are quite different than the facies of conglomerates in Fig. 3.6. especially as regard both the size sorting and the spatial orientation of the gravels. The pebbles building up the conglomerates of Ocongalla

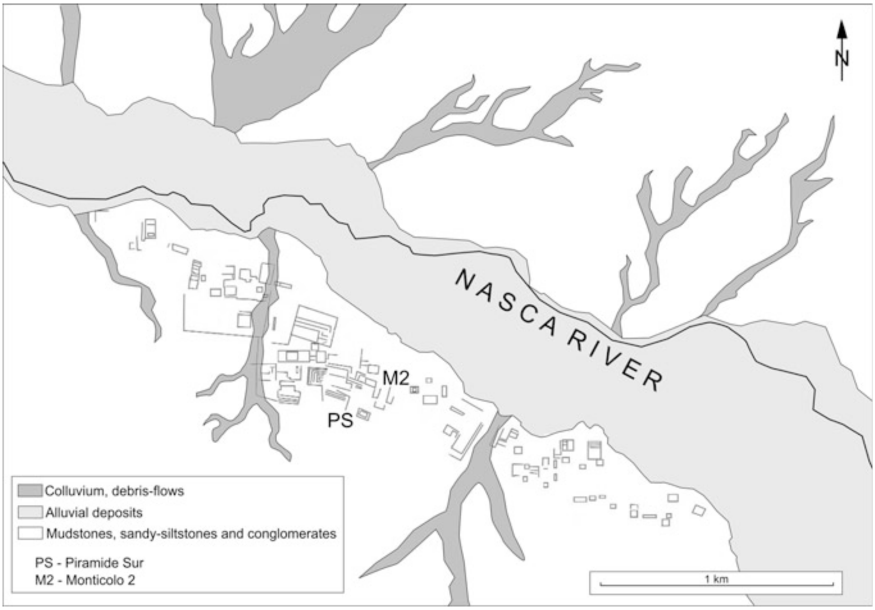

Fig. 3.7 Geological map of Cahuachi

Fig. 3.8 Alluvial deposits cropping out at Ocongalla. The exposure at the lower side of the photo is built up by poorly sorted pebbles sustained by heterogeneous matrix (see text for more details). Artefacts of the ancient aqueduct are visible at the *upper side*

range in dimension more than the conglomerates measured along the column of the Piramide Sur. Moreover, they usually show chaotic arrangement and few imbrication structures. Again, the pebbles observed at Ocongalla have a high degree of sphericity on average. Finally, matrix is heterogeneous in abundance as well as in composition.

The eluviums are debris deposits formed by *in situ* weathering of the bedrock followed by gravitational transport (occasionally also by brief water flows), and temporary accumulation. Large parts of the geological substratum beyond the alluvial valley of Río Nasca, especially along the sides and at the bases of the mounds, are covered by alluvial deposits, usually with a thickness from a few centimeters to a few decimeters. The thickest deposits (about 1 m) are present among the areas of *impluvium,* where they must more correctly be labelled as debris flows. They are smaller in size than the *huaycos* deposited at the foot of Cordillera. Dunes and other aeolian-accumulation forms are modest and delimited in size within the studied area. The aeolian deposits mainly consist of lag deposits, i.e., residual pebbles winnowed by the physical action of the wind. The coarse materials come from the selective erosion of the conglomerates inter-bedded with thinner layers which, as a whole, form the local bedrock. Somewhere such lag deposits are so dense and compact as to appear to be desert pavement.

As regards the main geomorphological features observed, what must be stressed are the erosive edges traceable to ancient fluvial terraces carved especially along the south side of the Nasca valley. Forms related to landslides involving the bedrock were not recognized.

3.6 Correlations and Interpretations

In the literature, there are two different descriptions of the geology of Cahuachi supported by maps. They are, in chronological order of printing: the geological sketch of Grodzicki (1990; Fig. 5); the 1:100.000 map published by the *Instituto Geológico Minero y Metalùrgico* (INGEMMET 1994). There are some basic differences between them starting with the nature of the sedimentary unit beneath the area of the ceremonial center. According to Grodzicki (1990, 1992, 1994) this unit mainly consists of conglomerates deposited as a consequence of three catastrophic El Niño events occurring 2100–1000 years ago. By contrast, the map of INGEMMET (1994) represents the Changuillo Formation. These different geological depictions imply two different landscape evolutions also involving the relationships between settlements and territory. However, the field observations previously explained enable one to synthesize them with these previous geological studies. A brief review of the state of lithostratigraphic knowledge is necessary to explain.

The Changuillo Formation was defined by the geologist mapper J. Caldas V. in 1981 in an area north of the village of Changuillo, inside the "Cuadrángulo de Palpa". The field mapping was then published as Montoya et al. (1994). According to these authors, the lower boundary of the Changuillo Fm is conformable and transitional with the Pisco Fm, whereas León et al. (2008) considered this contact unconformable by depositional hiatus. Anyhow, the Changuillo Fm shows nearly everywhere a sub-horizontal attitude except at the confluence of the Río Nasca and Río Grande where its strata present dips up to about 30°. Within the area-type, such a formation shows inter-bedding of partially weak mudstones, siltstones with desiccation cracks, and lenticular deposits of bioturbated sandstones, coarse fossil-rich concentrations, tufaceous dirty clayey, and diatomites. At the top of the succession present also are lenticular bodies of conglomerates having sandy-clayey matrix. In some localities, e. at km 415 of the Pan-American Highway, the upper portion of the Changuillo Fm exhibits thick conglomerates with a high amount of volcanic, imbricated, well-rounded pebbles. The top of the formation extensively crops out between the riverbed of Río Palpa and Río Ingegno, where the conglomerates are inter-bedded with alluvial deposits. As a whole, the facies evolved from marine shallow water to the shore face of the alluvial system. In some places, the prevalence of conglomerates at the top is so overwhelming that it requires the coining of an apposite lithostratigraphic unit, named the Canete Formation by the locality-type. The former informal definition of the Canete Fm can be attributed to Petersen (1954). A main sedimentological characteristic of such a formation is the presence of intercalation of cross-laminated coarse sands inside the conglomeratic bodies. Gravels and sands come from igneous, metamorphic and, sedimentary-rock sources and derive from the erosion of the adjacent ridges. At the basin scale, i.e., a large section on both the Llanuras costeras and the Depresíon Ica-Nasca, the Canete Fm is built up by several progradation alluvial fans. Along the Cordillera de la Costa, a staircase of terraces represent the corresponding deposits and suggest the episodic uplift of the Dominio Costero. The boundary between the Changuillo and Canete Fms is transitional (Montoya et al. 1994; León et al. 2008). Regarding the age, the Changuillo Fm belong to the Upper Pliocene as indicated by the presence of fossils of *Carcharondon carcharias*, *Dinocardium nov.* sp. *Aff.*, *D. Ecuadorialis* (Macharé 1987). The absence of fossils Canete Fm can be attributes, based on the stratigraphic regional relationships, of the higher Upper Pliocene—basal Lower Pleistocene (Sebrier and Macharé 1980).

Taking into account the aforementioned knowledge, the succession illustrated in Fig. 3.6 must be connected to the transitional stratigraphic level from the Changuillo Fm to the Canete Fm. I suggest evaluation of the possible definition of a specific unit as a member or a lithological facies belonging to the Changuillo Fm. Finally, I stress that the 1.8 m thick conglomerate at the top of the measured succession (Fig. 3.6) coincides with the layer that according to Grodzicki (1992) covers "the entire area of the ceremonial centre […] burying the monuments of the same […] effect highlighted especially on the Gran Piramide". Instead, as directly observed along the trench of the archaeological excavation on 2012 in correspondence of the Piramide Sur, the conglomerate unequivocally underlies the adobe constructions (Fig. 3.9).

The available data doesn't permit us to quantify the severity of the hydrogeological hazards threatening Cahuachi. However, some qualitative considerations

Fig. 3.9 The *top* of the stratigraphic section (Figs. 3.5 and 3.6). Mortar for adobes overlying the conglomerate (casts left by bricks are visible)

can be made. The adobe constructions are particularly vulnerable to weathering and water adsorption. Consequently, they tend to be weakened through time. As a result, small debris flows may damage such structures, especially when they are triggered by relatively long and intense rains.

3.7 Conclusion

The field survey performed at Cahuachi together with the geological regional knowledge developed by the *Instituto Geológico Minero y Metalùrgico* (Montoya et al. 1994; León et al. 2008), enable us to define the geological setting of the Nasca ceremonial center. In particular, the basic stratigraphic features of the bedrock have been determined and the actual relationship of the top conglomerate (Fig. 3.6) with the adobe constructions has been solved. The hypothesis that the deposition of this layer was due to the catastrophic El Niño event that occurred on the 10th century (Grodzicki 1992, 1994) must be rejected. Such a conglomerate corresponds to a facies of the uppermost Changuillo Fm (Upper Pliocene—Lower Pleistocene in age), the transitional stratigraphic interval to the younger Cañete Fm outcropping outside of the area of Cahuachi. What's more, the conglomerates along the measured column are evidence of the progradation of alluvial fans within the sea basin close to the emersion at the passage from the Pliocene to the Pleistocene. This obviously does not mean that the ceremonial center was not affected by catastrophic events. In fact, in accord with the geological hazards of the place, heavy rain events and earthquakes may have caused damage to the settlement as reported in literature (Orefici 2012).

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Chapter 4
Nasca Historical and Cultural Analysis

Giuseppe Orefici

Abstract Peruvian prehistoric man faced considerable difficulties to adapt to climatic and environmental situation of the area. The first coastal settlements are dated between 6000 and 3500–3000 BCE. The needs, arising from living in extremely adverse and diversified environments, led the first inhabitants to adapt physically and spiritually to a new reality. In the southern coastal region, which includes the Río Nasca valley, the earliest dating of cultural ritual nature is related to the early stages of Cahuachi. Other data on the deep stratigraphy of the temple area date the occupation of some structures of the ceremonial center to the middle of the second millennium BCE. The presence of cultural elements of Chavinoid type remained for a long time in the Nasca Culture area, due to the persistence of the Paracas influence that spawned the subsequent birth of Nasca culture. The Paracas society was probably ruled by a priestly class, but there is also evidence of war activities, unlike during the Nasca cultural domination, which was characterized by long periods of peace. The Nasca society produced very fine handicraft, thanks to technological achievements in the field of ceramic and textile manufacturing. The cultural influence of the last period of Nasca culture was the result of interrelations with the Sierra and the Wari cultures, which later assumed imperial characteristics and extended its dominion over the entire coastal region it had recently conquered.

Keywords Historical and cultural analysis · Settlement patterns · Late Preceramic Period · Initial Period · Paracas · Geoglyphs · Early Intermediate Period

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4.1 First Organized Societies on the Southern Coast of Peru

In the transition phase which coincided with the end of the last Pleistocene ice age (around 10,000 years before our era), Peruvian prehistoric man had to face considerable difficulties due to frequent climatic variations and changes to the morphology of the territory, mainly caused by the thaw. There were significant changes to the habitat and, most importantly, the availability of plant and animal species altered. Some areas gradually became free of ice, thus giving hunter-gatherers access to new territories to explore, especially in the Andean *Puna* and the expanses in the highlands that were rich in wildlife such as Andean camelids, deer, and various rodent species. The need to obtain food forced man to develop survival strategies essential for adaptation to different ecological niches and, at the same time, forced him to undertake a kind of continued transhumance from one ecosystem to another, thus creating pre-established paths to be used at different times of the year.

The early domestication of wild edible plants and the great potential for food resources from the ocean gradually led bands of hunter-gatherers to stay for increasing periods of time in those places capable of offering such means of subsistence.

Consequently, in the early coastal and highland settlements in southern Peru, placeable chronologically in a period roughly between 6000 and 3500–3000 BCE (Middle Preceramic or Middle Archaic Period),[1] evidence of human activity has been found in sites offering a variety of food resources and implying a deep knowledge of the environment by those exploiting it.

On the coast, the abundance of fish, crustaceans, and molluscs constituted an inexhaustible source of food and was the staple diet of the early fishermen and shellfish gatherers. What is more, the variety of fauna in the coastal habitat also comprised some marine mammals, including two types of sea lions (*Otaria byronia* and *Arctocephalus australis*) and a small salt-water otter (*Lontra feline*).

In this period, on the edges of the woods that surrounded the river courses, near the mouths and in the areas made fertile by the seasonal flooding of the mostly torrential rivers, some groups of humans had already started domesticating numerous plant species, giving rise to primitive forms of agriculture. Llama and

[1]The terminology used to establish the chronology of the sites mentioned in the article is mainly based on the classification used by archaeologists, so the entire period preceding the introduction of pottery is known as the Archaic. The Archaic Period began around 8000 BCE and ended around 1800 BCE, a date that commences the stage called Formative. This is divided into Early Archaic (8000–6000 BCE), Middle Archaic (8600–3000 BCE) and Late Archaic (3000–1800/1500 BCE). These dates may be subject to variation, depending on the interpretation of the archaeologists based on their research (Lumbreras 1969; Shadi Solis 1995). Other archaeologists (Lanning 1967; Rowe 1967; Rowe and Menzel 1967; Ravines 1970) use the term Preceramic, dividing it into six or five periods, or into Early, Middle and Late Preceramic (Chu Barrera 2008), the system adopted in this article.

alpaca breeding complemented the cultivation of plants from around 6000 BCE as the Andean camelids became indispensable for the transport of various kinds of products, as well as for the production of wool, milk, and meat. In addition to these, dogs and guinea pigs were also bred. Nevertheless, hunting and fishing continued to be an important source of food, as these valleys were rich in wild fauna, with the presence of deer, guanacos (*Lama guanicoe*), foxes, and many bird species.

4.1.1 Settlements of the Late Preceramic Period

The gradual settlement of these first communities in such diverse environments led to the need to adapt physically and spiritually to the new reality, thus promoting the rise of societies that differed from each other, both from the linguistic and from the cultural points of view, each one loyal to a religious system that resulted from the continuous evolution of beliefs. In this context, with the ever wider exploitation of resources related to fishing, agriculture, and camelid breeding, the first monuments of pre-Hispanic Peru came into being, characterized by ceremonial architecture. Archaeological studies reveal clear evidence of a concentration of the phenomenon in the northern and central coastal regions, where several villages were clustered around structures for public use that were strictly related to religious worship.

On the South Coast, in the Río Nasca Valley, the oldest dateable activities related to worship and culture associated with populations well-established in the area are from the first phase of occupation of the Cahuachi site. This happened long before the actual emergence of the ceremonial center, whose development was closely bound to Paracas-Nasca society. In 1988, under the base of the second platform of *Gran Pirámide 2*, the Nasca Project unearthed a small block-shaped ceremonial altar, carved into the natural clay layer. It contained the body of a woman who had most likely been sacrificed, as she was lacking the lower limbs and pelvis. Nearby, and in small offertory pits, double-faced projectile heads were found (Fig. 4.1) as well as forty-seven obsidian microliths, plus a number of scallop shells (*Argopecten purpuratus*). The five radiocarbon datings obtained from the analysis of the materials indicate a date between 4400 and 4200 BCE (Ziolkowski et al. 1994; Orefici 1993, 2012; Orefici and Drusini 2003). The finding at Cahuachi can be associated chronologically with what was happening further north in Cerro Paloma, on the Río Chilca, dating to 5200–2800 BCE (Engel 1980), where the remains of a village were discovered comprising not only dwellings but also a space for public use, with a twelve-meter-square stone-walled ceremonial enclosure. In the Paracas area, Engel (1963) also studied numerous settlements and pre-agricultural settlements at the Cabezas Largas and Santo Domingo sites, dating them to 4000 BCE.[2] It is clear that the coastal societies were already changing, and their socio-economic structures were evolving. In fact, they were redeveloping the

[2]Since then, some of these datings have been refuted and revised [see Velarde (2002)].

Fig. 4.1 Double-faced projectile heads found in Cahuachi at the base of Gran Pirámide II, related to an offer dated to 4200 BCE. The offer was made at a small ceremonial altar where a sacrificed woman's remains were found (Photo by G. Orefici)

Fig. 4.2 Huancor (Chincha–Alto Larán): large archaeological site rich of petropglyphs which date back to the second millennium BCE (Photo by G. Orefici)

areas set aside to meet their new administrative and religious requirements (Fig. 4.2).

The oldest ceremonial architectural complexes were built during this long period of formation of the earliest Peruvian societies, dating from the Late Preceramic (3000–1800 BCE). These centers had a cohesive function for the groups of settlers from the coastal area, both in terms of culture and religion. From then on, evolution was rapid for a number of reasons, coinciding with an increasing population, a growing specialization in food production, the further development of farming techniques, and the exploitation of the available water resources. The time around 2500 BCE gives the first evidence of cotton (*Gossypium barbadense*) cultivation, the use of which brought significant innovations in the development of artefacts and, above all, in the development of textile art, which began earlier than pottery. Greater access to resources and an increase in the availability of goods brought about a production surplus, thus enabling the support of individuals whose role was to manage collective activities, and this led to the development of hierarchical societies, where a group of people had the task of mediating with the gods in order to obtain favors. This almost certainly meant a priestly élite that, by lineage, corresponded to the group in charge of political functions. It was a group dedicated to religious activities that was also in a position to impose common rules on the population and involve them in building the first architectural complexes intended for public ceremonies. An architectural model developed in which pyramidal temples with steps were erected, and the majority were set out in the form of a “U”, with precincts, semi-underground plazas (sometimes circular in shape), stairs arranged symmetrically opposite each other, and access ramps to buildings. These new construction patterns have design features that denote refinement and decorative taste, as shown by the inclusion of the first polychromatic friezes with symbols connected to the local cults.

4.1.2 Development of Urbanism Between the Initial Period and Early Horizon

The number and concentration of settlements increased immensely, especially in the coastal area. The variety of architectural forms and town-layouts showed control over the environment together with an ability to adapt, as well as technological development thanks to complete mastery of the use of materials.

The most important centers, including Caral, El Áspero, Ventarrón, La Galgada, Kotosh, Bandurria, Punkurí, El Paraíso, and Sechin, are examples of a pattern that extended throughout Peruvian territory. One of their religious and cultural traditions, which took the name of Kotosh (from the name of its source in the heart of the Sierra de Huánuco), prevailed over the others in much of the eastern and center-north Andes. Here, as in Huaricoto and La Galgada, the centers of the main buildings housed hearths which were found to contain the remains of various materials burned as offerings.

In the Supe Valley, evidence has been found for one of the oldest monumental complexes in Peru, in particular, at the Áspero and Caral sites. The first is characterized by a platform made up of ten overlapping terraces, built in *adobe*. It is called *Huaca de los Ídolos* thanks to the finding of a large number of female figurines in unbaked clay, probably related to the cult of fertility. Human remains were found inside another monument, the *Huaca de los Sacrificios*; among these were those of two children who had been sacrificed, and, from the dating of organic material related to the burials associated with the construction, it has been possible to date this complex at approximately 2930–2553 BCE. The city of Caral is also a center of great importance in understanding the pattern of urbanization that developed in this final phase of the Pre-ceramic era. According to archaeologists, it is one of the oldest urban complexes in the Americas, and was a sort of primitive state that served as a model for the societies that would spring up later (Shady and Leyva 2003). The most important centers of this period, including (apart from those already mentioned) Las Haldas, Supe, Las Salinas de Chao, and La Florida, were each arranged along precise axes of symmetry. They had a U-shaped plan and were marked by the presence of circular pits or fences inside circular underground plazas. The building material used was mainly stone covered with plaster and then *adobe* in different forms, based primarily on the cultural model of origin. Further north, in the Valley of Chicama, lies the residential site of Huaca Prieta, where the earliest evidence of textile work has been found, especially fishing nets, one of which measured over thirty meters in length.

As for the South Coast of Peru, especially in the Río Grande Basin in Nasca, no clear evidence has been found of this transition between Final Preceramic and the era known as the Initial Period (or 'Formative' according to other authors, (Lumbreras 1969; Kaulicke 1994), apart from: the Pernil Alto site located on the right bank of the Río Grande in the lower-middle valley (Province of Palpa) dating from 3800 BCE (Reindel 2009, 2010; Reindel and Isla Cuadrado 2006; Reindel and Wagner 2009); some dating of the deep layers of a building in Cahuachi (Orefici 2012: 144; 481) which belong to the middle of the second millennium BCE; and evidence of ancient occupation in neighbouring sites, as at Estaquería, where the body of an individual without head or upper limbs was found, with elements indicating the second or third millennium BCE.

There remains, however, a void in this region that prevents the identification of the chronological transition from these cultural manifestations to those relating to the origins of ceramic production around 1800 BCE.[3] It is still impossible to identify a specific location connected to the manufacture of Andean ceramics, because its use tends to be considered the result of trade and cultural exchanges

[3]This chronology is currently in use because the earliest dated ceramic fragment corresponds to an artefact found in Wayrajirca (Higuera Valley, Kotosh, Region of Huánuco). However, there is another method of dating from material obtained from the Ucayali Basin (Dep. de Ucayali) associated with the Tutishcainyo from 2000 BCE.

with societies settled in northern areas, including today's Ecuador and Colombia, which had been producing fine ceramics from around 4000 BCE.

This period saw more extensive planning of settlements and large ceremonial complexes, built strictly along an axial alignment extending for kilometers and with a greater monumental impact. The walls of the temples and palaces were decorated with wall paintings and reliefs, representing sacred themes featuring the main figures from Andean mythology, especially the cat and the snake.[4] A form of socio-political organization flourished that exploited collective labor for the construction of public works, including major hydraulic engineering systems. In addition to ceramics and textiles, metallurgy also developed significantly, reaching excellent results thanks to the influence of the cultures of Ecuador and Colombia, especially in the manufacture of articles in gold. Almost certainly, for a number of reasons that cannot be established, the technological, artistic, and ideological characteristics of these centers in some way merged in the Ancash Region, at Chavin de Huántar, despite being located in different territories. Most probably, the prestige of the site represented the result of a process of cultural integration of great magnitude spanning a period from 1500 to 200 BCE.

The concentration of power and the theocracies became one of the main socio-political structure systems within the Peruvian area: in the case of Chavin de Huantar, it is evident that the cultural and religious elements tied in with this form of religious expression expanded into areas far from the source, confirming the charismatic influence that this center exerted, as well as its function as a center of attraction and cultural expansion. The influence of Chavin produced a unifying movement of cultural aggregation in almost all of Peru and certainly had implications of a political nature.

The exportation of the unmistakable Chavin iconography and its ideological component was not always complete, and in some places obvious forms of regionalism persisted, probably due to the strength of religious belief there. Centre such as those of Cupisnique and Pacopampa, despite being included to some degree in the integration process of worship and cultural being, dissociated themselves from the adoption of the new stylistic canons in vogue, which meant also not fully accepting the religious symbols of Chavin iconography. Elements of a religious pantheon, which partly draw upon the Chavin universe, are recognizable in the Cupisnique ceremonial ceramics, found mainly in the coastal valleys of Virú and Lambayeque, but they retain emblems such as the spider divinity in their iconography.

[4]The ceremonial centers of Pampa de Llamas, Moxeque, Cerro Sechin, and Sechin Alto flourished in the basin of the Río Casma, and were undisputed models of the authority of the priestly élite who held power. To the north, the Huacaloma site (Valley Crisnejo, Cajamarca) turned out to be one of the most interesting and complete examples of monumental ceremonial architecture in the center-north area of Peru. Other important sites were Huaca Florida, in the Rimac Valley and Cardal in the Lurin Valley (Region of Lima).

4.2 Development of the Paracas Culture

The presence of "Chavinoid"[5] elements is also evident on the southern coast of Peru (Fig. 4.3), mainly in the morphology and iconography of the ceramics, as well as in the motifs of some of the painted cloths found in Carhua, a site in the coastal region north of Ica. In the Paracas Peninsula and in the valleys of Cañete, Pisco, Ica, Chincha, and Nasca, we see that the local rulers had transformed the essential meaning to suit regional traditions and needs despite the evident acceptance and assimilation of Chavin ideology. During the first centuries of the Early Horizon, the southern coast, too, was affected by fervor for renewal and an increase in urbanization. Under the influence, and with the consolidation, of the Paracas and Topará traditions, structural complexes arose arranged in groups or in isolation. The edifices took the form of a truncated pyramid, with stepped platforms connected by inclined stairs and ramps, but the sites found and studied are still few. Almost all of these constructions were built using a small, wedge-shaped adobe, placed vertically in horizontal rows on a layer of clay binder and then plastered.

Among the more important examples of Paracas architecture are two large centers that flourished in the lower Ica Valley: Ánimas Altas and Ánimas Bajas, which cover areas of 100 and 60 ha, respectively. Ánimas Altas consists of 13 tall structures following the same orientation and with the same morphology; it has a defensive wall covered in adobe made up of various layers of vegetal material and earth. It has decorations engraved with figures of felines, which still have iconographic elements of "chavinoid" origin. The center had plazas, ceremonial enclosures, workshops, and a U-shaped platform. Ánimas Bajas is a complex of seven different mounds built with adobes whose shape is similar to corn grain.

However, important nuclei serving as dwellings or administrative buildings appeared in the territory of Chincha Province. Nevertheless, the layout of the town clearly indicates the presence of centers of worship. The Soto complex has three separate mounds aligned from east to west. The Huaca Alvarado site also has two major structural groups. Other contemporary urban centers, also characterized by buildings in adobe and the presence of ceremonial buildings, are located in Pampa del Gentil, San Pablo, and Santa Rosa.

4.2.1 Paracas Chronology by Julio C. Tello

During the course of his research in the Paracas area, the Peruvian archaeologist Julio Tello made archaeological finds of great importance for the definition of the stylistic features that mark out Paracas cultural expression. There were several sites located in the Cerro Colorado and Warikayan area dating back to a period between

[5]In the sense that they hold some stylistic features in common with the art at Chavin.

Fig. 4.3 Huancor (Chincha–Alto Larán): petroglyph depicting a stylized head with characteristics resulting from the Chavin style. The cultural and religious expression belonging to this ceremonial center expanded greatly in the territory of Peru around the second millennium BCE (Photo by G. Orefici)

around 700–500 BCE, as well as other archaeological remains, mostly cemeteries and settlements (including Arena Blanca, known as *Cabeza Larga*).

In an attempt to establish a chronological sequence based on grave type and associated artefacts, Tello sub-divided his data, organizing them into two different cultural components which he called *Paracas Cavernas* and *Paracas Necrópolis* (Tello 1928, 1959; Tello and Xesspe 1979). The phase that Tello named *Paracas Cavernas*, due to the discovery of deep graves in the Cerro Colorado and especially in Warikayan, probably relates to cemeteries left by local communities, although there are no indications of the presence of urban centers of particular importance, since the discovery of these tombs with collective burials and rich funerary bundles was made in desert areas and in locations far away from rivers and cultivable areas. The "Necrópolis" type tombs are real underground chambers; they are not very deep and have masonry walls. In both cases, the dead were buried in foetal position and were wrapped in multiple layers of fabric so they looked like a large bundle, generally called "fardo" from the Spanish.

However, the definition *Paracas Necrópolis*, which Tello (1959) used to fix his discovery chronologically, is currently under debate, because it would appear that the burials found at Warikayan were not part of a necropolis, but seem to be on the site of dwellings later used as a burial area. The funeral rites probably brought together people from various communities, vying to offer finely woven cloth produced in honor of ancestors of a certain rank (Peters 2009, 2012).

On the basis of a later analysis of cultural material from the “Necrópolis” already classified by Tello (1959), and after comparison with findings of further excavations in the second half of the last century, it has been necessary to review the data obtained. It is now certain that this was material from another tradition called Topará, named after a town in the Chincha Valley believed to be its place of origin. The spread of this form of cultural expression in the Cañete, Pisco, and Chincha valleys and the Paracas Peninsula shows that this was a powerful society able to interact throughout the region and even outside its territorial boundaries.

In fact, during excavations inside the Gran Pirámide of Cahuachi, the Nasca Project discovered an intrusive tomb inside the artificial fill within the temple building, using clearly Topará material, which leads to the assumption that there was also exchange with the cultures to the south in the basin of the Río Grande in Nasca.

Moreover, the Warikayan necropolis contained numerous funeral bundles and bones with evidence of cranial drilling or fractured skulls, leading to the supposition that there had been a period of great tension in the area, with frequent conflicts likely. However there are no unequivocal elements to establish that Topará culture had been imposed in the territory through wars of conquest and the subjugation of previous forms of cultural expression. The large refined polychrome mantles found in the necropolis of Warikayan, known as the Paracas Mantles, may perhaps be traced back to the presence of Topará or Nasca expansion in the area (for additional detail on textiles at the Necropolis of Wari Kayan see Chap. 18 by Frame). Paracas society was then certainly ruled over by a class of priests with a complex theocratic organization and a rigid class division based on different types of manufacturing. It was probably also a warrior society, given the human remains found in the graves showing clear signs of skull fractures and drilling performed to relieve internal inflammation. The trophy heads (see Chap. 5 by Drusini) depicted in the iconography refer, however, to gods and do not therefore indicate acts of war, but most certainly human sacrifices in honor of the religious pantheon.

The socio-economic organization of the population was increasingly oriented towards the adoption of a strict division of labor, favoring the emergence of real specialization in all areas of production, from agriculture to craftwork. In order to survive in desert land with little surface water, the population strove to create complex irrigation systems able to compensate for the lack of rainfall and to grow the crops needed for food. These include corn, various legumes, tubers and rhizomes, chilli pepper, and some varieties of pumpkin, as well as peanuts and several types of fruit.

Paracas culture was also advanced in the fields of metallurgy, textile art, and pottery production. The technical and aesthetic achievements derived from the Chavin tradition led to increasingly advanced solutions which took on the exclusive characteristics of the Paracas. The fabrics became very refined, with ever complex embroidery, and also ceramics evolved from simple forms to more elaborate articles, with fine colors, etched surfaces, and post-kiln coloring using pigments mixed with resins. The extensive iconographic repertoire on cloth and vases largely consisted of animal motifs, including cats, marine animals, two-headed snakes, and mythical characters, sometimes winged, wielding sacrificial knives and brandishing decapitated heads. Through an analysis of the architectural spaces, the content of structural fill, and the study of burial types, as well as grave goods and funerary rituals, it has been possible to document some aspects of society that developed during the Early Horizon in the territories of the Paracas tradition. The authority required to manage such a complex geopolitical system, based primarily on a form of ideological aggregation of various valleys' populations, could only be theocratic. In the region within the basin of the Río Grande of Nasca, the process of transformation that affected this area favored the growth and gradually expanding cultural influence of the Cahuachi ceremonial center on the territory, also in later periods, until the end of the Early Intermediate Period (Figs. 4.4 and 4.5).

At the end of the first millennium BCE and in the early centuries of the first millennium AD, over the period that coincides with the transition from the Early Horizon to the Early Intermediate Period, the coast of Peru underwent significant changes, as happened in the Sierra areas too. The decreasing influence of the great

Fig. 4.4 Anthropomorphic geoglyph engraved on a slope of a hill in the area of Palpa (Llipata). The style of representation of this character is typically Paracas and belongs to the first millennium BCE (Photo by G. Orefici)

Fig. 4.5 Geoglyphs engraved on a slope of a hill in the area of Palpa (Llipata). The style of representation of the anthropomorphic figures dates back to Late Paracas period, the last centuries of the first millennium BC (Photo by G. Orefici)

ceremonial centers and the disintegration of Chavín power had an uneven but decisive effect on the various geographical areas of Peru, as their ancient power as theocratic capitals diminished and was replaced by other traditions influenced by local cultural elements.

The social changes that ensued, and whose causes are difficult to establish, were radical, but were certainly favored by serious political unrest among those who held power. The societies that flourished in this period in the southern-central coastal areas had strictly regional characteristics and reached full maturity with cultural expressions such as the Nasca and the Lima. Further north, the Vicús and Moche cultures developed, while in the highlands the evolutionary process was equally innovative and fostered unique artistic styles, especially in the Northern Sierra in Cajamarca, in the region of Recuay in the Sierra Central and the Huarpa Valley (Ayacucho).

In the Lake Titicaca Basin and the southernmost Cordilleras, two major cultural hubs emerged: Pukará and Tiwanaku in its earlier phase, both with a wide sphere of influence. Administrative and religious nuclei sprang up everywhere, along with ceremonial and residential complexes, which were also centers of autonomous governments that controlled the populations of the different valleys. The entire Peruvian territory saw the interaction of heterogeneous cultural convergences, where it was possible to distinguish between many traditions, including non-local ones, identifiable by means of the varying construction techniques and ceramic and textile iconography. The result was a markedly hierarchical system in which craftsmen must have played an important role, as demonstrated by the high degree of specialization they acquired in manufacturing ceramics, weaving, metallurgy, feather art, and the manufacture of construction materials. Thanks to significant population growth, various improvements in technology occurred and with them a greater organization of collective work. There was significant development in irrigation techniques that enabled almost total control of natural resources and led to a greater concentration of the population in urban centers, leading to the abandonment of the former village economy. These societies, despite their heterogeneous nature, do not appear to have practiced aggressive expansionism: they maintained a form of religious aggregation presumably based on a legacy dating back to the Chavín or even earlier. This condition later culminated in an ability to coalesce which derived from the prestigious ceremonial centers, including Cahuachi in the Nasca area and later in Pachacámac in the Lurin Valley.

4.3 The Paracas Antecedents to Nasca in the Río Grande de Nasca Drainage

During the developments of the Early Intermediate Period, Nasca Culture, under the influence of the theocratic capital of Cahuachi, spread its cultural and religious dominance over a vast area that extended to the north through the Ica, Chincha, Pisco, and Cañete valleys and to Yauca and Acarí to the south. Further evidence of contacts which the Nasca had with other cultures may be found in the Arequipa region and in the Sierra of Ayacucho and Huancayo. Their origins are not clearly understood as they relate to much more remote local traditions that, at a given time, were influenced and enriched by previous cultural experiences from the Paracas and the Topará.

Proyecto Nasca excavations at the residential sites (Pueblo Viejo, Quemado, Atarco, Usaca, etc.) show that there was clearly influence and complete identification with Topará culture and, at the same time, these similarities lead us to question whether the source of this form of cultural expression is really the Topará and not perhaps, on the other hand, a location further south, whose initial phase is yet to be identified (Fig. 4.6). At any rate, the production of clay artefacts and especially Topará textiles was very complex and produced quality results. It is highly likely that, through mechanisms still largely unknown, the cultural and religious expansions of Cahuachi towards the northern area favored the spread of textiles to which a generic Nasca derivation was attributed, although they had previously been identified as Paracas Necrópolis and later as Topará. In fact, in Cahuachi, many textiles were found originating from later phases of the Paracas Necropolis or Topará Culture, as was some pottery contemporary to some intrusive elements, especially in the interphase between Cahuachi architectural phases II and III.

Nasca culture took its salient iconographic themes from Topará ceramics, such as the representation of the cat, the snake, and the killer whale: divinities related to land, water, and sea. Also very frequent were depictions of mythical birds, they too belonging to the Topará tradition. Even the style of the artefacts came very close to

Fig. 4.6 Cahuachi, Gran Pirámide: Topará-style double-spot–and-bridge bottle. This vessel, probably dating back to transitional Paracas-Nasca period, was found in an intrusive grave in the structures of the ceremonial center (Photo by G. Orefici)

this tradition, although the Nasca used innovative colors and iconography, adding many themes that had not previously been used.

4.3.1 Ceramics Between Late Horizon and Early Intermediate Period

The problem of drawing up a chrono-typology of Early Horizon ceramics, from which to understand all the local variants present in the valleys of the South Coast, began to be addressed in the 1960s (Menzel et al. 1964) and a ten-stage seriation was produced, which the authors called Ocucaje, based on data from excavations and surface material as well as private collections, in addition to radiocarbon dating from some of the archaeological contexts. In this sequence, it may clearly be observed how any connection with the Paracas is restricted to stages 7, 8, 9, and 10. Among these, the first two seem to correspond to Paracas Cavernas, with clear Chavín influences, while the last two (9 and 10) may be associated with Paracas

Necrópolis or, according to other interpretations, with Topará (Lanning 1960; Menzel 1971; Wallace 1986) and, most probably for the Nasca area, with phase 1 Nasca ceramics.

Later on, this sequence (Menzel et al. 1964) underwent correction, based on new data emerging from unequivocal stratigraphic features and the availability of more radiocarbon dating (Deleonardis 1991; Paul 1991; Massey 1991; Cook 1994, 1999), particularly for the earlier periods. The lack of reliable data for the first two phases (1 and 2) led to their existence no longer being taken into consideration, and instead attributing the start of Paracas to Ocucaje phase 3, where Chavín elements were still present. For the same reason, phases 4 and 5 were also left out, pending further information (Massey 1991; Silverman 1991, 1994; García et al. 1995; Deleonardis 1997; Cook 1999; Velarde 1999). According to archaeological evidence, the phases that could be more easily related to a southward spread would appear to be the 6th and 7th (Deleonardis 1997), while those for which there is comprehensive documentation across the Nasca Río Grande Basin are the 8th, 9th, and 10th (Orefici and Drusini 2003; Orefici 2012; Silverman 1991; Isla et al. 2003; De la Torre and Van Gijseghern 2005).

On the basis of what has been observed so far, Tello's Paracas Cavernas phase, whose name derived mainly from the shape of the tombs, being very deep and bottle-shaped and used for collective burials, would seem to correspond to Ocucaje phases 7 and 8. The ceramics associated with these burials were mostly engraved with geometrical decorations and were subject to post-firing painting using resin. Among other types of pottery, common finds include ceramics decorated with paintings "in the negative", particularly common in the Ocucaje area. Concerning painting engraved with decorations "in the negative", numerous examples of pottery related to this type were found at Cahuachi. The ceramics attributable to Tello's Necrópolis Phase (Ocucaje 9 and 10) were typically a mainly monochrome form of slipware, often shaped like a pumpkin (Fig. 4.7). The Necrópolis textiles were undoubtedly among the most precious and they stand out on account of their refined production and technical perfection, especially in simple, painted and embroidered cotton cloth.

However, accepting the existence of two traditions with their own rather undefined spheres of influence (the Topará further north, whereas in the south polychrome ceramics were more common), it is important to note that at the beginning of the transition to the Early Intermediate, Nasca pottery already stood out due to its use of polychrome post-firing decoration, rich in colored patches enclosed within etched or drawn contours. Similarly it may be observed that the iconographic repertoire of the last stages of Ocucaje is fully in line with the religious and mythical world of the Nasca.

During the excavations conducted by the Nasca Project at the Cahuachi ceremonial center and other contemporary dwelling sites, fragments of pottery were found belonging to Ocucaje phases 9–10 and Nasca 1. These artefacts were discovered close to the buildings, as well as inside them, but also in the artificial fill present in the large enclosures and plazas. Similarly, archaeological research in the neighboring valleys, such as Aja at the Puntilla site (Van Gijseghem 2004), showed

Fig. 4.7 Double-spot-and-bridge bottle with decorations in negative, dating back to later phases of the Paracas ceramic (last centuries BCE) (Photo by G. Orefici)

that these materials coexisted, probably due to the peaceful coexistence of the two different groups in the same places, one made up of "Paracas emigrants" and the other local (Montana). Despite the belief that this important factor has been explained in such a simple way, making no comparison between much larger areas, it is possible that different human groups, at certain times or on the occasion of special events, may have shared the same territories.

4.3.2 Cahuachi and Its Area of Influence

Over the several years of archaeological excavation at Cahuachi, it was possible to ascertain that there are areas (especially Y14) where the majority of the ceramics found did not belong to the sequence of the first Nasca phases, or it was not possible to discern its combination with that of earlier phases, as only Ocucaje 8–10 material was found. Very often these pottery fragments coexist in the stratigraphy with the first three phases of Nasca ceramics (Orefici 1993, 2012; Orefici and Drusini 2003);

a smaller percentage of pottery that does not include slipware[6] or with applications in relief and geometric incisions appears, but much of it is more often burnished material obtained in a reducing atmosphere, with rounded surface engravings (Orefici 1993, 2012; Orefici and Drusini 2003) (Fig. 4.8).

As for the development of Nasca culture, from the research carried out by the Nasca Project, significant differences emerge between the period of the activities of the Cahuachi ceremonial center and the period following its decline and abandonment. Most certainly, Cahuachi was the most important example of theocratic government on the southern coast and the main center of attraction and cultural aggregation over a vast territory, so much so that it became a place of periodic pilgrimage from places very far afield. Within the architectural structures, there were certainly textile, ceramics, and stone workshops among the other crafts relating to the preparation of the materials to be used (Fig. 4.9). There were certainly other centers of production, especially primary ones, near the towns, but, as was observed during research in the various residential areas, the principal skilled labor was carried out at the Cahuachi center.

Nevertheless, it is difficult to prove what type of production mechanism existed at the time, although some methods involved in a specific economic process can be deduced from the results of archaeological research. The buildings at Cahuachi provide conclusive evidence of a production surplus which enabled the distribution, redistribution, storage, and interchange of certain products, indicating a clear process of centralization of power.

The temple complex was built entirely of *adobes* and occupied a surface area of approximately 24 km^2. The central area was primarily made up of two distinct groups of buildings: both were surrounded by a wall, which served as a partitioning element for the activities carried out inside, in line with the Andean conception of the dual representation of sacred space. Studies conducted by the Proyecto Nasca over the last three decades have shown that Cahuachi was the major center of confluence and sharing of experiences, not only in the religious, but also, in the technological sphere. The discovery of selected agricultural products and offerings of the most diverse nature and origin make the extent of its immense power of attraction clear. The imposing stepped structures, such as *Gran Pirámide*, the *Gran Templo*, the *Templo del Escalonado*, and the *Templo Sur*, loom over a complex system of architectural forms composed of other buildings, plazas, passages, ramps, and stairways, which could accommodate a multitude of people attending the celebration of the most important religious ceremonies.

Due to the importance assumed by Cahuachi in the coastal area and nearby highlands, Nasca spread over a very large area, as did the religious concepts that were expressed through the iconography found on the artefacts (Fig. 4.10). The "*huacas*" (religious and administrative complexes) in the Río Grande became vassals of Cahuachi within the space of a few centuries, and it, in turn, increasingly

[6]Slipware is a type of pottery identified by its primary decorating process where slip is placed onto the leather-hard clay-body surface before firing by dipping, painting, or splashing.

Fig. 4.8 Cahuachi: Ceramic mug made in a reducing atmosphere. This type of pottery has been classified by the Nasca Project as type “Nasca 0”, because it is part a set of materials that have been defined as Paracas–Nasca transition, although it was also used during the early Nasca age (Photo by G. Orefici)

became a real theocratic capital. During the Early Intermediate Period, the Nasca set up urban settlements in the various valleys, on the edges of the river basins, building along a line parallel with the valleys themselves. Many of these centers were covered by alluvial material from a number of disasters, possibly connected with El Niño during the last centuries of the Early Intermediate. In the case of Pueblo Viejo, traces of floods are clearly evident, as is also the case in the center of Cahuachi, which suffered the same fate between 400 and 450 BCE. Among the main smaller settlements from the Nasca era, we find Tinguiña and Cerro Max Uhle in the Valley of Ica, La Muña in the valley of Palpa, La Ventilla in the Ingenio Valley, as well as Pueblo Viejo, Majuelos, Santa Clara, and Estaquería in the Nasca valley.

The urban settlements arose primarily in proximity to watercourses or natural sources able to provide the population with a water supply, but not sufficient to irrigate large areas of land. As agriculture was at the root of the Nasca economy, its

Fig. 4.9 Large double fabric of cotton found in an tomb in the Sector Y12 of Cahuachi, belonging to Paracas Necropolis style (Photo by G. Orefici)

population was able to overcome the difficulties caused by a dry climate and desert territory by building wells, pipes, tanks, underground aqueducts, and tunnels parallel to the beds of the rivers so as to collect water from seepage. This technology was applied especially in the middle and lower stretches of the river valleys. This irrigation system with aqueducts (*puquios*), faithfully replicated over a vast territory, further confirms the management of a rigidly organized social hierarchy.

The early Nasca exploited any product that nature could offer them, and they were able to cultivate all the plants they needed for food, especially corn (*Zea mays*)

Fig. 4.10 Ceramic miniature of a Paracas-style temple, dating back to transitional Paracas–Nasca phase. It was found at Majuelos (Nasca) (Photo by G. Orefici)

and various legumes, such as beans (*Phaseolus vulgaris*), the Lima bean (*Phaseolus lunatus*), Canavalia or *Pallar de los Gentiles* (*Canavalia ensiformis*), chilli pepper, peanuts, cassava, numerous types of pumpkin, tubers and rhizomes, amaranth, fruit plants, etc. Food was supplemented by marine products: molluscs, crustaceans and fish, probably with some fish-farming in small artificial lagoons near the mouths of rivers. Hunting was never abandoned and continued to be one of the privileged means of obtaining meat, especially deer and guanaco, both of which were common in the woods and on the coastal *lomas* at that time. Images on pottery very often show elements linked to the agricultural, marine, and terrestrial worlds.

Among the products used for packaging articles and which also had an industrial function, cotton was of particular importance as it was used to obtain yarns for fabrics. Also the scalps of camelids were important, being mainly used to prepare footwear, but also to make bottles or containers that could be used to transport various materials. Most timber was obtained from the woods which lined the rivers and was used to make supporting structures during building construction, either as fuel or as raw material for manufacturing agricultural tools, spoons, caps, or to make sculptures, etc. In the field of metallurgy, the Nasca did not introduce innovations with respect to earlier times or other cultures, and they limited themselves to working with metals; mainly gold, silver, and copper, using techniques such as laminate, embossing, and hammering. The decorations were obtained by punching, engraving, polishing, and applying elements in other materials, especially shells and stones.

There is no real evidence of trade, but, since the main pole of Nasca Culture revolved around Cahuachi, it seems clear that the pilgrims, periodically flooding into the Río Nasca Valley during the major religious festivities to participate in special events, transported ceramics and textiles obtained in the ceremonial center in exchange for agricultural produce which would be accumulated in the religious capital.

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Chapter 5
Anthropology and Bio-cultural Adaptation of the Ancient Nasca Inhabitants

Andrea Drusini

Abstract Bone findings belonging to 469 individuals (skeletons and mummies) excavated at sites of Pueblo Viejo, Cahuachi, Estaquería, and Atarco in Nasca, Peru, were studied. Archaeological evidence distinguishes three cultural phases: Nasca, Huari and Chincha. The paleodemographic data show that the infant death rate was 115‰ during the Nasca phase and 371‰ during the Huari phase. The life expectancy was 31–33 years, and was probably longer for females. The death rate for adults (21–40 years) increased from the Nasca to the Huari phase. From the anthropometric point of view, people of both sexes were of modest stature and fairly robust. Deformed skulls were frequent: rising to 75% for males and 73% for females during the Nasca phase; 56% for males and 13% for females during the Huari phase. Plagiocephaly was also present in some specimens. Nasca and Huari individuals can be discriminated according to some anthropometric measurements, e.g., splanchnocranium and post-cranial skeletons. The peoples from Nasca Valley had anthropological affinities with other coastal populations, but some characteristics recall the ancient Sierra inhabitants.

Keywords Nasca · Anthropology · Paleodemography · Cahuachi · Pampa de Atarco · Satellite remote sensing · GIS

5.1 Introduction

During the field work (1982–2001), the Nasca Project studied all the human bone remains found in the excavations at the Pueblo Viejo, Cahuachi, Atarco, Santa Clara and Usaca sites. They belonged to 630 individuals of all ages, in various preservation conditions and are more or less complete. The preservation conditions were classified as follows: bad, mediocre, good, and optimal, while assigning a

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quantitative value to each class (from 0.25 to 1.00), according to the suggestions from Nemeskéri et al. (1961). The same method was applied to quantitatively represent each sample, beginning with 1.00, the value that corresponds to a complete skeleton.

Fig. 5.1 Trophy heads: signs of bleeding, such as scarifications or superficial wounds (Photo by Giuseppe Orefici)

Fig. 5.2 Offering head wearing the typical frontal hole, through which a cord was passed in order to ease its carrying (Photo by Giuseppe Orefici)

Fig. 5.3 Perfectly preserved child skeleton. Both dental and bone ages correspond to a newborn (Photo by the author)

There have not been found any burial patterns related to gender, age, or other individual characteristics. Among the most important findings, the standouts are offering-heads or trophy heads (Figs. 5.1 and 5.2). The most frequent burials were made inside pots of a utilitarian type: children younger than two-years old were buried in globe-shaped pots or in holes some centimeters in depth. Typical to the Paracas–Nasca culture is the “barbeque”, vault-like tomb with a circular or parallelepiped shape, covered by canes of guarango tree sticks, which correspond more to adult individuals (Orefici and Drusini 2003). During the Chincha epoch, there appeared simpler burials, with tombs dug on the soil, typical of a social group whose economy was very rudimentary. With reference to the types of offerings left inside the tombs, there is not much difference between men and women, except for the presence of slings, which are characteristic but not exclusive to males. Generally, only very scarce offerings are found in children burials.

The most frequent position of the skeleton is flexed or squatted: the lower limbs folded under the chin, forming an angle of about 0°, while the upper limbs are often doubled over the thorax. In some cases, the hands are grasping an offering and the limbs may be tied with strings. This unnatural positioning of the bodies was performed within three or four hours after death, before rigor mortis set in. About the preservation of the bodies, three categories proposed by Allison et al. (1973) are present at the Pueblo Viejo site: skeletons with hair remains; bones with external integument residuals; and naturally dehydrated mummies. In particular, the use of the fardo (bale), a funerary wrapping made of cotton fiber, made possible almost perfect preservation of a considerable part of the skeletons belonging to children (Fig. 5.3).

5.2 Paleodemography

All the complete or well-preserved skeletons have been classified by age groups, according to Martin and Saller (1957): Infans I (0–7 years-old), Infans II (7–14), Juvenis (14–20), Adultus (20–40), Maturus (40–60) and Senilis (60–x). With respect to gender, 'm' was used for males and 'f' for females, and 'i' for cases of uncertainty as well as for children (Fig. 5.4). On the basis of archeological findings and site chronology, the studied individuals have been divided into three cultural periods: Nasca, Wari, and Chincha. The Wari group presents the largest number (106 individuals), while 37 belong to the Nasca phase, and 20 to Chincha. Figures 5.4 and 5.5 represent the age classification and the distribution of child mortality in the three studied groups.

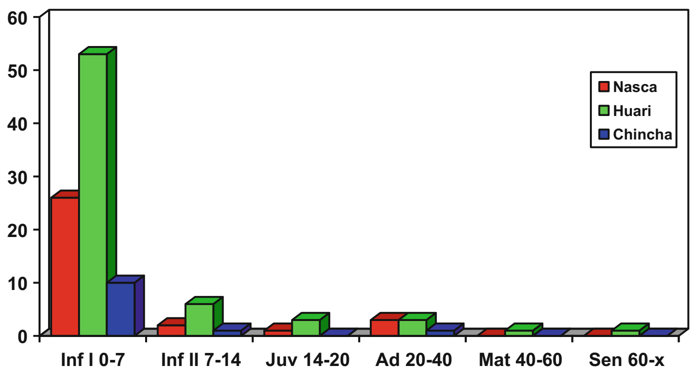

Fig. 5.4 Investigations in Nasca from 1982 to 1992: age classes of skeletons

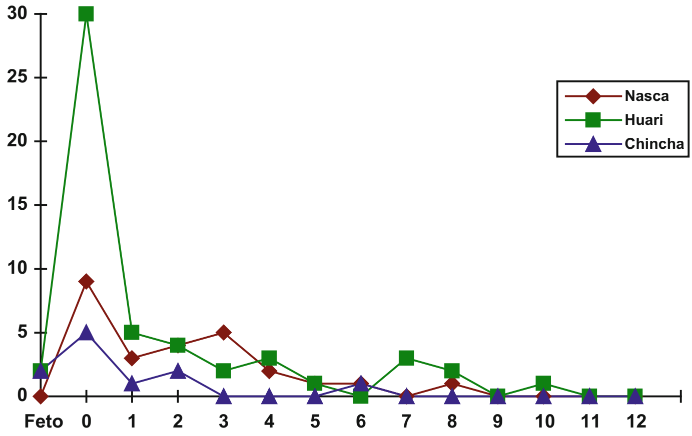

Fig. 5.5 Nasca 1982–92: infant mortality

Many of the children (29.4%) were younger than one year old when they died. In a recent study at Paloma (Chilca Valley, near Lima), Benfer (1984) registered a similar percentage (28%).

It has to be noted that the number of children who died within their first year of age increases from 34.6% during the Nasca period to 56.6% in the Wari period, and

Fig. 5.6 Dental pathology in the presence of osteolytic areas surrounding the roots of the mandibular left first molar. There is also a corresponding significant reduction in the alveolar surface (Photo by A. Drusini)

to 45.4% in the Chincha period. There exists a significant difference between these three cultures with respect to the −4 age group, with the Nasca period showing the highest number of individuals. This trend in child mortality and the difference between the three cultures cannot be reliably explained, but they could reflect the rise of stress factors in the coastal environment through the Wari period, probably due to the lack of water and food during weaning. Indeed, the geological analyses conducted in 1987–88 revealed the traces of three floods; two during the Nasca period and one, the strongest, during the Wari period, about 1000 AD. On the contrary, the excess of food that has been documented thanks to the presence of maize, canna edulis, etc., which were found inter-layered with sand in the building material used in Cahuachi, leads us to suppose the existence of better health conditions for the Nasca period. However, many skeletons show pathological traces, especially in their teeth (Fig. 5.6).

5.3 Morphological and Metric Characteristics

In order to produce a complete synthesis of the morphological and anthropological characteristics of the bone samples of Pueblo Viejo, we also refer to the publications by Rippa Bonati et al. (1988)—which comprises all the statistical analysis on the metric and morpho-metric data—as well as Drusini (1991a, b) and Drusini and Baraybar (1991). Here we comment the essential data belonging to the general biological reconstruction of this population.

With respect to determination of the age of the individual children, in most cases it has been possible to determine both the dental age—estimated on the basis of the appearance time, according to Ubelaker (1989)—and the bone age, based on the maximum length of the limb bones, according to Bass (1987). It has to be noted that, in general, the two ages do not always coincide and that in Pueblo Viejo the dental age is always greater than the bone age of the same individual: let us remember that bone growth is more sensitive than the eruption of teeth to food and pathological stress (Demirijan et al. 1973; Molleson 1986). It also has been observed that South American children show a certain precocity in dental emergence (Owsley and Jantz 1985) and that the differences between dental age and bone age tend to increase two years after birth (Visconti di Modrone 1987/1988; Rippa Bonati et al. 1988). The same difference is also noted in young individuals: the synostosis degree of the longer bones epiphyses (calculated according to Brothwell 1981), is behind dentition of the a same individual. However, the dentition examination has enabled us to use, in the case of children, less broad age groups than in the case of adults.

Unfortunately, determination of the gender of children could not be accomplished due, to the two afore-mentioned reasons. The sole way to determine gender would be by applying the chromosome Y test on the bones, which will be attempted in the future. In adult individuals, sexual dimorphism was determined applying the method proposed by Acsádi and Nemeskéri (1970)—which assigns a quantitative value to the morphological features of the skull and the post-cranial skeleton—and the methods proposed by Krogman and Isçan (1986) and Bass (1987) with reference to discriminant anthropometric measures, also taking into account the indications by Hamilton (1982), Giles (1964), and Giles and Elliot (1963).

On the determination of the age of adult individuals, it has to be noted that the state of the skulls sutures has rarely been significant, due to either the frequent artificial deformation of the vault or because not always does the enclosure of the ectocranial portion correspond to the enclosure of the endocranial side (Meindl and Lovejoy 1985).

Moreover, most of the skulls are deformed and that affects the interpretation of the age under the sutures method (Fig. 5.7). At times, the enclosure is also asymmetrical to both sides of the coronal sutures and the lambdoid sutures. In such cases, we followed the suggestions by Zivanovic (1983), so that it has been possible to divide individuals into adult, mature, and senile ones.

From the morphological and morphometric points of view, there is a certain continuity in the three cultures under study. In most observations, skulls are short or very short in length in males while females have medium-sized skulls. The cranial capacity is epencephalic in both genders. Skulls having the typical tabular- have been observed, while in the non-deformed skulls the prevailing shape is brachymorphic spheroid.

It must be said that the plagiocephalic aspect observed in a number of skulls is not simply related to the deforming practices, given that even the non-deformed skulls present a certain asymmetry. With respect to some non-metric skull features,

Fig. 5.7 Skull with a spectacular tabular oblique deformation, a more heterogeneous manner of ancient cultures, which compressed and changed the skulls of their newborns (Photo by Andrea Drusini)

metopism is present in 1.4% of skulls belonging to the Wari period and in 16.6% of those of the Nasca period. Wormian bones cover 29.8% of skulls belonging to the Wari period, and the orbital notch is present in 61.9% of the Wari skulls and in 50% of the Nasca ones. The supraorbital foramen has a 66.6% frequency in the Wari skulls and 50% in the Nasca ones, while the torus maxillaris is found in 1.8% of the Wari skulls (and in none of the Nasca ones).

The artificial deformation of the skull has already been studied widely, and there is not much to add to what has already been written (Dingwall 1931; Falkenburger 1938; Imbelloni 1925, 1930–1931; Imbelloni and Dembo 1933) (Fig. 5.8). In Pueblo Viejo, there have been found 13 cases of artificial deformation (six Wari, four Nasca, one Chincha, and two belonging to an unidentified culture) as well as 17 cases of plagiocephalia and one non-intentional skull asymmetry with a parietal-occipital flattened bone which has already been recognized by Topinard (1876). In the Nasca period, the deformation was exclusively of the tabular-oblique type (Falkenburger 1938), and in just one case the slightly bilobed shape has been found. In the Wari period, both the tabular-oblique deformation and, probably, the circular-oblique type have been found, with a sample of a slightly bilobed shape. In the Chincha period, the sole type of deformation is the circular kind.

The face is of middle height and a little shorter in the deformed skulls. The orbits are also of middle height: the nose possesses a narrow preponderance in males and a wide one in females; the mandible is small in general. The platopiaindexes (Woo and Morant 1934) have exhibited the typical facial flattening of the Amerindian peoples, without significant differences between the deformed and non-deformed skulls. The sexual dimorphism in the skulls is evident, especially in the maximum

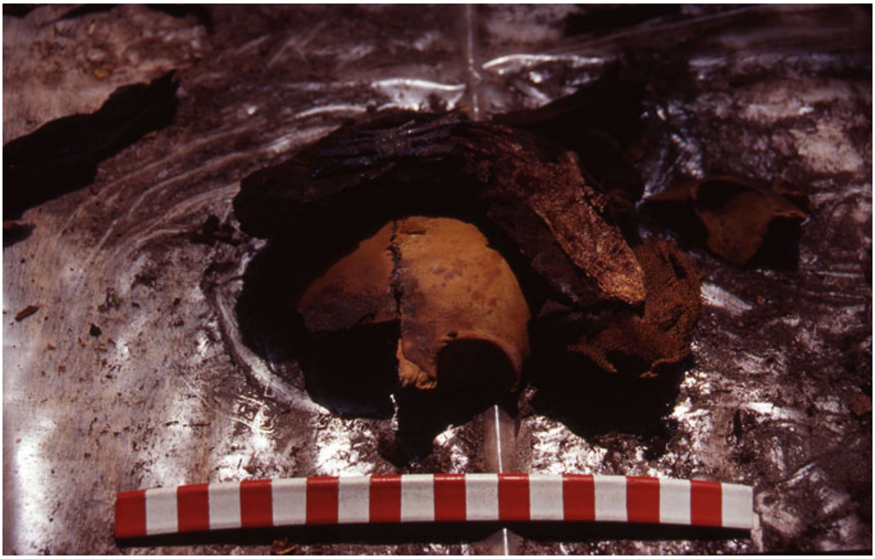

Fig. 5.8 Skull of a newborn with his apparatus used for cranial deformation (Photo by Andrea Drusini)

length, the maximum width, the basion-bregmatic height, the maximum width of the face, and the nasal height. The cranial dimensions have been compared to the series studied by Stewart and Newman (1963). There exists a certain craniometric continuity with the exception of the maximum length of the skull. In the Wari group in particular, a modest relationship is noted with other populations of the coast, but there also appears a certain affinity with the ancient inhabitants of the Andean region, thus confirming the archeological data that sustain the presence of Andean cultural elements in the Nasca Valley during the Middle Horizon period.

A process of interbreeding must have been the origin of the human group which, from the cultural point of view, we call Wari, according to the hypothesis proposed by Newman (1943) for the population of Calca (Cusco). In any case, the population of Pueblo Viejo is not homogeneous, as can be concluded from the multivariate statistical analysis (Drusini 1991a, b). There are many reasons to explain such variability: different environments in the coast and the Andean region, different social structure, characteristics intrinsic to the sample studied, etc.

Some morphological characteristics and anomalies have also been detected in the teeth. In particular, for the Wari culture, studies have been one on 41 children with deciduous or mixed teeth and 40 individuals with permanent and complete or almost complete teeth. For the Nasca culture, there exists dentition data on eight adults and 16 children, and for the Chincha culture, four adults and 10 children. In total, 1591 teeth, either deciduous or permanent, have been studied. Meanwhile, tooth wear was common and advanced (Fig. 5.9). Also, there have been found one case of hypodontia, two cases of "enamel pearl", and one case of protostylid, a typical Asian feature according to Sawyer et al. (1976). Also have been found two cases of root merging, three cases of disodontiasis of the third molar, and one case of connate incisors (Drusini and Swindler 1994). With respect to shovel-shaped teeth, this feature is found in 21% of the samples belonging to Wari, 31.8% in those belonging to Nasca, and 30% of Chincha, at the level of the upper incisors, a quite low percentage when compared with the North American Indians [76% according to the study by Hrdlicka (1920); and 96% according to Wissler (1931)].

The indexes of the post-cranial skeleton show a wide sacrum (both in males and females), a medium-valued robustness index of the clavicle, and a brachymorphic scapula in most cases. The humerus is mainly rounded in males (eurybrachy) and flattened (platybrachy), while the ulna, in both genders, presents in most cases an index of platoleny. The acetabulum-sciatic index, useful to discriminate between genders, shows a median of 97.0 in males and of 158.2 in females. The femur is generally flattened, at times ultraplatymeric, while the pilaster is less developed in both genders. The mesocnemya values in the tibia prevail in both genders. The intermembral indexes indicate a forearm and a leg longer compared with the arm and the thigh, as is common in many human groups of Asian origin. The olecranon foramen of the humerus is present in 21% of the case belonging to Wari (a percentage similar to the 24% indicated by Comas (1960) for the peoples of the Americas) and prevails in females as well, especially on the right bone, perhaps a sign of a more intense physical activity. In the Wari individuals, the third trochanter of the femur has 21.9% coverage and the squatting facets of the distal epiphysis

Fig. 5.9 Micro attrition of the occlusal surface of molars. Dental attrition is mostly provoked by the consumption of vegetables and seafood and the presence of silica particles in food. It can also be caused by the use of teeth as tolos (Photo by Andrea Drusini)

reaches 12.5%. This latter characteristic indicates that the squatting position was frequent in daylife as, and it can also be observed in the ceramic decorations. The gender differences between the post-cranial skeleton are more evident in the maximum length of the longer bones, in the circumference of the femur and tibia, and in the vertical diameter of the femur head.

Stature has been calculated applying the formulas proposed by Genovés (1967), which are based on the measurement of the longer bones of the upper and lower limbs (see Table 5.1). We have observed that, in general, the stature obtained from the humerus and femur was shorter than that obtained from the ulna, radius, tibia, and fibula, according to what we had already observed in the case of the inter-membral indexes, which means that the distal segments of the limbs are longer than the proximal segments. Other authors (Genovés 1967; Facchini 1977) have made the same observations in other Amerindian skeleton samples. It is also noted that the stature of the Nasca individuals—very few, unfortunately—is a little greater than those belonging to the Wari and Chincha periods.

Table 5.1 Nasca 1982-92. Average stature calculated on the longer bones (cm) by the method of Genovés (1967)

	Sex	N	Average	Range
Nasca	m	3	161.3	159.8–161.3
	f	–		
Huari	m	15	158.7	151.5–164.0
	f	17	145.4	137.4–151.2
Chincha	m	2	155.1	150.9
	f	2	146.7	145–148.5

m male; *f* female

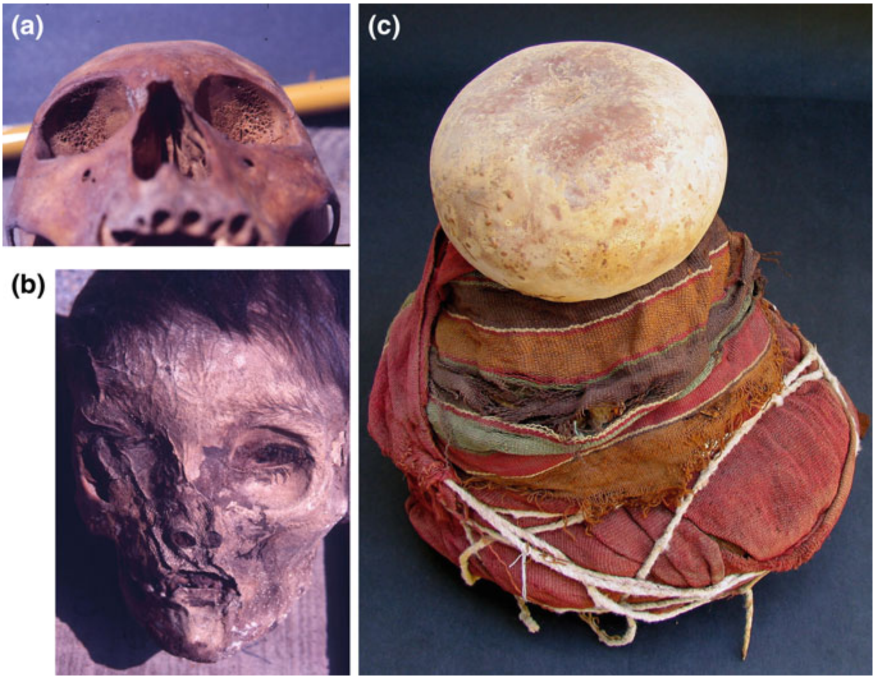

Fig. 5.10 **a** (*Upper left*) Cribra orbitalia in a skull of a young female individual, who also presented typical lesions of symmetrical porotic hyperostosis in the vault. This condition is associated with sideropenic anemia and causes hypertrophy of the bone marrow. **b** and **c** (*Lower left and right*) The remarkable preservation of the Nasca mummies has been favored by the dry climate and the silica content of the sand, for it produces body dehydration (Photos by the author)

If stature is interpreted as a non-specific indicator of health, it is noted that the latter diminishes progressively from the Nasca period to the Chincha period (Table 5.1). Whether this trend is a response to an increase of the environmental stress or the expression of various types of body constitution, it can only be clarified in posterior research, given the very limited number of studied individuals. A particular type of stress indicator is the cribra orbitalia (Fig. 5.10a). Thanks to the good preservation of the mummies, it has been possible to detect many cutaneous diseases (Fig. 5.10 b and c). With respect to the multiple paleo-pathology, the case of the offering head (Fig. 5.11a) should be pointed out, which is depicted with a guinea pig offering in its interior and which presents a peculiar characteristic that is common to the populations of Asian origin: the shovel-shaped teeth (Fig. 5.11b). What is more, the individual suffered from enamel hypoplasia, a stress indicator linked to malnutrition (Fig. 5.11c).

What we have tried to demonstrate in this chapter recalls the poem by Julio Garrido Malaver, *The dimension of the stone*:

I get out of myself, To look for me within the debris of Time, Which passes away without being able to be Time.

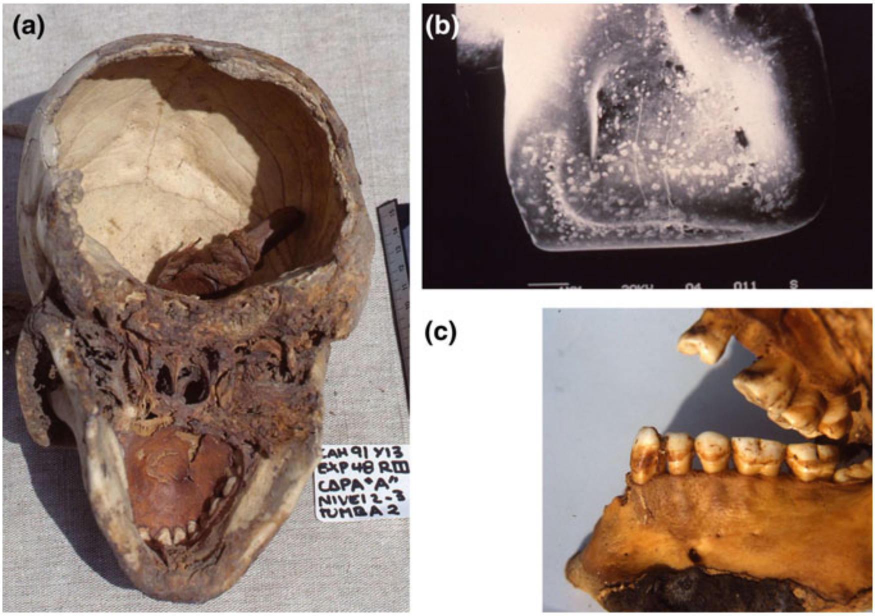

Fig. 5.11 **a** *Left* Nasca offering head depicted with a guinea-pig offering in its interior. **b** (*Upper right*) Shovel-shaped teeth peculiar characteristic common to the populations of Asian origin (scanning electon microscope, 6×). **c** (*Bottom right*) Traces of enamel hypoplasia: stress indicator linked to malnutrition (Photos by the author)

If we replace the word "stone" for "skeleton", these verses help to explain the purpose and objective of our research. Today, the task of the anthropologist is to reconstruct how the peoples of the past lived and not only know what their physical appearance was. Thus, our homage—both emotive and respectful—goes to the ancient mothers of Nasca, who lovingly and sorrowfully wrapped their newborns with a funerary fardo, sometimes putting a corncob in their small hands. That grief was talking to us from the past, and the past is making its presence felt when we think how immutable is human destiny.

Not even scientific work can be done without feeling (Garrido Malaver 2003).

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Chapter 6
The Role of Plants in the Nasca Culture

Luigi Piacenza

Abstract This paper presents the results of the study carried out on plant remains uncovered from various Nasca sites, especially during the archaeological research at the ceremonial center of Cahuachi. The analysis resulted in the identification of a total of 75 botanical species. On the basis of this information, and for the first time, we have evidence to compare similar data coming from several sites. From this study, the presence of several plant species is certain in all the sites, while others are rarely present or absent at all. Overall, this study indicates, that during the time of Cahuachi's apogee, agriculture was very prosperous in the region and was the basis for the development of Nasca civilization.

Keywords Nasca · Plants · Agriculture · Vegetable foods · Botany · Healing and magical plants

6.1 Introduction

In Cahuachi, the renowned ceremonial and religious center of the Nasca culture, plants played an important role in three ways: human alimentation, iconography, and ritual offerings. During the archeological research–which have been maintained for more than 20 years–several botanical samples have been recovered, which has enabled comparison with the remains of plants used as food that were found in a number of archeological sites of this culture (Piacenza 2003). Plants depicted in textiles (Fig. 6.1) and ceramics, on the other hand, have affected the relevance of the more important symbolic vegetables within the religious context.

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Fig. 6.1 Cahuachi, Nasca textile. Birds eating vegetables (Photo by Giuseppe Orefici)

6.2 Agriculture

The Nasca agriculture was well developed and founded on the selection and cultivation of several plants of alimentary and utilitarian use (Fig. 6.2). Among edible plants also have to be considered those non-cultivated herbs grouped under the word "yuyo", which refers to different species, generally of the genera Chenopodium and Amaranthus. Remains of these herbs were found among the ancient vegetables used at Cahuachi. We do not know whether the Nascas consumed them, but we believe that they did so because said plants were part of their environment.

The archeological research has enabled confirmation of the presence of 16 genera of cultivated nutritive plants: peanut (*Arachis hypogaea*), jack-beans (*Canavalia plagiosperma*), jíquima (*Pachyrhizus tuberosus*), beans (*Phaseolus vulgaris*), lima beans (*Phaseolus lunatus*), mandioca (*Manihot esculenta*), squash (*Cucurbita máxima*), butternut squash (*Cucurbita moschata*), sweet potato (*Ipomoea batatas*), ají (*Capsicum frutescens*), maize (*Zea mays*), achira (*Canna edulis*), cassava (*Inga feuillei*), lúcuma (*Pouteria lucuma*), apple guava (*Psidium guayaba*), and plum (*Bunchosia armeniaca*). These products were surely part of the gastronomic resources of the Nasca people.

Moreover, there are highly important plants of utilitarian use such as cotton (*Gossypium barbadense*), which enjoyed a great socio-economic interest, and the calabash or bottle gourd (*Lagenaria siceraria*), which was used as a container for

RECOVERED	82	IDENTIFIED 74
		WILD 56
		CULTIVATED 18
CULTIVATED SPECIES		
NUTRITIONAL	16	
USEFUL	2	
Nutritional species		
Arachis hypogaea	1	
Canavalia sp.	1	
Pachyrrhizus sp.	1	
Phaseolus sp.	2	
Manihot esculenta	1	
Cucurbita sp.	2	
Ipomoea batatas	1	
Capsicum sp.	1	
Zea mays	1	
Canna edulis	1	
Inga feuillei	1	
Pouteria lucuma	1	
Psidium guajava	1	
Bunchosia armeniaca	1	
Useful species		
Gossypium barbadense	1	
Lagenaria siceraria	1	

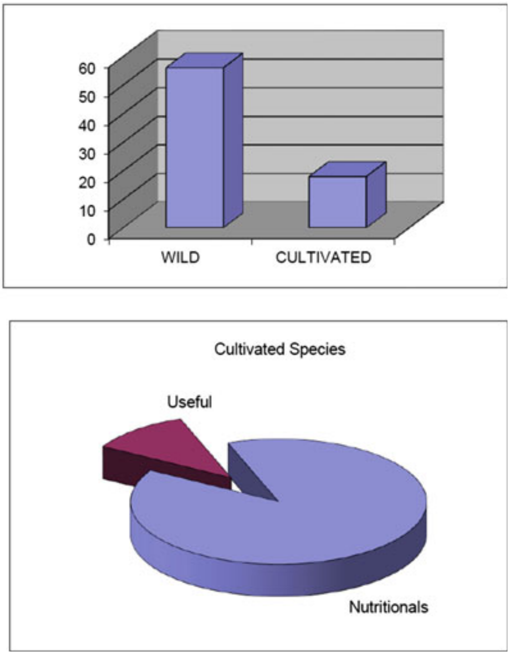

Fig. 6.2 Botanical species found at the ceremonial center of Cahuachi

liquids and food (Piacenza 2002). Another valued plant was the wingleaf soapberry (*Sapindus saponaria*), which was used as detergent and whose fruit and seeds, rich in saponin, were found as fillings inside the structures at Cahuachi.[1]

6.3 Vegetable Foods

The art of cooking consists of the preparation, with the use of natural products, of food adequate to the nutritional needs of humans. It is difficult to find out how the forementioned vegetables were cooked in pots, because most of the botanical

[1]*Boliche* or *choloque* (*Sapindus saponaria*) is included due to its importance in everyday life. Its peel contains saponine: a natural detergent which probably was used in personal cleaning as well as to wash cloths and clothes, for it is the sole ancient plant found in the excavations having these properties.

Fig. 6.3 Cahuachi. Utilitarian pottery (olla) placed as an offering in the base of the wall (Photo by Giuseppe Orefici)

remains come from ritual offerings. No remains of domestic garbage have been at Cahuachi, due to its nature as a religious center as opposed to a settlement where people usually lived and consequently produced cooking leftovers.

It has to be taken into account that only some domestic, intact pots were found at Cahuachi (Fig. 6.3), as well as various fragments, but without any evidence of their having been part of food containers. Only in some gourds can be found traces of purple color, perhaps left by the beverage prepared with purple corn (chicha).

There is no doubt that the Nasca people would have eaten the numerous agricultural products that are being found in excavations. But if we want to know how they were consumed, we must observe the fillings and platforms at the ceremonial center, where many roasted seeds can be found among the dispersed botanical remains. Roasting is a very ancient procedure whose purpose is to enhance the nutritional quality of products, for it enables carbohydrates to be transformed into sugary substances and prevents the fermentation of stored food. For instance, roasted seeds of maize, beans, and peanuts were found. Toasting was widely done, and it was probably the cause of tooth wear that has been noted by physicist anthropologists.[2]

[2]Tooth wear is noticeable, especially in molars, as it has been observed in numerous Nasca mummies. Tooth wear is the result, among other causes, of mastication of roasted seeds and the ingestion of molluscs because they normally contained sand traces. (Andrea Drusini, personal communication, August 2006).

Undoubtedly, maize was the most important product in Nasca agriculture. More than 70 kg of corn cobs and *corontas* (cobs whose kernels had been removed) that were retrieved from excavations justify its presence in iconography and emphasize its existence in the Nasca culture. What is more, corn cobs are the main components of the wells suited for offerings: their number varies from four or five cobs and up to 25.

The retrieved *corontas* weigh more than 60 kg. It is probable that many of them had been used in the preparation of chicha. The optimal conservation of the botanical remains has made posible recognition of some purple- colored cobs (Fig. 6.4).

The Nascas applied in maize cultivation the ancient practice of associating cereals with legumes, which was the basis of the development of various Pre-Hispanic Latin-American civilizations. Among the multiple advantages of said technique, the most important is the favorable influence on soil fertility, for it enables the addition of the nitrogen that cereals need. Moreover, maize provides support to legumes, as it has been showed in the research on maize-plant strata that were found in the excavations.

Trailing maize in importance, the most present and appreciated vegetable in the New World cultures is *ají* (*Capsicum frutescens*). This species is not only part of alimentation but also of the magical and religious traditions. Bernabé Cobo reports: “The most rigorous fast consisted in avoiding eating any stew that had ají as an ingredient” (Cobo 1891–1893; vol. IV, chapter XXV).

Fig. 6.4 Cahuachi. Offering of maize (Photo by Luigi Piacenza)

Fig. 6.5 Pueblo Viejo Sector X3 (Nasca). *Ají* depicted in Nasca ceramics. (Orefici 1992: 293, Fig. 35, drawing by Dolores Venturi)

The phytomorphic iconography represented in vessels depicts ají in all the phases of the Nasca culture (Figs. 6.5 and 6.6), generally associated with divinities of feline features and farmer characters. An interesting finding, due to its ritual meaning, was the three kilograms of *ají* fruits placed as an offering inside a pot that was retrieved in 1991 in sector Y1 Exp. 46.

With respect to legumes, they are highly important in tropical and sub-tropical regions for they provide the proteins necessary for a balanced diet. The Nascas cultivated two species of the genus *Phaseolus*: *Ph. vulgaris* (beans) (Fig. 6.7) and two varieties of *Ph. lunatus* (lima beans) (Fig. 6.8). In the offerings, seeds of these plants are found repeatedly and in various quantities. The standout is a burial with blankets and almost four kilograms of bean seeds that was found in 1998 in sector Y16 Exp. 67. This was the only finding of beans placed among eleven blankets richly woven and embroidered with Nasca iconography.

There are also other relevant bean offerings: one of almost seven kilograms and another one of more than one kilogram. These amounts represent 80% of the total of all seeds found. The remaining are grains that were retrieved from fillings and possibly were remains of former offerings.

Fig. 6.6 Cahuachi: handpieces of chilli offered in the *Pirámide Naranja* (Photo by Giuseppe Orefici)

Fig. 6.7 Beans legumes and seeds (Photo by Luigi Piacenza)

Peanut (*Arachis hypogaea*) was a very important legume oil seed in Nasca alimentation due to its high nutritional value. According to Paredes Carranza (1993), it contains 27.1% protein and 16.9% carbohydrates.

Fig. 6.8 Cahuachi. Nasca vessel decorated with motifs of pallares and legumes (Photo by Giuseppe Orefici)

Estrella (1986) points out that, due to its high content of niacin (21.6%), peanut "protects the organism against the emergence of a lacking disorder called pellagra".

The Nascas also cultivated other legumes such as canavalia, generally known as lima bean of the gentile, meaning the ancestors. Its seed have been found in the raw state—and in a great number—inside the ritual wells (Fig. 6.9), roasted among leftovers or carbonized within stove ashes. Roasting was performed because the integument contains cyanogenetic glycosides, which limit nutrition (Bruno Ángeles 1990: 129). The Nascas roasted the seeds of canavalia, took off the external part, and ate the internal cotyledons. Nowadays, this plant is found in the wild and is quite unlikely to be part of human diets.

Another significant finding has been that of the small tubers of a wild herb, the chufa sedge or coquito (*Cyperus esculentus*), which were found in 2001 in sector Y1 Exp. 83 (Fig. 6.10a, b). Formerly, finding isolated tubers within leftovers was an indication that they were part of occasionally consumed wild resources. *Cyperus*, commonly known as "coquito" (Sagástegui and Leiva 1993: 483), is a cosmopolitan plant. Its small tubers have as sweet taste and are rich in starch. Duccio Bonavia adds that "these wild plants, which have multiple industrial uses besides being used as food, have been available for humans ever since the gatherer-hunter epoch" (Bonavia and Weir 1985: 116). The finding of 300 g of this tuber, mixed with approximately one kilogram of peanut and maize, and some cassava (*Manihot esculenta*), cooked and placed inside an ordinary cotton bag, confirms that coquito tubers were part of the Nasca diet. The peculiar finding of cultivated plants next to a

Fig. 6.9 Seeds of Canavalia (Photo by Luigi Piacenza)

crop-invading plant demonstrates the coexistence of agriculture and wild-plant gathering.[3]

The root called jíquima (*Pachyrrhizus* sp.) (Figure 6.11) is also among the various tubers found. It is a legume which is frequently represented on Nasca ceramics and which attracted for the attention of botanist Eugenio Yacovleff (1933), who asserted that said plant was cultivated by the Paracas and the Nasca people. Its roots "are frequently found in the Paracas funerary fardos" (Yacovleff and Muelle 1934: 135), a hypothesis that was confirmed by their presence in archeological sites. It is depicted repeatedly in ceramics (Fig. 6.12) as well as Paracas and Nasca textiles, and even in the geoglyphs of the ritual space on the pampa of Nasca, which shows the highl esteem that jíquima may have enjoyed within this culture (Fig. 6.13).

Cobo (1891) reports that jíquima "is sweet and watery, edible as a fruit and very refreshing in hot season". Probably, this characteristic was well used by the Nasca people, who lived in such a dry and hot environment, and served as essential sustenance, particularly by those had to endure a long trips to the temples or

[3]Daniel Zohary asserts about this cosmopolitan vegetable that the small tubers of *cyperus* have been found in ancient Egyptian tombs (Zohary and Hopf 2000: 198). Also, Bresciani (1997: 37,45) contributes an Egyptian recipe for candies that were destined to the gods table and were processed with *cyperus* flour. In Europe, there is evidence of its cultivation for the preparation of food. Even today, in Valencia (southern Spain), the refreshing and nutritive beverage called *horchata de trufa* is prepared with the tubers of *Cyperus* sp.

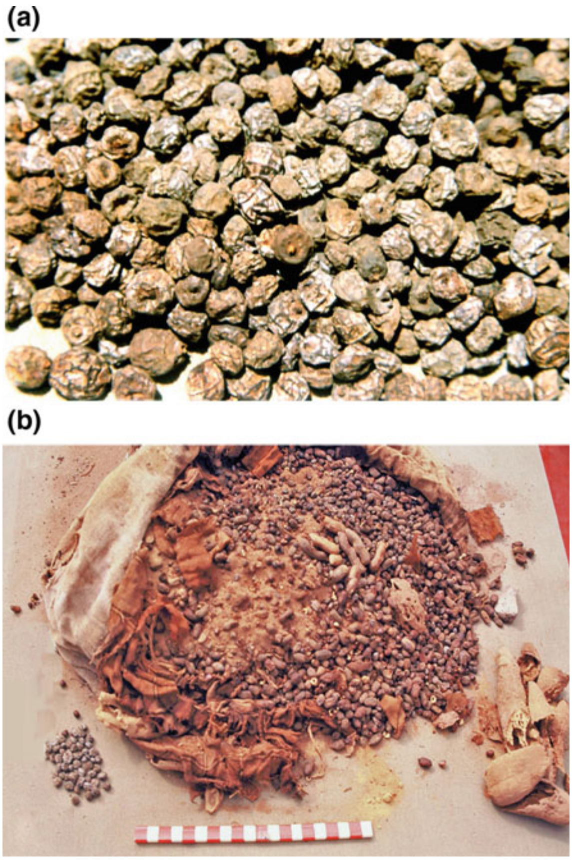

Fig. 6.10 **a** Cahuachi, Sector Y15. *Cyperus* (coquito) tubercles. **b** Cahuachi, Sector Y1. Discovery of *cyperus* tubercles, mixed with peanuts and corns, roasted and placed in an ordinary cotton bag (Photos by Luigi Piacenza)

religious centers such as Cahuachi. Jíquima also appears on the list of agricultural products that were subject to taxes (Valverde 1865: 98) during the Conquest period, a fact that confirms its cultivation within said times. In contrast, this plant is almost unknown today.

The other plants that contain edible tubers are: cassava or "yuca" (*Manihot esculenta*), sweet potato (*Ipomoea batatas*) (Fig. 6.14), and *achira* (*Canna edulis*). Their tubers have been found in great numbers and in good preservation conditions inside the wells suited for offerings. Likely, that not all tubers had the same quality as food, but they surely satisfied the carbohydrate needs in the alimentation of the Nasca population. It is interesting to point out the lack of archeological remains of potato (*Solanum* sp.), for it was a very common tuber after the downfall of the Nasca culture.

The Nascas also cultivated fruits, which in general enjoy a major position among the religious offerings. Lúcuma (*Pouteria lucuma*) (Fig. 6.15), apple guava (*Psidium guajava*), and plum (*Bunchosia armeniaca*), are typical plants of the Yunga region (Pulgar Vidal 1987: 57). Only their seeds and fragmented fruits were

Fig. 6.11 Cahuachi. Offering of jíquima tubers (Photo by Luigi Piacenza)

Fig. 6.12 Jíquima depicted in Nasca ceramics (Photo by Luigi Piacenza)

retrieved from the fillings, which probably were leftovers of the people living in Cahuachi and pilgrims who came from other areas. Also belonging to coastal fruits are the pacay (*Inga feuillei*) and the algarroba (*Prosopis pallida*) (Fig. 6.16).

Fig. 6.13 Jíquima figure in the Nasca Lines (Photo by web)

Their small branches, often with leaves, compose the fillings and embankments, and it is highly probable that they were picked in the surroundings of Cahuachi.

Also clearly evident is the massive and enigmatic presence of the fruit of an almost unknown tree: palillo (*Campomanesia lineatifolia*), which belongs to the Myrtaceae family (Fig. 6.17) and was described by Ruíz and Pavón in 1798 (Ruíz and Pavón 1957). The authors write that the indigenous name of the tree is *palillo*, like the fruit, and that it grows in maritime environments and in warm places in the Andes.

The aromatic fruits of palillo appear in almost all strata and levels of the excavations: they are found spread out or in clusters that can weigh more than two kilograms, such as the offering deposited in sector Y1 Exp. 4 (1986). In total, the fruits found weigh more than 16 kilograms, which places palillo among the most abundant vegetables that have been retrieved from the site (Fig. 6.18). Peculiarly, considering the amounts that has been found, so far palillo has not been identified in the Nasca iconography. Regarding its use, Ruíz and Pavón (1957) aver that Peruvian women used to place some of these fruits among flour due to their

Fig. 6.14 Cahuachi. Offering of sweet potato placed in the inside of a well (Photo by Luigi Piacenza)

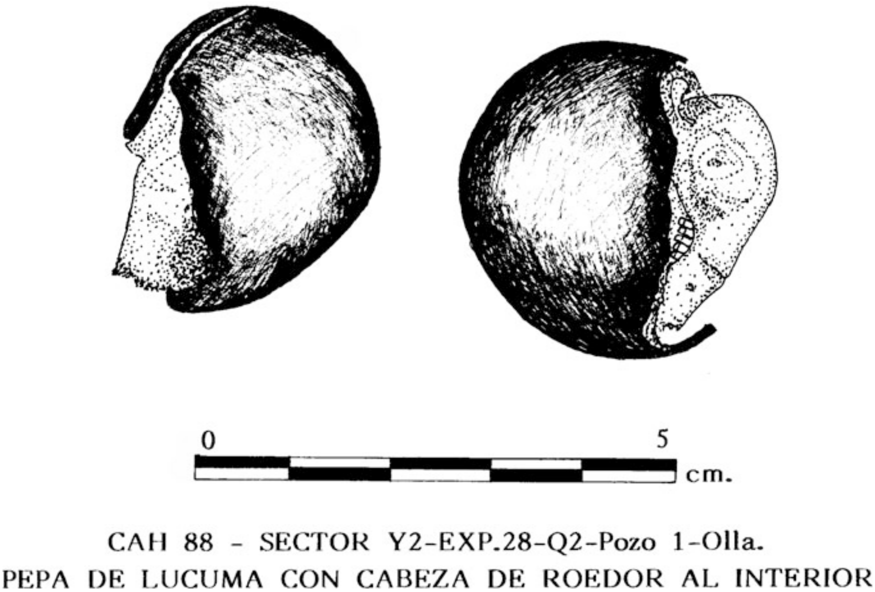

Fig. 6.15 Cahuachi. Offering of lúcuma seeds with roedors trophy-heads inside (Drawing by Dolores Venturi)

Fig. 6.16 Cahuachi. Algarroba seeds (Photo by Giuseppe Orefici)

Fig. 6.17 Cut palillo fruits (Photo by Luigi Piacenza)

Fig. 6.18 Cahuachi. Offering of palillo fruit. (Photo by Luigi Piacenza)

soothing aroma.[4] This may be the reason for its presence, as an air freshener in the internal areas of structures.

6.4 Healing and Magical Plants

The Nasca people selected plants based on their primary needs Diseases are part of the human condition and can be alleviated with the use of a great variety of natural products such those found in plants. Over time, the ingenuity of humans–their wisdom and cultura—were able to recognize the healing plants and so started using

[4]"Virus et usus: Fructus, quos peruvianae Feminae in forum mixtura odoris suavitate frequenter apponunt, lutei et edules sunt" (Ruiz and Pavón 1798: 128; 1957: 197). It is obvious that the name *palillo* is a Hispanicism. It seems that over time this species lost both its native name and its effective cultural presence. Soukop (1987) reports, in the vocabulary he researched, the vocable *suana* and related to *palillo*. Cobo (1890, V: 455) explains that *suana* is a root used to dye food yellow. Nowadays, the name *palillo* identifies a non-native plant, the curcuma (Zingiberaceae). Weberbauer (1911: 230) located in the upper Amazon rainforest the ecological stratum where *Campomanesia lineatifolia* grows. Raimondi (1942: 4) lists *Campomanesia* sp. among the vegetation that he could only find on the Tarma-Chanchamayo route he traveled in 1855. It seems that nowadays the arid Peruvian coast does not favor the natural growth of said plant.

Fig. 6.19 *Sampedro* cactus depicted in Nasca ceramics (Photo by Luigi Piacenza)

them. Among the retrieved samples of spontaneous flora, several species belonging to pharmacopeia were identified: mallcu or altamisa (Ambrosia peruviana), *cimarrón* tobacco (*Nicotiana paniculata*), *chilca* (*Baccharis lanceolata*), American nightshade (*Solanum americanum*), jimson weed or *chamico* (*Datura stramonium*), prickly poppy (*Argemone subfusiformis*), and *Sampedro* (*Echinopsis* sp.). The latter belongs to the Cactaceae family and was used in the magical rituals by priests in order to contact supernatural entities. This cactus has a long cultural history which dates back to the mythical times of the Chavín de Huántar divinities, a ceremonial site where an engraved stele depicts a priest handling an unmistakable sampedro. In the excavations at Cahuachi were found abundant samples of this cactus and also ceramics representing the sampedro (Orefici and Drusini 2003: 116) (Figs. 6.19 and 6.20).

All the found samples have been studied by the cactus specialist Carlos Ostolaza (Ostolaza and Piacenza 2002: 22), with the purpose of determining the species that the Nasca people had at their disposal. Ostolaza assures us that the botanical name of sampedro not only applies to *Trichocereus pachanoi*, but also to *Echinopsis peruviana*. Cabieses (1993) has published studies on the chemical components of *sampedro* (*Echinopsis*. sp.) and the mental effects produced on people who use it.

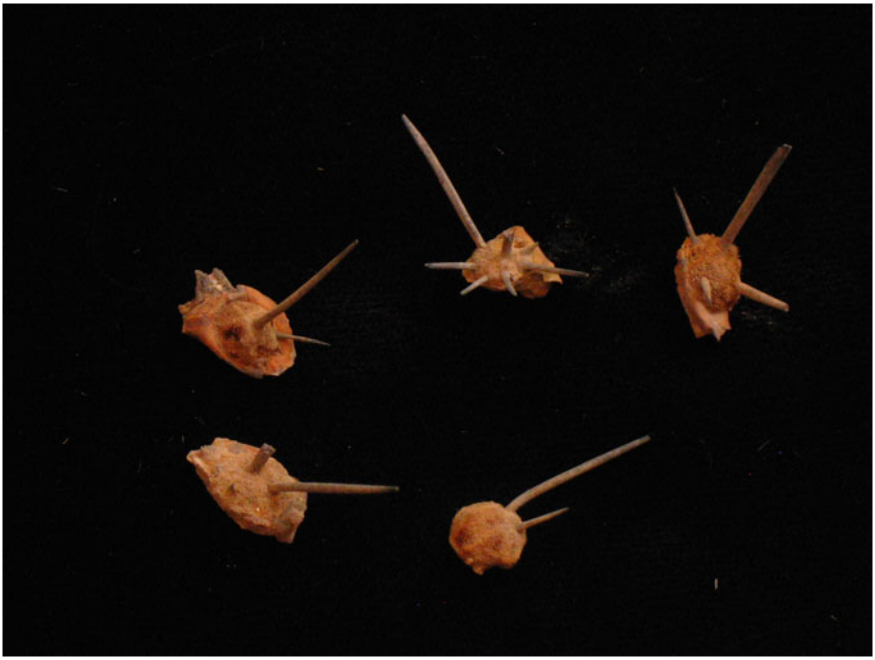

Fig. 6.20 Cahuachi. Remains of cactus sampedro spines. (Photo by Giuseppe Orefici)

Among the healing plants recognized and retrieved from excavations, there are other species that are not referred to in this chapter, for they were not cited in the historical sources herein consulted.

6.5 Final Remarks

This study aims to point out the purposes for the agricultural products (Fig. 6.21) used by the Nasca people: they were offered in their raw state as a ritual offering to their divinities, and cooked and placed in containers were offered to their dead as a symbol of the food they liked the most when they were alive.

In conclusion, we believe that at Cahuachi, the Nascas wanted the divinities that ruled the development of nature to favor their crops, as well as their own survival. Hence, they bestowed on their divinities offerings agricultural products that were considered among the best they had harvested. According to Rostworowski De Diez Canseco (1976), "the importance of a temple was measured by the adoration that their divinities inspired and by the offering bestowed by the faithful". In that sense, it can be assured that Cahuachi, given the amount of the offerings that were found there–the weight of the retrieved vegetables surpasses 250 kg–might indeed have been highly esteemed as objects of deep devotion and worship by the

ESPECIES / SPECIES	POPULAR	QUECHUA	AYMARA
Echinopsis peruviana (Br.y R.) Friedrich y Rowley	Sampedro / Sampedro cactus	Ahuakolla	Ahuakolla
Argemone subfusiformis Ownb.	Cardosanto / Prickly poppy		
Arachis hypogaea var. peruviana Krap. y Gregory	Maní / Peanut	Chocopa	Chocopa
Canavalia plagiosperma Piper	Pallar de los gentiles / Jack-bean		
Inga feuillei DC	Pacae / Pacay	Pacaya	Pacaya
Pachyrrhizus tuberosus (Lam.) A.Spreng.	Jíquima / Jícama	Villu	Villu
Phaseolus sp.	Poroto / Bean	Purutti	Purutti
Phaseolus lunatus	Pallar / Lima bean		
Prosopis pallida (H&B ex Will.) H.B.K	Algarrobo / Algarroba		
Manihot esculenta Krantz	Yuca / Cassava		
Bunchosia armeniaca (Cav.) DC.	Ciruela del fraile / Plum	Husum	Husum
Sapindus saponaria L.	Choloque, Boliche / Wingleaf soapberry		
Gossypium barbadense L.	Algodón / Cotton	Qhuea,	Qhuea,
Bixa orellana L.	Achiote / Achiote	Wanturu	Wanturu
Cucurbita maxima Duch.	Zapallo / Squash	Loche	Loche
Cucurbita moschata Duch.	Lacayote / Butternut squash	Yoko	Yoko
Lagenaria siceraria (Mol.) Standl	Mate / Bottle gourd		
Campomanesia lineatifolia (Ruiz y Pavón)	Palillo / Palillo		
Psidium guajava L.	Guayaba / Apple guava		
Pouteria lucuma (Ruiz y Pavón) O.Kuntze	Lúcuma / Lúcuma	Lukhuma	Lukhuma
Ipomoea batatas (L.) Poir	Camote / Sweet potato	Apichu	Apichu
Capsicum frutescens L.	Ají / Ají	Uchu	Uchu
Datura stramonium L.	Chamico / Jimson weed		
Solanum americanum (L.) Mill.	Hierba mora / American nightshade		
Ambrosia peruviana Willd.	Altamisa / Altamisa	Marcu	Marcu
Baccharis lanceolata (L.) Kunth	Chilca / Chilca		
Zea mays L.	Maíz / Maize	Çara	Çara
Cyperus esculentus var. leptostachyus Boeck, L	Coquito, Chufa / Chufa sedge		
Canna edulis Ker. Gawl	Achira / Achira		

Fig. 6.21 Taxonomic list of the botanical species of the Nasca people

multitude who came to implore the divinities for favors. According to Rösing (1994: 191), the latter is a realization of what can be defined as a reciprocity relationship: "Humans look for the encouragement and reconciliation with the supernatural entities by means of rites and offerings, which is a way of exchange, that is, of reciprocity: I give you something and you give me something back. Given that all human beings wish something from the divinities, the latter have the power over everything that matters to humans, and according to the value of reciprocity they have to give something back to the divinities. So they bestow offerings".

However, when the forces of nature–despite the invocations and offerings–destroyed Cahuachi with a huge mudslide (huayco), the survivors had nothing to do but to seal the religious center, but not before performing the great ritual offering of camelids.

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Chapter 7
The Paracas–Nasca Cultural Sequence

Giuseppe Orefici

Abstract Paracas cultural expression originated on the southern coast of Peru. Through constant evolution, it gave rise to a number of different manifestations. The main stages named *Paracas Cavernas* and *Paracas Necrópolis* (by J. Tello) were based on the types of tombs found during the excavations and the characteristics of associated materials, mainly ceramics. To understand the cultural evolution that affects the area of the South Coast, and in particular the Paracas Peninsula, it is important to consider the specific studies made by Menzel, Dowson, and Rowe, who traced a pattern of ceramic seriation examining material from Ocucaje, Tajahuana, and Cerrillos, including with the help of radiocarbon dating. With the loss of dominance to the expanding Paracas culture, one witnessed the emergence of Topará Culture and Nasca Culture. The latter, in the course of almost a millennium, took on the characteristics of a homogeneous culture of theocratic nature, where a society organized in specialized classes developed particularly advanced expressive forms of ceramics and textiles. Nasca Culture also distinguished itself in architecture, with the example of the ceremonial center of Cahuachi, as well as in the creation of geoglyphs and irrigation systems. With the expansion of Nasca Culture also in the Paracas area, there was a progressive overlapping of cultural expressions. The apogee of Nasca Culture paralleled the development and existence of the ceremonial center of Cahuachi. During the last two centuries of Nasca hegemony, the world of the Sierra imposed a progressive influence, ending with the Wari imperial expansion and the beginning of the chronological stage known as Middle Horizon.

Keywords Paracas culture · Nasca pottery seriation · Nasca culture · Cultural evolution · Economic and socio- political organization

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7.1 Introduction: Paracas Culture. Relative and Absolute Chronology

The Paracas culture originated on the South Coast and was named by the man who identified its first stylistic features: Julius C. Tello. With the archaeologist Samuel K. Lothrop and Lothrop's wife, he began exploring the Pisco and Chincha Valleys in 1921, discovering important burial grounds belonging to two distinct periods, namely the *Cerro Colorado* and *Cabeza Larga* on the Paracas Peninsula (Tello 1959; Tello and Mejía Xesspe 1967: 140). This research then made it possible to establish a relationship between the Central Andean, Costa Sierra, and Montaña cultures (Carrión 1948: 13–14). By analyzing findings identified between 1925 and 1928, he sought to achieve his main objective, which was to understand the origin of some embroidered fabrics and various ceramics observed in private collections in Lima. Working with Toribio Mejia Xesspe, during research carried out at that time, it was able to identify the archaeological site of *Cerro Colorado*, or WariKayán, as well as many other sites of archaeological interest, including Arena Blanca, also known as *Cabeza Larga*. During the excavation, considering above all the style of the materials analyzed, the types of tombs, and the architectural structures, Tello hypothesized the existence of a new and complex cultural identity that he called Paracas, also attempting to establish a chronological sequence based on its development (Tello 1928, 1959, 1967; Tello and MejíaXesspe 1979; Mejia Xesspe 1976).

Based on the observations that were made, Tello organized a complete record of information resulting from the types of findings, distinguishing two different cultural components that he called *Paracas Cavernas* and *Paracas Necrópolis*. In the case of *Paracas Cavernas*, the distinctive elements were the use of a particular type of pottery with incised decoration and the application of a layer of paint resin after firing and other containers decorated with "negative" paintings, found in very deep tombs, with wool or cotton bearing stylized geometric motifs, pyrographed pumpkins, various shell ornaments, and gold, placed together with items of basket work, food, and various tools (Fig. 7.1).

The tombs of the *Cavernas* type consisted of partly subterranean bottle-shaped chambers, sites for the collective burial of men, women (forming the majority), and youngsters of both sexes. *Paracas Necropólis* however, was characterized by a type of slipped monochrome earthenware, sometimes modelled in the form of a pumpkin, but its most interesting artefact was particularly elaborate and, above all, embroidered textiles. Between 1927 and 1929, a large mass grave containing 429 funeral bundles was found to the north of Cerro Colorado. Some of these were prepared according to a particularly elaborate process, whereby the deceased were wrapped in numerous swathes (Fig. 7.2). There was one case where over a hundred embroidered mantles were found. The bodies were placed inside the enclosures, and the smaller bundles were placed on top of the larger ones, suggesting the presence of a second mass burial connected with another elite group in the region (Massey 1990; Paul 1991a, b; Lumbreras 1999).

Fig. 7.1 Ceramic fragment belonging to the Negative Paracas style, found in the stratigraphy of the Gran Pirámide II, associated with the remains of construction built with conical adobe (Photo by the author)

Fig. 7.2 Detail of the decoration of an embroidered mantle depicting a character with ceremonial scepter and cephalic feathered ornament. It dates back to the Paracas–Nasca transition period Lavalle (1986: 58–59) (Drawing by D. Venturi)

The chronological sequence adopted by Tello and applied to a specific limited territory is of purely indicative value. In fact, based on subsequent research in the area, it turned out that he had found evidence of the latest Paracas culture, as was proved by a subsequent study of the stylistic sequence in Ocucaje in the Ica region (Menzel et al. 1964). Another important element to note is Tello's insight in observing certain similarities in style between the Cavernas iconography and style and the Chavin style (Kroeber 1944, 1953; Tello 1959; Rowe 1967; Rowe and Menzel 1967).

The detailed description that Tello made of the physical appearance of *Paracas Cavernas* individuals made it possible to obtain important information on the practice of cephalic deformation among the early inhabitants of the South Coast. In 1959, Tello observed that the type of cranial deformation found among the *Cavernas* was cuneiform, obtained using specific tools applied when the skull of an infant was not yet firmly formed and fully joined (Fig. 7.3). The head was crushed using these instruments, giving it an elongated shape towards the rear. Further important information concerns skull drilling (in approximately 40% of the graves), possibly related to forms of treatment of trauma or injury due to fracture. In many cases, there were also signs that the bone had grown back and that the treatment had worked (Tello 1929: 144). Referring to the *Paracas Necrópolis*, Tello said that the type of deformation was different from that used among the *Cavernas*, with an elongated almost cylindrical form of the *suyto-uma* type and that there were no signs of skull drilling (Tello 1959: 59).

Fig. 7.3 Cahuachi, Gran Pirámide, sector Y8 EXP 133 Q1. Severed female head, with oblique tabular deformation and scarification in the epithelial tissue of the skull. It was placed as an offering to Cahuachi ceremonial center and placed at the base of a wall. The Paracas–Nasca tradition is rich in representations of severed heads associated with deities or ceremonial places (Photo by the author)

Analysis of Tello's suggestion confirms that he believed in the possibility of a chronological and cultural continuity within the Paracas culture and the existence of a form of expressive unity along the South Coast where he had worked. Of course, to understand the evolution of the Paracas and, later, the Nasca, it is necessary to study the cultural development that took place at different times throughout the area between Cañete and Acarí: the study of each cultural phase must also include all of the archaeological remains that have come down to us and not only the ceramics and textiles. Among these, one of the most important indicators that can contribute to establishing the chronological sequence and influences resulting from another territory, is most certainly architecture, whose development along the South Coast is so far little known (Massey 1990, 1991; Orefici 1993a; Orefici and Drusini 2003; Engel 1991; Silverman 1991, 1994, 1996; Canziani 1992; Cook 1999; Orefici 2012).

However, it was not until the 60s that a better picture of the chronology needed to understand the cultural variations in the southern valleys and locally was established. Menzel and Dawson and Rowe, analyzing data from Wallace's excavations, together with observation of the material collected on the surface and in private collections, worked out a seriation in 10 phases, making a parallel comparison with the data from their research conducted in Ocucaje and Tajahuana (the Ica Valley) and Cerrillos (the Pisco Valley), with the help of radiocarbon datings from a number of contexts. In the sequence that they worked out (which became what is known as the "master sequence"), you can clearly see how the relationship with Paracas is limited to phases 7, 8, 9 and 10: of these, the first two (7 and 8) correspond to *Paracas Cavernas*, with clear Chavin influence, while the last two (9 and 10) may be associated with *Paracas Necrópolis* and, most probably, as regards the Nasca river valley and its tributaries, with Nasca Phase 1. In the final decade, with the growth of archaeological research in various settlements on the South Coast, an attempt was made to address the problem of how these stylistic elements spread in such diverse areas. According to previous studies (Lanning 1960; Menzel 1971; Wallace 1986), the explanation for the spread of Paracas materials over such a vast territory may be due to the existence of distinct ceramic traditions, the first centered on Cañete, Pisco, and Chincha, called Topará, characterized by its use of monochrome; the second, more widespread in the Ica and Nasca valleys, being largely a decorative polychrome. It must be emphasized that this stylistic–territorial distinction does not consider the problem that emerges from the fact that both these typological and iconographic forms exist in all the valleys and, above all, from the presence of textiles of an undoubtedly Nasca tradition, found in archaeological contexts very far from each other.

Currently, Ica seriation (Menzel et al. 1964) has been corrected mainly thanks to new data based on certain stratigraphic contexts and to the greater number of radiocarbon datings (Deleonardis 1991; Paul 1991a, b), especially the earlier phases. Due to lack of data based on clear evidence, the existence of the first two phases 1 and 2 is no longer credited, instead indicating that true Paracas culture began with Ocucaje 3 and had elements clearly derived from the Chavin stylistic tradition. For the same reason, phases 4 and 5 have been set aside awaiting more precise information (Massey 1991; Silverman 1991, 1994; García et al. 1995; Deleonardis 1997; Cook 1999; Velarde 1999). For this reason, the phases that may be more closely related to the phenomenon of the southward spread in all cases are 6 and 7 (Deleonardis 1997), while those most documented in the entire Río Grande de Nasca valley are 8, 9, and 10 (Orefici and Drusini 2003; Silverman 1991; Isla et al. 2003; De La Torre and Van Gijseghem 2005).

As for the regional differences that have formed over time along the South Coast, and above all the region most subject to the influence of Nasca culture, a major problem is to establish when separation, union, or parallelism took place with regard to their different forms of expression. Since the late 80 s, numerous studies have been carried out to define this issue, especially in the area that includes the Pisco, Chincha, Ica, and Nasca territory (Massey 1990; Peters 1988; Wallace 1986; Silverman 1993; Orefici and Drusini 2003). Thanks to this research, there is abundant evidence of the presence of ancient materials, previously classified as "Paracas", with all the features currently attributed to Ocucaje 8–9–10 and showing that interregional circulation took place for reasons which are still somewhat uncertain. One of the objectives of researchers in the Río Grande is to define the chronological transition between the Early Horizon and the Early Intermediate Period in this territory.

On the basis of what has been said so far concerning the existence of traditions coming from different areas (Topará to the north and the use of polychrome to the south), we know that Nasca pottery was characterized, already in its first period, by the use of polychrome in rich fields of solid color between engraved areas separated from the background by an outline in a different color. At the same time, the ceramic repertoire of the last phase of Ocucaje fully corresponds with what was represented by the religious and symbolic culture of the Nasca. Among the most obvious affinities in the iconography, is primarily the figure of the cat, in its pre-anthropomorphic form, together with deities with birdlike or snakelike attributes, as well as geometric symbols, among which prevails the step motif, clearly indicating that there was and remained a significant relationship between the Paracas and Nasca symbology. All these formal features remained similar, although the Nasca later added more expressive variations of new content, in addition to radical technological innovations in the decorative field with the use of pre-fire painting.

7.2 Paracas Evidence at Cahuachi

In the excavations conducted by the Proyecto Nasca at the Cahuachi ceremonial center and other settlements in the valley, there have always been Ocucaje 8–9–10 and Nasca 1 (Fig. 7.4) pottery associated with the construction, highlighting the existence of a direct continuity in the cultural development of the area. Other recent studies on the La Puntilla site (Van Gijseghem 2004) have brought to light the same coexistence of these materials: in this case it has been suggested that various groups

Fig. 7.4 Cahuachi: Sector Y12 EXP 47 Q3. Ornitomorphic vessel with bridge handle and after-firing decoration, associated with Nasca 1 phase (Photo by the author)

may have coexisted, one local (Montana) and one from outside, consisting of "Paracas emigrants". According to a subdivision of the phases based on the sequence drawn up by Menzel et al. (1964) and applied to the pottery collected from the surface during a specific dig, Schreiber (1998) proposed as a reference the sites of La Puntilla and Montana, associating the Puntilla phase with the Ocucaje 8 and the Montana period to the ceramic of the Ocucaje 10 and Nasca 1 phases.

Although more evidence is needed to formulate hypotheses like that of Van Gijseghem, this does not rule out the possibility that on certain occasions or in the case of certain events, various different groups may have lived together temporarily, and, in this regard, it is interesting to note a feature found in sector Y14 at Cahuachi, where most of the ceramics analyzed did not belong to the Early Nasca style found throughout the ceremonial centre, but were represented by fragments mainly belonging to Ocucaje Phases 8–10. For this reason, there may have been a non-local group residing in this area for a particular time connected with the remodelling of a group of temples. Certainly, in all the areas examined at Cahuachi, particularly ancient materials predating the true Nasca periods appeared, among which were a large percentage of ceramic fragments and complete specimens of a particular type, identified by Strong (1957: Lam. 9) as "Cahuachi Stylus " which he considered to belong to a transitional Paracas–Nasca phase specific to Cahuachi (see also the descriptions by Menzel, Dawson, and Rowe such as Ocucaje Phase 10 (1964: 344-lam.26), very similar to what Menzel (1971: 49, Fig. 4C) classes as Paracas T3, Paracas T4 (ibid: Fig. 6D) or Nasca 1 (ibid: Fig. 7C). Very often, this material coexists with the first three phases of Nasca (Orefici 1993b). It is possible to hypothesize that this type of pottery was a common element throughout the transitional phase not only because of the type but the nature of the iconography. It is found not only at Cahuachi, but also in Ica and the sites providing the strongest evidence for the development of the Paracas.

These materials, including fragments with negative decoration, and others with false negative technique and also a particular type of natural pottery without slip, with geometric engraving and applications–material that Silverman (1991, 1994) called Tajo–can hardly be included in a precise cultural stratigraphy, since for the most part they come from artificial fills at the temples, or environments in which they may have been mixed together when they were put there. There is no doubt as to the presence of the Paracas tradition in the area, probably earlier than the Necropolis culture, however, but it is yet to be clarified what it was and if there existed a network of circulation and distribution of ceramic products, which would also mean the location of production centers outside Cahuachi and would consequently determine its distinctive characteristics (Fig. 7.5).

The excavations at Cahuachi, plus the possibility of obtaining continuous information about the architecture, the use of space, and the nature of the ceremonies that were celebrated there, offer the opportunity, unavailable at other sites, to gather within its precincts testimonies to the continual contribution of heterogeneous material from those who went there on pilgrimage. This makes it possible to obtain, in one place, an overview vision of the entire production system in the territory.

Fig. 7.5 Cahuachi, site Y8 EXP 133 Q3. Intrusive burial inside the Gran Pirámide with an offer including Topará style pottery, which has been observed during the phases of archaeological excavations (Photo by the author)

7.3 Cultural Evolution in the South-Central Coast and in the Río Grande de Nasca Drainage

There is little information regarding the ceremonial architecture or dwellings of the Paracas, and still less about their monumental building. There are certainly structural and technological similarities with Nasca building systems (Canziani 1992; Massey 1983, 1990). A common element is represented by the use of conical adobe, the system for filling the stepped platforms using vegetable matter folded and tied together at the extremities, and the type of interior space, even if sufficiently reliable samples for comparison are lacking. In the Nasca Valley, no doubt, a very mature system of building developed, thanks especially to the continuous experience gained at the monumental site of Cahuachi itself and the subsequent introduction of other components, such as bread-loaf *adobe* in all its variants, the molar type, and the stretched bread-loaf and multiple type, always manufactured without the use of a mould. The specialists who devoted themselves to planning the construction of temples, the stages of remodelling, the organization of the production and transport of adobe, the search for raw materials such as clay and degreasing, as well as the coordination of the work, were the ones who proposed the model for construction to be carried out at the other sites. However, even where evidence and testimonials from other centers or religious and public buildings in the valley of the Río Grande and its tributaries exist, both during the Early Nasca period and subsequently, they never reached the size of Cahuachi, nor did they last as long as the ceremonial center.

To fully understand the evolutionary dynamic of the birth of the main administrative or religious centers during the development period of the Nasca Culture, it is necessary to work backwards through time several thousand years: the history of ancient Peru shows that Andean man, even before the settlement process and the use of ceramics, was able to adopt the necessary strategies to adapt to the various ecosystems that characterized the area. The early agricultural use of edible plants and the domestication of camelids, along with the great potential represented by the resources offered by the Pacific Ocean, gradually led them to settle in places able to supply the necessary means of subsistence. To understand how the main known cultures developed and especially the Nasca, it is essential to examine the facts that led to the unique characteristics of each society.

Examining the archaeological antecedents from which cultural development in the area arose, we can observe the presence of the first settlements already around 6000 BCE, in the form of an encampment consisting of a number of dwellings ranging from six to ten houses, grouped in a circle and able to provide shelter for 30–50 persons. During the third millennium BCE, corresponding to the Late Pre-ceramic, there was rapid development due to a number of causes that coincided with a significant population growth, and greater specialization in the production of food and the development of key technologies applied to agriculture, accompanied by the exploitation of existing water resources. With different means and at different times, this phase led in parallel to a greater sense of social hierarchy and the imposition of rules involving the various communities in building the first architectural complexes of a non-residential nature, but for public and social use. Throughout Peruvian territory, new settlement patterns evolved and with it a conception of architecture that reflected the complexity of the emerging cultural processes. The exchange of experiences accelerated this transformation and favored the spread of the phenomenon, giving rise to real local traditions and the propagation of a model that would be applied to architecture on a large scale and over a vast territory. A form of urbanism evolved with a clear separation between public or religious spaces and residential areas. From 3000 BCE, in the Eastern and Center North Andes, a tradition of ceremonial structures in the form of an enclosure with walls decorated with niches, ornaments, and reliefs began to spread: the best known are Kotosh and La Galgada. During the final Pre-ceramic phase, a ceremonial architecture developed with terraced platforms in vertical sequence, semi-subterranean squares, ramps, and symmetrically opposed systems of stairways at several sites of the Costa. Radical changes took place that reflected an increasing level of specialization, not only in food production, but also to the organization of society, with its division into categories based on the various professions. They attained total mastery of construction and hydraulic techniques, demonstrating complete human adaptation to the natural environment and the adoption of useful methods for controlling it. The most important examples are El Paraíso, Las Haldas, Las Salinas de Chao, Garagay, and La Florida. Their hegemony was represented in the Supe Valley by the presence of the city of Caral, considered to be a model of the primitive Andean state (Shady and Leiva 2003). The architectural complexes were designed and oriented along precise symmetrical axes in the characteristic U form. With the introduction and spread of pottery around 1800 BCE, these traditions soon became consolidated, and other important centers such as Garagay, Cardal, and La Florida were founded. A form of society took shape where the different economic activities were controlled with a strict division of labor at a time of increasing specialization in all fields. Without ruling out the existence of some form of regional or local government, it is more than likely that authority lay with hegemonic theocratic systems, much more suited to the creation of elements of cohesion through traditions and rituals applied to the religion of the different communities existing at the time. In this transitional phase between the Initial Period and the Early Horizon, there are compelling examples of the power and authority exercised by the priestly class, as may be seen in the centers of Pampa de Llamas, Moxeque, Cerro Sechin, and Sechin Alto (Valle de Casma), which prospered thanks to a socio-political organization in which emerged the need of public works to be carried out by means of collective labor. All these experiences came together at Chavin de Huantar in the Ancash region for a number of reasons which are difficult to explain, where there arose a highly prestigious political and religious nucleus, whose ideological and charismatic influence spread throughout almost all the Peruvian territory, resulting in a very broad cultural integration process, in a period between 1500 and 200 BCE, for which there is an extensive bibliography.

In this period of profound transformation, the South Coast apparently followed a different and separate evolutionary path compared with the north of Peru. As for the

Initial Period, the architectural evidence is very scarce and lacks the monumental character of the great ceremonial complexes in other regions. The only sites that can be placed within this process and that constitute an example are those of Acha, in the Acarí area and Otuna, near Paracas. It may be argued that only with the consolidation of the Paracas tradition during the Early Horizon did a true process of urbanization come about, as evidenced by the archaeological remains in the Pisco, Cañete, Chincha, Ica, Palpa, and the Nasca valleys. More than the expansion and size of the settlements, what is significant is the relationship that was created between the various centers and the villages: this created the necessary preconditions for a total renewal of socio-political organization, with the emergence of forms of regional autonomy.

In the Early Intermediate Period, the entire Peruvian coast was a theater for an evolution characterized by a political and economic process of evident regionalization with the strongest forms of cultural expression in the South, in the Nasca area and in the North in the Moche and Chicama valleys. In a short time, coinciding with the end of the ideological influence of the Chavin and the consolidation of the experience acquired over the previous centuries, all the coastal populations were organized according to new socio-economic, models with a corresponding increase in the number of autonomous regional centers. At the same time, other major societies achieved control over of the various ecosystems in Peru, including that of Lima on the Central Coast, and Cajamarca and Recuay in the northern *Sierra* and Pukará in the southern highlands.

Amid this complex cultural landscape, the South Coast stood out as a place of great transformation that was manifested through the dissemination of new iconographic elements, including a syncretic religious symbolism arising from the influences of various traditions. In the case of the Nasca Culture, the symbolic nature of the manner, in which themes relating to the supernatural world and the natural elements were expressed, was one of the reasons why it is difficult to speculate on the structure of society and the hierarchy among the deities they represented. The iconography and stylized expression embedded within the repetitive patterns described only in part the complex themes tied in with the Nasca pantheon and their relationship with the elements that came under their influence. The most reliable information was obtained only through a comparative analysis of the settlements, the ceremonial centers, and burial areas, establishing connections with the data gathered from a study of the materials associated with their stratigraphic context coupled with iconological and iconographic studies of ceramics and textiles. The sum of all these elements is one of the factors that make it possible to ascertain the area of influence of a culture.

Regarding the Nasca, archaeological evidence has confirmed that at its greatest expansion it reached most of the various coastal valleys, reaching as far north as Cañete and extending south as far as Acarí. There is also evidence of continuous trade with societies living on the plateau and in the northernmost coastal valleys with a view to replenishing the supply of products needed to manufacture tools, as well as exotic materials and minerals needed for use as mordants. In fact, among the substances used to fix the fabric dyes, use was probably made of acids found in plants such as Oxalis, in addition to ash and fermented urine, alum, copper, and sulphate, among others. A small package wrapped in a fragment of tissue was found in the sector called Y2 EXP19Q1 at Cahuachi. It had been placed inside a Nasca earthenware vessel containing kaolin impregnated with epsonite (magnesium sulphate), used in pharmacology, but also as a mordant and fertilizer. Surprisingly, despite that fact that epsonite is not found in Nasca, it is abundant in the *Sierra* (Orefici 1993a, b, p. 104, Fig. 129).

Lima Culture flourished along the Central Coast parallel to the development of the Nasca and Warpa cultures, the latter on the Sierra of Ayacucho, and with whom there were various forms of contact beyond the limits of their influence. We must also consider the importance of the religious and administrative centers located in areas controlled by other ethnic groups at that time, without underestimating the prestige that some of them enjoyed also far from their areas of influence. The Cahuachi ceremonial center was undoubtedly the most important example of theocratic government on the South Coast and was the major center of attraction and aggregation in an immense territory, i.e., a regular place of pilgrimage with people coming from great distances.

7.4 Nasca Culture. Economic and Socio-political Organization

According to research carried out by the Nasca Project, there is a substantial difference between the period when Cahuachi was active and the period after its decline. Evidence was found that, from the last stage of the Late Horizon until 350–400 CE, there were settlements in the Nasca Valley (Pueblo Viejo, Quemado, San José, Jumana) that grew up alongside the great religious center and were abandoned when it ceased to hold ideological power: some became burial areas, others underwent alterations adapting to the new architectural models originating from external influences. Undoubtedly, in the two centuries following the demise of Cahuachi, several independent settlements formed in the valleys of the Río Grande Basin (Usaka, Corralones, Carrizal, Las Brujas, etc.), mostly connected to Phases 5–6 of the pottery seriation. This coincided with a transition from a theocratic powerto the next phase arising from political and administrative fragmentation, which meant that the centers throughout the region gained their autonomy, despite being bound in a confederation. (Orefici 1992: 182).

Numerous theories have been advanced concerning the spread of elements from the Nasca culture across such an extensive territory. For some, Nasca was a state with expansionist ambitions right from the earliest stages (Rowe 1963; Lumbreras 1981; Proulx 1989; Massey 1988; Bonavia 1991). Based on their research in the valleys of Ica and Pisco, Sarah Massey (*ibid*) and Peters (1988) formulated hypotheses relating to Nasca expansion during ceramic Phase 3, and attribute this intrusion to a state-like act of conquest. Silverman and Urton, basing their interpretations on Andean social and political models, suggest the existence of a system applied to the region, with *Pampa* separating the two halves: one in the Valle del Río Ingenio and the territories to the north of it, and the other directly associated with the Nasca and Poroma valleys (Silverman 1992; Urton 1990). Silverman argues for a social organization based on feudal territories or in a confederation of such dominions (Silverman 1993: 320). It is still too early to confirm either of these models, i.e., until it is possible to compare the results of recent research in progress in the region.

Analyzing various sites with features belonging to early Nasca, some smaller centers of worship have been identified in the basin of the valley of the Río Grande de Nasca, showing that there was already a consolidated pattern of differentiated settlement (Silverman 1992: 37–38). A well-documented example was found at Pueblo Viejo during Nasca Project excavations and, as reported by other archaeologists, in some settlements in the Valley of the Río Aja, but these were smaller buildings probably used as local shrines.

It is extremely difficult to prove what type of production mechanism was in place as the Nasca Culture began to develop, but some rules at the basis of a specific economic process may be deduced from the results obtained by archaeological means. Plenty of evidence was found to indicate large surplus production at the Cahuachi ceremonial site, which enabled the surplus to be redistributed, stored, and traded. This presupposes a hierarchical society and the existence of privileged categories in all the communities of the towns. This socio-political system was based on mass labor, which provided the essential goods needed for the transformation of raw materials by specialists, thus creating the conditions for exchanging different kinds of goods. Such an organization caused a numerical imbalance where the majority that did the production had to maintain the minority which transformed the elite at the top of this pyramidal system, organizing every kind of work. This privileged group held a special position in the community, and its existence was justified by its acceptance of a set of shared ideological and religious values. The priests were in fact specialists, above all in the management and control of the distribution of the water required for agricultural activities. Their knowledge and experience in this field made them appear to be beings chosen by the gods, and thus they assumed increasing importance, being considered as intermediaries between the community and the supernatural world, ensuring the well-being, fertility, and the survival after death of the people.

Gradually, as the power of the priestly elite became more established, a form of increasingly influential theocratic government developed, exercising ever greater control and carrying out closer coordination of all economic activity, which justified the construction of the great monumental centers. Thus it was possible to carry out increasingly complex ritual activities promoting cohesion among the various groups, as the religious center was the source and dispenser of life and protection in exchange for material goods, labor, and offerings. This was not an interchange of economic benefits, but it was the way of returning, from an ideological standpoint, what the community actually offered. The form of power exercised under these premises manifested its influence thanks to an immense wealth of iconic images used as an effective form of propaganda. The population, in turn, could access the ceremonial center, or its vicinity, according to a fixed hierarchy, during celebratory events at certain times of the year, participating in rituals, religious festivals, or community activities.

Throughout the period when Cahuachi was active, there was clearly a social organization based on a stratified hierarchy, with various social classes with their various specializations which, through their work, contributed to the prestige of the theocratic capital. The system of production of mainly agricultural primary commodities was particularly advanced thanks to the organizational skills of the ruling elite which infused a new layout to agrarian territories in the surrounding valleys, through the distribution and permanent control of water. This can be deduced from the abundant production of very refined and valuable ceremonial pottery, highly technological and excellent quality fabrics, highly specialized monumental buildings, and the production of *adobes*, with their distinct forms (Fig. 7.6). In architecture, the Nasca demonstrated great knowledge of the use of materials and the application of the principles of physics, combined with the ability to produce preliminary typological models subsequently applied on a large scale throughout the territory (Fig. 7.7a, b, c). Throughout their evolution, these people was able to coordinate their skills in order to trace the geoglyphs in the pampas and to design hydraulic structures such as filtering tunnels, confirming that there was an institutionalized system in the division of labor roles.

Fig. 7.6 Cahuachi site Y8 EXP 124-Q5. Vessel depicting a character in an inverted position, with the neck open, that forms the mouth of the jar. It was found in a group of ceramics sacrificed and buried under an artificial fill in the lower square. It belongs to the Early Nasca tradition (Photo by the author)

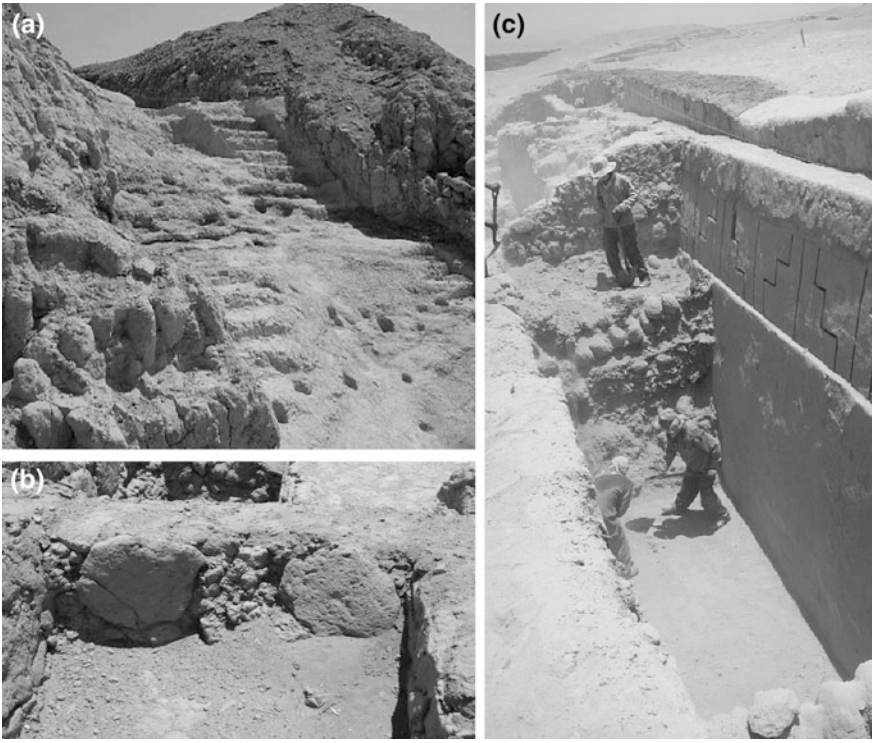

Fig. 7.7 **a** Interior room in the Gran Pirámide of Cahuachi. Although the first use dates back to the first millennium BCE, the structures of Paracas–Nasca transitional period appeared around the early centuries AD. The image shows the ancient stairway carved in natural clay layer. **b** Detail of typical Paracas–Nasca transition built with conical adobe, later supplanted by bread loaf adobe. **c** Excavation phase of Templo del Escalonado, north of Gran Pirámide, Cahuachi. The decoration of the double staircases interleaved pattern is typical of the Paracas–Nasca tradition (All photos by the author)

Undoubtedly, textile production and ceramics were also the main means of communication and dissemination of religious messages, teaching the people, even at great distances, the symbological characteristics of the divinities, mythological figures, and the religious ideas associated with them. In the corpus of themes illustrated on pottery, pride of place goes to agriculture as an essential element for survival, exchange, and offering within the sacred spaces. A number of artificial wells were found at Cahuachi containing kilos of pumpkin seeds, chilli peppers, maize, and other agricultural products, confirming the intrinsic value of these materials also in votive and ceremonial contexts. The high degree of specialization in the field of agriculture increased with the creation of irrigation channels and a network of aqueducts, as evidenced by the variety and quality of cultivated products found in the artificial fill used in the buildings at Cahuachi. The diet of the population was supplemented by animal protein from fishing, hunting, and animal husbandry, which mostly involved camelids and guinea pigs.

The iconography of the pottery also helps to recognize directly some elements that distinguish the various activities and the categories specialized in them. In hunting scenes, the characters wear a particular kind of sash and the head is normally protected by a special headdress. They also carry arrows, slingshots, or catapults made from fabric. Farmers are shown with items for working the soil and only a cloth tied around the hips. People carrying plant material cover their heads with a pointed hat, while fishermen cover their hair with netting. Looking at these distinctions, we can deduce that the people engaged in these activities were distinguished by the different kinds of garments they wore. Although the literature commonly describes the Nasca as a warlike people, we are not in possession of sufficient data to confirm the existence of a specialized warrior category, nor to say whether there was a distinct social class.

Studies in physical anthropology carried out during the Proyecto Nasca excavations reveal an absence of bones with signs of wounds or violent trauma, so we cannot establish with any certainty that there were clashes with neighboring populations. Analyzing the iconographic themes on the pottery, it can be asserted that scenes of military conflict belong to a later phase not represented at Cahuachi.

In a hierarchical society like Nasca, the degree of social standing can be deduced only by the amount and quality of funerary offerings and the luxuriousness of the fabrics used at burial (Figs. 7.8, 7.9 and 7.10).

Personal ornaments were produced using *Spondylus* shells, mussels, and other shells, and semi-precious stones, such as chrysocolla or anyway chosen for their rarity: these materials were manufactured to produce pendants or bead necklaces (*chaquiras*). Golden objects were reserved for high-ranking personalities or priests and consisted of crowns, breastplates, pendants, masks, *orejeras*, or *narigueras*.

The artwork on the pottery shows that those who were distinguished by their status were those who had political or religious endowment, without distinction of

Fig. 7.8 Fragment of painted fabric belonging to the tomb of a young priestess. It represents sequences of killer whales in the act of severing the heads of characters with an obsidian knife (Photo by the author)

Fig. 7.9 Two fruits of Pepino (*Solanum muricatum*), belonging to the Nasca tradition, which form the two bodies of the same small bottle fitted with stirrup handle (Photo by the author)

gender or age. It seems that women, as Jiménez Borja (1986) notes, played an important role in Nasca society. And not only the young, but also those who had reached a certain age were held in great esteem due to the very high social and hierarchical position they held. In pottery phases 6 and 7, female figures are represented whose beauty was one of the most important aspects. Most of these figures were sculpted in the round, emphasizing the contours of the body. Some are represented naked and have tattoos in the pubic area, around the vulva and buttocks, and may also be considered as supernatural beings associated with fertility. Other female figures belonging to later phases of Nasca civilization have richly decorated clothes, very showy hairstyles, and particularly realistic expressions. They reflect the image of an affluent society in which the female was a complementary element and whose power was at least equal to that of the men.

There are plenty of references in the literature to the presence of pets in the urban coastal areas. The domestic Andean camelid, such as the llama and the alpaca, were the predominant species, thanks to their usefulness as a means of subsistence. All the Nasca sites analyzed so far provide evidence for the great importance given to

Fig. 7.10 Tissue found in Y16 sector at Cahuachi, along with others which were part of a burial with ceremonial robes. This fabric depict killer whales, feline deities, and flying fishes. It is dated to the Paracas-Nasca transitional period (Drawing by Sarah Orefici)

these animals in the human economy. The camelids were the main source of animal protein and played an important role in the survival of the inhabitants of the valleys, and the inedible parts, such as fibres, bones, skin, and excrement, had a secondary use in the manufacture of artefacts or as fuel. The llama, moreover, was the only beast of burden available and was used to transport diverse materials, as can be seen in the rock art and ceramic iconography (see also Orefici and Drusini 2003: 96–97).

The ancient Nasca were able to use all the products that nature gave them, such as kaolin, wood, clay, stone, pigments, shells, and metals such as gold and silver, as well as plant and animal fibers. Materials not available on the spot were obtained directly or indirectly through trade with other regions. Given the presence of large amounts of products found at Cahuachi that were not native to the place, there is no doubt that there was an intense, albeit indirect, trade relationship between geographical areas with different climates and complementary production opportunities. Thus they were able to obtain the feathers of birds from the Amazon forest, obsidian from the Ayacucho area and Huancavelica, lapis lazuli from the far south, and other elements found at Cahuachi and in many other sites of the neighboring valleys. It is difficult to establish whether this type of activity was specialized and whether a class of people worked exclusively in the transport and trade sector, or if the presence of certain materials within the ceremonial center was due solely to the arrival of different human groups on the occasion of massed religious celebrations and coincided with the arrival of pilgrims from the most remote locations, in which case their presence in archaeological contexts may be the result of a supply system or exchange on specific occasions.

Among the most common were the manufacture of mats, baskets, and a very varied range of cords most of which were exclusively utilitarian. They were made from fibers obtained from *Caña Brava (Gymnerium sagittatum*), *totora* (*Typha angustifolia*), rushes (*Scirpus* sp.), *smooth flatsedge* (*Cyperus laevigatus*), *maguey* or American aloe (*Furcraea* sp.), and a bromeliaceae typical of the *lomas* (*Tillandsia* sp.). The most common technique was some kind of weaving, and, in basket work, very often two different colors of material were used (Fig. 7.11).

The production of ropes was very common, mainly due to the fact that rope was used in various processes of construction work, both for joining poles and rods, and to fix architraves and adobe walls. They produced woven material by interlacing two, three, or more previously twisted fibers. Much use was also made of *cucurbitaceae* of the *Lagenaria* species (gourds), which were used to manufacture most of the household containers of liquids, especially cups, bottles, and dishes, according to their shape and size. These artefacts, known as *mates*, also had a ceremonial function, as shown by the exemplars found in the artificial fill at

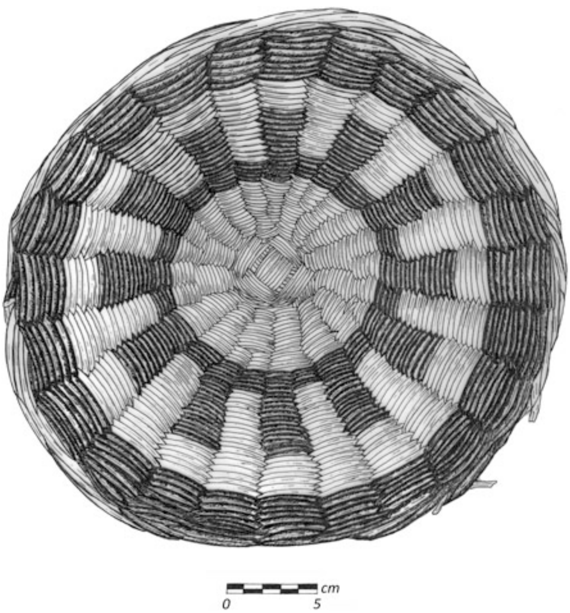

Fig. 7.11 Pueblo Viejo (Nasca), sector X5 Exp2 Q4 T2 OFR1. Dichromate rush container, typical of the Paracas-Nasca transition. Similar basketry works can be found in grave goods, but also among everyday objects (Drawing by D. Venturi)

Cahuachi containing numerous decorated items or as part of the funeral equipment in many tombs. The most common surface decoration technique was pyrography, but there were also various carved and painted items with illustrations of complex scenes and mythological characters. Endemic trees, and in particular the *huarango (Prosopis pallida),* the *sauce* (*Salix humboldtiana*), and the *pacae* (*Inga feuillei*), were used to provide the wood for building, as well as for farm equipment, spoons, the sling handles, darts, and harpoons. Archaeological excavations also brought to light numerous examples of work in miniature, such as needles for sewing and embroidery, small rods of spindle whorls, brushes, tops for containers, and moulds for hammer work in metallurgy. For certain, the discovery of sculptures or items worked with chisels was very rare, though they certainly existed, as attested by the presence of various components of this type on display in museums. In 2013, a small bone sculpture representing a human figure in the round was discovered. It had been engraved, and the incisions had later been filled with mineral pigment.

The most distinctive art work in which the Nasca excelled included the production of fabrics and fans adorned with decorative feathers, with which it was possible to obtain a three-dimensional effect, using different thicknesses and creating colorful compositions thanks to the bright colors of the feathers used. When making clothes and covers, they used the rigid parts of the feathers in long lines, resting them on the canvas base and then sewing them very carefully onto the support. To create masks and applique decorations, the feathers were glued one by one onto the base using a thick maize starch to make a collage.

Concerning stonework, we know that most of the artefacts were made using materials typical of the region, easily available in the alluvial conglomerates of the upper terrace of the Río Nasca. From an analysis of the finds, two different types of supply and use of raw materials emerge.

In the first and best represented, we see the application of an extensive ad hoc method for use on local raw materials, mainly diabase, quartzite, basalt and, more rarely, amorphous silicate rocks, such as flint and chalcedony. The examples found are essentially scrapers, drills, hammers, and instruments for smoothing and polishing, suggesting collective use. The work focused on pebbles, chips, or sometimes blades, with the sporadic presence of artefacts similar to *chopping tools* whose small size would indicate that they were not cores. Splinters were obtained using a core by striking on a special shelf to produce a simple, denticulate, flat, or biface effect. At Pacheco, 12 km east of Cahuachi, 14 small stone workshops were found distributed along an axis of one-and-a-half kilometers. The scarcity of cores found suggests that they were shaped in situ and then subsequently transported and processed elsewhere. Most of the material recovered was green diabase (Tomaszewski 1989), which indicates that the raw materials were specifically selected. The type of wear detected on most of the stone tools in Pacheco would indicate that they were mainly used to cut reeds, plants, or plant fibers in general. At Cahuachi, where there is a scarcity of flint, there is abundant quartzite, used for most of the tools analyzed. There is diabase, basalt, and quartz of excellent quality and two different tones: matte black and reddish black, shiny and translucent (Orefici and Drusini 2003: 104–106).

The second group includes a number of items manufactured with great skill using material very rare in the Cahuachi area. These are examples of bifacial obsidian points, with impeccable finishing touches from a school of highly skilled craftsmen. Obsidian bifacials were found at the excavations conducted by the Nasca Project, though these make up a small percentage of the Cahuachi collection and, in most cases, they predate Nasca occupation. Their importance should be assessed in relation to their role in sacrifice and war, as suggested by their frequent iconographic representation in pottery. Various smooth stone tools such as millstones and pestles for crushing and grinding foods, pigments, and minerals were also found.

In the Nasca, area there was a fairly widespread bone working industry producing tools. They mainly used the bones of camels, after making a preliminary selection of the most suitable materials for fashioning alternatives to those in stone, such as punches, chisels, blades, drills, and needles. They were preferred due to the greater flexibility of bone. The main technique was that of percussion on an anvil, completed by the use of scrapers and polishing; evidence was sometimes found of sawing on the selected parts to obtain segments of various sizes to be finished. Among the findings at Cahuachi, there is also a small amount of material ready for transformation into flutes and instruments for weaving.

In any case, the activities in which the Nasca excelled were pottery making and the production of textiles, which show the extreme specialization achieved and technical expertise reached, as well as knowledge of the subject matter. It is well known that Nasca had well-defined technological characteristics due to the use of polychrome decoration before firing, the extremely fine slip, the gloss and finish of the carefully polished surface, the extreme thinness of the artefacts, and the excellent firing. The most common forms included jars, jugs, bottles, cups and mugs, bowls, plates, flat canthari, and elongated cups. Among the most characteristic items, the frusto-conical bottles with twin diverging spouts joined together by a flattened loop forming a bridge stand out most. Vessels were also made with sculptural forms and various artefacts had embossed elements, especially anthropomorphic, zoomorphic, and phytomorphic forms. Nasca potters made their containers by hand, shaping blocks of clay and adopting mixed techniques, without the use of the lathe, which was unknown. In its place, a flat bed of clay or other material (a potter's plate) that enabled outstanding results and modelling of any shape: the proof of the use of this aid was found both at Pueblo Viejo, Cahuachi, and Usaca, where whole and shattered potter's plates were found. The next stage of production was to polish the still partially raw surface, using suitable instruments, such as strips of leather or canvas, the peel of pumpkins, containers, earthenware discs, and wooden or bone tablets, with which the surface would be smoothed and made uniform, eliminating all imperfections. Then the engobe was added to the artefact, coating it with a layer of clay or fine kaolin in liquid suspension, in order to make the container more resistant to cooking stresses and constitute a base on which to paint the decorative motifs. Pigment preparation was another procedure indispensable for obtaining the characteristic polychrome effect: it was made using oxides, hydroxides, and carbonate of copper, iron, and manganese, using cinnabar and various other clays and natural earth including calcite, gypsum, and other materials.

Study of the types and decorations of the pottery provides a basis, supported by radiocarbon dating and other types of analysis (thermoluminescence, radiography, etc.), to obtain correct dating in accordance with the stylistic sequencing.

7.5 Nasca Pottery Seriation

The problem of the ceramic seriation of the Nasca Culture has been addressed very thoroughly by several authors on the basis of the collections they analyzed (Tello 1917, Gayton and Kroeber 1927; Kroeber 1956; Kroeber and Collier 1998; Strong 1957), but the one that continues to be used as a baseline was established by L. Dawson in 1952, which established a sequence of nine phases according to a methodological procedure described in detail in the publications that came out in later years (Rowe 1959a, 1960, 1961; Menzel et al. 1964; Patterson 1966; Proulx 1968, 2006). Some authors have addressed the issue of seriation based on an analysis not only of the stylistic elements, but also considering cultural and evolutionary aspects (Roark 1965; Sawyer 1966; Lumbreras 1969).

Following recent research at Pisco, Ica, Nasca, Acarì, and Palpa, the sequence used showed some discrepancies concerning the attribution of some chronological stages (Orefici 1992; Orefici and Drusini 2003; Silverman 1993; Proulx 1968, 2006; Silverman and Proulx 2002). This is not the place to address all the differences observed, but we can briefly outline the distinctive characteristics of each stage.

The pottery of Nasca Phase 1 is the one that is currently being redefined more than any other, placing it in a period of transition between the Early Horizon and the Early Intermediate. We can distinguish two main groups, with a preponderance of very fine and thin orange or black monochrome, unlike the polychrome vessels of the second group, where the decoration uses only two or three colors. The most common forms of the monochrome type are open or closed containers with convex base, plates, and bottles with a double spout joined by a flattened bridge-shaped loop with anthropomorphic or ornithomorphic sculpted figures: there are also bottles with a double spout of a type dating from Ocucaje 7 and 8, which fix the date of this stage very well.

Within this earthenware production, a special black pottery stands out in particular that was baked in a reducing atmosphere, which Strong (1957: Fig. 9) called *Cahuachi stylus decorated and Cahuachi Black incised* including it in a Paracas–Nasca transitional phase peculiar to Cahuachi. Menzel (1971: Lam 4c) identifies a cup as belonging to "Paracas Phase T3, *decoración Patrón Bruñido*" (corresponding to Ocucaje 9). It is decorated inside with a zig-zag pattern. In illustration 6d, he classifies a dish from Ocucaje as "*Paracas T4 Patrón Bruñido*", and its inner pattern is very similar. In illustration 7c representing a cup decorated inside with converging parallel lines that separate fields with sigmoidal motifs, he uses the term *"Nasca 1-negro ahumado patrón bruñido"*. The author of this paper describes this kind of discovery in detail, calling it "Nasca 0", adding also the results of the analysis of thin sections of the mix under the microscope (Orefici 1992: 114–117; 1996: 173–197; Orefici and Drusini 2003: 144–148). (Figs. 7.12, 7.13, 7.14 and 7.15). The most common patterns include semi-circular sigmoidal lines and zig-zags, bands of parallel segments, and variations on these symbols: more rarely, examples with diamond shapes or naturalistic motifs such as fish or plants have been found. The polychrome type stands out on account of the application of pigments before cooking and the use of engobe: the most commonly used colors are white, red, and black. The ancient Paracas heritage can be seen in the decoration with "negative" engraving and painting.

In containers in general and on dishes, the exterior decoration was obtained by dividing the surface into panels using vertical incisions, separating simple figures with circles, step motifs, and stylized representations of animals. The image of the cat is recurrent, as are the images of the "Being with Big Eyes", which confirms the persistence of Ocucaje 8 elements. Strong (1957: 19–20) defines this pottery as *Late Paracas–Proto Nasca*.

Another type of material that is difficult to interpret is represented by the jars with twisted handles, or formed from two parallel, rounded elements, or with other applications in the form of a flap in the top third, found at Cahuachi and at other sites of the Río Grande de Nasca basin. These items are classified as Paracas T3 (Menzel 1971: Lam. 5b), Ocucaje 9 (Menzel et al. 1964: Fig. 22e); some authors believe that the jars with twisted handles can be dated to Phase 10; Strong calls this type of item *Modelled and incised Proto-Nasca* (1957: Fig. 27e–h). Basing her opinion on the results of exploration in the Ingenio Valley, Silverman (1994, 1996) tends to think of a local tradition from the Early Horizon, which he calls Tajo and which also includes natural ceramics decorated with incisions, the application of quadripartite circles, moulded figures, etc. At Cahuachi, the Proyecto Nasca

Fig. 7.12 Cahuachi, Sector Y1 EXP 50 Q3. Molded black dish, type patrón bruñido. Nasca phase "0" with geometric decoration inside (Photo by the author)

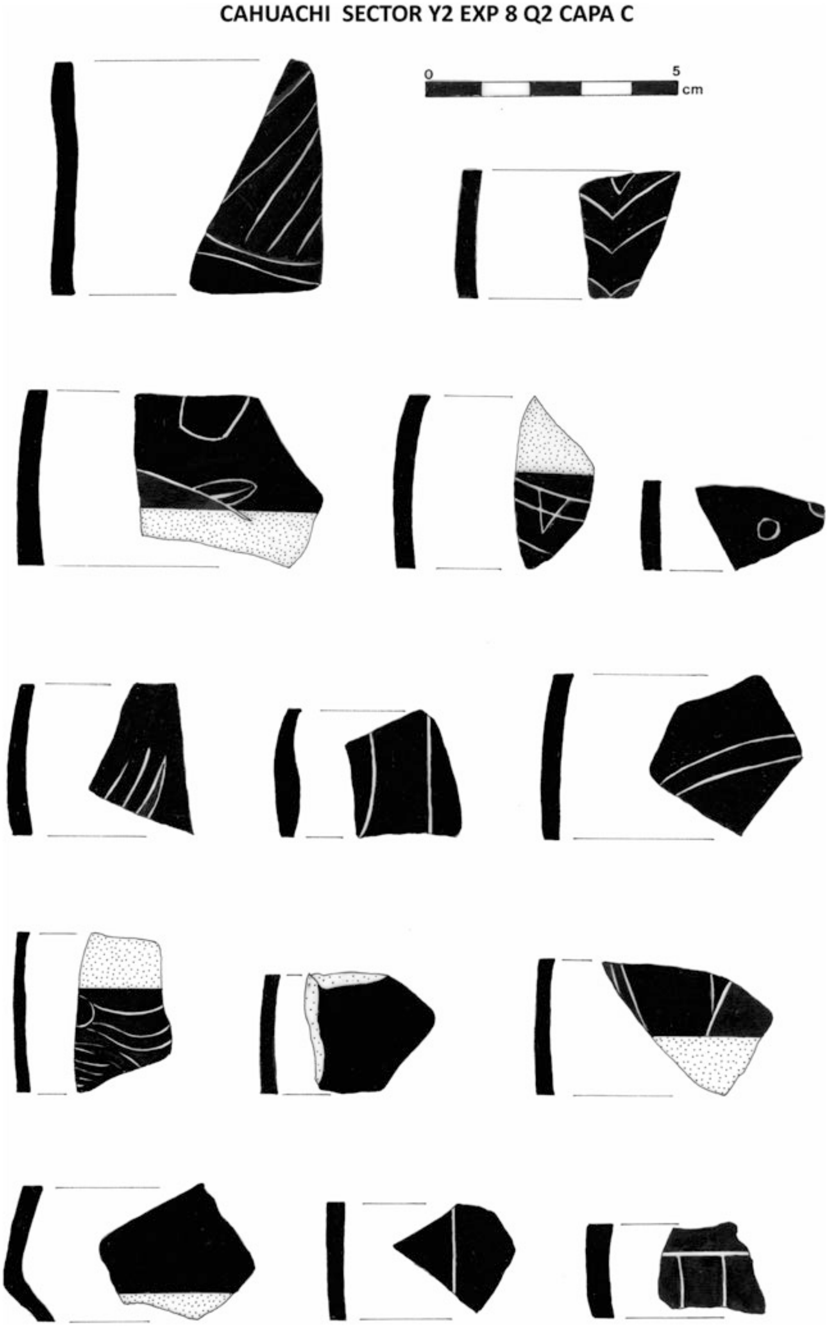

Fig. 7.13 Cahuachi, Sector Y2 EXP8 Q2. Pottery fragments type patrón bruñido of Nasca "0". Paracas-Nasca Transition (Drawing by D. Venturi)

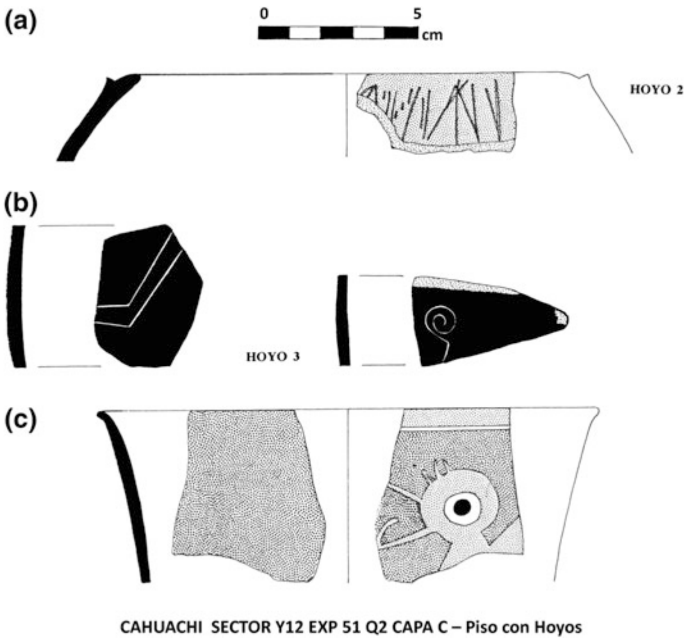

Fig. 7.14 Cahuachi, Sector Y12 EXP 51 Q1: **a** shard of engraved diagnostic pottery. **b** shards of pottery type patrón bruñido of Nasca "0"; **c** shard with negative decorations. Paracas–Nasca transition. (Drawing by D. Venturi)

(Figs. 7.16) found many examples with these features, both whole and fragmented, albeit in non-representative quantities (Orefici 1996; Orefici and Drusini 2003).

Phase 2 highlights an already mature state of development both in terms of shape and polychrome. The practice of separating the fields of color using incisions disappears; the most common containers are two-spouted bottles with a bridge handle, sculptured containers, vessels made from a double container base including a globular body, anthropomorphic ceramics, dishes, pots with slightly everted borders, and clay material with a convex base. The mixture is finer than that of polychrome ceramic Phase 1 and indicates greater control during firing. The surface always has a smooth engobe and forms the background for a very heterogeneous iconographic unit. Bottles generally have a central figure representing the anthropomorphized feline deity, which takes the place of the earlier Paracas "Being with Big Eyes" and shows some variations compared with the original model; it is often associated with trophy heads. In the interior decoration of the dishes, we observe the presence of fish with short, wide bodies, as well as various varieties of plants such as squash, beans, lima beans (*Phaseolus lunatus*), the *jiquima* (*Pachyrhizus tuberosus*), maize, and *huarango* beans. Sequences of these motifs, mainly in red and black, also decorate the outer surface of various forms of earthenware, especially cups and mugs: in this case, the alternate on a white engobe, divided into zones by vertical black lines. The zoomorphic themes are interpreted as archaic

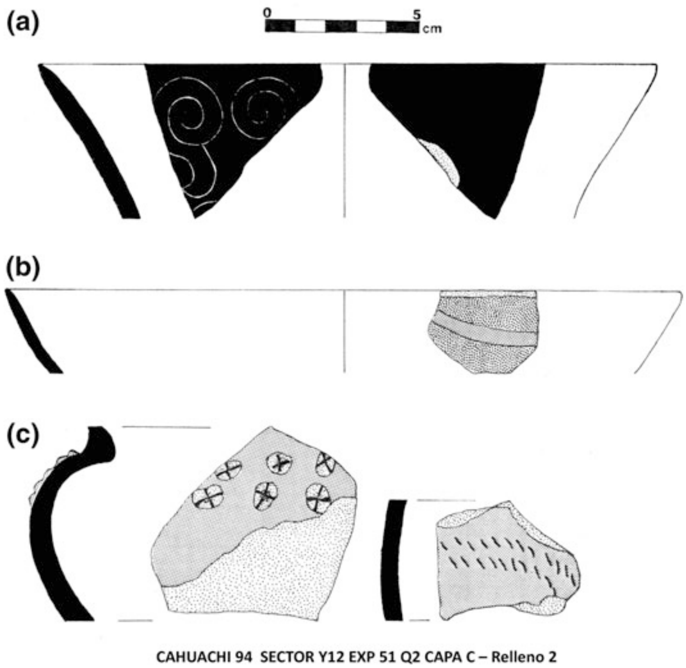

Fig. 7.15 Cahuachi, sector Y12 EXP 51 Q1: **a** pottery sherds type patrón bruñido, phase Nasca "0"; **b** e **c** sherds of diagnostic engraved pottery and with applications. Paracas–Nasca transition (Drawing by D. Venturi)

forms with various representations of animals, including ants, reptiles, and lizards, as well as frogs and tadpoles, which also characteristic of the next phase. The geometric patterns include double concentric rings in white and red or black and red, sigmoidal emblems, or polychrome scalar motifs, surrounded by a white line. The anthropomorphic vessels retain features of the Paracas type, although dark brown is now used together with a greater use of white and red. The human figure is very often represented bearing plants, mainly jiquima and chilli. Pottery decorated with rhythmic bursts of color without any figurative design is also found. Among the unpainted items, there are also large ovoid jars with flat handles and low inward-leaning neck, as well as others of smaller size with parallel, double, tubular handles.

Nasca Phase 3 corresponds to the period of greatest splendor of Cahuachi and is characterized by the quality of the production and the use of very sophisticated technology. There are certainly many variations in the morphology, if not in the size of the vessels and the mixture, which contains a degreasing with a greater particle size, giving more depth to the walls of the artefacts. Fishlike images become increasingly common and the representations of the killer whale seem to move away from the form in which it is represented holding a trophy head towards one where it holds an obsidian knife, or both symbolic elements, leading us to suppose

Fig. 7.16 (*Upper*, *left*) Cahuachi, Gran Pirámide, EXP 33-T3 Q25. Double spout and bridge vessel, with post-fire painting depicting two-headed snakes dated to Late Paracas period. (*Upper*, *right*) Cahuachi, sector Y12 EXP 51 Q2. Small olla with side handles depicting a relief decoration with zig-zag motif applied and engraved. Paracas–Nasca transition period. (Photo by the author) (*bottom*) Cahuachi, Sector Y8 EXP 33 Q24. Lens-shaped vessel with everted neck and side handles applied. It is characterized by decorations with white double-circular motifs on ingobbio. Late Paracas period (Photo by the author)

an increase in activities related to sacrifice to the sea god. Representations of birdlike wildlife abound and evolve, abandoning the characteristic stylistic features of the Paracas and taking on a particular importance in decorations. The most

Fig. 7.17 Cahuachi 1991, sector Y13 Exp 48 R1. Figure of killer whale engraved on a wall of a room with access to the staircase leading to the upper floor of the temple (Photo by the author)

common images portray the *vencejo* (*Cypselus* sp.), falcons (*Falco femoralis*), various owls, condors, flamingos, parrots, and seabirds: the hummingbird appears a little later together with flowers, in the act of taking the nectar they contain. This symbolism is also present in the *Pampa* de Nasca and is repeated in several areas. It was used several times in rock art. During its evolution, birdlike symbolism was often present at the same time as figures of fish, in particular sharks: there is a shift from early representations of isolated seabirds towards motifs of bands decorated with fish figures, but these remain separate within the composition of the scenes.

A later variant shows sequences of fish closed in between parallel bands, which gradually reduce in size until we reach the representation of the symbol of the bird figure feeding on fish. This metamorphosis of the symbol representing birds acquires greater frequency than that of the aquatic fauna, which through subsequent stylistic changes, shows a progressive decline together with the figure of the killer whale (Fig. 7.17). The anthropomorphized feline deity is represented with more stylized details and a growing wealth of detail in its decoration: the marks on its body are transformed into vegetable matter and its eyes stretch increasingly outward. Vessels continue to be decorated with depictions of plants or animals, albeit with richer detail and black or white outlines. The end of Nasca Phase 3 seems to coincide with the decline of Cahuachi and the abandonment of the most important areas of the ceremonial life of the center. Evidence of later stages within its environment is related to intrusive burials or reworkings of the older buildings.

Ceramics Phase 4 has been put forward because of the style, but there is no particular evidence of its stratigraphic presence, so it is difficult to establish a chronology. The changes in question regard a more reddish clay and the use of a degreasing with smaller particles, greater skill in the manufacture of forms, and thinner walls also in larger pottery. The images appear more contained, small, and numerous. Fishlike motifs are almost lost, as they become increasingly stylized and schematized, and significantly reduced. In the author's view (Orefici 1992: 134), the decline of Cahuachi may have brought about a series of innovations and changes indicating new socio-economic conditions in the Nasca Valley. For these reasons, the Phases 4 and 5 would seem to correspond to a period of transition that would lead to an ever greater development of the urban centers with peripheral autonomous government across the territory (Orefici and Drusini 2003: 151). Silverman (1992: 38), noting a decline in the pottery belonging to Nasca Phase 4 in the settlements in the Río Ingenio Valley, indicates that this stage highlights differences that may be largely a question of a regional stylistic phenomenon, adding that it is impossible to prove this stratigraphically, and she seems prepared to unite Phases 3 and 4. Görsdorf and Reindel (2002: 155, Fig. 5) propose six calibrated datings corresponding to Phases 4 and 5 from funerary sites and the occupation of the sites of Los Molinos and Muña (Palpa). Nevertheless, there has been no in-depth study of the results obtained nor a possible differentiation between the two phases able to help us to explain whether there is a time sequence between them.

In Phase 5, we can notice several important innovations in the iconographic *corpus* and a growing maturity with respect to previous styles. The ceremonial pottery takes on new forms and containers become more elongated and stylized. Anthropomorphic bottles now had only one spout and the bridge handle remained, while the base appeared more flattened and sometimes lenticular. Some bottles had a more slender cylindrical neck, ending in a wide-lipped border. The main change was the choice of illustrations which now presented in full the themes outlined during the previous stage. The stylized outline of the image developed with a proliferation of symbols, such as the use of sinuous trophy heads and more dynamic airy and refined tiaras with curved tips and scrolls. According to Menzel (1971: 64, citing Kroeber1 (1956, Fig. 39) and Strong (1957, Fig. 13d–e), the most significant symbol of this innovation is the presence of trophy heads with the depiction of the hair using curved lines and blood stains around the neck and mouth. The anthropomorphic figure assumes a dominant role over all other zoomorphic and phytomorphic representations, which reach their highest levels of stylization. Moulded containers appear with female figures with epithelial decorations in the pubic and sacral areas, possibly referring to female fertility. There were significant changes to the plain pottery: these transformations must have been produced in a very short period of time, corresponding to the transition period that was a prelude to transitional phases 6 and 7.

In Nasca Ceramic phase 6, previous shapes now become more accentuated: containers become even more elongated and sinuous, sometimes with the base divided into four with alternating black and white segments. There are great numbers of globular shaped bottles, still with only one spout and anthropomorphic head, linked together by a bridge handle, in addition to cups with diverging lips. The decoration is emblematic with its accentuated proliferation of iconographic elements. In the themes represented, there is a true “branching out” of symbols and the introduction of new forms of stylization such as the triangular heads of snakes, swaying zig-zag lines forming positive-negative stylized snake figures, and female human heads with smooth, flowing, black hair. The trophy head pattern now has more figurative details, with ornaments and elongated eyes: they are frequently associated with scenes depicting battles and warriors. The engobe is usually white, rich in decorations that almost completely cover the free spaces, expressing for the first time a true *horror vacui*.

Nasca 7 is not very well represented in the Nasca Valley, whereas its presence is greater in the Ica and Acarí areas. It includes progressively taller vessels and some new morphological elements, such as lenticular bottles, flat bases, and a single spout. Pots are in composite, tending to a bulbous form, while the base is flat or flat-to-convex. Containers and mugs have diverging elongated walls. There are complex ceramic containers with sculptural elements, and bottles with a single spout and bridge handle connected to an anthropomorphic, generally female, head continue to be produced. Several innovative elements appear in the iconography. According to Proulx (1989, 1994), the origin of this innovation could be possible contact with the contemporary Moche culture, which he explains by the sudden appearance in Nasca iconography of the figure of the *Mythical Monkey* and a later development where the monkey appears decapitated. At the same time, there even appears a figure of a fish suggested by an elongated body and dorsal proliferations, which will also be present in the later stages. The decorative elements are enclosed in various overlapping bands, with rhythmically and numerically repeated symbols. The proliferation of the images reaches its greatest extent. The definition of the female heads become even more complex, with hairstyles and face paintings which reveal very refined personages particularly attentive to their appearance. The mythical killer whale becomes a merely decorative element and reaches its highest level of stylization. There are also headless anthropomorphic figures and trophy heads with very showy tiaras. The forms of expression that emerge when analyzing Nasca 7 material may indicate the presence of local stylistic schools, some of which were still under the influence of religious dogmatism, and others that reflect the influence of new cultural impulses. During the research carried out by the Nasca Project in 1989 at Santa Clara and Jumana, the author unearthed some intact ceramic material at burial grounds and in deposits, and these were undoubtedly from 6–7, but the iconography reflected earlier themes once more (Orefici and Drusini 2003), which would seem to confirm the persistence of local traditions, but also influenced by new stylistic currents. Based on the data from her research, Silverman claims that Nasca 7 includes two types of pottery: one showing a direct continuation of Nasca 6 and the type called Huaca del Loro, traditionally classified as Nasca 8 (Silverman 1992: 38–40), which she calls “Loro” and which she suggests be deleted from the Nasca sequence. She proposes adding part of Nasca 7 to Loro, while one part should be included in what is considered Nasca 6.

Steps 8 and 9 show most clearly a total change, both in form and decoration. They correspond to a time when the cultural influence of the *Sierra* indicated the presence of the Huari on the South Coast. This period most definitely leads into the Middle Horizon and is abundantly documented by a very rich bibliography (Strong 1957; Menzel 1971; Paulsen 1983; Silverman 1987, 1992; Knobloch 1983; Schreiber 2000).

7.6 Economic Resources and Specialization of Production Activities

Textiles, cotton cultivation, and camelid breeding were areas that covered the demand for the raw materials needed. Artisans played a key role in fabric production, with their necessary patience and skill. It is almost certain they were a category apart, as were those who looked after the distribution of raw materials and those involved in the actual production of the textile products. To dye fibers, the Nasca used pigments made from animal, vegetable, and mineral matter, from which they could obtain a wide range of almost 150 tones. When necessary, dyes could be fixed by heat or some natural mordant. Red was obtained from *achiote* (*Bixa orellana*) and *achira* (*Canna edulis*); even though traces of opuntia have been found, there is no actual evidence of the use of cochineal in the Nasca valleys, while botanist Luigi Piacenza (see Chap. 6) found traces of plants with colorant properties at Cahuachi. These included *Chillca* (*Baccharis lanceolata*), *Argemone mexicana*, and *molle* (*Schinus molle*), though the latter was found in later deposits. Other plant species that provided traditional dyes found in the excavations are the *morado* (*Zea mays*), used to obtain the color purple, the *Solanum nigrum* for blue, and *huarango* for brown. Various earths were used for the mineral pigments, even if there is only certain evidence of the use of yellow and purple ochre, apart from some cases of red ochre or hematite (iron oxide), a deposit of which was found to the north of the Río Ingenio (*Mina Primavera*). *Oxalis* (a vegetable acid, used to obtain oxalic acid), ash, fermented urine, alum, copper sulphate, and others were used to fix the colors. Traditionally, weaving was predominantly a female activity, although male participation cannot be ruled out, as was proved by the discovery of a grave of a man whose grave goods consisted of material for embroidering and weaving (Y13EXP49Q3-Q5T1).

Among the many decorative techniques used in textiles, embroidery was without doubt the most widespread in the Paracas and Nasca eras, both in the form of a structure on top of a fabric base, and even for three-dimensional decoration. The precision and variety of the stitches used probably required the use of a loom and a support. The covers that were found in the coastal necropolis, adorned with three-dimensional fringes or embellished by the presence of embroidered figures, are the most admirable examples. The clothing of persons of high rank or of particular importance were often enriched by the application of colored feathers or decorative elements in gold and silver.

The mountain ranges of the Peruvian Andes are rich in gold and mineral deposits, situated on both sides, and they provided the raw material for metal working, providing craftsmen with significant amounts of native gold (in block form), often together with other metals, and in alluvial deposits (also known as 'secondary'). Silver too had a similar role to that of gold and was used for ceremonial purposes or for the preparation of various artefacts and jewellery. It was easy to find both on the surface and in its native state in the form of lead and argentiferous veins. According to the evidence, copper was used in the Nasca area from the first millennium BCE. The more accessible mines must have been in Marcona and in the Ica zone, although there is no evidence of their exploitation. It is therefore possible that the Nasca extracted copper, existing in salt form, from the numerous veins that surfaced in the territory. They exploited deposits of silicates (*chrysocolla*), carbonates (azurite and malachite), and sulphides (chalcopyrite, etc.), which contained copper in varying proportions. Another mineral used was mercury sulphide, known as cinnabar, which provided a typically vermilion pigment, found in some Paracas grave bundles, where small packets of deerskin containing cinnabar (86% HgS) and other mineral pigments were found. This dye, in addition to red ochre, was especially used in ceremonies and funeral rites to paint the face of the dead and in the epithelial painting of persons of rank and warriors.

Among the most common processing techniques used for metals, what stands out especially is the laminating technique, which consisted in beating the product until a thin plate or sheet was created. For the best results, they alternated beating and heating the objects, until the desired thickness was obtained, reaching even less than a millimeter (Fig. 7.18). This procedure gave the metal gloss and stiffness, even if it resulted in greater fragility: to overcome this drawback, the sheet was tempered by cooling it several times with water. The custom of heating the metal probably led to the discovery of fusion, used and perfected later. Plates or sheets obtained in this way were then repeatedly processed, cut, etched, polished or burnished, punched, drilled, and drawn; sometimes semi-precious stones were embedded or applied to the surface. The most used working tools consisted of stone hammers without handles, rolling mills in volcanic stone, and a base of hard rock used as an anvil. The engraving and punching were generally carried out using bone tools. When producing masks or concave objects, pre-existing models in wood were used, and the foil was placed on top of these in order to make them take the desired shape. Foil was also used to decorate ceremonial batons, mirrors, and other products for people of high rank.

One of the art forms most closely related to the collective religious spirit of the Nasca population was undoubtedly music, which can be considered a significant channel through which to communicate with the gods. The large number of musical instruments found in the temples of Cahuachi and their documented presence among Pampas geoglyphs are undoubtedly a highlight of the complex liturgical rituals which were celebrated there. The most popular instruments were wind instruments or aerophones, of which the most frequent and representative were panpipes in ceramic or *antaras*, (Fig. 7.19) various clay or bone whistles, ocarinas, trumpets, and flutes. Although we cannot know how these instruments were played,

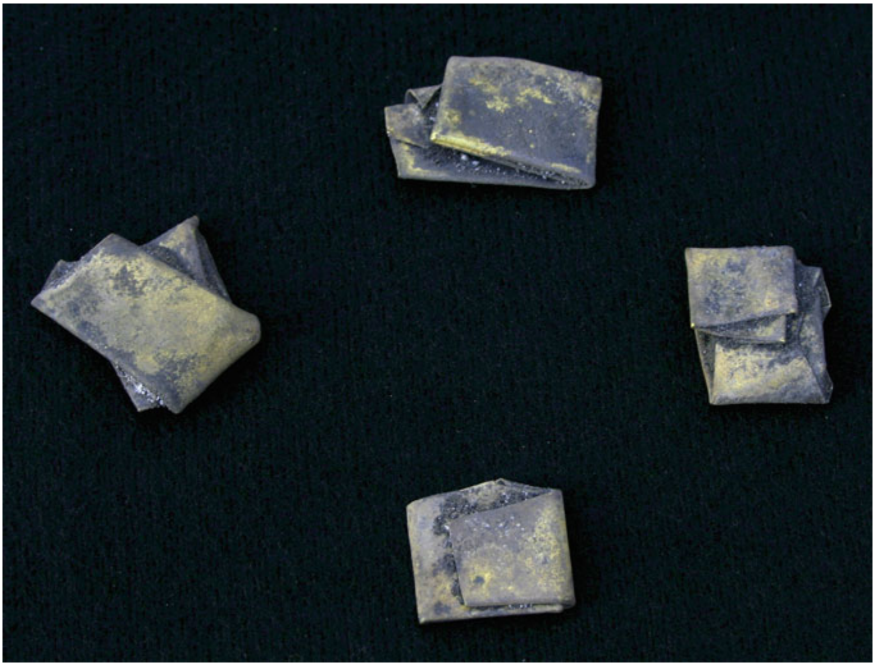

Fig. 7.18 Small gold plates, found as an offering in the vicinity of a small sacrificial altar in the north square of Templo del Escalonado (Photo by the author)

there are rare archaeological examples of scenes with the musicians in the act of playing them (for a description see Rossell Castro (1977); Bolaños 1988a; Orefici 1992; Orefici and Drusini 2003). From an analysis of the quality of the tools found in the Nasca area, it is clear that the music produced had complex features and that the music was played by soloists or groups. In ceramic iconography, there are scenes depicting a musician playing the *antara* and the drum or a rattle at the same time, and others characters sitting in front of a large jar, playing the *antaras* and drums and still others, of a more popular character, and groups of people and animals headed towards some unknown places, playing *antaras* and apparently singing or whistling.

Aerophones, with a scale or a series of intervals, include the ocarina, though these are very scarce, as well as a larger number of polychrome monophonic or biphonic whistles in the shape of animals and, more rarely, people. During the Nasca-Project excavation, some ocarinas were found in full working order (Orefici 1992: 148). Flutes were found with a single tube in bone or reed, albeit in lesser quantities than the *antaras*.

As for percussion instruments or membranophones, there was a great variety of high-quality products. Nasca drums varied in size and were generally made of pottery and decorated with polychrome designs: the largest drums reached 1.5 m high. The most common types were vascular, conical, or biconical, similar to an

Fig. 7.19 Woodwind musical instrument (antara) of Paracas-Nasca transitional period, with the black surface (photo by the author)

hourglass. The best known have just one skin, even though instruments of a smaller size have been found with a dual-active surface (two skins). The upper opening was closed by a membrane of camelid skin, which was perfectly taut having been tied below the flaring of the mouth. A smaller opening was left at the base to achieve better resonance. Ceramic paintings show the use of rattles, but it is not possible to establish the material from which they were made, although they probably used shells, gourds filled with seeds or stones, or small metal objects.

Some of the factors that brought about the agricultural development of Nasca were the water supplies from the rivers during flooding and the use of groundwater and springs at the bottoms of the valleys. In any case, the underground resources must have been used with techniques suited to their uptake, in order to irrigate large areas of land. In the area between the Río Nasca and the Río Las Trancas, systems were adopted in pre-Hispanic times based on the exploitation of water using filtering galleries, generally called *puquios*, thus allowing the development of settlements also in intermediate locations, thanks to the use of technological innovation unique within Peruvian territory (for additional details the reader is referred to Schreiber and Lancho Rojas 1988, 2009; Lasaponara et al. (2016)).

It is not clear what role Cahuachi had in this context, considering that the ceremonial center was built in a place with a constant supply of springwater, indicating that the archaeological complex was much older than the period in which the *puquios* were used, and this means that it was impossible to control the distribution of water downstream. The hypothesis, that there may have been upstream filtering tunnels at an earlier date than Schreiber puts forward, would perhaps explain how Cahuachi could coordinate agricultural activities over a much broader area. Without doubt, any idea of such territorial control would collapse with the partial abandonment of the religious center at Pueblo Viejo, Quemado, and other sites in the Río Grande Valley and Acarí after Nasca phase 3, suggesting a radical change in their socio-economic organization, as may be deduced by analyzing the towns from Step 5 and later. Cahuachi undoubtedly played an important role in territorial relations, extending its religious and political power throughout its entire area of influence.

In the complex cultural scenario that was developing on the South Coast at the end of the Early Horizon, there has a significant increase in the number of regional centers, whose influence could be seen through the spread of new iconographic elements responding to a more complex religious symbology. As difficult as it may be to explain the meaning of the symbols found on pottery and fabrics, it seems clear that, in most cases, they were associated with agriculture, and in others with the main divinities and their secondary manifestations, such as fish, birds, and snakes, clearly invoking the fertility of the earth and the abundance of resources, dispensed by the gods themselves.

Against this backdrop, Cahuachi gradually assumed the role of main cultural and religious hub around which the populations living in the Río Grande basin gravitated and were united under the same beliefs and political and social organization. The concept of the sacredness of the site is reinforced by evidence of sacrifice and continual offerings in the temple buildings (Orefici 1993a; Orefici and Drusini 2003; Silverman 1993; Orefici 2012). The last decade has seen new interpretations of the Nasca political system (Silverman 1992; Rostorowski 1993; Urton 1990; Orefici 2012), some of which may explain certain phases in the development of this culture, but there are still insufficient stratigraphic studies on the sites that have recently been located and others tied in with societies living in the highlands. The Andean model of dual division, despite belonging to a very ancient tradition, is not easy to adapt to such a chronologically remote society, given the lack of concrete evidence for its application.

The fact that centers of lesser importance accepted the sacred nature of Cahuachi increased the power of the "theocratic capital" and legitimized the privileged status of its religious leaders, intermediaries with the supernatural world, and unique representatives of ideological authority. Cahuachi's influence in the region brought about the need to increase the opportunities for cohesion and meeting between various human groups which, despite being united in the same religious beliefs, experienced different geographic, social, and environmental realities (Fig. 7.20).

In order to analyze the nature of the relationship between the various settlements, we may rely on observations and data obtained at the sites studied by the Nasca

Fig. 7.20 Overview of Zone A of Cahuachi dominated by Gran Pirámide, one of the leading examples of Nasca temple architecture (Photo by the author)

Project in the valleys of this territory. Another element that can confirm the existence of continued interchange is the variety of offerings made at Cahuachi, which includes non-native materials, such as plants, animal pigments, and minerals from different ecosystems (Orefici 1993a: 104, Fig. 129–130), demonstrating the religious devotion of groups that had access to other kinds of resources. Another factor that could explain the existence of relations between the ceremonial center and the urban centers that acknowledged its authority, was the spread of strongly indicatory elements, such as ceramics and textiles, expressing a message clearly meant to foster social cohesion through images.

Among the sites working in parallel to Cahuachi, one of the nearest was the residential settlement of Pueblo Viejo, which ceased to be occupied during the same period as the decline of Cahuachi, becoming a necropolis during the Middle Horizon, before becoming a densely inhabited settlement once more during the Late Intermediate Period and up to the Colonial Period. Also on the right bank of the Río Nasca, there are traces of large urban centers and graveyards, almost always with evidence of reuse of the sites in different periods. One of the most interesting that were studied by the Nasca Project was in Quemado, located near Las Cañas, 4 km east of Cahuachi: here in 1989, a mound was excavated indicating very early occupation (Nasca1). Carbon dating, together with the engraved *"Patrón Bruñido"* ceramic material beneath the oldest walkway, which is apparently not joined to the walls of the structure, confirmed a date of 2300 ± 25 BP. The dating of charcoal associated with the ceramic material "*Patrón Bruñido*" Incidentally, below the decking with greater antiquity, apparently not associated with the walls of the structure, it turned out to be 2300 ± 25 BP. and, due to their shape, they were probably used as deposits: this is derived from the ability to access these environments only from above and from the evidence of closure of the ancient entrances. During the same year, research continued in other sites at Jumana, Pacheco, Atarco, Santa Clara, and Usaka, chosen after surface prospecting carried out the year before. It was ascertained that Jumana was a residential settlement during Nasca Phases 1–2, and this was confirmed by the presence of ceramic materials together with the remains of very simple structures with walls in wattle (*quincha*), where holes for posts and traces of ash were found. The Jumana, Majuelos, Agua Salada and Santa Clara were very important because of their position midway between the Río Grande valley and Cahuachi and their relative proximity to the sea with its extensive *agarrobo* forests. For this reason, it is also important to consider the control that some sites exercised: for example, from Santa Clara it is possible to reach the valley of the Río Grande across the *Los Colorados* pass, which leads to Cabildo and from where a large part of both valleys can be seen. As for the architecture, *adobe* structures similar to those found in Pueblo Viejo and Quemado were found, but the *adobes* were loaf-shaped, something which had so far only been found at Cahuachi.

Further south along the Poroma basin, from Corralones towards *Hacienda Tunga*, lies a large fluvial oasis which extends into the lower part of the valley as far as the Usaka settlement near the bed of the Río Nasca. During the Early Intermediate Period, these areas must have had very intense relationships both among themselves and with the Cahuachi ceremonial center, favoring the birth and development of four large centers near the Corralones site, with another at Tunga, where there was a sizeable architectural complex probably used for administrative or public functions, and two residential settlements at Usaka. Traces of heavy river deposits can be seen at Corralones, covering any possible signs of previous occupation. When the first general studies were made at Tunga in 1982, evidence of large constructions in *adobe* were found. They were of a similar kind to those in Sector X5 in Pueblo Viejo and at Cahuachi, while the pottery corresponded to the first three Nasca phases. All the architectural remains have been destroyed due to the spread of farmland. Despite the work of grave robbers at the Usaka site, it was possible to identify five occupied areas used for dwelling and burial, two of which are from the Nasca period, plus an Early Intermediate burial ground and two others from the Late Intermediate Period. The Nasca settlements were on the left and right banks of the Usaka riverbed, both at a higher level than the current agricultural area, lying almost at the point of confluence of the Carrizal valley. The most densely populated areas of both sites date from Nasca 5–6, with signs of an earlier settlement in the form of pottery from Nasca 2–3. In the first group of buildings (EXP1Q9), two floors were discovered showing signs of sequential use. The buildings were of regular design, with *quincha* walls and a roof held up by posts, but which had been destroyed in a fire. Three groups of buildings were found at the second settlement, located at the base of a large dune which is gradually burying the river bed. Their walls were erected using blocks of pinkish limestone, joined by a clay-based mortar. Because of the size of the rooms and the absence of archaeological refuse dumps, it is thought that these buildings were not for habitation. Both Usaka settlements were reused as burial sites even in Nasca Phase 5 until being abandoned altogether at the end of Phase 7. Continuous signs of habitation were also found in the Atarco Valley from the first phases of Nasca culture until the Colonial Period. (Orefici 1992, 1993a, b).

Studies carried out at the various settlements reveal that, at least until Nasca Phase 3, the Cahuachi ceremonial center limited the growth of smaller centers in the valley, which would appear to be due to a form of architectural and functional control. In any event, with the decline and abandonment of much of Cahuachi, a radical change took place in the socio-economic model of the peripheral urban centers that which saw a new phase of expansion and cultural growth indicating strong independent development, which might be explained by a political organization based on a confederation of independent communities, bound by a shared cultural tradition and religious belief (Orefici 1992: 65). The transition from a centralized theocracy, which survived for one thousand years in the territory where Nasca culture spread together with its religion to a phase with fragmented power in the hands of feudal lords, thus brought about a rapid development of what were considered lesser settlements under the rule of the ceremonial center. Control of the water and the water distribution system were no longer at the mercy of the religious authorities, but depended on the accords of the local chieftains, based on their importance in relation to the nearby centers and the range of their own authority.

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Chapter 8
Religion in Nasca Culture

Giuseppe Orefici

Abstract The cosmocentric relation with nature was one of the factors that influenced the expression of the religious world of the Nasca Culture. In the earliest period of the Nasca civilization, deities belonging to the pantheon of the Paracas culture were represented, even if they were modified in their symbological content. The feline deity and the orca marine, in their dual connection with the land and the sea, were the highest religious representations of the Nasca cultural tradition. Some anthropomorphic or anthropo-zoomorphic deities underwent several changes in the evolution of the iconographic expression. The daily life of the Nasca population had a constant interrelationship with the supernatural world, and every action taken had a ritual purpose and a component of action with divine characteristics. Any building, renovation, and change in the ceremonial areas reflected a religious expression and the ritual activities.

Keywords Religion · Mythical gods · Sacredness · Iconography · Pottery · Rituals and ceremonies

8.1 The Supernatural World of the Nasca People

From the earliest stages of Nasca development, their mysticism and religion were extremely elaborate, drawing as they did on a belief system which would become increasingly complex within a universe of symbol and mythology that arose from the symbolism found in the iconography used in Paracas ceramics and textiles.

The deities, and a cosmocentric relationship with nature, were the foremost elements driving the development of the beliefs of the population. For many years,

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there were no major changes, and previous models were repeated without modification. The real phase of overall change occurred in the earliest Nasca period, during which new iconographic elements were introduced, reflecting a change in religious thought, although the main pantheon remained the same. Paracas symbolism was based on very rigid dogmas also respected in early Nasca art. The feline deity, the killer whale (*Orcinus orca*) (Fig. 8.1), and representations of marine and terrestrial fauna, were very similar, while the anthropo-zoomorphic and anthropomorphic deities underwent radical change with respect to the development of the specific traditions in the stages prior to the Ocucaje 7 sequence (Orefici 2012: 78–80).

The most diverse conjectures and theories on the subject of Nasca religion have been put forward without producing results able to contribute to a clear explanation of the ideological framework that supported the liturgical practice of this people for a thousand years. Various authors have addressed the subject (Tello 1923; Carrión Cachot 1959; Zuidema 1972; Rostworowski de Diez Canseco 1993), basing their theories on ethno-historical data which drew largely on colonial writers who had tried to interpret the mythical tales and elements associated with the oral tradition. The above-mentioned authors, with no possibility of breaking away from models of comparative methodology based on the survival of certain traditions among the indigenous peoples documented during the colonial period, could not help drawing

Fig. 8.1 The killer whale (*Orcinus orca*) is the highest divinity linked to the sea. Its representation belongs both to the Paracas and Nasca cultural expressions. This figure is shown in pottery decorations and in sculptural elements. It is a deity linked to ritual sacrifices and often holds an obsidian knife in one hand, while holding a severed head in the other hand (Photo by the author)

certain dangerous parallels. Moreover, attempts were made to compare examples of social organizations and the iconography of other cultures, looking to both contemporary and past examples, in search of similarities with that of the Nasca (Zuidema 1972; Rossel Castro 1977; Urton 1982; Reinhard 1988).

The study that can be considered most reliable for its analysis of the cultures of pre-Hispanic Peru's South Coast is that of Maria Rostworoski, in which she rigorously analyzes the existence of some forms of worship that may have maintained a relationship with their roots in the Early Intermediate Period, but were eliminated by the increasing Pachacamac influence. According to Maria Rostworowski (1993: 189–202), the image of the "*Felino volador*" found in Paracas iconography may be identified with the god Kon, an ancient deity responsible for the shortage of water, who thus had to be worshipped with sacrifices and prayers. According to this theory, Kon belongs to the *pantheon* of the Early Intermediate Period, since he disappeared from the myths after the arrival of the Pachacamac. As he was a winged god with the power of flight, the ancient inhabitants of the Nasca area, and above all the priests, thought they could communicate with this supernatural being by means of large drawings on the surface of the desert. On the other hand, Kauffmann Doig relates the Paracas and Nasca "*Felino volador*" divinity to another mythological tale from the Southern Andes and Bolivian territory concerning Qoa, a supernatural quadruped that moves through the air and has the power to bring rain (1989: 248–283).

From the studies carried out on the Nasca Project, it may be assumed that although certain traditions may have been maintained and are rooted in the thinking of Andean man, in the case of the Nasca, one can only count on archaeological data and the iconography found in the material culture. In addition, from recent results at Palpa in the Valley of the Río Grande and other Nasca sites, where villages, urban centers and groups of buildings contemporary with the Cahuachi are being systematically examined, it will be easier to obtain reliable data on the development of this society and to make comparisons that will provide a more realistic and unified view of what it was like.

The daily life of the Nasca population was clearly interwoven with the supernatural world and the gods who formed part of the *pantheon* which populated the religious sphere. The relationship between human activities and the gods was constantly represented in the material culture, including ceramics and textiles: human actions were shown in a ritualized image in which an anthropomorphic or anthropo-zoomorphic deity was depicted performing the same act. Subsistence activities, like the maintenance of the religious class and ceremonial activities, were part of daily life, as were construction, restoration, the filling, and remodelling of buildings and temples—all collective activities in which the people took part from time to time throughout the year. The religious world of the Nasca is represented by a wide range of personages, whose emblems probably indicate the activities in which they were involved (see Yacovleff 1932a, 1933; Roark 1965; Seler 1923; Ubbelohde Doering 1925/1926).

The representations of individuals performing various actions cannot be interpreted simply as symbolic figures in the act of engaging in an activity, but should be considered as manifestations of a divine liturgical ceremony. The human being becomes the transfiguration of a deity: the fisherman is celebrating a ritual where the act of fishing is part of the cosmogony of the religious life of the Nasca people. In the same way, the various activities, such as agriculture and hunting, or the very acts of the rituals themselves, including sacrifices, are the spiritual sublimation of daily activities. They reflect and blend with all the events and beliefs making up Nasca cosmocentrism, an integral part of every moment in the existence of this people. The job of the farmer is not seen as humble; rather, he performs what can be considered a sacred process as important as any other religious act. Symbolism is the common denominator running through all the actions depicted, and not only human activities, but also events in the life of the animal and botanical world. The birth of plants, the germination of beans or seeds in a peanut pod, and the activities of the different animal species in Nasca iconography are all part of a ritual vision running through the representations of real life, where every symbolic act contributes to the harmonious system arising from the centrality of the universe, which is also the core of the daily life of the Nasca.

8.2 The Mythical Gods of the Paracas and Nasca People

The deities are expressed in very different ways in Nasca religion, and their appearance is often not realistic, but based on a mixture of human or animal forms, thus emphasizing the divine essence of the personages and participation in a world that does not belong to reality. The main gods, such as the feline or killer whale, are often represented with additional features: the feline is frequently depicted with details that are definitely human, or with others belonging to various animal forms. The killer whale is sometimes shown with shark-like elements or with characteristics similar to those of other cetaceans. In various representations, the killer whale has anthropomorphic attributes, such as arms or legs covered by a loincloth. It should be noted that the killer whale (*Orcinus orca*) is a divine sacrifice, and, in the majority of representations, is depicted holding an obsidian knife and a severed head in his hands (Fig. 8.2).

The same kind of syncretism also appears in birdlike images, where combinations of features belonging to different species of birds may be found. As part of the work of the Nasca Project, a group of ornithologists tried to draw up a classification of bird species found in Nasca iconography, but they had to give up due to the impossibility of obtaining concrete data on the details that would allow clear identification of the birdlife depicted, as the images represented usually a combination of different species.

The feline is undoubtedly the deity that traditionally represents the highest form of divinity. It has supernatural powers and is a prodigal dispenser of bounty to humanity. In his body, in fact, one can often find different kinds of plants, trophy heads, or other items from Nasca iconography, coming out from its mouth through the tongue.

Fig. 8.2 Killer-whale-shaped vessel from Cahuachi. The figure has anthropomorphic attributes, such as legs covered by a loincloth, and is shown with shark-like elements (Photo by the author)

Since its origin, dating back to the Chavín iconography that expanded throughout the Peruvian coast, this can be regarded as the most important deity in Nasca culture, and its presence spanned the culture's chronological development. The symbology of the feline figure evolved, taking on distinctive elements that would become increasingly anthropomorphized in time. The attributes of the face and the objects associated with its image highlight the importance and the elevated position which this figure had in the Nasca pantheon (Fig. 8.3).

To emphasize the divine characteristics of the figure, the feline is most often represented showing features that do not belong to its true image. Its face, adorned with a tiara and a *nariguera* (sub-nasal ornament), is attached to a body that often includes a set of syncretistic divine symbols related to ancestor worship, perhaps linked to cosmic forces: the snake, the bird, or other animals contribute to further increasing the status of the highest divinity.

In almost all the representations with anthropomorphic elements, the feline's face is framed by *orejeras*, ear ornaments made up of four overlapping circular elements, often combined with textile elements which run down along the body. The eyes are birdlike, while the snake figure is characterized by a branching tail which often ends with a snakelike head (Fig. 8.4). In many cases, when shown with human limbs, the feline has a loincloth similar to the one worn by the killer whale.

Fig. 8.3 The feline is the deity that traditionally represents the highest form of divinity linked to earth. It is a prodigal dispenser of bounty to humanity by means of its tongue. Its face is adorned with a tiara and a sub-nasal ornament (Photo by the author)

The figure of the supreme terrestrial god most often wields a staff or a weapon, generally an obsidian knife. In this case, it represents the sacrificing deity and often bears severed heads. In other circumstances, the feline bears vegetation, such as the chilli pepper. The branching off of snakelike forms is hierarchical and occurs near the belly or the head of the deity, as in the case of the geoglyph of the many-eyed being with its snakelike protuberances from the stomach and the head areas.

In ceramic iconography, the figure of the cat depicted on globular bottles, especially the "double-spout-and-bridge" bottle, is fully developed: in many cases, the deity barely shows any anthropomorphic features; it has four limbs and in this case is often shown offering vegetation to humans, who can be seen inside its transparent body and protruding from the tongue. Among the plants most frequently

Fig. 8.4 Stylized iconography of the feline which maintains its typical nasal and cephalic ornaments (Photo by the author)

associated with it are corn, *achira*, *pallar* (the lima bean), flowers of various kinds, the peanut, and chilli peppers.

On cups or mug-shaped ceramic containers, the figure of the cat is wrapped around the curved surface, and its body is often in the form of a centipede or snake. In the case of the centipede, the later forms have arrow- or arrow-head shaped feet coming out of the body or the head. The surface of the body has catlike patches and the divinity often has two heads. The more realistic figures have animal attributes, always including large ears, which in their most complex form become tiaras or snakelike features. The cat is only occasionally associated with the *lúcuma* fruit, and, in its most stylized form, the feline has trophy heads within its body. In most cases, the tail ends in another head, associated with the two front paws. The snail-shaped body is quite rare: in an iconographic representation on a piece of fabric found in 1998, the cat figure was associated with a snail-shell shaped body. It is a complex representation of a myth, with flying fish, birds, killer whales, and other elements linked to the religious world of the sea and was probably the aquatic aspect of the feline figure, a very rare depiction in Nasca mythology.

In 2008, an unusual discovery was made on the east façade of the *Pirámide Naranja*, where an important temple offering involved numerous gourds (*Lagenaria* sp.) engraved and painted with resinous pigments, together with 88 intact pieces of pottery work and other associated objects and fabrics. Some of them had iconographic elements linked to the feline figure with bird's wings on the body, somewhat rare features in images of the supreme deity. Occasionally, the body of the feline terminates in a birdlike being at the end of its tail: in this case it is a *vencejo* (*Steatornis peruanus*), a bird of prey, or a parrot. In the above-mentioned birdlike representations, the body of the divinity contains larvae or unidentifiable seeds, sometimes encased in their pods, and, sometimes, there are chilli peppers depicted in the images of the *vencejo*.

In later Nasca ceramics, the figure of the feline is stylized and enriched with precious decorative elements which become its most important identifying symbols. In the latest representations of the feline, only the cephalic extremity appears without other figurative elements. Hook-like forms branch off from it. In some cases in which the figure of the feline deity appears in anthropomorphic form, it holds fruit in its hands and body to be distributed to humans. Among the most significant are *jíquima*, beans, and *achira*: chillies often hang from it short tunic. Corn on the cob is mainly found on the divinity's head, or in close proximity to it, while the chilli is shown in various other parts of its body.

The main god of the Nasca *pantheon* is also a sacrificing deity often associated with trophy heads, and in this case, it appears with a war club or staff in hand. Sometimes the body is decorated along the contour with arrows or obsidian arrowheads, especially in an iconography pertaining to figures associated with the end of the Ancient Nasca, which corresponds to the transition from Cahuachi theocratic centralism to the subsequent political fragmentation of the territory, with secular power becoming more prominent in the various urban centers as they gained independence.

Very occasionally, the body of the feline has recognizable sexual features, although in most cases it can be associated with the male sex, and the penis becomes a symbol of the distribution of fertility. The characteristic features of the cephalic branches of this deity include snakelike beings, also associated with water and fertility. The snakes coming out from its womb can be related to archaic Paracas interpretations, particularly common in fabrics. In the later phases, the feline is associated with the red pepper, which sprouts from its body and mouth. The nasal ornament it wears is considered one of the most important divine attributes.

Among the figures with anthropomorphic traits, the figure of the feline appears with a tail, terminating in another feline head with front legs attached. The supreme divinity is also very occasionally associated with figures of fish or other marine elements.

If the feline is definitely the highest expression of divinity on earth, the killer whale is undoubtedly the supreme sea god. Also in this case, the representation is not realistic, but has a series of anthropomorphic attributes, with arms, hands, and often legs, as well as a loincloth covering the genitals emphasizing the image of a being that not only has the characteristics of a species, but also has typical divine symbolic elements. In most representations, the killer whale appears with shark-like fins, as well as a feline face, bringing together two different land and sea gods. There are many examples of killer whales with feline ears, as well as spots along the body symbolizing those of the jaguar. The god almost always holds an obsidian knife in one hand and a severed head in the other, indicating very clearly the sacrificial nature of this divinity. The killer whale's teeth are always visible, and the mouth is generally open: in some instances the teeth are blood-stained. In certain allegorical images, the body has trophy heads inside, and in other cases there are fishlike gills, to increase the syncretic power of the image of the god.

The agricultural world appears in the products used by the Nasca and cultivated in the areas used to produce edible goods. The figure of the farmer is clearly not that of a human being, but represents an anthropomorphic deity connected with this activity. Both in ceramics and in textile art, this image, with special attributes such as a typical cone-shaped headdress stitched with black thread in front, is associated with agricultural products. It is almost always associated with a male being and decorated with birdlike motifs on the skin around the eyes. These elements, taken together, possibly have some connection with the category of people who were engaged in agricultural activities.

In some ceramics, of which sculptures form the majority, the divine being representing agriculture bears two fruits or plants in its hands.

In some rare cases, which are very important for an understanding of the divine character of the sacred being, there are ventral or cephalic branching extensions with chilli peppers attached, and the dangling penis is in the shape of the same fruit (Blasco et al. 1991: 46, n. 355). In other cases, cobs of corn protrude from the head (Blasco et al. 1991: 49, Número 357). Some ceramics show fruit between the legs of the personages or hanging from their arms, emphasizing the divine characteristics of the anthropomorph, which is always represented from the front wearing a loincloth.

8.3 The Sacredness of the Natural World

Among the most common plants represented in ceramics are the *achira*, the chilli, corn, the *jíquima*, the *lucuma*, the *yuca*, beans, and the *pacae*. The plant species are represented individually in simple form, inside metopes or panels for decorating cups and mugs. The *pacae* (*Inga feuillei*) has a special significance connected with death, as can be seen in the great Cahuachi cyclic changes. The leaves of this plant appear in the ceremonial structures of the religious center where they cover the walls of temples no longer used and intentionally buried, in the hearths or amid the sacrificial offerings buried or associated with the tombs themselves. In the religious world of the Nasca, almost all animal species had a sacred meaning. Among the other divine marine and terrestrial manifestations, there are many that can be added to the birdlike and fishlike forms, such as insects, spiders, ants, and bees. In the Cahuachi ceremonial fabrics and ceramics, the particular aspects of the terrestrial and marine symbologies can be classified as secondary manifestations of the divinity, a sort of *alter ego* or symbology that is not of vital importance. Among the less frequent are the figures of the monkey, which is sometimes anthropomorphized, as well as those of insects or larvae which are difficult to recognize, especially in representations of complex myths depicted in painted, rather than embroidered, fabrics.

The Nasca *pantheon* is extremely varied and rich in images of terrestrial and marine creatures: birds, agricultural products (Fig. 8.5), animals such as the fox, several species of fish, spiders, rats, and mice. In all cases, these images form a set of symbolic representations of deities that appear in un-lifelike forms. The religious world of the Nasca produced numerous images of birdlike beings that are part of a set of minor deities connected with the feline and killer whale (Fig. 8.6). Also in these cases, there are always syncretic elements relating to the divine beings that reinforce the importance of these birds, but they retain natural features. From the statistical data collected during the archaeological work in smaller Cahuachi

Fig. 8.5 Pallares (*Phaseolus lunatus*), peanuts (*Arachis hypogaea*), and chili pepper (*Capsicum* sp.) are part of the representations of Nasca ceramics, often combined with the figure of the feline, which becomes the divinity dispenser of agricultural products (Photo by the author)

centers, it was noted that the highest deities, the feline and the killer whale, appear much less frequently in outlying residential areas than in the main ceremonial center. This probably depended on the class of workers specializing in ceramic decoration and weaving, who worked much more often in the theocratic capital than in smaller centers. The big changes in the representation of the feline came about following the abandonment of the Cahuachi ceremonial centre.

Bird symbolism is very important in the Nasca relationship with agriculture, both as a balancing element, a marker of the seasons, and a destroyer of harvests. Similarly, seabirds too are an essential element in the sphere of fishing as they are associated with the presence of schools of fish. Also in agriculture, pest control is carried out by some species of birds, just as some produce is due to the excessive amount of birdlife. For this reason, images of green parrots, known to produce very substantial damage to fruit trees, are associated with the cyclic devastation that

Fig. 8.6 The hummingbird is part of the large amount of images referring to ornithomorphic figures. It is often portrayed in the act of sucking nectar of flowers. It is an iconic figure in the pantheon of Nasca and is also represented in many geoglyphs of Pampa. Its image is probably related to fertility (Photo by the author)

these birds brought to crops, as may be observed especially in the later phases of Nasca ceramics.

The figure of the *Vencejo* (Fig. 8.7) is one of the birds most represented in Nasca iconography. Its stylization and constant repetition also in the later phases show that this was an enduring form of symbolism in the religious world of the Nasca. Badaracco (1932) identifies the *vencejo* as the *huacharo* or *Steatornis peruanus* belonging to the Caprimulgidae, while Yacovleff (1931) considers it as an idealized syncretic figure, with elements belonging to the *Cypselus*, or "blind chicken", and the *Caprimulgidae*, with all the mythological implications of its image (see also Yacovleff and Herrera 1934–1935). This bird appears in large flocks during periods of greatest humidity, and this coincidence was surely observed and associated with abundant water on these occasions (Fig. 8.8).

Ceramic iconography shows various representations of birds such as birds of prey, falcons, condors, green parrots, herons, vultures, and hummingbirds. They all have connections with Nasca myths and religion, as they do not pertain only to iconography, but are also part of the divine manifestations themselves. Among the most common symbols representing seabirds are figures of cormorants and pelicans. Also in the periocular skin decorations of the personages, we can clearly see a connection with the morphology of the eyes of the birdlike forms.

Yacovleff (1932b) speculates that falcons were used in various periods of war, against other populations or during ritual combat. Some figures clearly show

Fig. 8.7 The vencejo (*Steatornis peruvianus* similar to the common swift) is undoubtedly one of the most interesting ornithomorphic images in the iconographic expression of Nasca religion. During its evolution, the figure has been stylized until it became a decorative symbolic presence (Photo by the author)

Fig. 8.8 During the later phases of the Nasca iconographic expression, the vencejo is represented by a triangular decoration, where one can recognize the hairs in near the beak (Photo by the author)

elements displaying birdlike characteristics around the eyes, symbolizing the power, speed, agility, and fighting ability of this bird. Birds of prey and parrots were also used for hunting or as pets and are represented perched on the shoulder of some personages and sometimes on an arm or on a stick.

It should be borne in mind that bird symbolism runs through the development of the main forms of culture in Peru, emphasizing the divine characteristics of the representation or the manifestations of the associated deities. During the phases known as the Middle Nasca, but also those belonging to the early Nasca period, there are personages with the head of a man and the body of a bird, and others with the body of a bird and a trophy head with sewn lips and eyes with offset pupils, a feature that symbolizes the deceased. In the majority of cases, land birds are associated with plants, while marine species are associated with fish.

During the 1988 Cahuachi excavations, full ceremonial robes and painted fabrics were found that formed part of the clothing used in the religious ceremonies at the ceremonial center. Various representations of myths relating to the presence of characters in combat were found among the group of painted fabrics, considered unique among the material known to belong to Nasca Culture, both because of their size and the fact that they were found all together in storage specially prepared for their burial. With them there were also representations of various kinds of marine and land birds. Fabrics with images of flying fish, seabirds, killer whales, and felines with snail-shaped bodies were also found. Other clothes featured painted scenes of condors feeding on people who had been killed and dissected before being left on the ground, probably in ritual combat. On this plain cotton fabric with painted figures, dozens of different characters may be recognized. They are characterized by hats, eye-painting, clothing, and tiaras. Condors feed mainly on the heads of the figures, which have been left severed from the bodies. It has been claimed that these are representations of myths, as two different fabrics were found, probably the work of different hands, but showing the same scene, with two llamas and a fox, although the descriptive elements appear in much simpler form than the attributes of the personages on one of the fabrics.

Another instance of the appearance of birds in ceramics is the presence of species of seabirds, mostly represented in rows, separated by black lines. Marine-bird life, represented mostly by pelicans and cormorants, appears together with various fish in the majority of cases. The land birds are often green parrots, little owls, hummingbirds, owls, vultures, falcons, and condors, which abound in the ceremonial ceramic iconography used in collective rituals. In addition to these species, there may also be flamingos, egrets, and others that cannot be recognized as they are in stylized form. Hawks and falcons are often associated with scenes involving anthropomorphic figures: they appear as accompanying characters with spears and arrows. According to Yacovleff (1932b), the hawk was of great help during hunting or was used during battles against enemy groups: some individuals wear hawk masks as well as painted decorations on the skin around the eyes, recalling the characteristics of this bird. It is therefore likely that hawks were also protectors or represented an *alter ego*, associated with the individuals who bore their symbols or belonged to certain social categories. Many birds, on the other hand, were important because of their feathers, essential for the production of tiaras, cloaks, and ceremonial robes. The hummingbird, the parrot, the ara (imported from the Amazon forest), and the flamingo have colored feathers suited to this purpose.

Among the most commonly represented birds, the hummingbird is undoubtedly the most frequently depicted, both in ceramics and geoglyphs, where it often appears at the moment of taking nectar from flowers. This bird must have had a particular significance, as its image recurs very often in Nasca iconography, both in ceramics and in embroidered fabrics. The relationship between the hummingbird and lunar symbolism was fairly common throughout the entire Early Nasca period, after which it was depicted more rarely. It also disappeared from the geoglyphs. For Cobo (1956/1653), the hummingbird was able to stop its heart in the event of danger and to start it up again later, relating this phenomenon to the concept of life after death and resurrection. Reichel-Dolmatoff (1973: 128), analyzing the symbolic meaning that the Desana attribute to nature, reports that the hummingbird is considered to be an ancestral creature and that the action of sucking the nectar of flowers symbolizes coitus.

Seabirds are very often associated with fish. The shark as represented on ceramics is particularly emblematic from the point of view of the evolution of how it was represented, shifting from depiction alone to images of ever-decreasing size and alternating with plants, seabirds, and land birds. In the last phase, before its total elimination from the figures depicted in earthenware, the iconographic sequence ends with scenes where sea and land birds are represented eating shark. There is no doubt that images of birds, sometimes associated with agricultural products, are linked to fertility, also because of the guano that birds produce.

There is frequent correspondence between birds, the worship of water and fertility, and the fecundity of the soil, as may be seen in the images portraying the rain bird, mainly found in examples of rock art, where there are numerous myths with this type of iconography. Among the collections of rock carvings in Las Trancas and Majuelos, there is evidence of scenes dominated by the figure of the rain bird performing a ceremony symbolizing the distribution of water from the sky, surrounded by anthropomorphic or zoomorphic representations.

The image of the snake appears very frequently in the first three phases of the chronological sequence of Nasca ceramics. During the Middle Nasca period, it appeared less frequently, only to rematerialize later in the final stages as a secondary manifestation of the feline. This symbol is also represented as a syncretic combination of different figures. It is clear that it is not a simple image of a snake, but of the god that takes on its form, as may be seen from the spots on the skin and the whiskers characteristic of the almost always two-headed snake figures. In nearly all Andean cultures, the figure of the serpent is connected, albeit with some variants, with fertility, water, and the renewal of life. In Nasca Culture, this is an effective representation of the concept of the metamorphosis of the feline god, of whom it is often an integral part, and is associated with agricultural produce. In the transition from Paracas to Nasca iconography, the figure of the snake appears to be connected with the highest anthropomorphic deity, i.e., the being with large eyes (the *oculate being*), as a ventral or cephalic extension of its image.

In the early Nasca period, snakes also interact with birdlike figures, in scenes where birds can be seen feeding on them. It is important at this point to distinguish between two different forms of snake representation: one as part of the main deity and another in which the snakelike being takes part in action relating to activities carried out by supernatural birdlike or snakelike beings.

8.4 Rituals and Ceremonies

The relationship between Cahuachi and the Nasca religion is very clear, as the temple complex is a ceremonial center that served for collective gatherings where large crowds would assemble. Groups came to Cahuachi from far and wide to take part in the collective ceremonies which constituted the principal form of Nasca worship. Pilgrimages were special occasions for which participants would travel even greater distances, and thus the population would come together in order to attend a ritual or religious event. The architecture at Cahuachi provides almost no clue as to what the relationship with the deities or what the rituals performed within the sacred areas were like. The majority of the evidence for religious activity comes from the images on the ceramics and fabrics that were used during the joint assemblies and liturgical events within the ceremonial center. A large number of important ceremonies must have been held at the Cahuachi temples, as can be seen from the size of the spaces for collective use. On the other hand, planned access to the closed architectural spaces was controlled by the construction of very narrow corridors and connecting passages designed to limit the movement of people.

Collective ceremonies must have played an important role in the everyday life of Cahuachi, even though it is currently impossible to establish how many people actually took part in the rituals, and the size of the ceremonial center leads one to suppose there would have been a massive influx. Religion was the most important element in the collective events, and the gods were constantly to be found in the images on the ceramic objects that were used in the sacred areas. They were also

Fig. 8.9 In the Nasca religion, the sacrifice is often present as a ritual element. The offered heads, which are inside the ceremonial centers, and trophy heads, often combined with important people, especially in the final stages of the Nasca Culture, are important and constant representations of the religion (Photo by the author)

found on the fabrics and sumptuous clothes of the personages attending. The most important theocratic center in the area occupied by people belonging to Nasca culture expressed beyond doubt the indissoluble relationship between the gods, the people and the priestly class, the true intermediary between the parties. For this reason, the fruit of this bond was expressed in communal events where the people could share in ceremonies and sacrifices (Fig. 8.9).

The rituals at Cahuachi were connected to the worship carried out in the areas featuring geoglyphs, both in the Nasca and Palpa Pampas, and near urban centers also located in peripheral areas. The duality between the two main poles was alternative and reciprocal, and both possessed the characteristics of universally recognized sacred precincts. It is impossible to know to what extent the population held events within the Cahuachi sacred sites, though it is likely that the priests who lived far from the religious centre might have access to the facilities in order to participate in collective ceremonies, while most of the pilgrims who came to Cahuachi used the areas where the geoglyphs are found for their ceremonies. After the theocratic complex was abandoned in the fifth century AD, collective rituals intensified within the geoglyph areas, as by this time the sacred spaces were now only found to the West of the religious center.

The most important temples were in close communication, enabling contact between the various groups of priests and those working within the complex. With regard to the collective rituals and ceremonies held in Cahuachi, it is impossible to say what form they took, as the only information available comes from the findings of archaeological excavations, including the remains of the sacrifices offered there.

Based on the materials found in the artificial fill used in the buildings at Cahuachi, the opportunity to prove the existence of different kinds of iconography related to the Nasca religion was one of the objectives that the Nasca Project set itself during the years of large-scale archaeological investigation. Certainly, the results did not highlight significant changes in the symbology used in the materials found in various temples, nor did they provide more information on the various modes of participation of those who came to the sacred spaces in Cahuachi. The statistical data collected do not show particular differences between the types of iconography associated with the different environments, nor the greater or lesser presence of the figures of the main deities, which in fact appear in standard form regardless of the temple structure they belong to.

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Chapter 9
The Functions and Distribution of Space in the Urban and Religious Centers of the Río Nasca Valley

Giuseppe Orefici

Abstract The sacred spaces were related to the ritual activities that took place during religious ceremonies and collective ritual activities. The relationships between spaces, corridors, and pathways that led to places of worship or sacrifice was very complex and not always identifiable. The entrances were generally narrow in size in order to facilitate the careful control over those who could participate in the events. The large squares and ceremonial enclosures also had collective functions, but they were always controlled by the priestly class. The size was often giant. Some activities, such as music or dance, had a singular relationship with some buildings or open spaces. During the archaeological excavations in the various temple sectors of Cahuachi, no residential structures have been unearthed. The urban centers and residential areas were located outside the main ceremonial center. In some cases, as in Pueblo Viejo, residential areas were interspersed with sacred and collective spaces used by the population.

Keywords Ceremonial architecture · Architectural spaces · Urban and religious settlements · Construction types · Cahuachi · Pueblo Viejo

9.1 Introduction

The use of the space inside the temples and the remaining constructions at Cahuachi, such as the large ceremonial precincts, squares, and platforms, the large crossways, and the corridors that led to different places inside the various nuclei, cannot be defined in a simple or certain way. There are no traces of the activity carried out and abandoned on the surfaces of the walkways, nor are there any clear

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indications as to the actual functions of the activities carried out in the various different areas of the ceremonial center due to the frequent renovations and repairs to the floors.

Surely the main function of the existing buildings was linked to large ceremonial events, but, also in this case, there is no certainty as to the scale of these events or the number of participants in the group celebrations. Large spaces are identifiable especially in the squares, ceremonial enclosures, and other intermediate areas between the large temple buildings. which presented architectural and symbolic characteristics in order to transcend their purely material aspect and respond to ritual or celebrative needs (Fig. 9.1).

Without doubt, understanding the ideological framework within which the internal routes were designed, or the relationships between the various areas of the same temple, and the relationship it had with other complex constructions, becomes very difficult, because this would tend to give certainty to some hypotheses that so far remain unproven. In fact, the archaeological data are not sufficient to explain the rationale of the Nasca priests or the principles underlying the concept of the liturgical movements of the people during the ceremonies and regular collective celebrations (Fig. 9.2).

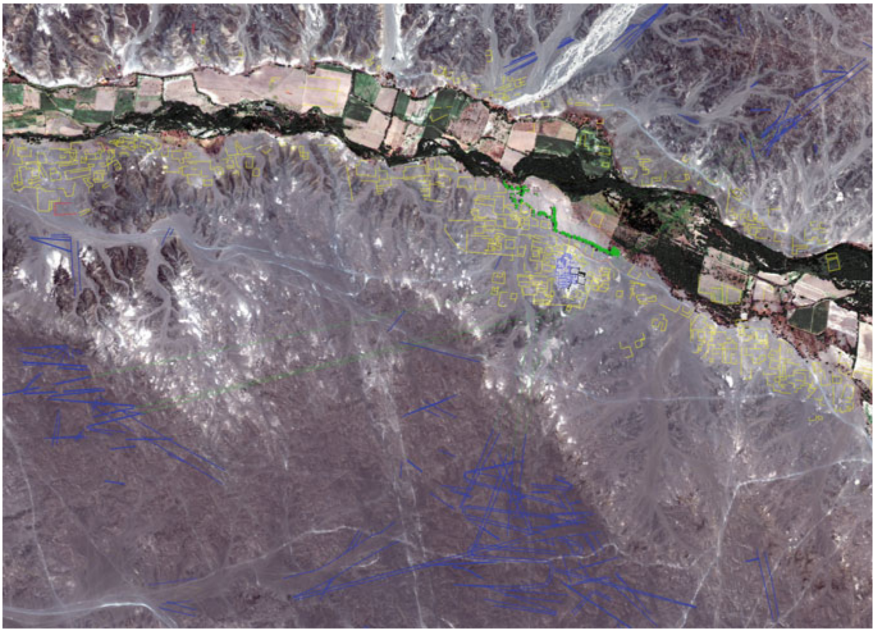


Fig. 9.1 Satellite image with indication of structures of Cahuachi (*yellow lines*) and the geoglyphs (*blue lines*) which are on the mounds south of the ceremonial center. [Elaboration by N.Masini and G. Orefici (For a more detailed map of geoglyphs at South of Cahuachi, see Chap. 12 by Masini et al. (2016))]

Fig. 9.2 Distribution of space in the ceremonial center of Cahuachi. The photograph shows the alternation of large ceremonial enclosures and spaces included in the temple platforms (Photo by the author)

Careful analysis of each structure in an attempt to understand the essential functions, depending on the size and characteristics of the small altars, niches, or other features of construction present on the site, and the offerings found in the different environments, is the only way to come closer to an at least general understanding of the functions that they had. We should also take into consideration the construction phase during which a given space was designed, in order to establish the relationships between the spaces and their organization or division, aided by an analysis of the materials found, together with their context (Fig. 9.3).

9.2 Use of Space in Various Architectural Groups

The points of access to the large ceremonial areas at Cahuachi were always small and very narrow, designed to enhance control over those taking part. Furthermore, each access communicated with only one environment and not with the surrounding spaces, which made it even more difficult to know the internal routes except for those people who knew the layout and used the ceremonial center frequently.

Fig. 9.3 Plaza Hundida of Cahuachi: half-underground space formed by removing part of the surface clay layer (Photo by the author)

The walls surrounding the squares and ceremonial enclosures were large and often constituted insurmountable visual and acoustic barriers, so that the functions performed within one environment did not interfere with others taking place nearby, especially if they were simultaneous (Fig. 9.4). It is highly likely that several hundred people could enter the ceremonial squares or enclosures at the same time, staying there for variable periods until the conclusion of the ceremonies: for this reason, there were differently-sized open spaces, but they were in any case always gigantic (Fig. 9.5).

At any given moment in the life of the ceremonial center until the end of Phase III, all the spaces at Cahuachi were monumental, designed to hold large numbers of people. Because of the structural change and volume of the buildings, Phase IV saw a reduction in the interior spaces of temples and buildings in general, with the various areas often being divided into smaller spaces (Fig. 9.6). The ancient and universal tradition of the space enclosed by intentionally large walls generates a kind of ambiguity in the relationship between inside and outside, as the viewer focuses on the façade as a focal element, which in this way both absorbs the tension of spaces and attenuates the contrasts. The thickness of the wall structures is often variable so that, besides their enclosing function, they can be seen as an interspace that intentionally defines this differentiation between internal and external space: the first protected and the second open towards the assembled crowd and the landscape.

Fig. 9.4 The great corridors of access to the platforms lead to specific areas by means of separate staircases (Photo by the author)

Fig. 9.5 In Cahuachi, the large enclosures chronologically associated with temples accommodated different functions over time. At the end they, were used as cemeteries or to hold ritual offerings (Photo by the author)

This period in Cahuachi's history also saw the rise of crafts and trade, even if this change did not imply parallel changes in the celebrative and religious functions in the areas used to these ends.

Thousands of fragments of *antaras* (ceramic Pan pipes; see Chap. 18) were found during the excavation of the main platform of the *Gran Templo* (Sector Y5,

Fig. 9.6 Some interiors were for the exclusive use of the ruling class. In Sector Y2, a tank for ritual ablutions and a small water-feed channel, excavated in the natural clay layer, have been found (Photo by the author)

EXP39) between two superimposed levels in relation to the parallel rows of columns on the walkway. They had been purposely broken during a ceremony of sacrifice and left beneath a new floor that was placed on top of this material. Such a quantity of remnants of musical instruments, as well as large ceramic fragments of a huge drum, placed in areas of fill and in small ceremonial wells in the floor of the sacred precincts, part of which were also placed in an utilitarian olla in the flooring of the walkway, suggests a close relationship between the spaces used for liturgical ceremonies and music within the ceremonial centre (Orefici and Drusini 2003; Orefici 2012; Orefici 2016).

In other cases, e.g., the sector called Y1, intact ceramic whistles were found, wrapped in fragments of cloth and placed in contact with the walkways, as well as fragments of ceramic drums offered to the gods inside the environs of the temples. Music seems to have been an essential element within the ceremonial spaces and was closely associated with the activities taking place within them, both as an act of celebration and as a cohesive force between those participating in religious activities.

Twenty-seven *antaras* were found in Sector Y13. They had been offered to the gods and placed in a crack in the floor caused by an earthquake that had brought down the south perimeter wall facing the outside of the building. This finding emphasizes the importance of music in the activities that took place inside Cahuachi. It seems that musical practices increased significantly during architectural Phases IV and V, possibly because in these periods in the life of the ceremonial centre, the number of collective rituals involving musicians with their artistic instruments also increased. The presence of large ceremonial precincts, squares, and areas suited to great celebrations show the roles that sacred music and the acoustics of the buildings had (Fig. 9.7). During excavations in 1996, an experiment was carried out, in which a ceremonial ceramic *antara* was played from on top of *Gran Pirámide* as recordings wre made sound in various areas of Cahuachi, both during the night and in daytime. The result was surprising, given that the music was heard without difficulty as far away as the Gran Pirámide II, at a distance of 950 m. This confirms that the sound of just one *antara* could be heard at a considerable distance and that, still today, the place has retained acoustics similar to those of many centuries ago. If it is assumed that music was performed on many hundreds of *antaras* at once, it is likely that the sound produced was heard at a considerable distance, giving a value and a special significance even to this supplementary activity to the liturgy of the ceremonial center.

The actual height of the walls at the time the buildings at Cahuachi were in use is unknown, but we can deduce that their size considerably exceeded that of the present walls (Fig. 9.8). In the Eastern Square of the *Gran Pirámide*, after emptying the open space of the alluvial deposit that had filled this ceremonial area, the surrounding walls were reinforced, simply restoring the plaster that covered the walls, without increasing the actual height. This operation produced significant acoustic effects, making it possible to hear sounds at a great distance. It is possible that working on

Fig. 9.7 The large enclosures associated with the temples covered different functions over time. In sector CAH91Y13EXP48RI, 64 sacrified camelids were found. The camelids were buried at the same time as an offering to the temple, before the final sealing (see Chap. 19 by Orefici 2016) of the ceremonial buildings, during the abandonment of Cahuachi (Photo by the author)

Fig. 9.8 Access to the interiors of enclosures or squares (Photo by the author)

these walls produced a kind of resonance chamber capable of transmitting words or sound great distances. If the space of the square was actually used for the accompaniment of rituals by musicians and dancers, there is no doubt how great the impact on those who attended the ceremonies must have been achieved. The main platform of the *Gran Templo*, with its columns that damped out the echo, must have been associated with the music and acoustics of the *antaras*, whose remains were found fragmented between the two walkways connected to the hypostyle area.

In Sector Y13, including the discovery of the *antaras* offered up in the aftermath of the earthquake, it can be said that the shrine was perhaps associated with music, as indicated by the presence of great numbers of fragments of large musical instruments found during excavations in the 90s. A special feature of the *antaras* found in Y13 was the uniformity of nine pairs of musical instruments similar in terms of morphology and decoration, from a total of twenty-seven specimens. According to Gruszczyńska-Ziółkowska (1995, 2009) each of these pairs of instruments had probably been made in such a way that it was identical to the other not only in its decorations, but also in its sound and sequence of sounds, unlike the *antaras* that were not part of a pair (Gruszczyńska-Ziółkowska 2009: 222–244; see also Chap. 17 by Gruszczyńska-Ziółkowska 2016). Another feature that indicates a relationship with musical activities, is the discovery of *antaras* scratched on the walls of the so-called “*Cuarto de lasEstacas*” by Helaine Silverman in 1984 (Silverman 1993: 180, Fig. 13.10).

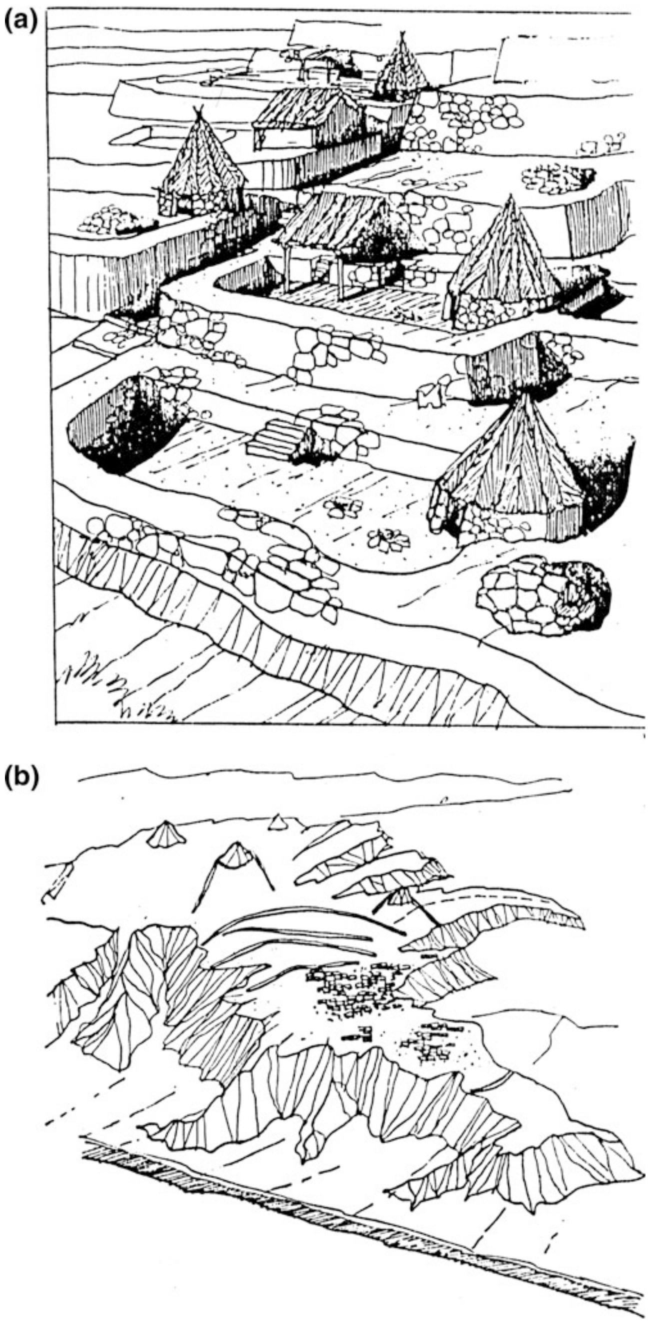
9.3 Typology and Use of the Architectural Structures in the Various Settlements

The difference in kind between the Cahuachi ceremonial center and the other Early Nasca nuclei that have been studied up to now is immediately evident, especially in terms of the significant variation in the size of the buildings and architectural complexes as a whole, according to the different functions performed. There is a substantial difference between the concept of ceremonial center and the city or nucleus of dwellings, both in terms of the construction model used and the choice of where to erect the buildings. In the case of Cahuachi, the prerequisites already existed for a settlement with ceremonial features, due to the existence of natural terraced layers in the clay close to the water.

The natural formations terracing down to the river valleys doubtless also favored the construction of dwellings, where villages sprung up in linear patterns and parallel to the contor lines, and the residential spaces were arranged on levelled embankments and delimited by retaining walls, facing the valley and covered by roofs supported by *huarango* poles and walls of *quincha* (wattle) used as a barrier (Fig. 9.9). However, the difference is visible in everything concerning the urban structure of the area where there are residential buildings, which are of a completely different type from those in a ceremonial center.

In Pueblo Viejo, where the Nasca Project carried out archaeological excavations between 1983 and 1988, an important and extensive settlement of dwellings was found. Its chronology and the types of structures varied, even if a uniform urban planning system was maintained, based on linear development over nearly three and a half kilometers, parallel to the *Río Nasca*, on the left side of the river. While no evidence of housing construction has been found at Cahuachi, in sectors X2, X4 and X5 at Pueblo Viejo, there is evidence of residential buildings, possibly divided by occupation or social class. In one of the areas examined to the west of the settlement (Sector X5–X7), different construction features from those of the oldest sector called X3 were found. Among the seven areas excavated in Pueblo Viejo, sector X3 corresponds to the oldest complex of the transitional Paracas–Nasca period. Three terraces were found which had been used as earthworks for the construction of early houses, following an ancient model present on the South and Central Coast. The walls containing these platforms were built using stones of fluvial origin mixed with clay (Orefici and Drusini 2003, pp. 46–51). Despite continuing its horizontal growth parallel to the riverbed, in this case, the architectural structures were erected primarily using *adobe*. The type that was discovered consisted of a sequence of buildings forming flat, partially-artificial terraces, alternating with inclined ones. Between them there were connecting corridors linking the different areas used.

In the area called X5, buildings designed for residential purposes were found. The buildings faced downstream and had a wall built up against a natural clay layer whichhad been hewn to provide a support for the structure that it bolstered. In contrast, the side walls had 40–60 cm bases of *adobes,* supporting walls made from


(a)
(b)

◀ **Fig. 9.9** Construction types of Paracas–Nasca period (according to Williams 1980). Chocholtaja (Ica): the houses rest on terraced embankments (andenes). Tajahuana (Ica): fortified settlement on a hilltop, overlooking the valley, protected by groups of defensive walls

quincha, and these functioned as partitions between the rooms that followed on in sequence. The average size of the rooms was approximately 6 m^2, and these communicated with corridors at slightly lower levels. The entrance was on the north side, looking towards the valley and the agricultural areas. Most roofs were presumably formed by a structure of *huarango* poles (*Prosopis pallida*) and supported trellises of reeds and bundles of vegetable matter tied together with ropes of reed and ***cattail*** (*Tipha* sp.*).* Although the discovery of these materials is very common in archaeological excavations, there is no absolute certainty that these are in fact the remains of roofing.

Among the different dwelling areas, there were areas without any buildings, possibly used as separators between different functions or to mark areas of different social levels or collective activities. In the case of Pueblo Viejo, it was possible to observe in an area midway between two dwelling areas (referred to as X1 and X3) the presence of a terraced complex with inclined platforms and a small ramp, which connected the highest parts to the base. The building work had extremely archaic characteristics, with its conical *adobe* and loaf-shaped superstructures. It is likely that it was a place of worship used by the inhabitants to celebrate religious functions, without interfering with the power of Cahuachi, which represented the main religious center in the whole area of expansion of Nasca Culture. The terraced type of construction, with a large monumental base, however, led to the supposition that this was a complex with very specific properties, that it was a building for the specific religion of the settlement, and that it may have been a multipurpose building for religious and ceremonial use, though for use by a smaller group of people.

The Nasca Project was able to carry out research and excavations in various urban settlements in the Río Nasca area and that of its tributaries. At Majuelos, Santa Clara, Quemado, Atarco, and Usaca, it was possible to ascertain the existence of numerous dwellings of different sizes. At Atarco, it was evident that they not only ran in parallel to the valley, but were also built up around nuclei. The types of dwellings had very similar characteristics in all cases, as could be seen during the excavation works that were carried out between 1988 and 1989. In the large urban centers in the valley of the Río Grande, such as Coyungo, Las Brujas, or in those that sprang up along the tributaries of the Río Nasca, such as Los Corralones and Mancha Verde, it was clear that the characteristics of the dwellings had strong similarities.

In the buildings belonging to the Early Nasca period, like those relating to the subsequent phases of development, the same construction model persisted, but, in the Middle and Late or Terminal Nasca, the houses were smaller and in some instances there was an internal or central patio.

The remains of large residential areas reused as a necropolis in Middle and Late Nasca were found in Usaca, where large areas were discovered occupied by dwellings connected to a vast urban complex currently covered by a very large dune that has shifted over the last 2000 years, completely hiding the village and the whole right side of the valley.

Among the building complexes at the ceremonial center at Cahuachi and in the smaller urban settlements, archaeological excavations revealed the presence of extensive layers of vegetation alternating with earth, indicating that this was a structural model that was repeated and was part of a cultural constant (Fig. 9.10). In many cases, the layers of vegetation were used to give greater elasticity to the overlapping walls in the event of earthquakes or landslides, as well as to confer draining capacity to the soil beneath in the event of rainfall (Fig. 9.11). The technique used for the construction of *quincha*, as well as that used for the walls in loaf-shaped *adobes*, was always the same in the various places where it was employed. The type of binder used between the unbaked bricks always had the same characteristics in parallel chronological phases in the various places where it was used. It is therefore a reasonable hypothesis that there were groups of specialists, workers specializing in the different types of buildings for urban or ceremonial use, that moved around according to the needs of the various villages or

Fig. 9.10 Large artificial fills constituted by alternating layers of vegetables, earth, and materials from ceramic sacrifices and offerings (Photo by the author)

Fig. 9.11 Artificial fill of the Plaza Hundida as a final seal of the space for the first abandonment of Cahuachi (Photo by the author)

religious centers, making *adobes*, and preparing various binders using degreasing chosen according to need. These specialists probably prepared and processed the plaster that covered the buildings at both the ceremonial center at Cahuachi and in the peripheral urban centers.

The relationship between the lesser sites and the ceremonial center was constant and productive. The urban centers probably supplied Cahuachi with agricultural products and consumer goods, also providing the manpower necessary to carry out maintenance and in some cases the occasional restoration of the temple structures. It can be assumed that the inhabitants of the peripheral areas were the direct protagonists of everyday life and in some of the religious festivals or during them, due to their proximity to the major ceremonial center.

By examining the presence of pottery in the houses located in areas directly related to Cahuachi, it is possible to notice some particular differences compared with the material produced at the religious center. It is likely that there were pottery workshops, and the statistics compiled by the Nasca Project show recurrent iconographic representations of plant life, geometric symbols, and trophy heads, with birdlike or fishlike figures.

Studies of material found in the small towns immediately reveal the use of different colors from those used at Cahuachi, and the techniques for producing the figures represented are less defined. Some of the religious themes represented on the earthenware at Cahuachi are almost absent in the small towns, as are the killer whale and the feline, while the figures of sacrificing officiants are sketchy and are depicted less elaborately. The images of the characters related to farming, fishing, and hunting are also less common in the peripheral areas, and woven or embroidered ceremonial images are very rare, or at least no trace of representations of the myths or complex iconography of the religious world typical of the Nasca have been found. Very often, there are simple images of plants enclosed in panels, as well as geometric shapes on a light or white background. The most common forms are the simple ones such as cups, mugs, and various containers in traditional forms, even though more complex forms such as double-neck bottles with bridge handles or containers with stirrup handles or sculpted earthenware do not appear.

The remains of textiles or other activities found in the areas of the smaller towns are scarce and, above all, cannot be identified as elements produced locally or at the Cahuachi ceremonial center, since they are certainly the result of grave robbing, as may be deduced from the fact that they were found scattered on the surface and all mixed up (Figs. 9.12 and 9.13).

Fig. 9.12 Tomb structure within a platform east Pirámide Naranja. The building, in the form of a small temple, coexisted with other activities related to the ceremonial life of Pirámide Naranja, though it was a burial place [This small temple covers the burial place of a young priestess discovered in 2009 via the contribution of geophysical prospecting by the ITACA mission of the Italian CNR (Lasaponara et al. 2011)] (Photo by the author)

Fig. 9.13 Column base belonging to one of the platforms of Gran Pirámide: this support system of roof structures was used in almost all the temples of Cahuachi (Photo by the author)

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Chapter 10
Petroglyphic Images and the Sacred Valleys

Giuseppe Orefici

Abstract The origins of American rock art derive from symbolic elements that follow the dynamics of migration of human groups during the Upper Paleolithic. It is a universal language of conceptual expression, enabling those who come close to a sacred area, with the presence of rock art, to identify issues pertaining to local history, but also enabling others to date an emblematic cultural heritage present in the Andean territory. The largest concentration of petroglyphs is in areas where earthquakes have caused landslides and fractures in stone blocks. Between Palpa and Nasca, there are numerous rock-art sites which have common elements of religious themes and symbols. Frequently, the rock-art sites have all the features required to be considered sacred. They are a sort of large open-air temple, where rocks become the most suitable material on which to inscribe thoughts and concerns, or to fix events in history and recognize common traditions linked to religion and ancient myths.

Keywords Petroglyphs · Paracas age · Palpa area · Chichitara · Las Trancas and Río Aja Valleys · Iconography · Symbology

10.1 Introduction

A comparison between petroglyphic images on the American continent, and in particular in Peru, with rock art in areas of Africa, Asia, and Europe reveals a much more homogeneous situation, and one that is, above all, less susceptible to external influences. No substantial changes emerge in the traditional forms, which became consolidated over time using very similar themes and *logos* everywhere from North

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America to the southern tips of Chile and Argentina. The evolutionary process was quite similar in terms of the use of symbols related to concepts linked to nature and the material on which the expressive dynamic could take shape. It should also be considered that technical execution often depended on the hardness of the rocks on which the scenes were produced and on the materials used to make the engravings or paintings.

The themes depicted often derived from myths or scenes in which episodes relating to different forms of religious expression became interwoven, such as the legendary transformations of the figures making up part of the world of the ancestral heroes or ancestor worship (Ravines and Bonavia 1972). In any case, dogmas relating to the gods were the basis for these representations, maintaining continuity between the symbols and the relationships between the various figures.

The origins of American rock art stem from roots that follow the dynamics of the migration of human groups, bearing witness by its very presence to the cultural heritage that was handed down from the territories covered during the slow migration through the American continents. Above all, what is preserved are the elements that make up a universal message of communication, unlike the forms of expression that derive from other types of iconographic representation, such as later ones linked to pottery or textiles, as these are more influenced by the religious classes or those close to political and social power as a means of communication at a distance.

Rock art, instead, needs to be (for those who arrive in places with artwork of this kind) a sort of contribution that becomes one with the territory, forming with it a single and binding element of expression bound to the society that produces the petroglyphs. This characterizes a new set of principles related to religion or magical—religious manifestations where the myth defines the canons of expression manifest in the concepts of rock art, be they engravings or paintings. In any case, this form of artistic activity makes reference to those universal characteristics of communication comprehensible even to those who do not belong to the same culture, but participate, as an element of the universal system of expression, in one of the symbolic values of communication. This happens because a sometimes heterogeneous vision is established, but it is equally comprehensible because it addresses themes pertaining to a common ability to take in concepts that can be considered universal. The symbolic meanings are recognized by anyone who approaches a shrine with petroglyphs or shelters where there are rock paintings that confer upon it a sort of sacredness. Archaeological research must always consider every aspect of the various expressions of culture, and rock art is rich in iconographic elements, often required for the interpretation of the symbols and related to the presence of mythological elements (Menghin 1952, 1957; Linares Málaga 1999).[1]

[1]Early studies in pictographic analysis were carried out in the north of Peru by Cardich (1964), Muelle (1969), and Ravines (1967, 1969, 1982, 1986). Further work on petroglyphs was done by Krickeberg (1949), Linares Málaga (1966) and Guffroy (1980–1981, 1987). Núñez (1986) analyzed thousands of petroglyphs, producing drawings, sketches, and photographs of the seventy major sites located throughout Peruvian territory, and his record is still considered to be one of the

Only in recent years has rock art become an object of serious study in Peru, as up until a couple of decades ago, it was considered of absolutely no use in the interpretation of archaeological data. Lately, more studies of rock art have also been carried out in the Coast of Peru, establishing a new trend in the analysis of rock art as a means of understanding the ancient pre-Columbian cultures and thus identifying through this study further elements of iconographic analysis. Before the 1980s, there was very little research into rock art, but there are now high-level studies that make it possible to come up with fresh interpretations of the thought of the ancient peoples who used this medium, bringing to the fore new data on their cultural, social, political, and economic characteristics as well as on collective ritual.

10.2 Nasca Project: Studies of the Rock Art in the Nasca and Palpa Areas

As of 1982, one of the main, and oldest, objectives of the Nasca Project was the development of the iconographic analysis of Nasca geoglyphs in parallel with the study of the motifs on the pottery and textiles from the San José archaeological site. The figures and scenes found on the walls of the sloping hills were identified separately, classifying them as macro-engravings belonging to a type of large-size rock art in the valleys of the Nasca and Palpa area after comparison with other similar ones in locations within the region.

The valleys where this form of expression appeared, in particular in the Llipata (Palpa) area, constituted a constant use of these spaces as sacred precincts, where the geoglyphs became an integral part of the rituals celebrated in the flatlands below. The representations were mostly of mythical heroes: ancestors, who were part of the collective cultural memory of the populations that entered the sacred valleys.

In parallel with the study of the geoglyphs in the Ica region, around a hundred rocks in Chichitara (Palpa) were studied, as this is one of the best examples of rock art in the area. Between 1982 and 1984, several studies were carried out in the Palpa and Nasca areas. Subsequently, the search was resumed in 2002, 2003, and again from 2011 to 2012, both on the petroglyphs and the pictographs found in several valleys in the region used as axes of communication between the *Sierra* and the

(Footnote 1 continued)

most complete in terms of picture quality and comprehensive documentation. This is essential reading for anyone wishing to approach the study and analysis of rock art in Peru. In 1999, Jean Guffroy published the first book that tried to create an overview of rock art found in Peru. In the Nasca area, Proulx (1998, 2007) carried out a thorough archaeological investigation which also included rock art, and Nieves (2006, 2007) analyzed all forms of petroglyphs found in the valleys of the Nasca territory.

Costa, including those that communicate with the Ayacucho[2] area, which has always been one of the starting points for migration to the south coast of Peru. Subsequent studies carried out by the Nasca Project were conducted in the valley of Las Trancas, on Huayhau micropaintings, and on the Aja Valley petroglyphs. In 2002, a study was made of the scattered engraved rocks in the Majuelos area as well as the rock shelters with their large figures of mythical characters, such as the killer whale and the dolphin in the same location. In addition to these two main images, there are also various petroglyphs partially destroyed by treasure hunters who dug below rock shelters in an attempt to locate the remains of tombs. In Majuelos, the concentration of petroglyphs on soft sandstone rocks is mixed with a series of small paintings and lines of cup marks, typical of places with strong sacred associations.

The engravings found in isolated places or in small numbers were mostly carved in porphyry, diorite, granite or andesite so that they would last much longer, and they would not deteriorate as happens with sandstone, where they endure for much shorter periods due to the effects of weathering (Orefici 2013).

Most of the concentrations of rock art are located near areas subject to landslides involving rocks from the uppermost areas of the adjacent hills or sites where the wide temperature range causes rocks to fracture. In addition, frequent earthquakes in the area cause large blocks of rock to fall to the bottom of the valleys. The highest concentration of rock-art stations is located along the Río Aja, especially at the Pongo Grande and San Marcos sites. In the Río Santa Cruz valley, petroglyphs are present in the middle area along the river, at a higher level, where two large rocks were found engraved with a number of different scenes[3] (Figs. 10.1 and 10.2). In the valley of the Río Grande, there are other isolated sandstone rocks with rock-art scenes of a more recent date than the petroglyphs in Ingenio, Las Trancas, Aja, and Hamca, which were the most important axes of communication between the plateau of the *Sierra* and the coast.

One of the biggest problems of interpretation, when dating the petroglyphs in relation to the local cultures on the basis of a known style with a precise cultural dynamic, is that of being able to define the relationship between the two periods when the works were created. In many cases, the cultural manifestations found in areas where there are also deposits of rock art do not correspond in chronological terms, as the human group that produced the petroglyphs or pictographs was often divorced from the indigenous cultural context (Orefici et al. 2009; Orefici 2012, 2013).

In many cases, the predominant culture depends on an evolution arising from the religious and cultural matrices that determined its presence. Rock art is very often

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[2]The pictographs and petroglyphs in the Río Aja valley are in a deplorable state. These are major elements of iconographic reference relating to the coastal valleys and the *Sierra*.

[3]Different rock art sites, mostly isolated or with a poor concentration of figures or particular scenes, were found in the Valley of the Río Santa Cruz. Two large stone blocks were identified on the left side of the river amid the various rocks, completely covered with figures and complex iconographic themes. The petroglyphs are located in an area next to large trapezoidal and rectangular geoglyphs. Overall, the site is a sacred place of great spiritual importance and was used for collective rituals involving the population of the valley.

Fig. 10.1 Santa Cruz. Large rocks with complex petroglyphs portraying characters with tall headdresses (Photo by the author)

Fig. 10.2 Santa Cruz. Large rocks with complex petroglyphs that highlight semicircular divisions of spaces and characters provided with control sticks (Photo by the author)

created using parameters that draw on existing local traditions, maintaining their patterns of transmission and representation of iconographic and conceptual data. In this way, the integration between the dominant society and sometimes geographically distant human groups, or those that settled in the same region but remained faithful to their ancestral cultural patterns, created new forms of interaction. In this scenario, the rise to power of a priestly or political–religious class could definitely become a point of reference for specific forms of an existing society, though the essential features of the iconography adopted by the theocratic élite did not always coincide with those established locally.

In some cases, there is also an overlapping of several iconographic themes, making it even more difficult to place the images within a reliable chronological framework. In other circumstances, a persistence of images and expressive systems crystallized over time insofar as there is a cultural dynamic that does not respect a developmental sequence. The continued use of a site for long periods of time constitutes a further difficulty in establishing a cultural sequence in terms of chronology or interpretation.

Positive results can be achieved on the basis of a relative chronology based on the study of overlapping figures or symbols that provide the data to obtain a relative chronological sequence, especially when considering all the stylistic elements and their evolution in the same place. Similarly, an analysis of the oxidation of the rocks and the patina on the engravings[4] can provide additional data for a study of chronology. The rock art in the larger areas can even make it possible to recognize forms of cultural relationships, migration, or periodic displacements of the population depending on the possibility of defining the existing symbols with certainty.

The iconography of the oldest petroglyphs centers on images of large wild animals and hunting scenes, where man is often the protagonist, killing animals using spears or projectiles thrown using *estólicas* (propulsors). The next stage in their evolution is presented through increasingly complex themes where the figures become stylized, more geometric, and more schematic: complex scenes appear where semantic *logos* form a true narrative sequence of events or myths that help define the cultural tradition of American man in all its components. There is a gradual transition from naturalistic and descriptive representation to themes full of symbols that represent the complex expression of myths in scenes containing various elements, often including characters of different sizes based on their power or importance. Similarly, there are often depictions of "big hands"[5] and rain-bringing birds with scenes showing the distribution of water to humanity. Even if in some cases these figures are found on rocks where schematic solar or lunar figures appear, these belong to a later date.

[4]Taking into consideration such additional factors as the nature of the rock, the wind, and exposure to the sun and rain.

[5]These are characters with giant hands emphasizing their spiritual power or that of the shaman being depicted. These characters are frequently represented in different sizes and are often larger than the other humans present in the same scene.

10.3 Chichitara

Two different studies of petroglyphs were carried out[6] at the Chichitara site, and 46 rocks were catalogued. In some cases, rocks showed more than one simultaneously. The cultural material observed on the surface consisted mainly of utilitarian and ceremonial pottery shards, as well as fragments of coarsely worked flint.

On the Chichitara rocks, the symbol most often seen undoubtedly represented the cat figure. It is an image devoid of anthropomorphic attributes and is readily identifiable, especially thanks to the tail and spotted coat.[7] The figure is reproduced in all its variations, from naturalistic to much more stylized forms, indicating that the theme of the cat does not disappear over time and continues to the most recent works in Chichitara, as this was considered to be the ultimate expression of the deity in the Costa del Peru pantheon.

Birdlike symbols (Fig. 10.3) are very numerous among the frequent depictions of nature, and they are always associated with symbols of water, both when they are represented frontally with outstretched wings and when the image shows the bird with drops of rain dripping from its wings.[8]

Anthropomorphic examples are also very frequent. In Chichitara the characters seated on a bench schematically reproduced are typical (Fig. 10.4). They are in hieratic position, and the attitude is one of control. In some cases, humans are included in complex scenes where they participate in activities related to water or fertility cults, often accompanied by other zoomorphic or anthropo-zoomorphic entities. In the representations, the characters can often be identified by their disproportionate limbs and can be classified as “big hands”, where the shamanic, or at any rate supernatural, power of the being is emphasized. Some anthropomorphic figures have limbs with extra fingers, indicating the relationship between this anomaly and fertility, and especially agriculture. In other cases, the anthropomorphic figures often have trophy-heads in their hands, indicating the attitude of sacrifice proper to the mythical character or deity, and are often depicted with large cephalic ornaments or with feathers arranged in a sunburst, reflecting solar symbolism. The animals most often depicted are undoubtedly camelids, cervids, and canids.

The iconographic evidence shows subjects that can be defined as belonging stylistically to the Final Early Horizon, the Early Intermediate Period, and in some specific cases, the Middle Horizon. There are few elements that can be defined as stylistically connected with Chavin representations, even if they provide sure

[6]The studies of petroglyphs at the Chichitara site were carried out in 1982 and 1983 (Orefici 1989, 2013).

[7]The spots are often represented in positive or negative context. In some cases, the figure of the feline is associated with solar symbology or complex representations, and, in other examples, with the two-headed snake, which appears with a spotted body.

[8]There are various representations of birdlike figures, the most frequent of which are condors, hawks, and birds of prey, in general. In many cases, the bird of prey is represented in the act of eating snakes or reptiles.

Fig. 10.3 Chichitara: deified ornithomorphic figures, with feline spots and circular elements associated with heads (Photo by the author)

Fig. 10.4 Chichitara area (La Viuda). Rock with hieratic figures of seated characters, with feline face and various cephalic attributes (Photo by the author)

evidence that some petroglyphs belong to this cultural period. Relative chronology can also be associated with some pottery remains which it was possible to identify in the Chichitara area. The most common technique used at this site is surface percussion with stronger engraving in the furrows to obtain greater depth using stone tools.

10.4 Petroglyphs in the Las Trancas and Río Aja Valleys

The Las Trancas valley is the site of the oldest petroglyphs, even if new examples have been found in recent years in the mountains that surround the valley itself and around the upper part of the river, although they are less concentrated than the better known examples on the bed of the watercourse. The oldest are those with greater levels of oxidation. Chronologically, the petroglyphic representations of Las Trancas can be placed between the Early Horizon and the Late Intermediate Period. The most numerous are those belonging to the Middle Horizon.

During an initial inspection to analyze and catalogue the petroglyphs in the Las Trancas area, 16 rocks were identified as having fallen from the sloping walls of the surrounding hills in the course of geological and climatic–environmental events. Most of them have a smooth and uniform surface. It was possible to establish chronological differentiation by means of the iconographic motifs and graffiti present, as well as the style and type of oxidation on the rocks. Three main stages of intervention were established on the Las Trancas rocks. The first phase is characterized by naturalistic figures, among which the predominant one is an image of a condor in profile with closed wings, but unfortunately it has been damaged in recent years, like many symbols in the flat part of the valley which were discovered in 1983. The most frequent scenes, on the other hand, are semi-natural settings with anthropomorphic and zoomorphic figures. These are of medium size and make up a large part of the petroglyphs in the valley. The images show sacrifices where the officiant is a human being, but wild and mythical animals also participate. It is likely that scenes showing these themes may be related to sacrifices made during cult rituals concerning water and fertility (Fig. 10.5).

In the second phase, most of the scenes are complex, but the iconography of isolated figures may best be attributed to the Andean *Sierra*, given the schematic and geometric nature of the composition. Some of these are more similar to those of Chichitara and the area of Río Aja, especially given their relationship with the religious and cultural development of the area.

The third phase concerns mainly scenes containing features that show elements of continuity between the figures participating in the settings, with actions and symbols belonging to a gestural form, but they communicate their messages dynamically. The technique used to make the petroglyphs of Las Trancas is mixed, consisting of percussion and abrasion using stone tools. A tentative chronology for the petroglyphs of Las Trancas falls between 1500 and 1000 BCE for the earliest phase, whereas the second and third evolutionary stages refer to the first centuries of

Fig. 10.5 Las Trancas scene of mythological representation with a central figure of an anthropomorphic rain-bird (Photo by the author)

the Common Era, including the entire Nasca Culture period. The rocks that were identified in the Quemazón area after 2000 have characteristics closer to the second and third stages of the stylistic evolution of Las Trancas, although in some cases their schematic and geometrized style shows the use of themes that are not typical of the Nasca valleys and are possibly part of a legacy coming from the *Sierra*.

The valley of the Río Aja was in use for a long period, as it formed one of the main communication routes to the area currently occupied by the Ayacucho Region in the Andean *Sierra*. The valley contains the remains of several urban centers, much used from the Paracas era up to the Late Intermediate Period. One of the most significant archaeological examples is the city of La Tiza, which was destroyed several times, but was nevertheless an important urban center; it had two-storey buildings, and was practically isolated from the rest of the valley during the Late Intermediate Period. All the flat areas of the river basin were used to locate dwellings throughout the chronological period. The constant presence of water for most of the year was definitely the main reason that the area was inhabited for so long: the rock art visible in several areas was due to the collective rituals that established the sacred character of the places with the greatest concentration of petroglyphs. In addition, at the time of the hunter-gatherers, the valley was characterized by very rich vegetation and numerous fauna. Thus, themes relating to fertility, hunting, and water were those most frequently depicted by settlers in the valley, and they used the various types of stone they found there to leave their messages engraved on the surface. Along the banks of the river, there are many blocks of diorite and andesite, though there are also petroglyphs worked in very compact sandstone boulders, with square and naturally smooth surfaces. The first site with any rock art is undoubtedly Pongo Grande, located on the lower bed of the valley, where there are 11 small rocks with petroglyphs that, according to Nasca Project studies, belong to three different phases.

The oldest can be dated to a late phase of hunting and gathering of wild fruits, alongside already well-developed agricultural practice. The figures show anthropomorphic features with solar emblems similar to those recorded in Chichitara. These are probably part of the narrative of myths including solar figures with human traits in the main roles. The second phase is characterized by the widespread presence of birdlike symbols participating in rain-magic rituals. These are the predominant form in the Pongo Grande, and show activities that center on the rain-bird figure. There are repeated lunar symbols and images of frogs, clearly referring to the cult of water. Anthropomorphic images are scarce at this stage and are mainly represented in scenes showing dancing or ritual fighting. Unlike the

Fig. 10.6 Pongo Grande, R4. Rock with various figures among which stands out a lizard engraved in negative (Drawing by Delia Perini)

more naturalistic stage, the second is characterized by geometric stylization that simplifies themes into a basic symbology, but the *logos* they contain are well defined. The next stage is characterized by the presence of anthropomorphic figures produced using the negative percussion technique, i.e., leaving the characters isolated within spaces around which the lithic surface material was removed. The iconography largely represents animals, especially reptiles (Fig. 10.6). Chronologically, Pongo Grande developed between 500 BCE and 500–600 CE, and it was occupied by a population that settled in the valley with a tradition linked to forms from the Andean *Sierra* area, showing very little influence on the part of the dominant presence of the Nasca iconography and iconology in the area.

The second group of petroglyphs in the Río Aja Valley is located further upstream at the San Marcos site where 12 major engraved rocks are visible. The petroglyphs are located near an ancient settlement with utilitarian surface ceramics, datable to the Early Middle Intermediate Period and the Middle Horizon. In this town, there are no elements showing a chronological sequence of stylistic phases, but there is a notable presence of figures added to the rocks at different times (Figs. 10.7 and 10.8)

In the San Marcos petroglyphs, the majority of the images are of camelids and deer. Many of the representations of camelids appear with a symbol of a foetus inside the womb, as if the animal figure were transparent. This also indicates the sex of the animal as an element of fertility and abundance. The anthropomorphic beings are in hieratic position, i.e., in full-body: most of the images that stand out show

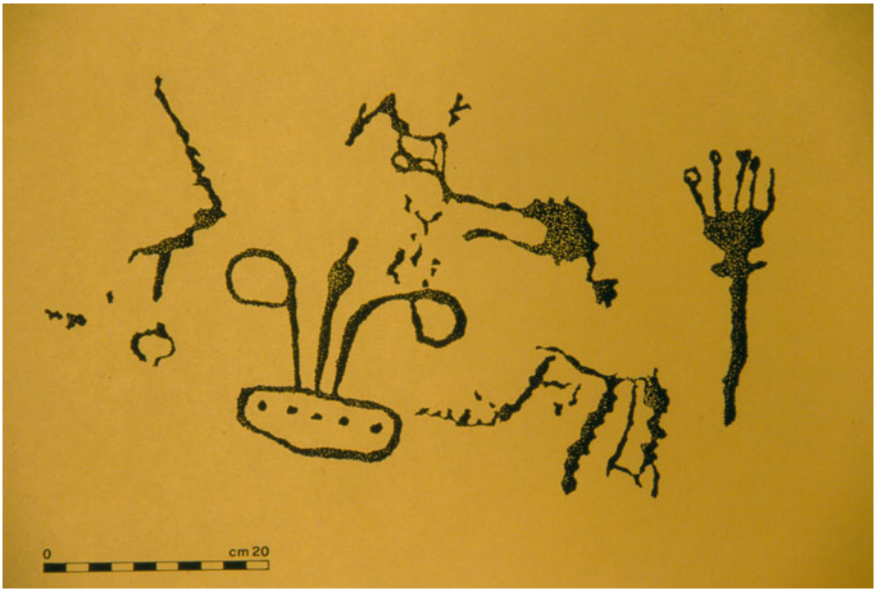

Fig. 10.7 San Marcos, R8. Representation of plant and a figure of a hand-shaped scepter (Drawing by Delia Perini)

Fig. 10.8 San Marcos, R10. Divine character with open arms in the act of distributing water. He has large pectoral (Photo by the author)

figures with a large breastplate, probably associated with mythical figures or divinities. These are very schematic figures, with large quadrangular ears elongated downwards. The breastplates are in the form of a “V”, with overlapping parallel bands. The most emblematic rock measures seven meters high and represents what may be a 2.1-m divinity which dominates the scene. Its peculiarity is the shape of the head, surrounded by a kind of halo with six elliptical circles connected to the headdress. The character wears splendid ornaments and a long tunic: it is possibly the image of a solar being or a humanized heliomorphic symbol.

Among the most frequent themes at San Marcos are the labyrinth and meander patterns. They are cut fairly deep, and suggest the involvement of an intermediary officiant who would have interpreted the signs moving a stick or rod along the grooves.

Also at San Marcos, there is a great difference between the themes represented in the Nasca iconography and those shown on the rocks at the site. The characteristics of the San Marcos figures show greater influence coming from the cultural heritage of the southern Andean plateau rather than the coast, which is more homogeneous and shows Paracas–Nasca influence. Chronologically, the San Marco petroglyphs can be placed between the first and sixth centuries CE, and the production technique used did not change from one scene to another.

In the highest part of the Aja valley, in the town of Pirca, there are a series of rock shelters with dark red pictographs and a large monolithic block in the central part of the valley. Among the main figures, there is a heliomorph with a large feathered headdress. In the lower part of the same rock, there is a lunar symbol repeated several times. This was added at a later date. Isolated rocks are decorated with schematic and geometric scenes as is the great rock of the central valley, where they are in painted form. Among the various images represented (in very bad condition), there is a figure with a trophy-head and a disproportionate head-dress in the form of a tree: there is nothing else comparable to this icon in the Nasca area.

While the paintings may be associated with a particular period of valley life between the fifth century BCE and the fifth century AD, the symbolism of the moon and the other meander patterns, including the geometrical drawings present, can certainly be considered the most recent on account of their style of execution. A careful examination of the rock art here reveals a geometric shield shape with marked characteristics denoting *Sierra* origins. At Pirca too, it may be affirmed that the rock art was imported from the plateau and that the symbolic iconography of the Nasca Culture had little influence among the population that settled in the valley, who isolated themselves from the culturally more dynamic and livelier coastal culture.

10.5 Other Rock-Art Stations in the Valleys of Río Grande de Nasca Drainage

In an overview of the rock art in the Nasca area, and in order to understand the influences and migratory movements that characterized the different forms of cultural expression occurring there, it is essential to include an analytical study of the Hauyhua site.

This site is located in the valley of the Río Hamca, 26 km east of Nasca near kilometer 46 along the path that leads to Puquio. The rock art is concentrated in an intermediate area between the plateau and the Nasca *Pampa*, at the edge of the *Yunga*[9] ecosystem.

The site shows evidence of continuous occupation from the Pre-ceramic period by a population of Andean origin moving from the *Sierra* towards the coast along one of the main axes of communication. It may have not have been solely a transit

[9]The term indicates, in most cases, the temperate ecosystem characterizing all the valleys, those that run down to the Pacific, and those on the Atlantic side, situated 500–2300 m above sea level. (Pulgar Vidal 1987: 51–64).

zone, but also a settlement for smaller groups of people as there was a local ecosystem which enabled types of vegetation to grow here that were less abundant on the Coast.[10] The settlements were located far from the valley and were protected by the steep sides of the mountains, which also constituted an important defense and lookout for wild animals, as well as for the possible presence of humans moving through the valley. In any case, this was a source of water and food and had also been used in the agricultural era.

The landscape appears particularly arid, but the Río Hamca irrigates the valley all year round and the location of dwellings at the top of the surrounding mountains represented a form of natural defense for the people who took refuge in the highest parts.

Rock paintings may be found in natural shelters on the tops of the steep mountains on both sides of the valley. There is a shelter constituting an important discovery because it contains sequences of cup marks covering the entire inner surface of a small cave. These are incisions in the rock with pre-numerical characteristics that, through the creation of rows of small cavities, may have indicated spatial or temporal dimensions, and were mostly associated with rain and fertility. In the area where the rock paintings are located, there are also the remains of circular or rectangular stone buildings with rounded corners; they are very large and their outer walls are formed from large boulders. On the upper surface of the dwelling area, there are large grinders for food and mortars used to pulverize minerals to obtain pigments. The surface ceramics are datable to Nasca phases 8 and 9 and the Middle Horizon. In the vicinity of the cave paintings, there is also a vast necropolis of the Late Nasca period, which was located in a place already long considered sacred. This site was considered a *Huaca* (a holy place) on account of its suitability for worship. The overlaying of paint strokes onto older images denotes the continuity of the tradition in the area. In fact, when the rock shelters were used to bury the dead, red markings were used to indicate the graves as a sign of burial, and this was also the case with the oldest rock micro paintings.[11]

In order to establish a chronological sequence, the micropaintings were divided into homogeneous groups, both from the point of view of the subjects depicted and the type of coloring applied. They were done on rounded fluvial stones which had been embedded in the clay deposited by ancient floods in the valley that formed the walls of the rock shelters. The most representative group of figures is that of single animals, mostly deer and camelids. Cat images are very rare, though they may appear along with other images of isolated animals. Figures are often represented standing or dancing, and they may represent characters dressed as animals or

[10]The presence in Huayhua of Pacae plants (*Inga feuillei) and Lucuma* (*Pouteria-lucuma*) is evidence of the constant presence of water which enabled this type of fruit tree to survive, even while they gradually decreased in the Nasca area.

[11]They consist of two or three superimposed parallel lines in red: these are grave markers unrelated to the ancient micropaintings, mostly representing complex and naturalistic scenes. As the place had a markedly sacred character attributed to it by the peoples who had made use of it in the past, the new users considered it a suitable site for burial many centuries later.

wearing skins to celebrate some ritual function. Among these images, there are also some where the characters wield weapons or staffs of office, and there are often anthropomorphized birds commonly associated with the arrival of rain.

The second group consists of interrelated standing figures of animals as they perform a ritual dance or some other type of collective activity. The sequence of figures always proceeds from left to right. The third group contains complex scenes with symbological and cultural characteristics, sometimes representing overlapping myths. In the images that have been altered the most, it is possible to identify up to four different chronological layers, based on the use of different colors to complete the scene. Among the most significant is a representation of a spider in its web, to which other characters were added later. The most emblematic is one that probably shows a mythical being with animal feet sitting in the center, with four lines hanging down between its legs. This is the central figure who dominates the scene and the sequence of actions performed by mythical dancing characters together with others who are climbing steps (Fig. 10.9).

In the center, there is a heliomorphic symbol that represents, together with the characters climbing the steps, an image connected to a solar myth. A fourth set of paintings comprises isolated abstract or geometric figures, while the fifth group includes the symbols drawn to mark graves during the Late Nasca period. The first Huayhua paintings represent natural scenes and can tentatively be dated between

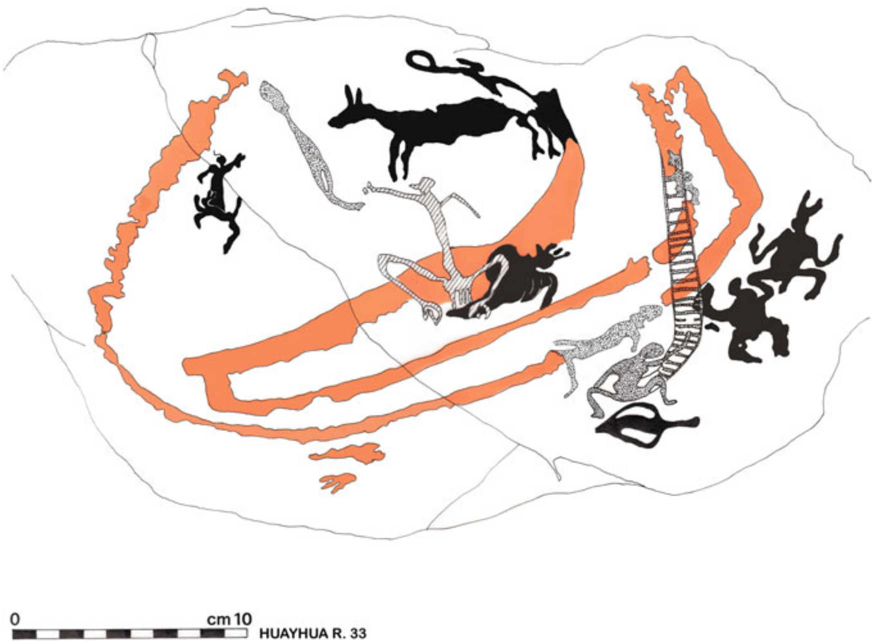

Fig. 10.9 Huayhua. Cave paintings with overlapping figures that represent myths related to the sun and associated deities (Drawing by Delia Perini)

the second and first millennium BCE, although too many elements are still lacking to be more precise.

Another important site with figures scratched into the rock walls in the Nasca area is in Majuelos, where the cemeteries excavated clandestinely have produced large quantities of ceramics and textiles, especially from the transitional Paracas–Nasca period, in addition to materials from Middle Horizon and Late Intermediate Period graves. The site occupies a valley that communicates with the Nasca *Pampas* plain, which is particularly affected by severe flooding. Majuelos has rock shelter figures belonging to the last centuries before our era, as evidenced by the existing cultural materials on the surface of the valley near the large linear geoglyphs. These belong to the Nasca culture, although several fragments of pottery from the last stages of Paracas culture were also found. There are some shelters within a rocky structure, the two most important of which contain figures of a dolphin and a killer whale, the latter being extremely rare in Nasca petroglyph iconography (Fig. 10.10). Both are very large, and the killer whale is over three meters long. This is a very unusual size compared with other stone carvings and is unique in this area. Other mostly isolated images are associated with the main figures, while, in the vicinity of these two shelters, there are some small rock paintings with effigies of trophy heads, characters, and complex scenes. It is likely that the location was used as a necropolis and subsequently looted by vandals, as even today one can observe excavations at the base of the cliffs, with human bones scattered around.

Fig. 10.10 Majuelos: killer whale etched in a rock shelter dating back to Later Paracas period (Photo by the author)

Many other rock art sites can be seen in the same valley in the areas where numerous stone blocks are present: there are scenes with characters and groups of animals, mostly camelids. Scenes of this kind certainly date back to the time of the figures etched into the walls of the shelters described above: the single petroglyphs, which also show themes representing a well-defined mythology, may be dated to the Early Intermediate Period, and more frequently, in the Middle Horizon.

The Valley of the Río Grande has concentrations of rock art running all the way to the sea. These are complex scenes representing characters in the act of making sacrifice or hunting. They provide new information regarding the thinking of the human groups that used the desert area of the Peruvian south coast; to date, studies have not produced a satisfactory general inventory of the petroglyphs in the area, which could make an important contribution to the study of archaeology.

In recent years, more studies of the rock art of the Ica Region have focused on the systematic and precise geographical location of some of the major finds. In the valley of the upper and middle Río Ingenio, important groups of petroglyphs have been found that are also associated with very early geoglyphs from the Nasca period. For the time being, just a few examples of Nasca area lithoglyphs can be described, but they show the persistence of archaic cultural elements, with deep Pan-American and Pan-Andean roots. The very clear relationship between religious and mythological tradition and the world represented in the rock art indicates the continuity between an extant phenomenon and the strong Chavin and symbolic influence of later periods. This occurs at the end of the transformation process undergone by the local population, associated with hunting and gathering, at the time when organization associated with institutionalized agriculture was leading to new cultural experience and worship. Subsequent social organization, however, brought with it the necessity to increasingly represent the magical and religious world in terms of the worship of water and fertility.

Very often, as in the case of Chichitara, the site has all the features required to be considered sacred, a sort of large open-air temple, where rocks become the most suitable material on which to inscribe thoughts and concerns, or to fix events in history and recognize common traditions. The widespread representation of rain-bringing birds is related to fertility and a supply of water for agricultural purposes. Ceremonial and collective activities are increasingly prevalent, and they feature images of people with trophy heads or performing sacrifice, marking the close relationship between these rituals and the intervention of priests, mediators between the gods, the people, and activities associated with the invocation of fertility and water.

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Chapter 11
Nasca Geoglyphs: Technical Aspects and Overview of Studies and Interpretations

Nicola Masini, Giuseppe Orefici and Josué Lancho Rojas

Abstract Archaeologists and scholars have long debated the purpose of the Nasca lines. During the last two decades, significant advances in the understanding of cultural and functional aspects of geoglyphs have been achieved. This chapter deals with the state of the art of studies, research, and field activities in various areas of the Nasca territory. In particular, the technical aspects related to the execution of the geoglyphs and dating issues are discussed. The chapter ends with reprise of the debate on the functions and significance of the Nasca lines from the Spaniard chroniclers to the most recent investigations, oscillating from calendrical/astronomical theories to approaches closer to the Andean model.

Keywords Nasca lines · Drawing techniques · Ritual ceremonies · Geoglyph interpretation · Dating

11.1 Introduction

The drawing of figures on the ground, making them more clearly and likely visible from the sky or from places at high altitude, is a cultural phenomenon of several civilizations, belonging to different chronological periods. Considering the

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Americas, it is worth pointing out the serpent-mound in Ohio (performed by adding alluvial material onto the level ground), the ornithomorphic figures drawn in relief in Wisconsin (Orefici 2009), the geoglyphs in the Atacama desert of Chile (Briones 2006), channels and embankments depicting geometric figures in the Acre state (Brazil) (Saunaluoma and Schaan 2012), and, finally, the ring ditches in the Bolivian Amazon (Erickson 2010).

In Peru, the geoglyphs are drawn normally on the desert coast, where the sandy loam soil, covered by alluvium, was more suitable for the conservation of large drawings, such as the Condor de Oyotún and the anthropomorphic figure in Pampa de Caña Cruz in the Lambayeque region (Alva and Meneses Alva 1984), and the geoglyphs of Canto Grande, near Lima (Roselló et al. 1985). As regards smaller-sized geoglyphs, comparable to petroglyphs, we cite Toro Muerto, near Arequipa, considered the largest rock-art site in Peru (Linares Málaga 1993). In general, the geoglyph motifs are unrelated to each other from both the chronological and functional points of view.

The most famous examples of geoglyphs are, without any doubt, those in the Pampa of Nasca, designated as a UNESCO World Heritage site in 1994.

Their pediment surfaces generally have a patina of dark-reddish-brown color due to oxidic weathering crusts (Fig. 11.1). Moreover, the lack of erosion and sedimentation, along with the action of nightly moisture and flush winds, prevents the accumulation of sand, thus preserving the drawings throughout the centuries. The geoglyphs in the territory of Nasca and Palpa have been the most studied, due to their high concentration, morphological variety, and breathtaking dimensions.

The most significant concentration of geoglyphs is located between the modern cities of Nasca, Ingenio, and Palpa. In particular, most of the drawings are located in the Pampa de San José, in the valleys of the Ingenio River, and the Grande River, including the area around Cahuachi. The latter has been the object of some recent investigations performed in the framework of the ITACA Mission in collaboration with Proyecto Nasca (see Chap. 20 by Masini et al.).

11.2 Notes on Technical Aspects of the Geoglyphs

The geoglyphs are 'earth markings' generally formed by shallow trenches, with depth ranging 10–60 cm, made by using four different techniques by means of subtraction and/or addition of soil and stones.

The most common technique consisted of the removal of reddish-brown-coated pebbles and gravels, covering the vesicular desert subsoil (Eitel et al. 2005), placing them aside, in order to create lines and figures which sharply contrasted in color and tone with the underlying yellowish–brown soil, composed of silty sand and/or clay (Fig. 11.2). The latter, along with the air humidity, fostered the development of a thin crust on top of the reliefs, thus protecting the drawings from the wind erosion.

Another way to draw lines was based on the cutting of narrow furrows and the positioning of excavated material along the two sides of the same furrows. This

Fig. 11.1 Detail of a trapezoid close to the north bank of the Río Taruga drawn by means of subtraction and/or addition of sand, gravel, and pebbles

technique is common in the areas of the Río Nasca drainage basin characterized by the uneven availability of pebbles, especially where the river cuts through the sediments. In these cases, the creation of geoglyphs required supplementary work: once the groove was made, pebbles and sand, not necessarily on-site, were heaped up on it to emphasize the edges of the drawings.

In many cases the technique was simply based on the removal of stones surrounding figures in order to improve the bas relief effect. In other cases, the drawing was performed just by arranging pebbles and lithic fragments along the line or the figure to mark them.

From the morphological point of view, we can distinguish two great classes of geoglyphs: the geometric and figurative:

- The geometric class includes two groups. The first one is given by linear motifs and is the most common all over the Río Grande drainage basin. It includes

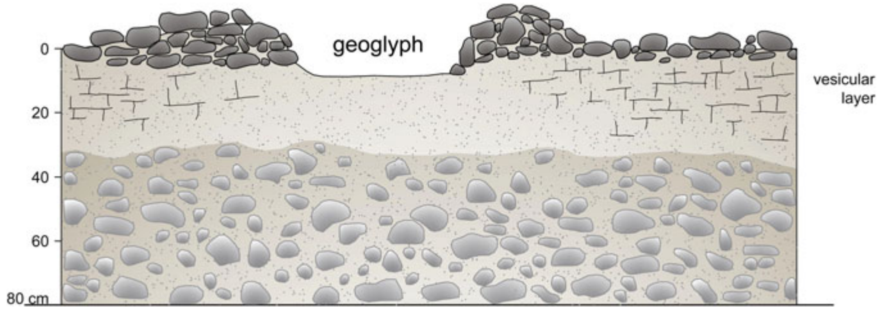

Fig. 11.2 Section of a typical geoglyph obtained by removal of dark pebbles and gravels of undisturbed desert pavements and placing them aside to expose the underlying lighter dust in order to create lines and figures [redrawing by Manuela Scavone, CNR-IBAM, of a sketch by Eitel et al. (2005)]

straight lines (Fig. 11.3), which can reach more than 1 km, U-shaped lines, and patterns which clearly evoke the sense of movement and the ritual path, such as meandering, zig-zag, and spiral motifs. These could be simple or double. The second group is areal and is composed of trapezoidal, triangular, quadrangular, or rectangular figures. The latter are called *campos barridos* when the surface layer had been removed or swept off.

- The second class of geoglyphs is given by figurative elements, mainly characterized by biomorphic motifs, in particular anthropomorphic (human bodies and heads), zoomorphic, and phytomorphic figures. The anthropomorphic figures are human bodies and heads, usually located on slopes or on the top of mounds as in the case of the Oculate Being, more commonly known as the "astronaut" (Fig. 11.4). The figurative class includes also inanimate objects and phenomena, defined by Lambers (2006) as "representational".

The huge size of some geoglyphs, in particular in the Palpa and Nasca valleys, is what catches the eye and imagination of the beholder. The linear drawings can measure more than 1 km in length, while dimensions of the biomorphic ones reach up to 300 m. The impressive size, the shapes, and functions have attracted extraordinary interest among archaeologists, historians, geographers, astronomers, and engineers for over a century (see Sect. 11.5). Numerous assumptions and theories have been advanced: some of them quite imaginative and others without any scientific or archaeological basis (von Däniken 1969).

One of the main critical issues was (and still is): Did the Nasca have the skills and adequate technologies to draw on the ground biomorphic figures of hundreds of meters in size and perfectly straight lines of more than 1 km in length?

An answer to this question was given by experimentation performed by Gerald Hawkins and Josue Lancho in 1969 (Hawkins 1969; Orefici 2009). On the basis of established models, the two scholars demonstrated that it was possible at that time to engrave such lines on the desert pavement, by placing stakes aligned or arranged

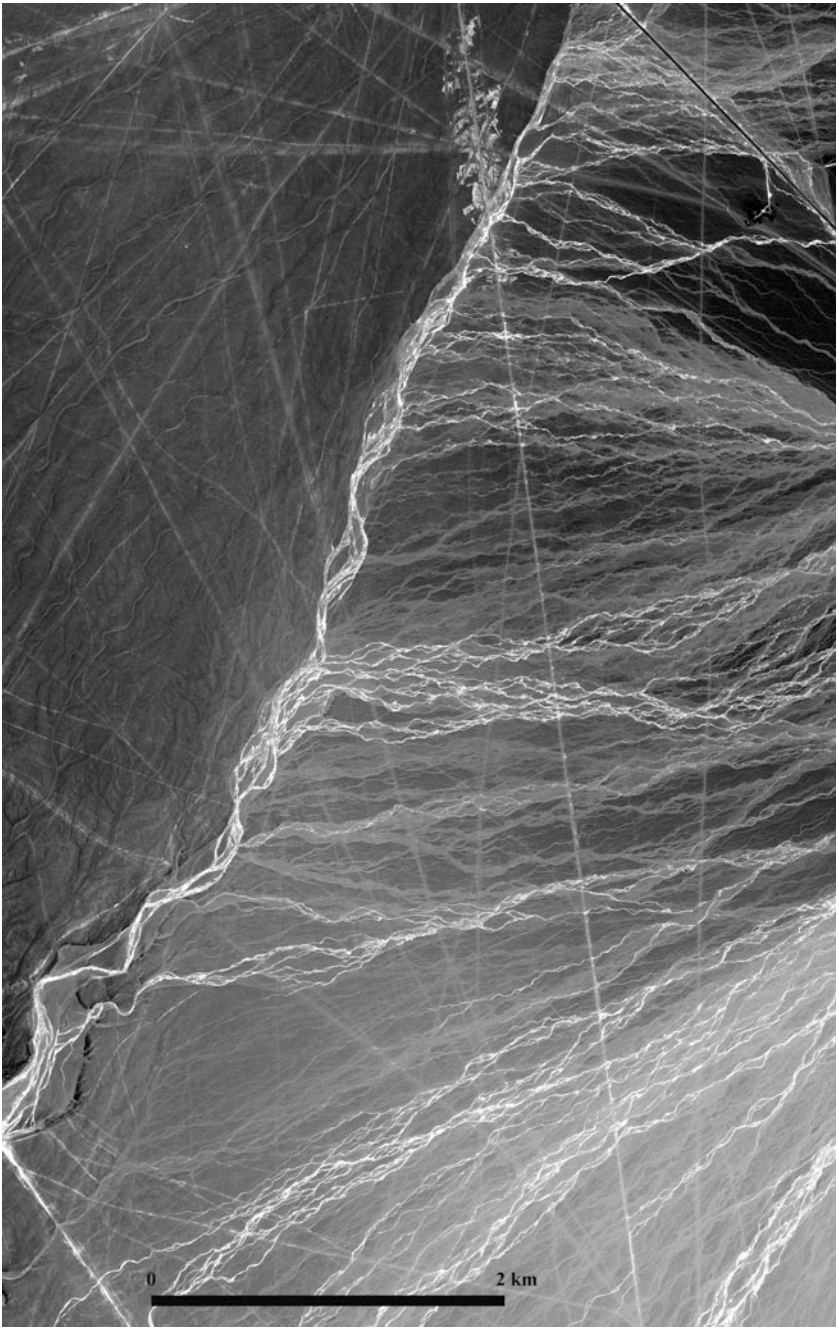

Fig. 11.3 Long straight lines in Nasca Pampa crossed by, or crossing, *huaycos* (World View-2 panchromatic image acquired on 11.11.2010)

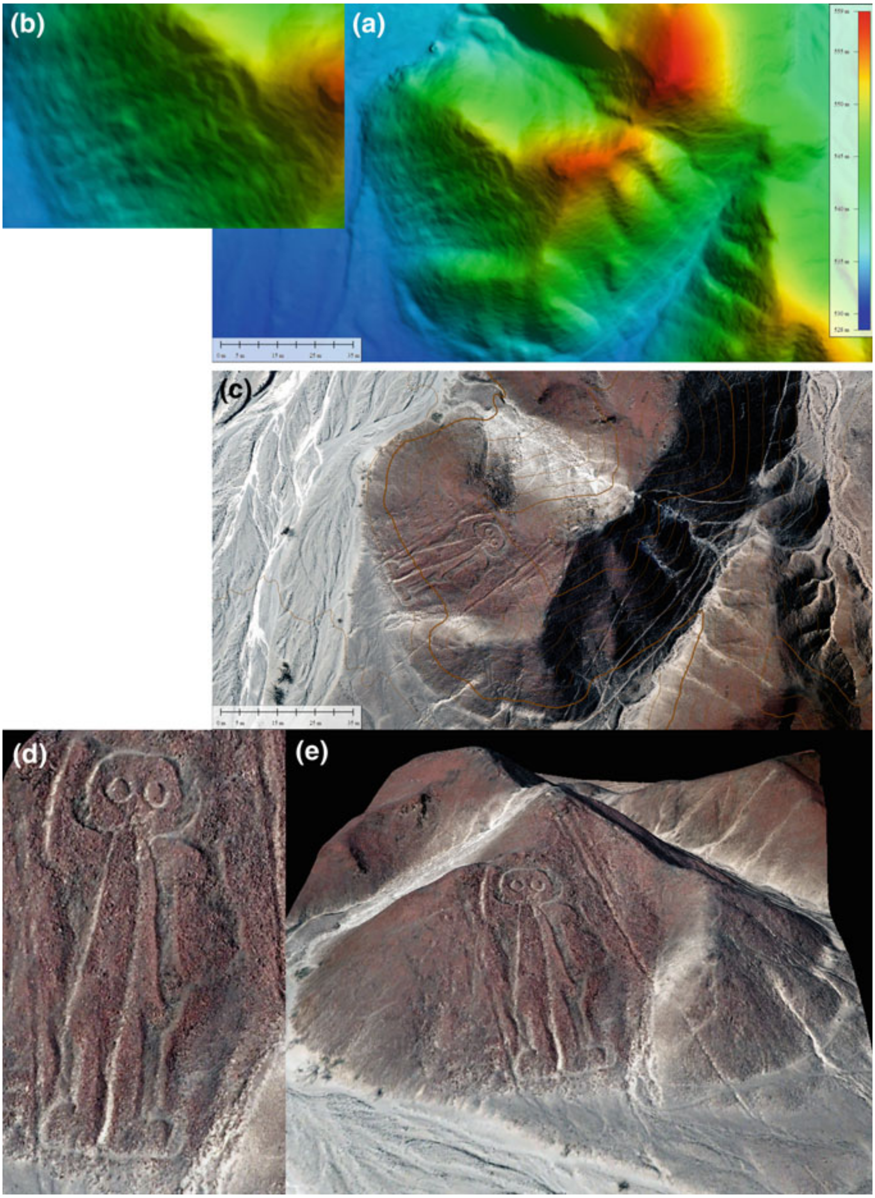

Fig. 11.4 The 'Oculate Being' engraved on the slope of a hill in Pampa Colorado. **a** DEM of the hill where it is possible to observe in relief the engraved anthropomorphic figure [see also zoom in (**b**)]; **c** ortho photo of the same scene; **d** 3d visualization of the hill, **e** detail of the anthropomorphic Fig. (3D images by Nicola Masini and Antonio Pecci)

to obtain spirals and other figures, as well as to achieve high accuracy in the straightness of the lines.

In this regard, it must be said that the Nasca monumental architecture was based on geometry, straightness of the walls, and their alignment along predetermined directions. A particular skill was found in building walls, seemingly parallel, but in reality converging with very small angles. With this regard, during the last ten years, excavations in Cahuachi have revealed the presence of converging walls, some of them diachronically superimposed on each other, forming angles less than 2°. Moreover, the Nasca were able to build sophisticated aqueducts that required sophisticated topographical capabilities. Finally, the Nasca experience in the use of trusses in the textile field (inherited from Paracas) could explain their deep knowledge and ability to expand a small-scale model to one of the required size (Orefici 2012; Vol I).

11.3 Dating Approaches

An open issue is the dating of geoglyphs. It is very problematic mainly due to the difficulty to find associated organic materials to be analyzed through scientific dating techniques. Results from radiocarbon dating in the 50s–i60s proved to be minimally indicative, because of the lack of a precise stratigraphic association (Strong 1957; Ravines and Rogger 1982). The lack of datable organic material directly associated to the geoglyphs has led the archaeologists to adopt two different approaches.

In the first one, the radiocarbon method has been used in the context of interdisciplinary research aimed at analyzing and reconstructing the relationship between Nasca lines and ancient settlements, as done in the framework of the Palpa Archaeological project (Reindel and Wagner 2009), in the valleys of the Río Grande, Río Palpa, and Río Viscas. The first investigation based on radiocarbon dating was performed on 12 samples from well-documented excavations in Los Molinos and La Muña, which enabled the definition of a Nasca chronology (Görsdorf and Reindel 2002).[1] The chronological model was improved on the basis of more than 100 ^{14}C samples. These provided a stable numerical framework for the ceramic derived periods of the Paracas and Nasca cultures (Unkel et al. 2007). As a whole, the association of archaeological evidence with geoglyphs, along with

[1]Görsdorf and Reindel (2002) ^{14}C ages with OxCal v 3.5 (Bronk Ramsey 2001) using the IntCal98 calibration curve (Stuiver et al. 1998). The choice of the calibration curve (i.e., with Southern-Hemisphere correction) is a controversial issue. For example, in respect to Görsdorf and Reindel (2002) whose Southern-Hemisphere correction of –24 ± 3 14C yr based on Stuiver et al. (1998), Unkel et al. (2007) used a correction of –41 ± 14 14C yr according McCormac et al. (2002).

results from the ^{14}C dating, established evidence of an origin linked to petroglyphic culture and a dating from 400–600 BCE.

In the second approach, a different dating technique was used. It was based on the analysis of rock varnish, i.e., a ubiquitous coating of manganese oxides, iron oxides, and clay minerals fixed by bacteria found on exposed rock surfaces (Dorn 1989). This method, used by Persis Clarkson, stimulated a lively debate among scholars and archaeologists. On the basis of the first results, she suggested a chronometric dating of the biomorphic figures to Early Intermediate Period (in particular, the second half of the 7th century AD), and linear geoglyphs to the Middle Horizon and the Late Intermediate (Clarkson 1990). These results were later reviewed by Clarkson and Dorn (1991, 1995) who dated some linear geoglyphs to the Nasca period.

To achieve a chronological sequence of the Nasca Lines, the comparative method with ceramic association also has been used with obvious problems of interpretation, since there were found fragments of both Nasca and later periods in the area. However, the existence of these elements are not indisputable evidences of geoglyph dating (Silverman 1992, 1993). This is a problem that affects the entire world of archeology and in particular the pre-Hispanic one in Peru where, historically, the radiocarbon method has been widely used, not only for dating single archaeological layers but also to support scientifically pottery seriations, fundamental in order to define the archaeological chronology (see, for example, Rowe (1967)).

However, despite its limitations, the method (if correctly used) can contribute to the development of a chronological framework as was done in the years 2000–04 by Proyecto Nasca on organic materials associated with a wide variety of geoglyphs in the valleys of the Sacramento, Grande, Nasca, and Palpa rivers. The results showed a predominance of materials belonging to the later phase of Nasca Period (Orefici 2012).

In order to overcome the problem of direct association between ceramics and geoglyphs, an approach based on the quantification, distribution analysis, and dating of ceramic material, within 'buffer areas' around the geoglyphs, was adopted by Masato Sakai and Jorge Olano (Sakai et al. 2014). In particular, in the study of the '*centros de lineas*' (starlike centers or radial centers), which are natural or artificial mounds with emanating lines and trapezoids, the collection and analysis of pottery and ceramic fragments was done in areas with a radius of about 50 m around those centers (Sakai et al. 2014). The same study placed into evidence that most of the pottery and ceramic fragments collected around the radial centers date to Early Intermediate Period (about 62%). Whereas the materials of the Late Intermediate Period and Middle Horizon represent the 10 and 5%, respectively (Sakai et al. 2014).

Finally, another approach for both interpreting and dating the geoglyphs is based on iconographical comparative investigations. Such an approach has been adopted by Orefici since 1982, in the context of Proyecto Nasca. In particular, some biomorphic geoglyphs, most of them identified during aerial surveys of Eduardo

Herran,[2] were analyzed in a comparative way with petroglyphs of Chichitara, Pongo Grande, San Marcos, Pirca, Las Trancas, and Quemazón Huayhua. They were made using the technique of low relief and are well visible due to the oxidation process of the surfaces and because they stand out in areas cleared of stones. They consist of small-sized zoomorphic and anthropomorphic motifs that, from the iconographical point of view, seem to be connected to the textile tradition, called 'Paracas–Caverna'. Based on the obtained results, we can definitely say that the figures drawn on the sides of the mountains (at North of Río Ingenio, and especially in the Palpa) form part of the complex of drawings characterized by the oldest iconography (Orefici 1993) (Fig. 11.5).

11.4 Interpreting the Nasca Lines: From the Spaniard Chroniclers to the Most Recent Investigations

Archaeologists and scholars have long puzzled over the purpose of the Nasca Lines. During the last two decades, significant advances in the understanding of cultural, functional, and technical aspects related to the geoglyphs debunked fascinating and outlandish theories that accompanied the historical and scientific literature of the first half of the 20th century. However, it that aura of fascination and mystery is still alive because many questions wait to be answered such as the dating, the function, and, above all, why many geoglyphs were drawn on such a large scale to be only visible from the air.

With regard to the meaning and function of the geoglyphs, the oldest reference corresponds to Luis Monzón (1586), a Spanish magistrate, who argued that the lines were '*caminos*' (roads) made in 'ancient times', when demigods (named Viracochas) reigned in the Nasca region. In the "*Cronica General del Peru*", the Spaniard chronicler Pedro Cieza de Leon (1576) interpreted the presence of signs bordering some areal geoglyphs as roads forming part of the "*Gran Camino de las Ingas*" (Inca Road) (Orefici 2009).

A vigorous debate on the function and significance of the Nasca lines started to come alive only beginning in the first half of the 20th century, thanks to the contributions of scholars from different disciplines. The first who attempted an explanation of the geoglyphs were Julio C. Tello and Mejía Xesspe (1939), after some explorations carried out between 1926 and 1927 in Cahuachi and its surroundings. In their opinion, the "*rayas*" (stripes) of Nasca, were sacred paths (in Spanish "*seques*" or "*caminos sagrados*"), culturally related to aqueducts and cemeteries (Mejia Xesspe 1942). Mejia Xesspe's hypothesis was the basis for Hans Horkheimer's theory (1947), according to which collective liturgical meetings and

[2]Eduardo Herran (1953–2015) was a pioneer of aerial archeology for the study and documentation of the Nasca lines. Herran, to whom we owe the discovery of numerous geoglyphs, provided an important contribution to the documentation, promotion, and protection of Nasca-line heritage.

Fig. 11.5 Anthropomorphic geoglyph engraved on one side of a hill in the area of Palpa (Photo by G. Orefici)

representations linked to ancestor worship took place along the ground drawings (Horkheimer 1947; Aveni 2000). This line of research did not achieve the critical success it deserved, because it was overshadowed by the most successful calendrical and astronomical theories.

In the early 40s, Paul Kosok come to Nasca to study the ancient aqueduct systems. He began his first field surveys and investigations on the geoglyphs, accompanied by the young German Maria Reiche, who took care of the translation of his scientific articles. Kosok had the first ideas to construct an astronomical theory by watching as the sun was in line with many of the linear geoglyphs on the day of the winter solstice in 1941. This thesis was developed in detail in the following years. On the basis of a heuristic approach, Kosok tried to show that the Pampa of Nasca was a great book of astronomy with the function of a calendar (Kosok and Reiche 1949). After the initial steps of the investigations, Kook "left the information" to Maria Reiche to continue his research (see acknowledgement in Reiche (1949)). Reiche deepened the theory of Kosok, introducing also mathematical concepts in the analysis of the geoglyphs. From that moment, the German scholar devoted her life to field work in Nasca and performed the astronomical study of the lines and figures recorded on the surface of Pampa.

Between 1967 and 1968, the Smithsonian Astrophysical Observatory in Cambridge sent six expeditions to Nasca under the direction of Gerald S. Hawkins in order to verify the validity of the astronomical theories. Through an algorithm, Hawkins reproduced the movement of the stars and the astronomical sky of Nasca over centuries. This enabled them to show that only 20% of the analyzed lines had some "astronomical" orientation, thus leading the scientist to disprove the "calendrical-astronomical theory" of the function of the geoglyphs (Hawkins 1969).

However, we must emphasize that, from a methodological point of view, Hawkins was extremely critical (Ziołkowski 2009) and his study probably flawed by prejudice or pre-established positions opposing Kosok and Reiche's theories. This motivated other scholars to partially rescue the archaeo-astronomical theory, using more refined methods of analysis (Ziołkowski 2009). In this regard, a significant contribution was provided by Aveni (1986, 1990) and Gary Urton (1990), who, although with different visions, assigned to geoglyphs a meaning associated to astronomy and the calendar, inspired by the Inca *ceque*.[3] In detail, Aveni focused on particular geoglyphic features previously observed by Maria Reiche, such as the 'radial centers' (or *centros de lineas*) that are cairns located at some prominences on the terrain, towards which several lines converge (Fig. 11.6). Urton proposed the concept of a dual vision of the pampas on the basis of an Inca model. This concept was criticized by Silverman who suggested that the Incas used an earlier pattern of organization in the area, dated to Middle Horizon or to the era in which Cahuachi and Ventilla were the most important centers of the Nasca territory (Silverman 1992).

Aveni analyzed around 750 lines, grouped around approx. 70 radial centers, located in an area of approximately 200 km^2. He found a prevailing orientation of 347°–352° which has no astronomical connotation, but it covers the so-called "solar-arc". The solar arc points in the direction in which the Sun appears in some periods of the year, as from 22 October to 2 November and from 10 to 22 February, corresponding to the temporal limits of the flood season in the coastal rivers, as was already postulated by Paul Kosok (Kosok and Reiche 1949; Aveni 1990). Furthermore, these periods of the year (November 2 and February 10) correspond to the steps of the sun through the zenith of the Pampa de Nasca, which are important events of the Andean people's worldview (Aveni 1990; Ziołkowski 2009). This along with other findings achieved by Aveni, such as the orientation of some lines towards the June solstice and the particular 'astronomical direction' of some radial centers from 500 AD to 1000 AD, gave apparently new life to calendrical-astronomical theories on geoglyphs. However, in reality, archaeo-astronomy together with the observation of the so-called radial centers led him to develop new

[3]The *Ceques* were lines or rays that originated from the city of Cusco. They were used to indicate the shrines or sacred places and to connect them to Cusco. Most of these lines was associated with ritual pilgrimages.

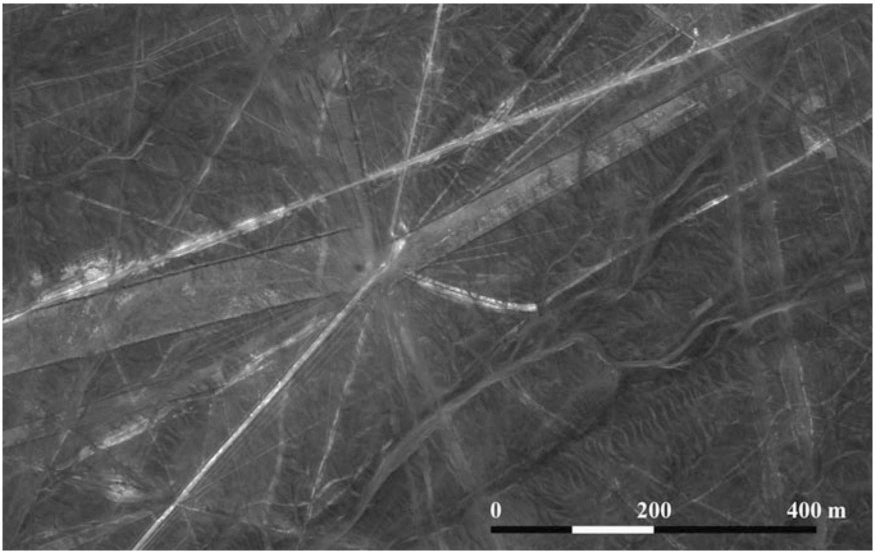

Fig. 11.6 Pampa de Nasca: example of a radial center (Detail from satellite WorldView-2 image)

hypotheses about a sort of ordered, hierarchical cosmographical map, inspired by Inca *ceque* system.

These interpretations were reinforced by new insights provided by Clive Ruggles. As Aveni had, he focused his attention on radial centers. In particular, he noticed a group of radial centers in the Pampa of Nasca, which exhibited a regular order of the converging lines, and covered almost uniformly around the circle, thus recalling the Cuzco ‘cheques’ concept (Ruggles 1990). As in the Inca Empire, the “radial cheques”, starting from the capital, served to organize a complex religious space system of sanctuaries, similarly to how, in the Pampa, the radial centers composed a network of religious places of strategic importance for ritual activity. The results from Aveni’s and Ruggles’ studies reflected the evolution of calendrical and astronomical theories towards a greater attention to Andean world vision. In particular, according to Aveni, the geoglyphs served as pathways leading to ceremonial and observational places (Ruggles 2014). In practice, after a hiatus of 40 years, there was a renewed interest in the early theories of Mejia Xesspe.

Tony Morrison (1987) rejected any astronomical and calendrical significance of geoglyphs. On the basis of some studies conducted in the *Altiplano*, between the 60s and 70s, he suggested a relationship between the mountains and sacred places (or *huacas*), adapting the Inca traditions of the Sierra to the Nasca environment, culture and, consequently, geoglyphs. According to Morrison’s theory, the lines were probably sacred paths leading to the *huacas*, during some periods of the year. Morrison agrees with Horkheimer in the interpretation of the areal geoglyphs (trapezoidal and rectangular shaped) as spaces dedicated to collective religious gatherings and rituals of ancestor worship.

Johan Reinhard (1988a, 1992, 1996) also agreed with this interpretation and added the concept that the linear forms were used for the worship of the mountain gods in charge of the rain and therefore related to the worship of water and fertility. On the basis of an anthropological approach integrated with archaeological data, Reinhard (1996) investigated the geoglyphs in the context of studies on Andean religious concepts and practices. His merit was to have understood the preeminent role of mountain worship in the religious rituality linked to water, fertility, crops, and climate.

Another debated theme is related to social aspects linked to the execution and management of the geoglyphs. In this respect, Reinhard explained the great number of lines by the fact that each of them was made, maintained, and cleaned by extended family groups (known in quechua as *ayllu*). According to William Isbell (1978), the scratching of the lines on the Pampa surfaces was a "social mechanism for investing unpredictable surpluses in ceremonial activities". It is a typically Western anthropocentric concept of the state which has generated skepticism among scholars of the Andean civilizations. In our opinion, it is very questionable, because it is not compatible with a highly hierarchical and theocratic society, such as the Andean one. Moreover, Isbell did not consider that the drawing of the geoglyphs required specialists able to draw lines and figures and not necessarily a large amount of labor. Both Gerald Hawkins and Josue Lancho demonstrated that the etching of the figures on the ground was not a greatly time-consuming activity and did not involve a great number of workers, probably under the influence of hallucinogens as suggested by Reinhard (1996) and other scholars on the basis of iconographical studies.

In this regard, one must consider that the representation of the sampedro (*Echinopsis sp*[4]) in ceramics and the finding of some samples of this cactus along with healing plants as the datura (*Datura innoxia*) in the ruins of Cahuachi are not sufficient evidence to prove how and when hallucinogens were used; not excluding their consumption only during special ceremonies.

A different line of research, aimed at reconciling diverse theories, was developed by Alberto Rossell Castro (1977). He proposed a typological and functional division of the geoglyphs into four groups. The first is given by tracks connected to irrigation and divisions of agricultural field. His previous studies on ancient irrigation systems influenced him in finding a spatial relation between water management systems, including the *puquios* and the geoglyphs (Rossel Castro 1942). The second group is associated with geoglyphs as axes connected with mounds and cairns. The third is linked to the astronomical interpretation and, finally, the fourth is linked to textile motifs. Rossel Castro had the merit of having attempted a sort of functional classification of geoglyphs. However, it should be considered that, within each group, was included a large variety of geoglyphs in technique, size, and stylistic features, thus making his theory weak.

[4]The *sampedro*(*Echinopsis* sp.) belongs to the Cactaceae family and was used in the magical rituals by priests in order to contact supernatural entities [see Chap. 6 by Piacenza (2016)].

Ethnohistoric perspectives contributed to enriching the scientific debate on geoglyphs. In this respect, Maria Rostworoski (Rostworoski 1993), studying legends reported in colonial narrative sources, suggested a relationship between the geoglyphs and the cult of the god Kon, linked to the flow of water in the rivers. Kon, principal deity in the Paracas and Nasca pantheon, is described as a winged being and characterized as Anthropomorphic Mythical Being (AMB). The hypothesis was criticized by Silverman and Proulx (2002), according to whom the Nasca icon identified as Kon was a form of AMB belonging to the proliferous style.

For Silverman the geoglyphs "were part of the larger Nasca social world", as well as the entire Nasca system of cultural meaning and expression (Silverman and Proulx 2002). She argued that the Pampa was domesticated to become a sacred place and a social space: a site of the Nasca people's collective memory and social identity (Silverman 1990; Silverman and Proulx 2002). She was also particularly careful in examining the spatial relationships between geoglyphs and settlements, including the ceremonial one (Cahuachi), between the Ingenio and Nasca Valleys. The geoglyphs, she proposed, were pilgrimage routes, gathering places of pilgrims on their way to Cahuachi, i.e., venues for civic ceremonial activities (Silverman 1994, 2000).

Clarkson (1990) paid attention to archaeological materials associated with the geoglyphs, not only for chronometric dating but also for providing information related to the function and drawing of the geoglyphs (Clarkson and Dorn 1995). With such a perspective, Clarkson investigated a number of materials, such as, stone circles, utilitarian ceramic vessels, and fineware ceramics. She interpreted the first two as materials associated with people drawing on the ground, whereas the third one were left on sites intentionally smashed during a ceremony.

In the last two decades, an important contribution has been provided by investigations conducted by Italian, German, and Japanese missions. The first is based on archaeological investigations of Proyecto Nasca by G. Orefici since 1982, with a contribution of Italian CNR in the framework of ITACA Mission, since 2007 [for additional details the reader is referred to Chap. 12 by Masini et al. (2016)].

The investigations by the German mission,[5] in the framework of the Nasca–Palpa Project directed by Markus Reindel, covered three valleys of the Palpa region, where a considerable number of Nasca sites, including ground drawings of different ages, were identified. During their work, they have identified fragments of various ceramic phases associated with geoglyphs. Reindel et al. (2006) suggested a possible relationship between groups of figures and places used as residential centers with the possibility that the ground drawings were made by the inhabitants of these urban centers. The German mission has elaborated a relative chronology to group the geoglyphs on the basis of their relationship with the sites, obtaining a chronological sequence of geoglyphs of Palpa, also by means of archaeo-metric

[5]The scientific mission of the German Nasca–Palpa Project was composed of the German Archaeological Institute (DAI, KAAK Bonn), the Institute of Geodesy and Photogrammetry of ETH Zurich, and other partners and archaeologists from Peru and Austria.

techniques (Reindel et al. 2006; Reindel and Wagner 2009). With respect to the interpretation, Reindel believes that the lines were related to rituals for water. Moreover, he rejects any possible interpretation linked to astronomical theories.

The Japanese mission, directed by Masato Sakai, Yamagata University, since 2006 has been working on the geoglyphs of Nasca, especially considering the associated archaeological materials. Sakai hypothesized that the straight lines had been designed to show the relationships between the various population centers of the region. Moreover, he asserted that almost a thousand lines of this type have been used to refresh the links between the various settlements and their populations. The work of M. Sakai was performed on the basis of a large quantity of satellite photos and also investigations directly on geoglyphs for the analysis of associated ceramic material, which currently already exceeds 10,000 fragments. Regarding the chronological indications, the geoglyphs dated to 400 BCE and were continually in use for at least 2000 years. According to Sakai, the figures drawn in the Pampas had various functions depending on the time of their creation. At first, they served as reference points in the paths of pilgrims. Subsequently, they were considered as places where people of Nasca conducted rituals and prayed for good harvests.

In our opinion, the phenomenon of the geoglyphs has its origin in a profound religious and cultural substratum of these populations, strongly influenced by the extreme conditions of the environment and the climate and, therefore, by the need to adapt to them, especially with the help of the gods. In the extremely arid Río Nasca drainage basin, populations derived their livelihood from an intensive agriculture that was very difficult due to the scarcity of water. From the practical point of view, the problem was solved by the ingenious filtration gallery system [for additional details see Lasaponara et al. (2016a, Chap. 13, Lasaponara et al. 2016b, Chap. 22)], which intercepted the underground aquifers and then channeled water for domestic and irrigation purposes. But the climate, the weather, and other imponderables and unpredictable factors could not be manageable if not through a form of mediation with the gods, in particular with mountain deities. Therefore, the ceremonial activities, taking place inside and outside the pyramids as well as on the geoglyphs, served as a mean of connection between human aspirations and the will of the gods. Most of zoomorphic geoglyphs are connected to the theme of water, such as the famous monkey with nine fingers and the hummingbird (Figs. 11.7 and 11.8). In ancient times in Peru, the monkey was associated with water, because they lived in areas with plentiful supplies. Moreover, the fact that the monkey has been drawn with nine fingers is not a sign of technical inaccuracy but rather a way to refer to a divine animal. In this respect, Reinhard (1988a, b) argues that, at the time of the Incas, it was a widely held belief to consider people or animals born with birth defects as sons of the lightning and the thunder. In ancient Peru, the hummingbirds (very closely related to the forest birds) were considered to be messengers of the gods as intermediaries between humans and mythological condors (Fig. 11.9), especially in the region of Lake Titicaca (Reinhard 1988a, b).

Other figures could be reasonably interpreted as motifs linked to water. For example, the shell and the ocean are represented by spirals, whereas streams and

Fig. 11.7 Pampa of Nasca: zoomorphic figure depicting a monkey or a feline, according to different interpretations (Photo by G. Orefici)

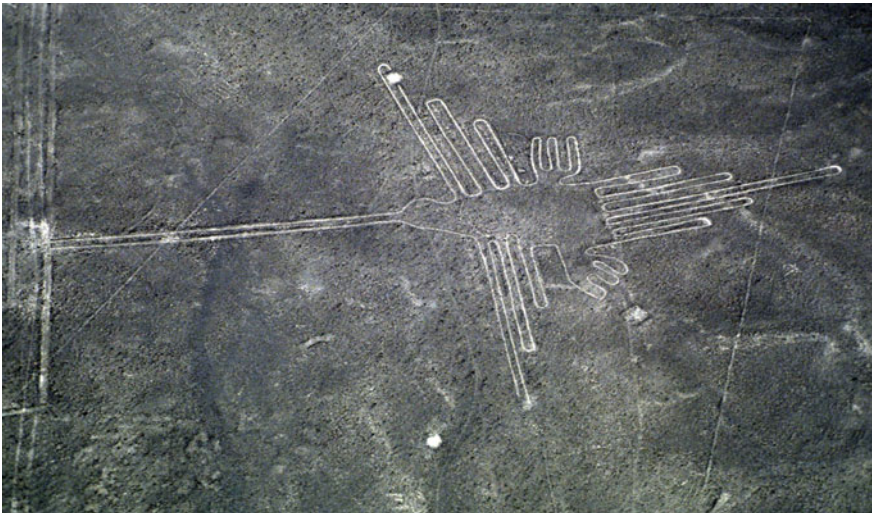

Fig. 11.8 Pampa of Nasca: ornithomorphic figure related to a hummingbird, which has been repeatedly analyzed by Maria Reiche (Photo by G. Orefici)

Fig. 11.9 The condor is the most powerful creature of the Nasca spirit world (Photo by N. Masini)

lightning are symbolized by zig-zag and meanders, as in the case of the geoglyphs in Pampa de Atarco (discussed in Chap. 12).

Finally, we cannot exclude a priori that the orientation of some lines, triangles, and trapezoids (Fig. 11.10) could be correlated with the water flow direction and water rituals, as argued by Reinhard (1988a, b, 1992).

In this regard, J. Lancho claims a clear relationship between the geoglyphs and the water. He analyzes some triangular geoglyphs pointing to a chain of hills including Cerro Blanco, the sacred mountain of the Nasca, which, according to some local legends, was the water source of filtration galleries (Silverman 1993). Lancho found a number of lines that end in water sources, so that the lines/pathways may have been made to persuade the gods to maintain the water running in the channels.

In our opinion, some connections between water searching/management and geoglyphs appear quite plausible. Therefore, it is worth continuing to explore other lines of investigation aimed at investigating all the possible spatial, functional, and cultural relationships between geoglyphs, hydrography, and availability of ground water.

In this respect, a contribution was made by Johnson who assumed a close correlation between groundwater resources and geoglyphs. Based on field observations and geophysical measurements, Johnson argued that some drawings mark

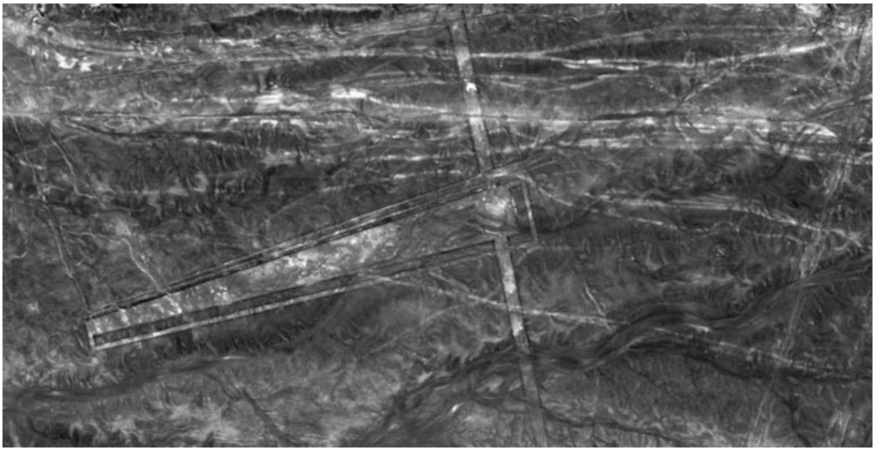

Fig. 11.10 Pampa de Jumana: detail of a trapezoid crossed by lines (Photo by N. Masini)

the paths of aquifers that bring water (in many cases collected by *puquios*) through geological faults and alluvial gravel (Johnson et al. 2002). In practice, the presence of groundwater could be detected by observing the presence of faults. According to Johnson, the co-presence in some areas of geoglyphs, faults, and sometimes *puquios* is not accidental. In this regard, an emblematic case is in Cerro Aja, crossed by a fault and characterized by the presence of a settlement, an aqueduct, geoglyphs, and radial centers. Afterwards, further field surveys have been conducted in order to obtain scientific evidence to prove Johnson's theories. To this end, some test sites were accordingly selected. The results indicated that the correlation between faults and geoglyphs was not statistically significant; though, it appears reasonable that a relationship between geoglyphs and subsurface water (Mayell 2000; Smith 2003) did exist.

As for all the other lines of research aimed at interpreting the geoglyphs (from the calendrical/astronomical theories to approaches linked more to the Andean world view), also in this case, it is desirable that more effort be made to produce more robust and conclusive evidence.

11.5 Conclusion

The review of investigations on geoglyphs shows how the different ideas and interpretations of the cited scholars converge, since the 80s, to a cultural, social and spiritual model, as result of a "long-term cultural tradition shared throughout the Andes that evolved slowly in time and proved persistent over the centuries" (Lambers 2006).

The geoglyphs were drawn on the Pampa surfaces by different social groups coming from various parts of the territory of Nasca and sharing common ancestors and land rights. The Pampa was a social space (Silverman and Proulx 2002) that contributed to strengthening the cohesion of various groups of pilgrims. But the Pampa was also, and above all, a sacred space dedicated to the worship of the mountain gods, the rivers, the elements of nature, and fertility. The ceremonies, processions, and ritual offerings of smashed ceramic vessels, food, and drink took place on specific dates of the Nasca calendar linked to agriculture. This may explain why some lines and, in particular, some points of the Pampa (including the line centers) were aligned with the sunset and sunrise in winter and summer solstices and spring and autumnal equinoxes, which marked the end and the beginning of the seasons. The geoglyphs were associated with distinct social groups (Silverman and Proulx 2002) for various functions such as gatherings and races in trapezoids, processions and races in biomorphic, meandering/zigzag, and spiraliform drawings.

The limits of the Andean model are mainly given by the difficulty of assessing its validity. In this respect, Lambers (2006) suggests two different strategies or approaches. The first is to question the analogies considering "the time interval between compared phenomena and their degree of similarity". The second must be based on the archaeological fieldwork aimed at investigating and dating contexts near or inside the areas of geoglyphs.

We agree on the two proposed approaches, especially the second, particularly when the research is focused on the study aimed at understanding the spatial, temporal, and functional relation of geoglyphs with neighboring civic–ceremonial settlements. To give substance to the Andean model, avoiding the risk of making it an abstract exercise, it is worth emphasizing the need to focus research efforts on the knowledge of the cultural and environmental peculiarities of the Nasca, among the Andean Pre-Inca civilizations. We refer to the influence that the extreme characteristics of the environment and the climate have had on the genesis and development of the Nasca civilization.

The constant observation of its ecosystem, the soil, and subsoil, as well as the scarce and varying availability of water in space and time, is reflected in the conception and perception of the Nasca landscape, cosmology, and religion. All of these aspects are interconnected to each other and synthesized in the ceremonial representations of the geoglyphs and inside the spaces of ceremonial temples, as in the case of Pampa de Atarco and Cahuachi, which are discussed in Chap. 12.

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Chapter 12
Cahuachi and Pampa de Atarco: Towards Greater Comprehension of Nasca Geoglyphs

Nicola Masini, Giuseppe Orefici, Maria Danese, Antonio Pecci, Manuela Scavone and Rosa Lasaponara

Abstract In the Nasca world, the geoglyphs represented a concept of sacredness, complementary, and alternative to, the ceremonial centers. In order to provide more data on the complementary nature of the sacred spaces of the geoglyphs and the temples, some investigations have been performed in Pampa de Atarco. The results from the surveys and mapping show intensive use of the desert pavement. The patterns analysis placed into evidence at least five groups of ground drawings, each of them characterized by a specific motif and shape, and associated with a distinct function. The morphological analysis reveals the centrality of one group characterized by a meandering figure, with a clear and distinct ceremonial function, which stands out on a number of trapezoids and lines, superimposed one on the other. The survey conducted by remote/sensing techniques revealed the presence of aligned along the directions of winter solstice and equinox sunset. As a whole, the complex

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of the geoglyphs of Atarco presents the spatial and functional characteristics of the venue of collective gatherings where ceremonial events linked to agriculture calendar were celebrated.

Keywords Nasca geoglyphs · Cahuachi · Pampa de Atarco · Satellite remote sensing · GIS

12.1 Introduction

The Nasca civilization, and those that followed it, devised a series of effective strategies to cope with the climate and adapt to the specific environmental and soil characteristics of the Nasca drainage basin which were not favorable to the production of food and to support livelihoods. Nevertheless, the Nasca were able to develop agriculture in one of the most arid places of the Earth by means of an ingenuous exploitation of arable lands, in the arid low and middle valleys. This was possible thanks to the deep knowledge and high technical capabilities of the management of the rivers and subsurface aquifers close to tectonic faults. The observation and the understanding of the spatial and temporal (intra- and inter-annual) variations of the surface water availability was of fundamental importance to make the most appropriate choices to face the problem of water scarcity. As a whole, to cope with the water shortage, the Nasca developed a double strategy: to mitigate the effects and to address the causes of the problem.

The 'effects' of the problem (water scarcity) were mitigated and managed through the building of *puquios*, the ingenious filtration gallery system built to intercept the underground aquifers (for detail the reader is referred to Chap. 13 by Lasaponara et al. (2016)). The empirical knowledge of the different degrees of soil permeability enabled them to create very deep drainage tunnels.

The 'causes' were and are linked to climate[1]: stable when dry and 'bizarre' with sudden changes when the rain in the sierra increases the height of the water table or destroys the crops due to the *huaycos*[2] that invade the fields making them unavailable and uncultivable for years. Another aspect of the adverse climate is related to the cyclical phenomenon of El Niño. The Nasca had the perception that climate, atmosphere, and ocean were unpredictable elements with catastrophic effects on humans and, therefore, they were regarded as instruments of the divine will or divinities themselves.

Hence the need of the Nasca to establish a lasting harmonious relationship with the supernatural through the mediation of priests. They presided over the ceremonial activities, composed of prayers, chants, rituals, sacrifices, and processions

[1]For details, see Chap. 2.

[2]Flash flood caused by torrential rains.

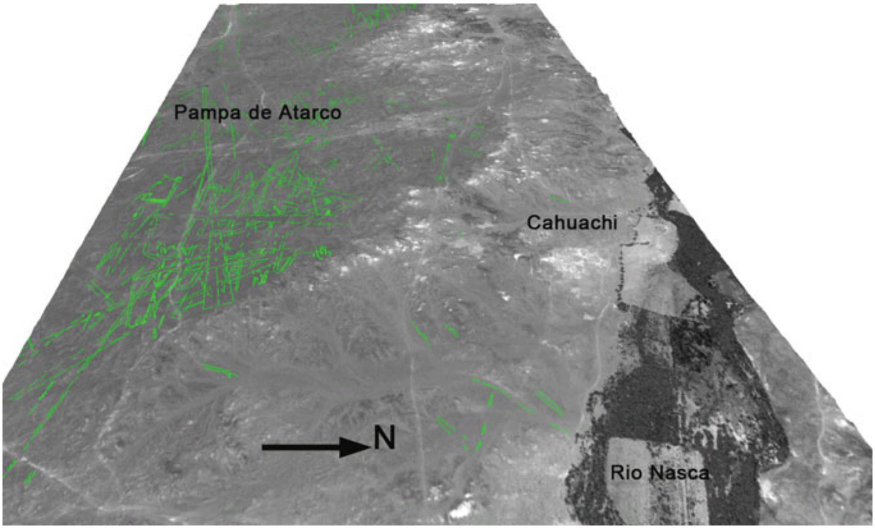

Fig. 12.1 3D satellite image (GeoEye 2011) including the geoglyphs of Pampa de Atarco, the ceremonial center of Cahuachi, and Río Nasca

which took place in the narrow corridors of the pyramids, in the squares (*plazas undidas*), and over the geoglyphs.

The worship of water and fertility were the elements that characterized the need to invoke the gods, performed by the Nasca in the sacred spaces of the geoglyphs.[3] These rituals and spaces were also important elements of social cohesion between various groups of people who shared the same religion and ceremonies.

The relationship between the sacred spaces of both the geoglyphs and the ceremonial architecture (Fig. 12.1) will be discussed in the following two Sects. (12.2 and 12.3). In the first (12.2), Cahuachi is analyzed in relation to the culture of geoglyphs, whereas, Sect. 12.3 focuses on the results obtained from the surveys conducted on the geoglyphs of Pampa de Atarco, the closest ground drawing to the pyramids of Cahuachi.

12.2 Cahuachi and the Geoglyphs

The studies on Cahuachi and the Nasca geoglyphs made so far, in particular in the framework of the Proyecto Nasca, lead to consideration of a dual form of collective manifestation, within the cosmological vision of the Nasca culture. Cahuachi was considered the theocratic capital, where only the elites of the pilgrims were allowed to access the ceremonial center and could participate in the rituals that took place

[3]See the overview on Nasca geoglyphs in Chap. 11 by Masini et al.(2016a)

there. Probably, the pilgrimages were organized only on special dates of the agricultural calendar, religious holidays, or specific peculiar events. Access to the sacred architectural complex was mostly precluded during the other periods of the y r. This led to the need for alternative places to conduct rituals and collective functions, mainly for pilgrims coming from the Valley of the Río Nasca.

Cahuachi exhibited a monumental architectural space which was highly visible from afar, thanks also to its very vivid colors that further enhanced its presence in the desert area. The monumentality was the most absolute element of prominence over the other features of the temple complex. Each building assumes a role in the theatrical expression of size and characteristics that actually contributed to sublimate its own divine nature.

The geoglyphs represented a concept of alternative and complementary sacredness to Cahuachi. They were formed by open spaces, delimited along their perimeter by rows of stones, with the function of enclosing the areas designed for a large amount of people who could access and celebrate collective rituals. The demarcation of the space, in this case, was more conceptual than real. The color of the earth and the relief edges (where people piled the pebbles and stones that made up the limits of the perimeter) were the elements that distinguished, even from a great distance, the geoglyphs from the remaining space. Their visibility was even greater if the spaces were occupied by a large number of people with colorful costumes. Collective ceremonies performed walking on geoglyphs made people aware of the iconographic symbols belonging to their cultural origin and religious, which reinforced cohesion between various human groups, all united by the same religious beliefs.

Most of the geoglyphs were located in proximity to urban centers, probably to assure close access to those sacred areas with a higher concentration of drawings, without traveling great distances.

In the valleys adjacent to the residential sites, often there was a concentration of geoglyphs, as it is evident in the valleys of Atarco, Usaca, Majuelos, El Ingenio, Pueblo Viejo, and Santa Cruz, just to name some. Even in the valleys of Las Trancas and Pajonal, in places situated between several settlements, there was a concentration of figures of varied sizes. To draw them, the Nasca often chose arid places not useful for cultivation and without evidence of flooding in order to preserve land for agriculture and to preserve the geoglyphs from floods.

To date, no studies have focused on or analyzed the relationship between the ceremonial center of Cahuachi and the geoglyphs in the immediate vicinity of the pyramids. This is probably also due to the fact that many of the main figures had been erased by the two large floods that occurred in 400 AD and from another similar event that occurred around 1000 AD.

For this reason, currently it is only possible to identify the most distant geoglyphs and those in higher positions and, therefore, less exposed to floods, as those in the Pampa of San Jose, to the north, and in the Pampa of Atarco, to the south (described in Sect. 12.3). There are some figures that originate directly from the ceremonial center and run in the direction of the Pampas of San Jose and also a long straight line that connected Cahuachi directly with the ancient urban center of La

Ventilla (Silverman 1990). These tracks were made up of straight lines, perfectly preserved still today, which were used as sacred paths.

In the Pampa, there are various types of geoglyphs, including naturalistic figures with motifs also present in the Nasca ceramics and textiles, as well as large geometric lines with trapezoidal, triangular, rectangular, and meandering shapes. It is reasonable to assume that the most relevant religious gatherings, which involved a large number of pilgrims, took place in the area of the geoglyphs and not in the ceremonial center. In fact, access was easier from both the valley and the desert plain, so that it was possible that the large processions would start from the ceremonial center in the direction of the geoglyphs. Following the route of the main lines, people could access the various figures to perform the rituals of the ceremonial calendar, within the spaces dedicated to these activities, bounded by stone reliefs.

Cahuachi constituted a sacred space dominated by the priestly class, the only one allowed to know the intricate labyrinthine paths inside the temples, which were reached through small entrances. The pampas of geoglyphs was, for more than 900 years, the alternative venue which could accommodate a multitude of pilgrims attending the celebration of the most important religious ceremonies, who in some cases came from almost a thousand kilometers away. In Cahuachi the large walls, which sometimes reached 9–12 m in height (Fig. 12.2), reduced the view of the ceremonial structures.[4] In general there were a few places, including the tops of the pyramids, where it was possible to have a global view of the entire temple complex. On the contrary, the sacred spaces of Pampa allowed a global overview of the immense human and environmental scenography that characterized the different phases of the ceremonies, with the simultaneous participation of various groups cooperating together in an impressive choreography, thus giving greater solemnity to the celebrations. This was possible thanks to greater visibility in the area of geoglyphs, as confirmed by some simulations based on viewshed analyses (see Fig. 12.3).

Cahuachi and the geoglyphs were two distinct ceremonial spaces delimited by well-defined perimeters, although characterized by different morphologies and types of fruition. Approaching Cahuachi, its monumental and gigantic size is dominant but, at the same time, the perception of space is lost, due to the fact that the diverse levels of the monumental pyramids were intricately decomposed and divided into corridors, stairs, and rooms covered and separated by the high walls of the various buildings. The corridors, often parallel to each other, led to different places and are not communicating: only those who perfectly knew entrances and paths could navigate inside the buildings. It was the opposite for the geoglyphs: their access spaces were well indicated. Paths that led to the perimeters of the figures were much easier to use, and their outline was visible and marked by the symbolic presence of stones which formed the boundary. Altars or mounds,

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[4]As in the case of *Templo del Escalonado,* which retained the original height of the 12-m perimeter walls, due to fact that it was completely buried (see Chap. 16).

Fig. 12.2 3D-rendered model of *Gran Piramide* of Cahuachi. (Drawing by Manuela Scavone, CNR/IBAM)

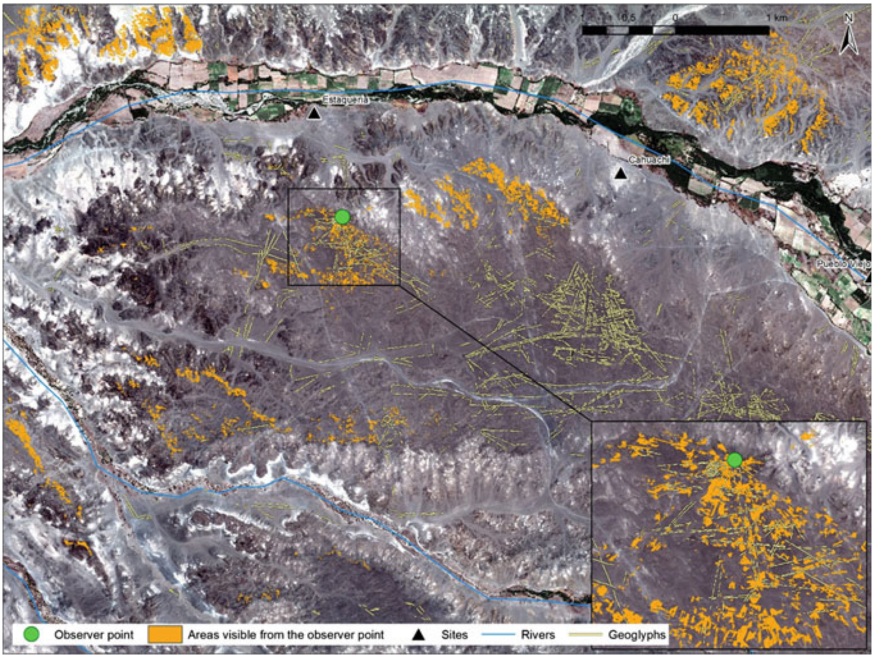


Fig. 12.3 Viewshed analysis of the geoglyphs in the Pampa de Atarco which places into evidence the great visibility among the geoglyphs dedicated to ceremonial activity. The selected observing point is a radial center (see Sect. 12.3.2)

observable within figures and especially in large geometrical spaces, were visible from a distance, facilitating access even to multitudes of people simultaneously. From several kilometers away, the ceremonies could be distinguishable and, if accompanied by music or dancing, became dynamic elements that enlivened the desert plain.

The oldest geoglyphs, dating back to the Early Horizon, are mostly concentrated in the pampas and in the sides of the valleys of Palpa. However, several examples of archaic figures can be observed in Cahuachi, in Majuelos, and in the Pampa of Nasca, such as the well- known anthropomorphic effigy representing the divinity of the " being with large eyes", located on a hillside (Fig. 12.4).

In general, the first examples of geoglyph culture consisted almost entirely of anthropomorphic figures or images linked to the cult of water or fertility. In particular, the anthropomorphic motifs, situated in the area of Llipata and in the valleys near Palpa, are mostly related to the worship of mythical heroes or ancestors. They are mostly small in size, produced in raised relief or sometimes with a mixed technique, that is, part in relief and part in negative, by removal of the lithic material around the figures (Fig. 12.5).

The anthropomorphic geoglyphs were drawn on the walls of the sloping hills looking over the valley, as large panels belonging to the sacred area used for ceremonies. It is reasonable to think that these figures were part of liturgies that included processions related to various representations of god, mythical heroes and deified ancestors belonging to local groups. The iconography of these geoglyphs

Fig. 12.4 Pampa Colorado: the Oculate Being, the most important anthropomorphic divinity dating to the Late Paracas period. Its popular name is the 'astronaut'. (Photo by G. Orefici)

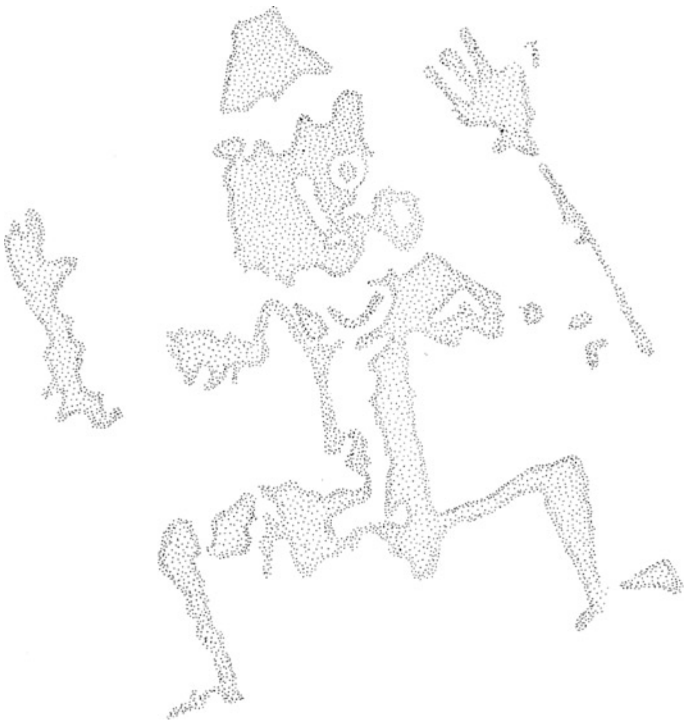


Fig. 12.5 Anthropomorphic figure praying with open arms and legs apart. The geoglyph is located in the area of Palpa. (Drawing by Delia Perini)

was inspired by the repertoire of the ancient Paracas textiles. As a form of expression, the geoglyphs continuously developed over time, starting with the transition of the Paracas–Nasca age. It can be considered as the first phase of a tradition that was consolidated with later iconographic, typological, and technical changes. The initial model is rooted in ancestral practices to create cultural and mythical scenes as exemplified by rock art in the area.

Later, the geoglyphs evolved into realization by macro-incisions on the ground, with the aim of communicating symbolic messages to the wide audience who was part of the choreography itself. The represented themes became iconographic elements tied to the production of textiles and ceramics. Among them, we can highlight mythical beings with symbols of command, or large cephalic ornaments with long ornamental feathers. In some cases, female figures can be identified, but generally the sex of the characters is not evident.

The following phase of the geoglyph culture is related to drawings made on flat surfaces of the desert areas and on hilltops of the Nasca drainage basin, including the hills surrounding Cahuachi. They were geoglyphs linked to the worship of water and fertility which probably, nearby the ceremonial center, assumed considerable importance during the events linked to the agricultural calendar. On certain occasions, the participation of groups coming from far away, was essential to confirm and seal the cohesive bonds through their common religious beliefs. Obviously, these are assumptions made on the basis of the still conserved geoglyphs. Unfortunately, we do not have the opportunity to rely on all the geoglyphs of that time, since most of them have been obliterated by the floods of exceptional intensity that affected the territory.

The majority of these geoglyphs presents an iconography with characteristics similar to those of the Nasca ceramics and textiles, with depictions of zoomorphic and phytomorphic motifs or complex scenes. They show images of the main gods of the Nasca religious world, such as the rain-bird, with wings (open or closed), the hummingbirds sucking nectar from flowers, marine and land birds, the spider, symbol of fertility, and finally, the most important of all, the killer whale and the felines (Fig. 12.6).

In this phase, we find the Paracas–Nasca spiritual world better matched by the geometric geoglyph culture. The figures were triangular, trapezoidal, and rectangular motifs, variable in size up to several giant examples, which are the most numerous ground drawings over the entire desert region of Ica.

In many cases, these newer figures are superimposed on more ancient drawings, possibly in a time of radical changes in the political and social structure of the theocratic capital of Cahuachi, perhaps following adverse events such as floods or an earthquake. The destruction resulting from natural events that have shaken Río Nasca valley and the ceremonial center was probably the main reason for the

Fig. 12.6 Pampa of Nasca: huge geometric geoglyph overlaid on a pre-existing figure related to a hummingbird sucking nectar from a flower. (Photo by G. Orefici)

Fig. 12.7 *Pampa de Nasca*: ornithomorphic figure located on a raised hill. The beak is crossed by a later long line. (Photo by G. Orefici)

changing use of the geoglyphs. The need to increase the ceremonial activities of great ideological impact and the celebration of rituals that would enable strengthening the cohesion between different social groups, led to devoting greater efforts on the areas of geoglyphs.

The aim was to highlight the great ceremonial spaces as an alternative to the temples of Cahuachi, which were destroyed by the earthquake and floods around 400 AD. Therefore, the drawing of several geometric figures was made with the purpose of accommodating a large number of people participating in collective rituals (Fig. 12.7, 12.8, 12.9 and 12.10).

Between el Río Ingenio and Cahuachi, there are many of these geometric drawings, as well as in the vicinity of the major urban centers. Silverman (1990) argued that an ancient road, named Leguía, overlapping a linear geoglyph, connected the ceremonial center of Cahuachi with the urban core of Ventilla, located on the left bank of the Río Ingenio.

Also south of Cahuachi, in the Pampa de Atarco, around the 5th century AD, large geometric figures with rectangular, trapezoidal, and meandering shapes were drawn. It is likely that many of the functions that took place in the ceremonial center moved to the area of the geoglyphs, at the end of Phase IV of Cahuachi.[5]

[5]This phase was characterized by the restructuring and reuse of walls built with the *quincha* which is a traditional construction system based on the use of wood and cane or giant reed covered in mud and plaster.

Fig. 12.8 Pampa of Nasca: ornithomorphic stylized figure commonly called "the parrot". (Photo by G. Orefici)

Fig. 12.9 Pampa of Nasca: an ornithomorphic figure. However it is commonly known as "the hands" and is located in close proximity to other zoomorphic and phytomorphic figures. (Photo by G. Orefici)

Fig. 12.10 Pampa of Nasca: arachnid figure (Photo by G. Orefici)

In the following two centuries, the pyramids of Cahuachi were abandoned as the ceremonial center along with the priests moved to Estaquería. This determined the final phase of the decadence of the ceremonial center and the transition towards a new political and social asset with the presence of local authorities (*cacicazgos*) . It is likely that, at this stage, the great choral activities which had taken place before in Cahuachi intensified in the geoglyph areas, to make possible the continuity of the collective religious activities. Over time, the areas where ceremonies took place were near urban centers which also included the pampas of geoglyphs dedicated to the worship of water and fertility. Music and dance were some of the components of the ceremonial activities, as indicated by the presence of many ceramic materials found in the areas of the geometric geoglyphs (Fig. 12.11).

As already stated, even before the decline of Cahuachi, the lines were made to hold collective ceremonies with the participation of a large number of people. The valleys around Llipata are an example of the use of geoglyphs to contribute to the consecration of specific spaces. The presence of geoglyphs gave greater importance to the function of the place as a venue for major choral events.

Cahuachi was the main center of pilgrimage, the ceremonial site of excellence, where groups of people came to offer their agricultural products, but also to pay homage to the gods with sacrifices of animals, human beings, ceramics, or textiles

Fig. 12.11 Pampa of Nasca: large geometric figure used for large group meetings. It is overlaid on a pre-existing ornithomorphic stylized figure, which is partially erased. (Photo by G. Orefici)

or to consecrate unions or alliances between different social groups.[6] It is important to remember that the territory occupied by human groups sharing the Nasca religious belief was very wide and the population involved was often from very distant places, bringing with them the most valuable and important offerings.

Pilgrimages to Cahuachi occurred on the occasion of important dates. It is quite logical that the whole mass of the population could not go directly to the temples. The pilgrims who had no access to the inner areas of the ceremonial center camped in neighboring areas where, likely, rituals and processions took place on the geoglyphs.[7]

[6]During the excavations of the *Gran Pirámide*, a number of ceremonial wells were found. They were filled with the offerings of pilgrims. These consisted of agricultural products as well as pottery materials that were often broken in the act of sacrifice and offered to the ceremonial center or to the gods.

[7]During the archaeological excavations of 1986 in the sector Y, evidence of intense activity from human presence in the vicinity of the main temples was found. Several human excrements, remains of hearths, and leftover food were found. It is thought that these places were used by the

With the presence of various, culturally distinct groups, the priestly class highlighted the need to promote their cohesion under their control. Participation in the same religion favored the absence of tension or belligerence among groups who felt subordinate to social rules dictated by the priests of Cahuachi. The uniformity of cosmogonic and cosmological vision, which stemmed from the common belief, enabled control of any discrepancies that might be caused by different interpretations of a collective conception, thanks to the participation in periodic rituals, where everyone felt part of the same community.

Cahuachi was the center of the Nasca religious universe, the element that made possible homogenization of diverse cultural expressions. It was an example of the constant control of the priestly class over the political, social, economic, and religious life of people with distinct traditions, united by the same faith. The geoglyphs were the alternative for groups, who travelled to the neighborhoods of the pampas of Nasca and Cahuachi, to feel united through participation in the rituals.

12.3 Pampa de Atarco: The Geoglyphs of Cahuachi

As previously discussed, the temple architecture and geoglyphs are two sides of the same coin: “close” and “open” sacred places designed by the Nasca for religious ceremonies and any other liturgical forms of religion. The two aspects were different and complementary.

The architectural environment composed of temples, platforms, and *plazas undidas* was the sacred space of excellence where people invoked the gods for the water and fertility and ask their protection from famine and disasters as floods, earthquakes, etc. The architectural complex also had a logistic function, fundamental for the management of the flow of pilgrims, as well as for the conservation of surplus of food and artifacts used during rituals.

The Pampa areas were an extension of architectural sacred spaces, a sort of a “reception” area for the mass of pilgrims who could not access all at once the Temple area.[8] The geoglyphs were also the place to experience a self-managed mode of interaction with the deities and rituals linked to the cosmology and the myths of the Nasca cosmogony. Therefore, the Pampa was at the same time a space where to camp and to exercise the faith and share the common religious belief, thus strengthening their sense of identity and belonging to a same social group. The complementary nature of the sacred spaces of the geoglyphs with the temples suggests their interrelationship and coexistence. Nevertheless we cannot exclude the fact that the abandonment of Cahuachi probably strengthened the function of the

(Footnote 7 continued)

pilgrims who were not allowed access to the inland areas and who camped around the ceremonial center.

[8]See Foonote 4.

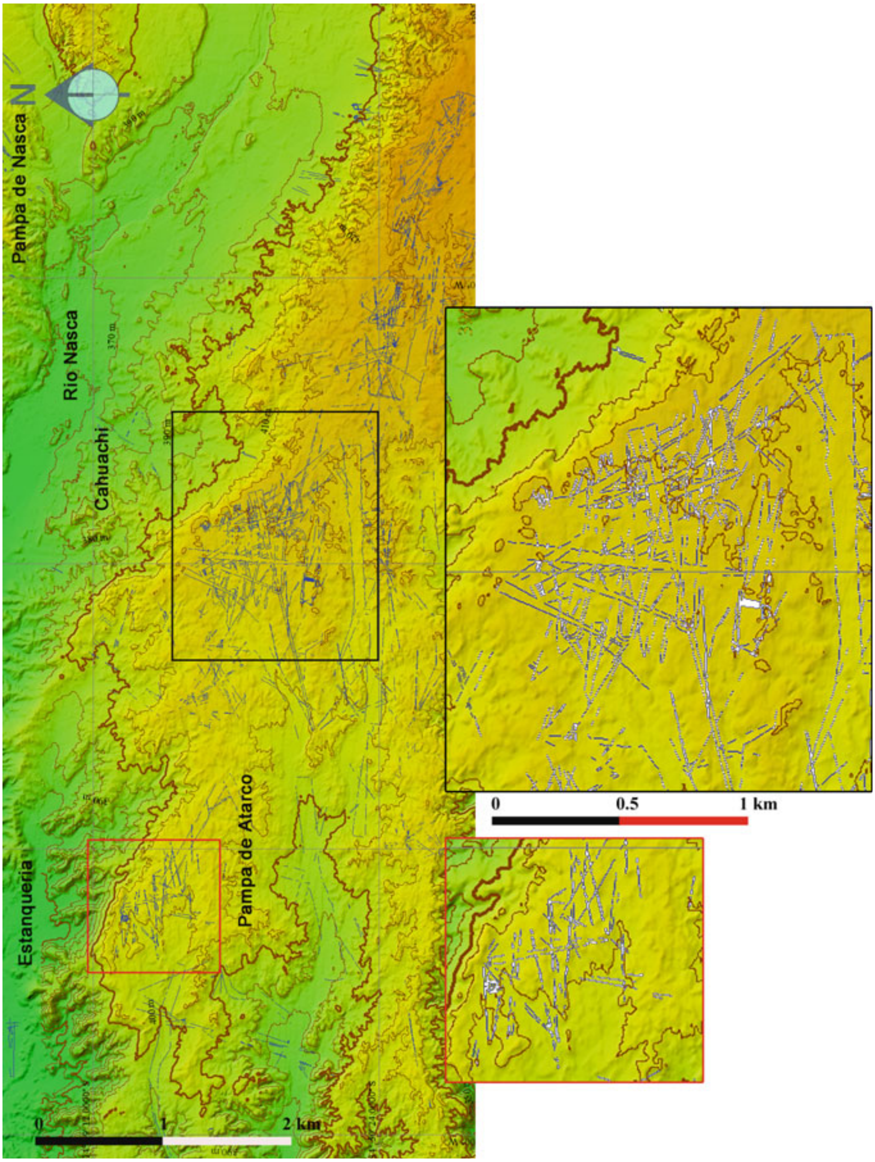


Fig. 12.12 DEM derived from a GeoEye stereo pair with map of geoglyphs of the Pampa de Atarco. The two zooms bordered by *black* and *red lines* are related to two groups of geoglyphs, named G1 and G2, respectively (see Fig. 12.17). The first is characterized by a meandering motif, the second one by a spiraliform figure. In all the Pampa de Atarco, no biomorphic figure has been found

geoglyphs as a ceremonial place and a widely recognized reference point for the Nasca culture and religion.

This is still today an open issue.

Much data and further studies are needed to diachronically understand the different roles of the geoglyphs and the temples in the ritual and liturgical activity linked to the myths of the Nasca Cosmogony. Cahuachi, center of the Nasca universe, was 6–14 km south of the geoglyphs of the Pampas de Jumana and Colorado. Moreover, the mutual visibility between the Pampa de Atarco, Cahuachi, and the Nasca Lines is not interrupted by any geo-morphological and hydrological features.

With the exception of some investigations conducted by H Silverman and J. Pineda in 1985 and some surveys carried out in the framework of the Proyecto Nasca between 1988 and 1989, there today is yet a lacks of systematic research based on a detailed spatial and typological analysis of these geoglyphs.

This prompted the initiation of the mission ITACA by CNR in 2011, a research project aimed at documenting, mapping (Fig. 12.12), and studying the lines still surviving in an area located in the immediate neighborhood of Cahuachi (within a radius of about 1–4 km from WNW to ESE of the pyramids). In this book, we present the first results of the survey, mapping campaigns, and morphological analysis of the geoglyphs.

12.3.1 Methodology

12.3.1.1 Remote Sensing and Ground Truth

The research has been aimed at analyzing, from the spatial, morphological and visual points of view, the ground drawings in relation to the surrounding context, including the pyramids of Cahuachi. The investigations have been strongly based on the use of a multiscale remote-sensing approach to obtain a georeferenced map useful for field work, as well as to provide features related to the geoglyphs. They are particularly difficult to recognize from the ground, especially south of the pyramids, due to the fact that the soil surface is composed of very-fine sand and pebbles of 3–10-mm size. Moreover, this makes them especially vulnerable to damage caused by incautious people incautiously walking, even with appropriate shoes, as those that are usually employed for the activities of field surveying in the areas of geoglyphs. Therefore, remote sensing has been chosen not only to observe and identify geoglyphs and other archaeological features, but also to provide digital maps to be promptly implemented in GPS and mobile devices. These tools have been used during the field-work campaigns to avoid potential involuntary damage to the geoglyphs. The maps were particularly useful in areas where geoglyphs are very difficult to identify on the ground, such as those made by curvilinear shape, zig-zag, or meandering motifs, or those characterized by the superposition of a number of drawings or signs of vandalism.

The surveys were conducted with photogrammetric techniques based on the use of monoscopic and stereoscopic satellite images, aerial photos taken from a fixed wing aircraft, an ultra-light aircraft, a drone, and topographical measurement of the ground points. The satellite dataset included optical and SAR images at different geometric resolution ranging from 90 m to 41 cm.[9] The optical space imagery includes high resolution (HR) ASTER and Landsat TM data, and very high resolution (VHR) provided by QuickBird, WorldView-1, WorldView-2, Stereo GeoEye-1, and Pleiades. The HR data were acquired from 1985 to 2014 and cover an area of about 2500 km^2, including Cahuachi, the Pampa of Nasca, and the Pampa de Atarco. The VHR satellite data[10] cover about 100 km^2, including Cahuachi, Estaquería, Río Nasca, Pampa de Atarco, and the puquios of Río Taruga and Las Trancas from 2002 to 2013 (in particular during the years 2002, 2005, 2008, 2010, 2011, 2012, and 2013). This enabled multi-temporal observation, which was very useful for the detection and analysis of changes as well as for the assessment of risks affecting the ceremonial architecture and the geoglyphs.[11] The rich available VHR satellite data set, acquired with various spatial resolutions, view angles, and bands, has been also fruitfully employed in a GIS environment to maximize the information in terms of visibility of features related to the presence of geoglyphs. The integration of the data has been particularly useful for assessing the impact of motorcycle/car tracks and for the analysis of the areas characterized by the superposition of multiple drawings. In particular, the multi-temporal observation along with the improvement of signal/noise ratio enables us to estimate indirectly and to understand the relative chronology of the ground drawings.[12] The DEMof the area including Cahuachi and the geoglyphs of Atarco has been obtained[13] by a stereo pair of GeoEye images acquired 29.02.2011 (Bitelli and Mandanici 2016). The DEM has been employed to produce contour, orthophoto, and perspective maps. The elevations of the surface terrain have been used for the ortho rectification of other satellite images not acquired on the same date as that of

[9]For details on satellite optical and SAR datasets, see Chap. 20 by Masini et al.(2016b) and Chap. 21 by Cigna and Tapete (2016).

[10]With ground sample distance (GSD) of panchromatic scene ranging 41–70 cm and multispectral ranging 164–280 cm.

[11]For additional details, see Chaps. 20 and 25.

[12]The visibility of satellite imagery depend on the time acquisition, the meteorological conditions, and the geometric resolution. By using the entire dataset, it has been possible to improve the quality of archaeological information as well as to detect changes related to damage caused by vandalism and tracks left by off-road vehicles.

[13]DEM carried out by Gabriele Bitelli and Emanuele Mandanici (see also Chap. 23 by Bitelli and Mandanici (2016)) has been obtained by using DEM Extraction Module of ENVI. The DEM extraction process requires a stereo pair of images containing rational polynomial coefficients (RPC). The process for the extraction of DEM is composed of the following steps: (i) selection of stereo image pair and ground control points (GCPs), measured by differential GPS surveying; (ii) viewing, adding, and editing GCPs; (iii) collecting, viewing, adding, and editing tie points; (iv) generation of the epipolar geometry and epipolar images that describe the relationship between the pixels in the stereo pair; (v) Selection of DEM Extraction Parameters; (vi) DEM Extraction.

the GeoEye stereo pair, in particular from 2012 to 2014. An update of the DEMs covering the monumental area and some geoglyph groups have been obtained using structure-from-Motion (SfM) methods applied to aerial images acquired from aircrafts and drones on 2013 and 2015.[14]

The satellite based DEM has been also employed to perform viewshed analyses, aimed to identify the cells in an input raster that can be seen from one or more observation points or lines. In particular, in the Pampa de Atarco, viewshed analyses have been used to understand the visual relationships between geoglyphs and their surroundings and to analyze the mutual visibility between geoglyphs.

The resolution of the DEM and the optical satellite images is not enough to discriminate all the minimal variations in height and roughness of the ground surface referable to geoglyphs. To cope with this drawback, some selected areas have been surveyed by aerial and drone flight. Moreover, the images have been enhanced by using algorithms based on convolution filtering. Among them, the directional convolution[15] proved to be the best in discriminating the various different features visible such as the geoglyphs, vandalic marks, off-road vehicle tracks, *huaycos,* and mudslides deposits. In areas characterized by the superposition of lines, as, for example, trapezoids and meandering motifs, the directional convolution makes the identification of the relative chronology of the execution phases easier. For example, Fig. 12.13 shows on the left a detail of a meandering motif in the Pampa de Atarco (M1 in group G1: see Sect. 12.3.1.2), from a panchromatic GeoEye image. The scene includes also two trapezoids and damage by off-road vehicles. On the right is the result of the convolution directional filter which emphasizes edges and micro-topography, thus facilitating the reconnaissance of the features and the superposed geoglyphs. In particular, from the filtered scene (Fig. 12.13, right), it appears that trapezoid t2 is older than meandering element (M1) and trapezoid t7. The latter seems to have been drawn after the meander. However, we cannot exclude contemporary use of both of the two geoglyphs (t7 and M1) as ritual paths.

Aerial images taken from 2007 to 2014 cover about 25 ha, including some geoglyphs around the pyramids of Cahuachi. Finally, a UAV[16] was been used for small areas of particular interest for the study of the execution techniques and the characteristics of the superposition of trapezoids and meandering figures. By means of procedure of structure from motion (SfM),[17] it has been possible to obtain very

[14]See also Sect. 20.3.3 by Masini et al.(2016b)

[15]The convolution filtering is an enhancement method for images, which acts on the single pixel changing its brightness value as a function of some weighted average of the brightness of the surrounding pixels. Directional is a first derivative edge enhancement filter that selectively enhances image features having specific direction components (for additional details, see Chap. 20).

[16]The survey was performed by a drone Dji Phantom Vision 2 plus, a radio-controlled quadcopter, able to take off and land vertically on any surface, equipped with a very stable two-axis gimbal, and a mounted DJi camera which can shoot video in full HD and take photos containing 14 megapixels.

[17]For additional detail on SfM, see Chap. 20.

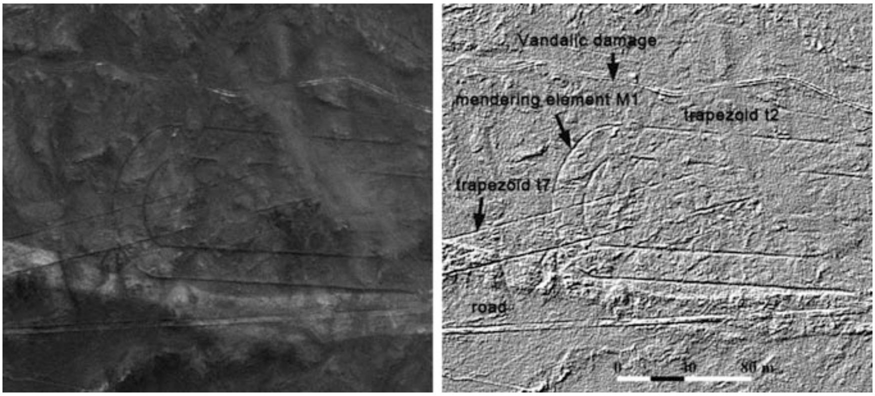


Fig. 12.13 Superposition of geoglyphs: detail from a satellite panchromatic image (*left*). The filtering enabled the enhancement of the image and facilitated the reconnaissance of all the features, including the geoglyphs and off-road vehicle tracks

accurate digital models which enables the analysis of the micro-topography of the geoglyph surface (see Sect. 12.3.2).

The identification and subsequent mapping of geoglyphs was carried out through the processing and interpretation of satellite images. This was performed after preliminary feature extraction based on object-oriented algorithms, with a good rate of success of about 80% achieved for the linear features. However, the low rate of success and the high number of false alarms in the presence of curvilinear features suggested concentration of efforts in the direct observation of satellite pictures and ground-truth investigations.

12.3.1.2 GIS-Based Analyses for Archaeology

Some GIS-based analyses have been performed exploiting the satellite based DEM. For the study and mapping of the geoglyphs, significant results have been obtained by viewshed analyses (VSA) and kernel-density estimation (KDE) .

VSA is a map algebra technique which is based on the following principle: given a specific location (observer point) and a split of the landscape into a series of squares (pixels), the VSA informs us about which and how visible are the investigated pixels for an observer at a given point, considering the landscape morphology (Fig. 12.14).

Today, thanks to the great diffusion of GIS over the last 20 years, VSA is largely used in many application fields such as urban and territorial planning (Danese et al. 2008a, b), protection of threatened species (Camp et al. 1997), visual impact assessment in wind stations (Kidner et al. 1999), and archaeology e.g., Lake et al. 1998).

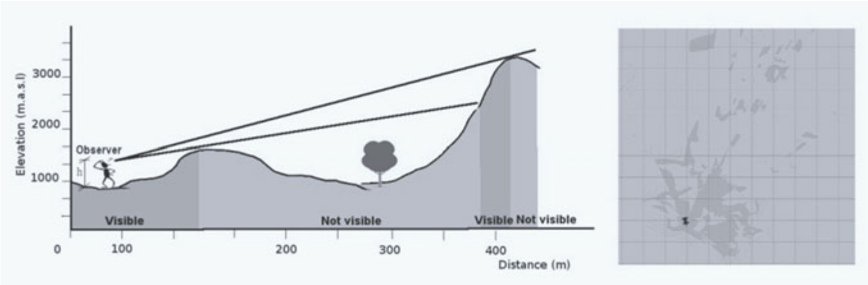


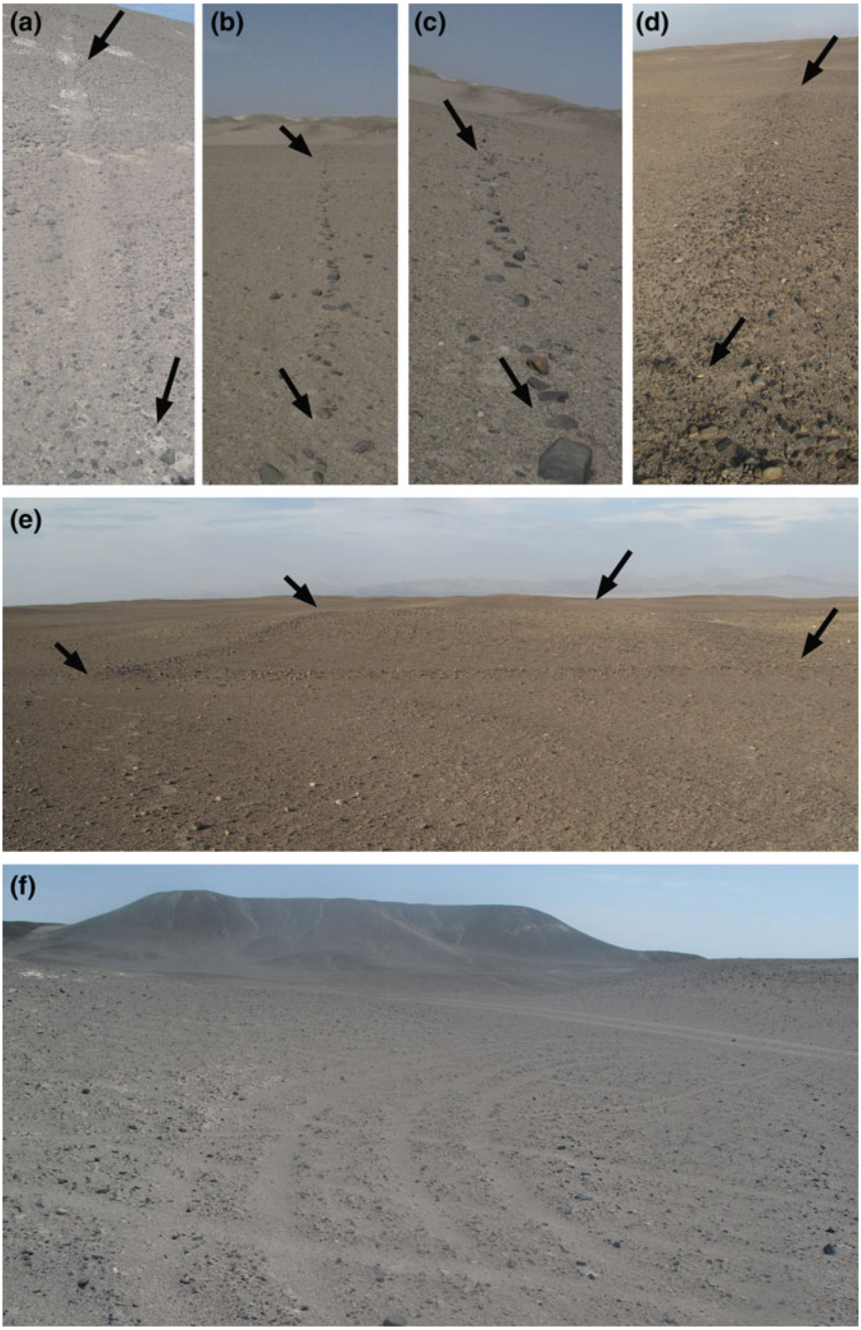
Fig. 12.14 Computation of visibility areas by viewshed analysis

Viewshed is created from a suitable digital elevation model using an algorithm that estimates the difference of elevation from one cell (the viewpoint cell) to the next (the target cell). To determine the visibility of a target, each cell between the viewpoint and target cell is examined for line of sight. Where cells of higher value are between the viewpoint and target, the line of sight is blocked. If the line of sight is blocked, then the target is determined to not be part of the viewshed.

In VSA, there are three interlinked main factors that influence results: the observer, the object to be observed, and the 3D landscape representation (Bishop and Keredaglis 1996; see Fig. 12.14).

The most important property related to the observer is its height above the terrain, which could completely change the amplitude of the visual field. The main properties related to the observed object are its dimension and appearance, such as the color and how this is integrated in the environment. About the environment, the main factor that could alter landscape visibility is the atmospheric conditions. However, the most important parameter is the landscape and, obviously, its 3D representation with a suitable digital-elevation model. First, it is important to choose the right cell size: a smaller cell size makes possible consideration of all the roughness and, therefore, could overemphasize the visible and not visible areas above the terrain; whereas a larger cell size could hide important visibility areas and overgeneralize the result. It is really important to build a digital elevation model as close as possible to reality, by taking into account not only the terrain surface, but also the dimension (in particular the height) of the objects (e.g., buildings, vegetation) on it.

In general, visibility is an important factor for archaeological site location because it enables the objective and quantitative description of the relationships existing among the given sites and between each site and the environment. If the basic information of the analysis is accurate, it is possible to know completely what is visible and what is not visible from a chosen site. Consequently, VSA became important for site location (Krist and Brown 1995; Maschner 1996), but also for cognitive issues (Ogburn 2006). For what concerns the region of study of this work, Lambers (2006) and Lambers and Sauerbier (2006) investigated the visibility of the geoglyphs at Palpa, trying to understand how geoglyphs were perceived from the


(a)
(b)
(c)
(d)
(e)
(f)

◄ **Fig. 12.15** Pampa de Atarco: details of lines **(a–d)**, a trapezoid (**e**), and a spiral (**f**) drawn on the desert pavement with different techniques consisting, with respect to the lines, in: **a** the removal and addition of stone material, **b–c** placing *dark-colored* gravels along the lines, **d** creating micro-relief by scraping and placing fine-grained material. Finally, the trapezoid is the result of subtractive and additive techniques, whereas the spiral is drawn by alternating the removal of fine-medium grained stone material and their placement along the curves adjacent to the grooves

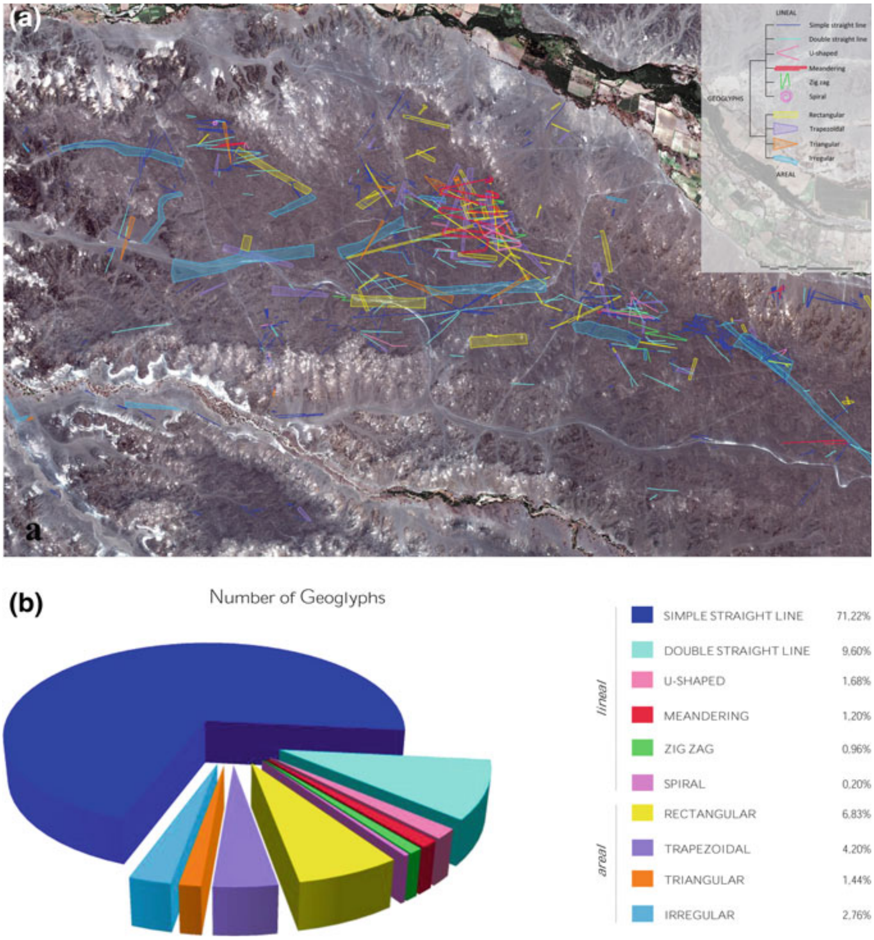


Fig. 12.16 Morphological features of geoglyphs. **a** Mapping; **b** percentage distribution of geoglyph morphological features

ground. In our studies on Pampa de Atarco, VSA made it possible to analyze the mutual visibility between the different groups of geoglyphs, between them, the temples of Cahuachi, and the Pampa de Jumana geoglyphs (see Sect. 12.3.2).

KDE is a spatial analysis technique that is used to investigate the local density properties of a spatial distribution. While a classical, "global" density informs us how many events (for example how many sites) there are for unit surface, with a unique number for the whole study area, KDE is able to inform us about how the density varies locally above the studied region, where high (hot spot) and low density zones (cold spot) are and, finally, how high and low they are. In human spatial phenomena, usually, a hot spot and the closeness between similar geographical objects means a stronger relationships between them, and this is important also in archaeological study, in particular for what concerns the settlement pattern and the distribution of archaeological sites over the landscape (Vining 2015; Charlton et al. 2012; Danese et al. 2014). For our investigations in Pampa de Atarco, KDE was used to analyze and map the different densities of ground drawings, in order to divide them into clusters, and then, on the basis of morphological observations, into groups.

12.3.2 Patterns and Morphological Features: First Interpretive Hypothesis

To the south, west, and southeast of the ceremonial center of Cahuachi, geologically characterized by the Formation of Changuillo, there is an intricate palimpsest of geoglyphs covering an area of about 3500 ha. What catches the eye is the occurrence of figures that appear to have been drawn, without a precise plan, according to processes of overlapping and clumping. However, a closer look reveals the presence of at least five concentrations or groups of geoglyphs (named G1, G2, G3, G4, and G5); each of them is characterized by the prevalence of a particular feature or pattern (Fig. 12.17). In general, we can notice the absence of biomorphic motifs and the prevailing presence of geometric figures such as straight lines, U-shape lines, trapezoids, triangles, rectangles, *campos barridos*, a spiraliform, and zig-zag and meandering motifs. Moreover, radial centers(known also as line centers and ray centers; see Aveni 1990) converge towards straight lines, triangles, and elongated trapezoids, and irregular shaped figures can be discerned.

From the technical point of view, different ways to create lines and figures have been observed. In particular the lines were engraved on the ground with three different techniques. The first one consisted of the removal of sand and gravels on the desert pavement to expose the underlying lighter dust and using the removed material to create two parallel lines located 15 to 30 cm between them (Fig. 12.15a). The second one is an additive technique (Fig. 12.15b, c), consisting of placing dark-colored, fine-to-very-coarse gravels along the drawn line. For one third of them, slight micro-reliefs were made by scraping sand and fine gravels and adding some darker gravels along the line (Fig. 12.15d). The trapezoid was made by subtractive and additive techniques: creating micro-reliefs, as above described, and adding some dark gravels and pebbles along the borders while scraping surface material inside the trapezoidal figure (Fig. 12.15e). Finally, Fig. 12.15f shows a

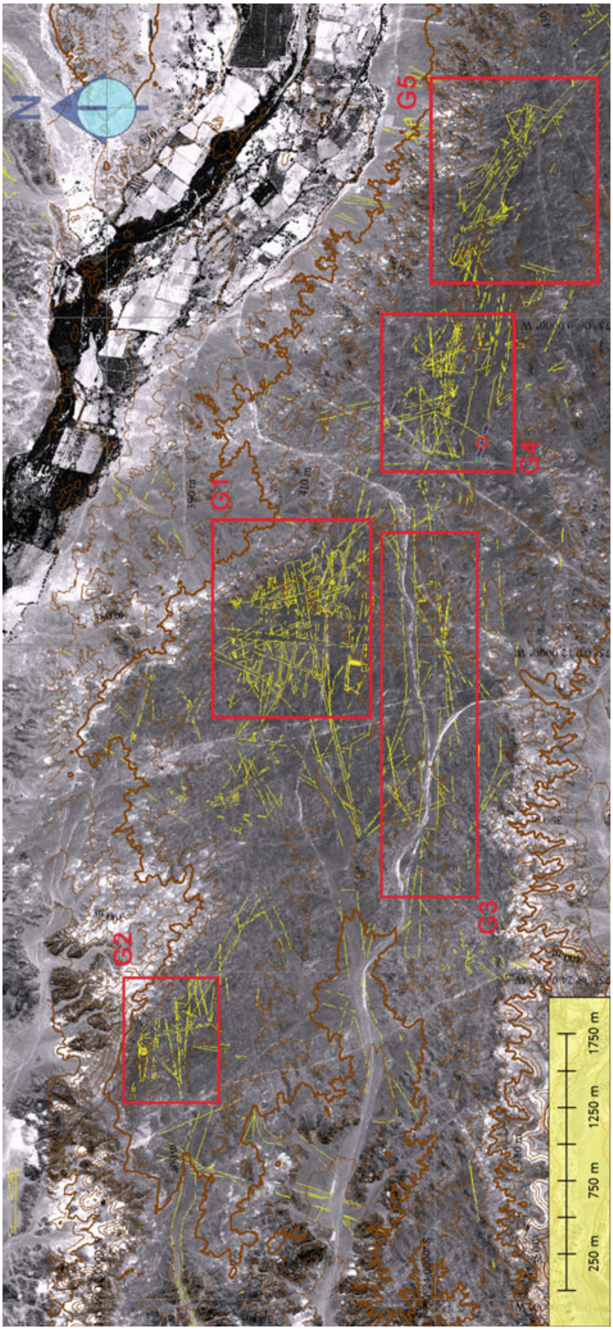


Fig. 12.17 Pampa de Atarco: satellite-based map of geoglyphs. Five groups of geoglyphs have been identified on the basis of morphological features (G1, G2, G3, G4, and G5)

detail of a spiral drawn by alternating the removal of sand, gravels, and pebbles and the placing of the same material on the curves adjacent to the grooves.

Each geoglyph has been measured, analyzed, and catalogued by GIS in consideration of their morphological aspects, drawing techniques, and state of conservation. In total, there are 834, among which 707 are linear drawings and 127 are of the areal type, corresponding to 84.86 and 15.233%, respectively.

The linear type is mostly composed of straight lines, divided into simple and double, equal to 594 and 80 respectively (corresponding to 71.22 and 9.60%). The rest of linear drawings consist of 14 U-shaped lines, ten meanders, eight zig-zag motifs, and one spiral. The number of areal geoglyphs shows a prevalence of rectangles (57), followed by trapezoids (35), irregulars Figs. (23), and triangles (12) (Figs. 12.16 and 12.17).

Their inhomogeneous distribution by the concentration of some types in some areas has been the basis for the identification of five groups which well fit with the results obtained from the kernel-density estimation (KDE). The KDE, used to investigate the local density properties, has been applied to an area including not only the Pampa de Atarco but also a strip of the Pampa de Majuelos (north of the river), and the Pampa between the ravines (*quebradas*) of the Atarco and Carrizal rivers (Fig. 12.18). The results from KDE places into evidence five areas of a high density of geoglyphs: three in the Pampa de Atarco (A, B and C), two north of Río Nasca (D), and south of Quebrada de Atarco (E), respectively (Fig. 12.18). The morphological analysis of the geoglyphs included in cluster A, B and C have suggested a further division into the above said five groups G1, G2, G3, G4, and G5. Remaining areas of cluster A and B, mostly characterized by irregular geoglyphs and radial centers, have been also investigated as is subsequently discussed.

We will examine in detail the five groups, starting from G1, which appears to be the most important with a clear ceremonial function. In fact, it is positioned at the center of the geoglyph complex, aligned with the three pyramids of Cahuachi (*Templo Sur*, *Gran Pyramide,* and *Grande Templo*) and 1–1.8 km from them, much closer than the other groups of geoglyphs (Fig. 12.19).

The presence of a meandering element (see M1 in Fig. 12.19) distinguishes G1 from the other groups, and it dispels any doubts as to its ceremonial function. It has a total length of about 4 km, composed of seven straight portions and six curves. The first one, not perfectly circular, has an average radius of about 70 m. The following are circular with radii ranging from 27 to 36 m, connecting straight linear portions, alternatively parallel or converging with angles of 6–10°. The straight portions vary in length, increasing and decreasing (from the first to the last, the lengths are the following: 213, 439, 608, 676, 587, 606, 441 m) along the path as well as the curvature radius. In our opinion, this is not random but due to the desire to make the procession more dynamic, with accelerations and decelerations, making the musical rhythm more engaging.

The meandering path is cut in several places by trapezoids, some of which had been apparently tracked before others, according to a relative chronology, and probably developed in four phases (Fig. 12.20). In total, eleven trapezoids (see t1–t11 in Fig. 12.19) are still conserved. The fact that the figures were engraved in

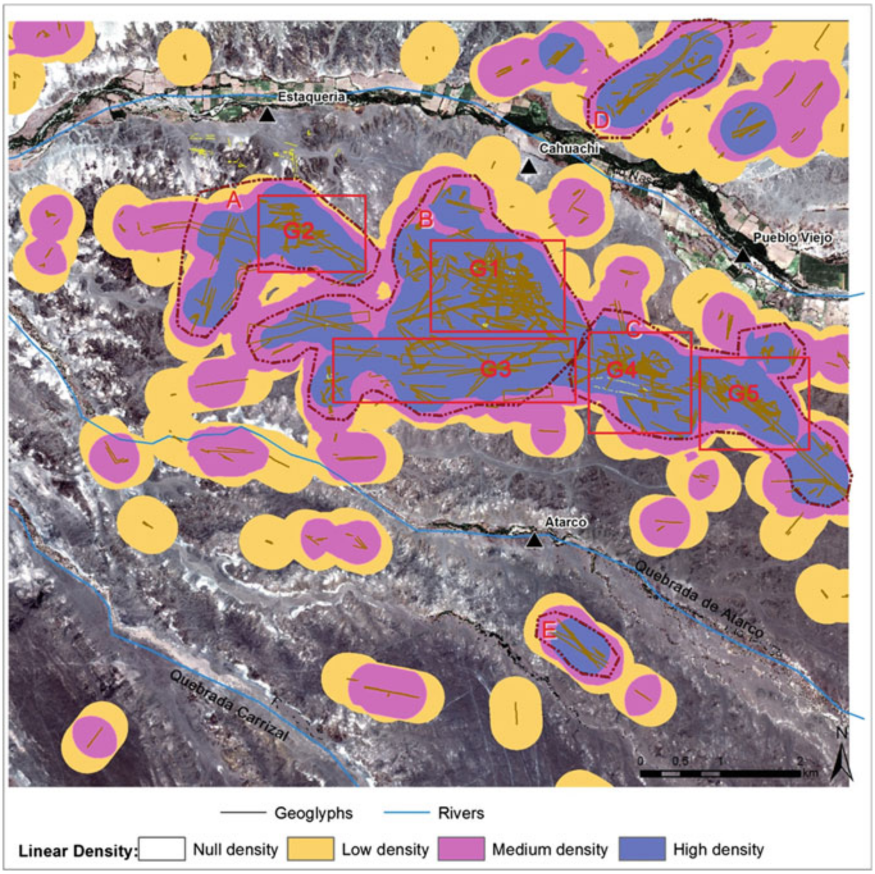


Fig. 12.18 Clustering of geoglyphs produced from the application of the kernel-density-estimation method

different phases does not preclude a contemporary use of part, or of all, the geoglyphs as ritual pathways. The identification of the relative chronology is an open issue to be dealt with by further detailed analysis of the geoglyphs.

To this end, a part of G1 has been surveyed by a drone in order to obtain a centimetric digital elevation model (Fig. 12.21), which enabled us to investigate the execution techniques. In particular the meander M1 and the trapezoids of G1 are formed by very shallow trenches, with depth ranging 8–15 cm (see profile X-X′ in Fig. 12.21), made by the subtraction and addition of gray sand and dark gray pebbles of very fine particle size (3–10 mm).

The color contrast between the added material (to form the lines or the edges of areal figures) and its surrounding is not so marked as to recognize the geoglyphs on the ground, with the exception of the straight lines 20 m long or greater. The drone represented a very important step forward in the effort to improve the quantity and

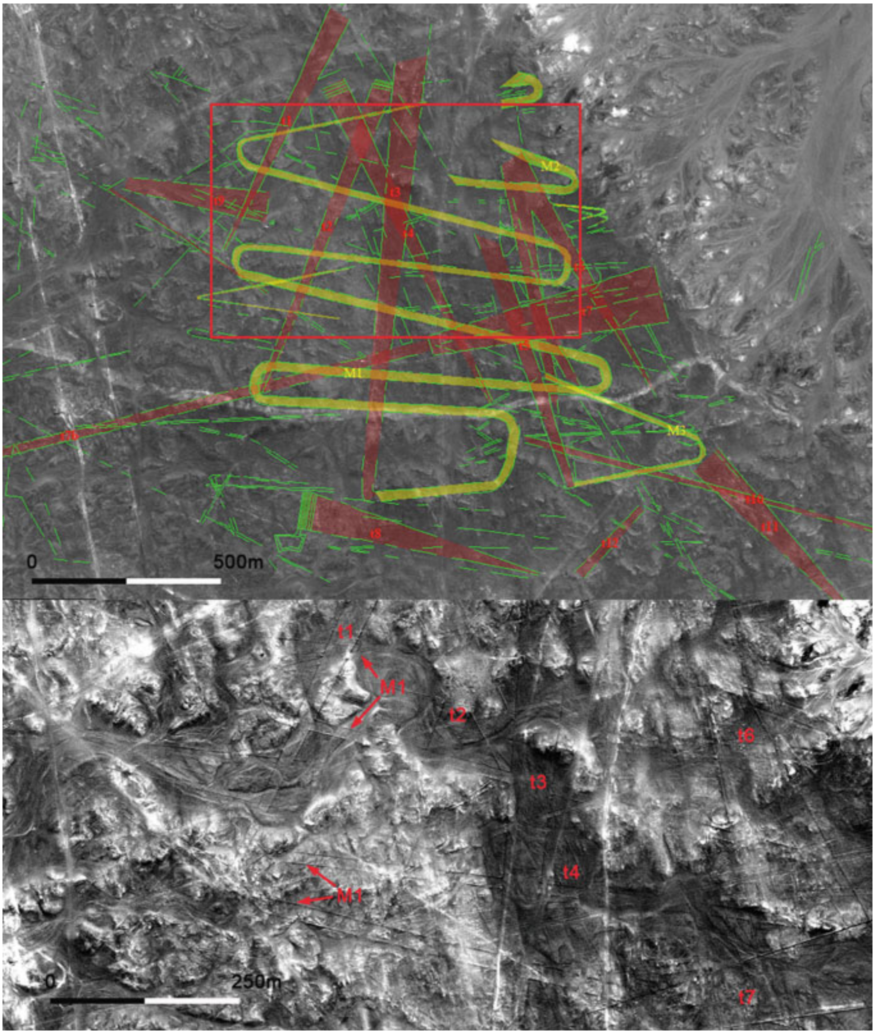


Fig. 12.19 *Top* Group G1 composed of a meandering figure crossed by a number of trapezoids. Some marks reveal the presence of older meanders. *Bottom* Detail of group G1

quality of information such as, for example, the presence of the oldest geoglyphs, partially conserved. In this regard, it is worth mentioning the discovery of traces of curved elements, related to one or two meandering paths (see M2 and M3 in Fig. 12.19 top) which most likely were drawn before meander M1.

Finally, another aspect of interest of group G1 is given by its visual and spatial relation with the temples of Cahuachi (Fig. 12.22). In particular, the segments which define the edges of some trapezoids (t1, t2, t3 and t5, see Fig. 12.20) are aligned with tops of *Gran Piramide*, *Grande Templo,* and *Templo Sur*. The latter, in

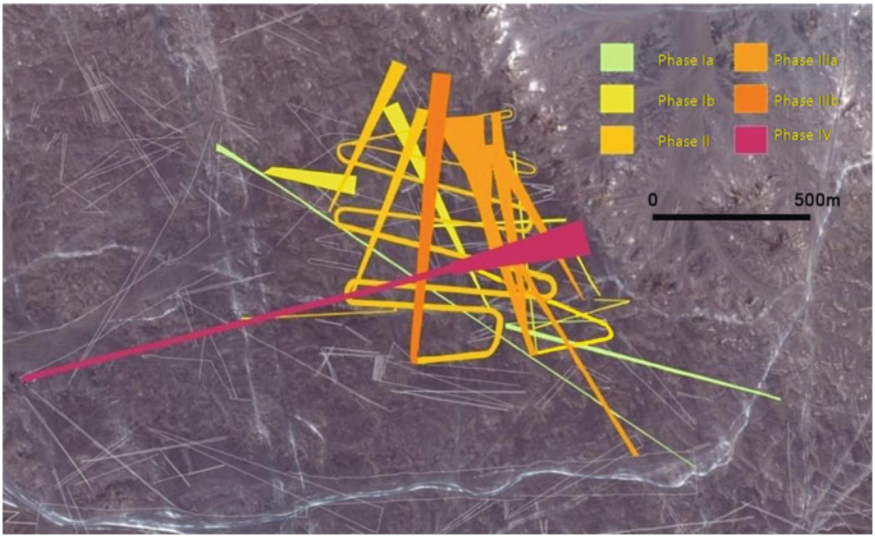


Fig. 12.20 Relative chronology of drawing phases of the geoglyphs

their turn, are visible from the north end of the trapezoids. Figure 12.23 shows the results of the viewshed analysis conducted by considering as observing points the north end of trapezoid t1 (Fig. 12.23, top) and *Gran Piramide* (Fig. 12.23 bottom).

From the trapezoid (Fig. 12.21, top) it is possible to view the tops of the main temples of Cahuachi, as well as all the geoglyphs of G1 and the southern *Pampa de Nasca*, known as Majuelos. From the summit of *Gran Piramide* (as well as from the summits of *Grande Templo* and *Templo Sur*), it is not possible to observe the Pampa of Atarco, also with the presence of a crowd of pilgrims (Fig. 12.21, bottom). This indicates unilateral visibility from the geoglyphs of Atarco to the temples, from which it is possible to observe *Pampa de Majuelos* and vice versa (see Fig. 12.24, which summarizes in a schematic way the mutual visibility between the three ceremonial areas: the *Pampa de Atarco*, Cahuachi, and the *Pampa de Majuelos*)

The group G2 (Fig. 12.25) is located in a decentralized position with respect to both Cahuachi and the geoglyphs of Atarco. Among the geoglyph groups, it is the closest to Estaquería, towards which the priest moved after the abandonment of Cahuachi, and to the Río Nasca, which in this area exhibits a perennial hydraulic regime. Moreover, G2 group is lapped in the north by a ravine that flows into the river, in correspondence to a bend characterized by arable land, probably one of the last oases of the river before joining the Río Atarco. One wonders if the strategic position of G2, near Estaquería and near the river, may have some relationship with the morphological characteristics of the geoglyphs. As in G1, G2 is dominated by a zig-zag-shaped path, named M9, which circumscribes a spiral, both of them thought to be motifs linked to the water cult (Fig. 12.13, top). Spiral (Fig. 12.27, bottom)

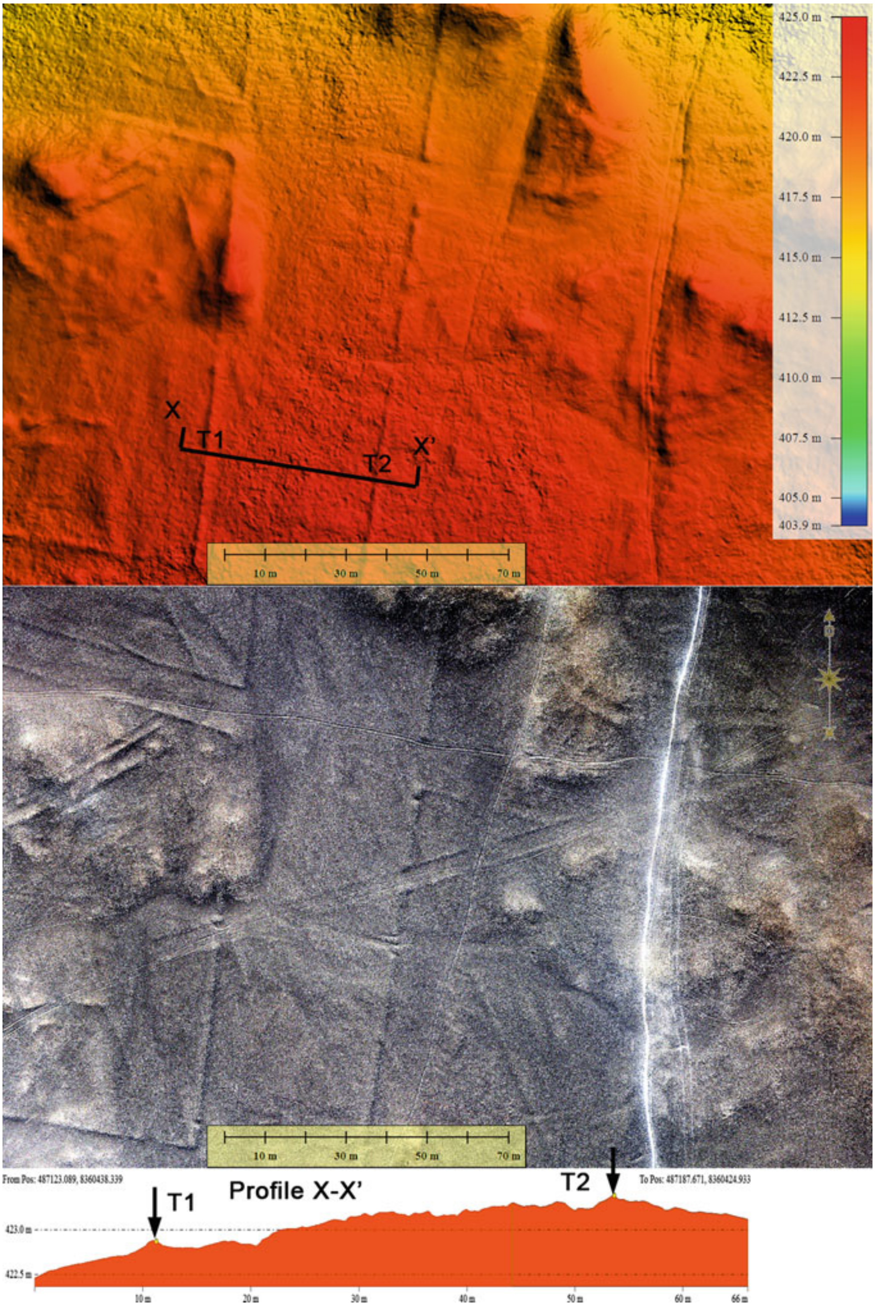


Fig. 12.21 Pampa de Atarco, detail of a trapezoid of group G1, from DEM (*top*) and orthophoto (*middle*) provided by SFM of images taken from a drone. *Bottom* profile X-X′ crossing the trapezoid

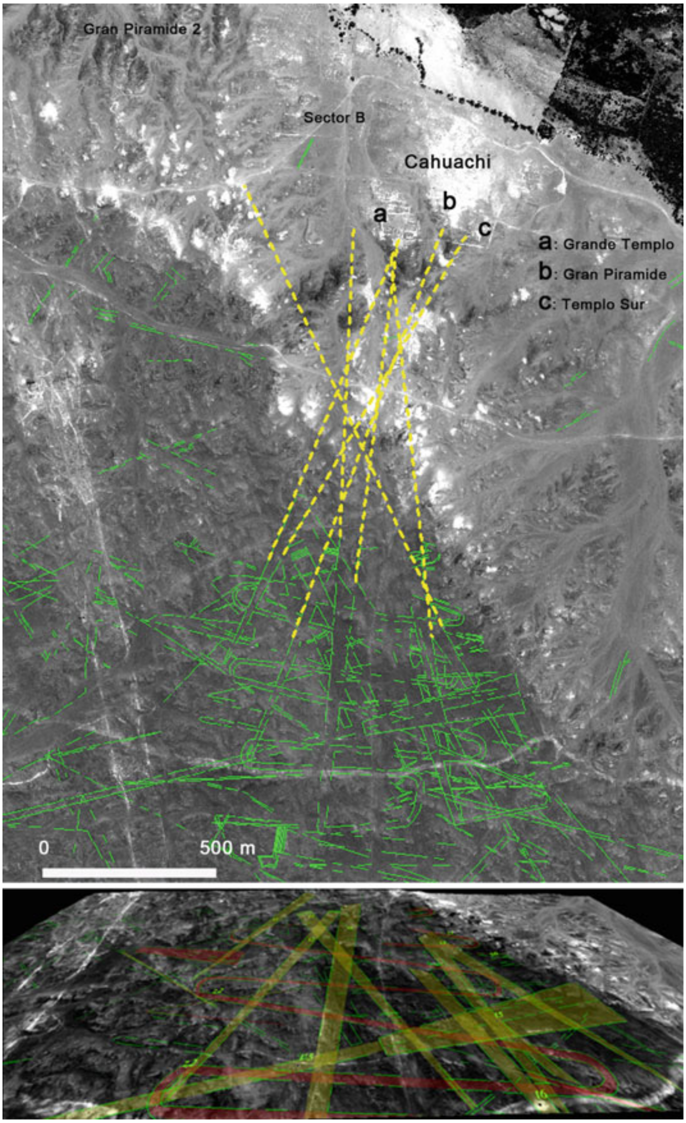


Fig. 12.22 Alignment of some lines and trapezoids towards the main temples of Cahuachi, such as *Grande Templo*, *Gran Piramide*, *Templo Sur,* and *Gran Piramide II*

was derived from the observation of conches which were used to call on the mountain gods or clouds to rain (Reinhardt 1988; Silverman and Proulx 2002). About the zig-zag, Reinhardt (1988) relates it to rivers, canal, lighting, and furrows.

At south of M9, six straight portions of another zig-zag element (M10) are well preserved. In this regard, it is not clear whether the two geoglyphs M9 and M10

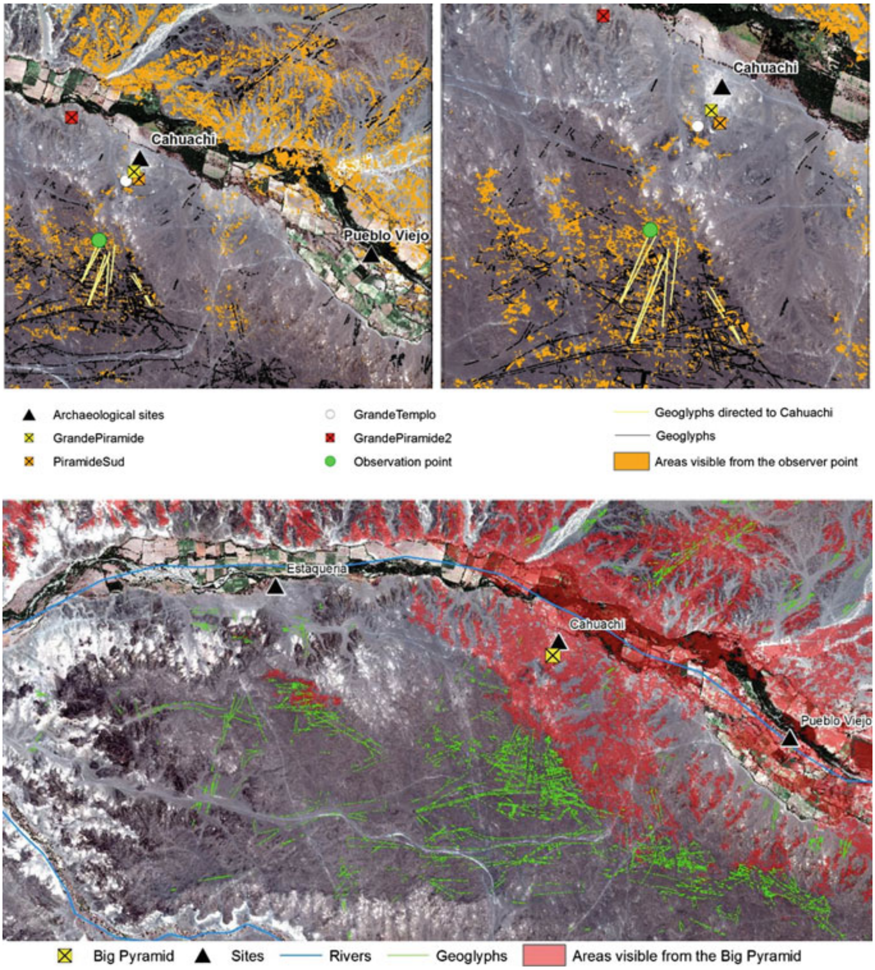


Fig. 12.23 Viewshed analysis in Pampa de Atarco and in Cahuachi. The selected observing points are: the northern end of one of the trapezoids belonging to group G1 (*top*) and Gran Piramide (*bottom*)

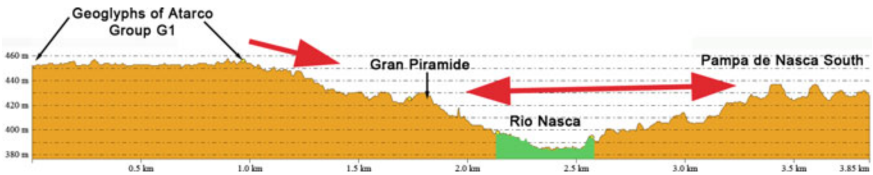


Fig. 12.24 Mutual visibility between the geoglyphs of Atarco (group G1), the Gran Piramide of Cahuachi, and the Pampa de Nasca South

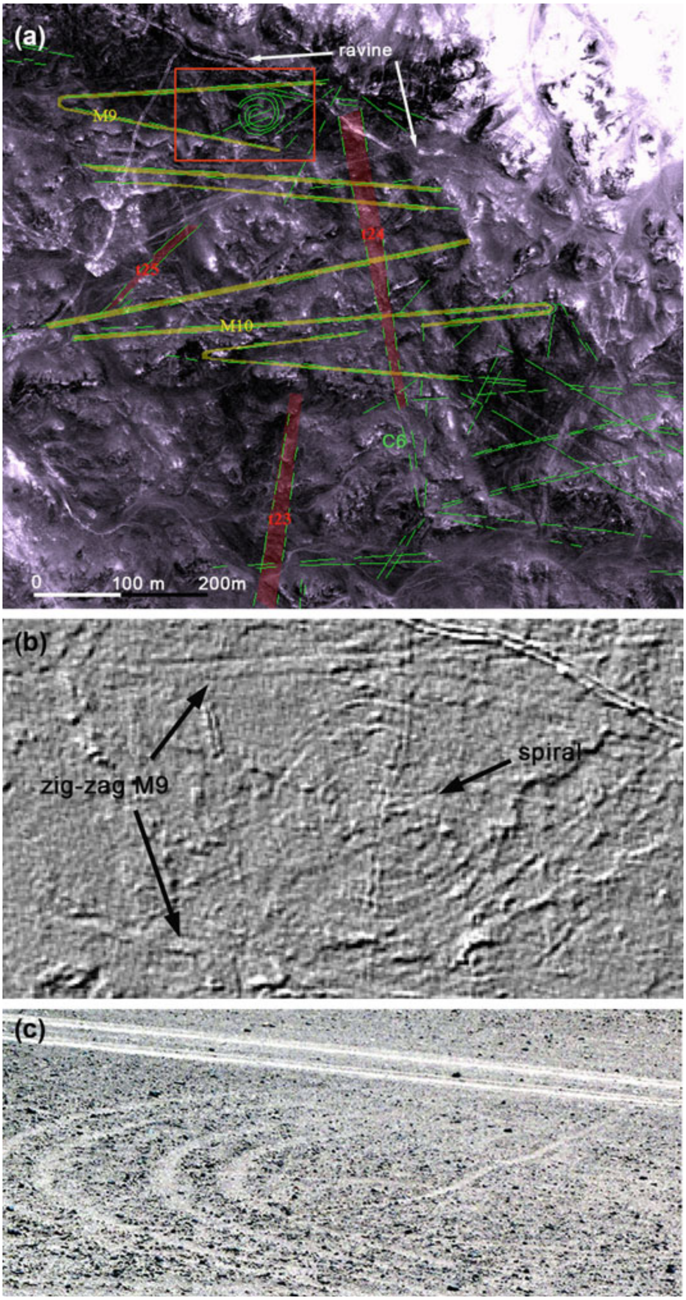


Fig. 12.25 **a** Group G3 from 2005 QuickBird satellite image. **b** The filtering of the same image enhanced it, facilitating the reconnaissance of the main features such as a spiral and a zig-zag element. **c** Detail of the spiral on ground

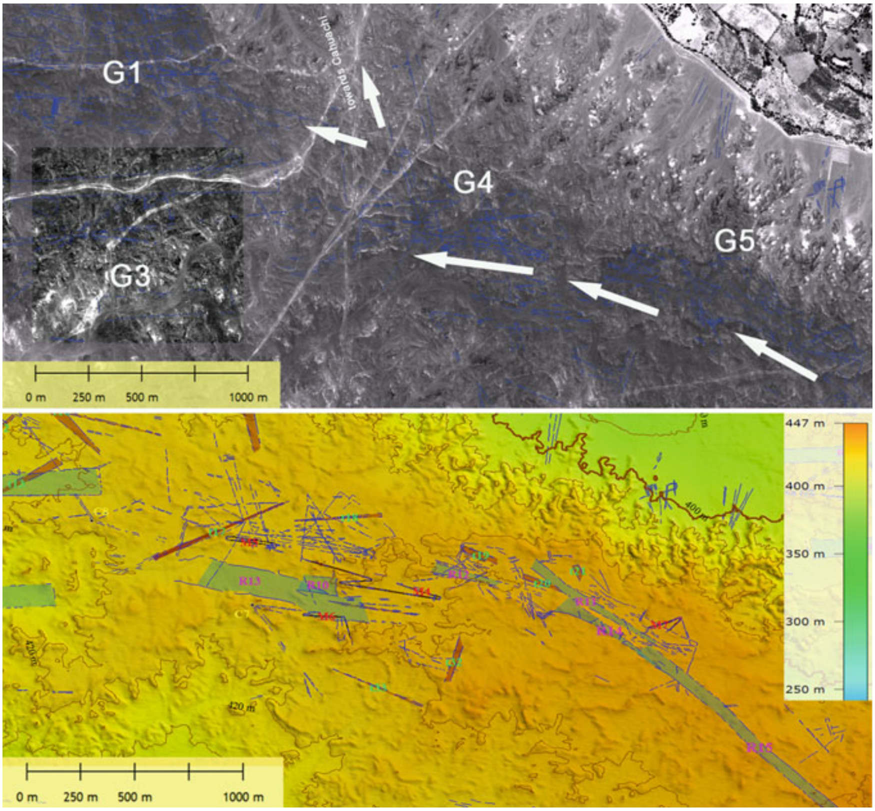


Fig. 12.26 Groups G4 and G5 mapped on satellite orthophoto (*top*) and DEM (*bottom*).The lines and the trapezoids appear to converge towards G2 and Cahuachi (see *white arrows* in the upper image)

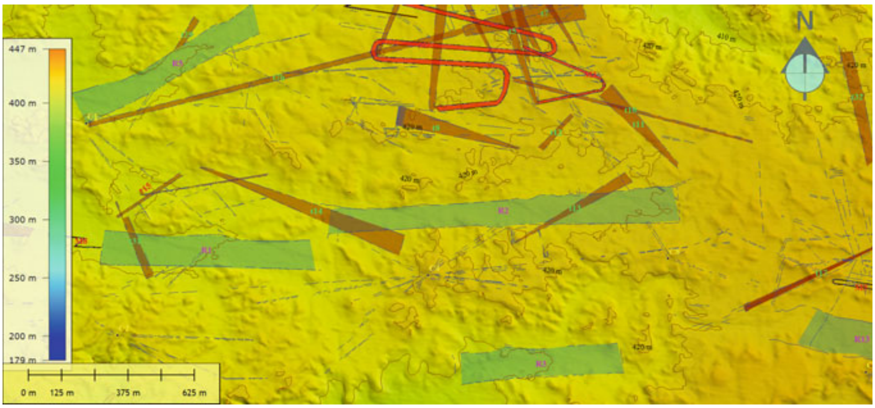


Fig. 12.27 Geoglyphs of group G3

were parts of a unique ceremonial path or if they belonged to two distinct zig-zag elements. The scene of the geoglyphs is enriched by two radial centers, C5 and C6, towards which some lines converge. C5 faces the ravine, the spiral, and the zig-zag M9. C6 is located south of the zig-zag M10. The two centers are connected by a trapezoid (t24) which crosses the zig-zag ceremonial path.

The grouping and distinction of G4 and G5 is possible thanks to an area with a low presence of lines and figures between G4 and G5. Further south of the two groups, a zig-zag element (M4) plays a pivotal role between G4 and G5, creating a common area with a clear ceremonial function. Despite the clear perception of the separation between the two groups that are described here together, they have many features in common. In particular, they consist of lines and elongated trapezoids, mainly oriented towards the center of Pampa de Atarco. From G5 to G4, directions vary progressively from 305 to 280°, so as to indicate a path of approach to the center of the ceremonial scene (first G3, then G1) (see Fig. 12.26). Moreover, a pair of trapezoids seem to indicate the path leading to the temples of Cahuachi.

In addition to lines and trapezoids, we note the presence of six irregular shaped figures (R10–R15), also pointing to the center of the Pampa de Atarco. Overall, G4 and G5 form a space of transition, with lines and elongated figures composing a sort of vector plane, perhaps to orient the pilgrims. However, it is also a set of places where pilgrims could manifest their belonging to the common religious beliefs and myths of Nasca cosmogony with rituals and ceremonies. In fact, there are several trapezoids and five zig-zag figures (M4–M7), not very large, with the exception of M4, located between G4 and G5.

The above described groups (G1, G2, G4, and G5) have in common that they present figures as meanders, zig-zags, and spirals which evoke a clear ceremonial event, composed of processions, races, and chants (meanders in G1, spiral and zig-zag motifs in G2, zig-zag figures in G4 and G5). Moreover their sizes do not exceed 1.1 km. The two common characteristics could be due to the need to guarantee adequate mutual visibility inside to each group of geoglyphs, as well as sufficient capability to hear sounds produced by musical instruments, such as the antaras. In the latter regard, it is worth to cite an experiment carried out in 1996 during which an *antara* was played from on top of the *Gran Pirámide,* while recordings were made in various parts of the ceremonial center. The music was heard as far away as the Gran Pirámide II, at a distance of 950 m (for additional detail, see Chap. 9 by G. Orefici).

Figure 12.27 shows the geoglyphs of G3 group south of G1. Its peculiarities are the presence of irregular shapes and line (or radial) centers. This gives us the opportunity to discuss these features which could be found inside of other groups and in other areas of the Pampa de Atarco, not included in the five groups.

Figure 12.28 shows a detail of one of these geoglyphs (R5) located south of group G3. Its edges consist of micro-relief of greater height than the borders of trapezoids and straight lines situated in other parts of the Pampa of Atarco, in particular in the group G1. With respect to them, they also differ by the larger particle size of the pebbles. Figure 12.29 is a map of the geoglyphs, based on GeoEye DEM, with the geoglyphs highlighted. They do not have geometrics shape but follow hydrographic marks, *huaycos,* and mudslide deposits. As a whole, 16 figures have been identified. They are all located west and south of Cahuachi and group G1.

Many of them are oriented either SW-NE or SW-NE (R10–R15, and R4–R6, R9, respectively), towards the geoglyphs of groups G1 and G3. Others seem to gravitate around G2 group, near Estaquería (R6–R8). Finally, the others in G3 group are oriented in the EW direction. Many of these geoglyphs incorporate, at the two ends, small circular mounds with stone material of small- and medium-sized particles.

What were these irregular trapezoids? Were they simple corridors to guide the pilgrims, or simply one of the many ceremonial paths? Were they also the result of the desire to strengthen a harmonious relationship with the gods, drawing a sort of virtual river landscape where they can have rituals and ceremonies linked to water and fertility?

Currently we do not have any data that can help us to answer these questions. The future investigations in Atarco will be geared to collect and analyze material of archaeological interest to be associated with geoglyphs.

Finally, other features were found in the Pampa de Atarco, namely, the radial centers from which emanate four to ten lines, triangles, or elongated trapezoids. They were placed on elevated points (with height ranging from 30 to 130 cm), in some cases marked by piles of stone of small- and medium-sized particles (see line center C5 in Fig. 12.30) and characterized by sparse pottery.

They are located outside of the figures dedicated to ceremonies and rituals, except for the radial center C5, which is close to the spiral of G3 group (Fig. 12.31). From a viewshed analysis, assuming the heights of the observer and the target to be 1.60 m, equal to the average stature of Nasca males (see Chap. 5, Table 1 by Drusini (2016)), we know that these centers were mutually visible. The location of these radial centers outside the denser areas of geoglyphs leads one to think them to be observation points for the ceremonial scenes, as confirmed by viewshed analyses (see Fig. 12.31).

However, we cannot rule out other hypothesis, such as the alignment towards equinox and solstice directions. Indirect measurements taken from satellite maps place into evidence that the lines connecting the centers C3, C2, and C7 have an azimuth ranging 271.2–272.8°, thus quite close to the direction of the autumnal equinox sunset. Other three pairs of radial centers are aligned along the following directions 294.3° (C1–C4), 294.1° (C6–C8) and 291.8° (C5–C9): the first two very close to the direction of sunset on the winter solstice.

The orientations to the solstice and the equinox of geoglyphs and/or the radial centers, as in the case of Pampa de Atarco, are an example of astronomical and cosmological associations that we do not know (Aveni 1990; Ziolkowski 2009). We could, however, think that the geoglyphs were used on some specific dates of the Nasca calendar linked to agriculture. The arrival time of the water in the river beds, the time of sowing and harvesting, as well as other events, were chorally celebrated in the ground drawings. The latter were both sacred and social spaces to

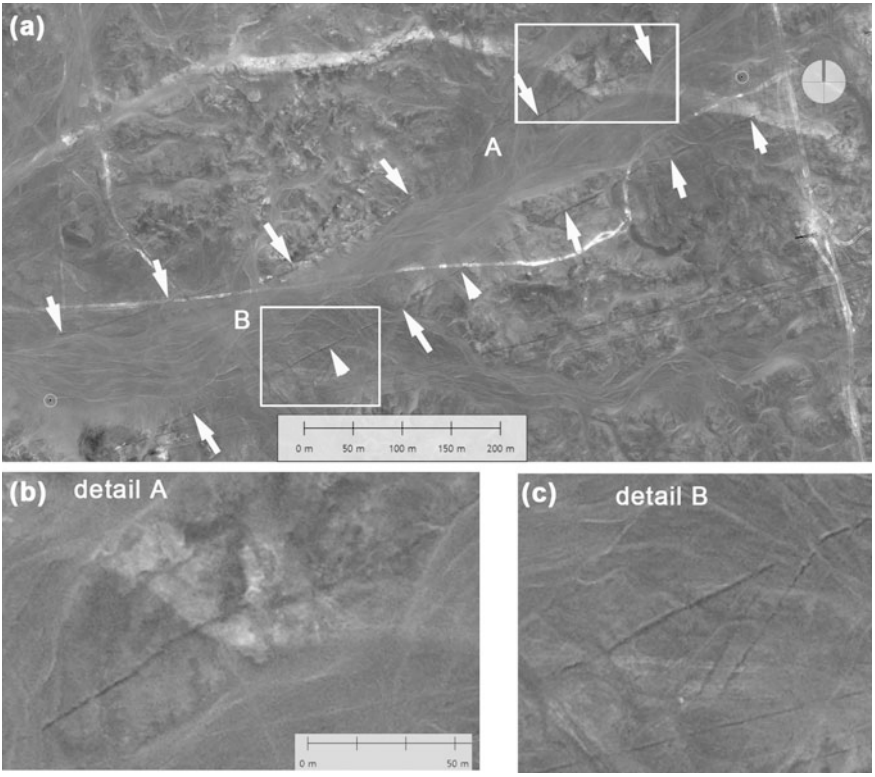


Fig. 12.28 Group G3: irregular shape geoglyph (**a**) and some details (**b–c**)

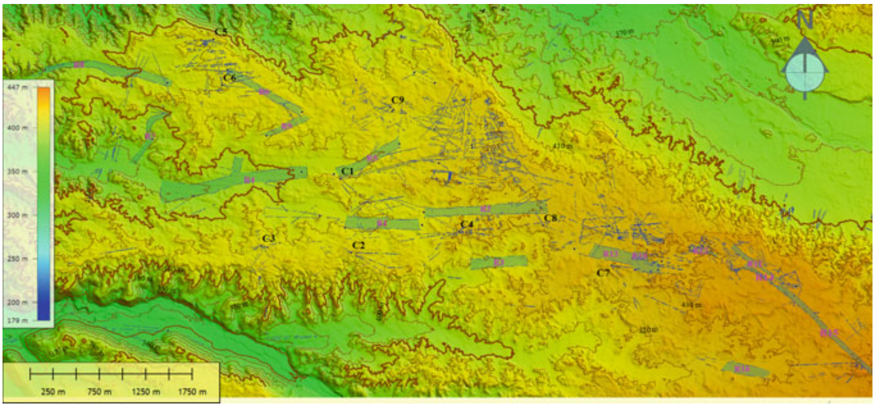


Fig. 12.29 Satellite DEM of Pampa de Atarco. R1–R15 indicate the areal geoglyphs characterized by irregular shape

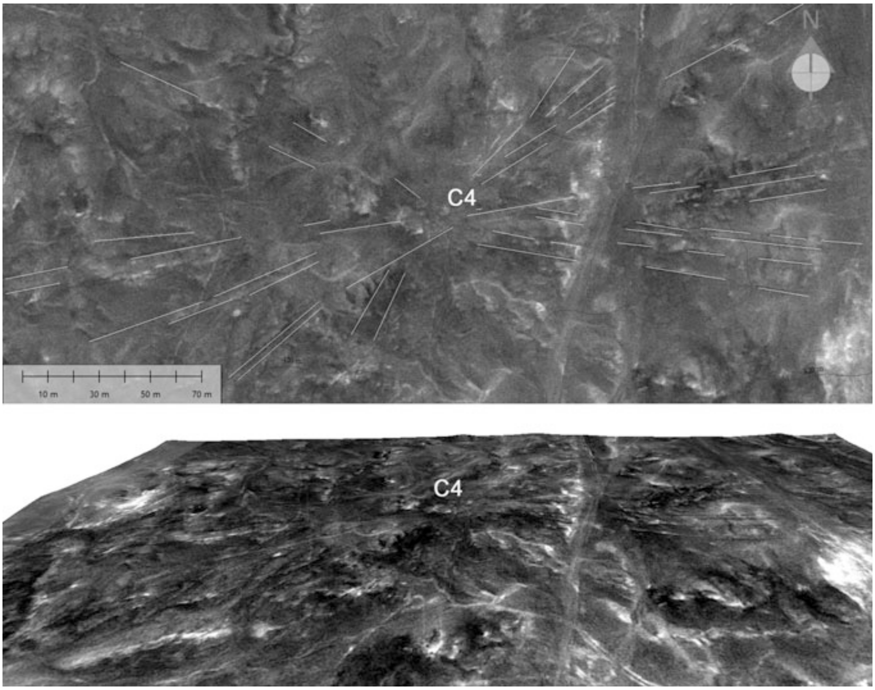


Fig. 12.30 Details of the radial center C4 (group G3) (GeoEye 2011)

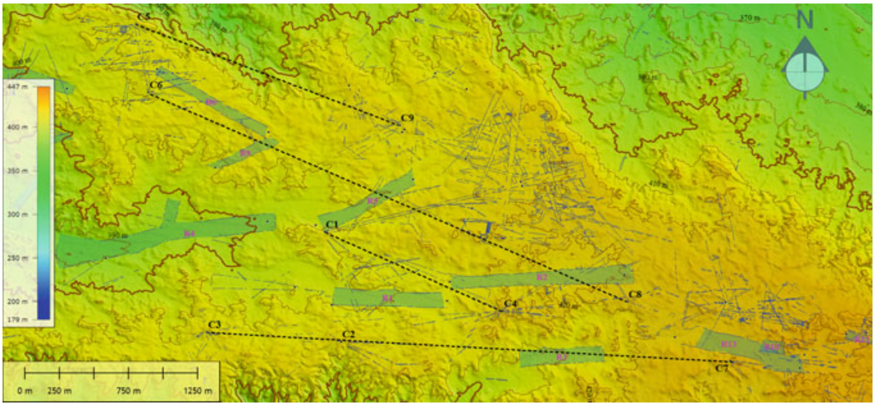


Fig. 12.31 Maps of the geoglyphs where C1–C9 indicate the presence of radial centers aligned to equinox and solstice sunsets. The map include also eight irregular areal figures

share a common cosmology and religious belief and to strengthen social cohesion between various groups of pilgrims that shared common ancestors and land rights (Fig. 12.32).

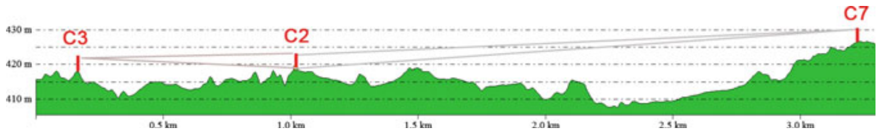


Fig. 12.32 Mutual visibility between the three radial centers C3, C2, and C7

12.4 Final Remarks

In this chapter, we revealed the first results of three-year investigations and a survey campaign on a little known area in the Nasca drainage, Pampa de Atarco, characterized by the presence of several geometrical ground drawings.

The interest in investigating Pampa de Atarco geoglyphs is given by their proximity to the temple complex of Cahuachi and, consequently, by the fact that their meaning and functions can be reasonably linked to the ceremonial center.

Other reasons which make it important to continue the research in this area are their dating and/or diachronic relation with Cahuachi: are they coeval with the temples, or later? This is only one of the open issues to be addressed in the future by investigating the area and studying and dating pottery or other materials which exhibit a relation or (better) an association with geoglyph activity.

We are just at the beginning of a project whose aim is to investigate the relationship between Cahuachi and the geoglyphs, in its functional, cultural, and religious aspects.

The results of the surveys and mapping show an intensive use of the desert pavement. In some areas at least five phases of figures etched on the surface could be discriminated by using multi-scale remote-sensing techniques and image-processing tools.

At first sight, what immediately is revealed by looking at the whole representation of geoglyphs seems like a chaotic scene. However, the morphological study and the pattern analysis seem to reveal a sort of ‘zooning’ composed of five (or more?) groups/clusters. Each of them is characterized by some motif and shape, to be associated to a distinct function, which is another open issue to be addressed in the future.

The ‘geoglyph cluster pattern’ seems to reveal the centrality of one group in respect to the others. It is a group of geoglyphs (named G1) where a meandering figure, with a clear and distinct ceremonial function, stands out on a number of trapezoids and lines, superimposed one on the other. The group is aligned along a north-south axis with respect to the core of Cahuachi, including the excavated pyramids and sector B, from which is it just 700–800 m distant. Moreover, some trapezoids seem to be aligned towards the three pyramids of Cahuachi: *Gran Piramide*, *Templo Sur,* and *Grande Templo*. Are these spatial relationships with Cahuachi casual or not? It is difficult to answer to this question. The interest and capability of the Nasca in choosing and creating places (pyramids and ground drawings), accurately studying their position, and orienting them with respect to the surrounding landscape is known.

The observation of the geoglyphs also places into evidence other peculiarities such as the presence of two groups (named G4 and G5) characterized by lines and trapezoids, which are prevailingly oriented towards G1 group, the ‘center of the scene’. They are areas which seem to indicate a direction to pilgrims. At the same time, they were also the venue of rituals as confirmed by the presence of a number of zig-zag and meandering geoglyphs.

Another group of geoglyphs stands out from the others because of its decentralized location, closer to Estaquería than to Cahuachi. The presence of a spiral, near to the river in particular where the water re-emerges, and a large meandering figure suggests a ceremonial functional linked to water and fertility worship.

The water seems to be the interpretive key for other features: the irregularly shaped geoglyphs parallel ancient hydrographic marks and *huaycos*, evocating a sort of fluvial landscape.

Finally, the observation of the geoglyph cluster pattern reveals the presence of radial centers (or line centers) from which emanate lines and triangles. These centers, in their turn, are aligned along directions of the winter solstice and equinox sunsets. This leads us to consider also a possible astronomical and calendrical interpretation, one that relates the geoglyphs to a primarily ceremonial use. They were the scenarios and the venues of collective gatherings where events linked to agriculture calendar were celebrated. At the same time, they served to strengthen social cohesion among various groups of pilgrims, sharing common ancestors and religious beliefs.

Acknowledgments The Ground Control Point measurements by differential GPS have been performed by Giacomo Di Giacomo of CNR/IBAM-Lecce, Gabriele Bitelli and Emanuele Mandanici of University of Bologna. We thank the Italian of Ministry of Foreign affairs for funding the investigations campaign in Pampa de Atarco.

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Chapter 13
Puquios: The Nasca Response to Water Shortage

Rosa Lasaponara, Josué Lancho Rojas and Nicola Masini

Abstract In this chapter, we provide an overview on the state of the art of the investigations conducted up to now on the ancient Nasca filtration galleries, locally known as *puquios*. They are located in the three valleys of the Nasca, Taruga, and Las Trancas rivers. The technological characteristics of *puquios*, along with the main archaeological issues still open today such as, for example, the dating and potential relationships between *puquios* and the Nasca Lines, are briefly summarized. Finally, outputs from satellite-based investigations along with a brief overview on the location of the existing *puquios*, their current conditions, and management issues are provided.

Keywords Overview · Nasca · Puquios · Hydrology · Satellite remote sensing · Water management

13.1 Introduction

In this chapter we focus on the investigations conducted up to now on the ancient Nasca filtration galleries denoted as *puquios*. The puquio name is a Quechua word meaning "natural spring" even if the Nasca *Puquios* are not natural but man-made. They were devised and built to cope with the shortage of water due to the scarce

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precipitation, long frequent inter- and intra-annual drought periods, and the specific local characteristics, which cause the rivers to disappear below the surface. The names “aqueduct” or “infiltration gallery” are also used and considered more correct. They are “horizontal” wells, which retrieve subterranean water available from the water table and to convey it to the surface by gravity.

The water retrieved from the *puquio* system was, and in many cases today still is, used for irrigation purposes (agricultural production) and domestic uses. It is believed that the Nasca started to build them from 500 to 600 AD, and probably before that, to cope with some exceptionally long drought periods; nevertheless, their dating, number, and spatial distributions are, still today, open issues (Rossel Castro 1942; Solar La Cruz 1997; Schreiber 2003; Schreiber and Lancho Rojas 2009). The construction of the *puquios* involved the use of particularly specialized technology. What is really impressive is the great efforts, organization, and cooperation required for their construction and regular maintenance which, for centuries until today, assured availability of water in the Nasca basin of southern Peru (Fig. 13.1) that is one of the most arid places of the Earth. Stings and maintenance activities were likely based on a collaborative and socially organized system, similar to that adopted for the construction of the Nasca geoglyphs. Actually, since the 40s several authors from Mejia Xesspe (1942) to Johnson et al. (2002) have correlated some geoglyphs with water in general and with the subterranean water canals in particular.

What is clearly evident is that the *puquio* system must have been much more developed than it appears today. Exploiting an inexhaustible water supply throughout the year, it contributed to intensive agriculture in the valleys. Another key point is to consider the importance of the network of aqueducts the control, over the communities that came under their influence, of water distribution by those in power.

13.2 The Nasca and Water

Over millennia, water has been a basic element for the first human settlements. Throughout the world, as in Peru, we could write the history of the development of man through its historical relationship with water. Also, throughout the world, civilizations have always developed in areas characterized by ample reserves of water such as rivers, lakes, lagunas, springs, etc. Surprisingly, as attested by archaeological evidence, in southern Peru, long human frequentation and settlements, persistent from one civilization to another (e.g., Paracas, Nasca, Huari, and Inca; see Ravines 1978; Regal 1970) were even found in the Nasca basin that was and is one of the most arid places of the Earth (Figs. 13.2 and 13.3). Therein, early civilizations made great efforts to dominate the arid environs also by devising small-scale gravity canals in higher-elevated coastal valleys to “manipulate” the hostile environment, increase the food production, and make feasible intensive habitation of the valleys in question. In the Nasca River valley, a form of socio-political organization flourished that exploited collective labor for the

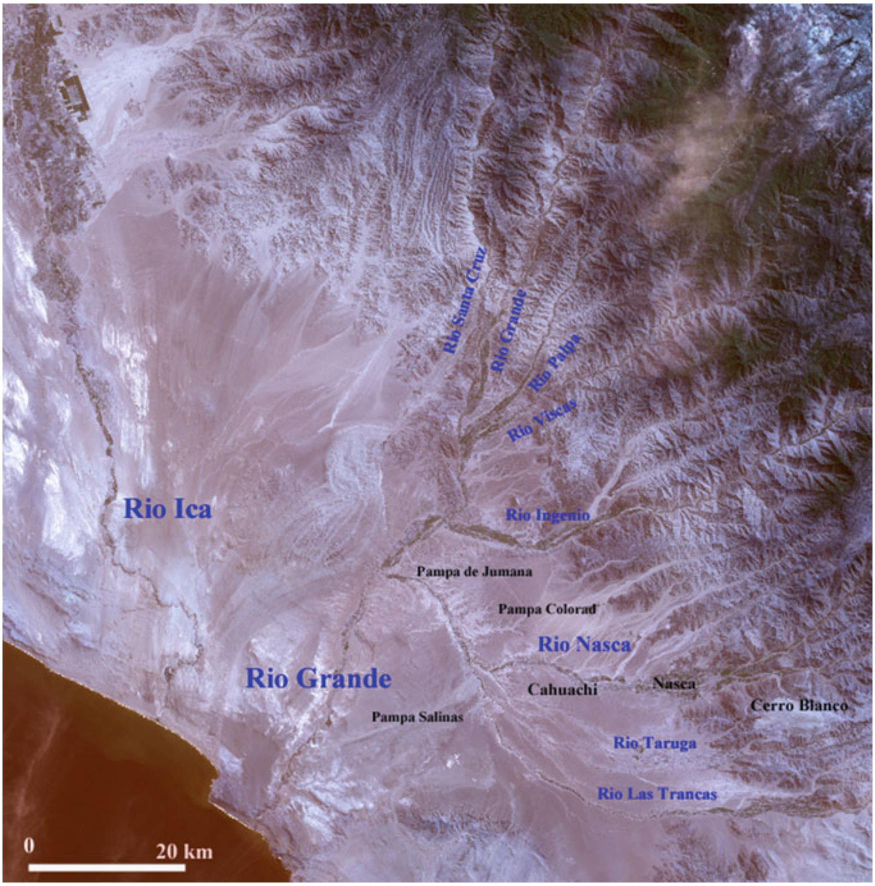

Fig. 13.1 The catchment basin of the Río Grande de Nasca extends between the Cordillera Occidental and the Pacific coast

construction of an efficient system for the retrieval and control of the water, based on an underground system of aqueducts.

The whole area was characterized by a desert environment with extremely arid conditions due to severe water scarcity. The lack of water was due to very low precipitations (so scarce that cannot be measured), as well as to the confluence of a cold ocean current (the Humboldt Current) which, along with other climatic factors, strongly limits rain (see Chap. 2).

These extreme conditions were the scenario where the Nasca devised and constructed the aqueduct system. The development of *puquios* made possible the transformation of one of the most arid areas of the world into “a green garden” densely settled as archaeological evidence clearly testify. Today, there are still 36 active *puquios*, distributed in the Aja, Tierras Blancas, Nasca, Taruga, and Las Trancas Valleys. Among them, 29 are located in the Nasca Valley which has

Fig. 13.2 The desert environs near Pajonal Bajo in the Río Taruga valley (Photo by N. Masini)

currently the highest concentration of *puquios*; whereas, five and two active *puquios* are located in the Las Trancas and Taruga Valleys, respectively (Schreiber and Lancho Rojas 2003). Even without written documentation, it is thought that this *puquio* system must have been much more developed than it appears today. In the last century, numerous ancient *puquios* have been completely lost and destroyed due the cessation of maintenance activities.

Being that the Nasca, as other Andean civilizations, lacked writing, the diverse aspects of the Nasca society including religious beliefs and ceremonial activities can only be deduced from other expressions of material culture such as pottery, textiles, and geoglyphs. All of the various expressions of the Nasca material culture today represent, and are, the only documentation available. The Nasca used geoglyphs, pottery, and textiles to symbolically communicate ideas, especially religious concepts, to the members of their society. All the expressions of the ancient Nasca material culture can communicate to us, if carefully investigated, what we usually find in books, texts, or inscriptions. Therefore, it is mandatory to use iconographic analysis, archaeological evidence, and ethnographic analogy to obtain an interpretation of the Nasca society, culture, religion, and cosmology.

It is thought that the Nasca believed in powerful natural spirits, generally represented by animals, such as birds or sea creatures, and by mythical beings, creatures made up of a combination of diverse animal shapes (often present in a variety of different manifestations) or having a combination of human and animal/bird/fish

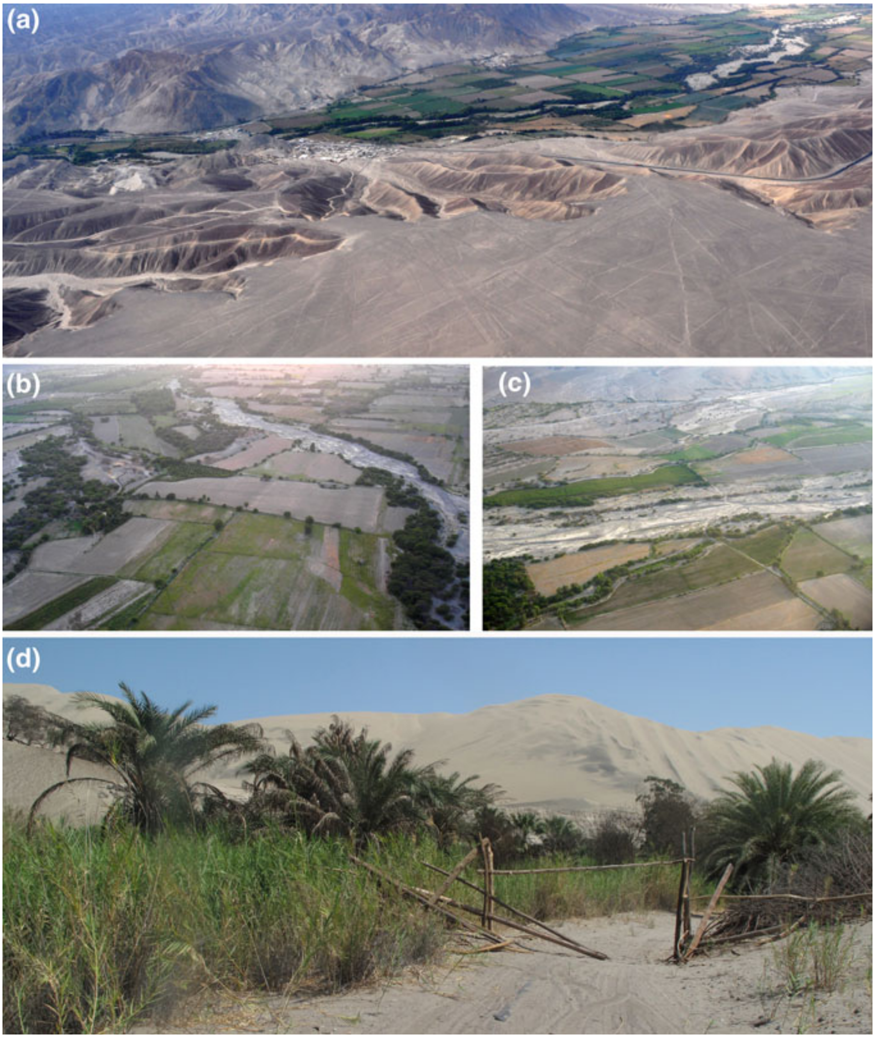

Fig. 13.3 **a** A view of the Río Nasca from the Pampa de Jumana including some trapezoidal geoglyphs (photo by Maria Sileo). **b**, **c** Some details of the Río Nasca valley including the dry riverbed and arable land, irrigated by a water supply guaranteed by filtration galleries able to compensate for the lack of rainfall to grow the crops needed for food (Photo by Nicola Masini). **d** Natural setting in an area of the Taruga lower valley where the water re-emerges (Photo by Rosa Lasaponara)

characteristics (see Chaps. 4, 8 and 9). These powerful natural spirits were thought to control the water, weather, crops, and health and to influence daily life.

Therefore, to cope with the water shortage, the Nasca adopted a sort of double strategy addressed to "pray the gods" in order to curry favor with them and to "dig the *puquios*" in order to access, manipulate, and control the subterranean water resources. In the Nasca view, these strategies enabled them to establish and maintain an harmonic relationship with the supernatural and the environment.

In this perspective, it is widely recognized that the Nasca were strongly attracted by sacred landscapes, known in the Andes as *huaca*. They were thought to have a concentration of spiritual forces, as for example, the several Pampas with their multitude of geoglyphs, or the confluences of the several tributary channels and main rivers. In this view, also the location of Cahuachi was selected for its specific characteristic, namely for the presence of aquifers which emerge on the surface in the form of springs (Schreiber and Lancho Rojas 2003; Silverman 1993) close to Las Caňas.[1] Probably for these reasons, Cahuachi was considered a sacred place starting from pre-historic time; when the ceremonial center fell into disuse, the whole huge area close to the main critical points where the Nasca river re-emerged continued to be used for burials and for offerings. In fact, the Nasca preferably located the cemeteries on the sandy slopes along the edges of the rivers (see Chap. 19).

Another important Nasca sacred place was Cerro Blanco (Fig. 13.4, bottom), the large sandy mountain overlooking the Tierras Blancas valley, which in many local legends was linked to water. Over the centuries, Cerro Blanco was considered as a "volcano of water" (Urton 1982: 10), and the place was used to pray to the gods and make offerings until several years ago, as confirmed by Reinhard (1988) who found offerings of ancient pottery. The sacredness of the place is also highlighted by the fact that some of the famous Nasca Lines point directly to the Cerro Blanco mountain (Reinhard 1988), (Fig. 13.5, top).

Mejia Xesspe (1942) developed for the first time a theory which related Nasca Lines with water in general and with the *puquios* in particular on the basis of the observed similarity between the linearity of both water-table-tapping channels and geoglyphs.

Aveni (1990) suggested that various geoglyphs were "parallel the direction of surface water flow" and the orientation of the triangles and trapezoids were related to flow direction of the superficial water, and therefore the lines were linked with water, irrigation, and planting.

Rossel Castro (1942) suggested that the Nasca Lines delineated ancient agricultural fields and irrigation systems thus re-proposing a similarly between the surface of the underground aquifers and the canals.

Johnson et al. (2002) made intense field surveys and statistical correlations between the Nasca Lines and the subterranean flows. He found a number of geoglyphs linked both to subterranean water and *puquios* such as those located in the drainage of Río Grande de Nasca, including Cantalloc, Aja, Orcona, Vista Alegre, Usaca, and Cerro Colorado.

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[1]Results from some geoelectrical investigations performed in 2014 between Gran Piramide and the Nasca River revealed the presence of shallow aquifers at 8–10 m of depth, confirmed by a well which has been excavated. This suggests that in Cahuachi, the Nasca were able to exploit the water tapped by using a water-supply system (including puquios?) and channeling for drinking and rituals. In this respect, small canals have also been found in Piramide Naranja (see Chap. 4 by Orefici).

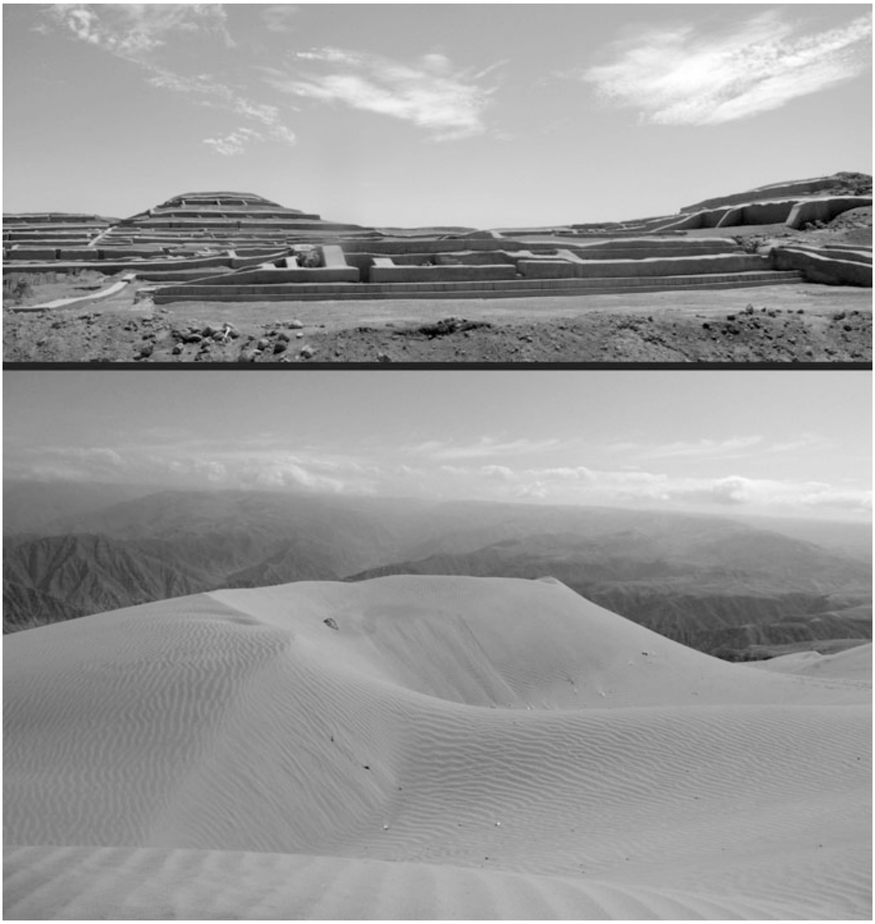


Fig. 13.4 Nasca sacred landscapes. *Top* Cahuachi: the huge ceremonial center whose location was selected because of the prevalence of water aquifers, emerging there to the surface in the form of springs; *Bottom* Cerro Blanco: the large sandy mountain (overlooking the Tierras Blancas valley) that in many local legends was thought to have a subterranean lake considered to be the water source of the Cantalloc *puquio*

According to Schreiber (2003), who followed the first interpretation made by Mejia Xesspe (1942), many Nasca Lines were in some cases probably "simple" roads, traced to locate the water along their path, as for example the "*Camino de Leguia*" connecting Cahuachi with Ventilla located in the Ingenio Valley. The path of the "*Camino de Leguia*" was traced across the whole pampa to provide to the travellers not only the road path but primarily indications where to locate the water, essential information needed for surviving in this arid desert land (see also Silverman 1993).

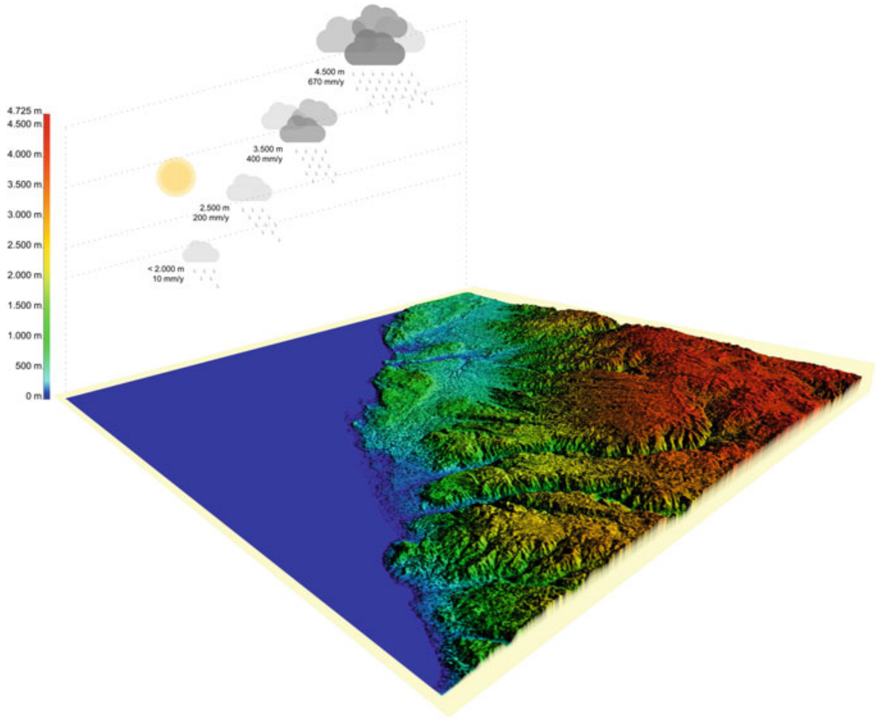


Fig. 13.5 Río Grande de Nasca drainage: annual precipitation for altitudes. 10 mm/year in the lower and middle valley (less than 800 m a.s.l., 200 mm/year above 2500 m a.s.l., 400 mm/year above 3500 m a.s.l. and 650 mm/year at 4500 m a.s.l.) (Photo by N. Masini)

13.3 Study Area: Hydrology and Land Use

The southern part of the Peruvian coast is one of the most arid places in the world, with annual precipitation ranging from 0 to 25 mm. Temperatures usually vary in a range from 10 to 32 °C. In this sub-tropical desert region, the climate is strongly influenced by the cold Humboldt Current of the Pacific Ocean which severely limits rain. The presence of a mountain barrier (to the west side) prevents the moist air from the sea, resulting in the typical climate of the Nasca area characterized by warmth and dryness. Summers are generally very hot and dry while winters are moist and foggy (see Chap. 2).

The area is adversely affected by El Niño, the devastating phenomenon caused by a warm mass of water that periodically migrates across the Pacific Ocean displacing the cold waters of the Humboldt Current. As a consequence of El Niño, there are periodically devastating flooding and torrential rains along parts of the coast and drought conditions elsewhere. In 1998, there was one of the worst El

Niño's events of the last 500 years which caused severe damage to the archaeological sites as well as to the modern settlements and populations of the area.

The geomorphology of the coastal desert area of southern Peru has been shaped by the drainage basin of the Río Grande de Nasca (about 11,200 km^2), which empties into the Pacific Ocean after passing through the coastal range (Fig. 13.6). As a whole, the Río Grande de Nasca collects water from many tributaries that flow

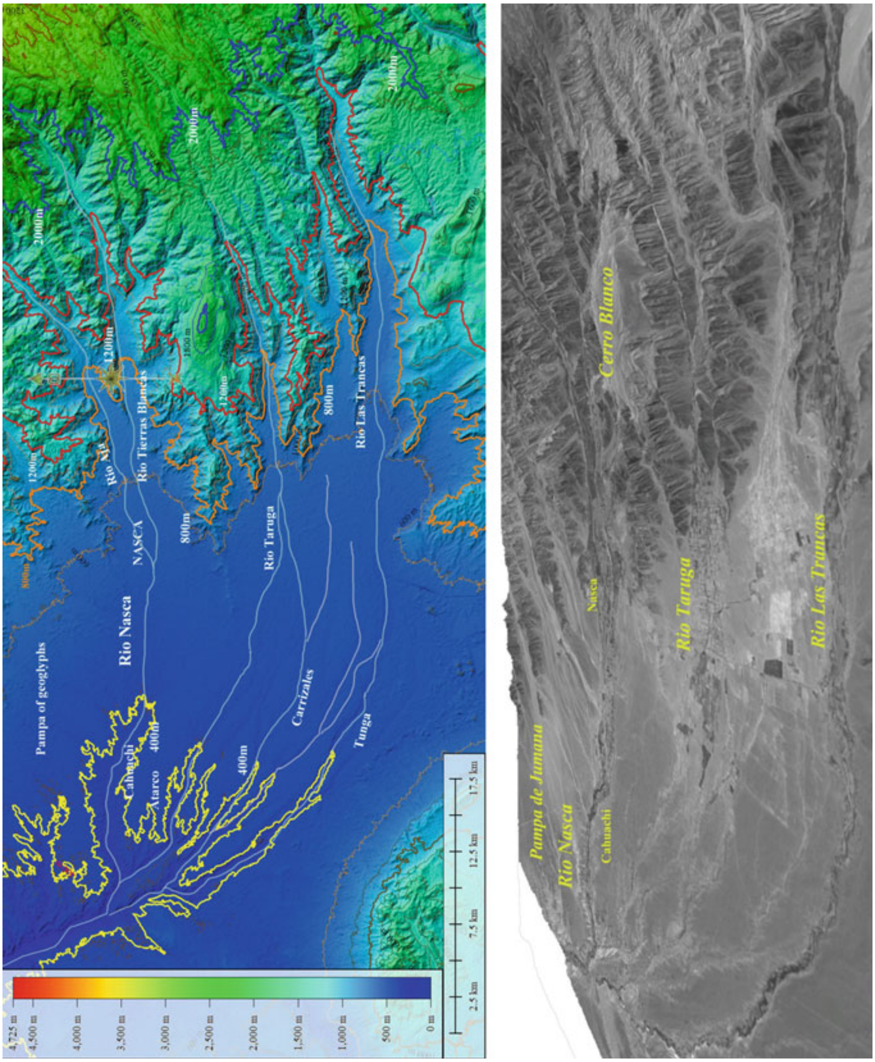


Fig. 13.6 *Left* Nasca drainage basin (DEM provided from SRTM of 30 m). The contours at 400 m (*yellow color*), 800 m (*red color*), and 1200 m (*blue color*) height define the limits of low valley, dry medium valley, infiltration zone, and upper valley. *Right* 3d ASTER image of the Nasca drainage

into the Río Grande, thus forming the largest river system of Peru. From north to south, the Río Grande first collects the water of the Vizcas, Ingenio, and Palpa rivers, then those of the Santa Cruz River, and afterwards joins the Nasca River, whose water flow is enhanced by the Aja, Tierras Blancas, Taruga, and Las Trancas rivers, to which are added the Atarco, Carrizal, and Usaca narrow ravines.

The southern tributaries of the Nasca River are smaller compared to those of the northern tributaries or to those of other coastal valleys. Nevertheless, with the exception of the Río Grande and Río Ingenio, all these rivers are usually dry for long periods of the year (Onern 1971) and are "through-flowing only two years out of seven, on average" (Schreiber and Lancho Rojas 1995).

The rainy season generally spans from January through March, even if in the area of the Río Grande System the precipitation is very low (around 10 mm) annually in the lower and middle valley (less than 800 m a.s.l.). From the Sierra to Andes, the precipitation dramatically increases, reaching 200 mm/year above 2500 m a.s.l., 400 mm/year above 3500 m a.s.l., and 650 mm/year at 4500 m a.s.l. (Baade and Hesse 2008; Fig. 13.5).

The severe scarcity of water in the valley is also due to the evaporation and high infiltration phenomenon, caused by the specific characteristics of the soil, which induces the rivers to drop below the surface, disappearing under the ground level (Schreiber and Lancho Rojas 1995).

As a whole, we can distinguish five distinct zones (Fig. 13.6), categorized according to their elevations and water availability, as follows:

1. Sierra: above 2000 m a.s.l. where it is possible to have agriculture exploiting the precipitation.
2. Upper Valley: from 2000 to 1200 m a.s.l. where there are rivers with water that is available during the whole year and, therefore, the agriculture is possible by exploiting the water of the river.
3. Infiltration zone from 1200 to 800 m a.s.l.: it is a transitional area where water is partially available during the year because of the infiltration of the river which drops below ground into the subsoil.
4. Dry middle valley: from 800 m to 400 m a.s.l., this is the drought area where no water is available except during periods of inundation, approximately February and March. This area is characterized by larger expansion of arable land and by the presence of *puquios*.
5. Lower valley: 400–0 m.a.s.l., in this region, rivers reappear on the surface to flow as perennial streams towards the ocean for around 9 km. The area is characterized by acid soil, severe wind, and hot climate that make living here difficult.

The infiltration capacity of the soil, which characterizes the so-called infiltration zone in altitudes ranging between 1200 and 800 m a.s.l., creates a substantial reduction in water transmission. This causes, as a result, the underground flow of the rivers and, consequently, there is no surface water available for irrigation and domestic purposes for a long period of the year (and sometimes for several years).

These rivers are called "influent streams" because they flow underground disappearing under the surface at diverse points, which tend to vary from one year to another or from one month to another according to the rainfall volume. Later they reappear on the surface, at about 400 above sea level in the Nasca drainage, to flow towards the ocean.

Considering the climatic periodicity in the region and the significant scarcity of the water in the whole area of the middle valley, there is no water available for irrigation as well as for household use. We can expect this to result in sparse occupation, but, on the contrary, the archaeological record clearly testifies that the area was densely settled in pre-Columbian times (Orefici and Drusini 2003). This is also much more surprising, considering that the distribution of the arable land is mainly concentrated in the middle valley areas which are characterized by a significant lack of water. Therefore, the area with the larger availability of arable land is the less appropriate for human housing, with the exception of the period of the seasonal inundations (Fig. 13.7). Moreover, in the middle portions of the tributaries of the Río Grande de Nasca, due to the climatic periodicity, water flows into the rivers only two years out of seven and, even then, with a volume of water that is far below that of the other valley systems.

In other words, within the Nasca drainage, the southern tributaries of Aja, Tierras Blancas, Nasca, Taruga, and Las Trancas have the least amount of water. For example, the Aja and Tierra Blancas rivers have an average annual flow of 58 and 46 million m^3 of water, respectively, compared to 110.8 million m^3 of water that flows down the Río Grande (Onern 1971; Baade and Hesse 2008).[2]

The amount of superficial water was and still is simply not sufficient for the inhabitants, both in the past and in the present time, especially during summer or prolonged drought periods. Therefore, people of the south Peruvian coast needed and need to retrieve water from alternative ground sources, to manage and to canalize water through reservoirs and canals in order to store, distribute, and use water for food production and domestic needs.

The problem was solved by the ancient Nasca by devising the *puquios*, i.e., sophisticated hydraulic systems constructed to retrieve the water from the underground aquifer. Schreiber and Lancho Rojas (1995) suggested that the *puquios* retrieve water from both the water table and the rivers in the area where they flow as underground streams. Therefore, *puquios* are expected to run mainly parallel to the fault that influences the distribution of the water table or to the existing river system.

According to Johnson et al. (2002), the puquio systems retrieve water from the underground water table and are generally perpendicular to the rivers, not parallel to them. This was deduced by considering the structural geology of the valley, which has a series of geological faults that "cut across the tributaries of the Nasca drainage, trapping water flowing down from higher elevations and conducting it at great distances into other parts of the drainage" (Johnson 1997).

[2]Río Taruga and Río Las Trancas have an average annual flow of 4.4 and 56.1 million m^3 of water, respectively.

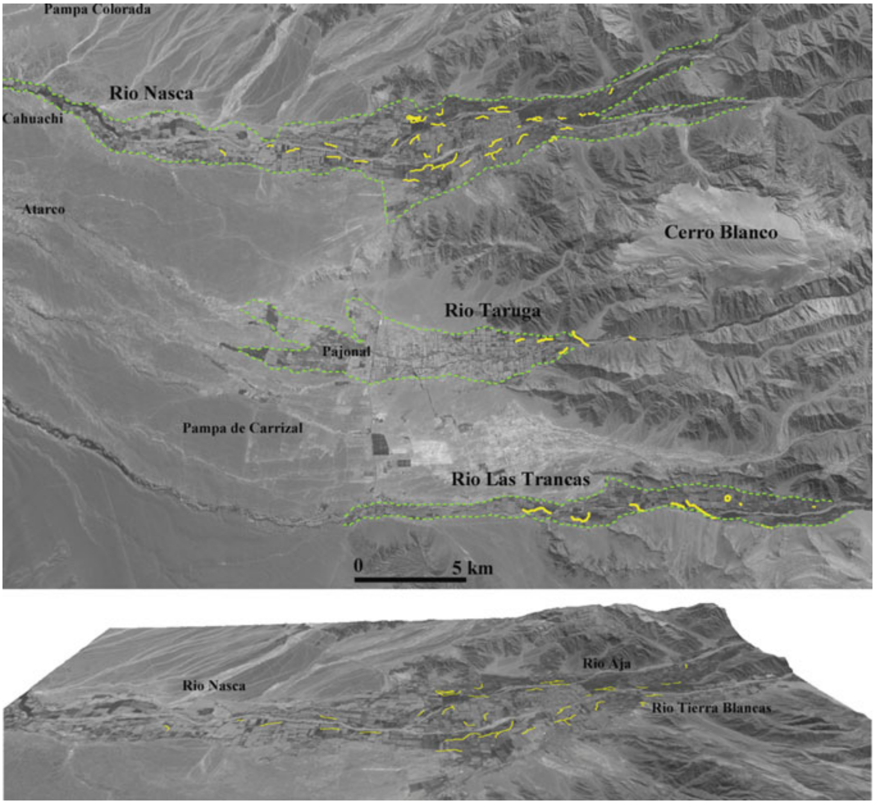


Fig. 13.7 *Top* map of the puquios in the Nasca drainage (ASTER VNIR band 1). *Yellow lines* denote the puquios and *dashed green lines* indicate the arable land. *Bottom* 3D-view of the Nasca valleys including the tributaries Aja and Tierra Blancas

On the basis of ground investigations, Schreiber and Lancho Rojas (1995) argued that, in some areas, *puquios* retrieve water from underground rivers whereas in other cases from the water table forced by faults that constrain the spatial distribution of the ground water (see also Solar La Cruz 1997). In both of these circumstances, in the past as in the present, it was and is possible to conduct agriculture and have rich exotic fruits and abundant food in this area that is one of the driest places on the face of the Earth.

Still today using *puquios*, farmers cultivate cotton, grapes, corn, beans, and tubers, among other agricultural products including fruits such as mangos and oranges. In the past, ancient inhabitants cultivated many of the same plants and vegetables as they do today, i.e., cotton seeds, coca, manioc, corn peppers (*Capsicum* sp.), and beans, as is evident from the archaeological findings. Additionally, today many other plants and vegetables can be found such as, for example, lúcuma (*Lucuma bifera*) (see Piacenza 2002; and Chap. 6).

13.4 Brief Notes on the Puquio Technology

Artificial irrigation systems are traditionally constructed using canals to modify the natural course of the water flows, diverting the water from the superficial rivers into artificial sub-canals. These systems in the Nasca region are only effective during the rainy season, approximately from January to April, when the water flows from the mountains down into the rivers and tributaries. Of course, as expected, this type of water canalization is completely ineffective to face the lack of superficial water that, in the region of interest, is quite severe and long-lasting. Drought generally occurs intra-annually in a prolonged period from April to December and inter-annually for a long periods depending on climatic periodicity. Therefore, in this area, to assure the subsistence for agriculture and domestic use, the retrieval of water from an alternative source is mandatory.

The problem of drought was solved by the ancient Nasca by devising the *puquios* that are sophisticated hydraulic systems constructed to retrieve water from the underground aquifers. The water intercepted underground was then canalized, distributed, and stored in reservoirs according to the specific needs. The strategic "puquio system" was the most ambitious hydraulic project in the Nasca area, and it made possible having water for the whole year, not only for agriculture and irrigation but also for domestic needs.

The construction of the *puquios* involved the use of particularly specialized technology. The filtration gallery system was completely different from the traditional aqueduct, because the aim was not only to transport and distribute water, but also to collect valuable water underground and channel it towards reserve deposits. Taking advantage of the natural slope of the alluvial layer compared with the sedimentary layer, and given that both run down in parallel from the plateau to the coast, the Nasca settled on a point to dig a well in order to identify the underground water. Later, they would dig horizontally, constructing tunnels where the water, which had been discovered by means of the well, was filtered and flowed up to the surface. To create this hydraulic system, it was necessary to build tunnels that would be partially subterranean where the watercourse was at its deepest and required inspection wells to oxygenate this precious resource.

The inner walls of the filtering tunnels were made of fluvial pebbles which had been carefully selected and bound together by a mass of special, particularly waterproof clay. When it was necessary to control the speed of the water better, the route was designed so as not always be straight, as evidenced by the presence of small intermediate decanters and right-angled curves. 36 *puquios* are still in use today, 29 of which are in the Nasca Valley (including Aja and Tierra Blancas tributary valleys), two in the Taruga Valley, and five in Las Trancas Valley.

From the constructive point of view, a typical *puquio* consists of several distinct parts, which have specific technological functions. In general, they are characterized by three sections: (i) an underground section that consists of a horizontal well where the water is captured from existing aquifers, (ii) a second section that is an open pit where water is captured by filtration of the aquifers, and (iii) a third section where the water is conducted to reservoirs.

The original *puquios* devised by the ancient Nasca civilizations can be categorized into three types according to their construction features, characteristic shapes, and sizes: (i) open trenches (Fig. 13.8), (ii) filled-trench galleries characterized by greater depth compared to the open trenches (Fig. 13.9), and (iii) tunnelled galleries to collect and use on arable lands.

It is recognized that the original construction features and early approach used by the Nasca was the open-trench typology (Schreiber and Lancho Rojas 1995). This

Fig. 13.8 An example of the open trench *puquio* typology (Photo by Rosa Lasaponara)

Fig. 13.9 Examples of a filled-trench gallery (*left*) and an open-trench puquio (*right*) (Photo by Nicola Masini)

actually is the simplest one based on the connection of two points with an open trench (Fig. 13.10). The main issue is the identification on the surface of the point connected with the phreatic layer where it is possible to intercept the subsurface water that is captured, canalized, and brought to the surface by the open trench that slowly steps down to keep the water flowing.

The open trench *puquios* are less deep compared to the filled-trench or tunnel-shaped *puquios*. They have generally a base of around 1 m and a width of around 10 m. They have generally one canal, even if in some cases multiple branches are also present in order to have more water. The borders were generally covered by river pebbles to build a sort of contention wall which needs yearly maintenance.

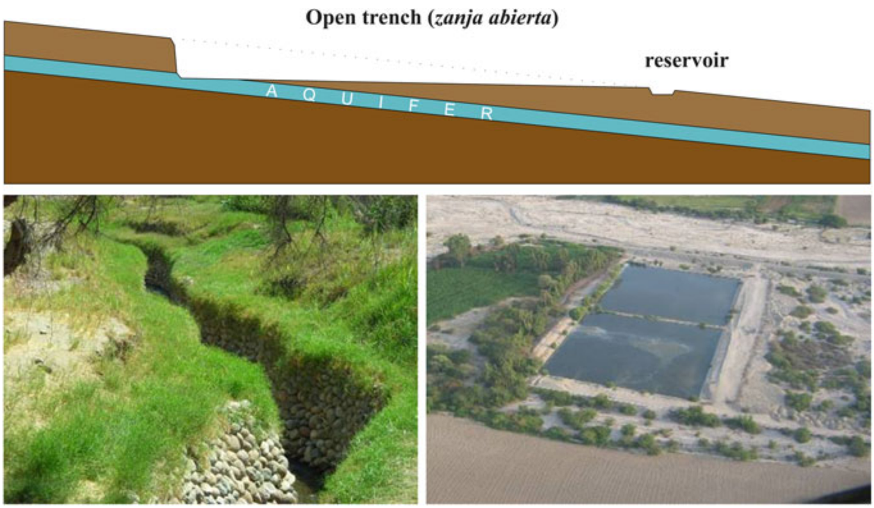


Fig. 13.10 *Top* Scheme of open trench (drawing by Manuela Scavone). *Middle* Open trench *puquio* of Bisambra. *Bottom* A reservoir (*cocha*) where *puquio* generally empties (photo by Nicola Masini)

The *puquios* of greater length and depth have a large part of their branches covered, thus creating what is generally called filled-trench *puquios*. Actually the galleries were constructed in two different ways: (i) tunnelling or (ii) filling the open trench (Fig. 13.11).

The deepest portion was generally excavated as tunnels with sizes approximately 1 m in height and width. The filled-trench are formed by filling an open trench, namely constructing gallery walls and a roof, and usually this type of gallery has a greater height.

The underground infiltration galleries are approximately rectangular, with an average base width ranging between 0.4 and 1.80 m, with walls lined with boulders. The longitudinal slope varies between 0.4 and 2.5%. The average maximum depth of the galleries is about 6.8 m. Soil permeability in the galleries varies between 1.5×10^{-4} m/s and 5.4×10^{-4} m/s. In the channels, the open-pit width at the base is on average 1.0 m, with the slopes not exceeding z = 0.5 (Rodríguez Zubiate 2003).

At various points along tunnels or galleries, at varying intervals, there are openings chimneys, or more commonly *ojos* (eyes) (Fig. 13.12) whose function is to allow the entrance of air and sunlight as well as to provide access for regular maintenance (annual cleaning). These chimneys are generally spaced 10–30 m.

Tunnelled galleries have generally large conical *ojos* whose opening can be around 15 m on the surface and 1–2 m at the ground (Schreiber and Lancho Rojas 2003).

In the case of filled-trench, the chimneys are generally much smaller, less than 1 m with a square form, surrounded by a stepped structure of walls built by pebbles, as in the case of San Carlos *puquio* (Fig. 13.12, right).

The most important critical issue for both tunnelled and filled trench *puquios* is the maintenance (Fig. 13.13) required to avoid that debris material t washes down and fills or contaminates the water in the tunnel. Several of these chimneys have been restored or completely reconstructed recently as, for example, those now visited by tourists at Cantalloc in the Nasca Valley (Fig. 13.12, left).

13.5 Dating Issues

13.5.1 Early Different Hypothesis

Throughout the years, several researchers investigated *puquios* and their origins, while attempting to date them. In particular, the dating of *puquios* has always aroused interest along with lively debate and disagreement (Barnes and Fleming 1991; Bray 1992; Clarkson and Dorn 1991, 1995; Schreiber and Lancho Rojas 1988, 2003).

Sixteenth-century chroniclers of the early Spanish colonial period, such as Cieza de Leon (1576) and Guaman Poma de Ayala, as well as the seventeenth-century

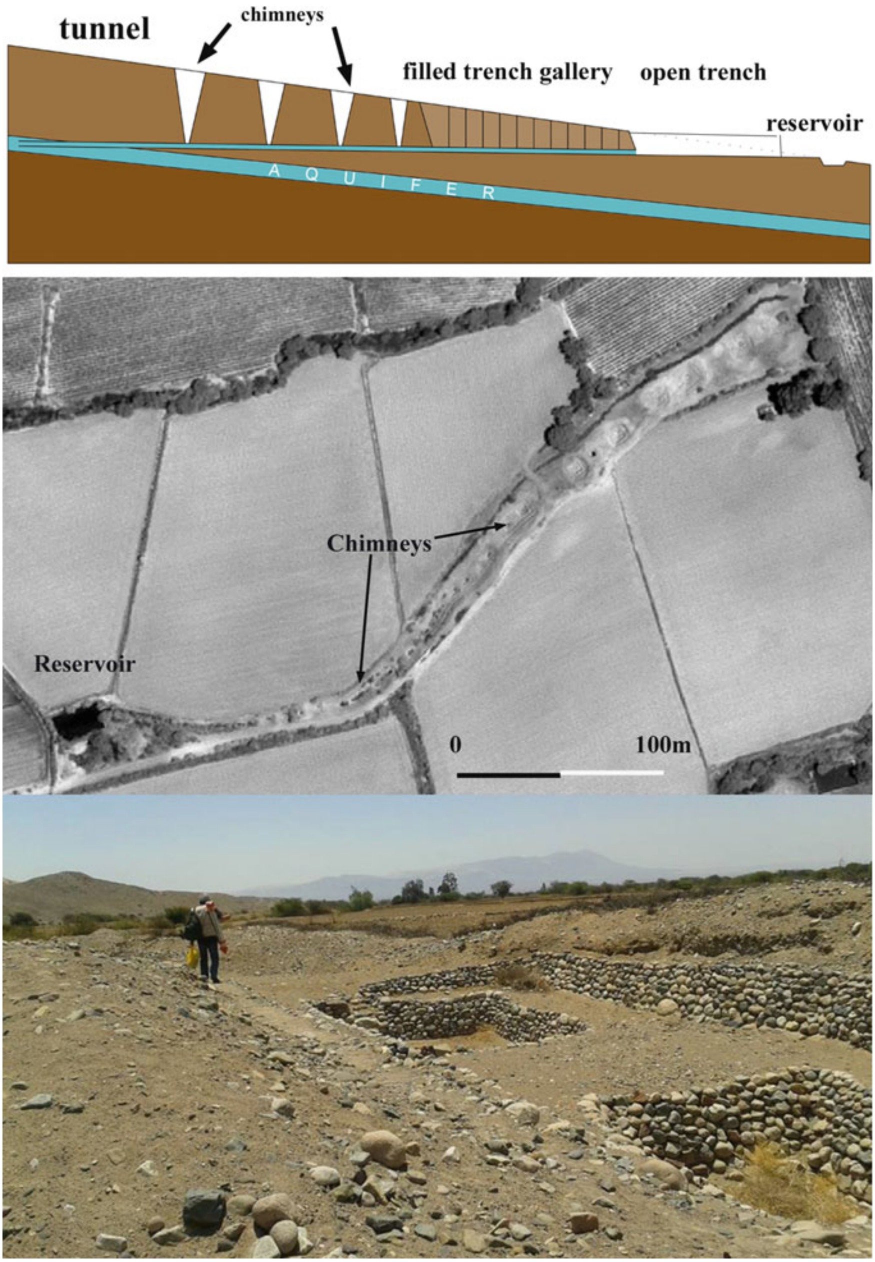


Fig. 13.11 *Up* Scheme of a *puquio*, composed of a tunnel, filled-trench gallery, and, finally, open trench, which empties into a reservoir (Drawing by Manuela Scavone, CNR-IBAM). *Middle* Satellite map of the *puquio* of San Carlos. *Bottom Puquio* of San Carlos, detail of the chimneys surrounded by square-stepped structures made by pebbles (Photo by N. Masini)

Fig. 13.12 Circular and square chimneys in Cantalloc and Santa Maria

Fig. 13.13 Critical issue of the conservation of filtration galleries: the lack of maintenance. The images show some detail of San Carlos *puquio* (Photo by Rosa Lasaponara)

chronicle of Vazquez de Espinosa, did not mention *puquios*. This was probably due to the fact that the Spanish were not aware of *puquios* and also because some of the chroniclers who wrote about Nasca had never been there. Moreover, as suggested by Kosok and Reiche (1949), the Spanish were only interested in luxury and the abundance of fruits and vegetables, without any interest in the method of their production. Doubts about the significance of the historical accounts of the Spanish colonial documents has been many times raised over the years, also on the basis of the evidence that many Spanish chroniclers had never been in Nasca. Even if some other Spanish chroniclers were in Nasca, they did not know anything about the *puquios*, but also about Cahuachi, the huge Nasca ceremonial center.

Early studies conducted by Joyce (1912), as well as by other researchers (Auza 1948; Conkling 1939; Gonzalez Garcia 1934), dated the *puquios* back to the Inca period.

Later, Rossel Castro (1942, 1959, 1977) emphasized that the Inca never built subterranean irrigation systems in any place of their empire and, therefore, he argued that *puquios* could not be attributed to the Inca civilization. Rossel Castro suggested a Nasca origin according to the artefacts he recovered close to several *puquios*. Nevertheless, it should be noticed that Rossel Castro did not leave any documentations related to the locations, descriptions, or illustrations of such artefacts. Finally, Rossel Castro also linked the geometric geoglyphs (Rossel Castro 1959) with the subterranean aqueducts as already suggested by Xesspe, who investigated in 1927 several *puquios* in the valleys of Las Trancas and Taruga.

On the basis of Rossel Castro suggestions, Petersen (1980) dated the *puquios* to the late Nasca times (around 400–800 AD). Barnes and Fleming (1991) re-considered the aqueducts as a post-Conquest construction made by the Spanish. They supported this hypothesis mainly for the following two considerations: (i) the similarity between *puquios* and Moorish qanats and (ii) the lack of references to the aqueducts in colonial Spanish chroniclers.

Schreiber and Lancho Rojas (1995) completely rejected this hypothesis, considering it totally unreliable. They stressed the fact that there was evidence of post-Conquest construction of a few *qanats* made by Spanish in Lima. At that time, Lima was a very important center chosen by the Incas as a capital (even if also characterized by water shortage), whereas Nasca was a peripheral area with only one Inca center, Paredones, very small compared to Lima. According to Schreiber and Lancho Rojas (1995), the main question is the following: why did Spanish build only a few qanats in the Lima capital, while making great effort to build a huge number of *puquios* in a peripheral center, as was Nasca at the Inca time? According to Schreiber and Lancho Rojas (1995), possible post-Conquest Spanish contributions to the filtration-gallery technology maybe (i) the construction of a few *puquios* in Nasca as, for example, probably the Cantalloc (Ministerio de Agricultura 2000) one and (ii) the evolution from open trench to the filled-trench technology characterized by the building of walls and ceiling of the conduit (tunnel) to save and use arable lands. A possible approach to date the *puquios* was attempted via a systematic investigation of the archaeological records and evidence based on laboratory dating, analysis of settlements, and artefacts conducted by Schreiber and Lancho Rojas (1995) as summarized in Sects. 13.5.2 and 13.5.3, respectively.

13.5.2 Laboratory Dating

Some efforts have been made also to determine the age of the Nasca *puquios* by using radiocarbon dating (Scharpenseel and Pietig 1974), performed on samples of wooden lintels from the Cantalloq and Majoro *puquios*. Results of this analysis yielded ages of 110 + 100 B.P. (Bonn-1971) and 140 + 100 B.P. (Bonn 1972), which are clearly related and consistent with the periodic replacement of wooden lintels, and with the fact that the *puquios* under investigation are still in use today and, therefore, under continuous maintenance.

To overcome this drawback, Clarkson and Dorn (1991) and Bray (1992) conducted investigations on the rock varnishes associated with cultural features in two *puquios*. Numeric age assessment of organic material encapsulated by rock vanish present on stone lintels was undertaken for the Orcona and Cantalloq *puquios*.

Accelerator-mass-spectrometer-radiocarbon analyses revealed, for Orcona, ages of around 552–644 AD and for Cantalloq 591–658 (Clarkson and Dorn 1995). This dating is consistent with those made by Schreiber and Lancho Rojas (2003) on the basis of both the artefacts found and the analysis of the dating of settlements and their distribution (Sect. 13.5.3).

13.5.3 Archaeological Evidence: Settlements and Artefacts

As evident from the previous brief notes in Sect. 13.5.1, one issue still open today is the question about by whom and when the *puquios* were built. Even if after the first doubts the *puquios* were thought to be built by the Nasca, only recent systematic archaeological investigations have been carefully directed to support this hypothesis.

Schreiber and Lancho Rojas (1995) undertook systematic archaeological surveys during two decades to deeply analyze and record all the sites in the Nasca, Aja, Tierras Blancas, Taruga, and Las Trancas Valleys. They conducted a complete and full-scale survey in order to search for the location and the nature of Nasca habitation sites, to date them, and to analyze their relationship and connection with *puquios*. The first important result of this research activity was the significant advancements in the knowledge and understanding of the Nasca habitation sites, in that other investigations had generally been conducted on Nasca ceremonial sites or cemeteries. Studying the aqueducts in more detail, in order to cast new light on the *puquios*, Schreiber and Lancho Rojas (1995) focused on the nature of the surface cultural remains in the Nasca, Aja, Tierras Blancas, Taruga and Las Trancas Valleys. Settlement sizes and patterns were recorded, analyzed, and finally compared with the presence of *puquios* and subterranean aquifers.

One of the first important results (Schreiber and Lancho Rojas 1995) was that, in the three valleys, most of the habitation sites of Early Nasca period (1–400 AD) were generally very small, with only a few exceptions.

The second important finding was related to the characteristics of the settlement patterns related to the Middle Nasca period (400–500 AD) when there was a significant increase in both the number and size of habitation sites in areas previously uninhabited.

In particular, in the Nasca Valley as well as in the Taruga and in the Las Trancas Valleys, numerous small and medium stable communities were established. These communities were clearly in direct association with the *puquios*. This provided evidence of *puquios* dating, because the presence of these settlements would have been impossible without the construction of the aqueducts that provided continuous availability of water. Additional confirmations were also provided by remains belonging to the phases Nasca 5 and 6 of the Early Intermediate Period found in the Totoral *puquio*.

The increasing number and size of villages was directly linked to the very long and severe drought periods that lasted for several years, as evident by the study on prehistoric precipitation conducted in the south highlands on ice cores by Thompson et al. (1985). According to the findings of this study, long drought periods mainly occurred from 540 AD to 560 AD, from 570 AD to 610 AD, and finally also from 650 AD to 730 AD. This change in the environmental conditions and the further shortage of was the main reason that forced the Nasca to move (i) towards the upper valley where the water was usually available flowing in the river during the whole year and (ii) towards the middle valley where the presence of subsurface water was "more systematically" exploited by the *puquios* technology.

The significant climatic and environmental changes of the Late Nasca times provoked, as evident from archaeological evidences, not only changes in settlement locations (towards both upper valley and middle valley) but also new arrangements within the socioeconomic organization. This is evident from the establishment of the new settlements based on larger communities, with a larger aggregation of population and an increased socio-political complexity, which substituted for the small inhabited sites of the previous Nasca periods (characterized by the presence of numerous but small villages). In the Late Nasca period, a limited number of very large towns can be found in the middle Nasca Valley, in the upper Tierras Blancas, and in the middle valleys of Río Taruga and Río Las Trancas.

Moreover, on the basis of the existence of the settlement of Pueblo Viejo on the lower part of the Nasca middle valley, Orefici and Drusini (2003) highlighted the possibility that the *puquios* were devised and realized in earlier periods probably during the Early Nasca phase at around 0–400 AD (see also Orefici 2009, 2016). This hypothesis has also been supported by Conlee (2015) who postulated that the construction of the Orcona *puquio* dated back to the Early Nasca period and was intended to intensify agricultural production at La Tiza.

Coupled with the presence of villages, Schreiber and Lancho Rojas (2003) also focussed their investigations on the presence of cultural material remains in elevated ridges or berms, created for the excavation of the trenches for the outflow from the galleries, on which limited habitation could take place. They have pointed out that, during their systematic field surveys conducted in many years (1986, 1988, 1995, 2003, 2006, and later), they found pottery and artefacts ranging from Nasca Phase 5 through the Middle Horizon and Late Intermediate Periods (see also Kroeber and Collier 1998). The presence of these materials clearly highlights that the construction of *puquios* was necessarily anterior to the Spanish conquest. Moreover, in several *puquios* such as Soisonguito, Agua Santa, Anglia, Achaco, Curve, San Antonio, Pangaraví, and Santa María, they found archaeological remains dated to the Middle Horizon, Late Intermediate, and Late Horizon Periods, and also the Colonial epoch. In the Pangaraví *puquios*, objects belonging to Early Intermediate 5–6 were found. Therefore, these remains, discovered in the above list of *puquios*, clearly testify that the use of aqueducts dated to these periods and their construction was necessarily earlier.

Finally, Silverman (2000) has also suggested that in the Nasca Valley the presence of late sites, such as the Middle Horizon Pacheco (Menzel 1964; Paulsen 1983) and Late Horizon Paredones, was likely linked to the availability of the pre-existing Nasca filtration galleries.

As a whole, we can conclude that Schreiber and Lancho Rojas (2003) analyzed the presence of the settlements belonging to the early stages of Nasca culture, which had developed in the upper part of the Río Nasca valley and below the line of springs at the bottom of the valley, excluding the middle part. Considering that the settlements above and below the dry intermediate area are older than those of the central area, the filtration galleries were necessarily built between the end of Nasca Phase 4 and Phase 8. But the archaeological evidence from occupied sites, already inhabited in the transitional Paracas–Nasca phase, like those of Ocongalla, Agua Santa, Pueblo Viejo, and others located in the dry intermediate area, seems to indicate as suggested by Orefici and Drusini (2003) and Conlee (2015) that there were *puquios* or other forms of water supply from the earliest Nasca phases.

13.6 A Space View of the *Puquios*

13.6.1 Characterization of the Environmental Setting Based on Satellite Data

Lasaponara and Masini (2012) were the first to investigate the *puquios* from space. Multispectral satellite images from medium- to high-spatial resolution were exploited to infer useful information on *puquios*, along with the Nasca environs and environmental changes. These investigations, mainly based on the use Landsat MSS, Thematic Mapper, ASTER, and very-high-resolution optical imagery, were conducted in some selected areas of the Río Grande basin. To extract as much as possible information stored in the satellite pictures, single-date and multitemporal maps of vegetation and moisture indices were analyzed (Ceccato et al. 2002a, b). For each data set, two spectral indices were computed: the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Water Index (NDWI). The NDVI is an arithmetic combination of the red (R) and near-infrared (NIR) channels, computed using the following formula NDVI = ((NIR − R)/(NIR + R)), which provides information about vegetation cover and its status (Jackson et al. 2004). The higher the NDVI values, the healthier is the vegetation. The NDWI, computed using the formula NDWI = ((SWIR − R)/(SWIR + R)), provides an estimation of the moisture content for both soil and vegetation, where SWIR is a band in the shortwave infrared (Peñuelas et al. 1993; Ripple 1986; Roberts et al. 1997).[3]

The investigations were performed using RGB maps, such as, e.g., the composition of the Landsat ETM + bands 3-2-1 (Fig. 13.14a), and bands' elaboration (Fig. 13.14b) as the Tasseled Cap Transformation (Kauth and Thomas 1976). This

[3]In the case of ASTER data, the selected SWIR channel is band B6 (named also SWIR_band5) at 2.145–2.185 μm wavelength. In the case of Landsat TM data, the selected SWIR channel is band 5 at 1.55–1.75 μm wavelength.

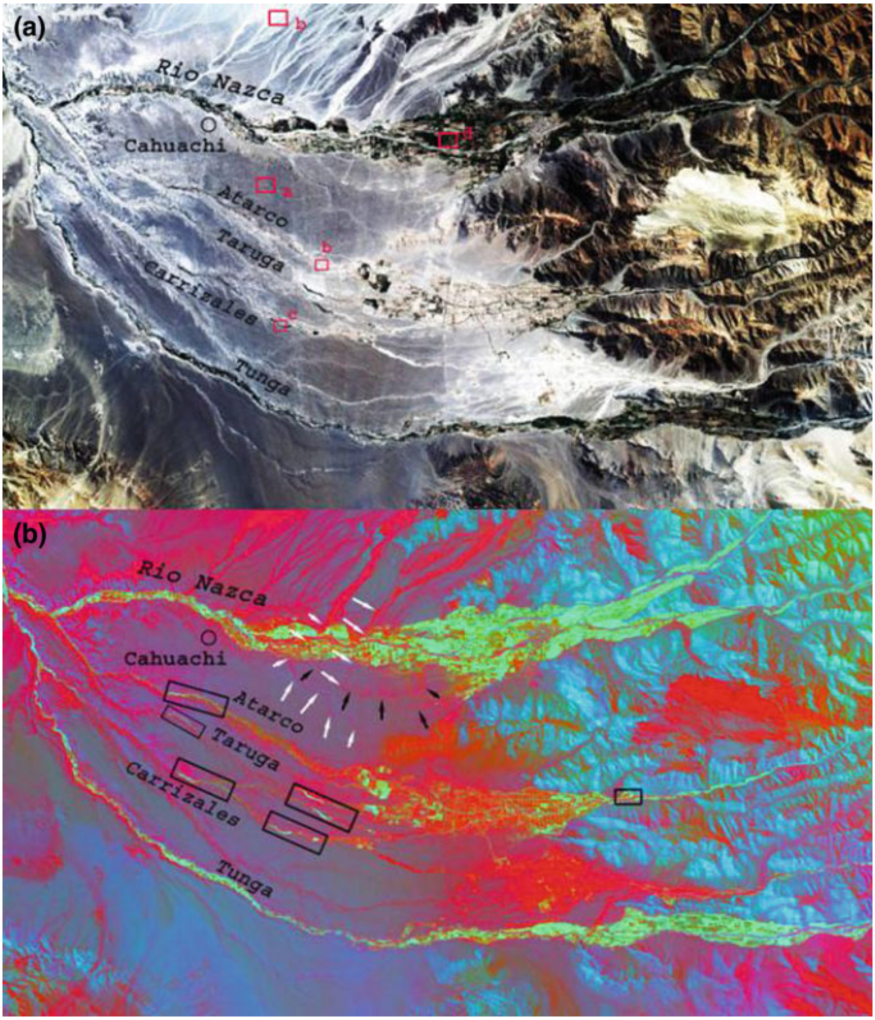


Fig. 13.14 **a** RGB composition of Landsat ETM + bands 3-2-1: *red boxes* denote areas related to four different land-cover types. **b** RGB composition of TCT components: *black boxes* indicate segments of the ravines. *White* and *black arrows* denote traces of past mudslides of the Nasca River and *huaycos* coming from the Pampa north of the river, respectively

enabled the identification of areas with different land-cover types, including the oases rivers, the *pampas*, and the ravines.

Moreover, the approach adopted by Lasaponara and Masini (2012) was also based on the multitemporal analysis of the above mentioned spectral indices and related maps. The assumption is that vegetation and moisture indices and their temporal changes are greater in correspondence of a shallow water table than in arid soils, as well in as in areas rife of water or in irrigated farming fields.

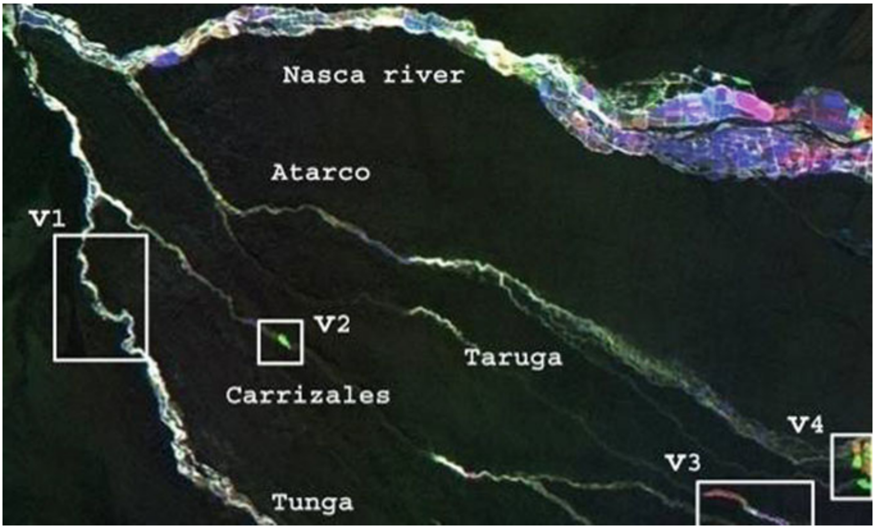


Fig. 13.15 RGB composition of the ASTER NDVI maps (R = NDVI2003; G = NDVI 2004; B = NDVI 2008). The *rectangular white boxes* denote significant NDVI variations within the considered period

These temporal dynamics were evaluated using a multitemporal dataset made up of three Aster images acquired on the same date (1 June, i.e., the dry season) for the years 2003, 2004, and 2007. The NDVI maps (Fig. 13.15) placed into evidence some variations related to vegetation-cover changes during the considered period. They are easily identifiable by the chromatic visualization offered by the multitemporalRGB composition. In particular: (i) constant low values over time are related to arid soil and can be identified by dark-grey to black tones; (ii) constant high values are related to healthy vegetation and visualized by lighter tones from white to lighter grey; (iii) non-constant values over time produce colors whose varying intensity levels of red, green, and blue depend on the NDVI values for the years 2003, 2004, and 2007, respectively. For example, a pixel with a higher intensity value is red in respect to green and blue is characterized by higher 2003 NDVI values than those in 2004 and 2007. It is worth noting that the investigated area from the *Pampa* to the beds of the ravines are mostly arid and therefore visualized in black in the multitemporal RGB image. However, we can identify some areas characterized by changes of NDVI over time, in particular in the fluvial oasis of the Nasca River and in the upper part of the Taruga, Carrizales, Tunga, and Atarco tributaries, where the presence of vegetation is due to a shallow water table and functioning *puquios*.

The multitemporal analyses of vegetation indices and associated maps provide clear evidence of the arable and currently cultivated lands. Actually, due to the loss of maintenance of the *puquios*, today agriculture is mainly practiced on land near stretches of rivers characterized by a perennial hydraulic regime or in areas with new technological facilities such as electric pumps.

13.6.2 Space View of the River Flow in the Nasca Region

The analysis of spatial variations (Fig. 13.16) of the multitemporal NDWI facilitates the identification of some spatial anomalies possibly referable to disused filtration galleries. Since the NDWI provides an estimation of the moisture content for both soil and vegetation, the NDWI maps were used to extract information about flow characteristics of the rivers south of the Nasca basin. In particular, from the multitemporal RGB composition (Fig. 13.16) of NDWI (R = 2003, G = 2004, B = 2007), we can distinguish three different spectral behaviors that can be associated to the three different hydraulic regimes generally categorized in the areas as (i) perennial, (ii) ephemeral, and (iii) dry.

Actually we should consider that the size of these water courses was, in some cases, much smaller than the ASTER SWIR pixel (30 m). Therefore, it was also possible to focus a small part of the pixel whose signal is enough to be appreciated but remarkably lower than the typical values expected in presence of rivers with significantly greater water flow.

The major findings are shown in Figs. 13.16 and 13.17. They depict the multitemporal RGB composition of NDWI maps (Figs. 13.16a and 13.17a) computed for the years 2003, 2004, and 2007 and the spatio-temporal profile of NDWI ASTER Index (Figs. 13.16b and 13.17b) for some transects. As shown in the profile of NDWI in Figs. 13.16b and 13.17b, from one year to another, the NDWI values change within a buffer which denotes that the water table is not very deep (visualized by a color with different intensity value of red, green, and blue). So, the inter-year water-level oscillations cause significant variations in soil moisture and also in the presence and status of vegetation, as detected by the ASTER multitemporal dataset analyzed in this work. The three NDWI change-detection patterns well fit those identified from the NDVI.

As a whole, the use of satellite information enabled the preliminary characterization of the environs and the diverse hydraulic regimes of the area, which, for the first time, was mapped in detail and dynamically analyzed from one year to another.[4] Moreover, the anomalies that were identified from NDWI maps were further investigated using high-resolution data, and this enabled the discovery of unknown *puquios* or lost branch of some *puquios*, as successfully verified from a field survey (Figs. 13.16 and 13.17).

[4]Chapter 22 in this volume provides results obtained from recent detailed satellite analyses based on a long time series (1985–2010) of Landsat TM pictures.

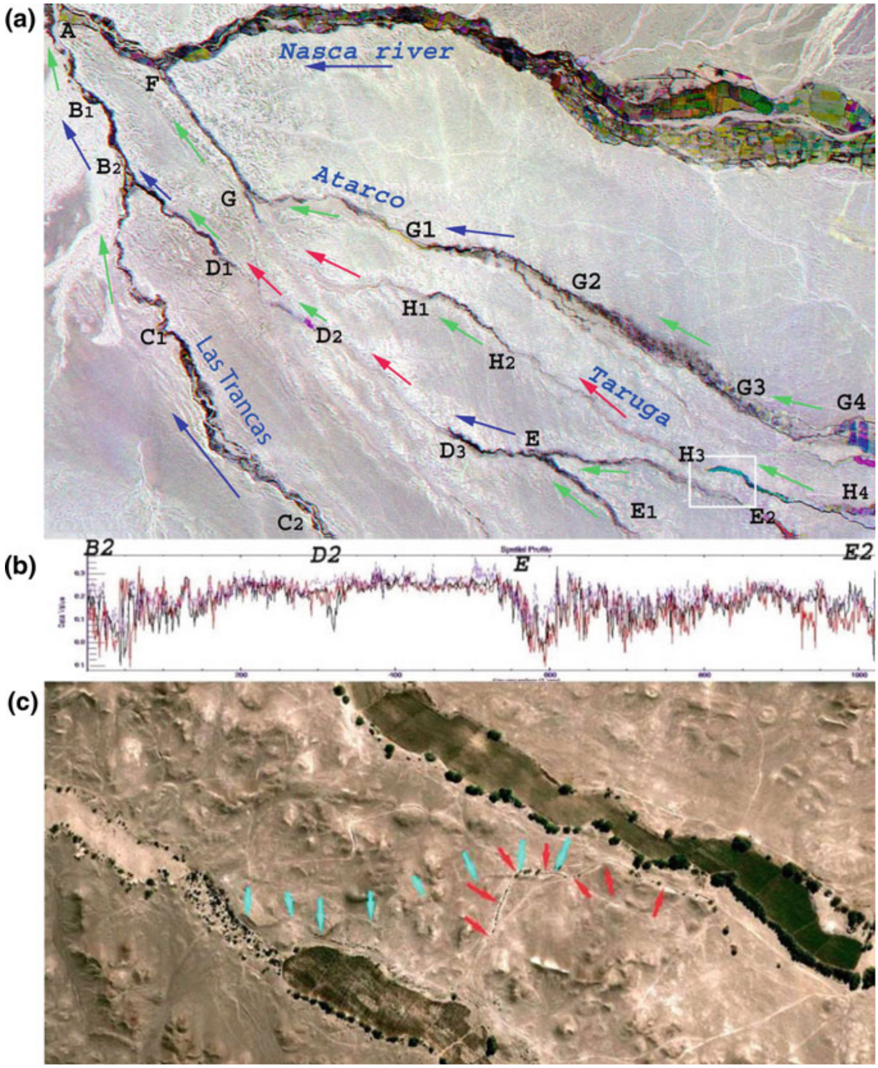


Fig. 13.16 **a** RGB composition of NDWI maps computed for the years 2003, 2004 and 2007. It provides preliminary information on the hydraulic regime (perennial, ephemeral, dry) of the four stream tributaries of the Nasca river. More detailed information have been obtained with a higher temporal resolution of Landsat TM data from 1985 to 2010 as discussed in Chap. 22, infra. The *black rectangular box* denotes an area where a subterranean channel has been detected. **b** Spatio/temporal profile of NDWI ASTER Index of the Carrizales which allowed the identification of variation of both the moisture content over time and relative "anomalies". **c** Buried channel identified by ASTER multitemporal data processing and mapped by using very high resolution satellite imagery

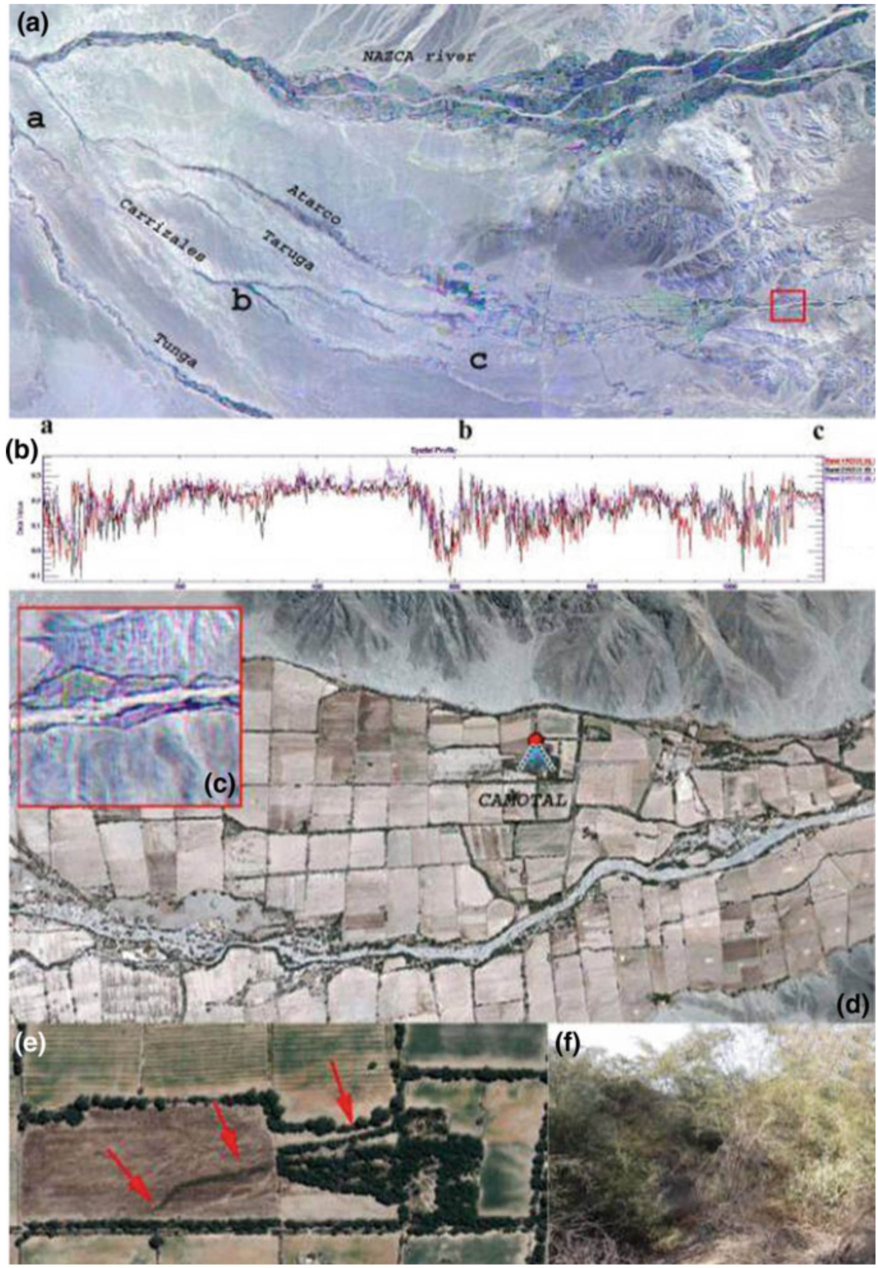


Fig. 13.17 **a** RGB composition of NDWI maps computed for the years 2003, 2004, and 2007. **b** Profile of RGB along the quebrada of Carrizales and the Taruga Rivers. The temporal behavior indicates the flow regime. **c** Detail of Río Taruga middle valley where a temporal dynamics of NDWI has been identified, thus suggesting the presence of puquios, among which one (in Camotal) is buried as detected in VHR satellite images (**d**, **e**) and in situ survey (**f**)

13.7 An Overview of Functioning and Disused *Puquios*

Tables 13.1, 13.2, 13.3, and 13.4 contain the coordinates, lengths, building typology, and, where available, archaeological record of the infiltration galleries of the four irrigation sectors of Río Nasca, the tributaries of Aja and Tierra Blancas, Río Taruga, and Río Las Trancas. The following sections illustrate and briefly describe some of the puquios of the Río Nasca drainage basin.

13.7.1 The Irrigation Sector of the Nasca River

This sector contains four *puquios* that are still in use today, named Soinsoguito, Conventillo, Agua Santa, and Ocongalla, plus one more named Soisongo that has been transformed into a reservoir. There is also an area downriver that may have been irrigated in the past by an additional *puquio* named Ayapana, today called "*puquio perdido*" (Fig. 13.18 and Table 13.1).

These *puquios* have a shallow depth, since the water table is quite close to the surface. In this area at Las Cañas, the water table joins the surface along with the river course, flowing in the direction of to Cahuachi.

Approximately 6 km distant from Las Cañas, there is Soisongo *puquio* (Fig. 13.18, N5) that was transformed into a reservoir. The Soinsoguito puquio (Fig. 13.18, N1), named from the quechua word "songo" that means earth, is recognized as an open trench, located south of the Nasca River and around 9 km west of the modern town of Nasca. It retrieves water captured quite close to the riverbed and extends some 579 m, measured from the starting point to the final reservoir. As an open trench, the point where the water is captured is absolutely clear. Therein, the water table is about 5 m deep. In Soinsoguito *puquio*, some artefacts belonging to Middle Horizon and some belonging to Late Intermediate Periods have been found.

The Conventillo *puquio* (Fig. 13.18, N2), from a Spanish word that means small convent, is realized as an open trench that ends into a cocha with a dimension at around 30 × 35 m.

Agua Santa *puquio* (Fig. 13.19, N3) is today an open trench with a length of around 552 m. In the past, as reported by Gonzalez Garcia (1934), it was an open trench for around 240 m and had a gallery which was in very poor condition, later completely removed.

Finally, Ocongalla (Fig. 13.19, N4) is an open trench which ends at a reservoir which is today smaller and located differently than in the past.

Table 13.1 List and details of the *puquios* located in the irrigation sector of the Nasca River

Puquios of Nasca irrigation sector of Nasca[a]								
Puquio N.	Puquio name	Lat	Long	L	Water source	BT	ArP	H
		Initial and end point		m				
N1	Soinsoguito	14°50′4.3571″S	75°00′59.8579″W	***OT596***	Nasca river	OT	MH LIP	457–462 m
		14°50′9.6313″S	75°01′18.4909″W					
N2	Conventillo	14°50′1.9459″S	75°00′6.2372″W	***OT555***	Water table	OT		478–482 m
		14°49′56.5330″S	75°00′23.4365″W					
N3	Agua Santa	14°50′18.4496″S	75°00′1.6679″W	***OT615***	Nasca river	OT	MH LIP Col	481–492 m
		14°50′15.2380″S	75°00′19.9493″W					
N4	Ocongalla	14°50′24.1399″S	74°59′22.1298″W	***OT603***	Nasca river	OT		493–501 m
		14°50′22.8434″S	74°59′42.0072″W					
N5	Soisongo[b]				Nasca river			443–448 m
N6	Ayapana[c]	14°50′14.4175″S	75°02′45.8259″W	***OT352***		BP		
		14°50′6.9468″S	75°02′51.9617″W					

Lat: latitude; Lon: longitude; L: length; W: width; BT: Building techniques; BP; buried *puquios*; OT: open trench; FG: filled-trench gallery; Tu: tunnel; ArP: artefact period; MH: Middle Horizon; LIP: Late Intermediate Period; Col: Colonial Age

[a]All the data have been provided by Schreiber and Lancho Rojas (1995, 2003) with the exception of the coordinates, the lengths in bold italic, and the data related to the *puquios* discovered by ITACA Mission and shown in Chap. 22

[b]The *puquio* of Soisongo has been transformed into a reservoir

[c]The Ayapana axe has been identified using satellite imagery

Table 13.2 List and details of the *puquios* located in the irrigation sector of the Aja and Tierras Blancas Rivers

Puquios of Aja and Tierra Blancas irrigation sector[a]

Puquio N.	Puquio name	Lat	Long	L	Water source	BT	ArP	Branches	Hmx–Hmin (m)
		Initial and end point		m					
AT1	Licuas Norte	14° 49′ 51.4642″S 14° 49′ 58.1622″S	74° 58′ 9.3802″W 74° 58′ 22.2364″W	349 OT 127 FG branches 127Tu 131 FG	Aja river	OT FG		2	541–530
AT2	Licuas Sur	14° 50′ 16.1017″S 14° 50′ 10.5937″S	74° 57′ 52.5594″W 74° 58′ 2.9183″W	272 OT 27 FG Branches 42 173	Water table	OT FG		2	543–537
AT3	San Marcelo	14° 49′ 58.9702″S 14° 50′ 9.2380″S	74° 57′ 36.7320″W 74° 57′ 40.8303″W	337OT 96 FG	Water table	OT FG			552–545
AT4	La Joya de Achaco	14° 49′ 51.4798″S 14° 49′ 59.6586″S	74° 58′ 40.2634″W 74° 58′ 47.2149″W	***334 OT***	Water table	OT			519–514
AT5	Achaco Norte	14° 49′ 21.3406″S 14° 49′ 19.5933″S	74° 58′ 6.4879″W 74° 58′ 26.1174″W	***352 OT*** ***Branches*** ***236 OT*** ***293 OT***	Water table	OT	MH LIP	2	542–533
AT6	Achacao Sur	14° 49′ 18.6337″S 14° 49′ 20.3363″S	14° 9′ 18.6337″S 74° 58′ 26.1119″W	***OT 1005*** ***Branches*** ***OT (?) 489***	Water table	OT	MH LIP	1	546–532
AT7	Anglia	14° 49′ 31.7902″S 14° 49′ 29.2062″S	74° 57′ 31.4087″W 74° 57′ 52.5904″W	OT 555 FG 36	Aja river	OT FG	MH LIP		558–549

(continued)

Table 13.2 (continued)

Puquios of Aja and Tierra Blancas irrigation sector[a]

Puquio N.	Puquio name	Lat	Long	L	Water source	BT	ArP	Branches	Hmx–Hmin (m)
		Initial and end point		m					
				Tu 4		Tu			
AT8	Curve	14° 49′7.3182″S	74° 57′ 34.7890″W	***OT 548***	Water table	OT			565–556
		14° 49′ 4.8549″S	74° 57′ 44.3609″W						
AT9	Cuncumayo	14° 49′ 20.8717″S	74° 56′ 31.3078″W	***OT 548***	Aja river	OT			584–578
		14° 49′ 20.9475″S	74° 56′ 48.8632″W						
AT10	Aja Norte	14° 49′ 5.7008″S	74° 56′ 4.2998″W	***OT 492***	Water table	OT		2	599–589
		14° 49′ 8.7669″S	74° 56′ 30.8894″W	***Branches*** ***OT 123*** ***OT 270***					
AT11	Aja Sur	14° 49′ 12.0548″S	74° 56′ 0.2083″W	OT 509 Tu 266	Aja river	OT Tu			599–587
		14° 49′ 7.1128″S	74° 56′ 20.0997″W						
AT12	Aja Alto			OT 245	Water table	OT			
AT13	Bisambra	14° 49′ 33.4040″S	74° 55′ 44.4440″W	OT 209 FG (?) 870	Aja river	OT FG			606–601
		14° 49′ 32.8108″S	74° 55′ 49.9570″W						
AT14	Huachuca	14° 49′ 25.3456″S	74° 55′ 15.1663″W	OT294	Aja river	OT FG Tu		3	618–609
		14° 49′ 23.8339″S	74° 55′ 37.0123″W	Branches OT265-FG173 OT48-FG299-Ind83 Ind150					
AT15	Tejeje	14° 49′ 21.5818″S	74° 54′ 38.9303″W	***OT 374*** Ind 151	Aja river	OT FG Ind			640–635
		14° 49′ 201482″S	74° 54′ 50.6258″W						
AT16	Cortez	14°49′15.4328″S	74° 54′ 12.0138″W	OT 244	Aja	OT			658–651

(continued)

Table 13.2 (continued)

Puquios of Aja and Tierra Blancas irrigation sector[a]

Puquio N.	Puquio name	Lat	Long	L	Water source	BT	ArP	Branches	Hmx–Hmin (m)
		Initial and end point		m					
		14° 49′ 15.6001″S	74° 54′ 21.4726″W	Ind 57	river	FG			
AT17	Vijuna	14° 49′ 11.9428″S 14° 49′ 14.5890″S	74° 53′ 58.8297″W 74° 54′ 8.1839″W	OT 229 Ind 60	Aja river	OT FG			663–660
AT18	Orcona	14° 48′ 37.7677″S 14° 48′ 45.9811″S	74° 53′ 32.9801″W 74° 53′ 37.1965″W	OT794 FG70 Tu132 Branches Tu12 Tu70	Aja river	OT FG Tu	LN	2	696–688
AT19	Majoro	14° 50′ 29.7141″S 14° 50′ 37.0932″S	74° 57′ 49.3395″W 74° 58′ 22.6888″W	OT907 Ind96 Branches Ind82 Ind246	Tierra Blancas river	OT FG		2	527–537
AT20	Majorito	14° 50′ 27.1934″S 14° 50′ 33.6521″S	74° 57′ 32.5593″W 74° 57′ 51.0945″W	***OT 630 + 254***	Tierra Blancas river	OT			544–540
AT21	Huairona	14° 50′ 18.1301″S 14° 50′ 34.6792″S	74° 57′ 17.4702″W 74° 57′ 36.5488″W	OT494 FG44 Tu304	Tierra Blancas river	OT FG Tu			559–547
AT22	San Antonio de Pangaravi	14° 50′ 21.1028″S 14° 50′ 30.0086″S	74° 56′ 56.2544″W 74° 57′ 10.1910″W	OT488 FG 22	Water table	OT FG Tu	LIP		556–551
AT23	Pangaravi	14°50′19.6491″S 14° 50′ 14.5471″S	74° 56′ 21.8418″W 74° 56′ 35.9807″W	OT262 Branches OT292 FG207	Water table	OT FG	MH LIP	2	589–575

(continued)

Table 13.2 (continued)

Puquios of Aja and Tierra Blancas irrigation sector[a]									
Puquio N.	Puquio name	Lat	Long	L	Water source	BT	ArP	Branches	Hmx–Hmin (m)
		Initial and end point		m					
				OT256					
AT24	Callanal	14° 49′ 49.6223″S	74° 56′ 12.0972″W	OT80 Ind370	Water table (?)	OT Ind		2	587–579
		14° 50′ 1.5527″S	74° 56′ 29.1243″W						
AT25	La Gobernadora	14° 49′ 44.5811″S	74° 55′ 34.6679″W	OT180 FG123 Tu372	Water table	OT FG Tu			605–594
		14° 49′ 57.9350″S	74° 55′ 48.7413″W						
AT26	Santo Cristo	14° 49′ 51.8916″S	74° 54′ 53.5644″W	OT201 FG220	Water table	OT FG			650–631
		14° 49′ 53.4821″S	74° 55′ 2.2861″W						
AT27	Cantalloc	14° 49′ 33.2858″S	74° 54′ 38.1677″W	OT102 Tu104 Branches Tu71 Tu265	Tierra Blancas river	OT Tu		2	645–638
		14° 49′ 36.4279″S	74° 54′ 49.0658″W						
AT30	Lost puquio in Majodal	14° 50′ 50.9336″S	74° 58′ 8.8846″W	***OT925***		OT			524–521
		14° 50′ 49.8572″S	74° 58′ 29.7067″W						

Lat: latitude; Lon: longitude; L: length; W: width; BT: Building techniques; BP; buried *puquios*; OT: open trench; FG: filled-trench gallery; Tu: tunnel; ArP: artefact period; Ind: indeterminate gallery; EIP: Early Intermediate Period; LM: Late Nasca; MH: Middle Horizon; LIP: Late Intermediate Period; Col: Colonial Age

[a]All the data have been provided by Schreiber and Lancho Rojas (1995, 2003) with the exception of the coordinates, the lengths in bold italic, and the data related to the *puquios* discovered by ITACA Mission and shown in Chap. 22

Table 13.3 List and details of the of *puquios* located in the irrigation sector of the Taruga river

Puquios of Río Taruga irrigation[a]									
Puquio N.	Puquio name	Lat	Long	L	W	Water source	BT	ArP	Addution branch
		Initial and end point		m	m				
T1	Santa Maria	14° 54′ 35.8246″S	74° 55′ 8.8727″W	***OT222 FG168 Branches FG23 FG41 Tu219***	10	Taruga river	Tu FG OT	MH LIP	2
		14° 54′ 39.4330″S	74° 55′ 20.3483″W						
T2	San Carlos	14° 54′ 49.3243″S	74° 54′ 38.3250″W	***OT60 FG141 Tu184***	8	Taruga river	OT FG Tu		
		14° 54′ 55.4414″S	74° 54′ 48.9862″W						
T3	Camotal	14° 54′ 35.5411″S	74° 55′ 40.7064″W	***Ind348 Branch Ind 60(?)***			Ind		1
		14° 54′ 39.4398″S	74° 55′ 51.4233″W						
T4	Tres Estrellas: possible puquio[b]	14° 54′ 26.0721″S	74° 54′ 28.9270″W	***Ind975?***			Ind		
		14° 54′ 45.0284″S	74° 54′ 9.0749″W						
T5	Travesia: possible puquio 1	14° 54′ 35.8131″S	74° 53′ 1.9964″W	***Ind240?***			Ind		
		14° 54′ 32.6010″S	74° 53′ 8.9498″W						

Lat: latitude; Lon: longitude; L: length; W: width; BT: Building techniques; BP; buried *puquios*; OT: open trench; FG: filled-trench gallery; Tu: tunnel; ArP: artefact period; MH: Middle Horizon; LIP: Late Intermediate Period; Col: Colonial Age

[a]All the data have been provided by Schreiber and Lancho Rojas (1995, 2003) with the exception of the coordinates, the lengths in bold italic, and the data related to the *puquios* discovered by ITACA Mission and shown in Chap. 22

[b]The hypothesis about the location of these *puquios* in Tres Estrellas and Travesia was made by Josue Lancho, on the basis of a map by Rossel Castro. Further investigations based on satellite remote sensing made by the ITACA-CNR mission in collaboration with Lancho enabled identification and mapping of the routes of these *puquios*

Table 13.4 List and details of the *puquios* located in the irrigation sector of the Nasca River

Puquio N.	Puquio name	Lat	Long	L	Water source	BT	ArP	Addution branch
Puquios of Río Las Trancas irrigation sector[a]								
		Initial and end point		m				
LT1	Chauchilla	14° 58′ 43.4896″S	74° 55′ 1.2200″W	OT1280 FG(?)	Las Trancas river	OT FG		
		14° 58′ 38.7461″S	74° 55′ 41.6295″W					
LT2	La Joya	14° 58′ 43.2611″S	74° 54′ 7.8466″W	***OT + FG 1057***	Las Trancas river	OT FG		
		14° 58′ 49.8932″S	74° 54′ 31.9291″W					
LT3	Copara	14° 58′ 40.7406″S	74° 52′ 50.2856″W	***OT692 FG(?) 582***	Water table	OT FG		
		14° 58′ 32.0588″S	74° 53′ 8.4619″W					
LT4	El Pino	14° 58′ 36.7218″S	74° 51′ 52.2640″W	OT436 FG128 Branches FG238 Ind123 FG54	Las Trancas river	OT FG		2
		14° 58′ 31.1406″S	74° 52′ 9.8020″W					
LT5	Pampòn	14° 58′ 51.0485″S	14° 58′ 51.0485″S	OT280 FG630 Branches FG536 Ind41 FG340	Las Trancas river	OT FG Ind		2
		14° 58′ 26.3114″S	74° 51′ 48.2667″W					
LT6	Huaquilla				Water table	OT		
LT7	Totoral	14° 59′ 5.4082″S	74° 49′ 45.3670″W	OT96 FG468 Ind90	Water table	OT FG Ind	Village Nasca V	
		14° 59′ 1.2019″S	74° 50′ 2.1963″W					

(continued)

Table 13.4 (continued)

Puquios of Río Las Trancas irrigation sector[a]								
Puquio N.	Puquio name	Lat	Long	L	Water source	BT	ArP	Addution branch
		Initial and end point		m				
LT8	Huayuri				Las Trancas river	OT FG		
LT9	Abandoned puquio: new discovery[b]	14° 58′ 59.0350″S	74° 50′ 21.5486″W	***1270***		FG (OT?)		
		14° 58′ 56.8996″S	74° 51′ 3.4880″W					
LT10	Abandoned puquio: new discovery (La Marcha?)[b]			***Ind458***		Ind		

Lat: latitude; Lon: longitude; L: length; W: width; BT: building techniques; BP; buried *puquios*; OT: open trench; FG: filled-trench gallery; Tu: tunnel; ArP: artefact period; MH: Middle Horizon; LIP: Late Intermediate Period; Col: Colonial Age

[a]All the data have been provided by Schreiber and Lancho Rojas (1995, 2003) with the exception of the coordinates, the lengths in bold italic, and the data related to the *puquios* discovered by ITACA Mission and shown in Chap. 22

[b]Puquio discovered by CNR-Mission. For additional details, see Chap. 22

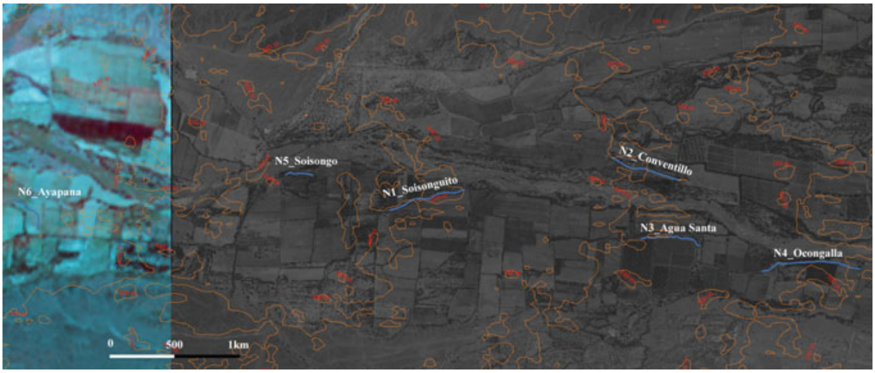


Fig. 13.18 *Puquios* along the Nasca River. *N1* Soisonguito; *N2* Conventillo; *N3* Agua Santa; *N4* Ocongalla; *N5* Soisongo; *N6* Ayapana (the map is partially composed of Pleiades and Aster data)

13.7.2 The Irrigation Sector of the Aja and Tierra Blancas Rivers

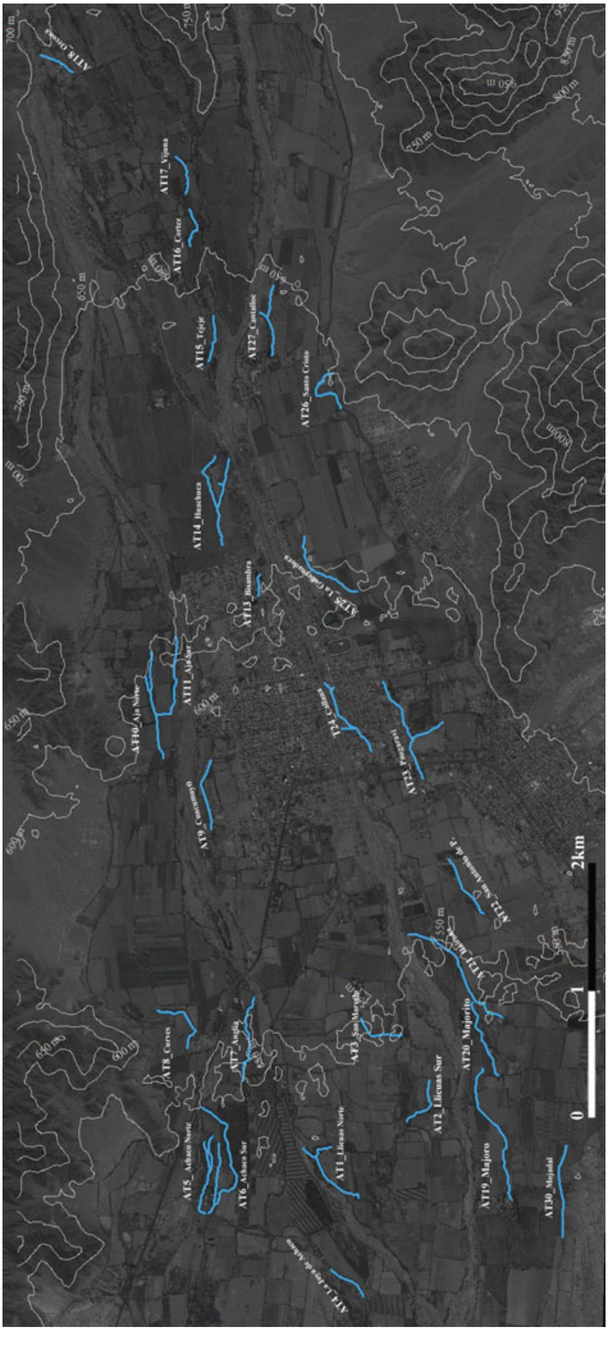
As a whole, in the Aja and Tierras Blanca irrigation sectors, there are a major part of the *puquios* still in use today (Fig. 13.19). In particular, in the Aja valley there are 16 *puquios* which can be divided into three sub-groups according to their locations and water charges.

The first subgroup is composed by four *puquios*: Licuas Norte, Licuas Sur, San Marcelo, and la Joya de Achaco, located close to the confluence of Aja and Tierra Blancas and characterized by low-water discharge.

The second sub-group includes eight *puquios*, all of them located close to the modern Nasca town: Achaco, Anglia, Curve, Cuncumayo, Aja, Aja Alto, Bisambra, and Huachuca. The *puquios* of Bisambra and Aja, have the highest discharge of water compared to the other *puquios* of the valley and are exceptionally long because there the water table reaches its deepest level. Cuncumayo and Aja Alto are relatively small and characterized by the lowest discharge compared with all the other *puquios* of the valley.

The third sub-group of Aja irrigation sector is composed of four *puquios* Tejeje, Cortez, Vijuna (Fig. 13.20, top and bottom), and Orcona (Fig. 13.21, top). In this part of the valley, the water table is less deep and, therefore, the *puquios* are shorter long than others.

In the irrigation sector of the Tierra Blancas River, there are nine currently active *puquios* Majoro (Fig. 13.21, middle), Majorito, Huairona, San Antonio, Pangaraví, Callanal, La Gobernadora (Fig. 13.21, bottom), Santo Cristo (Fig. 13.22, top) and Cantalloc (Fig. 13.22, bottom) plus a lost puquio in Mojadal. These *puquios* have discharges ranging from poor to very good and, the difference is mainly due to their level of maintenance. Cantalloc is the most renowned *puquio*, and one of the most attractive tourist destinations in the Nasca region. It had also a very important role



◀ **Fig. 13.19** Irrigation Sector of Aja and Tierra Blancas rivers: map of *Puquios* from 2013 panchromatic satellite Pleiades image. *AT1* Llicuas Norte; *AT2* Llicuas Sur; *AT3* San Marcelo; *AT4* La Joya de Achaco; *AT5* Achaco Norte; *AT6* Achaco Sur; *AT7* Anglia; *AT8* Curves; *AT9* Cuncumayo; *AT10* Aja Norte; *AT11* Aja Sur; *AT13* Bisambra; *AT14* Huachuca; *AT15* Tejeje; *AT16* Cortez; *AT17* Vijuna; *AT18* Orcona; *AT19* Majoro; *AT20* Majorito; *AT21* Haïrona; *AT22* San Antonio de P.; *AT23* Pangaravi; *AT24* Callana; *AT25* La Gobernadora; *AT26* Santo Cristo; *AT27* Cantalloc; *AT30* Majodal

in the local legend due to its proximity to Cerro Blanco, the sand sacred mountain, which, according to local belief, has a subterranean lake which is the water source for the *puquio* itself.

Considering both of the two irrigation sectors just described, it is important to note that today, in the Nasca Valley, all six puquios are open trench, without secondary branches, with lengths 500–600 m. A more articulated pattern, including secondary branches, and building structure, composed of tunnels, filled trenches and open trenches, characterize the valleys of the Aja and Tierras Blancas. This is due to the depth of the water table which increases in altitude, determining the building techniques. At altitudes less than 550 m a.s.l., where the water table is shallow, most of the *puquios* are open trench types. The depth of the water table

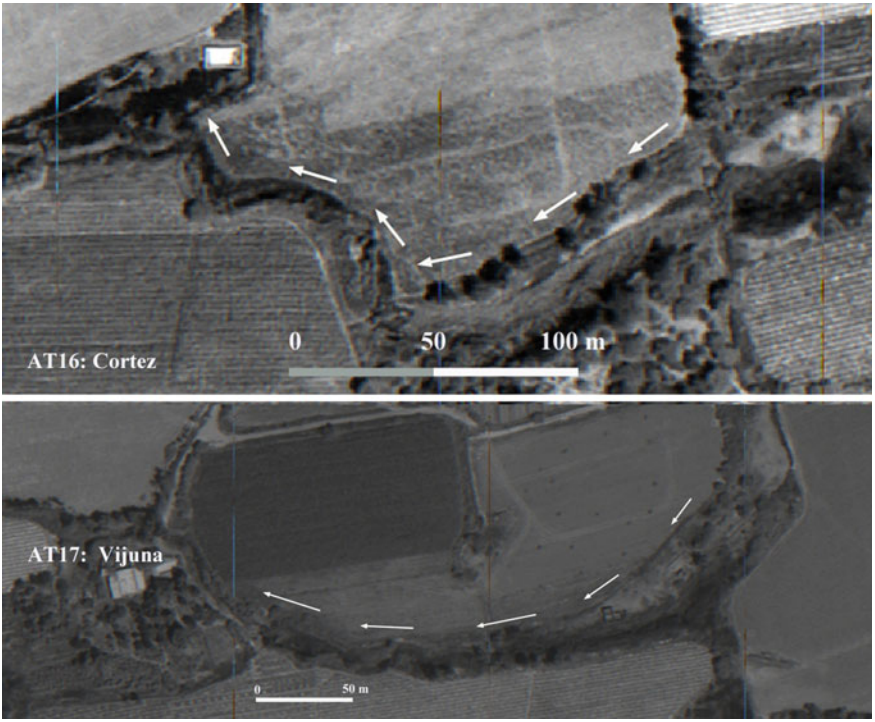


Fig. 13.20 Satellite maps of the *puquios* of Cortez (*top*) and Vijuna (*bottom*)

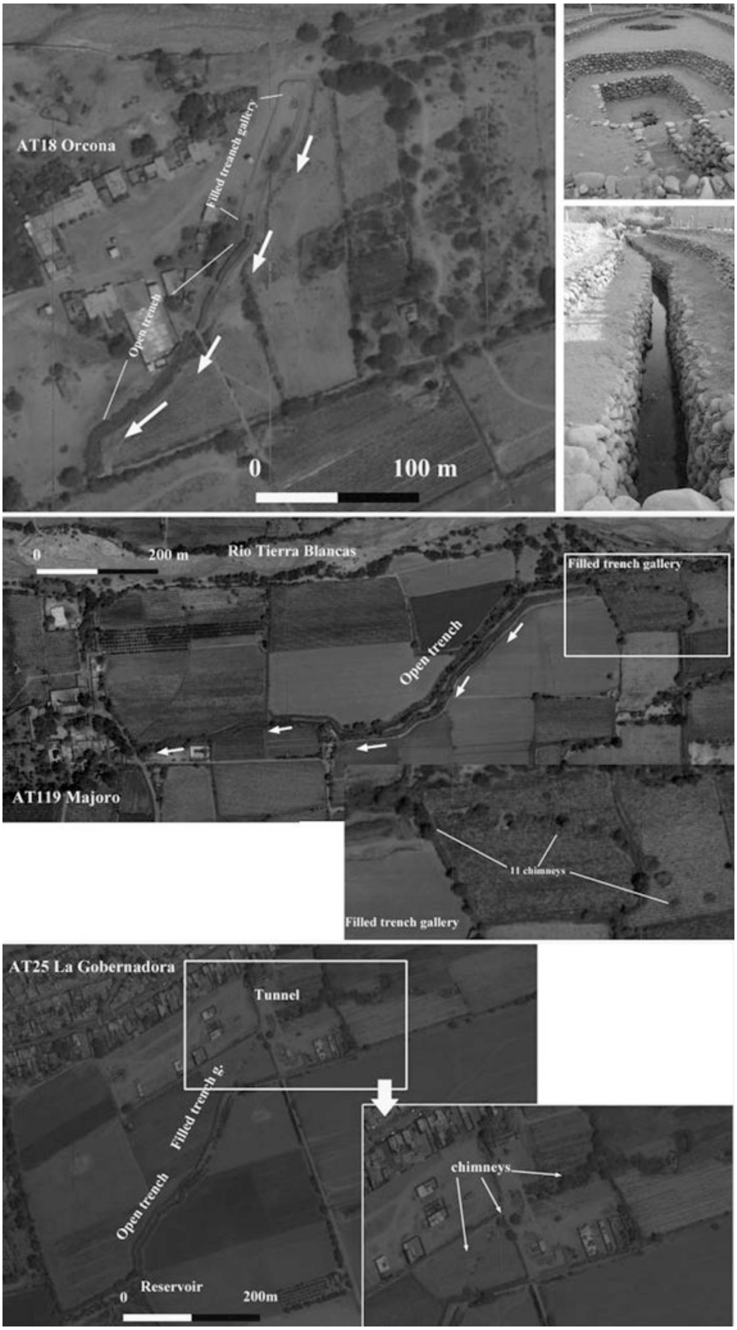


Fig. 13.21 Satellite maps of the *puquios* of Orcona (*up*), Majoro (*middle*) and La Gobernadora (*bottom*). The image of Orcona is related to a detail of the open trench

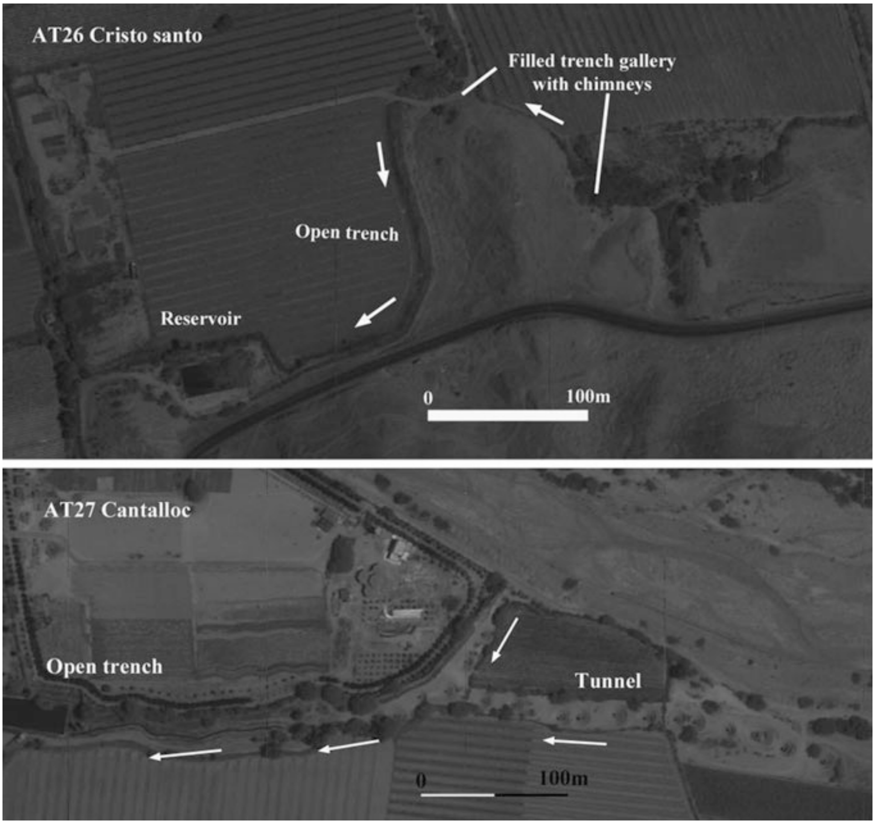


Fig. 13.22 Satellite maps of the *puquios* of Santo Cristo (*up*) and Cantalloc (*bottom*)

increases at altitudes greater than 550 m a.s.l. where most of the *puquios* are tunneled and filled-trench type (Fig. 13.23).

13.7.3 The Irrigation Sector of the Taruga River

The Taruga irrigation sector, located immediately south of the Nasca Valley, is the smallest of the other three valleys and begins only in the infiltration zone. It is characterized by the fact that the water level, starting from the critical infiltration points, drops gradually for a stretch of approximately 5 km. Then, suddenly, it reaches a depth of around 30 m or more (Schreiber and Lancho Rojas 1995).

This could be the main reason why, in this valley, only a small part is watered by *puquios* for an extent of some 5 km. The depth of the water, below 30 m, was probably beyond the technical capabilities of the ancient Nasca and the populations

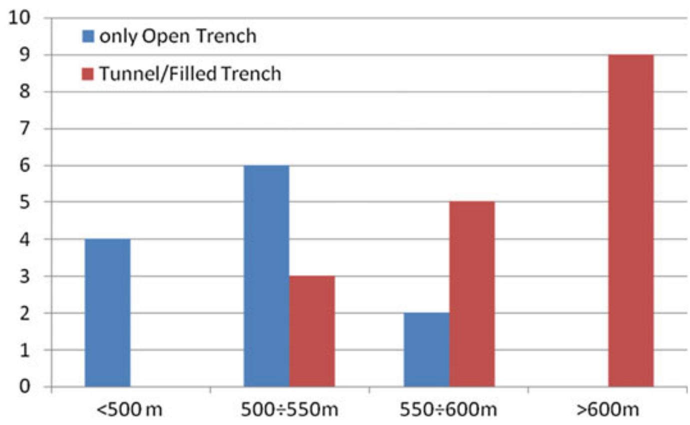


Fig. 13.23 Puquio types distributed by altitude in the Río Nasca Valley. At altitudes lower than 550 m a.s.l., most of the *puquios* are open-trench types. Tunneled and filled-trench *puquios* are at altitudes greater than 550 m a.s.l

who followed. Currently, there are only two *puquios* in use: Santa María and San Carlos, plus some others (today lost among them) such as Camotal (Fig. 13.24 and Table 13.3).

The Santa Maria structure begins as a tunnelled gallery, continues as a filled-trench gallery with around 28 *ojos*, and then, as open trench, empties into a reservoir that is today cemented over. Similarly to Santa Maria, the aqueduct of San Carlos also begins as a tunnelled gallery and continues as a filled-trench gallery and as an open trench. It empties into a modern concrete reservoir that was built close to the old one. On the west side of Santa Maria, at around 1 km, there are the remains of the Camotal *puquio*, not in use today. It was constructed as an open trench for a section and then shaped as a gallery.

13.7.4 The Irrigation Sector of Las Trancas

The Las Trancas River is the southernmost tributary to the Río Grande. This valley is characterized by a less steep gradient compared to the others and, for this reason, the *puquios* herein located are generally longer that those in the other valleys (Figs. 13.25 and 13.26, Table 13.4).

Nowadays, the following five *puquios* are still in use: Chauchilla, Copara, El Pino, Pampón, and Totoral. Totaral, Pampon, and el Pino maintain their original construction characteristics. In particular, Totaral is made by diverse sections, tunnel and filled-trench where more than 59 *ojos* are present. Finally, it continues as open trench and empties into a reservoir. The *puquio* of Pampon has very specific characteristics that make it unique: it starts by two initial filled-trench galleries that merge in a very spectacular way, considering that the two branches are at different

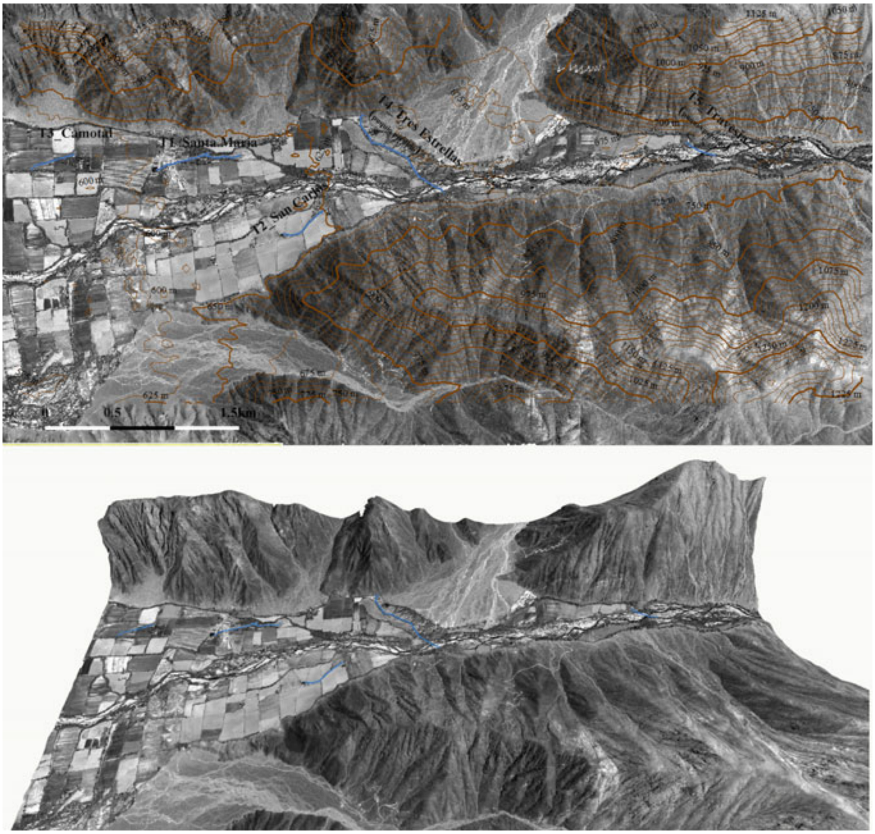
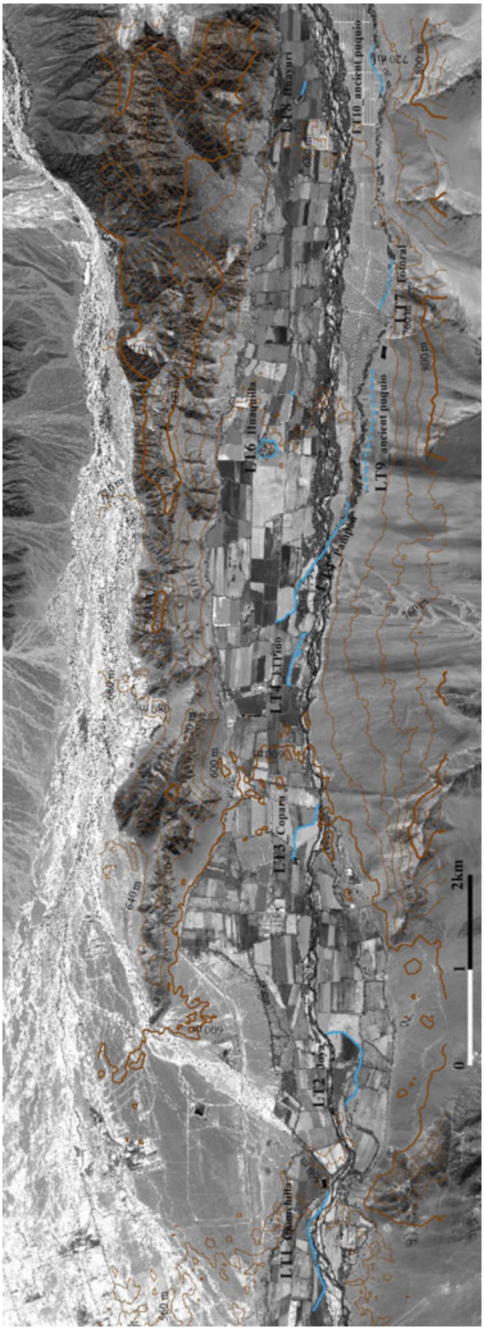


Fig. 13.24 *Puquios* along Río Taruga. Santa Maria (*T1*) and San Carlos (*T2*) are still functioning today, plus Camotal (*T3*) no longer functioning and the other two denoted as *T4* and *T5* are 'perdidos' (in Tre Estrellas and Travesia, respectively) and herein detected by satellite remote sensing. The pictures shown above are an orthophoto (*top*) and a 3D-view (*bottom*) based on a Pleiades satellite image acquired March 2013

altitudes. Finally, after a long route, it empties into the irrigation-canal system without any reservoir. El Pino *puquio* had many branches. Today, its northern branch has been converted into a *pozo-cocha*, whereas its second branch, shaped as a filled-trench gallery, empties into a recently installed small reservoir. Finally, the *puquio*s of Copara and Chauchilla were significantly modified and intubated in cement structures that follow the same path as the ancient *puquios*.

At least three more *puquios* once existed. They were known in the past as la Joya, Huaquilla Chica, and Huayurí. La Joya was destroyed some decades ago, whereas Huaquilla Chica and Huayurí were transformed into a well-reservoir (*pozo-cocha*). According to Josue Lancho, this valley had probably at least 11 *puquios*. Lancho's insights have been then partially confirmed by the results of recent surveys of CNR that led to the discovery of two filtration galleries along the south border of Las Trancas riverbed (for more details, see Chap. 22).

Fig. 13.25 Puquios along Río Las Trancas. *LT1* Chauchilla; *LT2* Joya; *LT3* Copara; *LT4* El Pino; *LT5* Pampòn; *LT6* Huaquilla; *LT7* Totoral; *LT8* Huayuri: *LT9* and *LT10* Abandoned *puquios* (Discovered by ITACA mission by satellite-based investigations; see Chap. 22)



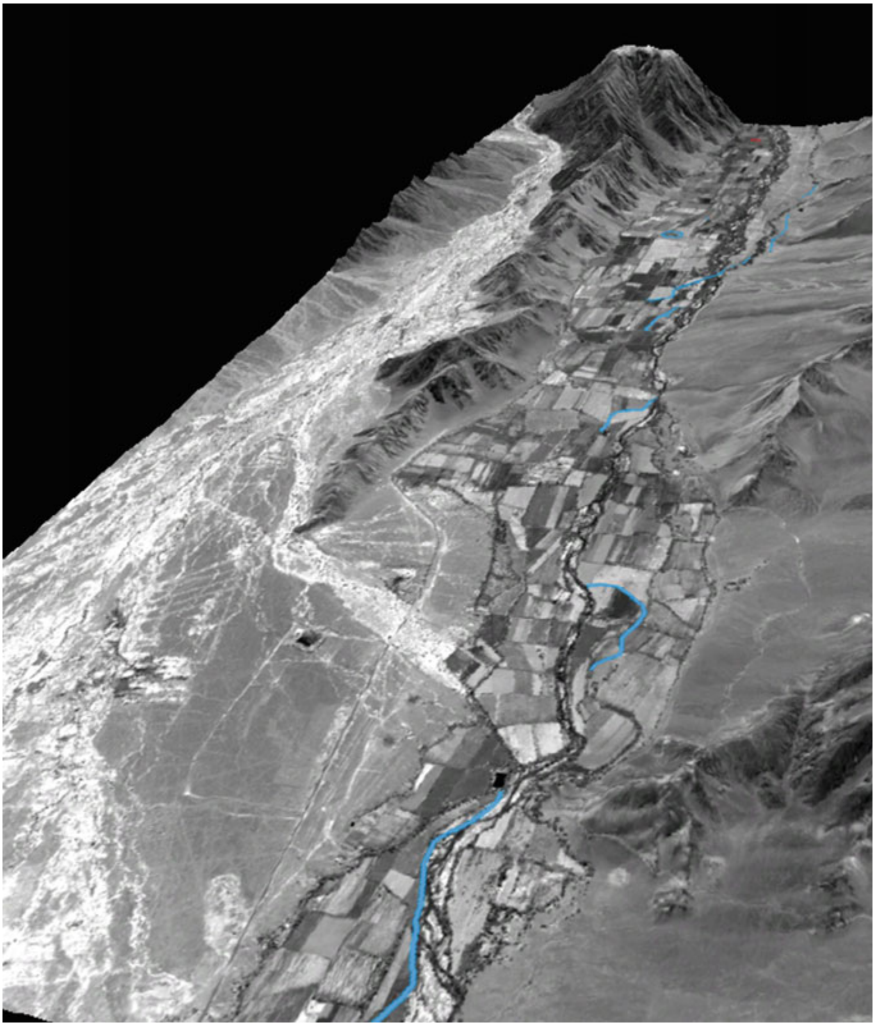


Fig. 13.26 3D-view of the *puquios* along Río Las Trancas

13.8 Current Status and Management of Nasca Filtration Galleries

The *puquios* are both water sources and historical monuments at the same time, therefore they are under the control of two different state institutions, with some resultant difficulties of coordination between them. Water issues are regulated by the General Water Law, whereas the historical monuments by the General Law of Protection of Cultural Heritage of the Nation.

The General Water Law is administered by the Ministry of Agriculture along with its subordinate body of the administration, the District of Irrigation, and the User Board. The General Law of Protection of Cultural Heritage of the Nation is administered by the Ministry of Cultural Heritage. The User Board manages only the water resource, together with the Irrigation District. The Ministry of Cultural Heritage, with its regional office, is in charge of managing the *puquios* as part of Peruvian culture heritage.

As in the past centuries, today maintenance activity (ONERN 1971) is the key point for the functionality of the *puquio* systems and the assurance of their operational success.

The ancient Peruvians properly preserved the filtration galleries; unfortunately over time, this maintenance work suffered neglect, and gradually the *puquio* system fell into disrepair (Lancho Rojas 1986). Currently the problem of systematic maintenance has worsened, mainly due to the loss of competencies, the abandonment of the area, and the increasing use of electric pumps to retrieve water.

As a whole, of the existing infiltration galleries,

- currently only seven operate in relatively good condition, the rest work only irregularly;
- while the quality of water from the infiltration galleries can be fit for human consumption, nevertheless, the population pollutes the watershed with waste in the area of the galleries;
- changes in galleries and boreholes to obtain water flow has decreased filtration and has altered the original structural conditions. An example of this can be found in the middle and lower parts of the valley, where the gallery structures have been coated with concrete. Some galleries in these conditions no longer work, because the concrete obstructs the proper filtration of water.

13.9 Final Remarks

An overview, focused on past investigations and achieved results as well as on open issues and scientific needs related to the ancient Nasca filtration gallery system, has been presented and discussed. In particular, dating issues, potential relationships with the geoglyphs, detailed and dynamical characterization of the environmental settings, as well as the detection of potential lost *puquios*, have been identified as the most pressing and urgent issues to be addressed. Fresh improvements and advances in knowledge about the *puquios*, and in turn about the Nasca capability to face the water shortage, can provide new insights into the Nasca civilization. After all, over the centuries, the scarcity of water has propelled technical innovations and social transformations, and water was, has been, and remains the mainspring of civilization. So water shortages were, have been, and are an engine of human innovation.

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Chapter 14
The Ceremonial Center of Cahuachi: Its Origins and Evolution

Giuseppe Orefici

Abstract The choice of Cahuachi as the main ceremonial center of the Nasca was determined by many factors, including its relationship with a natural system of springs that provide constant water throughout the year and the terraced shape of the hills, as well as the relationship with other existing places of worship in the area. Since 4200 BCE, the remains of human sacrifices and offerings have witnessed its use for worship. At the beginning of its history, Cahuachi was a *huaca*. Slowly, new and complex functions were added, such as handicraft production and depositing surplus goods and food to be redistributed to the population in case of natural disasters. This led to a more complex system of utilization of the temple architecture and spaces. The power of Cahuachi became stronger and stronger, culminating in its becoming the theocratic capital of the Nasca world.

Keywords Cahuachi · *Huaca* · Ritual offering · Nasca ceremonial architecture

14.1 The Early Origin of Cahuachi

The largest ceremonial center made of adobe in the world was built in a place continuously used for almost a thousand year. It arose as a small sacred space and was not conceived in advance with its future development in mind, but gradually was converted into a large multifunctional complex as a result of the regional cultural ferment which gave life to Nasca Culture.

To understand the historical evolution of Cahuachi, one should consider that the sacredness of a place comes from the combination of multiple factors, such as the location, appearance of the site and its territorial structure, size, nature of the terrain,

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ecosystem, and relationship with water and other places of worship including their inter-visibility.[1]

In many cases, the concept of sacred place or *huaca* was expressed independently of the people's participation in giving it special value. The proximity to a river, the topography and the nature of the soil, or the presence of a nearby mountain (to which special powers were attributed) contributed to generating value, so that the place was recognized for its sacred features. Sometimes there were natural elements or their manifestations on recurring dates during the year to indicate a site as a venue where to perform specific ritual events. Even the wind, rain, storms, and the relationships between them all might determine the choice of a place for its specific characteristics. These characteristics very often depended on several ancient factors, since the choice of spaces for choral events belonged not only to emotional but also instinctive factors that are common not only in human beings and nature, but also in animal attributes and collective manifestations. Therefore, the reasons why a place was considered sacred, were often based on instinctive perceptions of it. Among the physical perceptions linked to the characteristics of a place, additional important elements were relationships with a myth or with places that had a historical value or were considered important for supernatural manifestations, such as apparitions of deities. The reasons for which sacred attributes were conferred on a site usually had a relationship with the spiritual elevation which was not identifiable or definable on a rational basis.

Cahuachi, probably due to its geographical location and geomorphology, was founded on the south bank of the Río Nasca, where the hills appeared very similar to natural pyramidal structures. The constant presence of water, emerging between two points located upstream and downstream of Cahuachi, respectively, had crucial importance in the choice of the ceremonial location.[2] The particular spatial sequence of surrounding hills bestowed an architectural perception of the environment, as well as of special energy as only a sacred place evokes.

14.2 Cahuachi as *Huaca*

During the preliminary phase of this use, the site was considered sacred because of its peculiarities and, therefore, the presence of an intermediary in the relationship between the divinities and human beings was not perceived as a necessity. The place itself was enough, and around it a single individual or groups of people started to externalize their "manifestation of religiosity". The *huaca* was the place

[1]On the inter-visibility of sacred places in Cahuachi the reader is referred to Chap. 12 by Masini et al. (2016).

[2]On the hydraulic regime of Río Nasca, see Schreiber and Lancho Rojas (2006), Chap. 22 by Lasaponara et al. (2016b) and Lasaponara and Masini (2012)

of contact with deities, where the forces of nature converged to make more effective the manifestation of supernatural energy. The next step in the evolution of cultural and religious perception of the place was related to its use as a pilgrimage site. Its fame in nearby valleys expanded to broader and remoter areas, further increasing as it was linked and associated with other places already considered *huaca*.

Its subsequent complex evolution was then linked with the presence of "intermediaries" between the human and the divinities, at the beginning with a sporadic, and later on with a constant, presence in the place of one or more shamans who were considered as bridges between the *huaca* and the pilgrims The shamans interpreted the divine messages during religious functions, which were imbued with strong symbolic values for pilgrims coming to the *huaca* from various faraway sites.

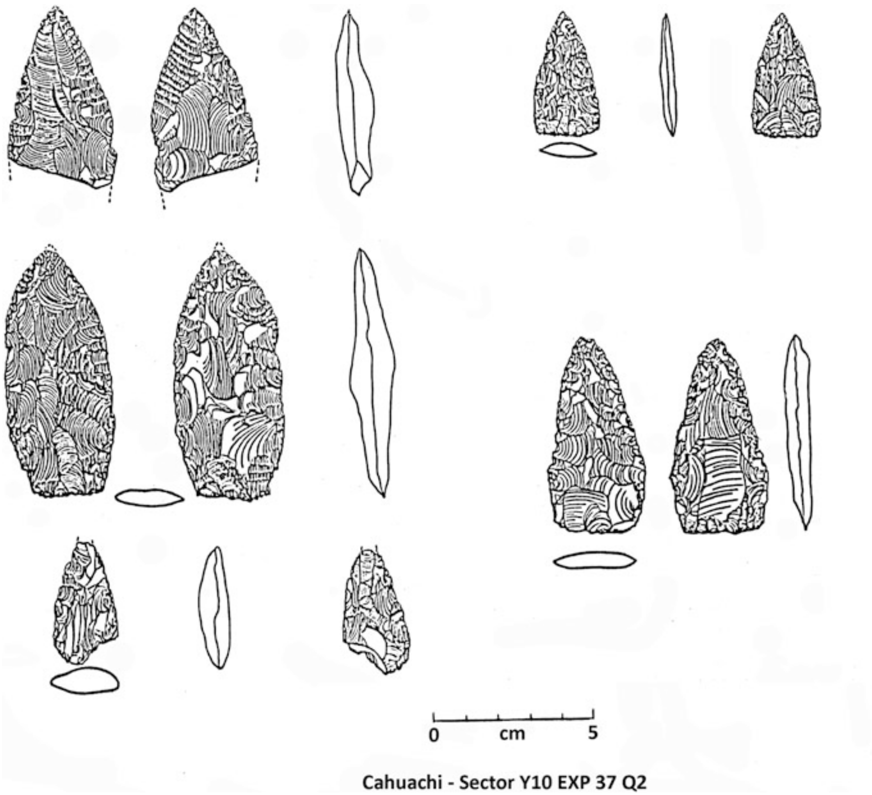

Fig. 14.1 Sector Y10 EXP 37 Q2 of Cahuachi: obsidian bifacial points, part of an offering (including also 47 microliths) found into an altar dated to 4200 BCE (Orefici and Drusini 2003, drawing by Johny Isla C.)

14.3 Early Architectural Forms in Cahuachi

The next evolutionary step of the concept of Cahuachi as a *huaca* was linked to the need to give to the sacred place some characteristics typical of human activities. To cope with these needs, the clay mounds were modified into architectural configurations shaped with leveled spaces and holes in the ground made to form geometric sequences over diverse areas. The architectural grandeur of the complex, along with the celebration of ritual functions, actively contributed to the process of transformation and helped to provide the proper element of sacredness to the area.

Some evidence of this was found in sector Y10 of Cahuachi (Gran Pirámide II) where, in the framework of the Proyecto Nasca, a small ceremonial altar was unearthed during archaeological excavations. This altar was made of natural clay, shaped and smoothed with rounded corners, obtained by digging a system of grooves along its perimeter. The altar contained small stakes and a series of geometric holes located on the east-west and north-south axes. This section was interrupted by other cuts in the clay layer inside of which there were offering wells containing various stone materials (microliths and obsidian bifacial points) (Fig. 14.1).

South of sector Y10, the natural clay layer was modified to receive offerings, such as, the mutilated body of a sacrificed female (Fig. 14.2) along with three valves of Pectinidi (Fig. 14.3) and a double-sided finely worked obsidian point. The presence of the altar and offerings lent a particularly intense sacredness to the place. This is the oldest evidence, until now, about the use of Cahuachi as a sacred place for ceremonial activities beginning in the Pre-ceramic period. The radiocarbon dating indicates a period between 4400 BCE and 4200 BCE, thus providing clear

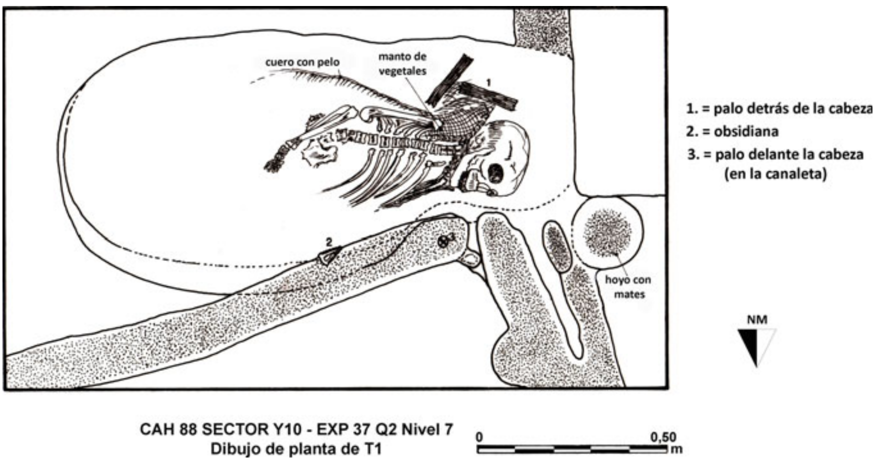

Fig. 14.2 Skeletal remains of a sacrificed woman, placed at the base of Gran Pirámide II, nearby a small ceremonial altar dated to 4200 BCE (Drawing by Elvina Pieri)

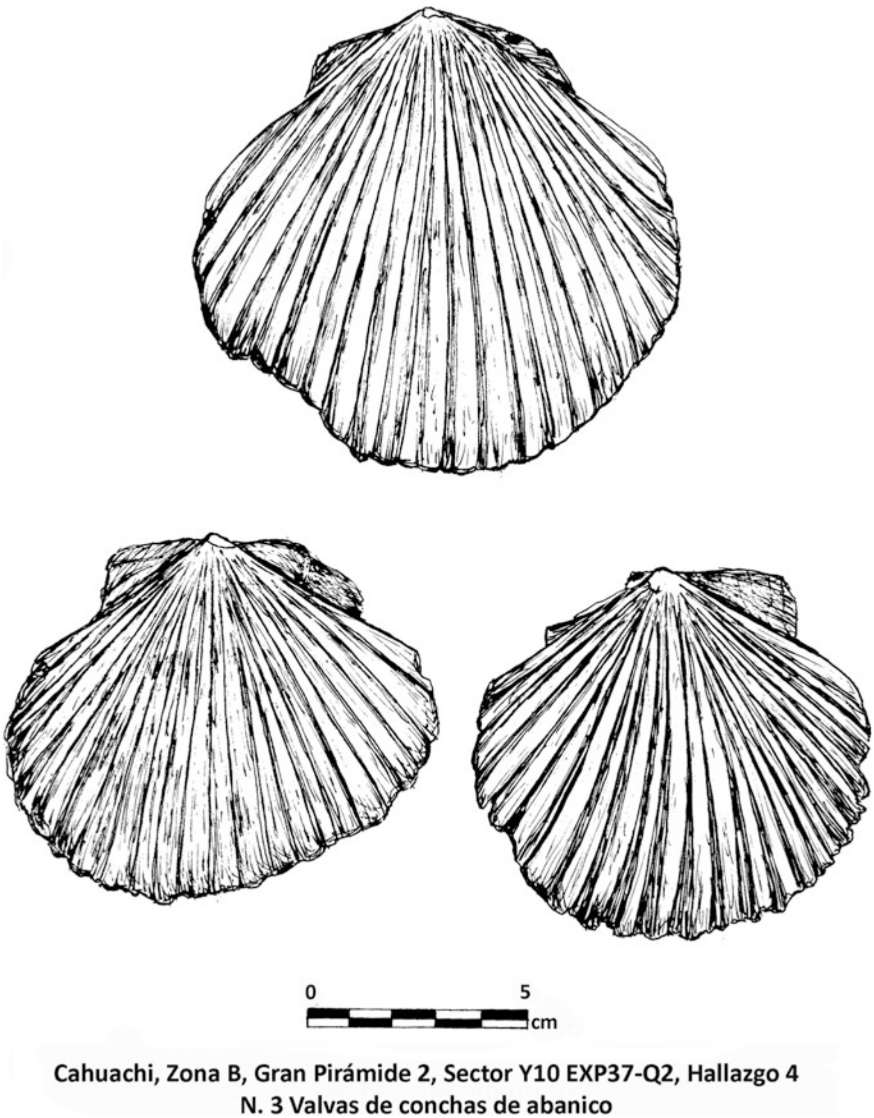

Fig. 14.3 Three shells of Pectinidi (*Argopecten purpuratus*) placed as an offering to a sacrificed character associated with a ceremonial altar dating back to 4200 BCE (Drawing by Dolores Venturi)

evidence that the place played a very important role and had sacred value very early in the development of the Nasca Culture.

The area where the small ceremonial altar was found, called Y10, was located in Zone B of Cahuachi, exactly below the second deck of Gran Pirámide 2, the tallest architectural structure investigated up to now. The ceremonial altar was found

Fig. 14.4 Stratigraphy at the base of Gran Pirámide II, where remains of human sacrifice dating back to 4200 BCE have been found (Photo by Giuseppe Orefici)

under a layer purposely filled and adjusted with the purpose of leveling the ground. Therein there was a stratified wall consisting of rows of conical adobes followed by a filling layer and finally by rows of loaf-shaped adobe.

This building technique was in use during the fourth phase of the construction of the ceremonial center. Clay layers were often remodeled over previous layers of clay already shaped and used. This is the first evidence of the use of Cahuachi for religious purposes and for the celebrations of collective rituals (Fig. 14.4).

The participation of people to the ceremonies held in Cahuachi along with the ritual offerings highlighted the fact that a special sacredness was widely recognized to the area. It was considered as reference meeting place for religious rites shared among populations coming from the *Altiplano* and the Coast (Orefici and Drusini 2003: 105; Orefici 2012: 133–145).

Subsequently the need to give to the place more complex functions corresponded to the appearance of a first architectural form in Cahuachi. The duality expressed by two large natural hills that dominated the whole area was one of the main important requirements in choosing the place where to erect buildings, according to the new architectural style.

14.4 First Architectural Phase in Cahuachi

There is not a clear view of what Cahuachi had been during the first architectural phase. At that time, the temples were built with large pilings of *huarango* wood.

In various contexts, we could verify the existence of large wooden posts placed in holes drilled into the clayey layer of the hills. These were connected to each other by means of a wattle bound by vegetal rope to form walls of *quincha*, which were subsequently plastered on both sides by means of a very compact clay layer with a thickness of several centimeters.

This is the oldest building system identified up to now in Cahuachi, although so far there is not a clear view of the frequency of its use compared to the totality of structures of the ceremonial center (Figs. 14.5, 14.6 and 14.7). In any case, its presence in most of the sectors analyzed up to now suggests that it was the first example of a global architectural style in Cahuachi, designed with the aim of creating a monumental ceremonial environment for pilgrims coming from various parts of the territory (Fig. 14.8).

Slowly, the use of Cahuachi became more and more complex with liturgical celebrations made for people who accessed the sacred area intermittently and also according to specific calendrical needs. The previously shared beliefs were incorporated into the new ceremonial systems and functions, so that Cahuachi was increasingly recognized as the main hub of the whole territory and, therefore,

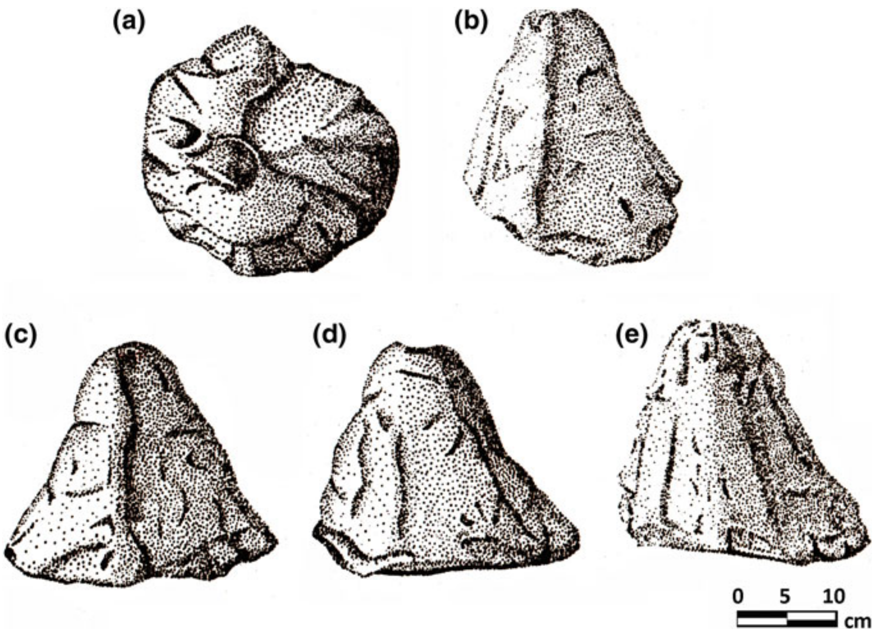

Fig. 14.5 Examples of conical adobe used in the oldest temples (Drawing by Elvina Pieri)

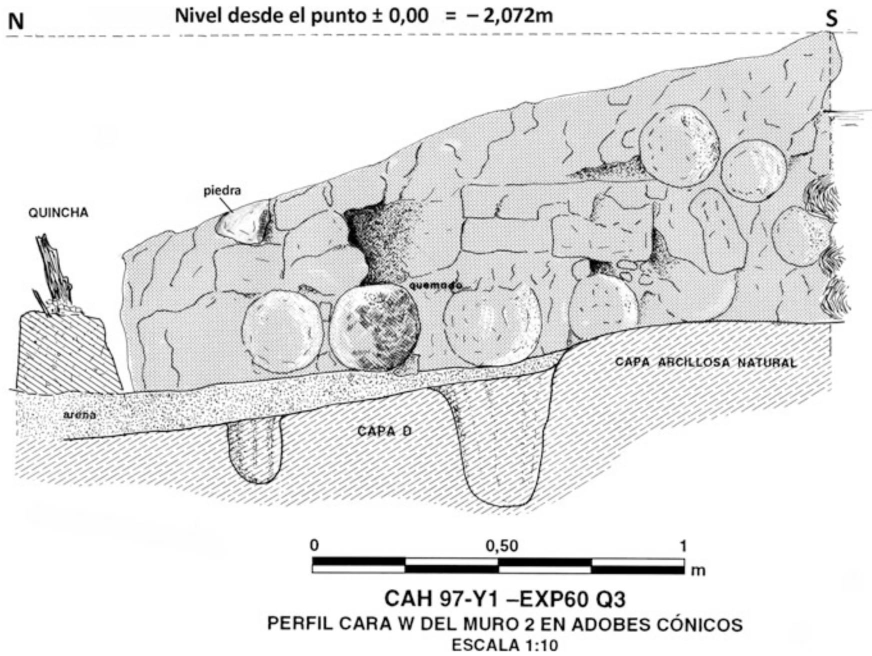

Fig. 14.6 Wall built with conical adobe found during the excavations in Sector Y1 (Drawing by Elvina Pieri)

converted and elevated to a real theocratic capital, from where ideological innovations spread by the pilgrims.

At this stage, the ceremonies of sacrifice of pottery, animals, and humans were intensified as is evident by the large quantities of materials offered with votive purposes. The acquired prestige and the economic power were manifested by the presence of large deposits of vegetable offerings (unearthed inside the temples of Cahuachi). The activities related to the development of ceramics, fabrics, decoration of the artefacts, and other types of handicrafts were directly made in Cahuachi: the life of the ceremonial center became much more articulated and complex. This determined new roles, functions, and spaces conceived not only for ceremonial activities, but also for hosting various categories of specialists whose presence made even more prominent its authority.

Probably on certain dates of the year, the ceremonial center was also a place, where pilgrims exchanged their products or luxury goods, such as pigments for epithelial painting and feathers for decorative tissues or other ornaments.

Cahuachi increasingly became a ceremonial place that attracted multitudes of pilgrims even from the most distant places where the Nasca religion had spread out. For many centuries, Cahuachi was a place for peace and interchange between groups that looked to it as the cultural and worship center of their religious faith.

Fig. 14.7 Conical adobe used in the oldest part of *Templo del Escalonado* (Photo by Giuseppe Orefici)

14.5 Cahuachi as Religious Capital, Political Core and Multifunctional Center

During the third architectural phase of Cahuachi, specific places were arranged for storing different products brought by pilgrims. The finding of ceramic material prepared and unfired, such as *antaras* (panpipes) ready to be placed in the oven, as well as unembroidered tissues, revealed that Cahuachi had been converted into a large craft center of ceramics and textile production.[3]

In the area known as Y1, the excavation of structures belonging to the fourth architectural phase placed into evidence the change in use of some urban sites, such as squares or large enclosures with columns, from ceremonial function to working areas. Therein, uncooked fragments of *antaras*, canvases with motifs ready to be embroidered, and partially decorated pottery were found. This suggests the presence of artisans or craftsmen priests, who coordinated or made artwork for themselves

[3]On *antaras, see* Chap. 17 by Gruszczyńska-Ziółkowska (2016).

Fig. 14.8 Wall decoration in *Templo del Escalonado* (Photo by Giuseppe Orefici)

within the ceremonial area. Also in the third platform of Gran Pirámide, unfired ceramics and musical instruments were found.

Archaeological excavations, carried out in on the north side of Gran Pirámide and on the large ramp of Pirámide Naranja (belonging to the fourth phase of Cahuachi), highlighted the presence of small enclosures designed to contain guinea pigs. This made it clear that various areas previously used as ceremonial places were later designated for other uses, especially during the fourth phase which is considered the period of greatest transformation.

During the archaeological excavations carried out in Zone B of area Y13, a large amount of bird droppings was found on the pavement of an enclosure. This suggested that the area was used to raise animals, not only for ritual sacrifices or funerary purposes but also for food production.

Cahuachi was developed continuously for more than 800 years and served a central function for human groups who considered it as the place of cultural and cultic origins. At the same time, it had also an important political control role. In fact, for many centuries human activity in the valley of the Río Nasca was controlled through the management of water resources based on a network of aqueducts, called *puquios* that played a critical role in the development of agriculture.[4]

14.6 The Control of Water and Agricultural Production

Due to this recognized religious and political role, Cahuachi assumed importance for the control of water, and in turn, for agricultural production. Undoubtedly the presence of two sites with water springs was crucial for the irrigation of the area. Moreover, the network of filtration galleries in operation in the middle part of the valley, since probably the Early Intermediate Period, was, at least in part, controlled by the ceremonial center. With the management and distribution of water, Cahuachi had directly and indirectly a prominent role in the foundation and growth of the settlements scattered throughout the area.

Cahuachi also affected the other older religious centers that then completely disappeared or were transformed to be adapted and used for other activities, as in the case of Quemado, a small multi-purpose center located 4 km east of Cahuachi, dating back to 500 BCE. The archaeological excavations therein conducted placed into evidence the transformation undergone by this settlement of ceremonial origin.[5]

The network of aqueducts and filtration galleries was a basic element for the development of agriculture in the area, making possible the cultivation of the majority of species of food plants commonly used in the diet of the ancient Nasca.[6] Later, some of these plants completely disappeared due to the introduction in the colonial era of new forms of non-native food crops.

Among the species of fruit surely consumed by the Nasca, there were Pacae (*Inga feuillei*), the lucuma (*Pouteria lucuma*), the Guayaba (*Psidium guayaba*), and Ciruela of fraile (*Bunchosia armeniaca*). Among the major food plants, there were peanut (*Arachis hypogaea*), Pallar de los Gentiles (*Canavalia plagiosperma*), Jíquima (*Pachyrhizus tuberosus*), bean (*Phaseolus vulgaris*), Pallar (*Phaseolus lunatus*), Yuca (*cassava*), the pumpkin (*Cucurbita maxima*), Lacayote (*Cucurbita moschata*), Camote (*Ipomoea batatas*), chili peppers (*Capsicum frutescens*), maize (*Zea mays*), and *Achira (Canna edulis*) (Figs. 14.9 and 14.10).

[4]Even if the greater development of hydraulic engineering was during the Middle Nasca. For additional details, see Chap. 13 by Lasaponara et al. (2016a).

[5]In the context of Proyecto Nasca in 1989, archaeological investigations in Quemado enabled the identification of the architectural features of this area and its shape as a small ceremonial area, with terraces and high fences.

[6]For more details on food plants, see Chap. 6 by Piacenza.

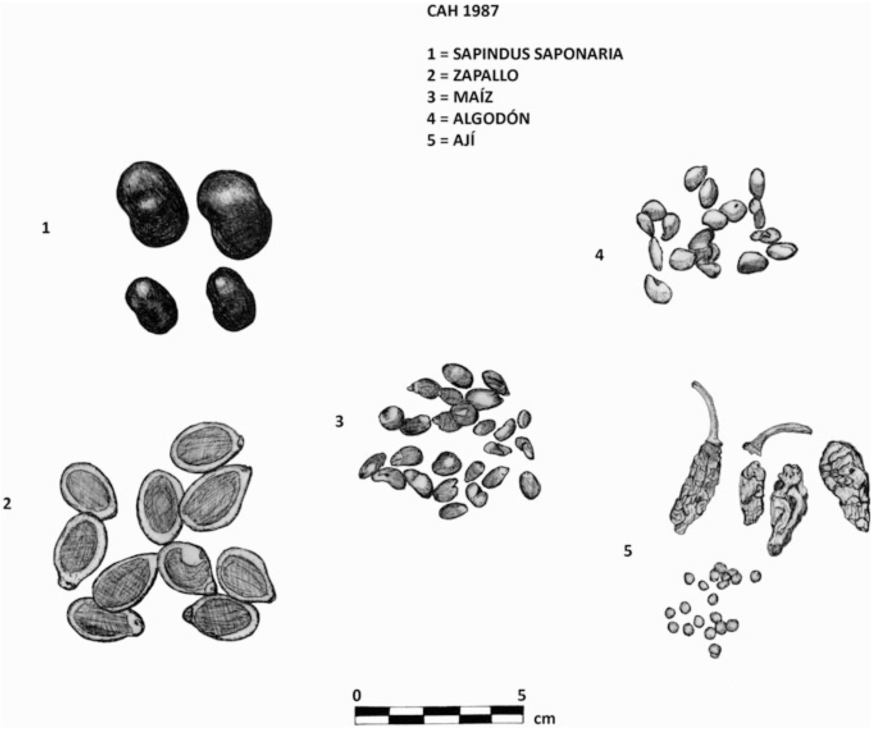

Fig. 14.9 Remains of plants placed as offerings, most commonly found in the excavations Cahuachi (Drawing by Dolores Venturi)

Currently it is very difficult to have a clear idea of how the Nasca were able to take advantage of the ground water in Cahuachi. Nevertheless, during the excavation of sector Y1, filtration galleries were identified. They were built to exploit a very shallow aquifer, completely dry today.[7] Moreover, remains of pipes, used to feed water directly into the ceremonial structures, were also found. In the hills where the temple structures were built, wells were dug in the clay layer. They had a narrow mouth of 35–40 cm and were bottle shaped. Their depth was about 2.80 m, and their maximum width was 2.40 m. The water probably came to the valley from the Atarco River and emerged naturally within the wells, filling basin formed in the clay layer.

A clay channeling system was also found. It was arranged to exploit the slope between the two different levels of the soil and used to transport the water from outside of the structures. Therefore, at that time, the amount of water was much greater than today, and, by means of these hydraulic systems, it was possible to

[7]This was confirmed by geophysical investigations performed by ITACA Mission.

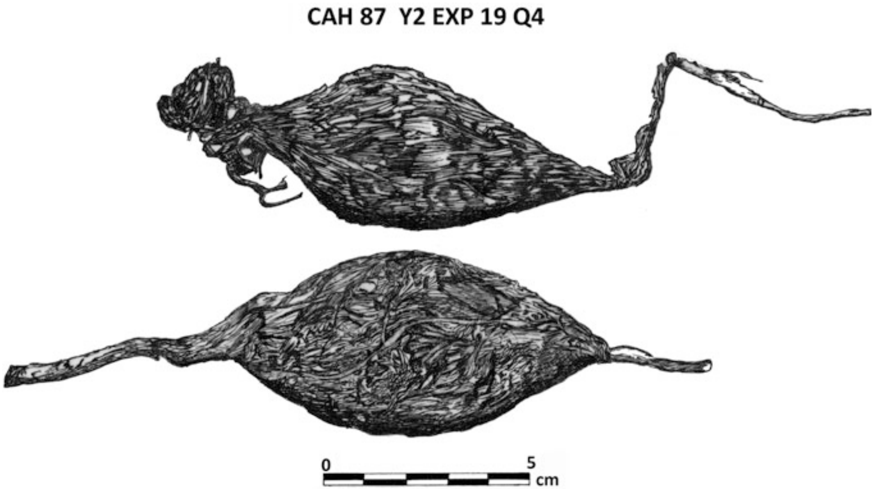

Fig. 14.10 Remains of Jíquima (*Pachyrhizus tuberosus*) found as offering in Cahuachi (Drawing by Dolores Venturi)

bring the water even into high pyramidal temples as in Pirámide Naranja, where remains of ancient water channels were found recently.

The amount of water that could be distributed to villages probably depended on the quantity of products that were offered by the people to the ceremonial center, which was the only organized structure able to accumulate and store large quantities of food stuffs, and, in return, provide water to the population for agriculture. By means of this production control system, the power of Cahuachi became stronger and stronger.

14.7 Conclusions

All the evidence and the archaeological data at our disposal reinforce the idea that the site has had a strictly ceremonial function since its origin. The hypothesis of W. D. Strong (1957: 13) on the existence of an inhabited village has not been proven up to now by any data on housing construction found during the archaeological excavations conducted by Proyecto Nasca in Cahuachi and its surrounding. From the C14 dating, it has been possible to know that the first occupation in Gran Pirámide 2 (sector Y10) was related to a ceremonial and religious function.[8]

[8]Similarly, in other areas near the ceremonial center, as for example in Estaquería, Proyecto Nasca found the body of an individual human being without a head and upper limbs, with indicative elements dated to the second or third millennium BCE.

Over the centuries, in addition to its role as a religious and ceremonial center, Cahuachi acquired new administrative and economic functions, becoming a real theocratic capital which developed around two centers, named Zone A and Zone B, surrounded by walls built during the fourth architectural phase. A third nucleus, named Zone C, maintained its ceremonial function even after the end of the status of Cahuachi as the theocratic capital.

Analyzing other cultural areas of Peru, two different functional transformations occurred: (i) one characterized by a transition of the liturgical center to a configuration of an urban complex; (ii) the second was a transformation of the urban settlement into a ceremonial area, though with non-homogeneous functions.

In Cahuachi, it seems that these functional changes did not occur and its characteristics were maintained over time, creating the largest adobe ceremonial center in the world. Subsequently, the ancient sacred place underwent a process of radical transformation: it became a theocratic capital and, subsequent to its abandonment, reemerged as a *huaca*, used mainly as a necropolis and ensconced in the collective memory as a place belonging to ancestors.

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Chapter 15
Cahuachi Architecture

Giuseppe Orefici

Abstract The history of Cahuachi architecture is characterized by substantial changes in the use of materials, building techniques, and space organization. The initial phase is distinguished by the use of *quincha* walls. Later phases (II and III) are marked by the use of adobe elements, first conic, then loaf-shaped used to build walls. The final phase, was characterized by the presence of substantial artificial fill and the reuse of old walls and adobe elements. The use of public spaces also varied as well as the most exclusive spaces located on the stepped terraces which shape the pyramidal constructions. The use of separate rooms, with roofs supported by columns on the outer perimeter of the temples, was maintained over time and intensified during the fourth phase of Cahuachi. The temples were interspersed with large public areas such as plazas, ceremonial enclosures, and corridors. An earthquake of major proportions, as well as frequent floods, led to the abandonment of the great temple complex, which for almost a thousand years was the religious center of the Nasca Culture.

Keywords Architecture · Cahuachi · Morphological analysis · Construction types · Building phases

15.1 Morphological Analysis and Orientation of Architectural Structures. Construction Phases

To understand the architecture of Cahuachi, it is necessary to study the various ceremonial spaces that made up its extensive and complex building morphology (Orefici 2012). The development of the temple complex began at a

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Fig. 15.1 Aerial image of the Ceremonial Center of Cahuachi (SAN, Perú 1955)

time prior to what may be considered the truly evolutionary phase of Nasca culture, although the current ceremonial layout of the internal spaces can be assigned to the various stages of development of the culture (Fig. 15.1).

At first, the site would have simply been considered a sacred place, without the multifunctional connotations related to the major religious and liturgical activities celebrated in the various areas of the temple. Cahuachi showed a tendency towards complex urban design right from the First Phase of its architectural evolution, thus reflecting a global vision of space, where a relationship with the territory and the functions of its various sectors were set out within a well-planned organic and systemic whole.

The temple concept is the most recurrent element among the architectural forms, rising vertically on a number of terraced staircases. In most of the buildings, height was achieved through a system of embankments constructed one on top of the other, adapting to the natural contours of the land, building on, and levelling out, the natural strata of clay to use them as a base for the *adobe* walls that constituted the construction feature visible from the outside. This way of building continued through the different evolutionary phases of the ceremonial centre, with no obvious changes except during the Fourth Phase of Cahuachi architecture, when much of the surface area of the structures was eliminated to leave mainly empty spaces in the form of uncovered platforms. Throughout the last two stages, there was a substantial change in the volume of the temple complexes, culminating in total annihilation of the inner spaces of the buildings and their definitive burial under a blanket of soil and debris from construction materials. The buildings are certainly laid out according to a complicated design following a rational plan based very much on religious and liturgical interpretation. The distribution of the buildings, however, followed an internal structural system within a complex overall footprint, but it was always balanced. The model for the construction of the temples is mainly that of a rectangular base, where the vertical elevation consists of ascending terraced platforms bordered by retaining walls. They form a truncated pyramid, built upon pre-existing natural mounds with the construction of embankments.

This system of construction is repeated in all the groups of temples located within the ceremonial center, including those separated by spaces. The size of the structures was extremely variable: on average, the sides of the base measured between 30 and 100 m, although in certain cases, such as the *Pirámide Naranja*, the base side reached, and exceeded, 200 m.

Most of the buildings within the ceremonial area looked directly towards the valley floor, i.e., north for the buildings on the left side of the river, and south for those on the right bank. In some cases, the internal paths corresponded to the surfaces of the staircases and were used to reach the intermediate areas of the facilities or to reach other temples located laterally. In the area known as Y1, on all the mounds on which the center is built, the side staircases of the temples provided a space used as pathways towards the enclosures on the main face or to the rear of the temple itself.

Access to the steps of the platform was by means of narrow stairs which led to the higher levels. At the top of the terraces, there were large areas with columns supporting the roofs: therefore the actual volume of Cahuachi was twice the current one thanks to these superstructures. The various levels and sizes of the steps were clearly visible on the façades of the temples, emphasized by the presence of perimeter walls. The entrances, leading to internal stairs and which had often been covered over, were also visible. The roofs gave the structure a marked outline and a *chiaroscuro* effect visible from a great distance. The tops of the buildings generally had constructions enclosing one or more closed rectangular spaces. Often, these structures had roofs consisting of posts, ropes made from vegetable matter, and straw, as demonstrated in 2013 during the excavation of the South Temple, through the discovery of a large roof which had collapsed and been buried on the surface of a terrace, thus providing an example of vertical construction methods. In most cases, the top surface of the corridors could be used as a walkway, so the platforms were larger than today. The floors were generally flat and very rarely had additional levels or associated stairways. Often, the temples were not isolated, but were connected to each other by means of intermediate precincts, squares, or patios separating the ceremonial spaces. In almost all the complexes, as can be seen from an analysis of the different phases of construction at Cahuachi, the temples sometimes underwent a radical change in the structure of the internal paths or in the routes to reach the building tops. The side facing downstream was always open, so that the staircases on the façade were clearly visible, while the side walls were smaller and served to separate the internal spaces. The temple buildings were always of monumental size and were very wide. Around them there were intermediate spaces of considerable size and, in most cases, they were areas occupied by ceremonial precincts directly connected to the buildings by means of stairs or corridors (Fig. 15.2).

In other cases, the buildings were in sequence, especially when the temple mounds were expected to be used as containers of food or other materials, as was seen in sector Y1 in Zone A, while in the eastern area of Zone B, there are smaller temples which contained sequences of silos where various products were stored. There are examples, such as the *Gran Templo* or the *Pirámide Naranja*, where the

Fig. 15.2 Aerial image of Cahuachi including the part of Sector A which has been restored: *Gran Pirámide* is in the *middle* of the photo (Photo by Eduardo Herrán)

building exceeded 200 m in length and had various covered areas alternating with open spaces. In the specific case of the *Pirámide Naranja*, the elevated surface of the temple was surrounded by walls of unknown height, although it may be assumed that there was a large ceremonial enclosure which would almost certainly have been open.

On the basis of the situation brought to light during the 50s and 60s by aerial photography, which provided a view of the temple area only, some open spaces were interpreted as enormous plazas by a number of authors (e.g., Strong 1957; Silverman 1993). On the basis of the excavations carried out by the Nasca Project in the intermediate area between Zone A and Zone B, the space that had always been interpreted as a *Gran Plaza* turned out to be a complicated set of corridors, platforms, and fences surrounded by walls and separated by ramps and stairs (Orefici and Drusini 1993). The same result was obtained from an analysis of other large open places, showing that the attribution of use as a plaza was based only on the apparent morphology of the soil, unchanged after the disastrous floods during Cahuachi architectural Phase IV. From 1994 to 1998, various structural complexes were excavated, all of which were located around the open area to the side of Zone B on its eastern front. On these occasions, there were large spaces without buildings, because the walls were destroyed by the flooding that devastated Cahuachi both during the last 50 years of its existence, and after its demise. Within this space, in 1984, Helaine Silverman and Miguel Pazos (Silverman 1993: 116–120) found data pertaining to the perimeter ring of Zone B. Because of the floods, the height of the walls did not exceed 30–40 cm, and, in some cases, the maximum height did not reach 5 to −10 cm.

During the Nasca Project, excavating inside the walls of Zone B, the surprising discovery was made that the wall originally thought to be just one element delimitating the open space was actually a peripheral element containing four large enclosures, divided by narrow access corridors. The enclosure had a single small opening to ensure greater control of the entryways to the area.

15.2 Construction Techniques, Spatial Organization, and Ceremonial Enclosures

In Cahuachi architecture, we see the very clear recurrence of a specific building model. In most cases, within the intermediate spaces between the temples, we find roofless ceremonial enclosures, which probably held large numbers of people for assemblies or elaborate liturgical functions. In the empty spaces inside the buildings, there are particularly thick perimeter walls that lead us to suppose that they were also of considerable height. During the archaeological excavations of 2014, two large perimeter walls over 3-m wide came to light at the base of the *Templo Sur*, suggesting that the structures must have been very tall. Similarly, other enclosures at the foot of the *Gran Pirámide* on the east side are over 2.5 m across at the base, although currently their height no longer exceeds 1.5 m.

The spaces that can be defined as real plazas have a number of connections with adjacent buildings and belong to a lower level than the floors of the spaces between the temples. This is true of *Plaza Este*, located on the northern side of the *Gran Pirámide*, measuring 45 × 50 m, and also of *Plaza Norte*, measuring 56 × 40 m, where the different accesses to various places are connected directly to the open space (Fig. 15.3).

There are some very large areas, though in most cases the squares or ceremonial enclosures follow the level of the ground, adapting to the natural clay platforms. In

Fig. 15.3 *Gran Pirámide* of Cahuachi after the works of restoration and structural rehabilitation (2002–2011). It is possible to observe *Plaza Norte, Plaza Norte II*, and the access ramp to second platform (Photo by the author)

the *Plaza Norte* of the *Templo del Escalonado,* there are signs of previous ceremonial areas within the precincts that were filled and levelled during Cahuachi Phase IV in order to obtain an even surface for use as a square. The interior corridors were eliminated, and the open spaces created by this modification were put to new uses (Figs. 15.4, 15.5).

In almost all cases, access was along an L-shaped path: a corridor leading to the main staircase that led to a higher level. The accesses were often covered with roofing made from reeds which supported a compact layer, joining both sides of the platform interrupted by the opening. During excavations on the second platform of the *Gran Pirámide* in 1988, a long corridor was found which led to a very steep, high staircase beneath a canopy which covered it (Fig. 15.6). A layer of partly baked clay reinforced the covering and gave the surface remarkable consistency, like that of a walkway. In this way, a route was created above the passageway, made from light but very durable material.

Very occasionally, the access routes were direct: this usually occurred only when there were no particular differences in height. The passageways were openings in the walls formed by slicing them from the highest part to the base where the walkway was. In the upper structures of the mounds or temples, the accesses were very small and each area had only one. In the connecting pathways of the long corridors that reached the stairs joining the platforms, there was usually a small compartment, possibly used as a vestibule. Sometimes a step was built to join differing floor levels. Parallel corridors were found in the accesses to the ceremonial enclosures, and these led to various places and did not communicate with each

Fig. 15.4 *Plaza Norte* of *Templo del Escalonado*. In the background *Gran Pirámide* and the *Templo Sur* (Photo by the author)

Fig. 15.5 *Templo del Escalonado*: restoration phase of the facade decorated with bas-reliefs. Note the decoration with stepped motif (Photo by the author)

Fig. 15.6 Access corridor to the second platform of *Gran Pirámide*. At the end of the corridor, there is a steep staircase (Photo by Patricio Estay)

other. Each of them led to a particular enclosure following an exclusive route with no other communicating passages. Only those with a perfect knowledge of the position of the various temples and how to enter the building could move within the labyrinth of pathways, and the height of the walls also prevented visual contact. This system for protecting the ceremonial center and its axes of internal communication of the sacred area confirm that it must have been impossible for anyone outside the priestly class to move around within the complex.

In most cases, the stairs were very steep, and the steps were made of clay. Every step was reinforced on the outside edge with a palette in *huarango*, whose function was to protect the step from wear, which would have caused its collapse. The stairs were very rarely any wider than 1.5 m, with the exception of the most monumental, which connected various platforms. The very simple steps were no wider than 60–70 cm across.

In the northern square of the *Gran Pirámide*, four different corridors were dug accessing the upper platform from their south side. Each access point led in only one direction, and the inner rooms of the platform itself did not communicate. Each corridor served solely to provide access to the upper room, which had no relation to any other space except through the North Plaza. On its western side, the only connection to the North Plaza was the Second North Plaza, by means of a narrow ramp that communicated with the southern side of the lower platform: there were no other connecting elements over the entire surface of the open space. During archaeological excavation, it became apparent that part of the North Square was covered by a large roof, possibly to protect stored products. A potential comparison could be made with the research carried out in sector Y13, where a corridor was found ending in a staircase covered by a roof in the temple itself, linking the upper platform of the minor temple with an enclosure located on the north side.

In the first platform of *Gran Pirámide II*, evidence of corridors was found with a path parallel to the second platform. They had accesses leading to narrow stairs built with treads reinforced by *huarango* posts. Thus, also the first platform was accessible from the area between two different groups of temples, by means of two parallel stairs of considerable size: this is one of the rare cases where flights of steps are placed parallel to each other. In mounds 1, 2 and 3 of sector Y1 in Zone A, stairways were found that led to corridors marking the perimeter of the temple structures.

15.3 Access Ramps and Connecting Stairs

To date, there is only one sure proof of the presence of ramps at Cahuachi, even though, in the ceremonial architecture, another access ramp leading to the top of the building was found, pertaining to Nasca architecture, in the pyramid built from conical adobe partially excavated on the archaeological mission at Pueblo Viejo, 1983–1988. At Cahuachi, a similar architectural feature was built during the Second Phase of construction and, in this case, it was a ramp separated by an intermediate wall of conical adobe on the south side of mound 1 (sector Y1). This was found during the archaeological excavation of 1985. During the searches carried out later, it became clear that the ramps in the area of the ceremonial center appeared only after the Third Phase of Cahuachi construction. Already between the Third and Fourth Stages, there is evidence of a disastrous flood involving many parts of the center and damaging the plaster surfaces. The flowing water damaged many of the walls and structures which were not restored afterwards. This marked the end of the large, covered areas separated by walls of various heights. The most monumental phase in the life of Cahuachi, with colonnades and covering decorated with polychrome plaster reliefs, was already in rapid decline: the debris left by the flood that destroyed most of the buildings remained on the ground, and, in 2007, some offerings were found in the form of fragments of colored plaster in relief from Cahuachi IV (Fig. 15.7). Clearly, these were part of the decorations of previous buildings destroyed by climatic and environmental causes at the end of Stage Three. There is ample evidence that ramps, on several occasions, were made only to compress the *adobe* that had fallen on the uneven levels of construction, where there had previously been stairs.

In the case of *Plaza Norte II*, it is evident that the ramp was built onto the staircase itself, which ceased to operate when it was covered over with debris. Ramps, with their different degrees of inclination, represent the most practical way

Fig. 15.7 Remains of painted plaster placed as an offering in the third platform of *Gran Pirámide* (Photo by the author)

of joining two different levels, reached by walking on an inclined surface above the underlying elements that previously functioned as grand entrances. Another advantage offered by this type of structure is that they made it easier to carry loads up and down, since it significantly decreased the effort required. Considering the symbolic nature of all forms of expression in Nasca culture, it may also be assumed that, in some cases, the use of the stairs was related to the sacred role to which this society attributed to the space. A staircase breaks the overall view, interrupted several times because of the care needed on the part of the user climbing the steps, so a global view of the complex that is being crossed is lost. The path of a ramp makes continuous visibility possible, keeping the eyes fixed on the goal set, according to three variables: distance, angle, and the height of the point of arrival. The ramp is therefore the most suitable route to obtain a three-dimensional view, but the stairs could represent a form of path that requires the climber to focus attention on different aspects, imposing a series of predetermined actions. At Cahuachi there is evidence of lateral and adjacent stairs and ramps, running in the same direction and for simultaneous use, as on the western side of sector Y1 (EXP29). In the case of the *Templo del Escalonado,* the exterior walls of the east side, which reached a height of nine m, were partially deconstructed at the beginning of Phase IV to create an access ramp leading to the platform built by placing fill in the rooms and corridors belonging to construction Phase III. In this way, a large inclined ramp was obtained, connecting with the upper platform, using only the constructions and debris from the previously collapsed buildings.

The ramp of the North Square of the *Gran Pirámide* shows traces of this architectural element from Cahuachi Phase IV, built over corridors or staircases from previous periods. However, it is difficult to interpret the actual function of the temples only on the basis of the use of space and to understand how people actually moved around inside. Nor can we determine the hierarchical level of those who used these connecting passages between the different buildings during ceremonies.

Looking at the way the accesses were constructed, they are clearly different from real doors, because these are considered to be elements that separate an access with a closure from other interior or exterior spaces. There are certainly some examples of functioning doors at Cahuachi, but they are not very frequent. In the North Plaza, there is an access way found during archaeological excavations in 1988, and later completed in 2002. During recovery operations on site, unmistakable traces of hinges were found in contact with the floor surface. It was a ten-cm hole dug into a depression in the wall, where a vertical post had been. Nothing pertaining to the actual door was found, nor were there any holes corresponding to a closure mechanism in the side wall. In other cases, such as sector Y13 (CAH 91, Sector Y13, EXP 48), a sealed door in a corridor leading to the upper deck was found in 1991. The door was in the corner of a covered access. From the east side, on the left, there was access to the upper floor inside the temple, and on the right, the opening had been closed off with *adobe*. During the excavations carried out beyond the seal, going down from ground level, the team were surprised to come across a false door in the natural clay layer. Evidently the walled access had only a symbolic meaning.

As for windows, there is only one exemplar at Cahuachi, where a passageway was found that descended in the form of a stairway inside a temple complex known as Y13. The staircase led directly to an opening that probably functioned during a previous architectural phase as a means of connection and access to the temple from the outside of the great south perimeter wall (Sector Y13 EXP55Q1, excavated in 1995). Internally, within the structure of the wall, there were two inner walls, one to the west and the other to the east, both of which are very well plastered. To the south, the staircase was open, but with a step below the level of the south wall to a depth of approximately 15 cm. The lintel of the window consisted of parallel rods (*Caña brava* or *Gynerium sagittatum*), on which a layer of very small stones of fluvial origin had been laid. Above it was a layer of leaves and cane shoots. This structure apparently had a completely uneven covering of earth. If the opening was ever used, it must definitely have been during the Fourth architectural Phase, at a time when important structural changes were carried out and buildings were restored after floods, but with unspecialized and often hasty methods.

The section of the wall containing the stairs was the lowest, and the window was built in this structure. As we suggested above, the south wall of complex Y13 contained a door instead of a window, and this was used to climb to the platform of the small temple. This opening was later closed and replaced by the window, perhaps to illuminate the interior corridor which possibly served as its roof. It cannot, however, be ruled out that the window, being the only one to be found in the ruins of Cahuachi, may have had a special function in the observation of the architectural complex further to the south, in a large intermediate open space (Sector Y16), where a store of painted fabrics was found.

15.4 Artificial Fillings

At the end of Cahuachi Phase III, substantial use of fill composed of various materials was found in most of the buildings, including debris from older structures, vegetable matter, the remains of offerings comprising large amounts of ceramic fragments, animal bones, fragments of *adobe,* and lumps of clay. The layers of earth were interspersed with vegetable matter chosen meticulously by type and placed with great care. They were laid out and arranged parallel to each other. One of the clearest examples of the use of fill made from earth and vegetable matter was found in the Templo del Escalonado, during excavations carried out between 2002 and 2008, in parallel operations to preserve and restore Cahuachi Zone A. During the archaeological work carried out to uncover the parallel corridors leading inside the structures, but with wooden roofs, an area within the temple structure was uncovered with a view to exposing the staircase leading to the upper platform. The artificial layers made from earth, clay, and man-made materials alternated with cushions of vegetable matter (grasses) according to a very regular pattern. During the same operation, it was possible to recognize all the strata of *adobe*, indicating the different stages of use at Cahuachi (Fig. 15.8).

Fig. 15.8 *Templo del Escalonado* (Y2). The image shows the stratigraphy of plant-based filling, a wall built with conical adobe, and some postholes, made in the natural clay layer (Photo by the author)

Phase I was clearly distinguished by the presence of holes for the large posts used to make the *quincha* walls. Phase II was marked by the presence of the substantial remains of conical *adobe* walls. Phase III was recognizable on account of the rows of loaf-shaped *adobe* above the wall structures made from conical *adobe*, while Phase IV was characterized by the presence of substantial artificial fill reaching up to nine m from the floor of the North Plaza in front of the temple.

In other cases, the fill formed superimposed buttresses of *adobe* perpendicular to the walls, without connecting mortar and with thin layers of vegetable matter placed in such a way as to protect the engraved plasterwork, prior to covering the whole temple with a final seal (Sector Y2, or the *Templo del Escalonado*). This work was carried out especially during Cahuachi Phase IV, at a time when most of the interior parts of the buildings began to be used for other purposes. This stage saw profound changes in the way of life of the ceremonial center, its passages, and the use of covered spaces that became open platforms following the removal of large roofs and supporting columns. The changes to the social and religious life of Cahuachi were a real cultural and religious revolution: in almost all the buildings, the use of interior spaces came to an end. They became mere platforms resting on fill and on the tops of buildings that remained standing. Within the ceremonial structures, a significant change took place in the functioning of the different complexes making up the heart of Cahuachi.

Artificial fill had a dual function: the first was to fill in the structures, using it only at the top of the platforms. The second was to help create an elastic element, using light and compact fill inside the buildings in order to maintain the pressure towards the outside, solving the static problems of the highest part of the mounds. At the same time, the composition of each bundle of vegetable matter had to be thought out according to a well-tried model that would above all be in harmony with the ritual and religious significance of the structure, its interior, and the materials that were used as fill.

The various elements were meticulously chosen and positioned very carefully. Various bundles and sheaves of vegetable matter were placed horizontally and sometimes formed the perimeter of the filling structure and in turn served as supporting elements. This material mostly consisted of maize plants or their stems, as well as *achira* (*Canna edulis*) and the branches of a leguminous plant (*Cassia* sp.) bound together by bundles of *Baccharis lanceolata* and *Tessaria integrifolia*, both from the *Asteraceae* family. The deeper layers were made up of very thin layers of *achira* or other plants which could vary depending on the different types of temple mounds. The layers of vegetable matter always pointed towards the interior of the structure, in order to control the static and dynamic forces that could compromise its solidity. This guaranteed greater stability and reduced pressure along the perimeter of the building. During excavations of Mound 1 (Sector Y1, 1984–1988), the tops of the temple buildings were found to be entirely made up of vegetable matter placed there for this purpose. However, the system did undergo some variations, since inside the same structure there were also arrangements with numerous layers of various plants. The presence of layers of vegetable matter inside buildings is a very common feature. In the sector called Y1 EXP4, there were several examples of these cushions of vegetable matter alternating with layers of compacted and homogenous earth, which proves very useful in the event of earthquake as it provides greater elasticity and stability. During the first excavations in 1986, 1987, and 1988 at the complex named Y2, which includes the *Pirámide Naranja* and the *Templo del Escalonado*, the oldest temple was found to have been completely covered by other structures that had been placed on top of the walls of previously existing buildings. To achieve this transformation quickly and reach the top of the building with little effort, very substantial layers of corn plants were laid in the upper part of the ancient temple. They were then covered with a layer of wet clay.

Light walls were added later to make the building more solid and acquire impressive volume, even if the material used was definitely not very weather resistant. The excavations carried out in 2007 and 2008 in Sector Y2 revealed the presence of buildings belonging to phases II, III, and IV. During phase IV, the front walls were covered with this system of topping made up of thick layers of plant material and clay, after the earthquake and floods which damaged the temples of the ceremonial center, in particular in around 400–450 CE. The new shape, modelled

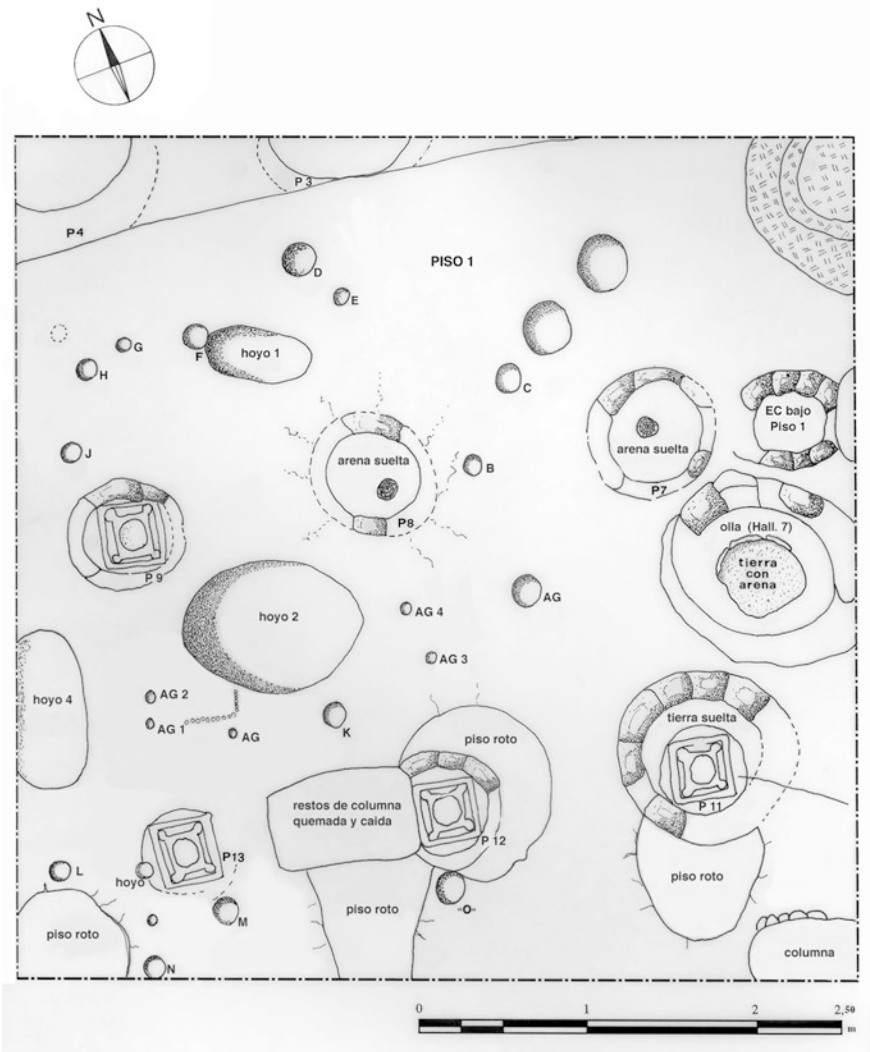

Fig. 15.9 Sector Y13. Artificial fill: circular structures including, in some cases, the remains of wooden poles and ancient pillars (Drawing by Elvina Pieri)

on the ancient temple buildings, completely hid the remains of the walls used before.

In Sector Y5, called *Gran Templo*, the excavations in the highest part and the platforms at the base of the structure revealed the presence of alternating layers of vegetable matter and earth. This fill belonged to Cahuachi Phase IV, when most of the hidden part of the *Gran Templo* was completely covered with layers of various materials, and the earlier structures were demolished. Between Phases III and IV, great changes were made to the height of the terrain, which was brought to the same level as the clay floor, using various materials, but especially earth and vegetable matter, mixed with the remains of construction material and votive offerings.

Circular structures appear in the fill in phase IV, and particularly in fill used between phases IV C and IV D. The first recorded examples during the archaeological excavations conducted by the Nasca Project were found in the sector called Y4, east of Zone A. Circular, truncated, cone structures built within artificial fill made up of fragments of *adobe* and lumps of clay without binder were discovered. These were connected to each other by small constructions built from the same materials and with no cohesive material. All the circular structures and the low walls joining them were placed inside the buildings at the same time as the artificial fill.

Fragments of *adobe* and lumps of clay as high as the surface of the seal were found in the fill itself, leaving the circular outline of *adobe* fragments clearly visible. In some cases, the circular structures were found to be made up from whole mudbrick. Inside, no material was ever found that was not the same as the fill that was deposited there. During phase IV, when the fill was deposited *en masse* inside the buildings, this simultaneous building-and-filling system helped give new life to the symbolic architecture of the ceremonial center, as the phenomenon was found throughout the entire complex (Sectors Y12, Y14, Y2, Y8, Y5, Y13, and Y1). In some cases, the circular structures were found at the bases of columns or other architectural elements, as if to emphasize their earlier presence as structural components (in Y13) (Fig. 15.9).

15.5 Floors, Roofing Systems and Colonnades

The walkways of the temples and other structures at Cahuachi were all made in the same way, i.e., from clay mixed with small quantities of degreasing consisting of small stones all of the same size. The choice of clay was very important in making flooring, so as to ensure that the surface was suitably firm. To improve consistency and solidity, it was probably mixed and beaten for a long period of time. The preparation of the floor surface was different from that of other construction operations: the clay was grey or beige and quite waterproof. No special measures were applied as protection against possible rainfall, nor was any kind of inclination envisaged. In many cases, the floods known to have hit Cahuachi irreversibly damaged the structures at the ceremonial center, including the walkways. Traces of human hair mixed with clay for the floors were found at the *Gran Templo* and in other temples at Cahuachi, which gave them particular importance, both in terms of symbolic and liturgical value. A human-head placed on the surface of the main platform was also found at the *Gran Templo* at a time prior to the construction of the walkway. The floors were mostly laid one on top of the other and were restored on numerous occasions because of the deterioration brought by constant use. The flooring was between 5 and 20 cm thick. Also in the fill, flat surfaces were found, prepared by compacting soil and plant materials. These often still bore the footprints of those who had helped to lay the great artificial top layers inside the

Fig. 15.10 Large structures found in the excavation of the western sector of the *Templo Sur* (Y24) (Photo by the author)

temples. In some cases, traces of charcoal or ash were found on the surface of the floors caused by lit fires.

Because of the precarious state of conservation of the vegetable material left on the surface of the temples and buildings in general, there are some rare remains of fallen roofs, since, during the various phases of restructuring, the roofs were removed when the structures were being cleaned out or when action was needed. Only at the *Pirámide Naranja* and the *Templo Sur* is there evidence that the roofs were built in *caña brava* and that the superstructures were supported by poles, pillars, or columns and then covered with bundles of vegetable matter bound with ropes of rushes (Fig. 15.10). In the case of the *Pirámide Naranja,* the weight of the roof was supported by square pillars. The lintels were probably made of *huarango* and could thus bear a heavy weight, especially if they were covered with decorations in clay as additional elements of the building. During archaeological excavations at the *Templo Sur*, the remains of a large roof that had collapsed onto one of the terraces with columns were found. Thanks to its location, the bundles of

Fig. 15.11 Details of large walls unearthed on the western side of the *Templo Sur* (Y24) (Photo by the author)

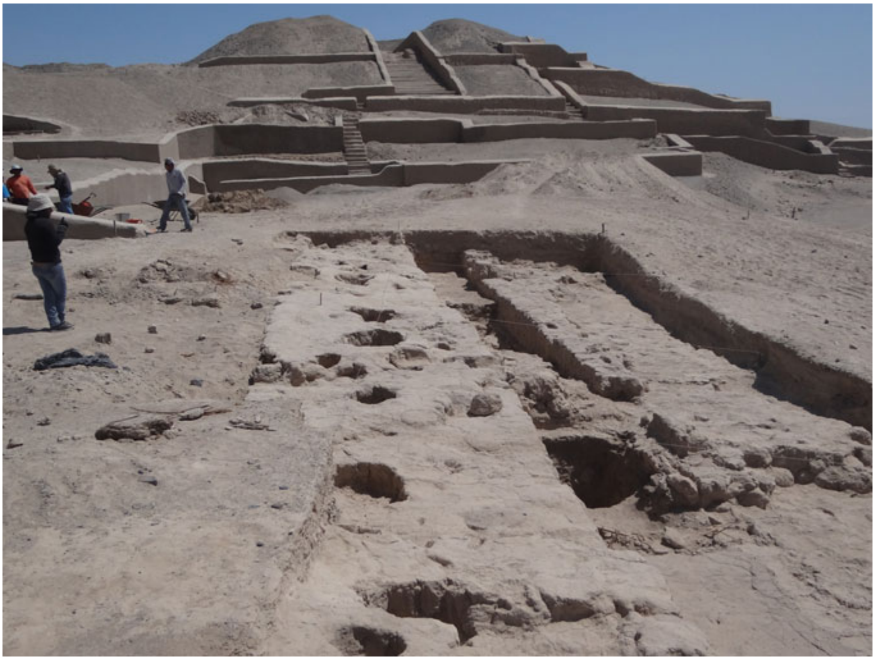

Fig. 15.12 Walls of the first platform found on the northern side of the *Templo Sur* (Y24) (Photo by the author)

vegetable matter and the ropes used to make the upper roof of the structure were found intact.

It was a large area whose roof was supported by columns, where, in various rooms separated by walls from phase IV, the spaces were used to light ritual bi- and tri-lobed ovens on the floor. The nature of the oxidation along the edges shows that they were used sporadically (Figs. 15.11, 15.12).

Most of the buildings found by the Proyecto Nasca had roofs supported by columns. This architectural feature was found mainly along the perimeter of the terraces, covering the stepped platforms or in the large floor areas, such as the *Gran Templo*. The number of rows of columns was variable and depended on the size of the spaces to be covered, most of which were platforms. The *Gran Pirámide* mainly had two different rows of columns on the platforms on the north side. The tops of the temples had columns on the *quincha* walls which completed the buildings with *huarango* and vegetable matter roofs. Columns were in use especially in Cahuachi Phase III, while the use of rows of even narrowly-placed pillars was typical of phases IV B and IV C. The columns were made of clay, with a *huarango* pole in the center to give greater flexibility to the building system. A layer of reeds was placed between the post and the outer clay, bound with ropes made from vegetable matter to bear the considerable weight of the roof. The diameter of the columns was mostly 60–80 cm, in proportion to the load that it had to carry. In some cases, the

Phase I	500(?) 400 BC 200 BC	Use of large walls of *quincha* (construction system with canes embedded in mortar and plaster) supported by *huarango* posts and with presence a clay plasters.	Buildings raised using large walls of *quincha*, formerly with templar function.
Phase II	200 BC 50 BC	Use of monumental walls built with large or small sized conical adobes. Absence of plaster on the external wall surface.	Large-scale structures with the base of the conical adobe outward-facing.
Phase IIIa	50 BC 200 AD	Different sized bread-shaped adobes, which are light gray, beige and dark-beige in colour. Partial reuse of conical adobe. Beige and gray clay plasters. Presence of colonnades and indoor coverage, subdivision of internal covered spaces. Many conical adobe structures are covered or hidden.	Large adobe structures with walls 80–180cm wide. The adobes are based on a natural clay layer. Presence of wall painted polychrome and monochrome decorations.
Phase IIIb	200 AD 300 AD	Light gray, beige and dark-beige bread-shaped adobes of different dimensions. Rare reuse of conical adobe. Beige and gray clay plasters. Presence of colonnades and indoor coverage, subdivision of internal covered spaces. All conical adobe structures are covered.	Large adobe structures with walls a 80–180cm wide. The adobes lie on the natural clay layer. Preponderance of monochrome wall painted decorations. Different orientation of the walls compared to the Phase IIIa
Phase IVa	300 AD 330 AD	Different sized light gray, dark-beige and orange, bread-shaped adobes. Reuse of the structures of the third phase with monochrome gray plaster, radical change in the routes of the third phase with new structures, that emphasize those of the previous phase. The colonnades and the large roofs are removed, leaving only those covering the corridors and the small connection rooms. Intense use of wall painting and painted decorations of the buildings.	Medium sized structures and reuse of the previous perimeters. Large fillings with earth and vegetables in alternate layers, as well as several sacrificial offering materials, related to the previous phases in the building of the third phase. Most of the constructions of the third phase are covered.
Phase IVb	330AD 360 AD	Light gray, dark-beige and orange bread-shaped adobes of different dimensions. Changes in the kind of clay and temper. The corridors are different compared with those of the third Phase and Phase IVa. Walls of small dimensions very often are placed on previous collapsed structures.	Buildings partially reusing previous temples, especially as platforms. Plasters placed directly on the third phase filling layers and reused adobes. Absence of large buildings, poor construction technology.
Phase IVc	360 AD 390 AD	Small walls, partial reuse of the early structures, ramps of entrance, large fillings hiding the third phase structures, alternating boulders and bread-shaped adobes.	The walls do not respect the pre-existing tours and they are not integrated with the previous constructions. Use of orange clay plasters. Superposition of squares and large enclosures to previous, partially changing the dimensions.
Phase IVd	390 AD 400 AD	Some areas, such as squares, are remodelled, and a new arrangement of small size internal constructions is made.	Use of poor technical constructive means, employing materials coming from final fillings of the spaces of the previous phases.
Phase V	400 AD 420 AD	Filling of almost all constructions and useof the previous phases buildings exclusively as platforms. Cancellation of the corridors and final seal of buildings.	Intense sacrificial activity of ceramic, animals, plants and humans. Abandonment of the ceremonial centre of Cahuachi, partial use only of the western area as a new ceremonial centre. New type of clay used to manufacture bricks (adobe).

Fig. 15.13 Scheme of the constructive phases of Cahuachi

huarango post sank a meter or even more into the floor, confirming the hypothesis that the columns had to bear very considerable weights due to the roof frame and the internal or lateral decorations. The columns were no more than 2.5 m apart, so as to leave the minimum space possible and make sure the buildings were of impressive dimensions. Fragments of plaster and the remains of the column with reliefs showing figures and painted external surfaces were found during archaeological excavations in the *Gran Pirámide* between 2005 and 2008 (Fig. 15.13).

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Chapter 16
Recent Discoveries in Cahuachi: The *Templo Sur*

Giuseppe Orefici

Abstract Within the monumental complex of Zone A of Cahuachi, the *Templo Sur* represents an important building, connected directly to the *Gran Pirámide* on the east side thereof. This temple was seriously damaged by alluvial phenomena that led to the destruction of most of the ceremonial center, as well as by a very severe earthquake. The function of *Templo Sur* is similar to that of the other temples, although the anomalous dimension of the structures shows greater monumentality. Since its construction, *Templo Sur* has had considerable importance in the life of the religious center.

Keywords Templo Sur · Archaeological excavation · Spatial organization · Geophysical prospecting

16.1 The Imposing Structure of the *Templo Sur*

The *Templo Sur* at Cahuachi is directly connected to the important eastern side of the complex called *Gran Pirámide* and to some of its annexes. It has raised platforms, ceremonial plazas, and side walls that were used during the ritual activities at

With the contribution of Nicola Masini regarding the geophysical part added at the end of this chapter.

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Fig. 16.1 Aerial view of *Templo Sur* during the 2012–2013 archaeological excavations (Photo by Eduardo Herrán)

Cahuachi. In contrast to the structure of the main pyramid in Zone A,[1] whose walls follow the rise and fall of the terrain, the morphology of the *Templo Sur* is linear and seemingly demonstrates the existence of areas set planned within a mainly rectangular shape. Only five of its seven superimposed terraces are visible from the outside, but the last two were located at the northeast end of the eastern side, at the base of the building. These are large and form a temple with well-defined characteristics different, on account of their size, from those of most of the temple buildings at the ceremonial center. Unlike the *Gran Pirámide* and other complexes, the building was abandoned at an earlier period, because the floods that characterized the climate during Cahuachi IV caused greater damage to the structures affected by a strong earthquake that compromised its stability. Consequently, the *Templo Sur* was abandoned, and many of its constructions were destroyed by the same priestly class, which profoundly transformed the original shape of the temple.

[1]The set of structures that forms the core of Cahuachi appears to be enclosed within two large enclosures of perimeter walls, named Zones A and B in the Nasca Project. The first group includes the monumental *Gran Pirámide*, *Gran Templo*, *Templo del Escalonado*, *Templo Sur,* and others, while the demarcation of area B surrounds some temple complexes to the west of the ceremonial center. There is also a Zone C, which coincides with the westernmost sector at Cahuachi, including the entire Estaquería site. This was used during the development of the five architectural phases of the ceremonial center and remained in operation even throughout the last two centuries of Nasca Culture.

The very linear *Templo Sur* building fits into one of two main groups of existing structures at Cahuachi, the so-called Zone A, which was abandoned at some time before Zone B. The latter, which extends much farther westwards, expanded most of all during the last fifty years of the life of the ceremonial center. Unlike the characteristics of the other buildings in the two main areas, this core extended and had walls of great size, which was very unusual compared to all the other buildings excavated and analyzed up to now, but they are contemporary with the main facilities. It is set back from the *Gran Pirámide* and marks the southern limit of the presence of the temple nuclei. In fact, there is no evidence of additional buildings, but only a series of natural hills in an area used by the population as a clay pit to make the *adobes* used to build walls (Fig. 16.1).

16.2 The Construction Phases of the *Templo Sur*

During the excavations that took place between 2012 and 2015, many anomalies were found, if one compares this with the areas of the *Gran Pirámide*, the *Pirámide Naranja*, and the temples, which form the core of Zone A. It is the walls that are of particular note. Their original height is unknown, but they often surpassed three meters in width. In one specific case, on the west side of the *Templo Sur*, a complex of four different walls overlaying each other was found, and together they formed a thickness exceeding 13 m, which also suggests a remarkable height (Figs. 16.2 and 16.3).

As in other structures excavated during the Proyecto Nasca, it became clear that there had been various building phases: the northern area in front of the *Templo Sur* shows evidence of the first and second phases of Cahuachi's architectural evolution; Phase III left the most marked traces in the complex, with a well-defined structure right from its initial design, almost without any later additions; and the fourth phase produced a lesser effect, revealing only improvised restructuring work, albeit of considerable importance in establishing the new functions of the complex and a superficial transformation of the masonry. Major changes occurred during this period of use, especially with regard to the functions that the *Templo Sur* had in the organization of the architectural spaces of Cahuachi.

The current surface area of the *Templo Sur* shows very clearly the traces of the two major floods that marked the end of Phase IV and also the destruction they caused. Large grooves in the wall structures, as well as in the natural layer, illustrate the force of the water that covered the temple complex and the size of the mass of debris deposited at its base, transporting building material and plant remains, possibly some belonging to the roofing materials. The collapse of the roof, as it was possible to note in the south west corner of the fifth platform, was particularly destructive, taking with it large numbers of posts supporting the roof framework, the pillars that held them up, and the large number of bundles of woven plant material that made up the top covering of the roofs.

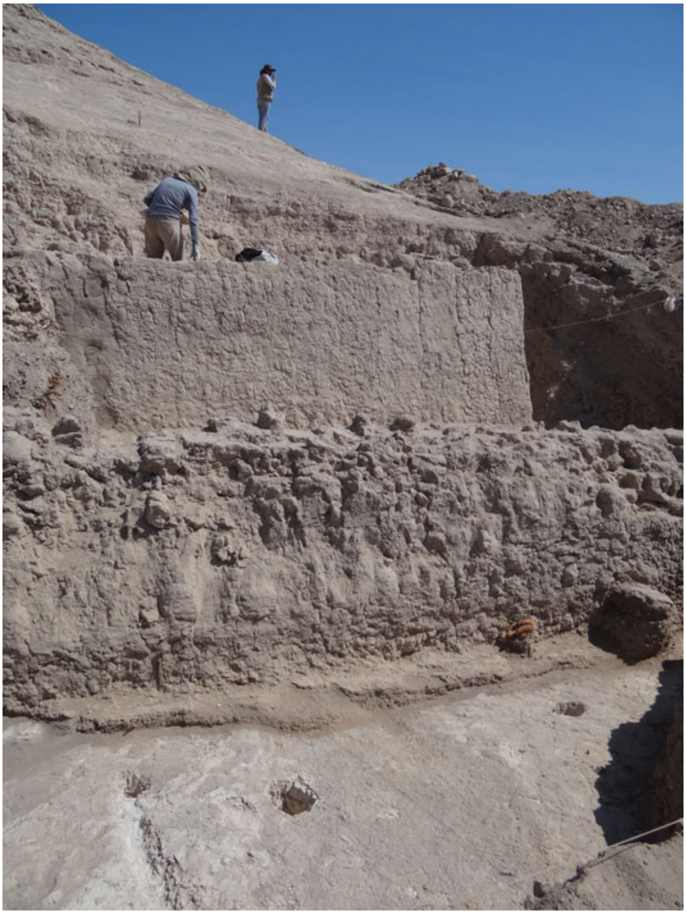

Fig. 16.2 Eastern sector of *Templo Sur*: detail of large perimeter walls (Photo by the author)

The highest platform has been partially excavated and has helped to clarify several important elements: during the first three stages of temple use, the surface was protected by a large roof supported by rows of columns. Each of these supports was circular and was manufactured in the same way as all the columns at Cahuachi: the central core was made from a *huarango* pole, surrounded by one or more layers of clay alternating with protective interlinked canes and, finally, plastered.

During Phase IV, the space was mainly used for ceremonial purposes, with very large offering wells, dug mainly into a layer of natural clay or packed with fragments of *adobe* within the artificial filling material (Fig. 16.4).

Subsequently, during the last years of human presence on the surface of the platform, a structural filling was used which had already been seen at Cahuachi,

Fig. 16.3 View of the four trenches excavated in 2012 (Photo by the author)

namely, the use of multiple circular formations[2] inside the layer of the artificial topping, in order to fill the walkway area with materials from other buildings or from the *Templo Sur*, before proceeding to the final sealing of the building. No offerings were found inside the circular structures, because this was a building system specifically intended to provide roofing for the buildings in front. As for the wells used for offerings dug into the natural clay layer, all materials deposited inside them were removed before they were abandoned and the circular structures were built prior to final enclosure. Equally, most of the small offering wells on the surface of the platform have been found empty and filled only with the material used during the final closure of the structures. The upper platform had several secondary entrances that were used primarily in Cahuachi IV, while the main entrances were located on the east and west sides: they were probably paths connecting up to the *Grand Templo*, located to the west of the *Gran Pirámide* and the main Temple complexes enclosed inside Zone A of Cahuachi.

The sixth platform has a smaller surface area due to a remodelling that occurred at the beginning of Phase IV when it was enclosed within walls of a smaller size, thanks to a rapid restructuring to repair the damage caused by floods and the earthquake that led to the destruction of the *Templo Sur*. The foundations of the

[2]This is a system made up of frusto conical or cylindrical structures constructed from fragments of *adobe* in clay, and subsequently earth and other cultural materials resulting from the ceremonial activities carried out at Cahuachi.

Fig. 16.4 Western sector of *Templo Sur*: excavation of a large artificial filling (Photo by the author)

columns were found at floor level, so during Phase III the surface of this platform, like all the others that have been subjected to archaeological research, was covered by an ample roof. This element also provided the protection for a small ceremonial altar, also with columns of smaller size, eliminated during rebuilding for the last phase of use of the platform. The western side of the sixth terrace had completely different characteristics from the other steps of the temple, considering that the perimeter wall was over 5 m in height and was made up of four different walls side by side, with a base area of more than 13 m^2 No accesses were found, apart from one of average size that was used only during Phase III and was later buried.

16.3 Spatial Organization and Function of Architectural Features

The lower platforms also had quite uniform characteristics, with *quincha* (wattle) walls that divided the spaces into distinct areas and also formed corridors parallel to the terraces, where the priests may have passed through without being seen, moving from platform to platform by means of stairs hidden in the walls. The *quincha* walls were made of clay plastering and earth, which covered reeds bound together by ropes made from plant material. Almost all of these precarious buildings were put up during the Fourth Phase of the ceremonial center, to maintain or to give a new function to the temple, which had been greatly damaged by flooding and earthquake. The highest platforms, on the east side of the temple, had numerous excavations in the natural clay layer, which formed part of a series of tombs used during Phase III and which were probably used for a different purpose before the platform was put to good use during phase IV. The surface of the terraces appeared, during the archaeological excavation, to be an area deeply affected by the floods: the walls were almost completely removed by the water, and the terraces were almost non-existent due to the erosion to which they had been subjected.

On the north side of the temple, there was a large well for ceremonial offerings, which fell out of use during the Fourth Phase and was completely sealed and buried. The third and fourth platforms of the *Templo Sur* had a peculiar feature: there are signs of the first two building phases at Cahuachi, with the use of conical adobe and walls whose orientation differed by almost 30° compared with that of the walls of the later stages. They also showed signs of having undergone significant structural changes to their access routes and used different materials. During Cahuachi Phase IV, the temple terraces were covered with a layer of earth contained by newly installed weak structures used to even out the terrain and level the earlier buildings. The new layout of the walls served to conceal the previous constructions and especially to place large terracotta jars for use as tombs in the soil. The offerings found in the artificial fill used in the temple were few and of little importance, apart from a red-painted, engraved figure representing a female character. The decoration was very detailed. The second platform contained a large square ceremonial enclosure, with walls almost three meters thick. Their height is unknown, but is assumed to have been substantial. The ceremonial enclosure was flanked to the south by a long, wide corridor leading to the eastern façade of the *Gran Pirámide*. Along the route, which was most certainly of ceremonial relevance, two large walls, which had been demolished towards the end of building Phase III to make way for new, more precarious buildings, were found. Numerous bodies of guinea pigs (*Cavia porcellus*), many of them looking upwards, had been placed inside during the alterations to the massive walls.

The peculiarity of the ceremonial enclosure was immediately apparent, since its surface was used as a burial area, though unfortunately it was completely ransacked in the early decades of the previous century. Analysing the contents of the graves there, consisting mostly of partial skeletal, a large number of artificially deformed skulls, some with a tubular–oblique Paracas–type deformation were discovered. Among the items found were fragments of fabric, embroidered borders, and large jars used as containers for dead bodies. Almost all the graves were covered with roofs made from *barbacoa* with *huarango* (*Prosopis pallida*) *logs* placed parallel to each other, while only a small number were in the form of circular pits of various sizes, without any form of covering. A constant observed in all the graves at Cahuachi were *pacae* (*Inga feuillei*) leaves, put in position when the graves were covered over. Twigs and leaves of this plant are constantly found in the tombs and are thought to be associated with the concept of death in people, animals, objects, buildings, or other activities including also rituals connected with the use of hearths.

No graves were found intact, except one that contained no grave goods. The only positive result was that it was possible to collect samples of *huarango* posts used in the coverings in order to obtain a dendrochronology and radiocarbon datings for the larger graves and with characteristics attributable to people of higher rank. The necropolis belonged to two different periods, but, in any case, prior to Cahuachi Phase IV, as attested also by the presence of conical *adobe* in the building on the perimeter and the orientation of the sequence of the tombs similar to that of the oldest walls. The necropolis was built over a previous settlement belonging to Cahuachi architectural Phase II, with signs of perimeter walls in conical adobe.

The first platform of the *Templo Sur* is visible only on the east side, where it stands out for its large size, separating the building from the other groups of buildings at a lower level in the direction of the valley. Floods and the changes made during Phase IV completely covered the first platform on the other sides of the building, leaving traces only of a large entrance on the east side. The use of large columns in several parallel rows supporting the roofs of the platforms was noted during the archaeological excavations in the lower part of the temple, where the large bases in clay and the remains of ancient huarango supports were arranged at regular intervals along the walkways. The NE corner of the first platform has not yet been excavated, but has been identified thanks to the use of remote-sensing technology.

The west side of the building was definitely of great importance, especially on the basis of the presence of elements connecting with the facilities of the *Gran Templo*, located a short distance to the west. It is believed that there was a large connecting route between the two complexes during the third Cahuachi phase, which is the most monumental and, chronologically speaking, the longest. This connection was located at the base of the south side of the *Gran Pirámide* and was possibly also achieved through the use of space that at the same time contributed to the layout of this pathway. The containing perimeter walls of each platform were at least five or six meters high, coinciding with the floor of the next higher terrace; sometimes these walls may have been even higher than the level of the terrace, thus forming a barrier and perimeter for the inner spaces. Some of the walls running parallel to the terraces also served to form passages, thus creating reduced transit areas. Remains of a large roof, which collapsed and formed an important element in the study of the characteristics of the roofing methods at Cahuachi, were found in the SW corner of the fifth platform. After it collapsed, the roof was particularly well

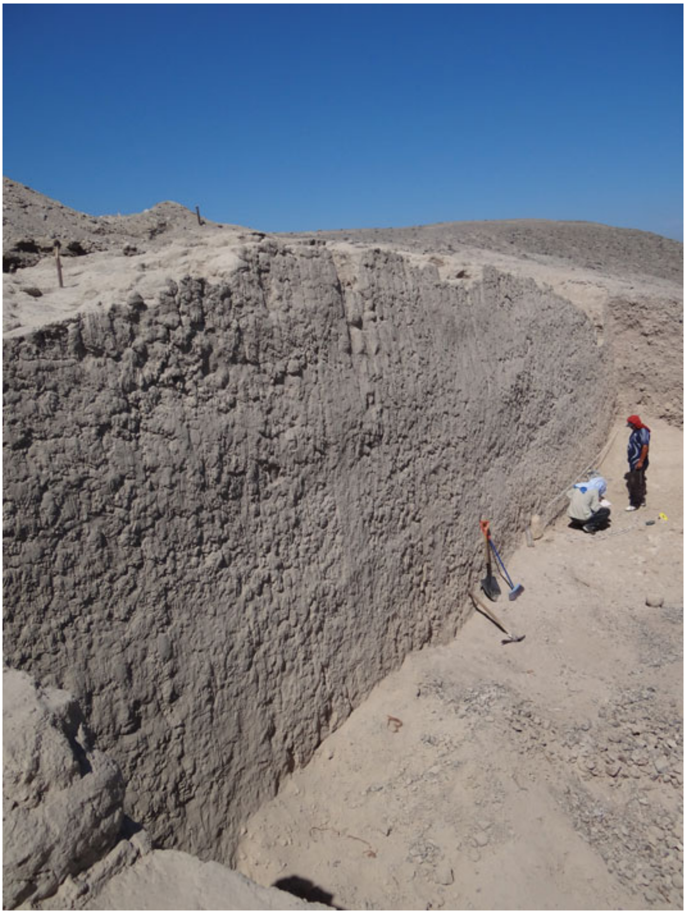

Fig. 16.5 Six-meter perimeter walls on the western side of *Templo Sur* (Photo by the author)

preserved, as it was covered with earth and fallen building materials. It was thus possible to analyze the large posts used to reinforce the roof, as well as the reeds bound together with ropes made from plant material and bundles of grasses used to supplement the wooden scaffolding (Fig. 16.5).

A characteristic shared by almost all the terraces of the temple was the presence of small bi- and trilobate ovens, which were used occasionally and non-intensively. They were probably used to burn plant offerings: in some places these furnaces were very numerous, as in the case of the third platform, where they were found in close proximity to one another, particularly in the NW corner. Both the north side and the walls connecting with the *Gran Pirámide*, were largely rebuilt after floods and earthquakes, in an attempt to re-organize the buildings at the ceremonial center after having been battered by the elements. The new buildings were no longer erected with walls in *adobe*, but with *quincha*, creating very precarious partitions

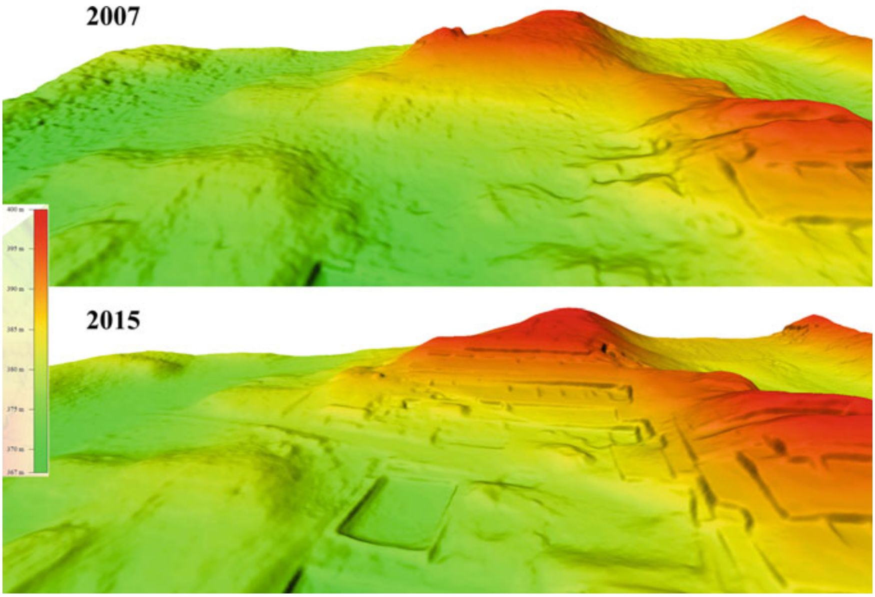

Fig. 16.6 3D DEM of *Templo Sur* in 2007 and 2015, obtained by the processing of aerial images taken from ultra-light aircraft and a drone, respectively (DEM by N. Masini and A. Pecci)

supported by *huarango* posts and reeds bound with cords made from plant material, so as to restore the temple buildings quickly and temporarily. The alluvial deposits to the north side showed the impressive strength of the debris that destroyed the great walls of the platforms in one go, leaving only a deep trough going down to the natural layer, demonstrating the momentum of the flow of water in the direction of the Río Nasca valley. The alluvial material had not yet been removed during Cahuachi Phase IV, given the large amount of matter that the water had dragged away.

The *Templo Sur* was separated, from the other temple complexes making up the great nucleus called Cahuachi Zone A, by a series of ceremonial enclosures, also affected by ancient floods They are located to the NE, and border the facilities of the Y1 complex representing the eastern boundary of the buildings enclosed by the great perimeter walls of this zone. This area ends in a wide platform sloping down to the river, even though today it has been almost totally destroyed by the axis road and agricultural activity. But it is certain that the buildings did not occupy only the known surface area, but were spread out without interruption as far as the cultivated area, continuing along the right bank of the Río Nasca.

The lower platforms of the *Templo Sur* indicate major structural changes during the end of Phase IV, a time in which the imposing structures of the earlier stage were razed to the ground, totally transforming the morphology of the temple. At the start of the archaeological excavations in the area, what was quite puzzling was that there was no clear evidence of temple structures, but only signs of cutting into the

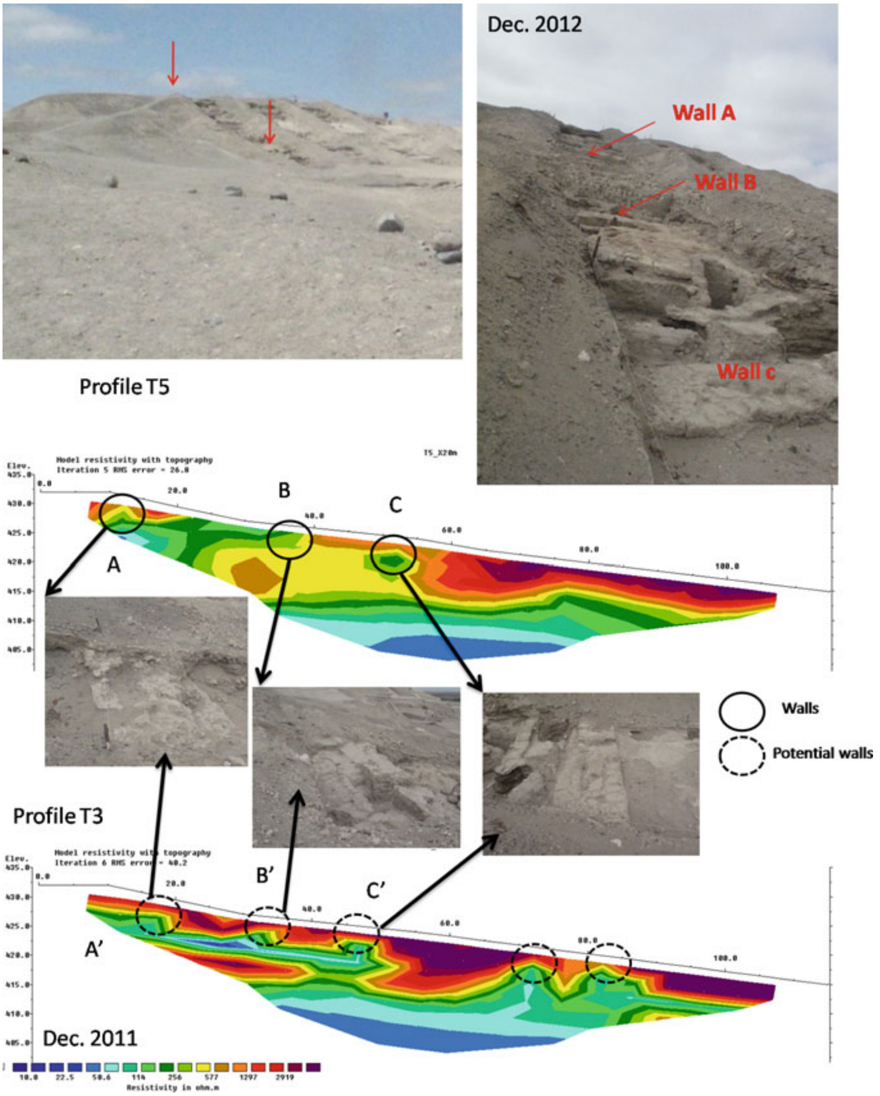

Fig. 16.7 Detection of the pyramidal structure of *Templo Sur* by geophysical prosping. The geoelectrical features are in agreement with the archaeological structures excavated by archaeologists (By N. Masini and E. Rizzo)

natural clay layer in order to create a difference in height between one platform and another, before the wall was erected against it to provide containment. Before the excavations, the outer surface of the *Templo Sur* showed no form of intermediate outline between the top and the base, instead appearing as a sloping side of the building. Digging began with four different, perpendicular trenches to obtain data on the terraced steps and then to proceed in a linear manner to follow new elements that came to light.

A large contribution to archaeological research was made by the geophysical study conducted by Nicola Masini and other specialists of ITACA Mission.[3] By means of the use of various non-invasive methods, including electrical resistivity tomography and ground-penetrating radar, it was possible to know in advance, before the excavations, the geometry of the pyramidal structure of Templo Sur (Masini et al. 2016). Before excavation, the observation of the relief of *Templo Sur* suggested the existence inside the mound of a structure composed of terraced steps and walls (see Fig. 16.6). In any event, the geophysical results enabled to confirmation and acquisition of information about the sizes and depths of the likely-to-be-found buried remains, thus helping the planning of the archaeological excavations. The integration of GPR, ERT, and the ground-truth activity has been an exciting opportunity to improve the interpretation of geophysical data for the detection and the characterization of a buried pyramid built with adobe (Fig. 16.7).

Reference

Masini N, Rizzo E, Capozzoli L, Leucci G, Pecci A, Romano G, Sileo M, Lasaponara R (2016) From remote sensing to geophysics: preventive archaeology in Cahuachi and in the Nasca territory. In: Lasaponara R, Masini N, Orefici (eds) Ancient Nasca world. New insights from science and archaeology, Springer, Heidelberg (chapter 20)

[3]The investigative campaigns directed by Nicola Masini and Rosa Lasaponara took place in 2011, 2012, 2013, and 2015. They consisted of: geoelectrical surveys (2011), acquired and processed by Luigi Capozzoli, Enzo Rizzo, and Gerardo Romano; ground truth verification by Nicola Masini in 2012; georadar survey by Capozzoli and Romano in 2014; and UAV-based surveys by Antonio Pecci in 2015. Giovanni Leucci contributed to the processing of georadar data with the third visualization of iso-amplitudes. Maria Sileo conducted geomagnetic surveys at the bottom of *Templo Sur*, the results of which will be published soon after this writing. For additional details on geophysical surveying in *Templo Sur,* see Chap. 20 by Masini et al.

Chapter 17
Nasca Antaras and Whistles: A Musicological Study

Anna Gruszczyńska-Ziółkowska

Abstract Preserved Nasca ceramic music instruments are numerous. The archaeological finds include the *antaras* or panpipes, whistles, trumpets, and ceramic drums. Mostly the instruments have been found in their ceremonial context, so their qualities have to be expected to be of the highest order. In effect, they tell us much about the skills and knowledge of their builders and confirm that the complex planning procedures applied in their construction set represent an unrivalled standard for instrument making.

Keywords Antaras · Whistle: construction techniques · Nasca musician · Musical practice

17.1 Introduction

Nasca musical instruments are a unique phenomenon not only in the Andes, but among the world's cultures in general. This is because of the material they are made of—namely, ceramics. Advanced ceramic technology, refined in detail at every stage of production, yielded both everyday household objects and special (e.g., ceremonial) items, frequently characterized by highly sophisticated forms and considerable dimensions. Among these objects, there are also ceramic musical instruments.[1] Even those that are broken or only partially preserved can still tell us much about the skills and knowledge of their builders. Their acoustic qualities are of the highest order and confirm that the complex planning procedures applied in their construction set an unrivalled standard for instrument making. Those procedures were grounded in geometry and depended on profound experience in the field

[1]Instruments made of other materials, such as cane *antaras* and *kena* bone flutes, are only sporadically found among the archaeological artefacts.

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of acoustics (naturally—as an empirical discipline in this case). The preserved musical artefacts demonstrate distinct links between Nasca and the traditions in which that culture was rooted. At the same time, though, the original, innovative, frequently even revolutionary, solutions evident in the instrument construction bear ample witness to the substantial developments that occurred in that culture, both in the field of ceramic production technology and that of empirical acoustic knowledge.

Some of the instruments have been found at burial grounds, preserved as grave goods, but the largest and most varied collection of comes from the ceremonial center of Cahuachi.[2] The creative and innovative craftsmanship of Nasca instrument makers was quite likely inspired by, and catered to, the special needs of the ceremonial centers. The instruments they made were later smashed as part of the ritual, and their broken fragments—deposited within the temple precincts as sacrifices (Fig. 17.1). Today the best known and numerous Nasca archaeological finds include *antaras*, or panpipes. No less precious among the ancient Nasca instruments are the anthropo- and zoomorphic whistles, trumpets with straight cylindrical tubes, and conical bells, as well as ceramic drums of all sizes—from small hand-held ones, to large standing kettledrums.

17.2 The Antara

A*ntara* panpipes consist of several to more than a dozen stopped edge-blown pipes, arranged stepwise in a row, from the shortest to the longest.[3] The pipe, though basically cylindrical, has a complex structure and is not uniform in diameter. Depending on the construction of the pipes (as the acoustically most important parts of the instruments), as well as on the way they are bound together, we can distinguish two types of *antaras* among Nasca finds.

The first of these—and most likely the earlier—is often referred to as the "Paracas model"[4] or the "Paracas–Nascoide".[5] It can also be generally described as the "pre-Nasca type", or—without reference to cultural relations, but only with

[2]This paper, like all my texts on Nasca music, makes use of empirical material collected during research in the Centro Italiano Studi e Ricerche Archeologiche Precolombiane in Brescia, as well as the "Proyecto Nasca" (Filiale CISRAP en Nasca) supervised by Dr Giuseppe Orefici. The research was made possible by collaboration between the Center for Precolombian Studies, University of Warsaw and CISRAP, and co-financed by the Polish Ministry of Science and Higher Education (projects: 1 HO1G 016 11; 1 HO1H 011 16; N N 109 217835) and the Institute of Musicology, University of Warsaw.

[3]After the Revision of the Hornbostel-Sachs Classification of Musical Instruments by the MIMO Consortium: 421.112.2 Stopped panpipes (http://www.mimo-db.eu/LinkedData/default.aspx?lex=4573, accessed in May 2015).

[4]Bolaños (1988).

[5]Pérez de Arce (1993).

Fig. 17.1 Musical instruments (*antaras*) in archaeological context (Cahuachi, Sector Y13)

regard to its characteristic feature of construction—as an "*antara* with composite tubes". The pipes consist of three or—less frequently—two elements,[6] usually connected by binding material in such a way that the shapes of the individual elements are clearly visible. The Cahuachi finds also frequently include *antara* fragments bound in a different manner, in which the pipes appear to be "sealed" in the binding material. They are wrapped in the binder in such a way that the smooth

[6]In tripartite pipes, the proximal (inlet) section with a round blowhole is slightly narrower than the central part and merges into a slightly elongated, narrow distal section. The construction of an instrument consisting of several pipes depends on the parallel placement of the wide central sections of the pipes and on bending the narrower sections so that their blowholes are placed close to one another, and the proximal ends of the pipes lean together towards the axis of the longest pipe. Another, slightly different, solution applied in bipartite pipes is to place the top (wider) sections parallel to one another and to direct the ends of the lower (narrower) section towards the central axis of the instrument.

Fig. 17.2 *Antaras* with composite tubes (Cah05 Y8 Exp.116)

and uniform surface of the instrument bulges only slightly in a few places.[7] This group of instruments demonstrates the following construction features:

- composite (tri- or bipartite) tubes, non-uniform in diameter;
- round blowholes;
- the wide sections of the pipes are parallel, and the narrow parts arranged in a radial pattern;
- the spaces between pipes are filled with binder;
- the wing is formed as a kind of extension to the binder;
- the shapes of the pipes are more or less distinguishable in the external form of the instrument as a whole (Fig. 17.2).

These instruments are relatively small (from one to about two dozen centimeters) and the number of pipes is limited (to ten). Many instruments have two small holes

[7]These *antaras* include instruments with distinct individual "sculptural" forms. Only small fragments of such sculpted *antaras*—not sufficient to reconstruct the complete form—can be found among the Cahuachi finds.

bored through the binder between the pipes (usually the outermost ones). It has been suggested that a rope to hang the instrument was pulled through these holes.

Instruments of this kind, known from Cahuachi, are a continuation of design concepts characteristic of the South Andes,[8] but with some unique features typically found in Nasca *antaras*: high-quality, sometimes very delicate clay; precisely moulded pipe shapes; a carefully prepared slip coating (engobe). The *antara* ornamentation often resembles the Paracas style, but the quality of production is closer to that of Nasca instruments. They were undoubtedly used in the period when Cahuachi functioned as a ceremonial center. It is even possible that their production was parallel to that of the Nasca-type. They seem to have been associated with the special function of Cahuachi as a ceremonial center, whose influence extended over a large territory, and with the presence of pilgrims coming from distant regions.

The dominant *antara* type with cylindrical pipes, characteristic of the Nasca culture, can be termed "Nascan", as it is an original product of that culture. It is characterized by the following features:

- cylindrical pipes with a short inlet section tapering toward the end;
- oval-shaped or fusiform blowholes;
- parallel placement of the pipes, which do not touch one another;
- thin binder, which leaves air-filled spaces between the pipes;
- a separately formed, flat wing.

Antaras of this type are in the majority among Cahuachi finds. They represent a well worked-out and tested, uniform, and recurrent type. Naturally, there are also individual peculiarities (e.g., in the composition of the clay, shape of the blowholes, or of the wing edge), but these should rather be considered as variants testifying to the individual skills of different craftsmen or to the different provenance of the instruments. Such differences can be found not only in objects from different archeological strata, but also in those thatch once formed one offering. This suggests that instruments for the Cahuachi rituals were produced by different ceramic workshops, an observation which adds significance to those features that the *antaras* had in common and especially to their musical qualities and features of construction that determined their acoustics. These qualities and features are remarkably consistent and prove that different potters applied the same models and standards.

17.2.1 The Making of the Instruments

Two important elements of construction ought to be considered that are of considerable importance to the musical qualities of the instruments. The first of these

[8] Pérez de Arce (2002).

Fig. 17.3 Broken-off elements of *antara* with evidence of the use of resinous glue

elements was the excellent quality of the ceramics: hard, durable (not brittle),[9] and light, with smooth walls of nearly identical thickness (Fig. 17.3). The *antaras* are frequently filigree work.[10] The second significant quality is the perfect precision evident in the moulding of the pipes and the entire instrument.

Among the wealth of archaeo-musicological material, there are numerous finds of unique significance, e.g., fragments of (Nasca-type) *antaras* made of clay, hardened by drying but not fired. Some of them are nearly complete instruments ready for firing, while other finds consist only of individual pipes or small partially formed *antara* fragments. All of these are unfinished instruments whose production was at some stage interrupted. In this state, they provide valuable information about the development of musical ideas,[11] since they illustrate the various solutions developed by Nasca instrument builders in response to construction problems. The unfinished instruments also provide us with excellent documentation of the entire *antara*-building process. They indicate that before firing the instruments went through four construction stages: preparing the ceramic material, forming the individual elements, binding the elements, and coating the surface with slip (Fig. 17.4).

The material was high-quality clay. The pipes themselves were formed out of very delicate fine-grained clay. There is much variety in the composition of the clay, which suggests that the instruments came from different workshops.[12] The

[9]The broken fragments can easily be reconnected. The Nasca people took advantage of this feature to mend instruments, most likely damaged by accident. The broken-off elements were re-attached using a resinous glue. The effects must have been satisfying, since this method was even used to mend damaged *antara* pipes (Fig. 17.3).

[10]One of the *antaras* found in 1995 had a pipe wall just 1-mm thick (the measurement for the short pipe; naturally, the longer pipes had thicker walls).

[11]These finds suggest that Lawrence E. Dawson's popular claim concerning the use of slip casting technique by Nasca instrument builders (Dawson 1964) ought to be considered verified. Evidently, the instruments were moulded manually. It is true that the cylindrical pipes that constitute the main element of construction are smooth and their walls are usually more or less uniform in thickness, but they demonstrate many features that can be viewed as evidence in favor of the manual moulding hypothesis, such as: scratches and marks on the inner surfaces, and especially, the modelling of the proximal and distal ends of the pipes.

[12]This is even true of instruments that belong to the same sacrificial context (such as the temple offerings from Sector Y13 in Cahuachi).

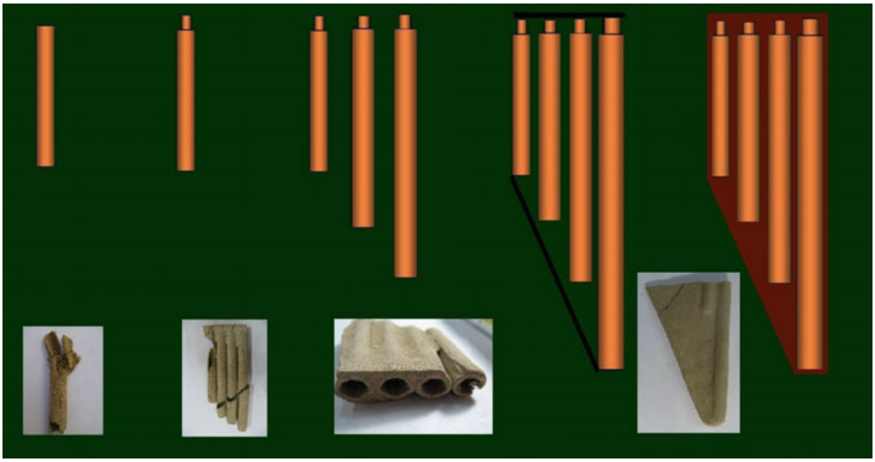

Fig. 17.4 *Antara* construction stages

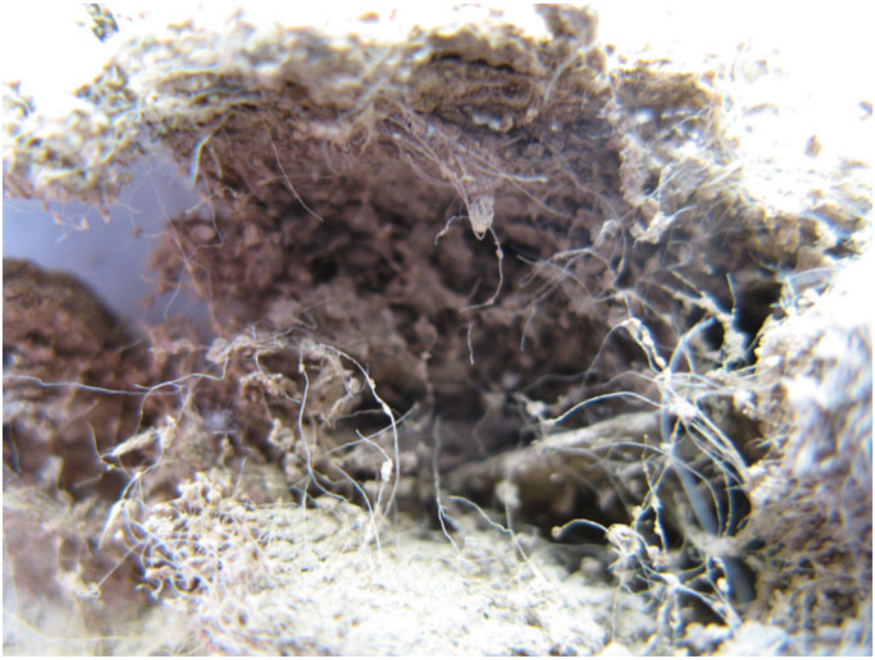

Fig. 17.5 Delicate and soft, organic material (cotton flowers) was an element of the clay

clay always contained an admixture of delicate and soft, organic material such as animal hair or cotton flowers, which made the ceramic subtly porous—possibly not without impact on its acoustic qualities (Fig. 17.5).

Thanks to the porosity of the material, the instruments were also light, which may have been important for performance practice. Iconography shows the use of *antaras* by dancing musicians. Small *antaras* of the older type could easily be carried around. The Nasca builders, however, introduced important changes not only in the construction of the *antaras*, but also in their size: the newer-type instruments have two to three times more pipes and are even four times larger. At the same time, they are relatively light: for instance, the largest of the hitherto discovered *antaras*, nearly 90 cm long and composed of 15 pipes, weighs as little as 2.2 kg.[13]

The pipes were moulded first. Most likely, this was done using stalks of appropriate length and thickness.[14] A clump of clay thinly and evenly rolled out was then wrapped round the stalks. The distal end was sealed.[15] The half-open pipes formed in this manner were later partly dried, and the stalks carefully pulled out.[16] After the removal of the stalks, the mouthpiece of each pipe was formed by narrowing its open end. Simultaneously, the fusiform or oval blowhole was formed.

Decisions concerning the tuning of the instrument had to be taken at the stage of moulding its individual pipes, when all their dimensions were planned: the length of each pipe and its ratio to the length of the tapering proximal (mouthpiece) section, as well as the proportionate pipe diameters and the relative wall thickness. The material recovered by researchers demonstrates a direct geometrical proportion between these dimensions in all the *antaras*, which confirms that the instrument builders were aware of the acoustic significance of pipe dimensions and wall thickness.

Ceramics shrink in the firing process. All the same, the surviving “finished” fired *antaras*, on which sound can still be produced, demonstrate a fine and precise tuning. It should be assumed, then, that the constructors were well aware of the degree to which the material would shrink and could predict the final effects. It is hard for us to establish what criteria were used to estimate the pipe length while it was being formed of raw clay, but most likely the craftsmen made use of some models or conversion patterns.

Thus moulded and dried (to protect them from chance deformations), the pipes were arranged in a row and bound together. The binder, as well as the flat “wing” of the instrument, was made of less fine-grained clay with the addition of mica and crushed ceramic. The binding technique seems to have been carefully worked out. The tube walls do not touch. A very thin air channel left between the pipes cushions the vibrations. In this way, the vibrations of one pipe do not affect the adjacent ones, but, at the same time, the pipe walls can resonate quite freely. As spaces are left

[13]Cah 95 Y13 Exp. 55 Antara 7.

[14]Made, for instance, of the cane of the species *Gynerium sagittatum*—popular in this region and highly versatile in use.

[15]The bottom parts of the pipes’ insides are irregular, frequently with various marks and protuberances.

[16]On the inner pipe walls, one can frequently see diagonal scratches suggesting that the pipes may have been rotated around the stalk.

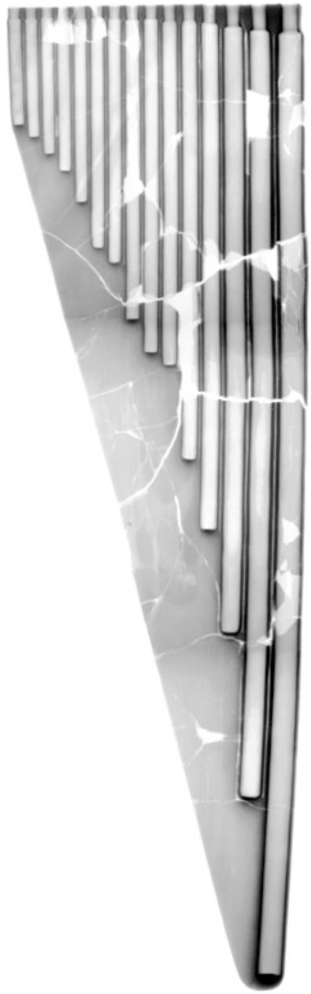

Fig. 17.6 Radiography of the *antara*

between pipes, and the binder is laid only on the bottom and the top of the instrument, the wing must take over the function of the *antara*'s backbone (Fig. 17.6).

Before firing, the instruments received a slip coating. The dominant colour of the Cahuachi *antaras* is that of claret, appearing in all kinds of tinges and shades (from brown to red). This subtle diversity of color—similarly diverse as the varied clay components and different shapes of blowholes and wing edges—may suggest that the instruments came from different places. Most of them had monochromatic decorations: a uniform background, with a different color for the top edges of the blowholes, and a frequently black, more rarely, white strip along the row of blowholes. There are also multicolored *antaras*, some with identical or similar decorations for the top and the bottom of the instrument, some with the top side quite different from the bottom side. The instrument decorations most likely had primarily symbolic significance.

17.2.2 Performance Practice—the Instrument

Of fundamental importance to any discussion of the musical practice is one crucial detail of the *antara* pipe construction—namely, its bottle-like shape (with a tapering proximal or inlet section). This shape means that two fundamental frequencies are produced simultaneously, and, since they are close frequencies, they will be dissonant. Blowing with moderate strength into a single pipe produces a dissonance audible mainly in the top registers. The dissonance results in the appearance of additional partials enriching the sound, which gives the impression of being rather unstable and oscillating. A more distinct beat effect can be achieved by blowing harder, especially into the pipes tuned to lower frequencies.[17]

When considering this feature of the *antaras*, we return to the question of Nasca inventiveness and the technological revolution that occurred in the field of *antara* construction. The older type of *antaras* (with composite tubes) is characterized by a sharp sound.[18] By blowing relatively strongly, we can produce a sound with a wide ambitus that exceeds the top limit of the human hearing range (so that ultrasounds are produced) and also reaches the bottom limit (the infrasound range). This sound consists of a dense band of frequencies from inside and outside the harmonic series. Some of the partials (especially the lower harmonics) appear as double or even triple and much more prominent than the others. The individual partials enter into "interactions" (producing, e.g., beat frequencies and resultant partials). This leads to the appearance of a kind of background noise (intensified colored noise) over the entire frequency band. The dramaturgy of sound formation is even more complex. What is important is not so much the combination of partials as the development of sound, i.e., the sequence in which the individual partials are fading in (phase α transients) and then fading out (phase β transients), as well as the relative intensity of the partials. Slightly different sound qualities are obtained by blowing moderately so as to identify the strength of the blast at which air vortices form inside the

[17]It has been assumed that beats occur when the frequency difference $\leq$ 10 Hz. Unfortunately, the state of instruments' preservation makes it impossible to test the original low-register tones with regard to the occurrence of beats. It should be stressed, however, that, among the finds dated to the final days of Cahuachi as a ceremonial center, there are many large instruments, which suggests a tendency to search for lower-range tones (down to ca 100 Hz). It has been calculated that the longest pipe of the largest known Nasca instrument (Cah 95 Y13, Antara 7, pipe No. 15) emitted tones of f_1 = 95.4 Hz and f_2 = 98.5 Hz; a frequency difference of about 3 Hz would have been highly favorable to the production of beat frequencies.

[18]José Perez de Arce compared the sound of composite tubes, typical of instruments from the South Andes, to that of the Chilean *pifilca*. That sound, called *sonido rajado*, is "loud, strong and dissonant, with a great vibrato. Its harmonic structure extends from low frequencies to high upper partials" (Pérez de Arche 1993, 2002: 292).

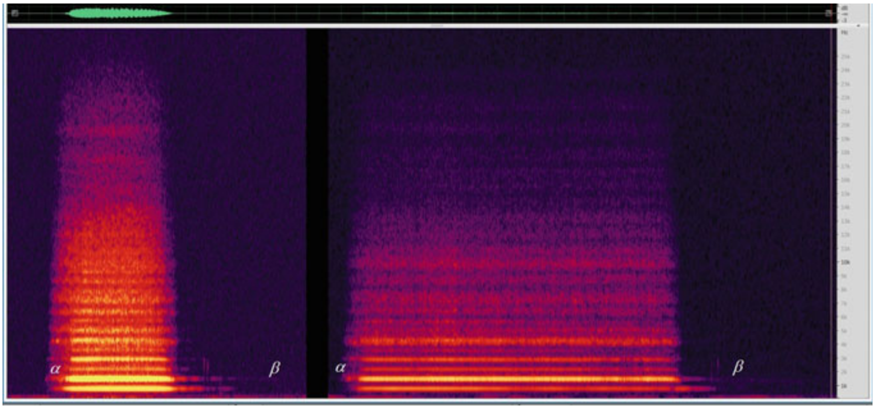

Fig. 17.7 *Antara* with composite tubes. Strong blowing versus light blowing: different combinations of partials and transients

pipe. The transients are shorter here, and a different group of partials becomes amplified. Additionally, the effect of pulsation or slight vibrato appears on various levels of sound. Yet another effect is produced by blowing lightly: the individual natural harmonics (also the top-register ones) become more easily distinguishable, but the sound without interference is much poorer and more stable (Fig. 17.7).

The development of a new type of *antara* did not mean that the Nasca musicians gave up the sonorous dramatic effects and stopped playing their "games" with sound. Quite the contrary—the invention of the peculiar bottle-shaped pipes helped achieve such effects. What is more, the number of possible combinations was significantly increased thanks to the larger number of pipes/tones (up to more than a dozen), the wider instrument ambitus (up to 2–3 octaves) and the introduction of twin *antaras* (Fig. 17.8).

An important feature of each *antara* is the individual selection of pipes, which results each time in a different series of tones.[19] A certain regularity can be observed here: in a given instrument, the higher octave repeats in principle the tone sequence from the lower octave, save that it comprises a greater number of sounds. The higher octave thus contains pairs or even "trios" of sounds very close to each other, sometimes only at micro-intervallic distances (40–60 cents), and these groups are separated by larger skips. There are no "perfect" octaves on the *antaras*, and quasi-octave relations are a rule. These minimal deviations, which give the interval a certain sharpness and a different color, are not accidental, but evidently planned and calculated.[20] There exists, then, a certain model for constructing the tone series based on repetition, but also on the division and chromaticization of intervals from

[19]The sequence of intervals between successive tones, and the way these intervals are grouped, though individualized in detail, usually tends toward tritone relationships.

[20]Examples of octave (the basic ratio of 2:1) "coloring": 61: 31; 63: 32; 81: 40; 92: 47; 109: 56; 143: 70.

Fig. 17.8 Twin *antaras* (Cah95 Y13)

the lower register in the higher one.[21] This tone series should undoubtedly be considered as a musical whole and may be interpreted as the sound of an instrument with a potentially melodic function.

Still another phenomenon that may have a bearing on the interpretation of Nasca performance practice is the existence of twin *antaras*. Such pairs of instruments have been found in a shared archaeological context, and their features, both musical (identical pipe/tone series) and visual (identical decorations) provide strong

[21]For instance, if the lower register series is represented as X-Y-Z-A…, in the higher register it may assume the form of: x′-x″-y′-z′-z″-z‴-a′…

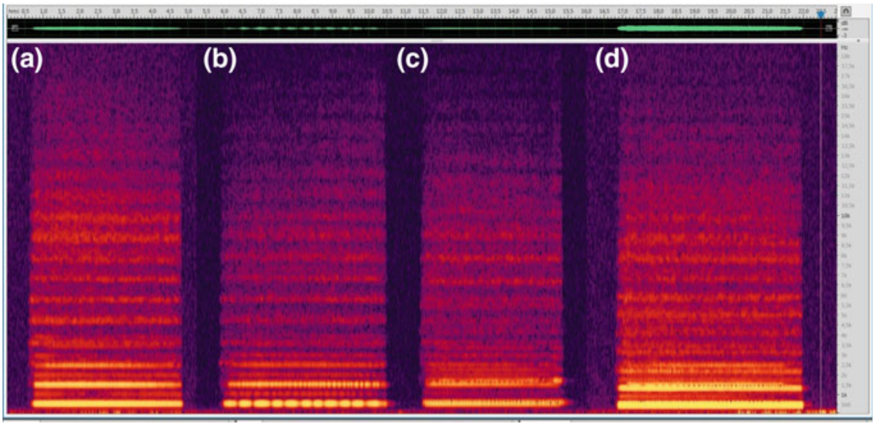

Fig. 17.9 Various kinds of dissonances: **a** a moderate blast of *antara* solo, pipe No. 2: the "double" nature of the sound makes it unstable and slightly fluctuating. This quality is not detectable on the level of the lowest partials, but clearly evident in the higher registers. Since it occurs in a relatively wide range of frequencies, it determines the overall impression of the fluctuation of sound as a whole. **b** A duo of twin *antaras*: two pipes No. 2—blowing simultaneously into two pipes with identical tuning results in a highly interesting effect. The two frequencies produce interference, and the sound is perceived as a pulsation—a kind of *vibrato*. **c** A duo of twin *antaras*: pipe No. 2 and pipe No. 1—blowing simultaneously into two adjacent pipes whose frequencies are at the interval of about a whole tone (213 cents). **d** A duo of twin *antaras*: pipe No. 2 and pipe No. 3—blowing simultaneously into two adjacent pipes whose frequencies are at the interval of about 1.5 tone (284 cents)

evidence for close links between the instruments in each pair.[22] A duo of such instruments offers more opportunities for sound development than in the case of *antaras* with composite tubes. As in the latter, we can produce a stronger blast, but we can also take advantage of tone chromaticization in order to subtly differentiate combinations within the available complement of harmonic relations, to modify interferences, to model dissonances of various kinds, to diversify the *vibrato,* and to prolong transients (Fig. 17.9). The scope of possibilities is also increased two–three times by the wider ambitus and by the multiplication of sounds.

The high quality of Nasca instruments justifies the claim that their sound was considered to be of utmost importance. If the Nasca culture cherished sharp dissonant harmonies, beats, and unstable tones, then the *antaras* can be regarded as excellent instruments for this purpose. They apply a tone system that is natural and simple in principle, derived from an arithmetic—geometrical procedure that depended on the multiplication of the pipe length. Thanks to the wealth of invention

[22]Nasca iconography suggests that harmonies occurring between instruments ought to be considered. This is evident in representations of musicians playing duos. That the subject is a relevant one is also confirmed by Andean music performance tradition, with its typically collective music-making and pairs of instruments (or their multiplications) as the basic units in ensemble line-ups.

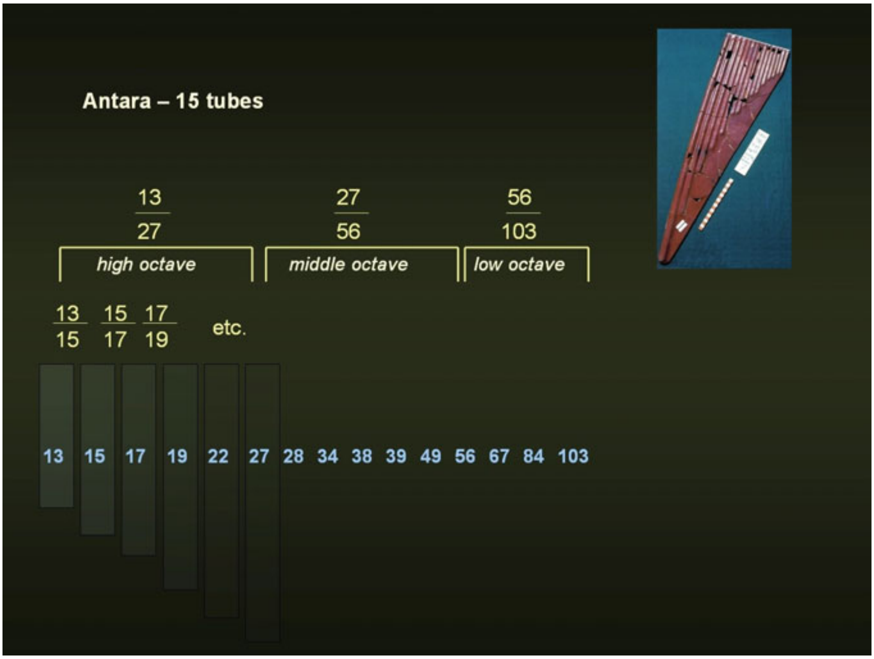

Fig. 17.10 *Antara* composed of 15 tubes: series of the relations and the structure of the octaves

exhibited by musicians and/or instrument constructors, this simplicity was somewhat concealed, and the whole tone system attained a degree of complexity owing to the build-up and multi-layered accumulation of such multiplication procedures. It needs to be emphasized, though, that all the manifestations of that complexity—such as the two distinct tones produced by each pipe, chromaticisms, quasi-octave relations, and twin instruments—are well contained within the basic system. Such an approach indicates that the use of diversified and overlapping dissonances was governed by a highly sophisticated and precise plan (Fig. 17.10).

17.2.3 Performance Practice—the Musician

Musicians appear in Nasca iconography usually in the context of ritual actions. Painted faces and metaphoric attributes—and sometimes also the context itself—indicate that musicians were not mere "producers" of sounds, but were deeply involved in the ritual activities. It is recommendable, therefore, that the performance practice be considered, first and foremost, from the perspective of the performer. We should consider three aspects which together form the full complex of acoustic—aural—mental phenomena: the physical sound, its reception, and its subjective impression. The sounds produced by a wind instrument are strongly internalized by the performing musician. This is natural because the musician's head and the source of sound enter into close contact, but another element also plays a major role: the vibrations activate not only the sense of hearing, but also the musician's sense of touch. The emission of sounds characterized by high intensity and variable dissonance is, therefore, of considerable importance to this phenomenon. Iconography provides interesting clues concerning the techniques that musicians may have used in order to intensify the impression of dissonance: for instance, an *antara* player holds the instrument in one hand, and rests the fingertips of the other hand on the head around his ear. Some representations show a musician putting a kind of tube or even a sizeable container to his ear.[23] Such an additional resonator would have created minimal differences in the timing of sound reception by one and the other ear, but it could also result in a different perception of the intensity of individual partials. There are also other representations that prove that music was used to create trance states *par excellence*. These include images of musicians accompanied by the column-shaped cactus *trichocereus pachanoi* (called *achuma*). *Antaras* fly around the musicians, penetrate their bones and joints, and squeeze into their ears; the images of the *antaras* and the cactus overlap; musicians play near a huge cactus with an antara lying at its foot. These are examples of the evident combination of powerful auditory experience and the effects of mescaline, which stimulates first of all the sensory centers responsible for visual perception.

17.3 The Whistle

The Nasca whistles are tiny instruments, about 6 cm in length. We can distinguish single-chambered (one-tone) and dual-chambered (two-tone) whistles. Their fundamental frequencies fall within the range of 3–4 kHz: these are high registers, but still inside the frequency band for the maximum sensitivity of human hearing (up to about 5 kHz). Their numerous partials, which appear in an orderly sequence, reach the ultrasound range.

The important elements of whistle construction are: a resonating chamber and an air duct. These two elements are moulded separately and then contained in a sculpted instrument body which also functions as the binder. For sound wave formation, the key stage is the moment when the air-stream hits the edge of the chamber, resulting in turbulence. Part of the air enters the chamber, where the sound is formed, and part is released through a window in the instrument body. The relative position of these two elements of construction is, then, of crucial importance, as also is the way in which the air-stream is directed towards the edge.

By comparing archaeological finds which can be dated approximately on the basis of their context, we can observe rather significant differences in the construction of both acoustically significant elements of the whistle as well as in their placement in relation to each other. As a consequence, we discover a tendency to

[23]Martí (1970: 166).

Fig. 17.11 **a** Double whistle *Silbato negro* (Cah87 Y5 Exp.16). **b** Double whistle *Pájaro* (Usa89). **c** Whistle *Felino 2* (Usa89)

introduce changes in the manner of sound production and formation. In whistles dated to an earlier period, the air ducts and the inlets of the chambers are wider than in later instruments (Fig. 17.11a–c). They are placed at such an angle to each other as to make the air-stream hit the inside surface of the top wall of the chamber. In whistles from a later period,[24] we can observe the introduction of narrower air ducts, which compress the air powerfully as it is directed toward the chamber. The inlet of the chamber is also narrower, the angle between the air duct and the chamber wider, and the air leaving the air duct hits the lower edge of the window. Acoustically, this

[24]In single-chambered whistles, this change can also result in a wider upper formant range, while in double-chambered whistles it can lead to the individualization of partials and a change in the resultant interference. In the "older" whistles, the two sounds, separated by a relatively small interval, produce a beat frequency, and a similar phenomenon occurs between their upper partials (*Pajaro*: ¾ tone—155 cents, *Silbato negro*: approx. a quartertone—63 cents). In the "newer" whistles, where the interval between the two tones is much wider, the interference creates series of new partials which make the sound "denser" (Hombre 1: a major third—422 cents, Hombre 2: an interval between a major second and a minor third—265 cents). The durations of transients also change, especially in the decay phase (phase β). In the "older" instruments, those durations are much longer than in the "newer" ones.

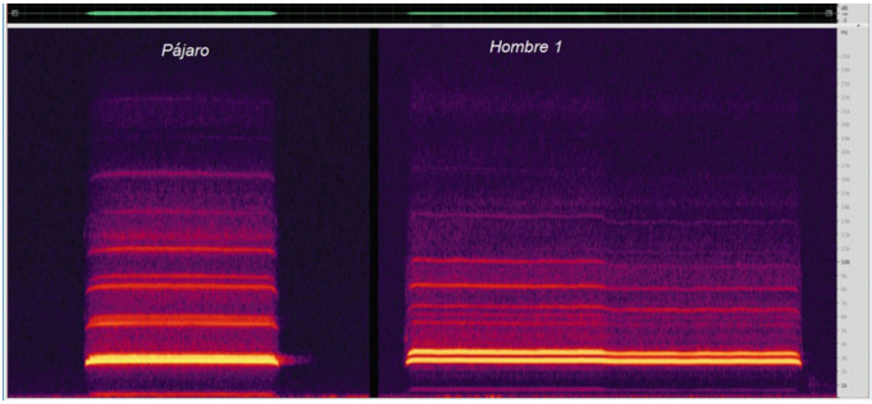

Fig. 17.12 Sounds of two double whistles compared: the "older" type (*Pájaro* from Usaca) and the "newer" one type (*Hombre 1* from Cahuachi Sector Y1)

change results in a different make-up of the sound produced: the number of clearly distinguishable partials is increased and the ambitus becomes wider.[25]

Similarly to the *antaras*, the whistles were built with utmost precision. This is corroborated not only by the surviving archaeological finds that can still emit sound, but also by a quite large collection of unfired clay whistles that provide an excellent illustration for the various stages of the construction process, as well as an insight into the details of the instruments' internal structure.[26] The type of clay, the shapes of chambers and air ducts, and the way these are embedded in the final instrument (i.e., the modelling of the binding material) make it possible to conjecture that, for the construction of the whistles, the Nasca instrument builders used the same experiences and principles that determined the construction of the *antaras*.

One of these principles concerns the moulding of the chambers. They are cylindrical, tapering toward the proximal (inlet) end, which gives them the shape of a bottle. This shape results in the appearance of two equally prominent fundamental frequencies (and their partials), producing a sound that is slightly oscillating and unstable. This feature gives particular sharpness to the sound of the double-chambered whistles, with their dissonant tuning and numerous harmonic and in harmonic partials, capable of producing additional effects in the form of *frullato* and beat frequencies, and—in some specific cases—even frequencies that could be interpreted as sub harmonic.

The second similarity between the construction of the double whistles and that of the *antaras* is the rather careful separation of both chambers and air ducts from each other. This is achieved not only by wrapping them separately in binding material, but

[25]Figure 17.12.

[26]This whistle collection (Cah08) is a uniform one, and the degree of completeness (even of the smaller fragments) seems to indicate that all of them went through the complete set of moulding and drying stages.

Fig. 17.13 Fragment of the unfired clay double whistle

also by leaving empty air-filled spaces between them (Fig. 17.13). The spaces function as insulation and an air cushion that reduces the transmission of vibrations to other parts of the instrument, but also prevents the deadening of vibrations and allows the air to vibrate freely. It was possibly due to this very element of c-construction that the Nasca instrument builders were capable of producing so many clearly outlined partials, whose series extended far beyond the range of human hearing.

The sculptural form of the whistle is highly suggestive and complemented by color decorations. Generally, one ought to speak of anthropo- and zoomorphic forms. A more detailed analysis of the visual aspects of the whistles is likely to bring many surprises, though. The represented figures are in fact hybrids; what attracts the observer's attention is not so much the ambivalence of expression inherent in the individual visualizations as the profound ambivalence of content. It seems that Nasca artists played a kind of "game" here, analogical to that apparent in the sound material, which stimulated the mind by creating optical illusions.[27]

We could say that the Nasca instrument builders controlled the observers' reactions in a masterly fashion. The first general impression results from the sculptural form and dominant color of the object (e.g., a black swift, a red fox, a

[27]Interestingly, in Europe this kind of art gained particular popularity in the 19th century (though a similar approach is already evident, e.g., in the paintings of Hieronymus Bosch), when psychologists began to use optical illusions to examine and control various parts of their patients' minds.

man in a cat's mask). After a while, however, one begins to notice details and surprising aspects of representation, which make one question the validity of the original identification and look for hidden clues (e.g., the swift has a condor's ruffle, the fox's snout turns out to be a hood above a human face, and the man in a cat's mask is in fact a cat). Also this interpretation, however, though relevant, is by no means the final one and does not invalidate the first impressions. As a consequence, the observer engages in another intensive round of analysis, and the observer's view gains more and more depth as new clues are collected and considered. The suggestiveness of those incomplete, partial clues inspires our reasoning despite the awareness that the clues themselves are mutually contradictory.

One example is an anthropo-zoomorphic whistle.[28] At first sight, it seems to represent a human figure holding some kind of vessel whose inside is perfectly carved and originally most likely contained some applique (a precious stone, a shell, or a similar object). What attracts the observer's attention is the figure's gesture and the object inside the vessel. However, when we turn the instrument around (e.g., in order to produce sound) we suddenly realize that it is, in fact, an animal: a cat sitting with a lowered (red) tail. In order to verify our first impression, which are now at odds with later observations, we look at the cat *en face* again. Though we still see a man, we now notice his feline traits. Therefore we accept a compromise: it is a man dressed in a ceremonial robe imitating a cat figure, and, in particular, he is wearing a *Felino* mask. In order to confirm this impression, we then look at the whistle from behind again, expecting to see a human figure in a peculiar garment. We can see the details of the garment, but we are in for yet another surprise: rather than a man in a cat costume, it is a cat dressed in a special costume. We can clearly see the bands crossing on his back and genuine cat's ears stick out above the mask… And so, we conclude, it is a cat dressed in a human garment that imitates some feline creature… But what will be the next stage in this process of interpretation? Naturally, we will look at the figure from the front again, the turn it round again, and again… (Fig. 17.14).[29]

[28]Cah97 Y1 Exp60 Q4 Capa A al N del Muro 2 Nivel 5–Hallazgo 1; the whistle is referred to here as *Felino1*.

[29]That this kind of playing with our senses is not merely accidental and the observer's impressions are carefully controlled is confirmed by another, most likely slightly earlier, find: a very similar anthropo-zoomorphic whistle demonstrating the same kind of dimorphism (a man in a cat's mask, who is at the same time a felid: Usa89 Exp. 1). A similar dimorphism can also be easily observed in other Nasca whistles, such as the anthropo-zoomorphic, dual-chambered whistle from Hamburgisches Museum für Völkerkunde (Hamburg 57.57: 452). From the point of view of overall form, it represents a bird; still some of the details of representation, enhanced by colour, make the movement of the wings look like a human gesture: e.g., the right wing leans forward and is bent like a human hand. At the same time, the bird's head is in fact a human head in a mask or with a strip of paint across the eyes, and it is covered with a hood-decoration in the shape of a bird's head (Purin 1990, vol. 2, No. 157, p. 126). Similar examples are provided by the anthropo-zoomorphic, single-chambered whistles from the Maiman Collection, which represent a fox holding a vessel in its front paws/hands (MCC 429) and a fox with a human head or a man with a hood in the form of a fox's head (MCC 430). Here I would like to express my gratitude to Dr. Alfredo Rosenzweig and Batami Artzi for allowing me to see and hear the instruments from the Maiman Collection.

Fig. 17.14 Whistle *Felino 1* from Cahuachi Sector Y1

17.4 Conclusions

Due to their special features of construction, and as part of a conscious design, Nasca instruments are characterized by double tones. They produce complex series of partials, which are both harmonic and inharmonic, enriched by resultants of the fundamental frequencies and again by their successive partials. A study of the characteristic features of the Nasca *antaras*[30] and makes it possible to postulate that the strong tendency or predilection for various dissonant combinations is evident not only in the construction of individual instruments, but in the entire Nasca musical practice. The existence of *antara* duos and double whistles is part of a conscious design for the creation of musical situations that favor the interference of sound waves resulting from the non-uniform qualities of sound sources. Such clashes of sound do not result in acoustic chaos, though. On the contrary, they initiate acoustic phenomena that create the impression of dynamism of sound, of energy, and of movement. This overall impression is produced by means of diverse effects: from harmonies that may be perceived as "sharp" to the sense of intense oscillation between two frequencies, pulsating and fluctuating sound waves, *frullato*, beat frequencies, and the emergence of sub harmonic partials that sound like an "undertone". This sense of movement and of high sound energy, further enhanced by the intensity of the upper partials, leads to an impression of a vast, spacious sound and focuses the listener's attention on nuances of sound.

[30]Cf. Anna Gruszczyńska-Ziółkowska (2003, 2014).

Fig. 17.15 Embroidery from Cahuachi—an example of endless combinations of three-dimensional objects

Nasca tradition contains numerous examples of such multi-layered mental games based on the subtle changeability of sensual stimuli. This trend can be illustrated mainly by decorative motives appearing, e.g., on some textiles (two-dimensional objects) and in embroidery (three-dimensional objects) (Fig. 17.15). What seems at first sight to be a monotonous repetition of geometrically arranged elements, turns out, on closer observation, to contain numerous changeable details (e.g., transformations of color, elements rotating horizontally or vertically or along both axes at the same time). We thus realize that the apparent "sameness" of the repeated elements is an illusion, and that their repetitions depend on the use of variant solutions. Having grasped the general principles of order, we can now begin to classify the variants and attempt to establish the rhythm of their appearance, or their particular type of cyclicity. This, like the previous one, is an endless game: especially so, since due to the accumulation of numerous elements and variable details, the time factor plays a major role in the processes of perception and interpretation (taking place on many levels simultaneously). As in music, it forms the fourth dimension of the work.

The wealth of sonorous qualities in Nasca musical practice corresponds with the activation of visual perception and provides a constant stimulus for the stream of perception. Our hearing and eyesight are adaptable: exposed to an unchanging stimulus, they grow accustomed to it. This is the basis for a holistic type of aural/visual perception. The essential quality of Nasca art is that it permanently undermines this tendency of our senses to adapt by introducing changeable data that constantly demand identification and force the recipient to activate the analytic mode. The result is an intensification of the activity of our senses (eyesight or hearing), but also—of the more advanced mental processes. This type of perception may be particularly appropriate in the context of ritualistic activities.

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Chapter 18
Cahuachi and the Paracas Peninsula: Identifying Nasca Textiles at the Necropolis of Wari Kayan

Mary Frame

Abstract In 1996, the team of the Centro Italiano Studi e Ricerche Archeologiche Precolombiane (CISRAP), headed by Giuseppe Orefici, discovered a small cache of elaborate Nasca textiles at Cahuachi that provides new bases for identifying Nasca-style textiles in other regions, including those excavated on the Paracas Peninsula by Julio C. Tello. In the late 1920s, Tello's team excavated 429 mummy bundles, some of them very large and elaborate, within the walls of earlier buildings at the site that he called the Necropolis of Wari Kayan. Although some authors persist in calling the Wari Kayan textiles "Paracas" textiles, similarities with the Cahuachi textiles indicate that a significant proportion of the embroidered textiles from the Necropolis of Wari Kayan are Nasca style. To support this contention, I will first present a detailed description of the techniques and imagery of the three Nasca textiles excavated at Cahuachi in 1996, and will then select a small number of distinctive features. The distinctive features will be used to correlate textiles from the Necropolis of Wari Kayan with similar clusters of features, which identify them as Nasca style. The expanded sample of Nasca-style textiles, including those from the Necropolis of Wari Kayan, contains strong indications that the Nasca people embedded extensive bodies of systematic numerical data into their textiles, which will be briefly described here. Finally, issues of the style and chronology at the Necropolis of Wari Kayan will be reviewed and updated.

Keywords Textiles · Mantles · Knotted openwork · Wari Kayan · Funerary bundles · Iconography

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Fig. 18.1 An olla, which contained three textiles, is shown with its clay cap during the excavation in Sector Y15-EXP58 Q4 at Cahuachi in 1996 (Photo courtesy of Proyecto Nasca)

18.1 Three Textiles and an Olla

The Great Temple and the Grand Pyramid are major monuments visible at the site of Cahuachi. Even after two thousand years, their outlines dominate the area and provide orientation points for less visibly distinct parts of the site. The three textiles that will be described here,[1] for instance, were excavated in a hill area with architectural features that is located 500 m north of the Great Temple in a sector denominated Y15 by the archaeologists (Orefici 1999: Fig. 91). The olla was encountered in what appeared to be an intrusive tomb, but which proved not to have a body. The textiles had been rolled together, along with some detached figures from the border of one, and placed inside the olla before it was capped with clay (Fig. 18.2). The informality of the arrangement in the olla, along with the detached figures, suggests that the textiles might have been collected from an earlier burial and re-used as offerings in the empty tomb. One of the textiles has a mended tear, which does indicate that it was used in daily life, and mended, before it was initially interred. What appears to be a secondary interment in the olla has fortunately preserved a large compendium of Nasca imagery and technical data, but no clues to an earlier context (Fig. 18.1).

The three textiles are flat, rectangular cloths with borders (Fig. 18.3a–c). The dimensions of two of them suggest they are mantles, and their colors and similar border treatment indicate they are an asymmetric dyad, or complementary pair. The more elaborate mantle is black with red borders, and its mate is red with black borders. Both have a large range of figures on their borders. The third cloth, which is smaller and is constructed of strips of openwork knotting, may be a head cloth. The technical details and the imagery of each cloth are described below.

[1]The technical and iconographic information on the Cahuachi textiles from the olla is included in a manuscript that was submitted in 2000 for publication in a conference proceedings that has not so far been published. A brief description of the textiles, with photographs and drawings of the iconography, has been published (Frame 2009b: 200–209).

Fig. 18.2 The red and the black mantles are partially visible inside the olla, after the cap was removed (Photo courtesy of Proyecto Nasca)

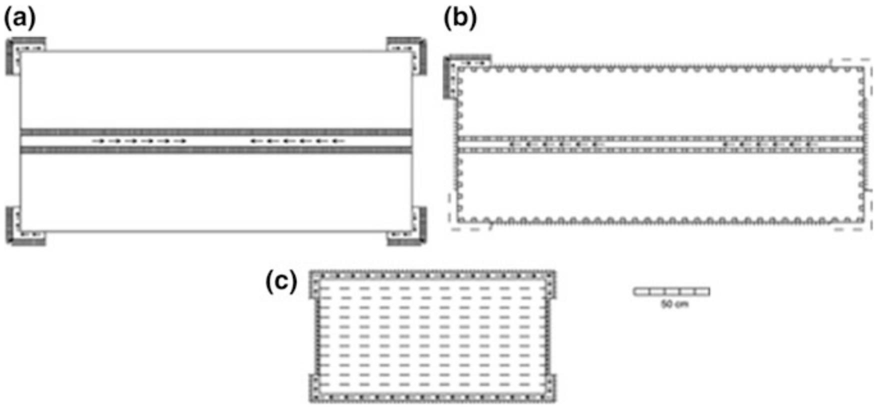

Fig. 18.3 The three textiles from the olla, showing construction features and the direction of border figures: **a** Mantle 1, black with red borders, 278 × 135 cm. **b** Mantle 2, red with black borders, originally 291 × 121 cm (including missing corner borders and fringe). **c** Knotted openwork with embroidered borders, 145 × 90 cm (Drawings by the author)

18.2 The Black Mantle

The black mantle consists of two woven fields plus center and corner borders and three-dimensional edging figures (Fig. 18.4, left). The three-dimensional figures, which are in the form of humans wearing skirts and carrying a fan and baton, are attached to the outer edge of the corner borders, like a fringe. The same figures also flank the center border and attach it to the field cloth (Fig. 18.4, right). The borders have a woven base fabric hidden inside, and are veneered on both sides with an embroidery stitch called “crossed loop stitch” (Fig. 18.5, left). Rows of stitches are

Fig. 18.4 *Left* The embroidered figures on the center and corner borders of the black mantle (Photo courtesy of Proyecto Nasca). *Right* Detail of the center border and the three-dimensional figures that flank it (Photo by the author)

worked continuously across the top face and then the bottom face, and contrasting colors pass through the base fabric to appear in figures on both faces of the border. Figures are repeated in matching positions on the two faces of the borders, as far as can be determined from checking accessible areas. Each border figure is built up in horizontal rows through many changes in color (Fig. 18.5, right).

The mantle is made of two-ply camelid fiber yarns, spun Z and plied S, (S(2z)). The borders have a red background and some figures have black outlines. Seventeen distinct hues are present, including a natural white and a grey. Bi-color plying, combining red with yellow or with white, is also used. The three-dimensional edging figures (Fig. 18.5, right) are also worked in spiraling rows of crossed loop stitch, but they have an armature of bunched threads that acts as a core for the body, head, and limbs. Black hair, now deteriorated, was originally attached to the forehead and back of the head. The baton is embroidered over a yarn core inserted through the figure's hand. While some details are worked by changing colors, the skirt and the nose are added layers of crossed loop stitch. The original number of skirted figures, which hold a fan and baton in different positions, was more than 600, calculated from the density of figures in intact areas.

The black mantle has an interior border that repeats a square motif with protruding tabs nine times on the corners of the ground cloth (Fig. 18.6). The squares and tabs are also embroidered in crossed loop stitch and are worked on both faces of the mantle. The needle must pass through the ground cloth to continue the spiraling row on the other face to make these motifs. While the black mantle is finished on

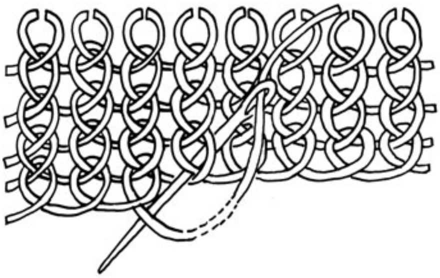

Fig. 18.5 *Left* Diagram of the crossed loop stitch. *Right* Detail of the flat borders and the three-dimensional figures that are worked in crossed loop stitch (Drawing and photo by the author)

both sides, its faces are not exactly identical. The three dimensional figures, for instance, have facial features on only one side and the position of their arms (in front of or behind their body) differs.

Ten figure types, including animals, humans, and composites, occur on the central band in a non-regular sequence. Although the band is broken in several places, 44 complete or partial figures remain attached to the mantle. Despite some fabric loss, the order of most figures can be determined and partial figures can be

Fig. 18.6 The three parallel border treatments on the corner of the black mantle: an exterior "fringe" of three-dimensional figures; an added flat border with figures embroidered on both faces; and an interior border of nine squares that is embroidered on the ground cloth (Photo by the author)

reconstructed (Fig. 18.7). One group of three figures repeats four times, while several other triads repeat twice. The figures include gendered beings, identifiable by their clothing, as well as many beings that combine plant or animal attributes with human attributes. Several types of flying insects are included in the center border.

The corner borders of the black mantle display some of the figures from the central band, as well as 16 additional figure types (Fig. 18.8). Two of the corner borders introduce angular figures with double outlines in markedly different styles. These figures include a rayed face (see Fig. 18.5, right), a feline with serpentine streamers, orcas and fish with human limbs, and sea creatures which may be squid. It is significant that these angular figures occur in the same textile with curvilinear Nasca-style figures. In the terminology that Dwyer (1979) used for the embroideries from the Necropolis of Wari Kayan, the feline (Fig. 18.8, bottom of the second column from the right) would be classified as "linear" style. Dwyer considered the "linear" style to be earlier than the curvilinear "block color" style, which corresponds with the majority of the figures on the black mantle. This mantle provides evidence that the styles existed in the same temporal phase, at least at this point in time. I have proposed that the varied styles at the Necropolis of Wari Kayan could be accounted for as the artistic traditions of different ethnic groups that participated in the mortuary rituals on the Paracas Peninsula (Frame 1995: 15). That the styles of imagery could appear in the same textile from Cahuachi suggests that South Coast ethnic groups were in close contact and occasionally produced hybrid textiles.

Figures within borders are arranged head-to-foot in a linear fashion that implies movement and direction. The consistent orientation of the figures' heads on the

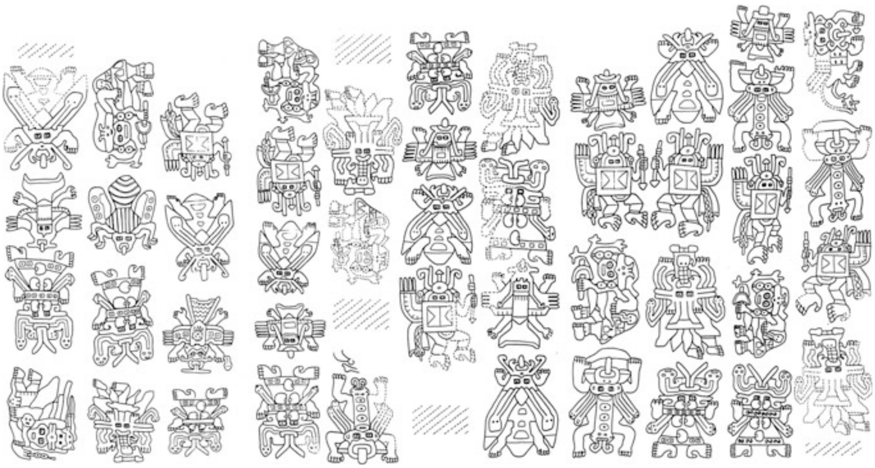

Fig. 18.7 Reading the columns upward, beginning at the *lower right*, reproduces the order of figures on the center border of the black mantle, which trend in two directions toward the center (Drawings by the author)

Fig. 18.8 Reading the columns upward, beginning at the *lower right*, reproduces the order of figures in the corner borders of the black mantle, where figures circle the mantle in a clockwise direction (Drawings by the author)

corner borders implies a circling around the periphery of the rectangular field (Fig. 18.3a). The direction is clockwise on one face of the mantle, but counter-clockwise on the other. On the central border band, the orientation of figures reverses in the center, as if two processions were converging there (Fig. 18.3a). The direction reversal of figures is a slightly unusual feature, but it does occur on the borders of two well-known Nasca textiles (Kajitani 1982: 42–43; Sawyer 1997: 23, 122).

18.3 The Red Mantle

The second mantle from the olla reiterates many features of the black mantle, notably the layout of the figured bands (Fig. 18.3b), the embroidery technique (Fig. 18.5a), and the two finished faces. Although only one corner border survives, it is clear that the red mantle originally had four, like the black mantle. The red mantle is similar in size and proportion to the black mantle, although not exactly the same. The most striking difference is color: this mantle has a red ground and a black background for the figured bands (Fig. 18.9a). The two mantles can be seen as a

Fig. 18.9 *Left* The red mantle with figures on the center band and one remaining corner border (Photo courtesy of Proyecto Nasca). *Right* Detail of the crossed looped figures on the center border of the red mantle (Photo by the author)

pair with color inversion, a special relationship of artefacts that is no doubt significant, as it recurs in other circumstances.[2]

Another difference is the use of flat embroidered squares as an edging for the center band (Fig. 18.9a, b). Only the square tabs on the inside of the remaining corner border are made as three-dimensional units that protrude from the mantle plane (Fig. 18.10). The red mantle has a short yarn fringe on all sides and a longer fringe on the remaining corner border. The fringe (Z(2s(2z))) was constructed and attached to the mantle in one process, probably using highly twisted plied yarn.

The complete center band of the red mantle has 49 figures (Fig. 18.11) and all figures trend in the same direction (Fig. 18.3b), without changing direction at the center. Figures on the only remaining corner border trend in the clockwise direction, like those on the black mantle. The corner border has seven figures (Fig. 18.10), and they are exactly the same as the first seven figures in the central band, starting at the lower right of Fig. 18.11. Originally, the red mantle would have had 77 figures, somewhat less than the projected total of figures on the black mantle. Although there appears to be some emphasis on the number seven in this mantle, the colors in the fringe on the corner border exhibit an eight-part repeat. The

[2]The grave contents of a high-ranking girl that was excavated at Cahuachi (Orefici 2012: 547–565) included a pair of red and black garments, which I examined in 2011. One was a black garment with a red sewn-on border, and the more fragmentary one was a red garment with black sewn-on borders. Both garments had woven tabs on the exterior edge, beyond the sewn-on borders.

Fig. 18.10 The remaining corner border on the red mantle has a long fringe on the outside and an inner border of tabs (Photo by the author)

tiny figures (standing birds?) in the squares that edge the borders do not repeat in a discernible color sequence.

Twelve figure types occur in the border bands in a sequence that is non-regular. Small groups of figures occur in the same sequence in different parts of the center band, but the overall pattern of repetition is not regular. One figure, a splayed, cat-eared figure with its tongue in a tuber, occurs multiple times on both mantles. Three figures that repeat on the red mantle occur once or twice on the black mantle. The thematic content of the imagery on the two mantles obviously overlaps, but there are also some striking differences as well. The flying insects are confined to the black mantle, and so are the flying birds with their wings outspread (Figs. 18.7 and 18.8). The birds, or part-human birds, on the red mantle are shown with wings folded and feet oriented to a ground line. There is marine imagery on both mantles, including crayfish and possibly squid, as well as orcas and birds that prey on fish (Figs. 18.8 and 18.11). The red mantle has feline imagery, including a pampas cat with banded legs and a transforming clothed figure with a cat's tail showing below his tunic. The red mantle contains more references to the animals of the terrestrial and marine realms, while the black mantle has more references to the celestial realm through figures that fly. The red and black mantles, while sharing features with other textiles, are most similar to each other, in technique, design, and imagery. Together they exhibit 34 figure types, and significantly expand the corpus of Nasca imagery.

Fig. 18.11 Reading the columns upward, beginning at the *lower right*, reproduces the order of the figures on the central border of the red mantle. The first seven figures are repeated on the corner border (Drawings by the author)

18.4 The Knotted Openwork

The third textile from the olla is the smallest (Fig. 18.3c). The field is constructed of twelve strips of knotting that are joined together by a separate element (Fig. 18.12, left). The cloth has woven borders on the long sides, which wrap around the corners for a short distance and which are embroidered with a single figure type. The figures are embroidered in single-faced stem stitch, an embroidery stitch that is not equally clear on both faces (Fig. 18.12, right). The size of this cloth, as well as the openwork texture, suggest that this cloth might be a head cloth, rather than a mantle. The multidirectional give of the knotted openwork is suited to being draped on or wrapped around the head.

The field was knotted in long strips, each about 7 cm wide, using replied cotton yarns (3Z(2s(2z))). The simple knotting (Fig. 18.13b) was done in transverse rows, probably using a gauge to produce the evenly sized mesh. A finer element was used for the knotted joins between strips. The joins are perpendicular to the rows of knotting, but use the same knot. It is evident that the knotted field was over-dyed after it was complete. Specks of red are visible inside some knots where the yarn has resisted the final dyeing. The final dye bath was likely indigo blue, to produce the purplish-brown color now visible.

The bi-color flat tabs that are sewn to the ends of the cloth (Fig. 18.13a) are made in simple looping over a foundation element (Fig. 18.13c). The tab was constructed with a needle, using the tail end of the looping element as the straight "foundation" element. The tabs were worked onto a heading cord, and cords with 80 tabs were sewn to both the ends of the cloth, between the terminations of the bracket-borders. To my knowledge, the technique in Fig. 18.13c has not been

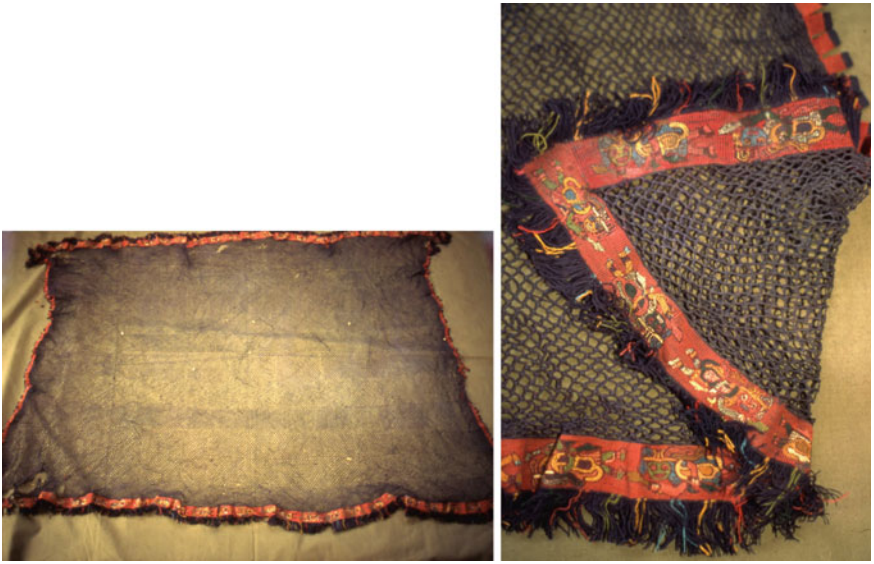

Fig. 18.12 *Left* Twelve lengthwise strips of knotted fabric comprise the third textile from the olla. *Right* The added borders are embroidered in single-faced stem stitch and repeat a clothed figure that holds a peanut and tuber (Photos by the author)

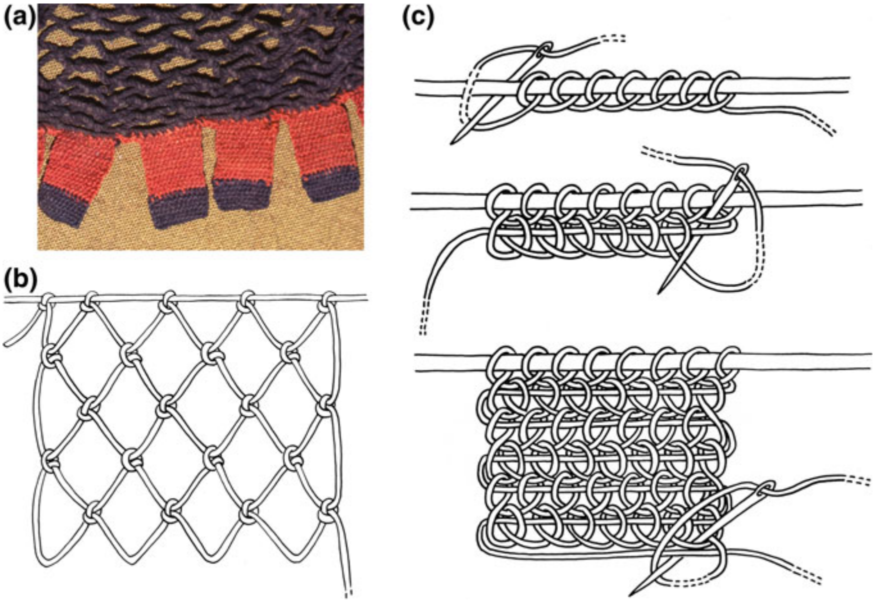

Fig. 18.13 **a** The third textile has an openwork knotted field and rectangular tabs at the ends. **b** Simple knotting, the structure used in the field. **c** Simple looping over a foundation element, the structure used in the tabs (Photo and drawings by the author)

published accurately before. O'Neale shows the structure of similar square tabs as simple looping without the foundation element, which is in error (1937: Plate LXVa and g). Simple looping over a foundation element is a distinctively Nasca technique for edgings, but less well-known than the three-dimensional plants and animals made in crossed looping that O'Neale (1937: Plates LXII and LXIII) illustrates.

The embroidered border figure is male, identifiable by the sleeved tunic he wears. The figure, depicted with an over-sized pod between chest and arm and a tuber in one hand, is repeated 66 times in the borders. The pod with the pointed tip is likely a peanut, and the tuber with the bulbous top may be jiquima, both of which are plants that produce their edible parts below the earth. The figure brandishes an implement with a blunt triangular head, which may depict a digging stick. The mythological character of the figure is conveyed through the animated forehead ornament he wears and the serpentine streamers that sprout from his head.

The head-to-foot orientation of figures indicates a clockwise motion around the borders, while the left-right alternation of the erect figures may mimic the left-right ambulation of humans (Frame 2004). The figures are colored in five different ways, and repeat in a consistent ABCDE sequence, except to close the 66-figure circuit. The fringe alternates colors from the embroidered border among the purplish-brown threads. The strongest pattern in the contrasting pairs of fringe follows a five-color repeat in a seven-part sequence (ABACDCE).

18.5 Bases for Comparison

The descriptions of the three Nasca textiles from the olla that were excavated at Cahuachi provide a large compendium of Nasca figures that could be used to identify Nasca textiles from other sites (Figs. 18.3, 18.4, 18.5, 18.6, 18.7, 18.8, 18.9, 18.10, 18.11, 18.12 and 18.13). Certain figures, which are sometimes interrelated, will be emphasized here: women, felines, and beans. The women wear a distinctive type of bordered dress, one that has been found in large numbers at Cahuachi in a deposit of women's dresses and shawls (Frame 2005, 2009b, 2012; Orefici 2012: 487–505). The depicted dresses, like the actual dresses, usually have borders at least at the hem, but also in some cases across the lower edge of a folded flounce on the bodice. The woman depicted on the black mantle from Cahuachi has five beans on her dress (Fig. 18.14, left). A feline from the same mantle is depicted dorsally and has a band of beans along the backbone and tail in one of its variants (Fig. 18.14, right). Females are often associated with felines, beans, and severed heads in Nasca art (Frame 2008: Fig. 5), but beans also occur on their own in Cahuachi textiles, in garment borders where they are embroidered in stem stitch (O'Neale 1937: Plate LVIIa), or in three-dimensional sculptural edgings that are made in crossed loop stitch (O'Neale 1937: Plate LXIIg; Silverman 1993: 268, Fig. 6). While beans are also depicted in the Moche style from the North Coast (Larco Hoyle 1943), depictions of them are not common in South Coast styles, aside from the Nasca style.

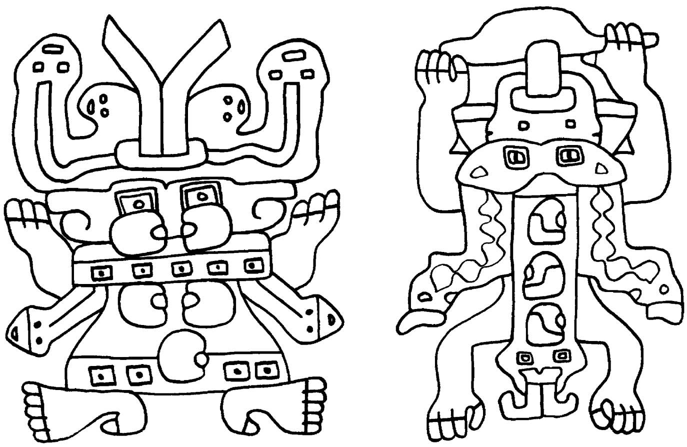

Fig. 18.14 *Left* Figure from the black mantle of a woman wearing a dress with beans superimposed. *Right* Figure from the black mantle of a splayed cat with beans along its back (Drawings by the author)

The central border arrangement of the two mantles from the Cahuachi olla (Fig. 18.3a, b) is another distinctive trait that will be tracked among the textiles from the Paracas Peninsula. At the Necropolis of Wari Kayan on the Paracas Peninsula, this is an uncommon border format (Paul 1991: 186), and so it is a more useful attribute for identifying one type of Nasca-style mantle at the site. Mantles with center borders are not published as often as checkerboard mantles, which have figures covering the field in alternate squares. However, checkerboard mantles repeat figures that belong to several styles, whereas mantles with lengthwise central borders invariably repeat Nasca-style figures (Frame 2007: 72). The mantles with center borders have a variety of exterior treatments, ranging from no borders to several, some of which have been published in line drawings (Aponte and Thays 2013: Figs. 4a and 6a, [bundle 298]; Carrión-Cachot 1931: 76, Fig. 18.14e–h [bundle 253]; Paul 1991: Figs. 5.2, 5.10, 5.11 [bundle 89]; and Tello and Mejía 1979: Fig. 119 [bundle 253]). A rare, but related, example has two center borders and bracket borders on the long sides (Dwyer 1979: Fig. 23).

The fabric technique of simple looping over a foundation element (Fig. 18.13c), which is used for rectangular tabs at the ends of the smaller, knotted textile from the olla, will also be tracked among the textiles from the Necropolis of Wari Kayan on the Paracas Peninsula. This distinctive technique is used in several ways on other Nasca textiles. The flat tabs sometimes connect an embroidered border to the edge of a woven fabric (Frame 2005: Plate 1; Sawyer 1997: 135), or they adorn the exterior edge of a garment (Fig. 18.13a; O'Neale 1937: Plate LXVa). Simple looping over a foundation element is used for making *flat* tabs for edgings, in contrast to the three-dimensional edgings of hummingbirds, flowers, and other figures that are made over an armature of threads in crossed loop stitch (Fig. 18.5, left). While edgings made in crossed loop stitch are a widely recognized "hallmark" of Nasca textiles, the technique of simple looping over a foundation element is a distinctive but less common Nasca edging technique.

The foregoing features—images of women, felines, and beans; mantles with center borders; and flat tabs made in simple looping over a foundation element—are the attributes drawn from the Cahuachi textiles in the olla that will be tracked among textiles in the bundles from the Necropolis of Wari Kayan as indicators of the Nasca style. As textiles with these traits are illustrated, additional traits that are typical of the Nasca style figures will be seen to recur with them, confirming the selected traits as sound indicators of the Nasca style.

18.6 The Embroideries from the Necropolis of Wari Kayan, Paracas Peninsula

The funerary bundles from the Necropolis of Wari Kayan, located on the flanks of Cerro Colorado on the Paracas Peninsula, contained a wealth of embroidered textiles which have been the subject of many studies. In the relative chronology of the South Coast (Menzel et al. 1964), the textiles span the time period from Early Horizon 10 (EH 10) to Early Intermediate Period 2 (EIP 2), approximately 100 B.C. to A.D. 200. A persistent problem in nomenclature has led to confusion about Paracas and Nasca textiles in publications (Bird 1954; Carrión Cachot 1931; Dwyer 1971, 1979; Lavalle and Lang 1983; Musée du quai Branly 2008; Museo de América 2009; Museo Nacional de Arqueología Antropología e Historia del Perú 2007; O'Neale L and Kroeber 1930; O'Neale 1942; Paul 1979, 1990; Tello 1959, 2012; Tello and Mejía 1979). Paracas and Nasca are used as names for styles of artifacts and the ethnic groups who made them, but they are also used as names of sites, regions, or valleys. However, not all textiles from the Paracas Peninsula are Paracas style, and Nasca style textiles are not limited to the Nasca drainage.

The selected attributes of the Cahuachi textiles in the olla compare most closely with textiles from the Necropolis of Wari Kayan bundles that Jane Dwyer (1970: Appendix B, 1979) and Paul (1990: Table 5.2) assigned to Nasca 2 (EIP 2), although they are also present among textiles from bundles they assigned to prior phases, Nasca 1B or even Nasca 1A (EIP 1A and 1B). Although Paracas and Nasca ceramics can be distinguished more readily on technical, material, and iconographic grounds, the ceramic seriation is not without its problems and critics, including the phases that correspond with the early Nasca style discussed here (EIP 1 and 2). The ceramic seriation, which was developed in Berkeley in the 1950s and 60s (Menzel et al. 1964), has been used for 50 years and inconsistencies or anomalies in it are showing up, as reports from recent excavations are compared to it. As Helaine Silverman notes, "Ocucaje 10 (EH 10) does not provide all of the necessary antecedents for the subsequent Nasca 1 pottery style" (Silverman 2002: 75). She also notes that the "thumbed foot was a principal attribute in Lawrence Dawson's definition of the Nasca 2 ceramic phase" (2002: 85), but cites textiles from Nasca

1B bundles from the Necropolis of Wari Kayan, as I have done (Frame 2001). She notes that a Nasca 1 panpipe also has this attribute, a theme that Patrick Carmichael treats in detail (2016). In an iconography article, I proposed that the "thumbed foot" is an attribute that is acquired as figures which belong to a larger narrative transform in stages toward animal counterparts (Frame 2001), rather than a time-sensitive attribute which can indicate a temporal phase. Because Dwyer tied her definition of the textile phases at the Necropolis of Wari Kayan to the ceramic seriation, she also imported its problems, including that of the "thumbed foot", which is not limited to textiles from bundles that she places in EIP 2.

The grouping of textiles from the bundles that will be discussed in the following section is visually unified, as Dwyer was aware when she spoke of the group as "easily recognizable" (1979: 112). However, my more recent studies (Frame 1995, 1999, 2001, 2004, 2007, 2009a) indicate that this is a style grouping, i.e., Nasca style, and not a temporal grouping that is limited to EIP 2, as Dwyer proposed. It is not, in my opinion, possible to distinguish between EIP 1 and EIP 2 textiles in the Nasca style from the Necropolis of Wari Kayan, a topic that will be returned to in the conclusions. Textiles from the bundles that were excavated at the Necropolis of Wari Kayan will be identified by a bundle number, followed by a hyphen and a specimen number. Following bundle/specimen number, the registration number in the Textile Department (RT) of the Museo Nacional de Arqueología, Antropología e Historia del Perú will be given.

18.6.1 Bundle 38

Bundle 38 from the Necropolis of Wari Kayan has textiles that match all the selected attributes of the Cahuachi textiles. It has a number of mantles with center borders, and they display a cohesive set of images that can be recognized as Nasca in origin. Many figures on the textiles, including females, have beans associated with them. Even the embroidered textiles that do not have the selected traits appear to be Nasca style in bundle 38, including a number of mantles with checkerboard patterning.

The first example of a mantle with a center border repeats the figure of a "bean monkey" in the center and exterior borders of the mantle (Fig. 18.15a, b). The bean monkey has two streamers attached to the back of the neck, one filled with beans and one filled with severed heads. The monkey grasps a bean vine above its head with both hands and alternates in facing left and right in the border. Figure orientation is correlated with an arrow and the arrows chart the directional motion and symmetrical alternation of figures in the garment borders. The monkeys repeat in glide symmetry, alternately facing left and right. Because the feet are clearly not on a ground line, the alternation of figures probably mimics the left-right motion of hand-to-hand swinging, rather than walking (Frame 2004). The border pattern is slightly altered in this mantle by the insertion of seven beans in the lower left corner.

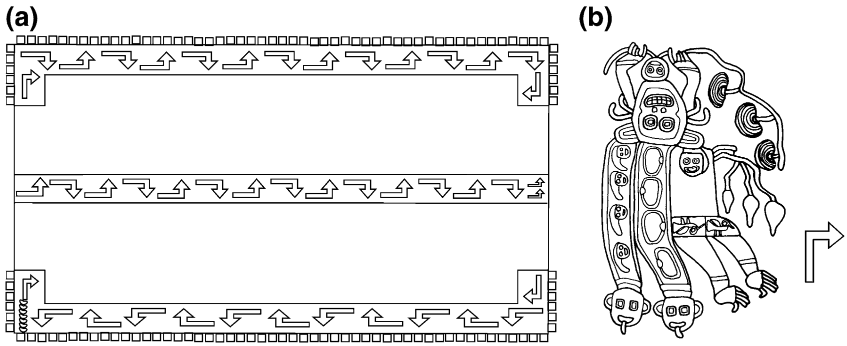

Fig. 18.15 **a** Mantle with center and side borders from the Necropolis of Wari Kayan, 38-46, RT2699. **b** A monkey figure holding onto a bean vine repeats on the borders in the orientation indicated by the *arrows* (Drawings by the author)

This mantle is associated with another kind of garment in bundle 38 through shared imagery, and so it is certainly Nasca style as well. A rectangular garment with continuous borders on four sides and braided ties on the four corners forms a matched pair with the mantle (Fig. 18.16a, b). It is likely that such garments are loincloths, based on the presence of ties on the corners (Frame 2007: 68–69 and 72–73), and the fact that this type was found with males in Kroeber's Cahuachi burials (O'Neale 1937: 191, Plate XXXIVa). The four ties suggest the garment was fastened around the waist, like other garments with ties.

Another Nasca feature of the matching garments is the use of looped tabs for an exterior edging. The structure is simple looping over a foundation element, like the Cahuachi looped tabs described earlier (Fig. 18.13c). The mantle has square tabs (Fig. 18.15a) and the loincloth has triangular tabs (Fig. 18.16a).

The garments with four ties have been a cause for puzzlement to authors, who have variously called them *anakos*, or dresses (Carrión-Cachot 1931: 83), mantones/*llikllas*, or shawls (Tello and Mejía 1979: Fig. 128), or hangings (Paul 1991: 205–210), but do not convincingly explain how the ties might have been used. Ann Peters agrees that the garment is Nasca style (2012: 10), but does not offer an opinion on the garment type. Some of the puzzlement over the garment type may be attributable to the fact that only some of the loincloths in the Necropolis bundles retain any traces of the four corner ties.[3] Those that form a matching pair with a mantle with a center border can be assumed to be loincloths, even if there are no traces of the corner ties.

[3]It is possible that different types of garments had continuous borders on four sides, which would make it difficult to identify the garment type if all traces of ties were obliterated. There is, for instance, a garment with four continuous borders that has a horizontal neck-slit cut into the center (319-23, RT1264). Also, an unusual example of an embroidered poncho with a vertical neck-slit has continuous borders (Frame 1999: Plate 12).

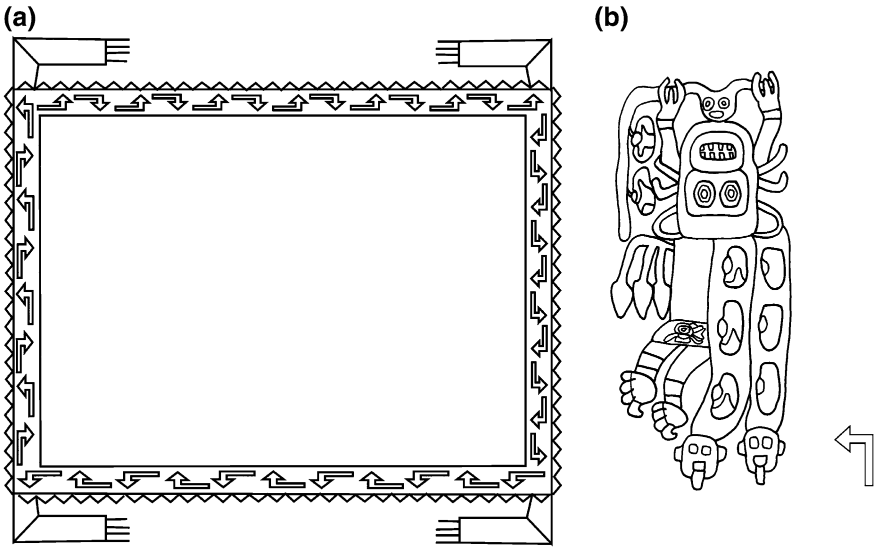

Fig. 18.16 **a** Loincloth with four corner ties, 38-38, RT950, from the same bundle as the previous mantle. **b** A monkey holding onto a bean vine repeats in the continuous borders (Drawings by the author)

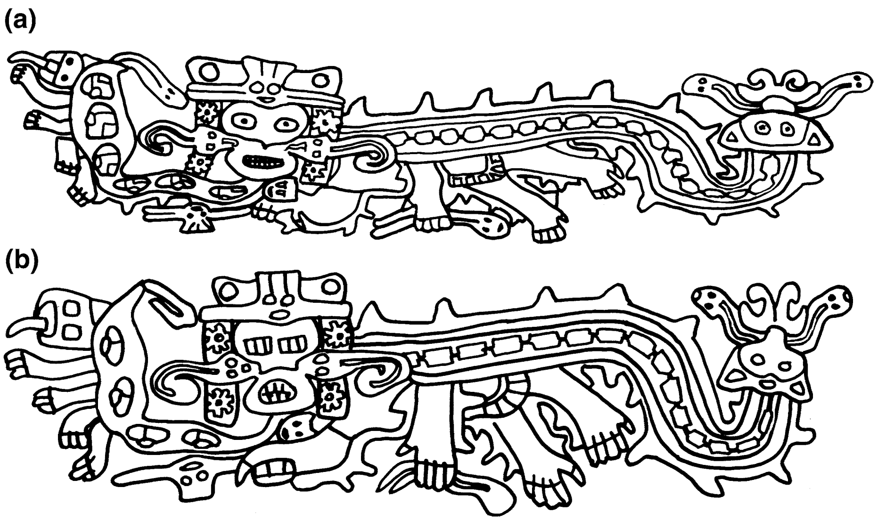

Fig. 18.17 **a** Figure of a clothed male with a "bean cat" attached to his chin from a mantle with a center border and C-shaped side borders, 38-12, RT103. **b** A similar figure from a matching loincloth, 38-39a, RT2843 (Drawings by the author)

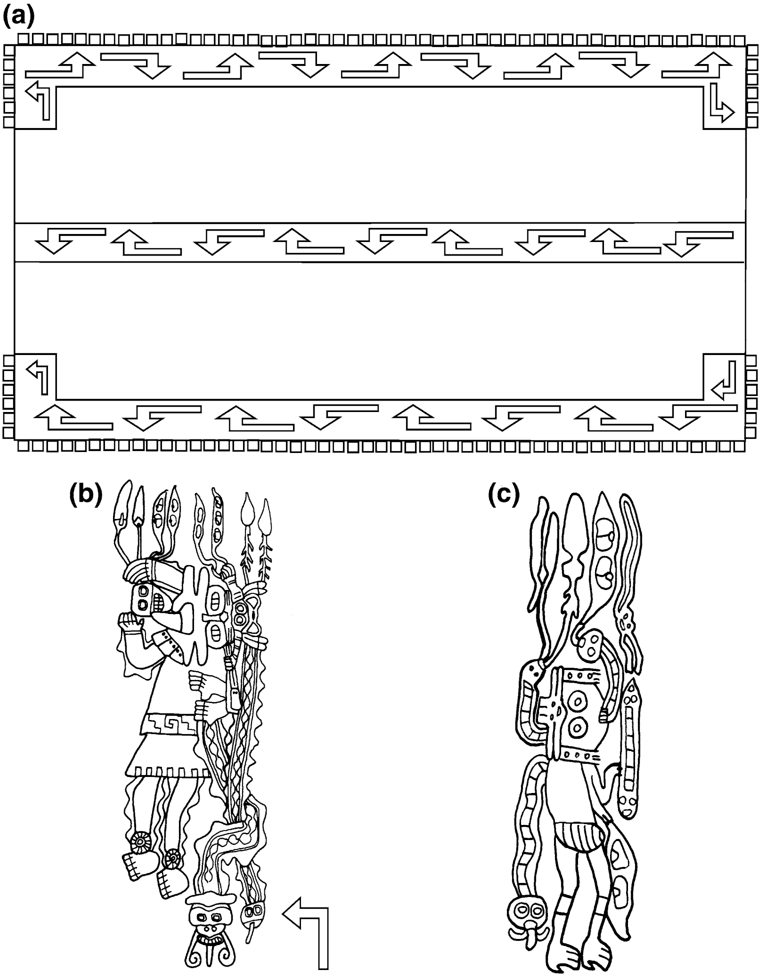

Fig. 18.18 **a** Mantle with center and side borders, 38-37, RT1988. **b** A bipedal figure that sprouts plants repeats in the borders. **c** A related figure that wears a loincloth rather than a skirt from the borders of a fragmentary, matching loincloth, 38-39a, RT 1622 (Drawings by the author)

A second set in bundle 38 is in less complete condition, but the fragments of the mantle indicate that it had a central embroidered border and C-shaped side borders with square, looped tabs on the outside edges, very similar to the mantle in Fig. 18.15a. A clothed, male figure that has a "bean cat" attached to his chin by a streamer repeats in the mantle borders (Fig. 18.17a). An almost identical figure repeats on the continuous borders of the loincloth (Fig. 18.17b), which has remnants of four corner ties and triangular looped tabs on two sides. Both figures also have a serpentine streamer emanating from the back of the head. The figures wear an elaborate mouth-mask, perhaps a whiskered feline mask, and the posture is

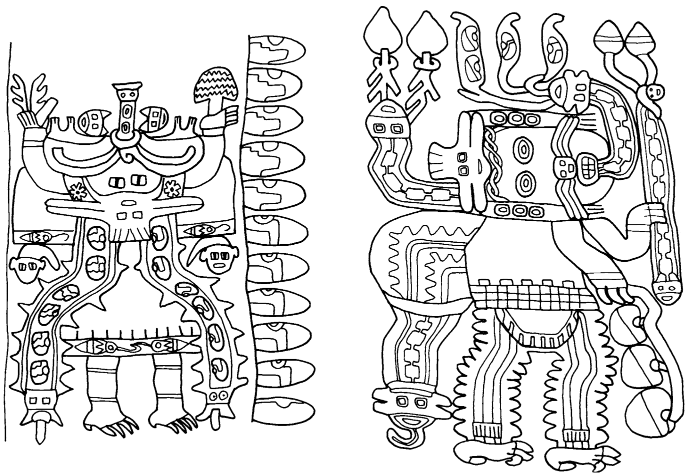

Fig. 18.19 *Left* A female figure with bean-filled streamers from a mantle with an edging of bean tabs that repeat in groups of five, 38-15, RT1410. *Right* A clothed male that has a body of a seed that sprouts plants, including beans, repeats on the checkerboard field of mantle 38-4, RT1559 (Drawings by the author)

between that of a biped and a quadruped, probably indicating a stage in the transformation between human and feline counterpart (Frame 2001). A small insertion, which fills a corner space in the loincloth border, has a trophy head with carrying cord, a line of beans, several geometric patterns, a double-headed snake, and a splayed "bean cat".

In a third set in bundle 38, a clothed biped that holds plants and sprouts plants from its head repeats on the center and side borders of a mantle (Fig. 18.18a, b). Four bean pods are associated with each figure, and tubers and other fruits are also present. This mantle has square looped tabs on the edges of the exterior borders. The continuous border, which is all that remains of the matching loincloth, repeats a simpler figure that wears a loincloth, rather than a skirt, but sprouts similar plants (Fig. 18.18c). The loincloth border also has an edging of square tabs that are made in the technique of simple looping over a foundation element.

The figures on the matching sets in bundle 38 are all associated with plants, particularly beans. Several garments in this bundle that do not have matching pieces also display figures associated with beans. Specimen 38-15 is a mantle with an all-over checkerboard design of repeated female figures in the embroidered field and borders (Musée du quai Branly 2008: 23). The depicted woman is shown from the back with head thrust upwards and has streamers filled with beans sprouting from her neck (Fig. 18.19a). This figure resembles the woman on the black mantle from Cahuachi (Fig. 18.14a), who also wears a dress with two horizontal borders and is associated with beans. The border of the mantle is edged with flat bean tabs that repeat in sets of five (Fig. 18.19, left) in a series of 60 or 61 sets. The technique of the beans in the edging is simple looping over a foundation element

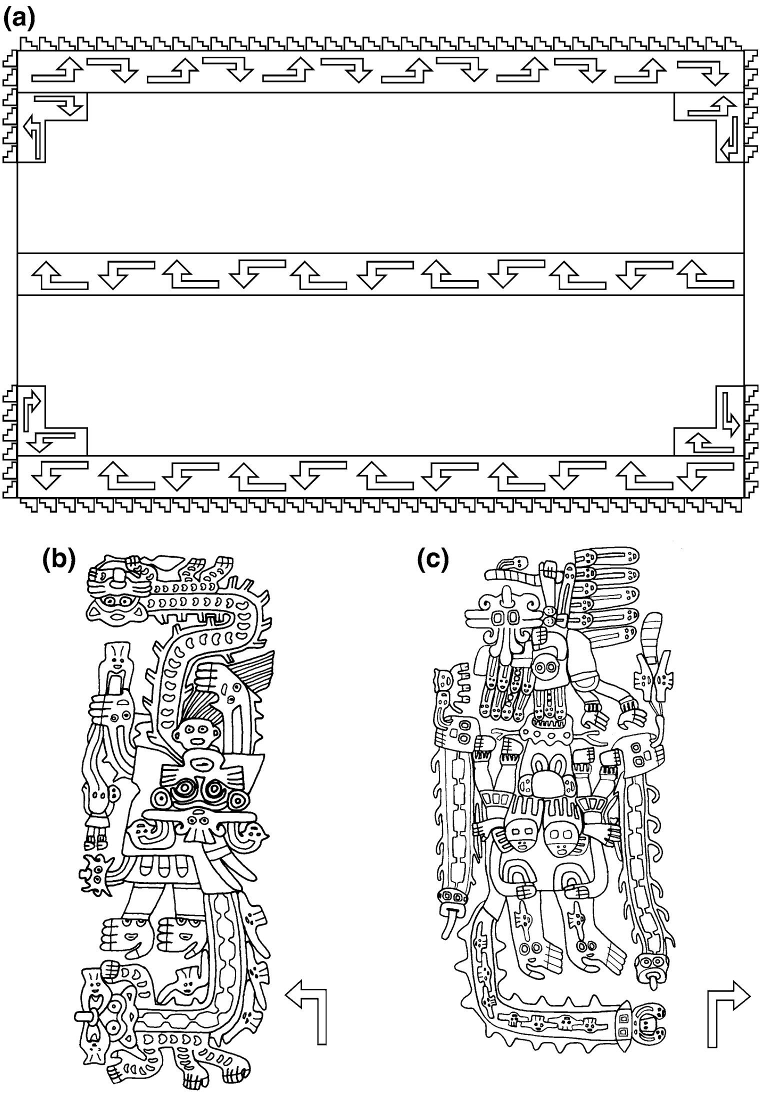

Fig. 18.20 **a** Mantle with multiple borders and a flat, looped edging of stepped triangles, 38-50, RT2759. **b** One type of figure is repeated in the center and corner borders **c** A different figure is repeated in the long, side borders (Drawings by the author)

(Fig. 18.13c). Another mantle with a checkerboard pattern in the field repeats the figure of an anthropomorphized bean dressed in male clothing (Fig. 18.19, right). This figure also holds a vine with beans and has plants sprouting from his head. The figure occurs once in the border of a mantle already discussed (Fig. 18.18a). It is shorter in length than the clothed biped that sprouts plants (Fig. 18.18b), and may have been chosen to substitute for this reason. Certainly the two figures are connected thematically, as both have plants sprouting from their bodies.

An unusual mantle in bundle 38 has a center border and four corner borders, like the Cahuachi mantles, but it also has borders on the long sides (Fig. 18.20a–c). The center and corner borders repeat a figure dressed in male clothing that has felines on the ends of sprouting streamers (Fig. 18.20b). The felines have bean-shaped markings on their pelts. On the two exterior borders, a complex, bipedal figure that has sprouting streamers and several secondary figures attached to it is repeated (Fig. 18.20c). The edging on the mantle, which is in the form of flat, stepped triangles, is made in simple looping over a foundation element. While there are other mantles with center borders and loincloths with continuous borders in bundle 38,[4] this is the most interesting of the garments that do not form matching sets.

Matching sets are not a criterion for establishing which garments are Nasca style, and nor are the center-border format for mantles or the continuous-border format for loincloths. These border formats are less common features that are always coupled with Nasca imagery, and so make identifications of Nasca textiles more convincing, especially when flat looped tabs and bean imagery are also present. Bundle 38 has a cohesiveness that suggests that almost everything in the bundle is Nasca style.

18.6.2 Bundle 253

Bundle 253 is quite comparable to bundle 38 in that it has mantles and loincloths, as well as edgings, that are similar to those just discussed. Bundle 253 has a set consisting of a mantle with a center border and bracket borders on the long sides (Fig. 18.21a, b) and a matching loincloth with continuous borders and the remnants of four ties on the corners (Fig. 18.21c). The embroidered figure on the garment borders wears a skirt and has a gaping hole it its stomach, from which a spondylus shell pendant is emerging. The figure's head is bent backward and a severed head is attached to the figure's tongue. The figures have huge feet, skinny legs, and beans embroidered at the ankles. Both the loincloth and the mantle have flat edgings in the form of fish, which are made in the distinctive technique of simple looping over a foundation element. The fish-shaped tabs alternate in color pairs in an extended color sequence, similar to pairs of beans on other Nasca textiles.

A fragmentary mantle with a center border, 253-8, RT3229 and RT3355, also had edging figures made in simple looping over a foundation element. The elaborate edging figures were in the form of a backward-bent figure that wears a skirt and carries a fan and baton. Almost all figures are now detached and most are reduced to the torso. Two anthropomorphic figures, one transforming into a whale

[4]Specimens 38-13, RT2710 (see Frame 2001: Fig. 4.6a) and 38-47, RT3222, are additional mantles with central borders while specimens 38-39b, RT2555 and 38-39c, RT2936 are additional examples of the loincloth with continuous borders on four sides.

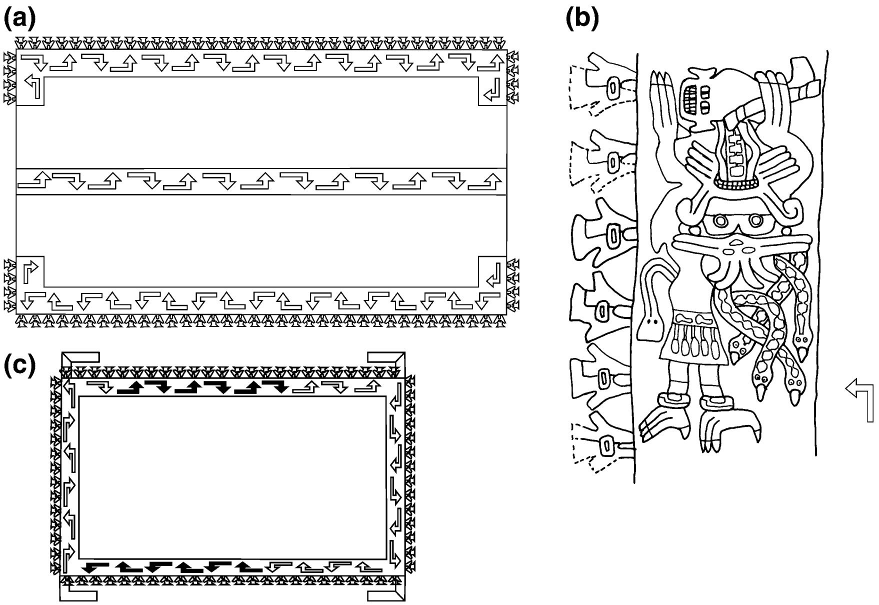

Fig. 18.21 **a** Mantle with center and side borders and a flat, looped edging of fish, 253-62. RT 3140. **b** The figure that repeats on the borders of the mantle and a matching loincloth. **c** The matching loincloth also has the edging of fish, but some of the border figures have deteriorated, 253-67, RT2712 (Drawings by the author)

or shark and the other transforming into a bird (Paul 2010: Fig. 39a, b), are repeated in the center border of the mantle.

Another mantle with a center border repeats a clothed male that wears a feline headdress and a fringed tunic that has a border of beans (Fig. 18.22a, b). A feline and two birds are attached to him by sprouting streamers, and one bird carries a bean pod. An edging of square tabs, worked in simple looping over a foundation element, is still partly present. A plaid mantle has a center border and corner borders with remnants of a long colorful fringe (Fig. 18.22c, d), like that on the corner of the red mantle from Cahuachi. The clothed male figure on the embroidered borders has a headdress with beans in it and has a feline and a bird attached to him by serpentine streamers. An interior border of embroidered severed heads repeats colors in a long sequence along the center border and the interior edge of the corner borders.

Bundle 253 has two more mantles with center borders, 253-63, RT2749 (Tello and Mejía 1979: Fig. 119, 1; for the figure, see Aponte and Thays 2013: Fig. 5b), and 253-64, RT2726 (Tello and Mejía 1979: Fig. 119, 2; for the figure, see Aponte and Thays 2013: Fig. 7a). The first repeats a transforming clothed figure that has falcon attributes in its patterned tail and a falcon attached to its mouth by a streamer. The second repeats a figure that is a conflation of condor, feline, and killer whale attributes.

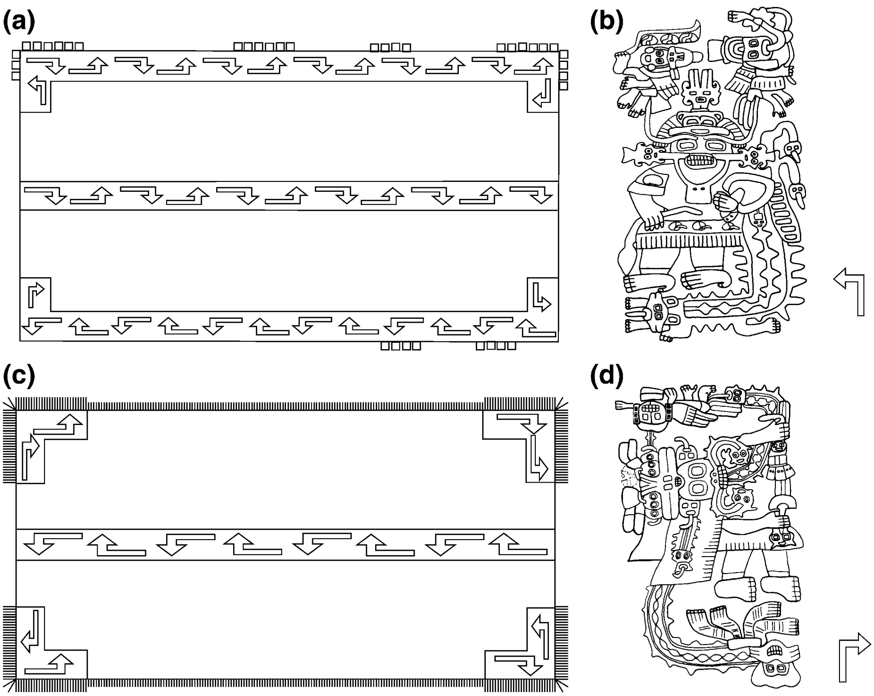

Fig. 18.22 **a** Mantle with center and side borders and an edging of square tabs, 253–26, RT1688. **b** The male figure repeated on the border wears a tunic with beans on the border. **c** Mantle with a center border and corner borders with long fringe, 253-27, RT1028. **d** A male figure that wears a headdress with beans repeats on the border (Drawings by the author)

As well, the bundle has at least two more garments with continuous borders that are probably loincloths, 253-66, RT2995 and 253-68, RT2931, for a total of three. No signs of corner ties remain and fringes, rather than looped tabs, are used as edgings. The first of these repeats a transforming birdman that carries a bean pod, and the second repeats a clothed human that carries a bean pod and has a second one attached to his back. The field of 253-66 is embroidered in double-faced stem stitch with a design of interlocked stepped frets. This variant of stem stitch has long been regarded by specialists as an exclusively Nasca technique (Bird 1954; Rowe 1991: 106–107 and 121, note 24; Sawyer 1997: 27).[5]

Bundle 253 is a large bundle, and many of the garments not mentioned here are strongly related to the Nasca style through the iconography, including the incorporation of beans in the garments that figures wear or in the streamers that emanate

[5]Single-faced stem stitch, which is the more common stitch and has only one good face, moves forward over four threads and back under two threads of the ground cloth. Double-faced stem stitch, which has two good faces and is an interlocked stitch, moves forward over six threads and back under four threads of the ground cloth (Bird 1954: 99).

from their bodies. Outstanding features of bundle 253, in addition to the mantles and loincloths just described, are the number of headbands and wigs, and the large number of miniature garments that accompanied the bundle.

18.6.3 Bundle 319

Bundle 319 also has mantles and loincloths similar to those described in bundles 38 and 253, but bundle 319 has fewer mantles with center borders and many more loincloths. The mantles and loincloths generally have fringes, rather than looped tabs, on the exterior edges, which indicates that more than one edging treatment (flat-looped tabs, three-dimensional figures, or fringes) can adorn the exterior edges of Nasca garments. One fragmentary mantle appears to have no edge treatment at all (Fig. 18.23a). A clothed figure with many serpentine streamers who carries a severed head and a banded staff repeats eight times in the center border of the mantle fragment (Fig. 18.23b). Another mantle repeats a transforming falcon figure in the center border and in the bracket borders on the long edges (Fig. 18.23c, d). The theme of transformation is expressed in this case, and many others, by combining the clothing and erect posture of a human with animal attributes, such as the wing and head of the falcon, which emerges from the mouth of the human. The "thumbed foot" is an animal attribute that is present on many transforming figures. The serpentine streamers seem to indicate the mythic aspect of the transformation, which probably refers to the transformation of the ancestor in the funerary bundle into an animal counterpart (Frame 2001).

Bundle 319 has many elaborate mantles with all-over checkerboard patterns, and some display figures that incorporate beans. The same figure repeats on a pair of mantles (Fig. 18.24a and 319-7, RT31783). The main difference is that the second mantle has a black field with red background embroidery in the borders and around figures (Musée du quai Branly 2008: 196–197) and the first has a pale red field with black background embroidery (Lavalle and Lang 1983: 112, detail). The figure is a bipedal anthropomorph with sprouting streamers and two felines with beans attached to their tongues. One of the serpentine streamers has two bean pods for a tongue. The inverted color schemes of these two mantles echo the pair of mantles from the Cahuachi olla, which are also red with black borders, and vice versa (Figs. 18.4a and 18.9a). Each of the mantles from bundle 319 has a different number of figures on the checkerboard field, and so the pair is also an asymmetric dyad.

One of the most elaborate "bean" figures is repeated on another checkerboard mantle in this bundle (Fig. 18.24b). The clothed male figure has a long streamer filled with beans emanating from his head, as well as five more streamers that each terminate in a full figure, either a bird, a feline, or a human. The central figure is itself like a seed or tuber that sprouts streamers and figures from multiple growth points. Another checkerboard mantle in this bundle repeats a figure that wears a cat-pelt headdress that is covered in beans (Fig. 18.24c). A simpler figure, whose cat-pelt headdress has only one bean, is repeated on the narrow, continuous border

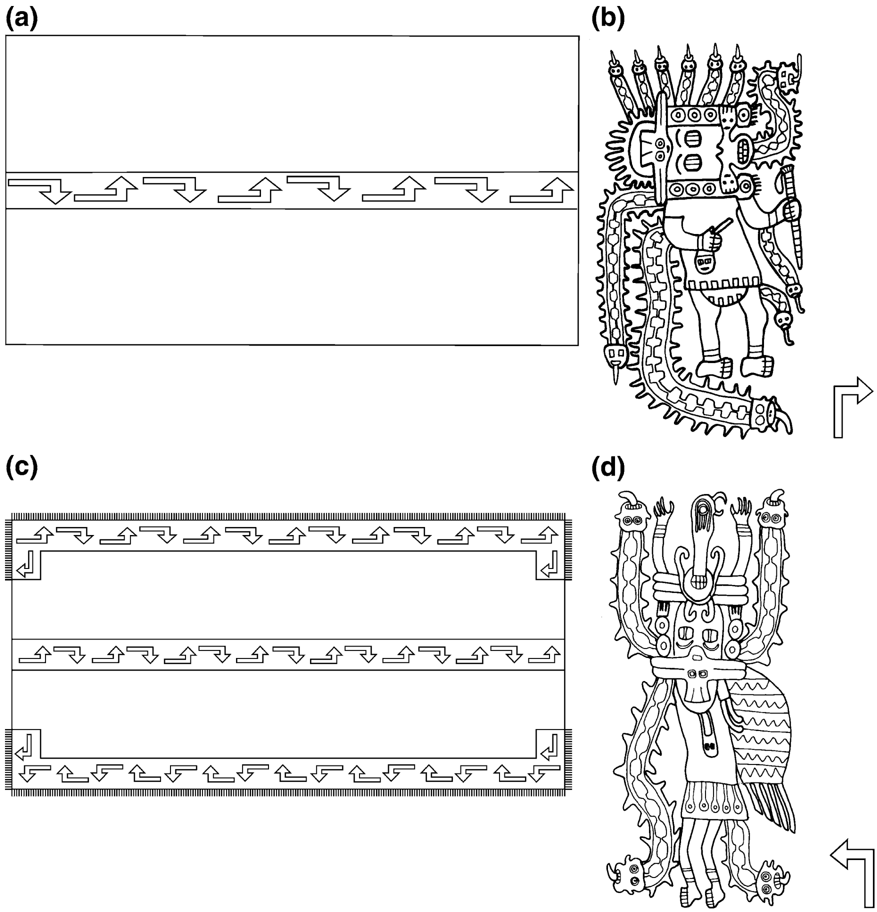

Fig. 18.23 **a** Mantle with center border but no edgings, 319-53, RT2752. **b** A male figure with many streamers repeats on the border. **c** Mantle with center border also has bracket borders with fringe, 319-84, RT3120. **d** A transforming falcon figure is repeated on the borders (Drawings by the author)

of a loincloth (319-26, RT624). The splayed feline with beans on its back from the black Cahuachi mantle (Fig. 18.14b) may in fact represent a pelt, rather than a living cat, which are usually shown in profile, with feet oriented to a ground line. A clothed male that has beans in his headdress and a "bean cat" on the end of a streamer that sprouts from his back (Fig. 18.24d) is repeated on another checkerboard mantle in bundle 319. This figure is very similar to one that repeats on a mantle with a center border in another bundle (Fig. 18.22d). The use of the same figure on mantles of the center border type and checkerboard type indicates that both types of mantles are included in the Nasca style at the Necropolis of Wari Kayan.

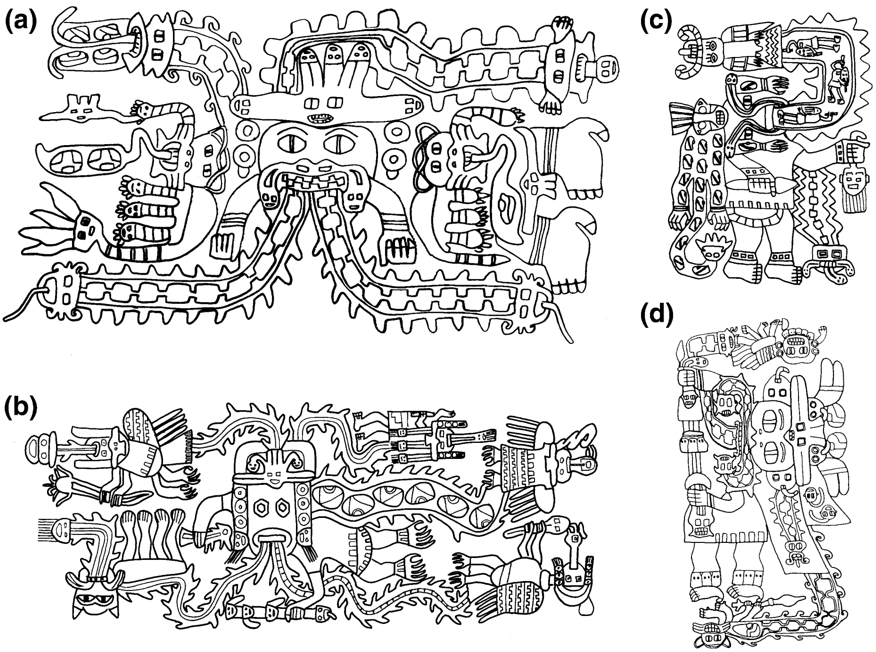

Fig. 18.24 **a** Figures with bean attributes from four checkerboard mantles in bundle 319 include 319-8, RT1457. **b** 319-13, RT1682. **c** 319-48, RT1720. **d** 319-55, RT1520 (Drawings by the author)

One small cloth (Paul 2010: Fig. 18), which may not be in its original form, has an edging of paired beans that repeat around the outside of an embroidered border that has two alternating figures with feline attributes (Fig. 18.25a). The same figures alternate on the field in bands that appear to be made of sections of a long border that has been cut up and applied to a backing cloth during conservation. The paired beans are made in simple looping over a foundation element, like the beans that edge mantle 38-15. The condition of the beans in the edging is too fragmentary to reconstruct the color sequence. A second small cloth, which has stepped frets woven in gauze weave in the field (Paul 2010: Fig. 12), repeats the figure of a "bean fox" in the embroidered borders (Fig. 18.25b). The profile, bi-color fox has a bean emerging from its mouth. The foxes alternate orientation by pairs, forming an unusual symmetry pattern in the embroidered border.

The twelve loincloths with continuous borders and corner ties in bundle 319 that I have been able to identify[6] exhibit a range of figures, including a clothed figure that wears a cat headdress with a bean on the pelt (319-26, RT624), and a cat with

[6]Loincloths with continuous borders in bundle 319 include 319-14, RT2892; 319-22, RT608; 319-26, RT624; 319-69, RT2764; 319-82, RT2551; 319-91, RT4142; 319-92, RT2934; 319-93, RT 2455, 319-94, RT2604; 319-108, RT2890; 319-110, RT2969 and 319-111, RT2515.

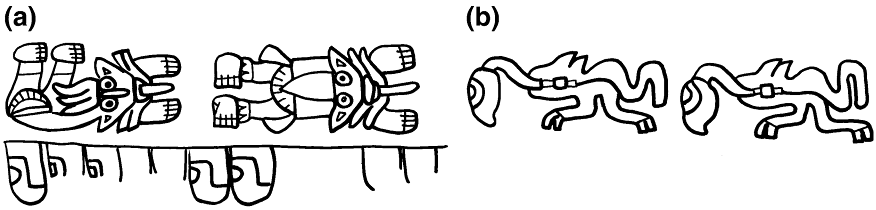

Fig. 18.25 **a** An edging of beans adorns a small cloth that repeats two transforming felines in the border, 319-24, RT1685. **b** Embroidered "bean foxes" repeat in the border of a gauze-weave head cloth, 319-31, RT2926 (Drawings by the author)

beans on its body (319-111, RT2515). Bundle 319 has several mantles with center borders and many loincloths with continuous borders. The bundle also has some of the most complex Nasca figures, many of which incorporate beans, repeated in a checkerboard pattern on mantle fields.

18.6.4 Bundle 451

Bundle 451 has six mantles that have a center border, and two loincloths with continuous borders. The figures on the mantles include clothed anthropomorphs, females and males, who sprout serpentine streamers from their heads and bodies (Fig. 18.26a–d and Fig. 18.27a–d). The other two figures from mantles with center borders are illustrated in Tello and Mejía (1979: Fig. 98b, c, 451-25, RT182 and Fig. 99a, 451-22, RT127). Most wear forehead ornaments and mouth masks and some have feline attributes, such as ears, claws, whiskers, or the thumbed foot. The female is depicted as wearing a dress with a horizontal border at the hem and a second border across the bodice (Fig. 18.26b), which is the type of Nasca dress that was excavated at Cahuachi (Frame 2005, 2007: Fig. 7). Two of the mantles (Fig. 18.27a) and one of the loincloths (Fig. 18.28a) have triangular tabs on the outside edges and one of the mantles (Fig. 18.26c) and the other loincloth have square tabs. The flat tabs are made in the Nasca technique of simple looping over a foundation element (Fig. 18.13c).

The two loincloths with continuous borders have narrow patterns of double-headed creatures that combine feline and snake attributes (Fig. 18.28b, c). One of the loincloth figures (Fig. 18.28b) appears on a mantle with center and corner borders in bundle 298. Specimen 298-37 (Thays and Aponte 2012a: 508, upper half), however, has a red background in the border rather than a pale gold background, so they cannot be construed as matching garments. The other loincloth figure (Fig. 18.28c) has two feline heads and a sinuous two-part body that resembles a plied cord. Only parts of the borders of this loincloth survive.

Bundle 451 has other textiles that are clearly Nasca, in particular, a neck surround for a small poncho that is embroidered in crossed loop stitch, which is the

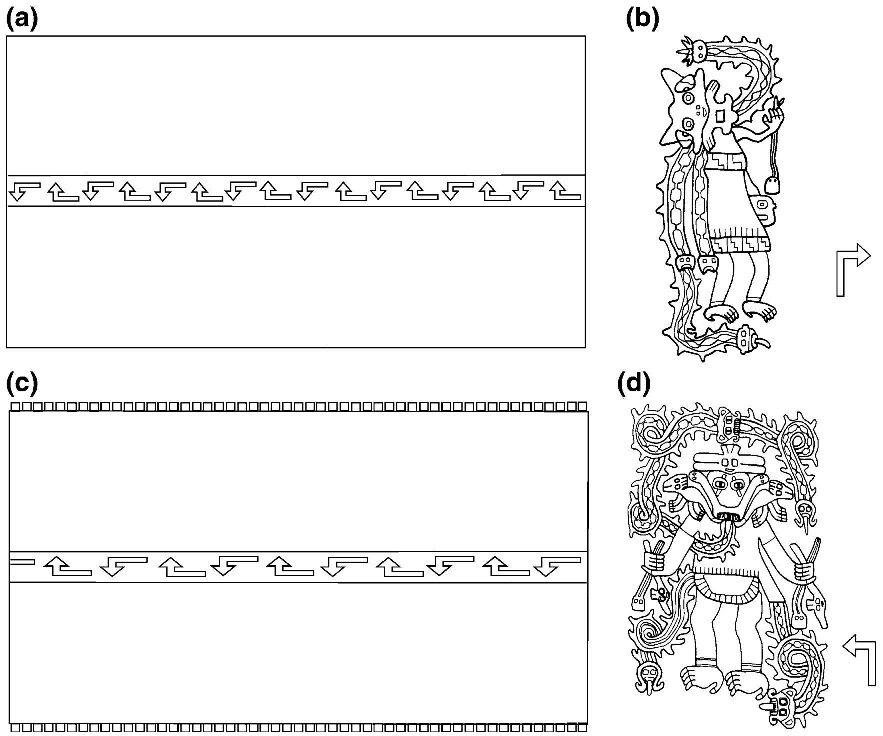

Fig. 18.26 **a** Center border mantle from bundle 451, 451-27, RT 3032. **b** Female figure that wears a dress repeats on the border. **c** Center border mantle, 451-23, RT675. **d** Male figure that wears a tunic and loincloth repeats on the border (Drawings by the author)

same stitch that is used to veneer the borders of the Cahuachi mantles described earlier (Fig. 18.5a). The neck surround has figures of felines, a severed head and various types of birds (Paul 2010: Fig. 27). Like the Cahuachi mantles, the neck surround does not have a regular repetition of a single figure. Bundle 451 also has some checkerboard mantles that are patterned with complex figures, similar to the Nasca figures on the mantles with center borders.

18.6.5 Bundle 89

Bundle 89 has mantles with center borders, loincloths with continuous borders and four corner ties and flat, looped tabs used as edgings on some garments. The three mantles with center borders have much simpler figures than those in other bundles. The figures include a bipedal figure with a skull-like face and bird feet, a series of fans, and a figure that conflates attributes of a killer whale, condor, and feline (Fig. 18.29a–f). The mantles have triangular tabs as edgings, but no embroidered

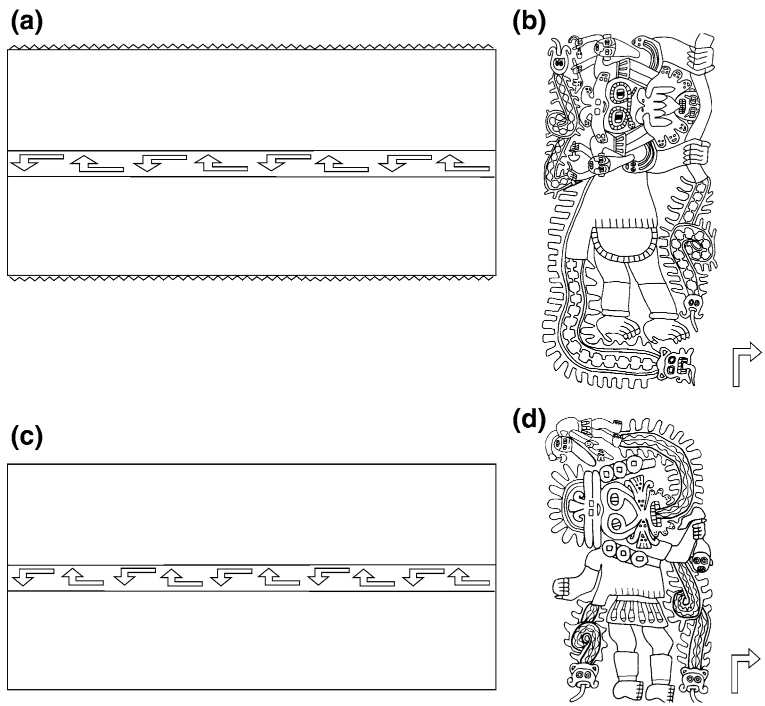

Fig. 18.27 **a** Mantle with center border, 451-28, RT5908. **b** A male figure with an elaborate mouth mask repeats on the center border. **c** Mantle with center border, 451-29, RT3071. **d** Male figure that wears a skirt and tunic repeats on the border (Drawings by the author)

exterior borders. The tabs are made in simple looping over a foundation element (Fig. 18.13c), which is the technique that is used for the tab edgings on three small ponchos and one of the loincloths with continuous borders in this bundle (Paul 1991: Figs. 5.20, 5.21, 5.23, and 5.28).

The bundle has six, or possibly seven, loincloths with continuous borders (Fig. 18.30a–e and 89-23, RT2605; 89-34, RT3171; 89-56, RT unknown; and possibly 89-53, RT2933, which are diagrammed in Paul (1991). Only one has all four ties at the corners (Fig. 18.30e), while another has three ties remaining, and four more have two ties remaining. One of the loincloths repeats a double-headed "bean snake" in the border (Fig. 18.30b). All examples seem to have had continuous borders, except one that may be unfinished: it has borders on three sides and no ties at the corners (Fig. 18.30c). The same figure, possibly a sea creature belonging to the squid family (Fig. 18.30d), repeats on the borders of two loincloths (Fig. 18.30c–e). This figure is directly connected to the Cahuachi mantles, as it is also depicted on two corner borders of the black mantle (Fig. 18.8). The squid-like figure reappears on a head cloth border from bundle 298 at the Necropolis of Wari Kayan, and will be mentioned again.

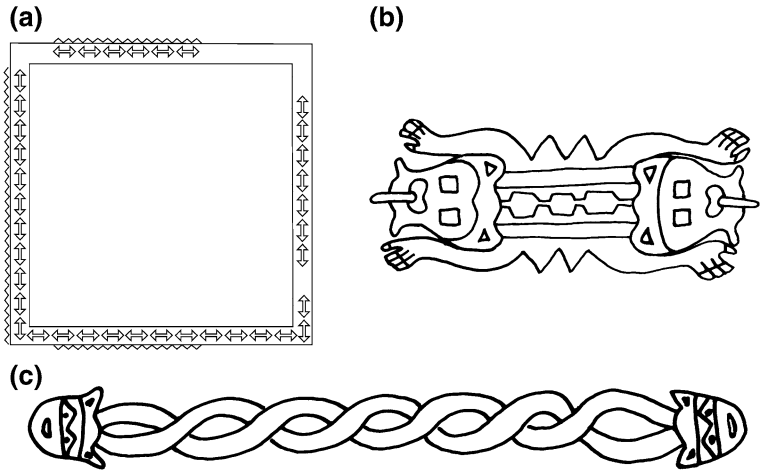

Fig. 18.28 **a** A loincloth with triangular tab edging, 451-26, RT2558. **b** A double-headed creature repeats in the continuous borders. **c** A double-headed creature with a body made of twisted elements repeats on border fragments from another loincloth, 451-17, RT71 (Drawings by the author)

The mantles and loincloths do not form matched sets in bundle 89. However, a small poncho, 89-48 (Paul 1991: Fig. 5.23a, b) matches one of the mantles with a center border (Fig. 18.29e, f). Both repeat a figure that has killer whale, condor and feline traits. This pair of garments indicates that mantles with center borders could be matched with several types of garments. Interestingly, the figure on the mantle and matching poncho is also depicted on two mantles from bundle 253: a mantle with a center border and corner borders (253-64, RT2726, Tello and Mejía 1979: Fig. 119, bottom) and a mantle with figures repeated in the checkerboard field and bracket borders (253-6, RT1683, Lavalle and Lang 1983: 82–83). As the same image is on a checkerboard mantle and a small poncho, it appears that these garment types are also Nasca style. However, they are not exclusively Nasca style garments, as the garment types sometimes display figures belonging to other styles.

Some ponchos are very small, such as 89-28, RT2002, which repeats a "bean cat" in its borders. The body of the small cat is composed of a single bean with a sprout, which corresponds with the tail. There may be oblique references to bean imagery in several other specimens. The fans on mantle 89-32 (Fig. 18.29d) may be metaphorical beans, with the fan handle doubling for a growth shoot. The arced shape and the varied patterns on the fans are shared with depictions of beans. The hunched figure with a skeletal neck on mantle 89-2 has a bulbous body with a point at the shoulders (Fig. 18.29b), a shape that is reminiscent of some Nasca representations of beans that are pointed at one end. Bundle 89 is unusual for the number and variety of loincloth types and the small size of some garments.

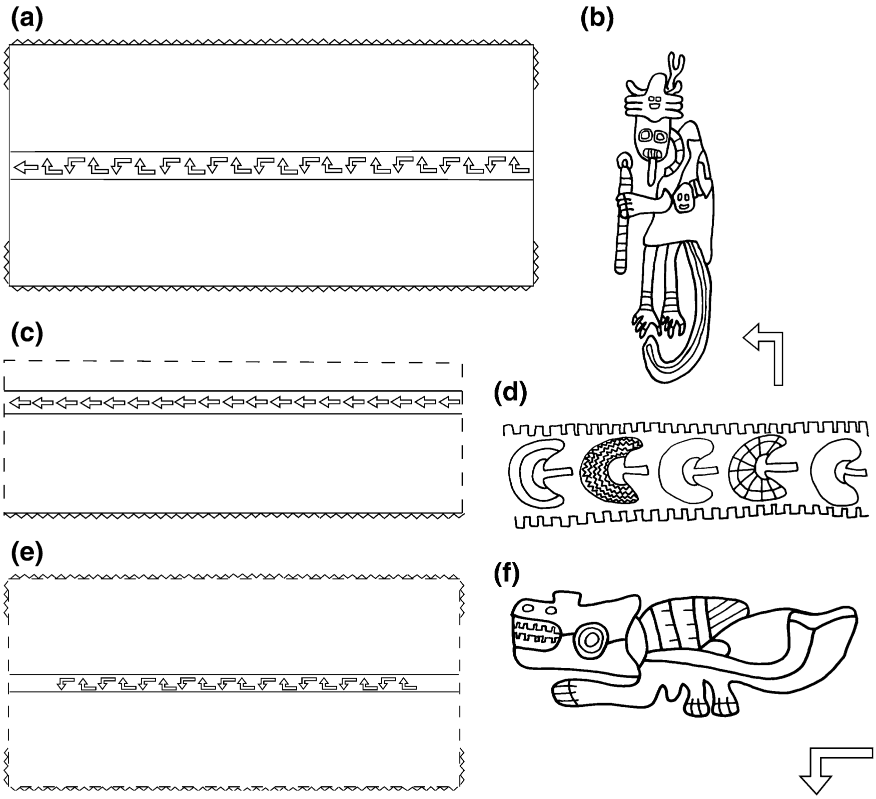

Fig. 18.29 **a** Mantle with center border from bundle 89, 89-2, RT1533. **b** A skeletal figure repeats on the border. **c** Mantle with a center border, 89-32, RT2553. **d** Fans repeat on the border. **e** Mantle with center border, 89-52, RT3204. **f** A composite figure with killer whale, feline, and condor traits repeats on the border (Drawings by the author)

18.6.6 Bundle 378

Bundle 378 has a set of garments that is tightly related to the Nasca style in garment format, theme, and edging technique. The set displays the figure of a "bean cat" in the embroidered borders of a mantle with a center border (Fig. 18.31a, b), a small poncho (Fig. 18.31c, d) and a skirt with a woven tab fringe (Paul 1990: Plate 12). The cats walk on two legs and carry a forehead ornament in their hands, as if they are at an intermediate stage in the transformation between human and animal counterpart.

They have beans within their bodies and the more detailed figures on the skirt sprout beans from their heads. The mantle and the poncho have flat tab edgings in the form of colored beans, which are constructed in simple looping over a foundation element (Fig. 18.13c). The beans in the edging clearly convey number data,

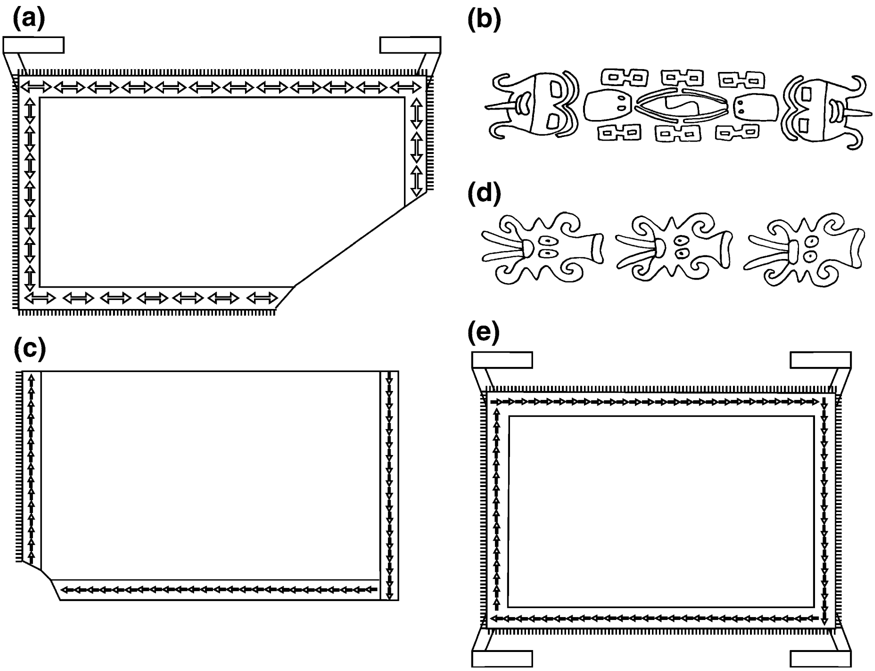

Fig. 18.30 **a** Loincloths with continuous borders from bundle 89 include 89-29, RT2557. **b** A double-headed snake with a bean in its body repeats in the borders. **c** Loincloth with continuous borders, 89-30, RT3017. **d** A sea creature, possibly a squid, repeats in the borders. **e** Loincloth with continuous borders that repeats the same sea creature, 89-33, RT2924 (Drawings by the author)

as they repeat in groups of five on the poncho, probably totaling 117 originally, and in groups of eight on the mantle, probably totaling 351 originally. The skirt has woven cloth tabs on the lower edge, and the embroidery of the bean cats on the tabs is unfinished. It is unknown whether the skirt would have had bean tab edgings, if it were finished.

Two more mantles with center borders are in the bundle (378-7, RT2673 and 378-19, RT2695), but neither has matching garments. The first is unusual in that it has two center borders and exterior bracket borders (Dwyer 1979: Fig. 23). The second has a row of transforming sharks in the center border and small backward bent figures on the flanking fields (Dwyer 1979: Fig. 17).

Two, or possibly three, loincloths with continuous borders are in the bundle (Fig. 18.32a–d and 378-34, RT2738), but only one has the ties attached to the corners (Fig. 18.32c). A bird with a fish in its bill is repeated in the borders (Fig. 18.32d), which is similar to a figure that recurs on the red mantle from Cahuachi (Fig. 18.11). A “bean monkey” repeats in the borders of a loincloth that has fringe on two sides and triangular looped tabs on two sides (Fig. 18.32a, b). The monkey is depicted as swinging from a vine with beans on it, similar to the

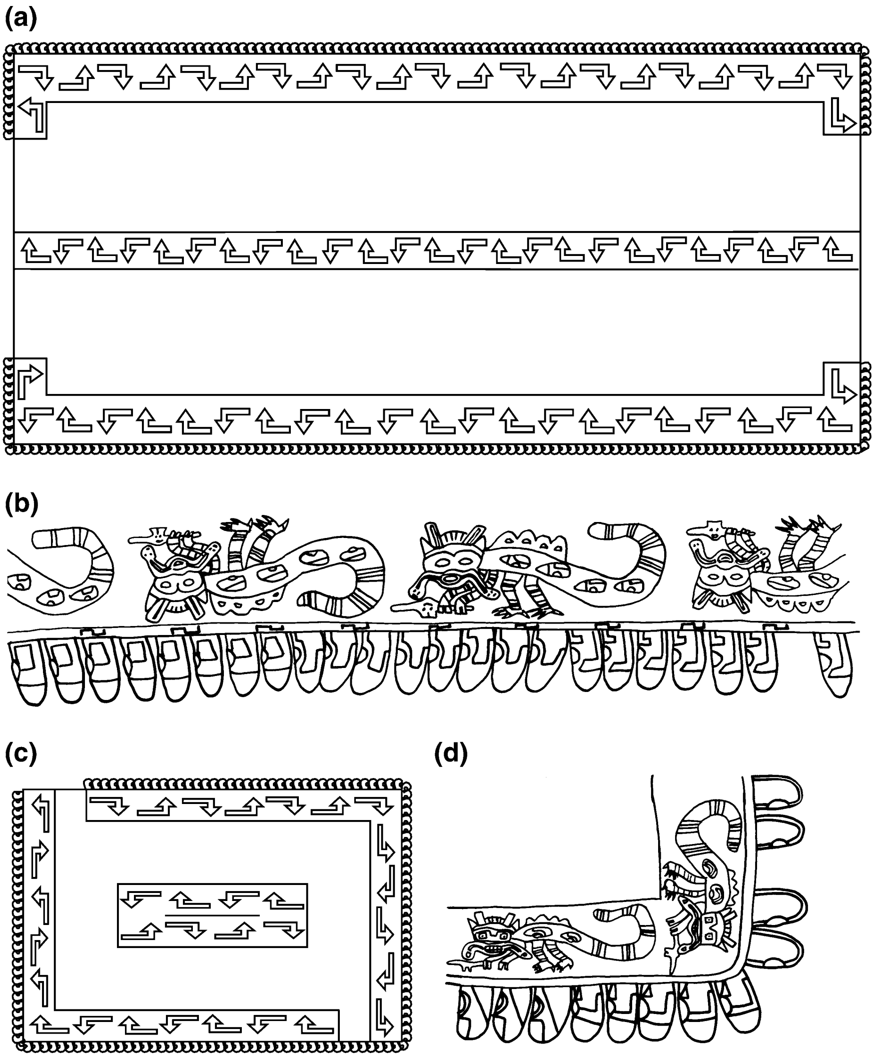

Fig. 18.31 **a** Mantle with center and bracket borders, 378-6, RT2697. **b** "Bean cats" repeat in borders and bean tabs repeat as an edging. **c** A small poncho that matches the mantle, 378-21. RT625. **d** "Bean cats" repeat on the borders and bean tabs repeat in groups of five, rather than eight, on the edges of the poncho (Drawings by the author)

figures on a matched set in bundle 38 (Figs. 18.15b and 18.16b). The third loincloth, 378-34, RT2738, repeats transforming sharks in the borders (Paul 1990: Fig. 7.10).

The bean imagery in this bundle is continued on the borders of an unusual mantle, where the field of stepped triangles is woven in ten colors using the discontinuous warp and weft technique (Paul 1990: Plate 3). The embroidered figure

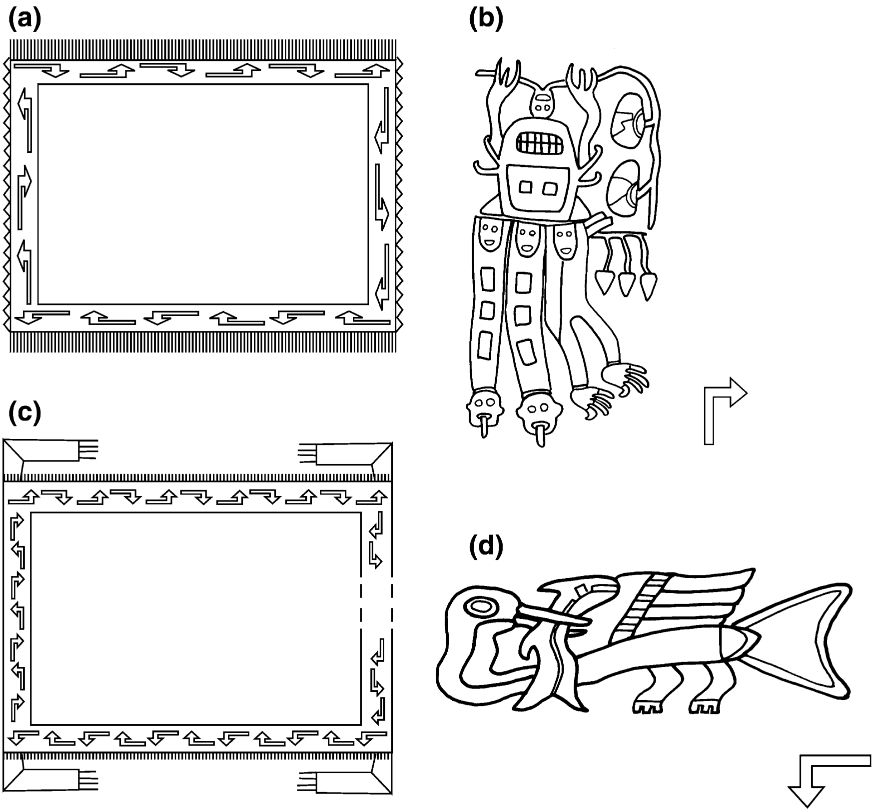

Fig. 18.32 **a** Loincloth with continuous borders, 378-58. RT3219. **b** A "bean monkey" repeats in the border. **c** Loincloth with continuous borders, 378-59, RT2869. **d** A bird with a captive fish repeats in the border (Drawings by the author)

in the border is bipedal and clothed, but has a bean-shaped body (Fig. 18.33). The stepped triangles in the field repeat in a sequence of ten colors that are organized as five pairs. In the second repetition of the sequence, the two colors in each pair are inverted. This appears to be yet another way in which number data is expressed in Nasca textiles.

18.6.7 Bundle 310

Although bundle 310 does not have mantles with center borders, the textiles display some figures that connect them to mantles with center borders in other bundles. For instance, the "bean cats" on the borders of a small poncho (Fig. 18.34a) are very similar to those on the garment set in bundle 378, which includes a mantle with

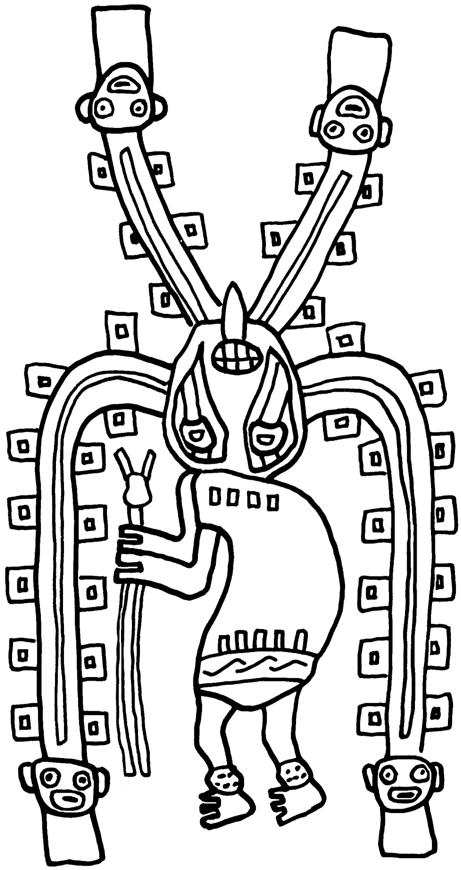

Fig. 18.33 The border figure from a discontinuous warp and weft mantle is a bipedal anthropomorph with a body shaped like a bean, 378-8, RT3554 (Drawing by the author)

center border (Fig. 18.31a, b). The poncho with "bean cats" also relates to a poncho in another bundle that is about one-quarter of its size. The colors of this poncho, purple borders and a brown ground cloth, is the same as that of a little poncho in bundle 89, which repeats a tiny cat with a bean in its body (Fig. 18.34b). A similar little bean cat is repeated on a narrow turban border with triangular tabs, 310-53, RT3262 (Paul 1990: Fig. II.19).

Bean figures are common in this bundle. One example is a splayed figure, possibly a frog, with four beans in its body (Fig. 18.34c). The prominent eyes suggest a frog or toad, and the symmetrical position of the limbs and dorsal viewpoint correspond with canons for depicting the tandem locomotion of hopping animals that live close to the ground (Frame 2004). The tail-like part between the hind legs may refer to the tadpole stage, and the beans within the body may suggest eggs. Another figure is a bird that has a single bean in its body and a worm in its bill (Fig. 18.34d). The bean in the bird may similarly express the fertile egg. These textiles were part of a block of textiles near the center of the bundle. Paul suggested

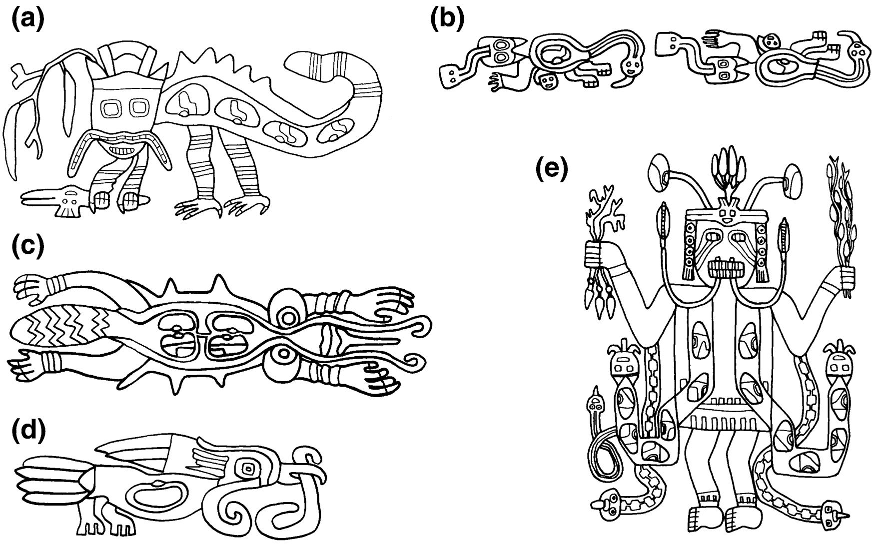

Fig. 18.34 **a** The "bean cats" in the borders of poncho 310-31, RT3860 are from a large poncho. **b** The "bean cats" in poncho 89-28, RT2002, which is one-quarter of its size, are much smaller. **c** A splayed creature, 310-54c, RT2522, possibly a frog, has four beans in its body. **d** A bird on another textile has a single bean in its body, 310-54a, RT unknown. **e** A clothed anthropomorph from mantle 310-2, RT3142, has beans in streamers, and sprouts beans and other plants (Drawings by the author)

that most are turbans, although she lists some as unidentified garments (Paul 1990: 138–148). The most spectacular bean figure in this bundle is a clothed anthropomorph that wears male clothing and sprouts two streamers filled with beans (Fig. 18.34e). Beans and other plants sprout from his head and he holds plants in his hands. The frontal figure that repeats on the mantle border has twelve beans in the two streamers and is larger than the figure that repeats on the checkerboard field, which has eleven beans in the streamers.

Bundle 310 also has images of severed heads, which seem to substitute for beans in Nasca art, on several mantles. Specimen 310-4, RT3141 is a large red mantle, and severed heads that display various colors and types of face painting are repeated in the bracket-shaped borders. Specimen 310-24, RT3206 (Paul 1990: Plate 25) repeats a half-human, half-bird figure that has three severed heads in the wing, and four pairs of heads in the backbone area. A conflated figure with cat and bird attributes from this bundle, 310-45, RT2601, has severed heads in the wings and attached to the body by streamers (Paul 1990: Fig. II.21).

Bundle 310 has many head cloths or turbans. These lightweight cloths have bracket-shaped borders on the two long sides and many of them have exterior edgings made of flat, looped tabs. In this bundle, at least 13 garments have triangular tabs and two mantles have trapezoidal tabs, all of which are made in the Nasca technique of simple looping over a foundation element (Fig. 18.13c).

18.6.8 Bundle 298

The Wari Kayan bundle that corresponds most closely with the excavated Cahuachi textiles discussed here is bundle 298, a bundle that was unwrapped in 2005 and 2006 at the Museo Nacional de Arqueología, Antropología e Historia del Perú (Thays and Aponte 2012a, b). Like Nasca textiles from Cahuachi, bundle 298 has mantles with central borders, and the imagery includes females in Nasca dresses, bean figures, and transforming figures. Two mantles with center borders have recently been published in excellent detail. A complex falcon figure is repeated four times in the center border on mantle 298-5 (Aponte and Thays 2013: Fig. 4a–c). A figure that has shark or killer whale attributes is repeated six times in the center border Mantle 298-8 (Aponte and Thays 2013: Fig. 6a–c). Each figure combines a bipedal, clothed anthropomorph with attributes of a different predator, which suggests that these figures may represent the mythic transformation of the ancestor into an animal counterpart. Although the border of the second mantle is detached from the field, the authors, who were also present for the unwrapping of the bundle, could ascertain that the two mantles originally had a simple fringe that extended around the corners from the long edges, and no other border treatment.

Bundle 298 has at least six more mantles with center borders, although some are quite fragmentary. Specimen 298-20 repeats the figure of woman with head thrown backward and arms extended upward (Fig. 18.35a; Thays and Aponte 2012a: 503, center). She is identifiable as a woman because she wears a long dress with a horizontal border at the hem and another at the bodice, which corresponds with the form of the Nasca dresses in a deposit excavated at Cahuachi (Frame 2005, 2009b). This female figure is quite similar to the female on the Cahuachi black mantle (Fig. 18.14a) and on mantle 38-15 (Fig. 18.19a). Two more mantles with center borders display bean figures of different types. Mantle 298-22 repeats a figure that is splayed dorsally and has two beans on each of four legs (Fig. 18.35b; Thays and Aponte 2012a: 504). This may be a version of the "bean cat" with additional serpentine streamers. The cat on the black Cahuachi mantle is also splayed dorsally, but has beans along the backbone (Fig. 18.14b). The other bean figure is a standing anthropomorph with four beans on his tunic (298-38, Thays and Aponte 2012a: 508, bottom). This mantle had square tabs on the long sides. Several small fragments of what may be another mantle border (298-24) display a partial figure with plants and fruits, including beans, attached to its head by slender appendages (Thays and Aponte 2012a: 505, top).

Small fragments of a probable mantle, 298-34, have the figure of a crustacean repeated along its center border (Thays and Aponte 2012a: 506, bottom, and 507, top). The figure is similar to the pink crustaceans on the borders of the red and black mantles from Cahuachi (Figs. 18.8 and 18.11). A tiny fragment of another mantle has been painstakingly reconstructed by Delia Aponte to show that the figure in the center border had hummingbirds circling around the forehead ornament of a standing figure (Thays 2010: Figs. 6 and 7).

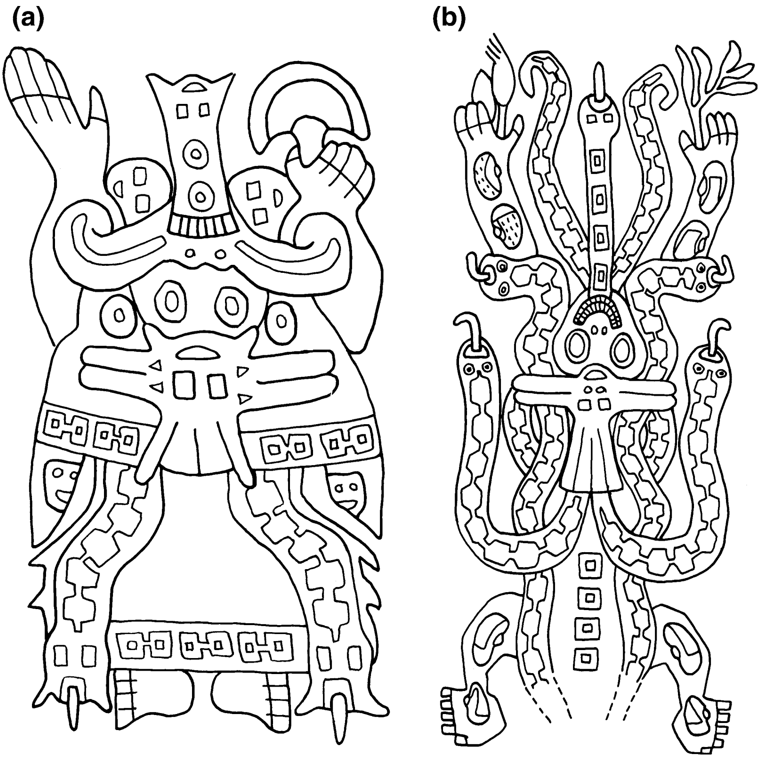

Fig. 18.35 **a** The figure of a female with head thrown backwards is repeated on the center border of mantle 298-20, RT unknown. **b** A splayed figure with beans on its four limbs is repeated on the center border of mantle 298-22, RT unknown (Drawings by the author)

The mantle in this bundle that most resembles the two mantles from Cahuachi has a center border and corner borders with fringe on the exterior edge. Small square tabs, worked in simple looping over a foundation element, connected the borders to the field cloth originally. The embroidered figure is a double-headed feline with a snake or centipede body (Fig. 18.36; Thays and Aponte 2012a: 508). The figure is very similar to the figure on a loincloth with continuous borders (Fig. 18.28b). The mantle 298-37 and the loincloth 451-26 are embroidered in different variations of stem stitch (double-faced and single-faced, respectively). In double-faced stem stitch, the figure is very clear on both sides of the fabric. While the use of double-faced variant of stem stitch in textiles at the Necropolis of Wari Kayan has been accepted as indicating Nasca manufacture by scholars for many years, as mentioned previously, the converse cannot be taken to be true. These two examples with the same figure, 298–37 and 451–26, convincingly illustrate that both double-faced and single-faced stem stitch in the Wari Kayan bundles can be Nasca style. Single-faced stem stitch is the more common stitch, and is used on the borders of the knotted cloth from the Cahuachi olla (Fig. 18.12b), but it is not

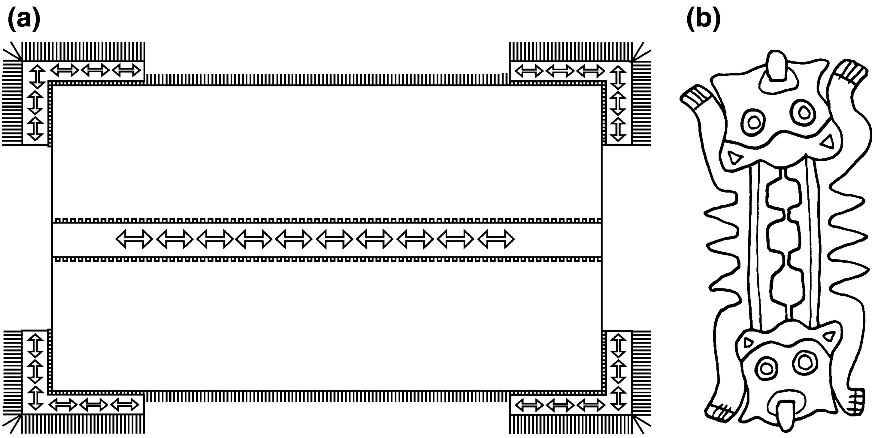

Fig. 18.36 **a** Reconstruction of a fragmentary mantle with center border and corner borders, 298-37, RT unknown. **b** A double-headed feline with snake or centipede body repeats on the center and corner borders (Drawings by the author)

exclusive to the Nasca style. Double-faced stem stitch is exclusive to the Nasca style, but it is rarer.

There are no loincloths with continuous borders and corner ties in bundle 298, but there are three head cloths, or ñañakas, which share Nasca traits with the textiles excavated at Cahuachi. Specimen 298-35 repeats a sea creature with dominant eyes and multiple legs, possibly a squid, on fragments of what were bracket-shaped borders with fringe (Thays and Aponte 2012a: 507, center). The same figure appears twice on one of the corner borders of the black mantle excavated at Cahuachi (Fig. 18.8 and Frame 2009b: 206, lower left and upper right corner). On 298-35, the figures are embroidered in double-faced stem stitch, an embroidery stitch that is exclusive to the Nasca style. The same figure is repeated on the borders of two loincloths from bundle 89 (Fig. 18.30c–e), but it is embroidered in single-faced stem stitch in those garments.

An unusual head cloth with double-cloth panels, 298–23, has tapestry borders that display a series of Nasca figures (Thays and Aponte 2012a: 504, bottom). The red and beige double-cloth repeats a long-necked bird in pursuit of a sea creature in five rows that run the length of the head cloth. The tapestry border displays many of the figure types that are on the borders of the red and black mantles from Cahuachi: flying and walking birds, sea creatures, flying insects, transforming felines, and women in long dresses. The tapestry border on 298-23 also includes an anthropomorphized weaving comb that wears a dress. Although this figure is not on the Cahuachi mantles discussed here, a conflation of comb and dressed female is one of eight figures on a mantle border that is embroidered in double-faced stem stitch (Sawyer 1997: 59–67). Another Nasca trait of this extraordinary head cloth is the line of square tabs that join the tapestry border to the double-cloth panel. The tabs are made in simple looping over a foundation element, like the tabs on the ends of the knotted cloth from the Cahuachi olla (Fig. 18.13a and c).

The third head cloth, 298-2b (Thays and Aponte 2012a: 495, bottom), has an embroidered border flanking the deep purple field cloth where beans repeat in a semi-regular pattern. The beans have many variations in colors, zones, stripes, and speckled markings. The beans are displayed in groups of four on border backgrounds of different colors. The color background repeats in a ten-part sequence on the 22 compartments on each side of the head cloth, with the same sequence starting at opposite ends. The beans are organized in pairs of pairs in each color compartment. The first cycle of 40 on each side border, starting from opposite ends, is the same, but there is variation in the subsequent repetitions. Bundle 298 has textiles that correspond with virtually all of the distinctive Nasca traits selected from the Cahuachi textiles for comparison.

18.7 Discussion

In illustrating the close relationship between textiles excavated at Cahuachi and those from some bundles at the Necropolis of Wari Kayan, I have used a few specific attributes drawn from the textiles in the Cahuachi olla. They correspond with distinctive types of Nasca textiles, rather than the most common types. Thus, the mantle with the center border is one type of format, among several, but this format is exclusive to the Nasca style. All the mantles with center borders at the Necropolis of Wari Kayan also have Nasca style imagery (Frame 2007: 72). Checkerboard field patterns or plain fields with bracket borders are more common types of formats, but they are shared by several different styles at the Necropolis, in addition to the Nasca style. The mantle with center border sometimes matches another distinctive garment, the loincloth with continuous borders and corner ties. This is another garment type that is exclusive to the Nasca style and invariably has Nasca imagery (Frame 2007: 72). The flat tabs that are made in simple looping over a foundation element are a distinctive technical attribute that is exclusive to the Nasca style. While other edging treatments, such as fringes, are common Nasca techniques, they are not exclusive to the Nasca style at the Necropolis. Images of women in Nasca textiles are less numerous than images of males, and they are identifiable by a distinctive dress, which has one or two horizontal borders depicted and no pins at the shoulders. Beans are distinctive, additive motifs that are incorporated into Nasca figures in a variety of ways: on bodies, limbs, tongues, streamers, and pelts, or incorporated into costume elements. As might be expected, the foregoing attributes quite often occur in various combinations in a single textile.

Certain bundles from the Necropolis of Wari Kayan have been singled out for discussion in the preceding section because of the large number of correlations with the Nasca attributes selected from the three textiles found in the olla at Cahuachi. Other bundles also contain textiles with some of the attributes. Bundle 318, for instance, has checkerboard mantles with Nasca-style transforming figures, and some of the figures incorporate beans. A clothed falcon figure has a bean cat on top of its wing (Fig. 18.37a), while a flying insect with human limbs that has beans flanking its head is repeated on another mantle (Fig. 18.37b). Bundle 27, which is in the Museo Inka in Cuzco, has several mantles with center borders (Pardo and Galimberti Miranda 1963: 33; Peters 1991: 7.9 and 7.47), and 27-10a repeats a transforming "bean cat" that walks on two feet and has human arms. Bundle 258 has a small poncho with a "bean cat" in the borders, 258-4, RT2930, as well as other textiles that are embroidered with Nasca-style figures. Bundle 262 has many Nasca-style textiles (see Peters 1991: Figs. 7.26 and 7.28), including a mantle with a "sprouting bean man" (262-13, RT2857 and 3778), which is similar to an illustrated figure from bundle 38 (Fig. 18.20b). Bundle 421, which has textiles in several different styles, has a skirt with Nasca "bean cats" on the borders (Fig. 18.37c). Bundle 190 has a skirt with a similar feline in the border, but it has severed heads rather than beans inside (Fig. 18.37d). The discussion could include examples from all of the bundles that Dwyer (1970, annex B) and Paul (1990: Table 5.2) placed in Early Intermediate Period 1B and 2, as well as some examples some from the bundles they place in phase 1A.

18.7.1 Beans and Severed Heads

Bean imagery is intimately associated with the Nasca style and is used in multiple ways. Beans are incorporated in many figures, from clothed humans and transforming anthropomorphs to cats, monkeys, birds, frogs, and foxes, as illustrated here. Beans are repeated on bodies and limbs and on streamers that emanate from bodies. At times, they substitute for pelt markings, but more commonly they appear to be the "seeds of life", shown through an X-ray view as being inside bodies. Beans and severed heads are used interchangeably, as indicated by the presence of both in the streamers emanating from a monkey (Fig. 18.15b). A pair of similar feline figures, one with beans inside its body and the other with severed heads (Fig. 18.37c, d), also indicate they can substitute for each other. The beans and the heads with long hair on or in the felines are roughly the same shape, so the visual analogy works. However, the relationship that drives the metaphoric substitution seems to reside in fertility, which beans, as seeds, naturally embody. Severed heads and blood rituals were probably associated with fertility rites as well (Aponte and Thays 2013; Frame 2001). The coherence of the interchanging metaphors likely turns on the association of water and blood as fertile fluids, which are necessary for agricultural growth and for the regeneration of the ancestors in the mythic cycle.

Beans and severed heads are motifs that are treated in similar graphic ways in Nasca embroideries and looped edgings, which is another indication that they substitute for each other. The beans are distinguished by different colors, speckles, lines, and zones (Fig. 18.38), and can be patterned in as many as 52 different ways in a single textile (Sawyer 1997: 117). More frequently, the bean edgings made of looping over a foundation element are patterned in pairs (Fig. 18.25a), although

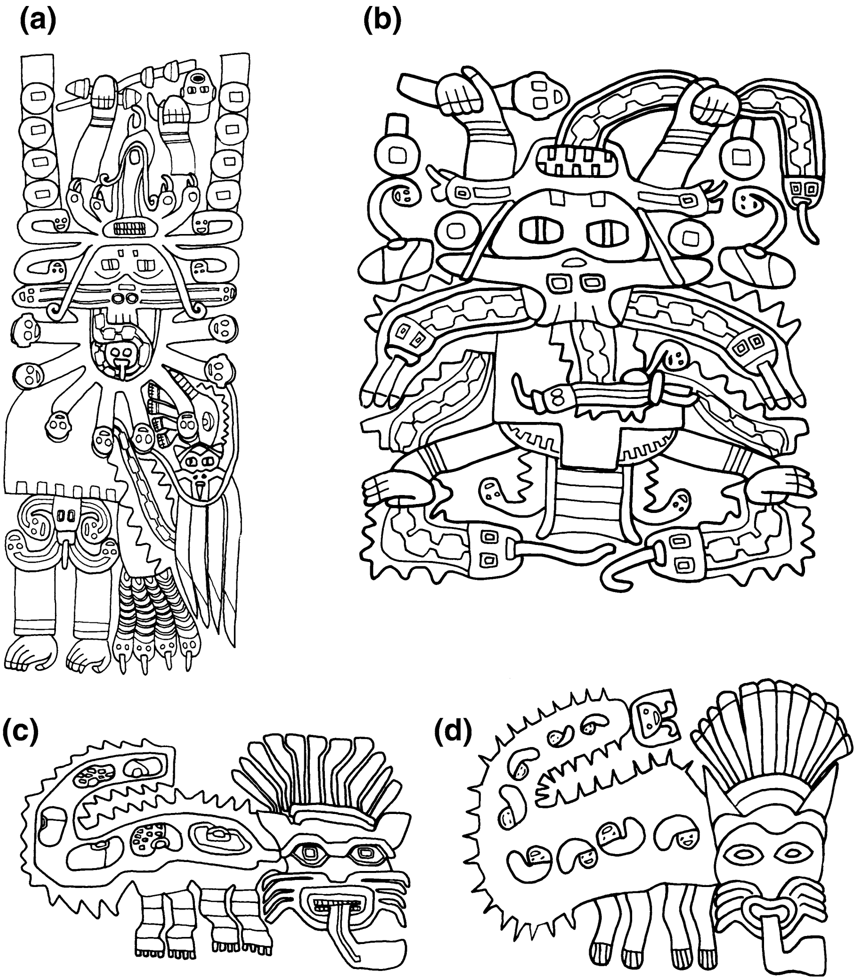

Fig. 18.37 **a** "Bean" figures from additional Wari Kayan bundles include a falcon man with a "bean cat" on his wing, on mantle 318-5, RT1655. **b** A transforming insect accompanied by beans, on mantle 318-9, RT743. **c** A "bean cat", on skirt 421-116, RT1770. **d** A similar cat with severed heads, rather than beans, on skirt 190-31, RT3208 (Drawings by the author)

they are also repeated in blocks of four, five, and eight on some textiles (Figs. 18.19a, 18.31b, and d). These pairs or blocks then repeat in cycles of variable duration. Borders that are embroidered with beans can add another level to the patterning by changing the background color of the border behind regular groupings (Thays and Aponte 2012b: 526–527). The same color can be used as background for four beans, organized as two pairs with different markings. Severed heads with varied colors and patterns of face painting are also used as border treatments, as in a matching mantle and skirt in bundle 382,[7] where severed heads with different types of face painting alternate in long sequences on the embroidered tabs that line the long, outside edges of the garments (de Lavalle and Lang 1983: 69–71). Another mantle also alternates heads with varied facial designs in the borders (310-4, RT3141), although the borders are too fragmentary to discern the length or regularity of the sequence. A set of garments from bundle 378[8] has severed heads of different colors repeated as motifs that cover the field of a head cloth, small poncho, and unfinished mantle (Paul 1990: Figs. 7.27–7.29 and Plate 23). On another mantle (Fig. 18.22c, d), tiny severed heads of different colors outline the center and corner borders of a mantle. The painted designs on faces occur not only on severed heads, but also on full-figure images, particularly on Wari Kayan mantles with checkerboard repetitions of large, Nasca-style figures.

18.7.2 Signs, Cycles, and Syntax in Nasca Textiles

The decoration of heads and beans, and their patterns of repetition, are worthy of further study. The structured repetitions of colored and patterned beans and severed heads suggest that they are signs that belong to a system of information based in the Nasca community of textile makers. Although the meaning of the signs is not accessible, the syntax of the information system is partially discernible in the expressions of numbers and cycles. This is not the only structured use of signs among the Nasca textiles at the Necropolis of Wari Kayan.

The bundles that are strongly Nasca in character often have one or more headbands with geometric images that resemble twisted strands, zigzags, or a combination of the two. These headbands were made using weaving and braiding techniques simultaneously: The bands were woven under tension with multiple wefts, and the interspaces between them were produced by obliquely braiding the multiple wefts with each other, after they were woven through the bands (Frame 1991: Figs. 4.29c, 4.30c and 4.40). The ones that are Nasca style exhibit a range of colors that includes light colors (gold, yellow, white, and pink) in alternation with darker colors (navy, purple, and dark green).[9] Those that have images of twisted strands or zigzags in these colors display two to eight colored strands, and are present in bundles 38, 253, 258, 298, 310, 319, 382, and 451.[10] These headbands are generally present in the Wari Kayan bundles that have a preponderance of

[7] 382-10, RT5904 and 382-48, RT1017.

[8] 378-23, RT1345, 378-27, RT2809 and 378-31, RT2633.

[9] Red headbands with images of three or four twisted or braided strands in dark threads (Frame 1991: Figs. 4.2, 4.10, and 4.13) may correspond to simpler color patterns on embroidered mantle borders and fields of the “silhouette” or “linear” style, which are non-Nasca styles in the Wari Kayan bundles.

[10] Many of these headbands have been published in Frame (1991: Figs. 4.1, 4.5–4.7, 4.11, 4.14, 4.16, 4.17, 4.28, 4.34) or Thays and Aponte (2012a: 495, center).

Fig. 18.38 Cahuachi border fragments, which are embroidered with sprouting beans in a long sequence of colors, Cahuachi 2007-Y2EXP8 Q23 (Photo courtesy of Proyecto Nasca)

textiles that share the Nasca attributes of the Cahuachi textiles, which suggests that the headbands themselves are Nasca in origin. The color range also suggests the headbands are Nasca style. The headbands, like the tab edgings in the form of beans, clearly express numbers and cycles, but in this case they use the visual metaphor, or icon, of a plied cord to embody them. The regular variation within the headband sample indicates that the images of twisted strands, which are similar to the actual plied cords of Inka *khipus*, are signs that also belong to a system of information.

The headbands may have been templates for the color patterns on Nasca embroideries from the Necropolis of Wari Kayan (Frame 1991: Figs. 4.27 and 4.28). Like the headbands, the color patterns on the embroidered garments with checkerboard repetitions of figures are strongest on diagonals. The color patterns on the field of Nasca mantles in bundles 318 and 319 from the Wari Kayan Necropolis frequently run to sequences of 28 differently colored figures, which are organized on four adjacent diagonals spanning seven rows on a checkerboard field (Paul 1997).[11] In the case of 319-56, RT1012, the color repetition extends to a cycle of 52, which is organized on four adjacent diagonals spanning 13 rows. Another mantle, which I examined in the American Museum of Natural History (41.0/1507), has a color repetition of 42 color blocks, organized on six adjacent diagonals spanning seven rows. The length of the color sequences on the Nasca embroideries from the Necropolis of Wari Kayan suggests that the Nasca practitioners had

[11]In 1984, I proposed a joint project on the color and symmetry patterns of the Necropolis embroideries to Anne Paul, on which we worked together until 1993. Paul published the color project in 1997.

developed complex systems of information with long cycles that perhaps corresponded with calendrical cycles. That they chose to embed these cycles in their textiles suggests a reason for the florescence of the textile arts in the early phases of the Nasca style.

Nasca textiles, particularly those that can be identified as Nasca at the Necropolis of Wari Kayan, indicate that the figures are interconnected with numbers and cycles. The extent of the number data in the Nasca embroideries is far greater than in the embroideries belonging to other styles at the Necropolis of Wari Kayan. The "silhouette" style, for instance, which I described in a paper presented at the Society for American Archaeology in 2008, is a style where almost all color patterns in the embroidered garments are restricted to three or four color blocks (ABC, ABCB, or ABCD). In this style, the curvilinear figures have simplified outlines and little interior detailing, hence the name. The silhouette style figures are generally monocolor, and my definition of the style includes what Paul called the "broad line" style (1982).[12] The styles are similar in most respects, except that the "broad line" figures generally have a small figure set within the center of the main figure's body. I have proposed elsewhere that the "silhouette" style (including the "broad line" sub-group) likely corresponds with the Paracas/Ocucaje tradition (Frame 2009a: 58), as many of the figures occur on ceramics of the late phases of the Paracas/Ocucaje tradition (for example, see Sawyer 1966: 91–95). Another style at the Necropolis, denominated the "linear" style by Jane Dwyer in her seminal studies (1970, 1979), also has more restricted color patterning, although some have six or more color blocks. The breadth and complexity of the number cycles that are embedded in the color sequences of Nasca textiles at the Necropolis becomes particularly evident, when compared to the simpler color patterns on textiles of other styles at the Necropolis of Wari Kayan.

18.8 Conclusions

Forty-five years ago, Jane Dwyer wrote a thesis and authored an influential study of the textiles at the Necropolis of Wari Kayan (1971, 1979). She recognized the presence of different styles of textiles at the site and attempted to link them into a sequence of gradual change that spanned the final phase of the Early Horizon (EH 10) and the end of the second phase of the Early Intermediate Period (EIP 2). Dwyer used the attributes of the ceramic seriation developed at Berkeley (Menzel et al. 1964) to define the textile phases. Essentially, the seriational sequence was thought to span a continuous stylistic tradition that bridged the end of the Paracas style and the early phases of the Nasca style. Complete mummy bundles were

[12] Paul (1982) considered the "broad line" style might be a family style because it was concentrated in four bundles. The "silhouette" style, which includes the "broad line" sub-style, has a wider distribution among the bundles at the Necropolis of Wari Kayan.

assigned to a phase or sub-phase in the sequence, and stylistic attributes that defined the phases and sub-phases were described. The phases assigned by Dwyer were largely adhered to by Paul in her many publications on Paracas Necropolis textiles.[13] However, a close look at the contents of specific bundles shows that individual textiles contradict, rather than support, the phase assignment for complete bundles in a number of cases (Frame 2001: 88–89 and p. 92, note 24; Frame 2007: 71–73; Frame 2009a: 58). The anomalies indicate a problem with the premise of a single evolving tradition, which underlies both the ceramic and the textile seriation. Another model is required to account for the different styles that are present in some of the same bundles at the Necropolis of Wari Kayan, and the presence of similar figures in bundles that are assigned to different phases. In 1995, I proposed that the "mixture of textile styles within some bundles, as well as the bundle size and wealth of decorated cloth, suggests a ritual on a grand scale, using tribute cloth from groups with different artistic traditions" (Frame 1995: 15). In recent articles, Ann Peters has expressed a similar opinion, referring to ethnic groups that were "brought together in mortuary ritual" (2012: 11), or "producer communities" that brought textiles together to be placed in the same tomb (2014: 111).

Dwyer was correct in many of the traits by which she defined "the very distinctive and easily recognizable (Nasca) style" (1979: 112), but the anomalies in the seriation indicate that she was not correct in limiting this style to EIP 2. The archaeologist Alfred Kroeber also recognized that many figures on the Necropolis textiles corresponded with figures on Nasca pottery, rather than Paracas pottery (O'Neale 1937: 128, preface; Kroeber 1944: 33). Duncan Strong accounted for the Nasca imagery on the textiles from the Necropolis of Wari Kayan by suggesting that the Nasca dead could have been transported across the desert for burial on the Paracas Peninsula (Strong 1957: 16).

Helaine Silverman tried to resolve the Paracas Necropolis–Nasca issue in the Dwyer/Paul seriation by tackling the problem in an article entitled "Differentiating Paracas Necropolis and Early Nasca Textiles" (2002). While she usefully summarized many of the problems that inhere in the assignment of phases to south coast textiles, she was unable to differentiate between the styles in a consistent manner. This is not surprising, because the site of Paracas Necropolis (i.e., the Necropolis of Wari Kayan), as argued here, has multiple textile styles, one of which *is* the Early Nasca style. She did put her finger on various problems in the ceramic seriation (Silverman 2002: 75–85), which were translated into the textile seriation. Patrick Carmichael has recently addressed difficulties in the traditional Berkeley Nasca pottery sequence through a re-examination of Nasca 1 and 2 phase markers as defined by Lawrence Dawson. Working from a larger sample than available to Dawson, Carmichael demonstrates that several key traits previously considered restricted to Phase 2 were already present in Nasca 1 (Carmichael 2016). This

[13]Paul (1990: Tables 5.2 and 5.3) added bundles and made several small changes to Dwyer's seriation. She moved bundle 27 to EIP 1B from EIP 2, and moved bundle 258 to EIP 2 from EIP 1B.

requires rethinking the temporal placement of textiles previously assigned to different epochs on the basis of comparisons with Phase 1 and 2 ceramic motifs. Both Silverman and Carmichael recognize that my proposition of tribute and offerings from different ethnic groups participating in a regional cult at the Necropolis of Wari Kayan (Frame 1995: 15) at least partly resolves the issue of distinct textile styles appearing together in the same bundle (Silverman 2002: 101).

The multiple styles at the Necropolis of Wari Kayan include the Nasca style, as documented here by the presence of textiles with clusters of distinctive Nasca traits in many of the bundles. I have also mentioned the "silhouette" style at the Necropolis of Wari Kayan, which I suggest corresponds with the Paracas/Ocucaje ceramic tradition (Frame 2009a: 58). Ann Peters also describes "Topará tradition" textiles as being part of the bundles at the Necropolis (Peters 2012). While it is probable that there are Topará textiles at the Necropolis of Wari Kayan, because of the presence of Topará ceramics at the site, it is lamentable that Peters does not explain her evidence or reasoning for associating the "linear 1" style with Topará or for the attributes she cites for the Topará textile style.

Radio carbon dating (León Canales 2007) has also contributed data that supports the contention that there are multiple, overlapping styles of textiles in the bundles at the Necropolis of Wari Kayan. Bundle 451, which was considered to be the latest bundle in EIP 2 on stylistic grounds by Dwyer (1971: Annex B; 1979) and Paul (1990: Table 5.2), is shown to be earlier than expected. It is centered in the same range of dates as bundle 49, a bundle that Paul placed in EIP 1A on stylistic grounds. Painted textiles from the Cleveland Museum of Art that would be seriated to EH 10 and EIP 2 on stylistic grounds have similar radio-carbon dates, and "linear" and "block color" embroideries from the World Culture Museum, which should be in different phases according to the seriation, also have similar radiocarbon dates (León Canales 2007: Table 1 and accompanying discussion). The tabulated radiocarbon dates indicate that the different types of embroideries and painted textiles that Dwyer and Paul assigned to different temporal phases on stylistic bases are likely contemporaneous.

Patrick Carmichael, after many years of working with the Berkeley ceramic chronology, offers grounds for adjusting the ceramic seriation of the first two phases of the EIP in an article that discusses a sample of antaras (panpipes). He shows that traits originally used to define Phase 2 are present in Phase 1 as well, which essentially collapses the two phases into one phase (2016). His adjustment to the stylistic bases of the phases fits quite well with adjustments in dating indicated by the radiocarbon tests (León Canales 2007). Both indicate that Nasca style figures can be contemporaneous with other styles that formerly were seriated to earlier phases. Ann Peters, however, continues to adhere to "style groupings used by previous researchers to propose a chronological sequence in the Wari Kayan cemetery" (2014: 111), despite the evidence that the seriation is internally inconsistent and that it is contradicted by radiocarbon dates.

Chronology at the site of the Wari Kayan Necropolis is a subject that should be re-examined, but in the light of a different model than that of a single evolving tradition, which is the model that underlies the chronology used by Dwyer and Paul.

The model should be one of multiple ethnic groups, participating in a regional mortuary cult. Chronological depth may also be present in this model, but it will be more complex to illustrate. If the mortuary rituals at the Necropolis of Wari Kayan continued over a period of centuries, we might expect to find multiple ethnic styles represented in the textiles of some bundles, but each style would have its own temporal duration and evolution, as well as time spans when the styles overlapped with each other and/or mutually influenced each other. Styles would need to be mapped across bundles, as well as within bundles, to provide a coherent picture of chronological change.

The Cahuachi textiles from the olla provide a fresh set of distinctive attributes with which Nasca textiles at other sites can be identified. They also contribute to an understanding of Nasca interactions on the South Coast, including participation in a mortuary cult at the Necropolis of Wari Kayan on the Paracas Peninsula. With the expanded corpus of textiles that can be identified as Nasca-style, including some highly patterned garments and headbands from the Necropolis of Wari Kayan, it becomes possible to describe several Nasca systems of numerical data that are embedded in the textiles—in the bean tab edgings, in the woven and braided headbands, and in the long sequences of color block repetitions in the embroidered figures on garment fields. Comparisons with other styles of textiles present at the Necropolis of Wari Kayan indicate that the Nasca systems of patterning are much more complex than those of the other styles, which appear embryonic by comparison. It is a matter for future scholarship to contemplate what, in particular, precipitated the upwelling of systematized numerical information that is embedded in Nasca textiles, and what the cultural and/or natural correlatives for the numerical cycles and sequences were.

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Chapter 19
The Decline of Cahuachi and the End of the Nasca Theocracy

Giuseppe Orefici

Abstract Following the natural events that led to the end of the ceremonial center, the influence of Cahuachi in the Río Nasca Valley greatly reduced, and the great temple structures were used mostly as large cemeteries. The theocracy that for centuries had ruled the political and social system of the Nasca society gradually turned into a mosaic of small towns with their own power over their territories based on the importance of local *curacas*. In parallel to the disintegration of the social organization system, the pressure of the Wari society from the Sierra also increased. Only one area for ceremonial purposes survived in zone B of Cahuachi, although with significant structural and functional changes during the last two hundred years of the Nasca Culture. Religion was still the most important element in the artistic expression of ceramics and textiles, although representations of the powerful local lords gradually replaced the image of the gods and the traditional symbols.

Keywords Cahuachi · Decadence · Earthquake · Floods · Climate

19.1 Evidence of Anomalous Events Within the Temple Buildings

Looking at the various stages in the chronological evolution of the Cahuachi ceremonial center, it is apparent that the various temples indicate no abrupt transformations: indeed, their architectural development retained over the centuries the specific characteristics of previous edifices, incorporating them into the new buildings. We can easily see that the changing phases are the result of a constant

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evolution of thought, but also of a lifecycle linked to the chronology of phases that have a clear meaning according to the order established by the priestly class. As life at Cahuachi went on, there were nonetheless some particular moments when sudden events caused unusual changes. The last century of the life of the ceremonial center, including the phase called III b and the one known as IVb, witnessed an event for which no sure explanation exists. The buildings with columns and roofs that covered even quite large spaces were suddenly set on fire. The ceremonial center most certainly included architectural complexes containing enclosed environments, but in some cases an evident boundary had been created by the presence of separating walls or large open spaces that would never have allowed fire to spread. Thus, there is no clear explanation as to how the fire could have spread throughout the whole Cahuachi area and through most of the temples in zones A and B–unless it had been started deliberately. The impressive platforms of the *Gran Templo* were damaged, as well as the higher surface of the *Gran Pirámide*: traces of combustion are visible also in less important structures, such as the complex known as Y1, which includes four temples: M1, M2, M3 and M4. Archaeological research was carried out in various parts of Cahuachi during the Nasca Project, and in most of them, columns or walls with significant burn marks could be found inside the structures themselves.

During the excavation of the temple known as M1, it emerged that the platforms were in fact burned, and the bases of the columns visible on the surface of the floor areas showed signs of internal charring both on the supports and the layers of reeds bound by ropes made from vegetable matter.

Also on the platform of the *Gran Templo*, columns belonging to Stages IIIa and IIIb and belonging to two different stages in the sequential construction of the walkways, were found to have been eliminated at the beginning of Stage IVb. The surface of the *Templo Sur* (Sector Y 24) has the same features, with the base of the columns probably having been burned at the same time. In all the large walls constructed using the *quincha* technique and sustained by posts, there are signs of combustion on the surface of the platforms at the base of the posts.

The same situation can be found in Cahuachi's Zone B: in Y13, deep burn marks were found on the walls and at the base of the posts dating from the last period in which the surface of the upper platform of the temple was used before being finally covered over with fill, in which many sacrificial objects were also incorporated. In all the areas where archaeological research was carried out, it is possible to suggest that there may have been a large fire covering the entire surface of the ceremonial center. Even without certain proof that the fire had broken out in all sections at the same time (due to the *margin* of error of radiocarbon datings), it is thought that the flames could have spread simultaneously across the Cahuachi area. This event may have had any number of different causes, but there is no doubt that this disaster at Cahuachi opens up new perspectives on the last phase in the existence of the ceremonial center.

If the fire had been accidental, it could not possibly have spread over such a wide area, considering that there are very large open spaces occupying the intermediate sectors, especially between Zone A and Zone B. The second hypothesis is that a series of fires broke out at the same time as a result of a Ríot or revolt against the priestly class in the ceremonial center, but in this case, the traces left would be much more chaotic and there would be other corroborating signs, such as various different burned materials, signs of fire along the large perimeter walls of the temples, or bodies of people who died near the burned areas. Most importantly, in this case the remains of fallen roofs would have been found along with the supporting posts and charred vegetable matter. The third hypothesis, which is possibly closer to the truth, is that of a ritual burning of the structures at a time of cyclic change, explained by the absence of any burned remains of construction materials on the walkways or other elements typical of accidental fires. As a confirmation of this hypothesis, during excavations in Y1 in 1998, the charred remains of the base of a column were found. This had later been covered in clay mortar in order to position the *adobes* needed to erect a new structure: this evidence shows that the layer of clay was added while the underlying structure was still burning and that a new building was being constructed at that time, which suggests that a ritual fire took place at Cahuachi, at a time of cyclic change when all the roofs, including those of the temples, were removed, forming wide open spaces enclosed by walls, but not protected. It is possible that the changes were made at Cahuachi after one of the great floods hit the area because of intense climatic anomalies in the region during the fourth phase, when obvious changes drastically affected the life of the ceremonial center (Fig. 19.1).

Fig. 19.1 Cahuachi: structures of the third phase destroyed by a violent earthquake that hit Cahuachi simultaneously with two large floods. During the fourth phase, the temple structures were covered with vegetable matter and earthy materials (Photo by the author)

19.2 The Spatial Reorganization During the Phase IV of the Construction of Cahuachi

Innovation at Cahuachi was thoroughgoing and involved radical metamorphoses of the interior spaces of the buildings, so that only some of the activities that had been carried out in the covered areas could continue. The very appearance of the ceremonial center underwent a profound change in terms of sheer volume, becoming almost unrecognizable without the large roofs that covered the sacred spaces or those of the large platforms: even in the perimeter buildings, the rows of columns that stood around the walls of the main platforms underwent total change, the only volume element being the steps, in the absence of roofs supported by large columns.

Although there is no absolute certainty, from the excavations carried out in the *Gran Pirámide* and in other areas such as the *Pirámide Naranja*, it would seem that columns were never used again after the fourth phase, as from that time on, quadrangular pillars were used, like those of Cahuachi Phase IVb and IVc, found during excavations on the north face of the *Pirámide Naranja*.

Cahuachi Phase IV was certainly the one that brought the most changes in terms of the use of internal spaces and the volume of the temples (Fig. 19.2), which sometimes underwent radical changes, with significant use of fill (Fig. 19.3). These changes were not due to cyclic remodelling of the buildings, but to climatic and environmental changes that affected the Nasca valley in particular.

Fig. 19.2 The monumental buildings of Phase III were largely removed during Phase IV for changes due to new needs and to conceal the damage caused by the two floods and the earthquake (Photo by the author)

Fig. 19.3 During the Phase IV the internal spaces and the volume of the temples underwent radical changes, with significant use of fill (Photo by the author)

As in Phase IVa, there was frequent flooding caused by local rains and the effects of large bodies of water affecting the whole valley and the tributaries of the Río Nasca. Marks produced by rain are clearly visible on the walls of the temples and in the plaster, where there are still signs of precipitation (Fig. 19.4). The alluvial layer beneath the perimeter wall enclosing Zone A at Cahuachi was built between Phase IVa and IVb, and it is different from the one that covers the building itself, providing evidence that two similar climatic events took place in the last century of the life of the ceremonial center. The damage caused was enormous, with flooding and large deposits of mud and debris, involving not only the buildings close to the river, but also those in higher areas. During this period, which witnessed changes not brought about by the priests but due to causes beyond their control, the way in which the temples in the sacred space were used changed radically.

After the ritual fire and the sacrificial rituals that took place at that time at the ceremonial centre, there were also important changes to the way the inner temple buildings were used (Fig. 19.5). During the digs carried out between 1984 and 2001, it became evident that the spaces between the platforms joining mounds 1 and 3 were used as manufacturing areas where pottery and textiles had been produced. There were large quantities of items made of raw clay that had not yet been fired

Fig. 19.4 Cahuachi Phase IVa. The effects produced by rain are clearly visible on the walls of the temples and in the plaster, where it is possible to observe signs of the precipitation (Photo by the author)

Fig. 19.5 New walls of Phase IV are often used for containing the filler material composed of earth and vegetable matter (Photo by the author)

Fig. 19.6 Cahuachi Phase III: offering of guinea pig (*Cavia porcellus*) deposited in an artificial filler (Photo by the author)

and fabric, with only the outline of the pattern outlined in black. In other cases, there was evidence that before the fabrics were embroidered, the chosen motif was marked in black before the outline was then embroidered. Sometimes the pattern would not be embroidered, but painted in different colors, filling in the blanks to create colorful paintings to which edging and decorated braid would be added separately. During excavation of the *Plaza Inferior* of the *Gran Pirámide*, it emerged that the large access ramp to the platform to the west had been closed off by a wall marking out the new inner spaces and that the entrance had been re-used to create a space for guinea pig breeding, as amply demonstrated by the consistent layer of excrement found within these areas (Fig. 19.6).

The changes in function were very substantial at this time, as can also be seen in the *Plaza Inferior* and the upper platform that joins the *Gran Pirámide* and the *Pirámide Naranja*. The new structures were built in loaf-shaped *adobe*, but they appear less carefully constructed, and they are made from clay with a different texture from that used in Cahuachi Phase III. On the north side of Zone A, radical changes were made in the areas connecting the various complexes or environments during Cahuachi Phase IV. The stairs and corridors were much smaller and reflect modest building skills, as if the specialists and the workers who normally carried out this activity were absent or unable to take part in the restoration or construction of the new areas. In this same period, large ceremonial enclosures were adapted for

Fig. 19.7 Access ramp dated to Cahuachi Phase IV, built with remains of walls destroyed by floods and earthquakes (Photo by the author)

use as cemeteries, to accommodate the gravesites laid out at this time. This was done during the construction of the outer walls, and the structures were affected by the flood that covered the walkways and enclosure. Subsequently, the debris that had settled was not cleared away from the internal areas, which were used as burial grounds, where graves were dug in the last period of Cahuachi's existence.

Phase IVb also saw the use of new methods of building in the ceremonial center, with the aim of constructing other buildings altering the front structures, already damaged by flooding and the earthquake that took place at the same time (Fig. 19.7). Although the routes were changed, the main entrance routes to the temples remained unchanged, although some specific areas were abandoned. In the temple connected to the *Gran Pirámide* on the south side, the high areas that were left outside the enclosure wall that was built at the beginning of Phase IV were abandoned, just as mound M1 in sector Y1 was left outside and possibly no longer used after the earthquake and before the floods. Even in the *Gran Templo*, the hidden part on top of the building was largely excluded from the construction of the perimeter wall. At the same time, the new part of the *Pirámide Naranja* was built, a very important temple in the final period of Cahuachi life. The construction system changed radically, and very soon an attempt was made to make façades that did not at all have the same consistency as those in front, in many cases plastering the

Fig. 19.8 Gran Pirámide of Cahuachi: remnants of painted plaster which decorated walls dated to Phase IV (Photo by the author)

layers of filling directly, albeit with particular attention to the decoration and coloring of the surfaces.

This paradigm contributed to the total destruction of the ceremonial center, when new flooding destroyed the artificial filler that had come out, resulting in the destruction of the external surfaces that lacked consistency. In this very short, but nevertheless intense, period, the façades of the temples were covered with several overlapping layers of painted plaster, but external surfaces of structures with reliefs and engravings were built to cover the damaged walls and give them renewed, albeit temporary, splendor (Figs. 19.8 and 19.9).

The priestly class was anxious to maintain continuity in the life of the ceremonial center, trying in every way to hide the evidence of the destruction caused by the floods and earthquake. In some cases, the grey clay plastering was done with special care, to hide the destroyed walls and the collapse of the many monumental walls, which were then re-used as filler material in areas between the large buildings. The new walls were built hastily and with little care, without employing the specialist workers of the kind who had always been the architects in the construction of Cahuachi during all its various phases.

During Phase IVc, a total change in the physiognomy of the ceremonial center came about. At the end of Stage IVb, most of the structures were buried, and the interior was filled with materials from the various collapses that occurred during the floods and earthquake. The half-buried squares disappeared under layers of artificial

Fig. 19.9 Remnants of painted plaster and fragments of musical instruments found inside artificial fillers dated to Cahuachi phase IV (Photo by the author)

fill, and the platforms themselves were modified by the significant addition of further material. Most of the buildings were altered dramatically. The large enclosures between the temple structures were also transformed, and many were used for burial, and perhaps even to house the victims of the ferocity of natural events. The outer walls of the squares were altered and were often overlapped with older structures belonging to earlier stages. It is not possible to establish whether the sacred spaces were abandoned within a very short time or not, but the absence of wind-blown sand between the surface and the flooring laid during Phase IVc would seem to indicate they were not abandoned gradually like other parts of Cahuachi and that others continued to be used. The fill used in the various built-up areas of almost all of the ceremonial center was definitely as important as the construction of Cahuachi itself, confirming the presence of a highly organized society at a time of particular economic opulence. Filling in the various temples in a series of almost simultaneous operations was carried out during a transformation of the ceremonial center that involved the use of a large number of people in transporting and placing tens of thousands of tonnes of various materials from different places.

Moreover, not just any fill was used in construction, but also selected materials alternating with a considerable amount of layers of vegetable matter, in order to lighten the construction. The lack of fill around the structures shows that the operation was carried out with great care and with an organization that never suggested signs of crisis at the ceremonial center. This was the last phase in the life of Cahuachi, the conclusion of a lifecycle, but also the birth of another time period that manifested itself in the transformation of sacred spaces. The ceremonial center was particularly important because of the various activities carried out within it, at least until the end of Phase IVc. More space was now given over to the area related to craft activities in order to satisfy an ever-growing need for ceramic products and textiles, in addition to the large quantity of musical instruments essential for collective ritual celebrations. The ceremonies were huge events performed within the precinct, and there is evidence that these activities continued with the same intensity or perhaps even more so. The area became a sacred space only at the end, after the second disastrous flood, when the areas used for ceremonial activities had made way for the emergence of large burial grounds. Cahuachi constituted a place of peace, pilgrimage, and exchange for more than 700 years, where the massed ceremonies required the construction of the buildings that stood within the large enclosures. In the final period of life of the ceremonial center, these functions changed or lost their meaning, while the theocratic capital was about to transfer its large-scale events to the sacred areas circumscribed by the large linear geoglyphs found in the Pampa and surrounding areas. Slowly, Cahuachi became an empty space, but it remained for some time a venue for celebrations and pilgrimages, preserving its charisma as a sacred place, being nonetheless "*huaca*", despite having lost its ancient characteristics. The temples, platforms and squares were used for the last magnificent votive ceremonies before their function changed, becoming a burial place for the population of the valley and for some persons of rank, brought to Cahuachi for burial in the higher parts of the complex after it had been abandoned.

19.3 The Importance of Climatic Anomalies and Seismic Phenomena in the Social and Ideological Crisis of Cahuachi

Considering the various issues related to Cahuachi's development, Phase IV was one of the most important and complex, seeing the biggest changes in the use of the ceremonial center, as well as its historical structures and functions. The crisis, brought about by mostly environmental causes rather than a change in economic or manufacturing opportunities, shows how the ideological factor became the main element in the relationship between the people and their holy place. The ceremonial center was built to exist forever, becoming a theocratic capital and assuming a supremacy not only in the sphere of worship, but also in political and socio-economic matters, which become more and more closely related to religious phenomena. It stands as a place inhabited by the gods and their intermediaries and interpreters. Cahuachi was the place where the balance between the divine world and the priestly class broke down. This important social group, serving as an intermediary between the pilgrims, the local population, and the gods lost importance, power, and credibility. In a short time, Cahuachi was devastated by an earthquake of gigantic proportions and two major floods the like of which had probably never been seen in living memory. These phenomena came together as an apparent expression of the will of the gods.

Ideologically, the different climatic events were fundamental in addressing the uncertainty that the Nasca and the pilgrims felt. The latter, coming from any number of ever distant places, travelled great distances to take part in the enormous ceremonies at the ceremonial center. The certainty of the permanence of Cahuachi and the religion that arose and developed within its temples came to be seriously questioned after a series of natural events took place within a fairly short time. The catastrophe that hit the area, involving the temples themselves and the abandonment of vast areas of the ceremonial center, but above all the absence of any possibility of a lasting relationship between man and gods through the mediation of the priestly class, was the major cause of the deep crisis that faced all the communities in the area. The economic situation of the population's agricultural output had seen no profound changes, as evidenced by the presence of a large amount of corn plants used as filler in the walls of the temples and religious structures. These plants were considered important for the food supply of the Andean camelids during various stages of farming. The animals were an essential component of the food chain of the population, as shown by the large number of llama and alpaca bones among the archaeological detritus of the period. The collective action intended to fill the 24 km squares of the ceremonial area, employing thousands of people, suggests that, if there had been a deep economic and social crisis with the consequent lack of raw material for nourishment, the results would have been very different. On the contrary, it was possible to set up an organization probably hitherto unknown in the life of Cahuachi, with the population working in such a way as to bring about a profound transformation of the ceremonial center, though doubts about its future role probably began to spread not only among the population but also within the priesthood itself. The certainty that they had reached the end of a time-cycle sowed the seeds of doubt about the unstable future of the relationship between man and the gods. Moreover, the partially destroyed ceremonial center caused uncertainty and fragility, partly due to the awareness of the impossibility of Cahuachi being able to play its role for religious, cultural, political, and social aggregation and propitiation of the gods to the full. For these reasons, it is very likely that the ceremonial e was not actually abandoned, leaving the destruction wrought by time and inclement climatic conditions to take their toll on the temple structures. As a result, clearly demonstrating the still great power of the center over the religious thought of the population, it was decided to make Cahuachi eternal by converting it into a place that would be sacred in space and time. The buildings were buried under large layers of fill, and lastly covered over with an upper layer of clay. The outlines of the temples were hidden under meters of earth, along with ceremonial objects, remnants of sacrifice pertaining to the daily life of Cahuachi, perfectly preserving the last offerings placed during the final moments of the life of the ceremonial center (Fig. 19.10).

Another possible reason for the radical change at Cahuachi may be connected to the interruption of an effective relationship between the priesthood and the gods,

Fig. 19.10 Buildings buried under large layers of fill, and lastly covered over with an upper-most layer of clay (Photo by the author)

expressed through the rejection of historical memory and the subsequent burial of the temple buildings, underneath a substantial layer of filler. If that were the case, Cahuachi remained as a memory that Nasca society rejected in its relationship with nature and the deities related to it, even though, after an analysis of a number of incidents that took place during Cahuachi Phase IV, there would seem to be no foundation for this hypothesis.

The area that underwent the greatest change, during the phase that led to the abandonment of the ceremonial center, was most certainly the *Pirámide Naranja*, in Zone A. In this temple complex, consisting of several buildings that were then joined together during Phase IV into a single building, we can see the re-use of construction materials such as conical adobe (Fig. 19.11) to seal the buildings belonging to Cahuachi's earlier phases. In addition, internal paths leading to different environments were eliminated, symbolically closing these access routes for ever. This action, which seems almost inexplicable, considering the chronological sequence of the life of the ceremonial center, probably emerged from the idea of circularity in the Nasca conception of time. Particularly ancient materials were re-used and the recent fill was removed to uncover the buried walls of the ceremonial buildings, in order to make new offerings. New contact was sought with the old structures, as if, at that specific time, it was necessary to re-establish a relationship with the historical past of the traditional life of the ceremonial center. During previous excavation of Sector Y1, the fill used in Cahuachi Phase IV was found to contain evidence of a finding of conical adobe dating back to a period before the buildings had been buried, as if there had been an attempt to use

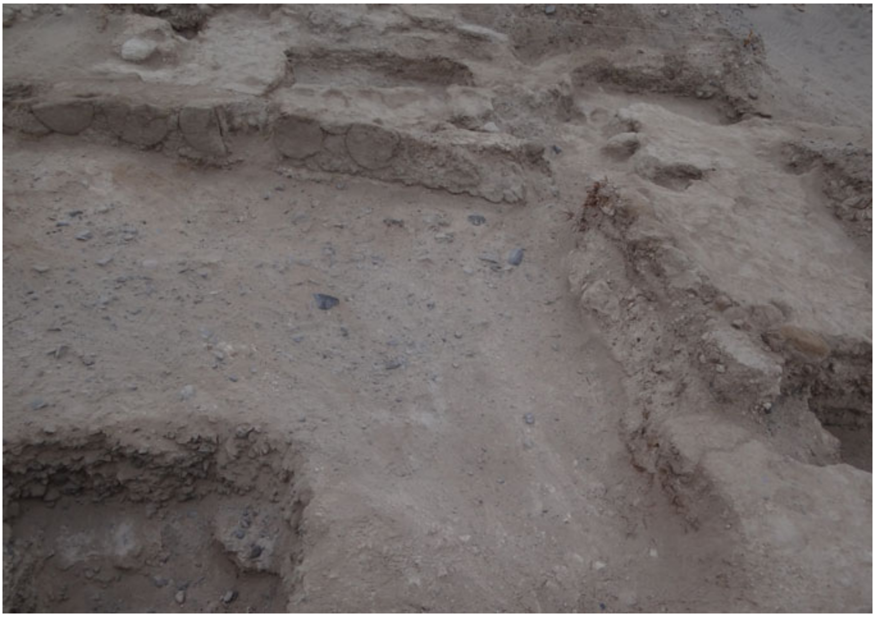

Fig. 19.11 Re-use of conical *adobe* during the last part of Phase IV (Photo by the author)

materials dating back to the earliest times. When remains of buildings belonging to Phase II of Cahuachi were found, offerings related to the ancient building materials were made. These were covered with *pacae* leaves and buried again under heavy layers of filling. Further evidence of behavior compatible with this way of thinking was found in Sector Y8, at the base of the *Gran Pirámide*, where it could be observed that during Phase IV, building material belonging to Phase II such as conical adobe had been used to make a number of tombs in the form of *barbacoa*. They were not used, but an ideological requirement to use ancient building materials can clearly be seen here. Between the *Plaza Inferior* of the *Gran Pirámide* and the eastern side of the *Pirámide Naranja,* a large tomb belonging to a person of high rank was discovered: it was a little girl priestess, with a very valuable collection of funeral objects. When the surface of the tomb was dug out in the shape of a small temple with four columns that originally supported a flat roof, a conical adobe was found. It had collapsed in on itself because of its weight, and had been covered with grey plaster to form a funerary memorial. Evidently, the presence of older material was related to historical events and an attempt to break out of the time sequence, cancelling it out by using materials from different periods in order to simultaneously relive different stages in their history and make their own the last phase of the life of the ceremonial center. Even in the *Templo del Escalonado*, the re-use of conical *adobe* during the last part of Phase IV, superimposing it over the loaf-shaped adobe of Phase III, is undeniable evidence of the necessity–in Nasca thinking–to constantly have a global view of its history, also during the final stage of the development of the ceremonial center. In the structures of the northern *Pirámide Naranja*, where archaeological excavations were carried out between 2007 and 2009, the entrances were filled in, using conical adobe at the time when the use of the corridors was discontinued. This may be interpreted as the last act of the formalization of the sequence of Cahuachi's historical past, relived in a form contemporary to the events that made up the temporal symbolism for the life of Nasca Culture itself. Structures were placed on top of the buildings in conical adobe to be used in the final phase of Cahuachi's existence, and new walkways, large pillars, and new roofs placed on top of the artificial fill were constructed in Phase IV, before the buildings were abandoned (Figs. 19.12 and 19.13).

The end of religious life in Cahuachi caused the loss of the cultural values common to the Nasca, as well as the disappearance of its main fulcrum. The smaller urban centers, which for centuries had not given obvious signs of expansion because of the control Cahuachi exercised across the territory, began to enlarge, developing new sectors and urban centers. The changing climate probably meant that there was more water available for a more efficient and fruitful agricultural system thanks to the excellent network of filtering tunnels, which made it possible to exploit much wider areas for cultivatable land. The rising influence of the *Sierra* permitted the use of new and more sophisticated hydraulic systems, which were no longer under the control of the ceremonial center but developed alongside the urban centers arising in conjunction with technological progress in the agricultural areas.

Fig. 19.12 During the last part of phase IV of Cahuachi, the use of the traditional buildings was lost. This images shows loaf-shaped adobe alternating with rows of original stones (Photo by the author)

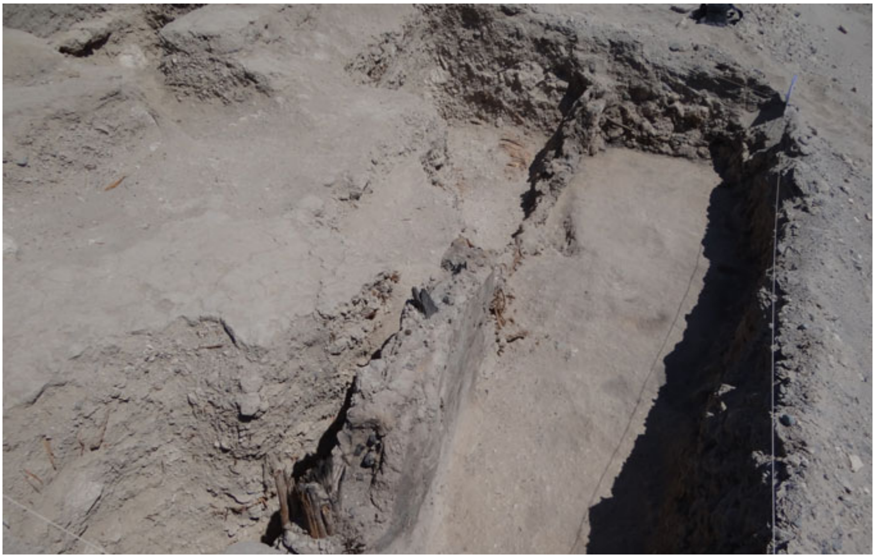

Fig. 19.13 Decayed plastered walls built in *quincha* used during the phase IV of Cahuachi to cover the effects of the damages caused by floods and an earthquake (Photo by the author)

The rise of new social elites and the simultaneous disappearance, or drastic reduction, of the priestly caste that had led to the increasingly complex development at Cahuachi meant that the new political class became more involved in wielding secular power, in part free from religious influence on cultural organization.

19.4 Social Restructuration in the Final Stages of Cultural Evolution of the Nasca Society. The Role of Estaquería After the Decline of Cahuachi

The smaller settlements in the *Río Grande* Valley and its tributaries developed autonomous political classes concentrating their power across a fragmented territory, with rising new *curacazgos* (dominions, chiefdoms). The patterns on ceramics and textiles also underwent major changes, and there is clearly the presence of a new social order, indicated by the presence of the portraits of high-ranking personages. The increasing use of the human figure began to predominate, replacing many of the emblems and the usual attributes of the divinities. Also, the vessels themselves changed significantly, and ceramic manufacturing became more elaborate. It is likely that the production of ceremonial objects was largely in the hands of a new class of craftsmen replacing the previous ones, too close to the Cahuachi priestly class. The artisans probably had much closer ties with the local nobles who exercised power. Therefore, representations of these men, symbols of an emerging power, increasingly tended to replace figures of deities or icons related to the animal and plant world. In the scenes depicted, man is the center of the Nasca universe, clearly indicating a rapid change from a cosmocentric worldview, which had held sway for nearly 700 years, shifting to an anthropocentric view of natural life, with images representing collective activities and rituals, real or symbolic battles, and the severing of heads. This too is probably a reflection of what was happening as the new political and social regime was being formed, with internal tensions between the different urban centers that had expanded enormously. Despite the opulence and abundance of agricultural production that allowed a generally high standard of living among the population, a struggle for territorial power began in order to solve the conflicts between the various local lords, the *curacas*.

The religious elite lost much of its authority, and the aggregating function performed by the priestly class among various groups, which had previously come to Cahuachi to celebrate collective rituals was lost, creating yet more tensions. At the same time, external powers began to make their influence felt on an even larger scale, gradually encroaching on Nasca territory. For a long time, the ceremonial center had been an important provider of the peace and prosperity, which was favored by the religious, spiritual, and socio-political cohesion that stemmed from its undisputed presence. This element also constituted a deterrent and dissuasive force against the surrounding political powers due to the presence of very powerful divinities, which allowed the spread of a shared form of religious expression far beyond the Valle del *Río Grande* and its tributaries. After Cahuachi was abandoned, communication between the various urban centers vastly decreased, resulting in a reduction of agricultural activity and reduced exchange of products. The redistribution of power thus involved considerable changes in the political and social arenas, but the economy also suffered deeply, despite abundant agricultural production. The priesthood, however, clung to reduced power locally for the next two centuries of Nasca cultural development. Once the Cahuachi cultural site had been abandoned, only a small westernmost area remained in use, adopting a new form of architecture, and it was here that the final legacy of the old Nasca theocratic power was concentrated.

The area now called Estaquería was the only one to remain active after most of the ceremonial functions of the center had been abandoned. This area, which is located further to the west of Cahuachi Zone B, dominated by *Gran Pirámide II* and the important temples connected to it, is made up of architectural sectors Y17 and Y18 and other adjacent ones, extending as far as the area that was also used in the Middle Horizon, with its *Templo de las Estacas* (Fig. 19.14). This temple is situated on a platform occupied from the Pre-ceramic Period to the Late Intermediate Period. On the western side, descending towards a more open area, there are a Middle Nasca pyramid and other funerary constructions. Estaquería was the most important religious center after Cahuachi was abandoned, but this importance was, however, limited to the coastal valleys in which the Nasca Culture developed.

The position of prestige previously held by the Cahuachi religious authorities, extending their influence as far afield as the various cultural centres at Sierra and the Costa del Peru, decreased gradually and was reduced to include only the

Fig. 19.14 Aerial photo of *Templo de las Estacas* in the westernmost area of Cahuachi used after the abandonment of the ceremonial center. This temple covers some earlier structures dated to Paracas and Nasca periods (Photo by the author)

neighboring valleys. Despite the fragmentation of political power, the populations throughout the territory continued to produce pottery of similar design, as may be seen from the ceramic remains found in the Ica, Chincha, Pisco, and Acarí valleys. A small group of priests who had held on to their religious power may still have exercised a form of control over the production and distribution of sumptuary goods, while urban centers were developing and autonomous governments were being set up, perhaps strengthened by the formation of confederations, and marking a period of major conflict. This may in fact be seen in the images of people with weapons in ceramic art and the increasing use of force to obtain the coveted trophy heads. In any case, the use of violence became much more frequent, as shown in the statistics regarding the cemeteries belonging to this period relating to the prevalence of people who died from weapons injuries. Between 450 CE and 550–600 CE, Cahuachi had already lost its political and religious power, with the exception of the western sector, where there were several pyramids made from loaf-shaped adobe alternating with rows of stones of fluvial origin. This building method was also found in the buildings constructed at the end of Cahuachi IV, where some late renovations were made in this way that had never been used before. Perhaps due to the lack of building materials, the absence of a sufficient number of experts in religious building, and the use of new materials thanks to new technologies and aesthetic factors, unusual models were adopted in the erection of these architectural works.

At Estaquería, the temple complex known by the abbreviation Y17 shows signs of a violent natural phenomenon. A flood destroyed much of the platform that contained a large square, accessible via two symmetrical staircases. The effect of this flood on the original structures was the re-use of some areas of the western front by building large stepped temples, later restored in loaf-shaped *adobe* and fragments of natural limestone and stones of fluvial origin. As previously mentioned, it is possible that, due to the lack of construction materials or a shortage of labor skilled in the construction of sacred buildings, it became necessary to make changes to the structural features within the last large space for ceremonial purposes. This part of Cahuachi continued to function during the Middle Nasca, using temples designed for ritual offerings and sacrifice. Walls in poor condition and constructed in a very rough and disorderly way were found in the area known as Y18. Precariously made buildings, not constructed according to any uniform model, were plastered over to conceal the imperfections. Similarly, the rest of the facilities that were constructed around the main pyramid came to be used differently, becoming funerary structures, possibly after the area was abandoned by those responsible for keeping Nasca cultural heritage alive during its final centuries. In the excavations carried out by the Nasca Project in the *Templo de las Estacas*, there were very clear signs of Wari presence from Ayacucho, from where they had a strong influence over the plateau and all along the Costa del Peru. In this temple, dating from the expansion of the Wari into the Nasca area, remains of offerings were found at the base of the buildings, including remains of important figures as well as pottery from the final stages of the actual Nasca culture. Also in the platform where the large wooden *huarango* posts were placed, a number of bodies of Nasca people were found, but with the deformation of the skull typical of sacrificial victims and with mutilated lower limbs.

During the Middle Horizon, the assimilation of the Wari was very traumatic in the coastal regions. There was simultaneously a total change in the use of materials, the clay used in the mud bricks, and most probably also in the employment of specialists dedicated to manufacturing ceramics and textiles. Changes were made to building methods, urban layout, and even the concept of the use of the interior space of sacred areas. With the disappearance of the specialist craftsmen and the increase in the categories involved in the production of agricultural goods, ancient high-quality ceramic and textile production skills were lost, concentrating now on quantity, to the detriment of the quality of the artefacts, which were mainly for daily use. The arrival of a new way of looking at existence, together with the different socio-economic models typical of the Plateau, brought a sudden change to the way of life of the population. There were also drastic reductions to the living spaces, where people lived together with their animals: Infant mortality increased significantly, and there was a consequent reduction in the life expectancy of the population. Diet, disease, and customs changed abruptly, coming to resemble the way of life of the plateau settlements, and the Nasca tradition was abandoned after almost a thousand years of development throughout the territory. It is likely that a rigid political policy was established with the advent of Wari culture in the Nasca territories, where their religion was particularly deep-rooted, and a cosmocentric world-view was still present in the minds of the population. The need to impose a new way of life and art was very obvious in the South Coast area of Peru, unlike the situation during Wari expansion in the other conquered territories on the coast and on the plateau.

Chapter 20
Remote Sensing and Geophysics for the Study of the Human Past in the Nasca Drainage

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Abstract This chapters presents and discusses the results of investigations performed by ITACA Mission of CNR in the Nasca drainage basin, including the ceremonial center of Cahuachi, from 2007 to 2014. The employed approach was based on the multiscale and multisensor integration of remote-sensing methods, including geophysics. Most of the applications have been intended for preventive archaeology, in particular, for providing information on the presence of buried sites and structures by identifying different surface characteristics such as arid bare ground in the Pampas and vegetated areas in the river oases. The operational use of earth-observation technologies has been the occasion to develop ad hoc approaches to data acquisition, processing, and interpretation for the detection of earthen buried structures that is a crucial and challenging issue due to the subtle physical contrast between earthen remains and the

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surrounding subsoil. This made necessary amassing experience in, and the testing of, various techniques to investigate the subsoil by geophysical and remote methods, working side by side with archaeologists, involved in the interpretation of the results. The obtained results have been the discovery of previously unknown sites in the Nasca drainage basin, the identification of buried ritual offering, the characterization of the stepped structure of Templo Sur, and the mapping of areas of archaeological interest.

Keywords Satellite remote sensing · Archaeo-geophysics · Georadar · Magnetometry · ERT · Nasca · Cahuachi · Peru

20.1 Introduction[1]

Remote sensing in archaeology is one of the most fascinating challenges in the field of sciences applied to the study of the human past. Such a challenge is particularly motivating and exciting when the features of archaeological interest and the boundary conditions, mainly linked to geographic regions and climate as well as to the land cover and environmental setting, are not ideal for a standard use of remote sensing. This makes necessary the development of 'ad hoc' approaches to data processing and interpretation (Wisemann and El Baz 2007; Lasaponara and Masini 2012c; Comer and Harrower 2013).

This is the case of Cahuachi and of most of the archaeological sites in the Nasca drainage, where ITACA Mission of Italian CNR directed by Nicola Masini has been operative in cooperation with Proyecto Nasca since 2007 (Masini et al. 2012).

Remote sensing consists in obtaining qualitative and quantitative information of the earth's surface and/or specific targets, using sensors that measure the electromagnetic radiation they emit, reflect or transmit (Lasaponara and Masini 2012c). Active and passive sensors can operate on spaceborne, airborne, and ground platforms.

Passive sensors capture energy reflected or emitted from the ground surface in diverse portions of the electromagnetic (EM) spectrum, ranging, for example, from the visible, near-infrared (NIR) , thermal infrared (TIR) to microwave regions. Active sensors transmit energy toward the target and measure the intensity of the returning signal (echo). LiDAR (Light Detection and Ranging) and SAR (Synthetic aperture radar) technologies are examples of active sensors operating in the optical and microwave range, respectively.[2]

[1]This chapter is an integrated and updated version of Masini et al. (2012) dealing with the results of ITACA Mission from 2008 to 2011 which are herein briefly mentioned. In addition, new insights from investigations performed on Templo Sur of Cahuachi, in Paredones, and in the Pampa de Nasca will be presented and discussed in this chapter.

[2]For SAR application in Nasca, see Chap. 21 by Cigna and Tapete (2016), Cigna et al. (2013), and Tapete et al. (2013).

Far from seeking to continue this discussion on the most common physical/theoretical aspects of earth observation sciences, this brief introduction functions to introduce one of the typical issues of remote sensing applied to archaeology, i.e., the parameters and the boundary conditions that determine the ability of these sensors to detect and recognize 'signals' (or features) of cultural interest.

It should be noted that aerial photography is actually the most "ancient" remote-sensing tool, widely used since the twentieth century to recognize and survey traces, marks, and textures due to past human activities (Crawford 1929).

The probability of identifying and mapping traces of cultural interest in general depends on the intensity and persistence of changes caused by human activity (buildings, roads, land reclamation, channelling) in terms of physical and chemical properties as well as topographical variations. The interaction between archaeological deposits and their surroundings produce the so-called crop/soil/shadow/damp marks (Wilson 1982; Beck 2007; Lasaponara and Masini 2007) that are the most common proxy indicators of the presence of ancient buried and surface remains.

In particular, the crop marks, well visible in some seasons from traditional aerial images, are the result of the differentiating growth of vegetation, due to local variations in moisture content and nutrients, induced in the subsoil by archaeological artifacts and structures. The use of multispectral satellite imagery places into evidence the greater capability of the NIR range compared to other spectral bands to discriminate crop-marks (Lasaponara and Masini 2007).

Damp marks appear on bare ground because buried archaeological remains can alter drainage capability and, in turn, water distribution.

Soil marks are manifested as color/tone differences with respect to the rest of the soil. They are due to the presence of underlying deposits, visible on surface, especially in ploughed or harrowed fields. Both of them could be observed by traditional images in specific superficial conditions (e.g., after rain). An improvement, depending on the geometric resolution, could be obtained by using some spectral bands (in particular the red one) of the currently available sub-metric multispectral satellite data (QuickBird, WorldView, GeoEye, Pléiades)

Finally, shadow marks refer to micro-topographic relief variations which can be made visible by shadowing them in low sunlight angle conditions (Lasaponara et al. 2016a, b, c).

Most of the above cited archaeological proxy indicators, in particular those linked to physical interaction between buried remains and surrounding soil (crop/damp marks), are generally not present in the arid desert environment of Nasca. In fact, this area is characterized by very scarce precipitation and the absence of vegetation, except for the fluvial oases. Moreover, most of the buried architectural structures in the investigated sites (Cahuachi and Paredones, see Sects. 20.2.1 and 20.2.2), were built in earthen material which is very difficult to identify due to the very low contrast with the surroundings. The particular complexity of archaeological layers in the Nasca region makes challenging the use, processing, and interpretation of remote sensing and geophysical methods, such as ground-penetrating radar (GPR), geomagnetic methods, and electrical resistivity tomography (ERT) (Rizzo et al. 2010).

GPR enables the detection and spatial characterization of buried archaeological features by the analysis and processing of the radar signals. They are transmitted by an antenna into the ground and then reflected by discontinuities in the electrical properties of the soil. In the investigated sites, GPR capability to detect such discontinuities is strongly limited by the fact that the building materials of walls (adobe) and its surrounding soil (which in Cahuachi case is composed of sandy and slightly clayey silt or silty and clayed sand) exhibit similar dielectrical properties [see, e.g., Bonomo et al. (2013)]. Moreover, the above-said characteristics of the soil also limit the penetration capability of electromagnetic waves, unless, low frequency antennas (200 MHz) can be used but, unfortunately, they reduce both the resolution and accuracy of results (Conyers and Goodman 1997; Goodman et al. 1995; Bonomo et al. 2013).

Geomagnetic methods enables us to identify and map buried artifacts and features by exploiting its capability to measure and record spatial variations in the Earth's magnetic field. In the Nasca region, archaeological findings are, generally, given by a number of materials characterized by magnetic susceptibility (pottery, coal, ash, gold), thus making geomagnetic methods suitable for archaeological purposes. However, in many cases, the depth of the expected features could limit the effectiveness of the geomagnetic investigations.

The last mentioned geophysical method, the ERT, is based on the measurement of an electric field artificially, created in the ground, by two pairs of electrodes fixed on the ground surface and connected to a specific instrument. The obtained tomographies enable us to characterize the electrical resistivity of the subsoil, providing information on possible archaeological layers or other kind of features of cultural interest, such as channels, caves, etc. Considering the soil-texture characteristics in Cahuachi, the ERT could represent an effective method to prospect very deep layers, but with low resolution.

It was just the need to develop proper archaeo-geophysical approaches, based on remote sensing and geophysics, which led us to work in this region since 2007. Cahuachi has been the main focus of our investigations and tests. A number of sites, including the Inca site of Paredones and the Río Nasca riverbed, have been also the object of investigations whose results, along with those obtained in Cahuachi, are reviewed in this chapter. Further geophysical prospections have been carried out on some *puquios* in Río Taruga valleys. The obtained results are part of Chap. 22 by Lasaponara et al.

The cooperation with Proyecto Nasca, directed by G. Orefici, enabled us not only to provide important information useful for archaeological investigations (many of which made possible the discovery of archaeological findings, such as Templo Sur and ritual offerings in Piramide Naranja and Templo del Escalonado), but also to assess limits and potentialities of the earth-observation sciences for archaeological studies in the Nasca drainage basin.

20.2 Context, Study Areas, and Aims

In this section, we briefly describe the study areas, from the historical, geographical and archaeological points of view. For a more detailed discussion, the reader is referred to Chap. 2 by Orefici and Lancho Rojas (2016) for the geographical and environmental settings, Chap. 3 by Delle Rose (2016) for the geology, Chap. 4 by Orefici for the historical-cultural analysis, and Chaps. 14, 15 and 19 by Orefici for Cahuachi history and architecture.

20.2.1 Cahuachi: Brief Historical and Archaeological Overviews

The study area spreads out on a Pre-Montane desert formation near the coastline, geologically located on Quaternary sedimentary rock formations (that are riverine and riverine alluvial) of a tectonic depression (Ica-Nasca Depression; see Chap. 3 by Delle Rose). A few kilometers away are the Andean foothills, composed of Jurassic and Cretaceo formations (Montoya et al. 1994).

The climate is hot and arid, characterized by very little annual rainfall (generally not measurable because it is so little), due to the confluence of a cold ocean current (the Humboldt Current) along with other climatic factors (Schreiber and Lancho Rojas 2009; see also Chap. 13 by Lasaponara et al.). These difficult and complex environmental conditions have characterized the drainage basin of the Río Grande over the past centuries and millennia.

The geomorphology of the coastal desert has been shaped by the drainage basin of the Río Grande, which empties into the Pacific Ocean after passing through the coastal range and collecting water from nine tributaries. Nevertheless, the ecosystem of the valley of the Nasca River and its main tributaries (Fig. 20.1) has been essential in forming the first complex societies, since around 5000 BCE.

This territory has been characterized by a long and intense human activity since the Formative Period (2000–800 BCE) to the Early Intermediate Period (200 BCE–500 AD) when the region flourished under the Nasca Culture and Cahuachi was founded and developed. In particular, at the end of the Early Horizon, several regional centers with a religious function developed. Cahuachi stood out among the other centers due to the uniformity of the religious beliefs, the formation of an incipient autonomous social organization, the control of water sources[3] (favored by the fact that it is just over 1 km from Río Nasca, where the river water emerges), and its strategic location between the Pampa of Nasca and the Pampa of Atarco, characterized by the presence of geoglyphs (see Chaps. 11 and 12 by Masini et al.).

[3]See Chaps. 13 and 22 by Lasaponara et al. (2016a, b, c)

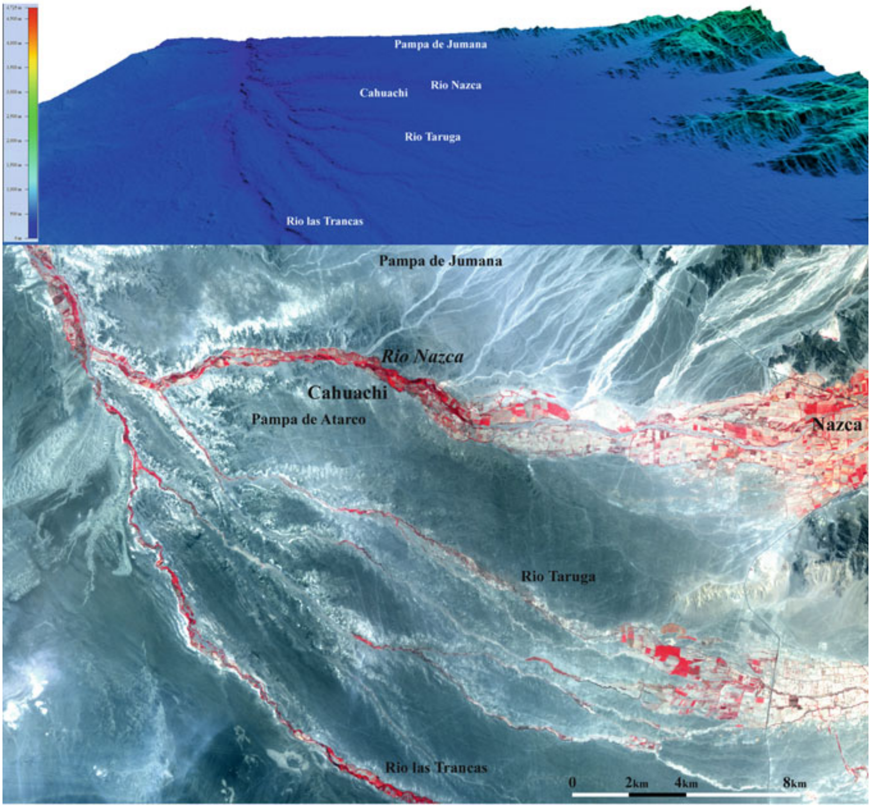


Fig. 20.1 *Top* Location of Cahuachi in the drainage basin of Río Nasca from 3D DEM derived from SRTM data at 30 m resolution. *Bottom* ASTER VNIR false-color image at 15 m geometric resolution

The first studies in Cahuachi date back to the 1950s. Between 1952 and 1953, W.D. Strong investigated an early village occupation. From the archaeological record, Strong credited to Cahuachi a housing function–although limited to only some periods of its development (from a report of Strong cited by Orefici 2009b). Rowe (1963) supposed a transition process of Cahuachi: from a sacred place to a city. Since the eighties, additional and fundamental data have been provided by the investigations performed by Silverman, who postulated a prevailing ceremonial function for Cahuachi (Silverman 1993). Further data have been provided by systematic investigations and excavations, carried out on more than 150 sectors by Giuseppe Orefici, since 1984 (Orefici 1993; Orefici 2012).

In particular, the archaeological research has been focused on two sectors, named A and B considered to be the core of the entire ceremonial settlement (Fig. 20.2). Up to today, more than half of sector A has been unearthed and most of

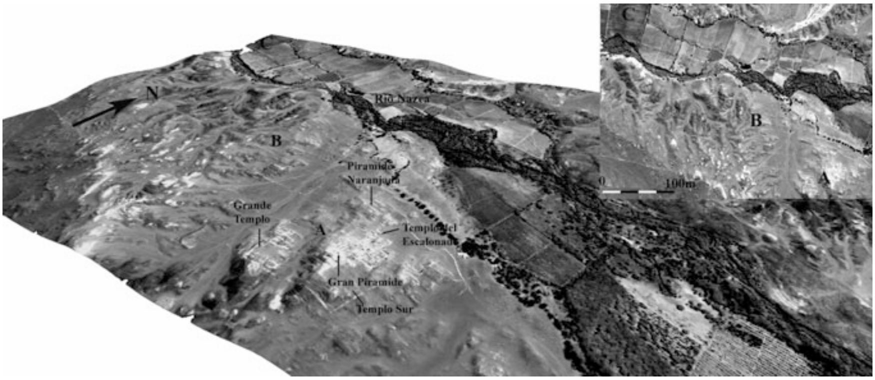


Fig. 20.2 3D visualization of the Nasca River and the monumental complex of Cahuachi composed of the two sectors A and B. Sector A includes *Grande Templo*, *Gran Piramide*, *Templo Sur* (at the date of acquisition it had still not been excavated) and *Templo del Escalonado*. *Upper left* Ortho photo of the same scene including the Nasca River, sectors A and B. (GeoEye panchromatic image acquired on March 2011)

the excavated monuments have been restored, among which are the Gran *Piramide*, *Piramide Naranja*, *Templo del Escalonado,* and, more recently, *Piramide Sur*.

The archaeological findings of Proyecto Nasca enabled the identification of three main construction phases, covering Nasca Phases 1–4 (200 BCE–450 AD), during which changes in architectural types, building characteristics, materials, ceramics, and stylistic and iconographical features were recorded. Each historical phase, characterized by enlargement and remodelling of pre-existing walls and platforms, was a response to specific climatic and environmental conditions and reflects the functional and cultural evolution of the site (Orefici and Drusini 2003; Orefici 2012; see also Chaps. 14, 15 and 19 by Orefici).

From the beginning (200–100 BC), this has been a sanctuary or *huaca*. The architecture was characterized by two stepped platforms and walls of *quincha*, composed of cane or *guarango* tree branches, interwoven by ropes of vegetal fiber, covered in mud and plaster, which supported a straw roof.

In the second phase (100 BC–100 AD), Cahuachi became a ceremonial center. The architecture, built with conical adobes, became more monumental and broader than in the past. The new platforms were composed of more than two steps, and pre-existing structures were transformed into large storehouses. Moreover, the distribution of spaces was more complex and articulated than in the past, thus reflecting the hierarchic structure of the society, dominated by a religious élite. The new earthen architecture was also the result of works of remodelling and filling with material, including remains of votive ceramics used in ritual ceremonies (Fig. 20.3).

The third phase (100–350 AD) coincides with the apogee of the ceremonial center, whose core was sector A, including four big pyramids known as *Gran Piramide*, *Grande Templo*, *Piramide Naranja,* and *Piramide Sur* (see Fig. 20.4). The latter has been recently unearthed, also thanks to geophysical investigations, as

Fig. 20.3 The excavations commonly unearth a variety of building technique, revealing several phases of reuse of structures and spaces. **a–b** A wall built in conical adobes and the filling of spaces between walls and the closure of a gate or corridor are shown, respectively. **c** Depicts the superposition of walls belonging to different phases. The difficulty in the processing of geophysical data (in particular GPR data) and the interpretation of results is not only due to the low geophysical contrast between target (e.g., wall, filling, tombs) and medium (subsoil), but also to the complexity of building succession and reuse of materials

will be shown later. These pyramids were surrounded by several minor temples which are connected through plazas, enclosures, stairs, corridors, and intermediate spaces enclosed by high walls. These buildings are examples of both the opulence that the Nasca society enjoyed during this period and the maximum specialization reached by artisans.

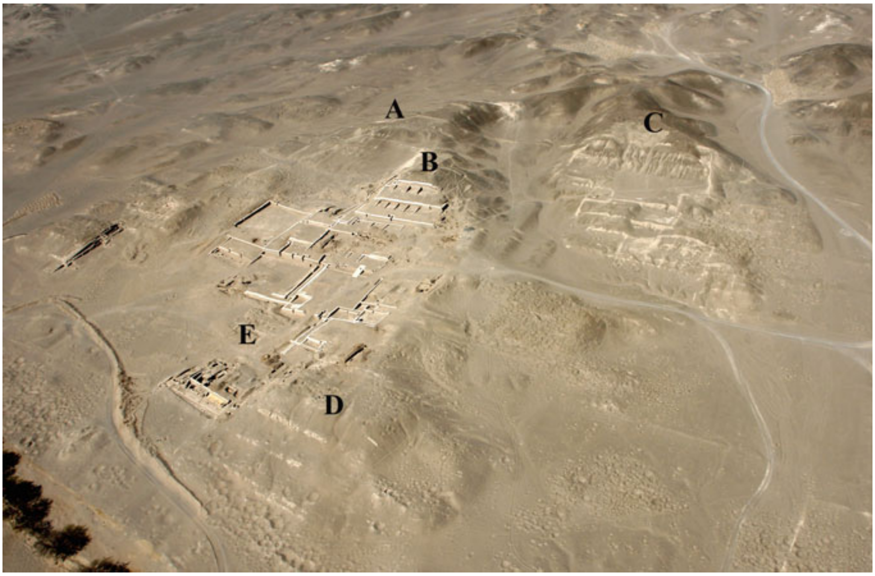


Fig. 20.4 Aerial view taken in 2007 of the core of Cahuachi. Letters indicate the main temples: **A** *Templo Sur* **B** *Gran Piramide* **C** *Grande Templo* **D** *Piramide Naranja* **E** *Templo del Escalonado* (Photo by Nicola Masini)

The building system, which used loaf-shaped adobe placed in horizontal rows on a layer of clay binder and plastered, follows the same evolution: the interior structures were transformed into platforms filled with materials used in the rituals; while large perimeter walls hid the temples and the interior buildings friezes (Orefici 2009b; Orefici 2012). However, the excessive use of wood to fire pottery and to build and the intensive exploitation of agriculture and environmental resources could have resulted in ecological change, partially counterbalanced by the construction of irrigation canals for the distribution of water (Orefici 2012). Some temples were used as storehouses thus indicating the overproduction of food to feed the multitude of artisans and the specialists working in the transformation of Cahuachi.

Probably, in this phase, Cahuachi reached its maximum urban expansion, with two monumental complexes with u-shaped courtyards (the so-called zones A and B, Fig. 20.2) characterized by temples facing north, towards the river and the geoglyphs of *Pampa de Jumana* and *Pampa Colorado* (Fig. 20.1).

The fourth phase (350–400 AD) was rich in cultural expressions but was also a time of profound and rapid changes that underline a crisis caused by a series of mudslides and a very destructive earthquake (Orefici 2012). The entrances to the temples were altered, and several of the most important buildings lost their monumental functions. The large enclosures were filled so that new embankments could be built and a large part of the terraces with columns and decorated ceilings were demolished in order to make space for the large platforms. During this period, the *Grande Templo* was completely uncovered due to the elimination of several rows of columns, after a ritual in which thousands of *antara* (pipe flutes) were destroyed and placed under a new clay floor (see Chap. 17 by Gruszczyńska-Ziółkowska (2016)).

In the fifth phase (400–450 AD), Cahuachi was abandoned. As in the previous phase, the ceremonial enclosures were filled after an intense series of great collective sacrifices of animals, ceremonial objects, and human beings. The offering holes, intensely used during the Fourth Phase, were emptied; the tops of the temples were covered by layers of earthy materials and sealed with clay. The structures of Cahuachi were converted into grand platforms. The sacred character of the ceremonial center was maintained but its primary functions were modified as it was transformed into a large cemetery which was used until the Late Intermediate Period. The collapse of Cahuachi was also due to the loss of power by the sacerdotal class after the mudslides and the earthquake that struck in the previous phase. The theocratic regime of the Nasca culture was lost during the last 50 years of its epoch, resulting in the fragmentation of power among local lords (*curacas*), whose political system ruled the urban centers then spread in the valleys, right where the ideology of a central government had developed in a homogeneous manner before (Orefici 2009b, 2012).

After the abandonment of the temples, the ritual activities moved to Estaquería, 3.5 km NW from *Gran Piramide*. Estaquería was occupied during the hegemony of Cahuachi and perhaps it functioned as a small temple (Sánchez Borjas 2009). Its importance and its cultural influence on the surrounding territory had been strongly increasing after the collapse of Cahuachi, thus contributing to the transmission the Nasca ideology, towards the west and in the lower valley (Orefici 2012).

20.2.2 Paredones

Paredones rises on the slope of the rocky mountain of Los Altos, 2 km south of the modern Nasca town and very close to the road to Cuzco. Since archaeologists began their studies, they have identified this archaeological site as "Paredones". However, historical studies have found that the original name, of Inca origin, was "Caxamarca". Paredones represents the most important settlement of the Middle Horizon in the Nasca region. Probably, it was built during the government of Tupac Inca Yupanqui (1471–1493), in the period of the greatest Inca expansion. The region had been under the rule of the Huari culture. Its inhabitants maintained the aqueducts and irrigation canals built by their Nasca ancestors.

The archaeological findings, as well as the architectural structures and the urban fabric, indubitably Inca, suggest that Paredones was an administrative hinge between the Coast and the Sierra, as well as the place of residence of the representative of Cusco in the Nasca region, who served as a link with administrators, soldiers and the local people.

The archaeological site covers an area of almost 15 ha with dimensions of 1.3-km long and 90–130-m wide. Its architecture is based on the use of rectangular adobe bricks, placed on low walls, built with finely carved stones, typically Inca.

A large trapezoidal space is the centerpiece of the settlement. All around there were administrative buildings, warehouses, ceremonial areas, temples, and a tower from which to observe the middle valley of Nasca. The surrounding hills are covered with remains of houses, tombs, and ceramic fragments.

Some geophysical investigations were performed in 2012 and 2013 in order to detect the sites of major archaeological interest, as well as to suggest and plan the archaeological excavations which were subsequently done by Giuseppe Orefici from 2012 to 2014.

20.2.3 Archaeological and Research Issues Addressed by the ITACA Mission

After more than 25 years of investigations (1985–2007), including systematic excavations focused prevailingly on sector A, one pyramid had been unearthed and restored (*Gran Piramide*) and two other temples were in advance states of excavation (*Piramide Naranja* and *Templo del Escalonado*). The archaeological findings enabled the reconstruction of the historical outline of Cahuachi from the Paracas period to its abandonment.

However, several issues related to Cahuachi and its surrounding territory needed to be addressed. To this aim, since 2007 the Italian mission of CNR (ITACA) was requested by Proyecto Nasca to provide a scientific and technological contribution, mainly based on remote sensing and geophysics.

The main issues faced by the ITACA Mission were the following:

(a) The real extension of Cahuachi: does it include also the Río Nasca riverbed and the hills on the right bank of the river?
(b) Hills, mounds, pyramids, and platforms: How can we recognize and distinguish them by remote sensing?
(c) Preventive archaeology: Is it possible to detect buried earthen structures and, consequently, to develop predictive models in Cahuachi?
(d) Geoglyphs and pyramids of Cahuachi: Does a spatial and functional relationship exist between the ceremonial center and the geoglyphs, with particular reference to those in Pampa de Atarco?
(e) *Puquios:* Are there cultural expressions and technologies later than Cahuachi? Is it possible to detect abandoned or lost ancient filtration galleries?
(f) Cultural heritage protection: Can technology help and support decisions about the management and monitoring of the extremely fragile heritage of Nasca Cultural, continually threatened and damaged by grave robbers and vandals?

Issues (or tasks) ‘*a*’, ‘*b*’, and ‘*c*’ are the objects of this chapter. In particular, ‘*a*’ and ‘*b*’ have been tackled with two different satellite data-processing approaches. The first has been aimed at emphasizing the reflectance values of micro-reliefs and surface adobe structures; the second one has been focused on the enhancement of vegetation and moisture changes linked to the presence of buried structures. Issue '*c*' has been handled by integrating different remote sensing methods including geophysics. Issue '*d*' is partly addressed in this chapter, in terms of image processing, and partly contained in the specific chapter dedicated to geoglyphs of Cahuachi (Chap. 12 by Masini et al.). Finally, issues '*e*' and '*f*' are discussed in the Chaps. 22 and 25, respectively.

20.3 Rational Basis of Archaeogeophysics

20.3.1 Satellite Dataset

A multitemporal and multiscale satellite dataset has been used for both archaeological purposes and for the study of the environmental setting. In particular, we used: (i) 30 m Digital Elevation Models (Fig. 20.1), maps derived from SRTM (http://srtm.csi.cgiar.org) and ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer), respectively; and (ii) multispectral ASTER and Landsat TM images to study land cover and the hydrographic pattern of the Río Grande drainage basin. For the first results of these studies, the reader is referred to Chaps. 13 and 22, related to the *puquios*.

Remote sensing has been applied for archaeological prospecting by using very-high-resolution (VHR) satellite imagery acquired from: (i) QuickBird-2 (QB2), (ii) WorldView-1 (WV1), (iii) WorldView-2 (WV2), (iv) GeoEye-1 (GE1), and (v) Pléiades (Pl).

QB2 has panchromatic and multispectral sensors with a ground-sample distance (GSD) of 61–72 cm and 2.44–2.88 m, respectively, depending upon the off-nadir viewing angle (0–25°). The panchromatic sensor provides images in a bandwidth ranging from 450 to 900 nm. The multispectral sensor acquires data in four spectral bands, from blue to near infrared (NIR) (http://www.satimagingcorp.com/satellite-sensors/quickbird.html).

WV1 provides panchromatic imagery with GSD varying from 50 cm to 59 cm, depending on the off-nadir viewing angle. Additional details can be found at http://www.satimagingcorp.com/satellite-sensors/worldview-1.html.

WV2 acquires panchromatic imagery with 50-cm GSD, and eight-band multispectral imagery with 1.8-m resolution (http://www.ulalaunch.com/launch/WorldView-2/WV-2_MOB.pdf)

GE1 collects images with a GSD of 0.41 m in the panchromatic and multispectral band at 1.65-m resolution. The available GeoEye panchromatic images are re-sampled at 0.5 m. (see http://launch.geoeye.com/LaunchSite/about/).

Pl collects images with a GSD of 0.50 and 2.00 m in the panchromatic and multispectral band, respectively.

Details of the VHR imagery used for this study are in Table 20.1

Table 20.1 Very-high-resolution satellite imagery used for detecting unknown ancient sites, as well as for mapping and monitoring archaeological areas in the Nasca drainage basin

Acquisition date	Satellite sensor	Panchromatic GSD (cm)	Multispectral GSD (m)	Off-nadir (°)
16.09.2002	QuickBird-2	61.90	2.48	7.90
25.03.2005	QuickBird-2	63.40	2.54	15.29
31.07.2008	WorldView-1	58.10		23.90
11.09.2010	WorldView-2	50.00	2.00	2.70
29.02.2011	Stereo GeoEye-1	50.00	2.00	
28.11.2012	Pléiades 1A	50.00	2.00	
26.01.2013	Pléiades 1A	50.00	2.00	
13.03.2013	Pléiades 1B	50.00	2.00	

20.3.2 Satellite Image-Processing Approach

The image-processing approach used for exploiting VHR satellite data aimed at improving the potential of imagery both in the spatial and in the spectral domains, by means of pan-sharpening, enhancement, and edge detection algorithms (Lasaponara and Masini 2012b). Before processing the images, radiometric errors from sensor defects, variations in scan angle, and system noise need to be compensated, in order to obtain the true spectral radiance at the sensor. To this aim, the calibration to reflectance and radiance has been performed. This has enabled the conversion of relative radiance to absolute radiance (in units of [(μW)/(cm^2*nm*sr)]), using the calibration factors of the VHR metadata, including the nominal bandpass widths.

20.3.2.1 Feature Enhancement Based on Pan-Sharpening Techniques

The first step of data processing has been pan-sharpening that is, an image fusion method used to provide the spatial enhancement of the lower resolution of satellite multi-spectral (MS) data (i.e., the four bands of QB2, WV2, GE1, and Pl).

The protocol employed can be summarized in two steps: (1) extraction of high-resolution geometrical information from the panchromatic image; (2) injection of such spatial details into the interpolated low-resolution MS bands through proper models.

According to this protocol, the pan-sharpening techniques can be divided into two main classes: (i) component substitution (CS) techniques, which are based on a spectral transformation of the MS data followed by the substitution of the first transformed component with the pan image and reverse transformation to yield back the sharpened MS bands [the most widely used CS-based methods are Intensity-Hue-Saturation (IHS) , Principal Components Analysis (PCA) and the Gram-Schmidt (GS) orthogonalization procedure (Tu et al. 2004; Laben and Brower 2000)]; (ii) techniques that employ multi-resolution analysis such as wavelets and Laplacian pyramids (Lasaponara and Masini 2012a). These methods extract from the Pan image the geometrical information that will be added to the MS bands.

Due to the variety of surface covers in Cahuachi (bare-ground surface in the archaeological area, vegetated in the Nasca riverbed), and archaeological features (e.g., crop marks in the river oases, micro-relief (or shadow marks) related to stepped structures and holes left by grave robbers, and surface archaeological structures), more algorithms, such as GS, enhanced GS (Aiazzi et al. 2007) with context adaptivity (GSA) and generalized Laplacian pyramid (GLP) with context adaptivity (Aiazzi et al. 2006), were used.

The comparative analysis, performed in a qualitative way, has placed into evidence that the methods based on CS technique (GS and GSA) provide fused images with high geometrical quality with some spectral impairments, whereas the GLP is spectrally accurate, but is unsatisfactory in terms of spatial enhancement, as already experienced in other archaeological test sites (Aiazzi et al. 2008).

20.3.2.2 Feature Enhancement Based on Linear Combinations of Spectral Bands

The spectral indices are generally computed by a linear combination of different spectral bands in order to obtain quantitative measures of surface properties. Spectral indices are used to attempt to quantify surface properties such as brightness, moisture, biomass cover, and vegetative vigor. The widely used index is the Normalized Difference Vegetation index (NDVI) obtained by using Eq. 20.1:

$$NDVI = \frac{(NIR - R)}{(NIR + R)} \tag{20.1}$$

The NDVI operates by contrasting intense chlorophyll pigment absorption in the red against the high reflectance of leaf mesophyll in the NIR. On the basis of the vegetation spectral properties, the NDVI provides a quantitative measure, suitable to assess biomass, vegetation type, and vegetative vigor. High values of NDVI identify pixels covered by substantial proportions of healthy vegetation, while disease or stressed vegetation exhibits lower NDVI values.

Principal Component Analysis (PCA) has been also used to optimize the spectral information content for improving the discrimination capability of features of archaeological interest for both bare and vegetated surfaces (Lasaponara and Masini 2012b). PCA is a linear transformation that decorrelates multivariate data by translating and/or rotating the axes of the original feature space (Richards and Xiuping 2006). Therefore it transforms the input multispectral bands into new components whose number is equal (or less) than the input channels. In detail, the first component contains the major portion of the variance and provides a sort of average of all the input channels. Each successive component contains less of the total dataset variance and may represent information for a small area or essentially noise; in this case, it must be disregarded. The PCA should be able to make the identification of distinct features and surface type easier. This is a direct result of different facts: (i) only the meaningful low-correlation data can be considered, (ii) the effect of noise can be easily identified and strongly reduced because it is in the later components. Moreover, the PCA can be used to obtain a new color enhancement technique, “decorrelation stretching”, based on the following steps: (i) PCA transformation; (ii) each PCA component is contrast stretched; (iii) stretched components are rotated back using the inverse PCA transformation; and finally (iv) the resulting components are shown in RGB.

Finally, in order to better identify spectral signature anomalies on both bare ground and vegetated areas, Minimum Noise Fraction (MNF) transformation has been applied. By examining the images and eigenvalues, MNF makes it possible to determine which bands contain the coherent images, thus segregating and removing noise from the pansharpened multispectral channels (see Boardman and Kruse 1994). By using a routine of ENVI, based on MNF transformation modified by Green et al. (1988), the procedure is named two-cascaded Principal Component transformations.

The first transformation, based on an estimated noise covariance matrix, decorrelates and rescales the noise in the data. This first step results in transformed data in which the noise has unit variance and no band-to-band correlations. The second step is a standard Principal Component transformation of the noise-whitened data. For the purposes of further spectral processing, the inherent dimensionality of the data is determined by examination of the final eigenvalues and the associated images. The data space can be divided in two parts: one part associated with large eigenvalues and coherent eigen images, and a complementary part with near-unity eigenvalues and noise-dominated images. By using only the coherent portions, the noise is separated from the data, thus improving spectral-processing results.

20.3.2.3 Feature Enhancement Based on Spatial Filtering

Once pan-sharpening and spectral combinations computed, in order to further improve the edges of objects (surface archaeological structures) and marks (possibly related to buried archaeological remains), some convolution filters, including high pass, low pass, Laplacian, directional, Gaussian High Pass, Gaussian Low Pass, median, Sobel, and Robert filters, have been used (Lasaponara and Masini 2012b).

The best results in terms of sharpening of the image and enhancement of the edges have been obtained by using “high-pass filtering” which removes the low-frequency components from the images, thus retaining the high frequencies related to local variations in the presence of surface archaeological structures.[4]

[4]The filter has been applied by adopting a 3×3 kernel with a value of 8 for the center pixel and values of -1 for the exterior pixels.

For rectilinear features of cultural interest (i.e., the edges of stepped platforms on some mounds) good results have been obtained by using a directional filter that selectively enhances image features having specific direction components (gradients). The above-said image processing routines have been applied to various test areas in order to select those to be systematically adopted in the areas to be investigated.

Unfortunately, the identification of buried and/or shallow remains (i.e.., walls) in the arid area of Cahuachi by using optical imagery is a very complex challenge, due to the building material whose composition (sun-dried earth) is quite similar to the soil that covers the archaeological remains. This has been confirmed by multi-temporal observation of aerial and satellite images, which enabled us to compare some areas before and after the excavations (Masini et al. 2008, 2009).

The comparison places into evidence that, for bare surfaces: (i) buried adobe structures are generally not visible in an aerial and/or satellite view; (ii) surface-wall remains are identifiable thanks to the high contrast in brightness between the white clay of the earthen walls and the surrounding darker color alluvial deposits; and (iii) micro-relief related to shallow walls are sufficiently detectable thanks to the small shadow produced on the ground (Fig. 20.5).[5]

To face the challenge of detecting archaeological features, once selected and used with the most-suited pan-sharpening and filtering algorithms, further processing methods have been applied on some test sites which place into evidence the good performance of the Principal Component Analysis (PCA) for the bare-ground sites and vegetation indices for the vegetated and damp areas of the Nasca riverbed (Fig. 20.6).

20.3.2.4 Geostatistic Approach

A further methodological approach has been adopted in Cahuachi. Based on spatial autocorrelation statistics, it has already been used to extract features and changes over time caused by looting activity (Lasaponara et al. 2012, 2014; see also Chap. 25). Spatial autocorrelation measures the degree of dependency among events (or pixel reflectance), considering at the same time their similarity and their distance relationships. In particular, having selected a neighborhood for each event (pixel), spatial autocorrelation expresses how it is modified from the presence of other elements belonging to same variable inside that neighborhood. In particular, two effects cause the presence of autocorrelation in a spatial distribution: (1) first order effects that measure how the expected value varies in the space, and (2) second order effects that concern local interactions between pixel/events and are measured by covariance variations. Under their effect, a distribution can be: (i) clustered, (ii) uniform, or (iii) random, for which the autocorrelation will result

[5]See also Fig. 20.16, which shows part of *Gran Piramide* and *Templo del Escalonado* before (1955) and after the excavations (2008).

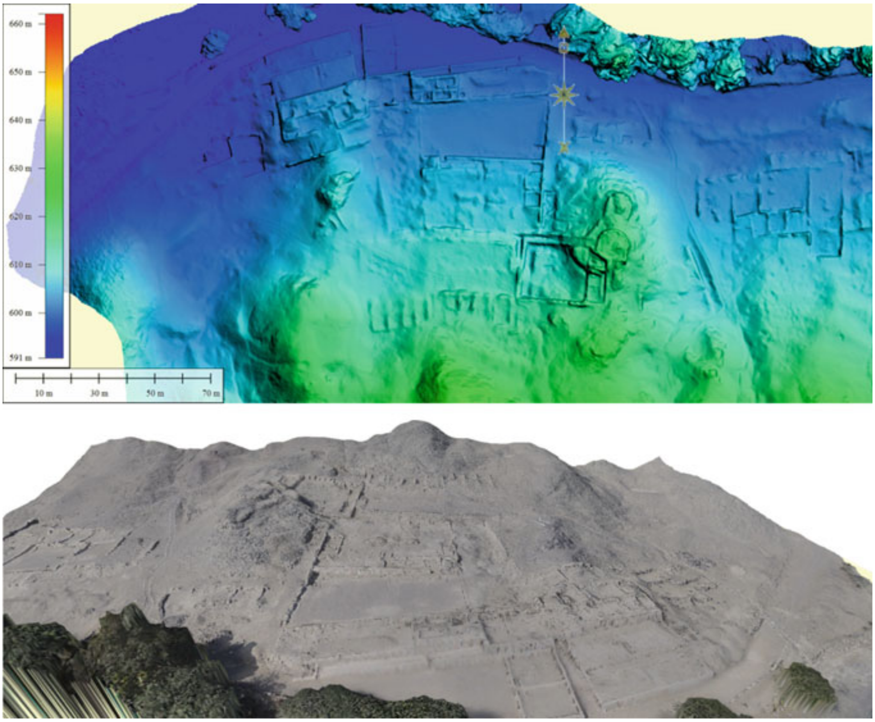


Fig. 20.5 *Top* DEM of Paredones obtained by the SfM processing of aerial images taken from UAV. *Bottom* 3D textured visualization of the same scene of the DEM

positive, negative and null, respectively. In other words, we can have respectively: (i) attraction between pixels (when they are near and similar); (ii) repulsion between events (when, even if they are near, they are not similar); and (iii) no spatial effects, neither about the position of events nor their properties.

According to what has been said, the study of spatial autocorrelation seeks knowing: (i) the quantitative and (ii) the geometric nature of dataset.

In the context of image processing, the quantitative aspect is given by the intensity equal to the value of each spectral band. So, it is necessary to measure the degree of dependency between spectral features.

As a whole, the output is a new image which contains a measure of autocorrelation for each pixel. Such measure could be done by computing global and local indicators.

Global indicators of autocorrelation measure, with one summarizing value, if and how much the dataset is autocorrelated. Local indicators of autocorrelation enable us to understand where clustered pixels are, by measuring how much are homogeneous features inside the fixed neighborhood.

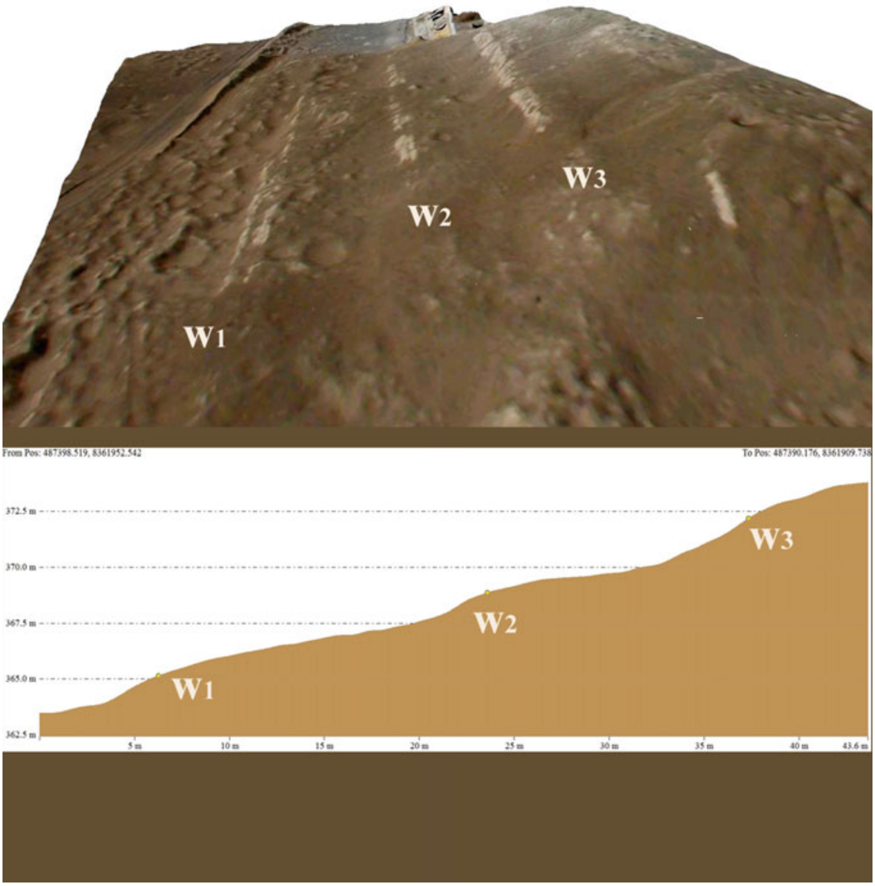


Fig. 20.6 Shallow and surface walls are visible from remote by means of the shadow and the reflectance of the clay adobe walls. *Top* 3D detail of microrelief related to shallow stepped structures on the northern slope of *Piramide Naranja*. *Bottom* Profile of the northern slope of Piramide Naranja. *W1*, *W2* and *W3* indicate the three-stepped structures shown both in the 3D image (*top*) and in the profile (*bottom*)

In this study, we have used three indicators: the Local Moran's I (Anselin 1995), the Local Geary's C (Cliff and Ord 1981), and the Local Getis-Ord Gi (Cliff and Ord 1981; Illian et al. 2008).

These indicators comprise a different concept of spatial association:

- the local Moran's I high value means positive correlation for both high values and low values of intensity;
- the Local Geary's C enables one to identify areas of dissimilarity between pixels and its surrounding, enabling detection of edge areas characterized by dissimilar neighboring values

- the Getis and Ord's Gi high value means positive correlation with high values of intensity, while low value means positive correlation with low values of intensity.

20.3.3 Aerial Photogrammetry by Means of Structure from Motion

Aerial images of Cahuachi, taken from ultralight aircrafts by using consumer-grade digital cameras and processed by applying Structure from motion (SfM) methods, enable us to create high-resolution digital elevation models (DEMs) and orthophotos. SfM is a range-image method which enables us to reconstruct the shape of objects through automatic collimation of points from a set of photos. The SfM approach addresses this issue by using multiple images, with a minimum overlap of 60%, by a highly redundant, iterative, bundle-adjustment procedure based on matching features (Westoby et al. 2012). The SfM has been popularized through a range of cloud-processing softwares, most notably Microsoft®Photosynth™ and Agisoft PhotoScan. The 3D geometry reconstruction of Cahuachi has been obtained by using Agisoft PhotoScan, whose procedure comprises four main steps (Agisoft PhotoScan 2014).

In the first step, the photo alignment is performed. In particular, the SfM algorithm finds the camera position for each scene and refines camera-calibration parameters. To this aim, it searches for and matches common points on photographs. The result is a sparse point cloud with the original color. In the second step, on the basis of the estimated camera positions, a dense point cloud is provided. In the third step, the algorithm generates the 3D-polygonal mesh model representing the object/landscape surface based on the dense point cloud. Finally, the obtained product can be textured and used for orthophoto generation. In 2015 very highly detailed orthophotos and DEMs have been obtained by using images taken from a low-cost unmanned aerial vehicle (UAV) and processed by applying SfM. The result enabled the surveying of temples, platforms, and squares at the scale of the wall. UAV has been also used to identify small micro-relief to be investigated later by geophysics in order to detect and map shallow structures. The SfM approach enabled the reconstruction of the 3D geometry of Cahuachi over time. The available aerial data set has made it possible for to document the various stages of excavation from 2007 to 2015 (Fig. 20.7), as well as to provide information on damage caused by illegal diggings. UAVs have also proven to be particularly useful in studying the drawing techniques of geoglyphs in Pampa de Atarco (see Chap. 12 Masini et al.) and in other areas including the Río Taruga Valley.

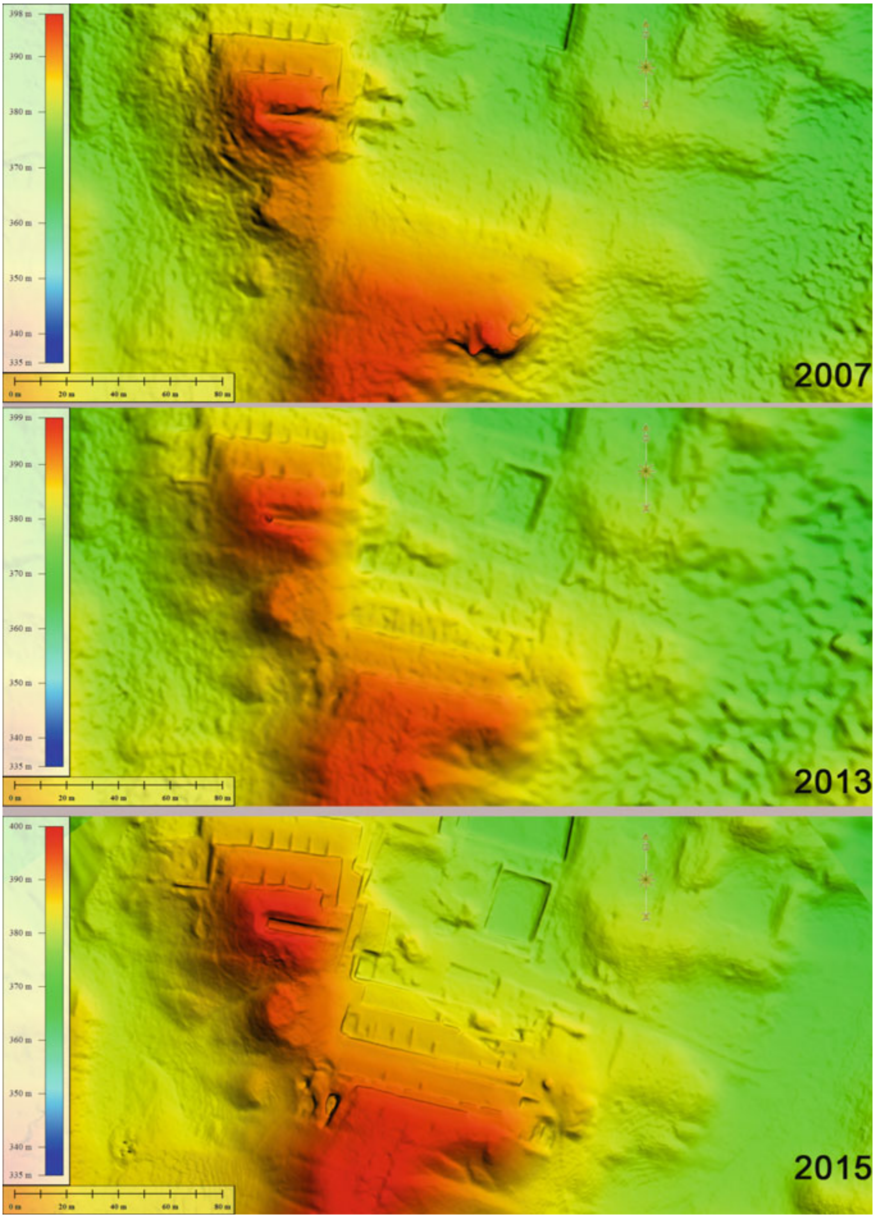


Fig. 20.7 DEM derived from SfM processing of aerial images acquired on 2007, 2013, and 2015, the first two from ultralight aircraft and the third from a drone

20.3.4 Geophysical Approach

The main aim of Geophysical prospecting in archaeology is to investigate the presence of ancient buried structures by means of non-invasive methods such as geomagnetic, georadar, and geoelectrical ones (Fig. 20.8). These methods are characterized by high-resolution, rapid data-acquisition rates and reduced costs. They are able to provide useful information for identifying and mapping shallow structures and giving guidelines for the subsequent archaeological studies and excavations. The approach used took into account all the parameters and information which define the archaeo-geophysical problem: from the physical parameters of the targets to be detected and its surrounding soil to the characteristics of expected archaeological findings.

In the Nasca drainage basin, including Cahuachi and Paredones, we are in presence of a large variety of archaeological remains in the subsoil, such as walls, floor, tombs, and ritual offerings. Moreover, the archaeological stratigraphy, usually found by archaeologists, is very complex, because of the superposition of walls and floors, filling material (earth, ritual offering materials, and vegetable matter), and the reuse of older walls (Fig. 20.3).

Finally, the crucial geophysical issue is the low contrast, in terms of resistivity and dielectric constant, between archaeological structures, mainly composed of earth[6] and the surrounding alluvial subsoil. In particular, the soil texture is composed of: (i) silty and clayed sand along with pebbles in the area of *Gran Piramide*; and (ii) sandy and slightly clayey silt along with pebbles in the *Piramide Naranja* (Lasaponara et al. 2011). The analyses of some samples of adobe, conducted in the laboratories of CNR-IBAM and IMAA, placed into evidence a highly variable granular composition, with ranges of: 15–25% of clay (grain size $\leq$ 0.002); 20–35% of silt (0.002 < grain size $\leq$ 0.063); 40–55% of fine sand (0.063 < grain size $\leq$ 0.2); and, finally, 10–15% of medium sand (0.2 < grain size $\leq$ 0.63).[7]

In the Nasca drainage, the techniques used for prospecting buried archaeological remains have been the geoelectrical (DC), ground-penetrating radar (GPR) and geomagnetic (GM) ones. The DC method consists of measuring the electric field after a current has been injected into the subsoil. The GPR introduces into the subsoil electromagnetic signals and detects the reflections on the surface. Finally, the GM measures the local variation of the local magnetic field due to the presence of surface objects, shallowly buried objects, and structures characterized by magnetic susceptibility.

[6]With the exception of some walls in Paredones, built in adobe and based upon stone foundations.

[7]Comparing the loaf-shaped adobe with a conic one, no significant differences in granulometry has been recorded, with the exception of a slightly greater percentage (around 5–10%) of sand in the loaf-shaped adobe elements.

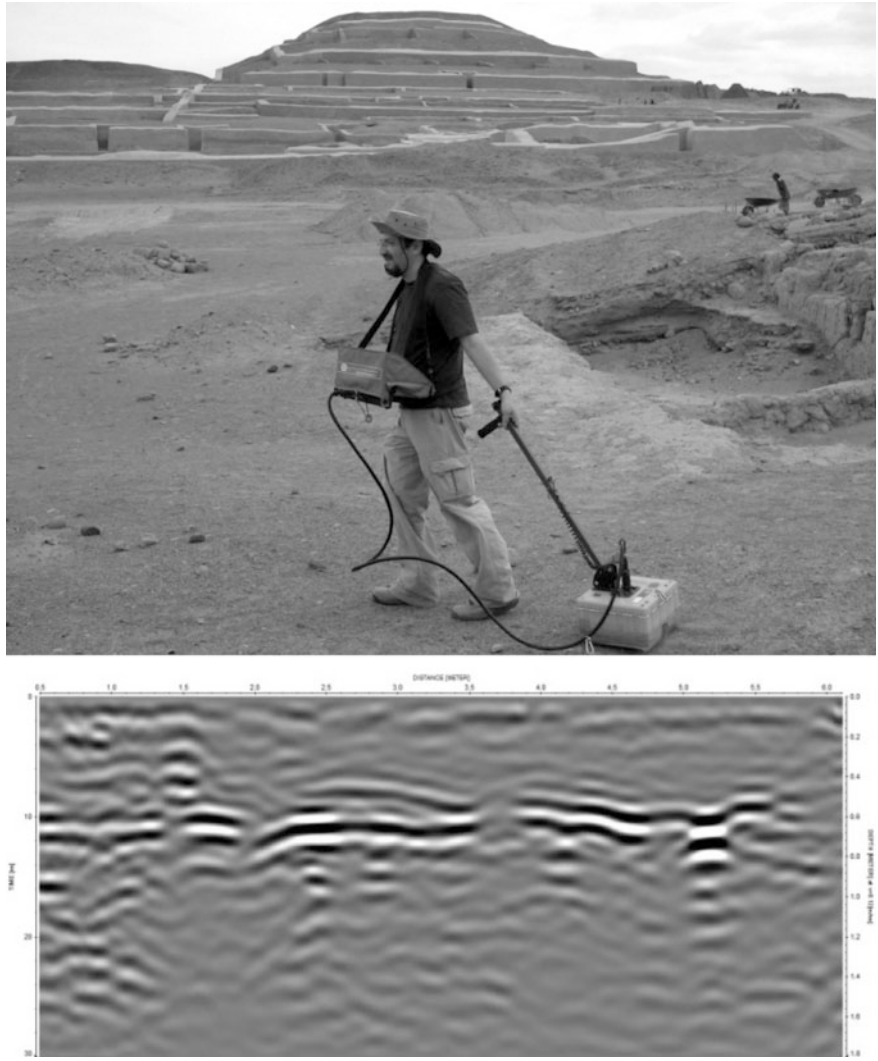


Fig. 20.8 *Top* GPR data acquisition by using antenna at 400 MHz frequency. *Bottom* Typical radargram provided in Cahuachi which places into evidence a scarce penetration of the signal due to the low physical contrast between the target to be detected, generally earthen walls, and the subsoil composed of clay, silt, and sand

Case by case, the most effective strategy has had to be chosen. Generally, the integration of various different geophysical methods has been largely used to identify the buried remains, because each geophysical technique measures and analyzes a physical parameter which is able to highlight some pattern of the target (Rizzo et al. 2005). In the following sections, we describe each geophysical method.

20.3.4.1 GPR Method

The GPR is an electromagnetic (EM) method that uses radar pulses to image the subsurface for several kinds of applications and at various depths. The archaeological targets are generally investigated by using antennas operating in frequency bands ranging from 100 to 1000 MHz. GPR measurements are performed by using an instrument which consists of a digital control unit with a keypad, VGA video screen, a connector panel, and a 12-V DC battery. The central unity produces EM pulses which are introduced into the soil by a transmitting antenna. Usually GPR systems use dipole antennas, either in monostatic or bistatic arrangement. In the first case, the same antenna serves both as a transmitter and as a receiver, in the second case, two different antennas are used.

The EM-wave frequencies along with the electrical characteristics of the subsoil (permittivity and electrical conductivity) determine the resolution and the depth of investigation. The GPR radiates short EM pulses into the ground and detects the signals reflected from subsurface structures. The reflected signal is generated in the presence of a dielectric contrast between potential targets and the surrounding soil (Annan 2003). This has been the crucial technique in Cahuachi because the adobe bricks have characteristics similar to the alluvial soil in terms of resistivity and dielectric constant.

In Cahuachi, GPR measurements were performed by using two different instruments: SIR 3000 by GSI and Hi-MID by IDS. The first is equipped by a monostatic antenna at 400 MHz frequency, the second by two antennas at 200 and 600 MHz.[8] In order to estimate the average electromagnetic wave velocity, a wall of known thickness fitted with a metallic plate was used to gain a maximum reflection of EM waves. A velocity of about 0.1 m/ns has been estimated observing the half two-travel time of the corresponding metallic plate reflection. The radar scans have been acquired in continuous mode with a two-way time range of 40 ns.[9] An interval band-pass filter of 100–800 MHz was used to reduce electronic, antenna-to-ground coupling noise, as well as other low- and high-frequency noise.

The high quality of the traces required only standard analysis techniques for reducing background noise, linked to trace editing and data enhancement.[10] In particular, the data processing steps have been:

- amplitude normalization, consisting of the de-clipping of saturated (and thus clipped) traces by means of a polynomial interpolation procedure;
- acquisition-gain removal and zero-time correction;

[8]Both of them consist of a digital control unit with a keypad, VGA video screen, connector panel, and are powered by a 12-V DC battery and connected by fiber-optic cables.

[9]Due to the incoherent sand of soil surfaces, the survey was acquired without a ‘wheel accessory’, so that a speed variation could occur. To reduce uncertainties on the antenna position, a reference meter rule was located along each profile and marked at each meter.

[10]The Reflex W software has been used to process the data (Sandmeier 2006).

- background removal by using filters based on a simple arithmetic process which sums all the amplitudes of reflections that have been recorded at the same time along a profile, and divides by the number of traces summed;
- Kirchhoff 2D-velocity migration in order to trace back the reflection and diffraction energy to their "source".

An interactive velocity adoption, based on EM reflection waves, has been used to estimate the average EM-wave velocity of the geological material that covers the archaeological deposits.

20.3.4.2 Geomagnetic Prospecting

Among the geophysical techniques employed for the archaeological prospections in Cahuachi, the magnetic method with a gradiometric configuration has been adopted because it proved to be the most effective. Therefore, it has been the most often exploited geophysical technique due to its capability in detecting magnetic changes caused by the presence of materials characterized by high magnetic susceptibility, such as: (i) pottery, which could be found in great quantities in tombs and ritual offering, (ii) filling spaces close to walls, (iii) ritual fires, and (iv) in some cases, metallic objects.

The measurements were performed using a cesium-vapour magnetometer G-858 Geometrics in gradiometric configuration, with two magnetic probes set in a vertical orientation at a distance of around 1 m from each other. Such a configuration enabled the automatic removal of the diurnal variations of the natural magnetic field.

Before defining the acquisition modalities, it was necessary to set up the proper orientation of the two magnetic sensors of the cesium magnetometer. The orientation depends on the survey direction and site location. To this aim, CSAZ software (by Geometrics) has been used. It provides information about the parameters of the Earth's magnetic field including total field, inclination, and declination anywhere in the world, using the IGRF (International Geo-Magnetic Reference Field).[11] The data have been generally acquired along parallel profiles 1 m apart with a sampling rate of 10 Hz and processed and interpolated to create regular grids. Successively, the acquired magnetic data have been elaborated in order to increase the signal/noise ratio by using pass-band filter, spike elimination, and destripe algorithms. The final image is a geomagnetic map visualized as a color or a shaded-relief image, in order to highlight the main magnetic anomalies (Fig. 20.9).

[11] After entering the latitude and longitude of the archaeological site and indicating the survey direction, the software enables the oriented cesium sensor to achieve the maximum signal and best performance. Therefore, the instrument was set with a tilt angle of 45° and the survey was defined along a parallel profile in N-S direction.

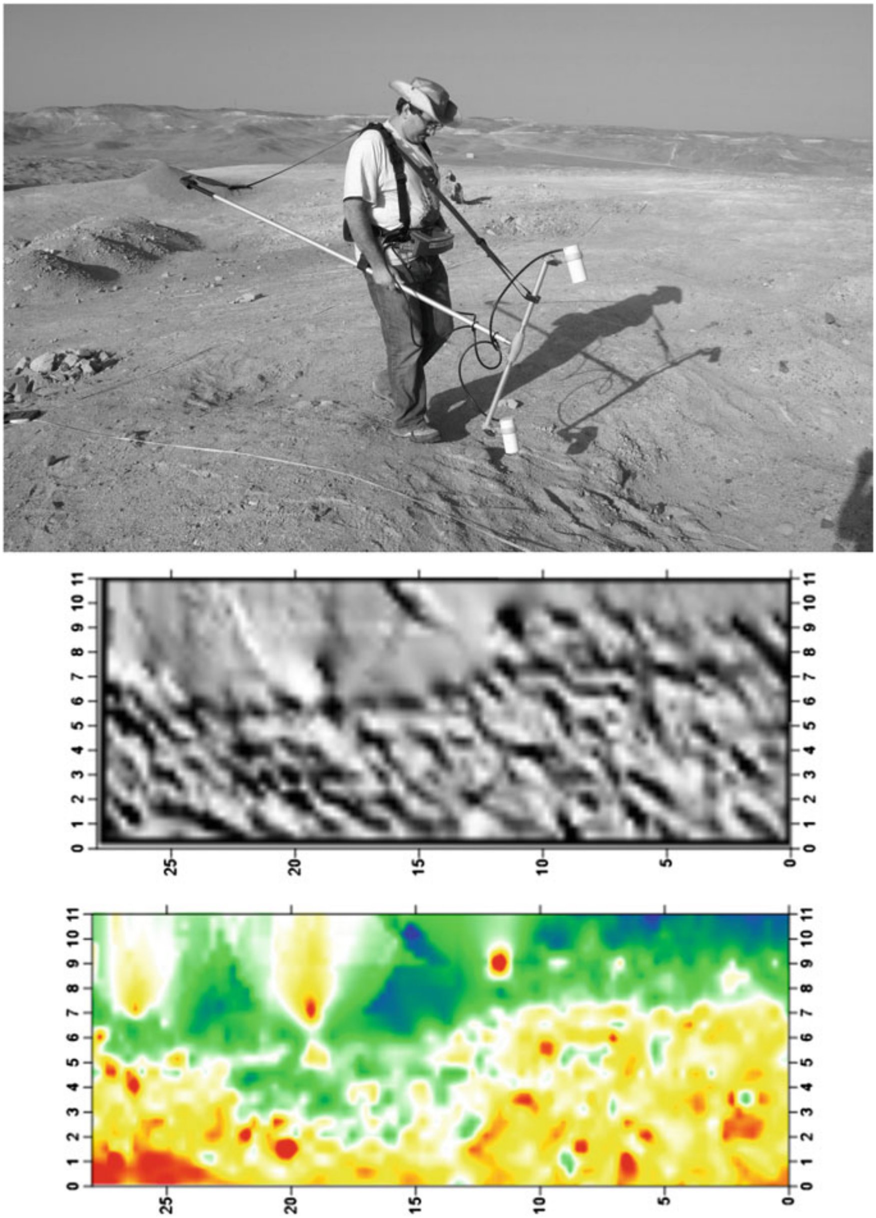


Fig. 20.9 *Top* Geomagnetic data acquisition by using a caesium vapour magnetometer in gradiometric configuration. *Bottom* Shaded-relief and colored geomagnetic map

20.3.4.3 Geoelectrical Method

The geoelectrical (DC) method is based on the measurement of an electric field artificially created in the ground by two pairs of fixed electrodes: one pair used for the current injection circuit, the other for the measuring circuit of the potential difference (dV) generated in the ground by the passage of the current itself. The physical parameter measured is the electrical resistivity, whose variation is due to presence of structures, voids, and aquifers in the subsoil. To study the distribution of electrical resistivity, a georesistivimeter is necessary. It enables energizing of the electrodes inserted in the ground and measuring the resistivity at various depths.

The data acquired are expressed in the form of apparent resistivity $\rho a = \Delta V/IK$, where ΔV is the measured potential, I the transmitted current, and K the geometrical factor, which depends on the position of the electrodes. The apparent resistivity values are then interpreted in terms of real resistivity and depth by means of an inversion software. The resistivity measurements in Nasca drainage basin (including Cahuachi) were acquired using a georesistivimeter (Syscal) connected to a multichannel electrical cable, consisting of two multichannel cables at 24 channels with a variable electrodes spacing (Fig. 20.10 top). The result of processing, is the Electric Resistivity Tomography (Fig. 20.10 bottom) which enables us to investigate the deep electrical-resistivity distribution of the subsoil, in order to detect large buried features such as channels, large walls, and tombs.

In Cahuachi, another method based on the measurement of georesistivity has been employed. This technique measures the resistance encountered by an electrical current in passing through the subsoil between four probes (the instrument used is RM-15 Resistance Meter by Geoscan). One pair of probes is fixed far from the investigated area, while the second one is mounted on a frame and inserted into the ground at regular distances. In the investigated area, the interval distance was 1 m along parallel lines with a regular distance of 1 m. Each reading is a measure of the amount of the resistance encountered by the current as it passes through the soil. In presence of adobe walls in the subsoil, low resistivity values are expected. On the contrary, electrical current should encounter greater resistance in tombs and ritual offering, due to the presence of voids and a high content of pores.

20.4 Remote-Sensing-Based and Geophysical Investigations: Approach and Results

Before the first systematic archaeo-geophysical campaign in 2008, some preliminary investigations in 2007 into the archaeological area and its surroundings have been carried out on some test sites. This enabled the decisions concerning the most suitable remote-sensing, geophysical data-acquisition, and processing approaches to be used for different expected archaeological features (walls, tombs, pits) and land cover.

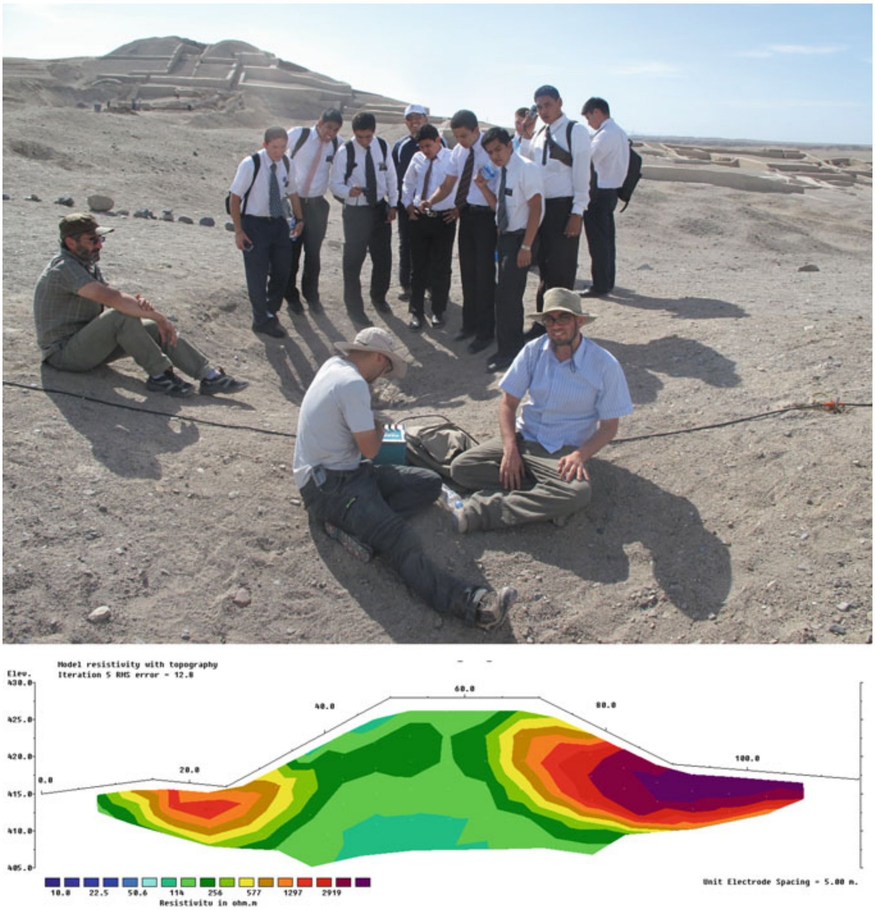


Fig. 20.10 *Top* Data acquisition by georesistivity equipment, while some young students show their interest in geophysics. In the background is the *Gran Piramide* of Cahuachi. *Bottom* ERT performed between *Templo Sur* and *Gran Piramide*

Herein, we discuss the results obtained in some areas in the ceremonial center of Cahuachi, in the Nasca riverbed and in Paredones.

Some of the results focused on the use and processing of satellite imagery: i) on arid surfaces aimed at detecting micro-relief linked to the presence of platforms and mounds (see S1 in Fig. 20.11; and Sect. 20.4.1), and identifying geometrical and biomorphic geoglyphs (S2 and S8); and ii) on vegetated areas for the reconnaissance of proxy indicators such as crop and damp marks, referable to possible buried remains (see S7 in Fig. 20.11; and Sect. 20.4.3).

Other case studies were investigated by using mostly geophysical prospecting often integrated with remote sensing for the detection of buried remains close to archaeological areas in Cahuachi (S4-S6) and in Paredones (S9).

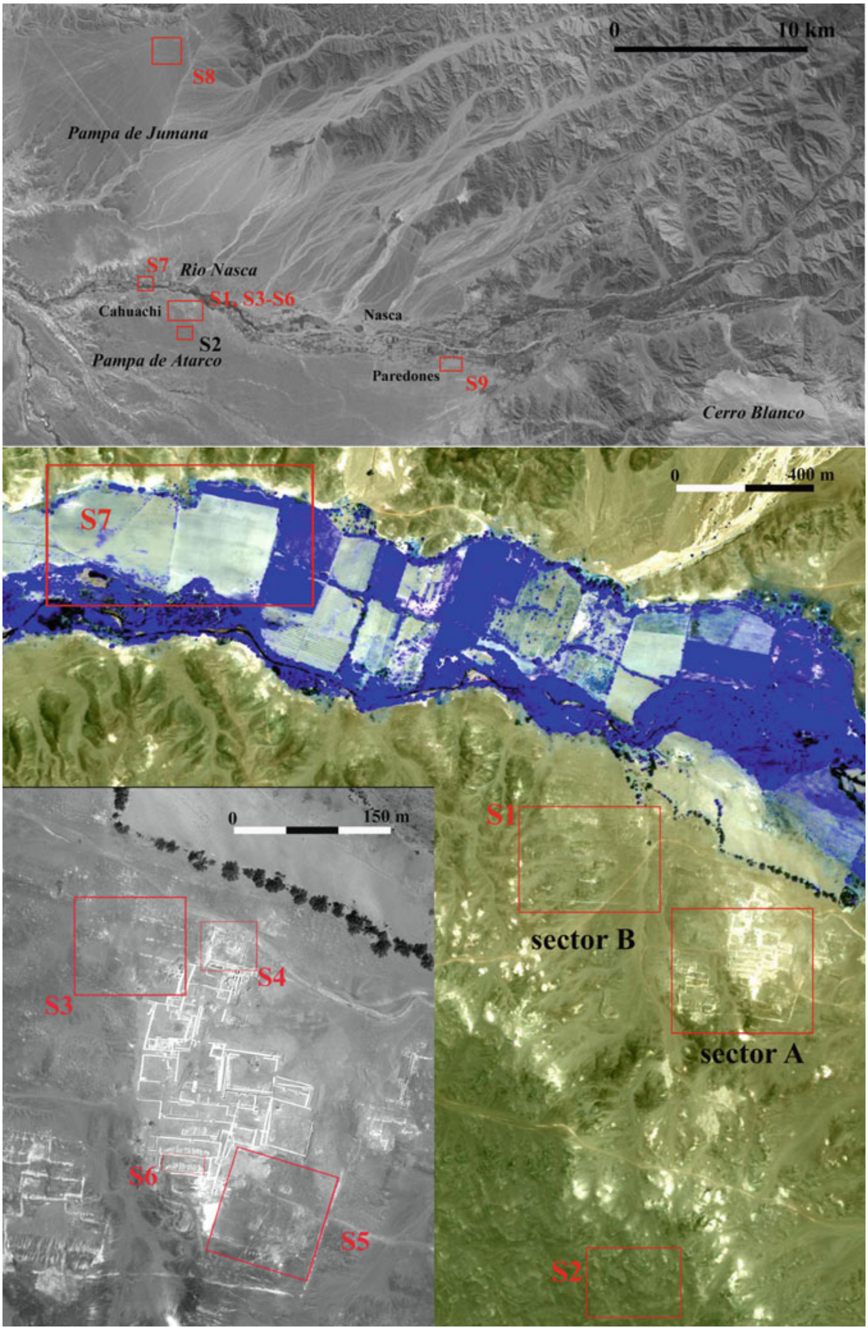


Fig. 20.11 *Top* Río Nasca drainage from Aster band VNIR 1 acquired on 25.04.2011 (GSD = 15 m). *Middle* Río Nasca Valley, Cahuachi, and Pampa de Atarco from a false-color GeoEye image acquired on 29.02.2011 (GSD = 2.00 m). *Bottom left* Sectors A and B of Cahuachi from GeoEye pancromatic image (GSD = 50 cm) acquired on 29.02.2011. The *red boxes* indicate the areas investigated by remote sensing and geophysics

20.4.1 *VHR Satellite Image Processing: Approach Devised for the Arid Surfaces of Cahuachi*

The reconnaissance of archaeological features by using remotely-sensed optical data in the arid surface of Cahuachi is very challenging due to the lack of the typical proxy indicator of archaeological features, linked to vegetation and moisture changes. This is confirmed by a multitemporal observation of historical aerial and satellite images which enabled us to compare some areas before and after the excavations (Masini et al. 2008, 2009). The comparison places into evidence that: (i) buried adobe structures are generally not visible from an aerial and/or satellite view; (ii) surface-wall remains are more easily identifiable thanks to the high contrast in brightness between the clay of the surface adobe walls and the surrounding alluvial deposits (which cover a large part of the mound); and (iii) micro-relief related to shallow walls are sufficiently detectable thanks to the small shadow produced on the ground.

Given the difficult detectability of buried structures by using remotely-sensed images, from traditional aerial photos to multispectral satellite images, our attention has been concentrated on the detection of surface remains as well as micro-relief of archaeological interest.

In this section, we present and discuss the results of some applications made on sector B and on a test area in the Pampa de Atarco, including some geoglyphs. In both cases, we tried to define the most effective approach for enhancing multispectral imagery with the aim to improve the visibility of medium/small reliefs in sector B (with changes in elevation (c.e.) ranging from 20 cm to 1–2 m), related to platforms and terraces, and very small relief (c.e. less than 20 cm) related to geometric geoglyphs.

20.4.1.1 Site 1: Sector B of Cahuachi

The capability of satellite data processing for investigating arid surface has been assessed in sector B. It is characterized by a chess-board shaped layout, including mounds (Fig. 20.12), terraced platforms, a square, and a U-shaped enclosure, strongly affected by looting. The U-shaped courtyard is an urban pattern that characterizes the ceremonial towns since Early Horizon (Gavazzi 2009, 2010). In Cahuachi the U-shaped courtyard of sector B, faces north, in the direction of the geoglyphs of the Pampa.

From the mounds, it is possible to look eastward to the sacred mountain of Cerro Blanco, thanks to the offsetting of sector B with respect to sector A, in the east-west direction, and the mutual offsetting of the mounds, in the same direction.

The mapping of such a kind of cultural landscape is not easy because of the shadow and the high reflectance of surface adobe material, which make difficult the interpretation of topographical relief and, consequently, the discrimination between geomorphological and cultural features, in particular between modified and

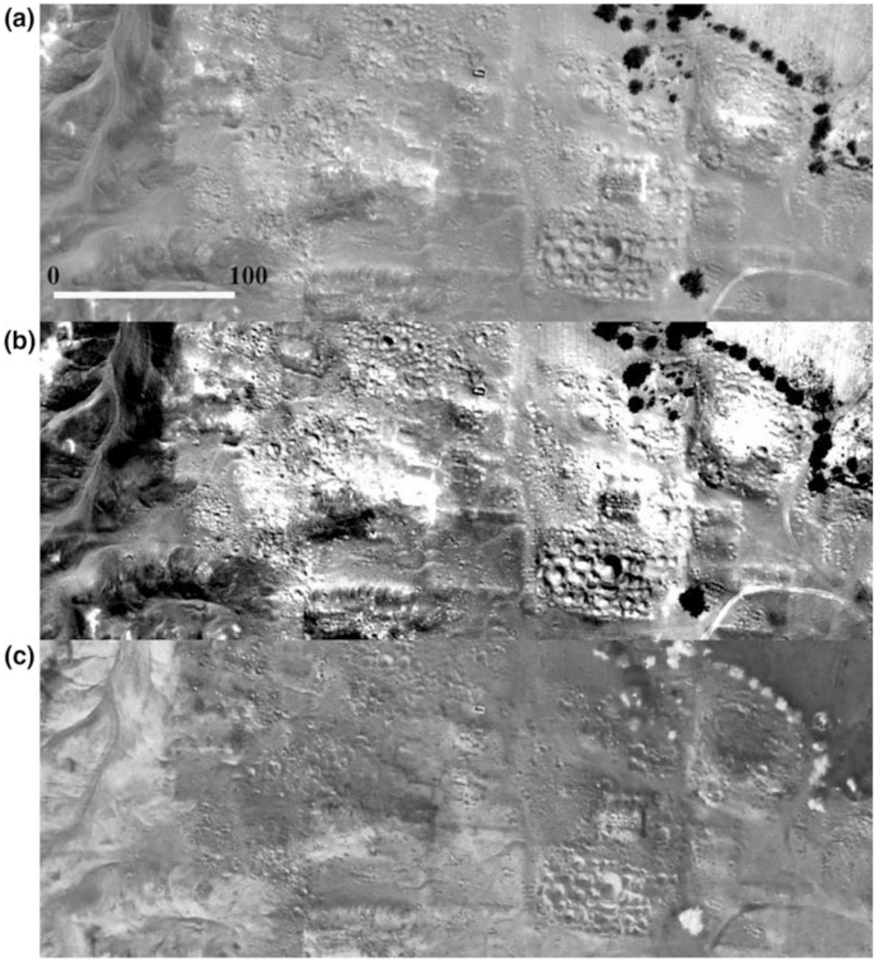


Fig. 20.12 Detail of sector B from **a** 2005 QuickBird satellite panchromatic image. **b** PC1. **c** PC2 results

non-modified natural hills. In the future, new insights may be obtained by using VHR SAR data (Chen et al. 2015).

All these archaeological features in sector B are sufficiently visible from the panchromatic image (Fig. 20.12). However the shadow produced by the micro-relief (linked to terraces, platforms, and walls), the circular looted area and the presence of chaotic surface material (residues of adobe structures) make difficult their identification and surveying.

To overcome these limits, the feature-enhancement approach, described in Sect. 20.3.2.3., has been adopted. In particular, once the most suited pan-sharpening (GS) and filtering algorithms (directional-filter angle) have been selected and employed, further processing methods such as PCA and spatial autocorrelation were applied. With respect to the panchromatic image (Fig. 20.12a), the first principal component analysis (PC1) places into evidence the effects of water erosion, such as gulleys or channels cut in the earth by running water after prolonged, as well as infrequent, downpours (Fig. 20.12b). Moreover, PC1 enhances the edges of the platforms and of surface adobe walls. Better discrimination of some archaeological features has been obtained by PC2 (Fig. 20.12c). The latter makes easier the identification of edges related to mounds and platforms plus some parts of the U-shaped enclosure. This is in perfect accordance with the fact that the first PCA substantially provides an average of all the input spectral channels, e.g. a map very close to the brightness of the scene and quite similar to the panchromatic image. Whereas the second component cannot be associated with a general meaning, it is obtained from statistical computation and depends on the current dataset.

As the Local Geary's C index identifies areas of high variability between a pixel and its neighboring pixels, it enables us to detect edge areas. In particular, the result of Local Geary's C algorithm applied to the red-pansharpened image (Fig. 20.13a) has made possible the identification and quantification of circular-shaped looted area (indicated by white arrows in Fig. 20.13a), as well as surface *adobe* structures along the U-shaped enclosure and on the top of some mounds (denoted by red and yellow arrows, respectively). Finally, the direction-filter angle (Fig. 20.13b) selectively enhances image features having specific direction components (gradients) and emphasizes geometrically-oriented features related to surface walls and the edges of terraced platforms. The RGB composition (Fig. 20.13c) of the feature enhancement results (PCA, Local Geary's C, and convolution direction filter angle) displays the added value of each of them. This enables us to map, at highly detailed levels, all kinds of cultural and natural features, including the destructive effects of looting and recent anthropogenic activity.

20.4.1.2 Site 2: Geoglyphs of Pampa de Atarco Cahuachi

Better results of PCA can be observed in site S2 (Fig. 20.14), which is an area located in Pampa de Atarco, about 1–2 km south of *Gran Piramide*, where several geoglyphs can be observed (Fig. 20.14a, c). They are lesser-known geoglyphs, from the iconographical point of view with respect to those of *Pampa Jumana* and *Pampa Colorado*. Here we do not find any biomorphic ground drawings. However, they are important because they are clearly part of a ritual complex closely related to Cahuachi. These are mostly pathways used by pilgrims on their way to the Ceremonial Center.[12]

[12]For additional details on Pampa de Atarco geoglyphs, the reader is referred to Chap. 12 by Masini et al.

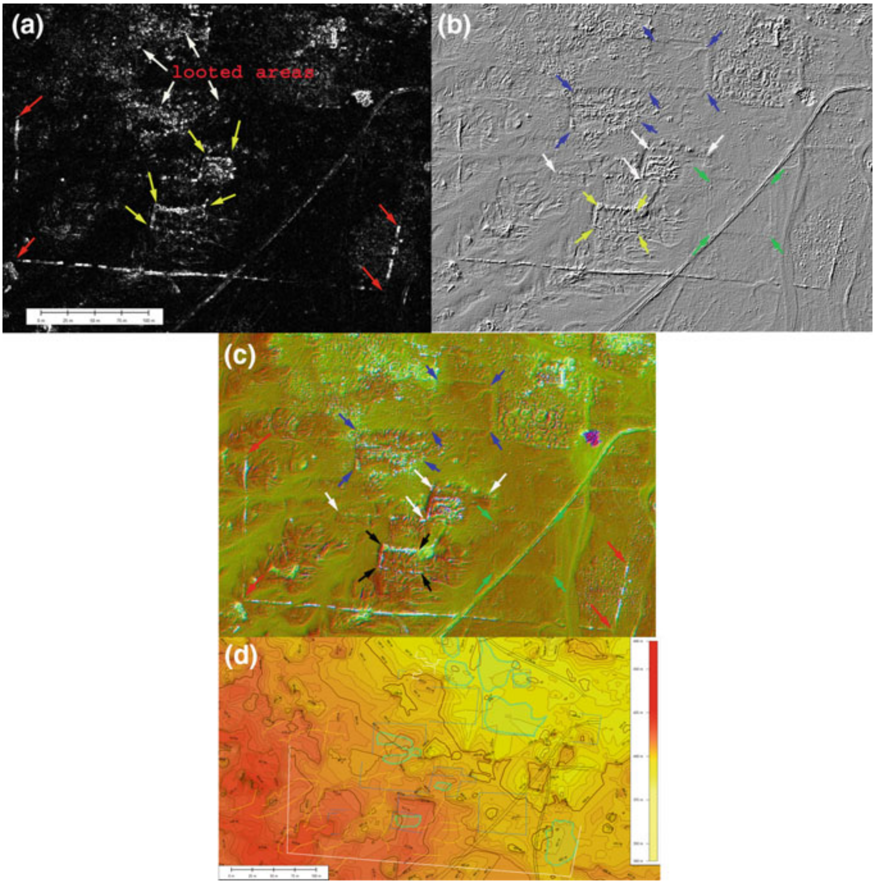


Fig. 20.13 Processing results of 2011 GeoEye imagery on sector B. **a** Local Geary's C algorithm applied to red-pansharpened image. **b** Convolution directional-filter angle (45°) applied to panchromatic image. **c** RGB composition of: convolution directional-filter angle (45°) applied to 2001 GeoEye panchromatic image (R), PC1 (G), and Local Geary's C algorithm applied to red-pansharpened image (sector B). **d** Digital Elevation Model (DEM) derived from the stereo pair of GeoEye images. The *rows* indicate the edges of platform, surface walls, and areas affected by looting

Such geoglyphs have been produced by removing stones from their original place to create different broad motifs, such as lineal (straight lines, U-shaped, meandering, zig-zag, and spiral) and areal (trapezoidal, rectangular, and triangular), as illustrated in Chap. 12 (by Masini et al.). In some cases, the contrasting light-dark had been obtained by removing darker stone material (pebble and gravel) and unearthing the lighter-colored subsoil. The image processing of QB images has been done to improve the lines' contrast. The test site has been selected because it is characterized by the superimposition of more geoglyphs. The convolution filters and PC2 enabled the identification of the temporal sequence of the drawn lines. The

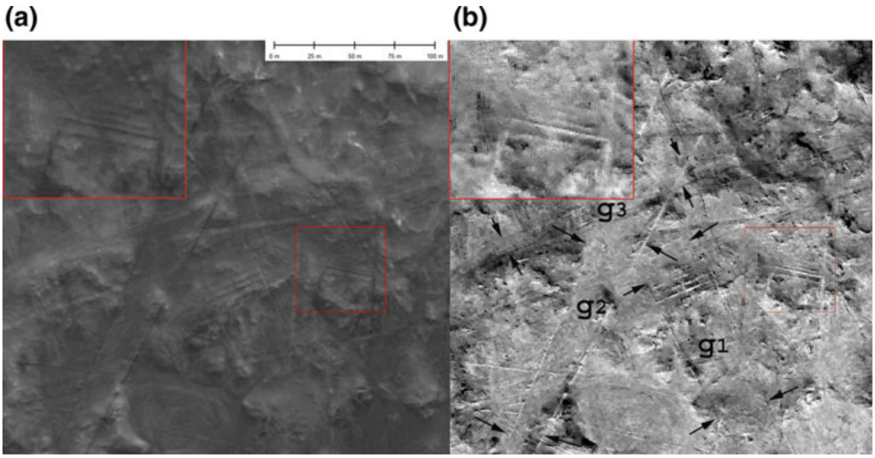


Fig. 20.14 Detail of geoglyphs in Pampa de Atarco (see also figures related to group G1 in Chap. 12 by Masini et al. **a** 2002 panchromatic image with a zoom in the *corner upper left*. **b** Visualization of PC2

visualization of PC2 in Fig. 20.14b places into evidence at least three different drawing phases (g1, g2, and g3). Such superimposition did not necessarily mean the destruction of a line and the creation of a new one. In some cases, the superposition of geoglyphs created an intersection of pathways to be walked. Highly detailed ortho images and DEMs have been obtained by processing images taken from drones.[13]

20.4.1.3 Feature Enhancement of Satellite Images Including Biomorphic Geoglyphs

The submetric spatial resolution of the VHR satellite imagery enables the detection of geoglyphs characterized by geometric shapes, such as straight lines, trapezoids, meandering, and spiraliform motifs. However, they are still not adequate to identify all the biomorphic figures. Even in the cases where the geoglyphs are recognizable, the VHR satellite does not discriminate all the features including figurative details, superposition of geoglyphs, and damage caused by human and natural factors. This makes enhancement of the edges necessary.

An area located north-east of the Pampa Colorado has been selected to apply diverse processing techniques (Fig. 20.15). It includes one of the most famous geoglyphs of Nasca: the hummingbird, considered the messenger of the gods as an intermediary between humans and mythological condors. The ornithomorphic

[13]For additional details on the enhancement of satellite images and high resolution DEMs provided by images taken from drones related to geoglyphs, see Chap. 12 by Masini et al.

Fig. 20.15 **a** The hummingbird from satellite World View-2 panchromatic image acquired on ► 11.09.2010. The scene also includes part of a huge *trapezoid*, *triangles*, *lines*, and several marks of damage caused by natural and human factors. **b** Result of the processing which enhances the image and makes the reading of some details of the ornithomorphic figure easier. The image is given by the RGB composition of the panchromatic image, the result of the Local Geary's C index and the product of the convolution directional filtering. **c** Zoom of the hummingbird from the panchromatic image. **d** From the result of the elaboration, as described in Fig. 20.15b

geoglyph, 117.2 × 120.6 m in size, is surrounded by several lines. Some of them are geoglyphs connected to it within the framework of the scene. Other features are tracks of off-road vehicles and traces of past *huaycos* that make the identification of the ornithomorphic motif difficult. The scene is dominated by a huge trapezoid that is very visible in the satellite image despite the several signs of vandalism and marks related to *huaycos*.

The best results in terms of discriminability of the ground drawings, in particular the borders of the hummingbird, have been obtained from Local Geary's C index (see Sect. 20.3.2.4) and convolution-directional filtering. The Local Geary's C index identifies areas of high variability or dissimilarity between a pixel and its neighbors, thus making it effective for detecting edges.

The convolution-directional filtering selectively enhances image features having specific gradients. Figure 20.15b shows the RGB composition of the WorldView-2 panchromatic image, the Local Geary's C index result, and the product of the directional filtering. The final result enables us to appreciate more details of the biomorphic figure. This is due to the fact that the elaborations emphasize the edges and reduce noise effects due to fine-grained sand scattered by Paracas winds.[14]

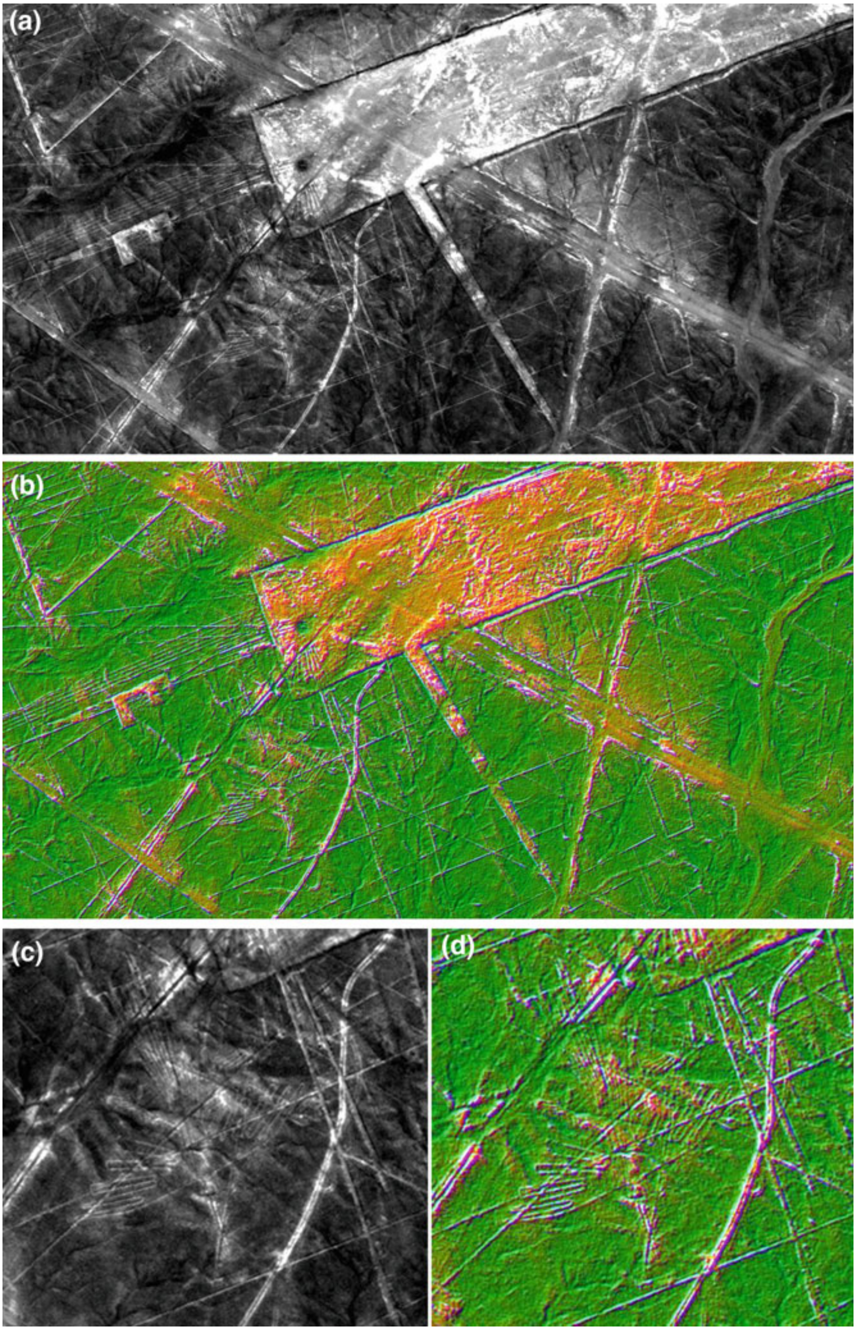
20.4.2 Archaeo-Geophysical Investigations and Results in Sector A

20.4.2.1 Site S3. from Satellite to Geophysics: The Discoveries in Piramide Naranja

Archaeo-geophysical investigations have been conducted since 2008 with two aims: (1) the identification of surface and shallow archaeological features referable to walls in order to spatially characterize the trunk-pyramidal structure; and (2) the detection of buried archaeological deposits related to tombs and ritual offerings.

For the first aim, two different approaches have been adopted. The first was based on the analysis and processing of VHR satellite imagery with particular attention paid to multitemporal observation of a time series of both aerial and VHR satellite images. The second approach was the integration of aerial and satellite data

[14]Paracas winds usually blew with great velocity in the period of satellite image acquisition (11 September).


(a)
(b)
(c)
(d)

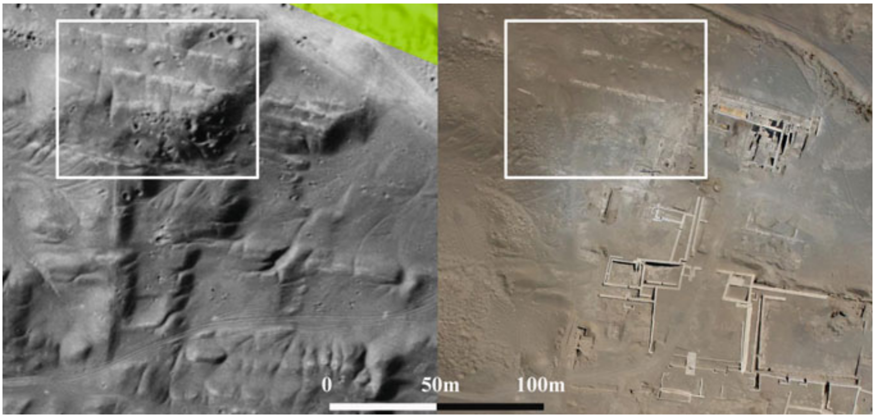


Fig. 20.16 1955 and 2007 aerial orthophotos (*left* and *right*, respectively) including *Piramide Naranja*, inside the *white rectangular box*

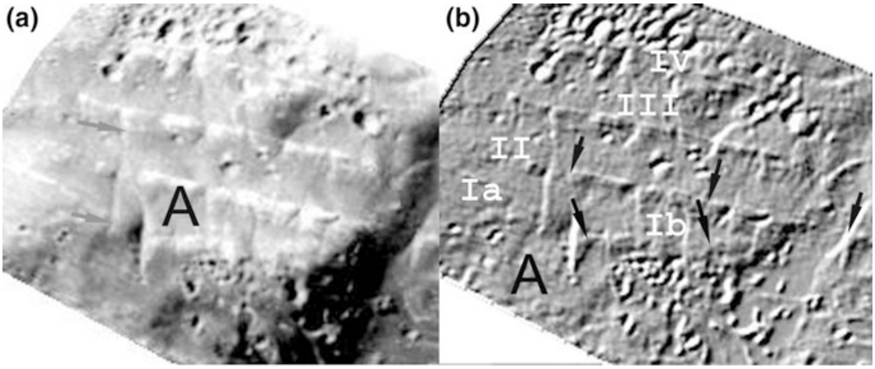


Fig. 20.17 **a** Aerial image taken in 1955 (courtesy by G. Orefici). **b** Result of using a convolution filter. *I*, *II*, *III* and *IV* indicate the edges of the steps of *Piramide Naranja*

with geomagnetic and georadar methods. The geomagnetic method has been employed to confirm the presence of shallow walls already visible from the optical data set, as well as to add further information. The georadar was used to obtain information on the depth of buried walls even if, due to the attenuation linked to soil characteristics, the radar signal is capable in this case only to survey shallow reflections referable to the upper part of buried walls.

Figure 20.16 contains two aerial orthophotos, from 1955 and 2007, depicting the *Piramide Naranja* characterized by an asymmetric shape and four stepped platforms. A visual comparison of the two pictures shows some changes at the site, most of them caused by looting activity. The mapping and interpretation of the archaeological features have been performed by using a dataset composed of the aerial images taken in 1955 and 2007 and two multispectral satellite QuickBird data acquired in 2002 and 2005.

Figure 20.17 contains the 1955 aerial photo ortho-rectified (on the basis of the available DEM) and the result of a convolution filter applied to it using a direction angle of 90° and kernel size = 3 × 3 (Fig. 20.17b). This filter improves the contrast of the edges of pyramid steps *II*, *III* and *IV* and enables the identification of the edge of the top platform I.

Figure 20.18a shows the 2002 QB2 panchromatic scene along with the results of the directional high-pass filter, PCA, standard deviation, and spatial autocorrelation. The best discrimination of linear archaeological features has been obtained by the directional convolution (Fig. 20.18b), PC2, and the standard deviation. With respect to the panchromatic image (Fig. 20.18a), the directional convolution (Fig. 20.18b) reduces the noise due to the high reflectance of the clay. PC2, the standard deviation (Std), and the result of Geary's C index show the above mentioned oblique feature I, whereas Moran's index enable the identification of a subtle linear feature aligned (on the western side) with feature III.

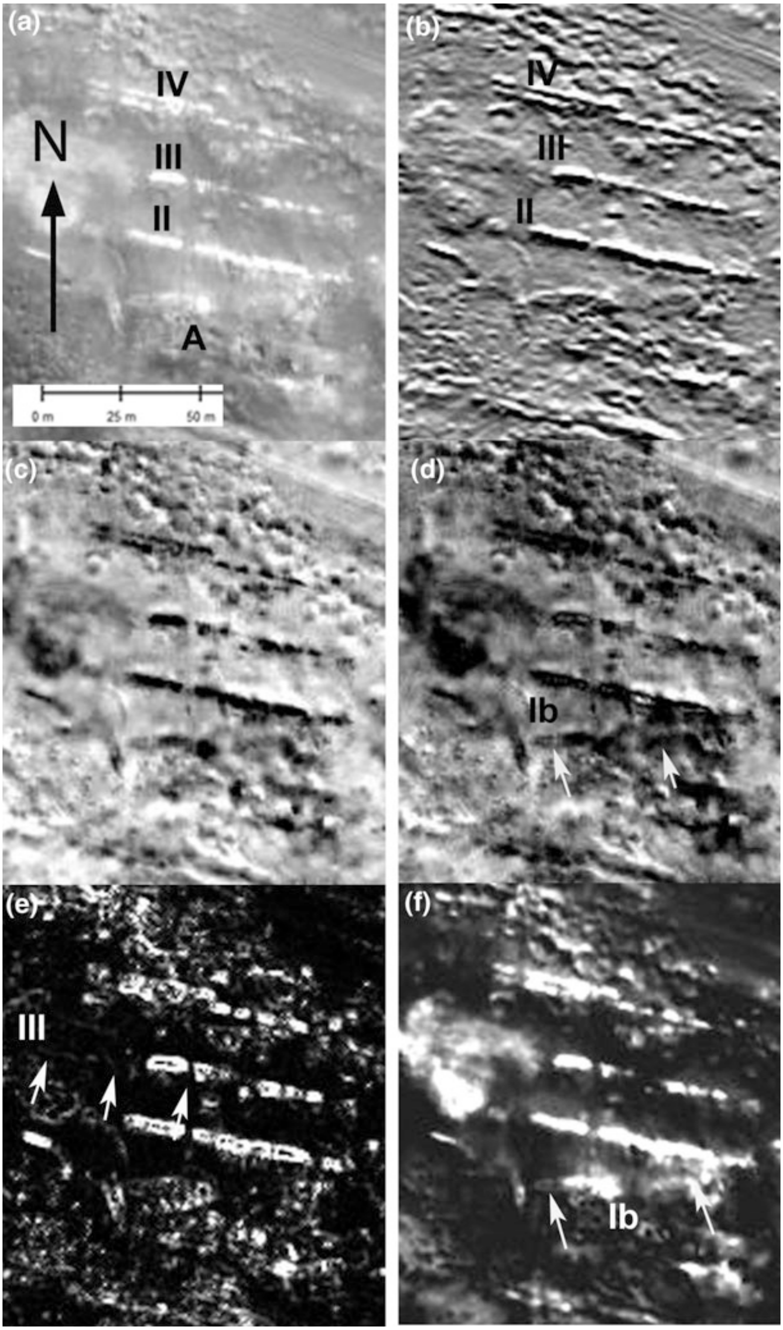
After mapping, the linear features related to the edges of terraced platforms geomagnetic investigations were performed. The aim was to detect materials characterized by magnetic properties such as metals, ceramic, and coal associated with possible tombs and ritual offerings. Lower variations of the magnetic field between the shallow walls and its surrounding were also expected. The total size of the surveyed region was around 56 × 60 m, thus covering three terraced platforms on the northern slope of the pyramid.

Figure 20.19a shows the location of the investigated area. On the right of the same figure (Fig. 20.19b), the geomagnetic map obtained from gradient data is shown.

The overlay of the magnetic map on the satellite image facilitated the interpretation of the magnetic anomalies. Linear anomalies (in E-W direction) correspond to the archaeological features, already visible from the optical dataset (see I, II, and III in Figs. 20.16, 20.17, and 20.19a), probably linked to surface and shallow walls that limit the external edges of the pyramid steps. Other linear anomalies, oriented in N-S direction, suggest the presence of walls related to ramps and corridors connecting the various different levels of the pyramid.

Strong circular magnetic anomalies are also observed (Figs. 20.19b lower). Most of them are pits, sometimes dug by grave looters, whereas others do not exhibit any mark of digging and are N-S aligned, orthogonally to the steps of the pyramid (Fig. 20.19b). All these circular anomalies can be linked to tombs.

To verify this hypothesis, georadar prospecting of one of them (indicated by a white square in Fig. 20.19b) was performed before proceeding with excavations. For the sake of brevity, herein we only focus only on one profile, representative of the final results and shown in Fig. 20.19c. The profile has an investigative depth around 2 m (with *Vem* = 0.15 m/ns). It shows several reflections, at depths ranging 0.45–1 m. The excavation of the first 50 cm unearthed remains of *huarango* trunks and branches (Fig. 20.19d), as expected from the reflection in the radargrams. The *huarango* wood typically covered a Nasca ceremonial offering and/or tomb. The excavation of the


(a)
IV
N
III
II
A
0 m
25 m
50 m
(b)
IV
III
II
(c)
(d)
Ib
(e)
III
(f)
Ib

◀ **Fig. 20.18** **a** Northern slope of *Piramide Naranja* from 2002 QB2 panchromatic image and the results of post processing applications such as: **b** directional convolution; **c** PC2; **d** standard deviation; **e** Geary's C index; **f** Moran's index. The letters *II*, *III* and *IV* denote features related to the stepped structure of the pyramid

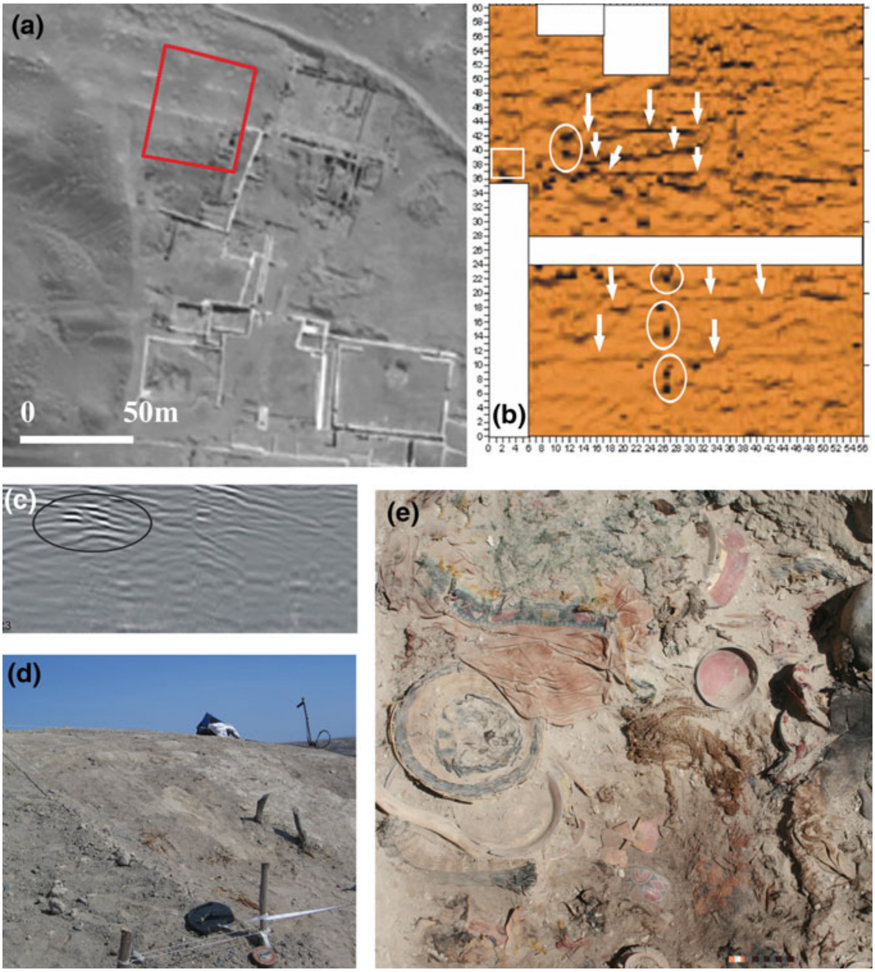


Fig. 20.19 **a** Location of the area of *Piramide Naranja* investigated by geomagnetic method. **b** geomagnetic map: *white arrows* indicate some linear magnetic anomalies related to shallow stepped structures of the pyramid and *white circles* denote magnetic anomalies thought to be possible tombs or ritual offering, among which one (denoted by a *white square box*) has been further investigated by GPR (see (**c**)); **c** Migrated radargram depicting some reflectors. **d** The investigated area. **e** Archaeological findings consisting of polychrome vessels, antaras, painted pumpkins, and textiles

subsequent layers revealed the existence of a rich ceremonial offering (Fig. 20.19e), which contained eighty ceramics, painted textiles, precious metal objects, and painted pumpkins of the Nasca Culture and two human bodies, one a child and o an adult. Both of them were sacrificed and formed part of the ceremonial offering.

20.4.2.2 Site S4: Templo Del Escalonado

Between 1984 and 1988, the Italian archaeological mission of Proyecto Nasca unearthed a monumental structure belonging to a transitional period between the architectural phases II and III of Cahuachi, characterized by precious incised friezes with stepped motif on the walls, from which the name of *Templo del Escalonado* derives (Orefici 1988). Since 2001, the investigations were expanded to a flat area below the temple. Trial excavations unearthed some walls. However, the archaeological records were not enough to understand the spatial and functional relationships between this area and the *Templo del Escalonado*. This made it necessary to conduct additional investigations by using geophysical methods. They were carried out in two different investigation campaigns performed in April 2008 and November 2008, by using GPR and a magnetometer.

Figure 20.20a shows the studied area by using geomagnetic and GPR. The GPR prospecting covered an area of around 235 m^2 that was surveyed by performing 26 profiles 18 m long and with a separation distance of 0.5 m.

Figure 20.20b–c show some anomalies detected using both GPR and geomagnetic prospecting carried out with a gradiometric configuration over an area (black box in Fig. 22.20b) larger than that of the GPR survey (results in the colored box inside the black box in Fig. 20.20b).[15]

Figure 20.20c shows the final geomagnetic map, where black arrows indicate the main magnetic anomalies and white circles and squares place into evidence pits excavated by looters. In particular, the gradiometric map shows two anomalies A2 and B2 that could be correlated with ones localized on the GPR time slice at 0.15 m depth, A1 and B1 of Fig. 20.22b, respectively. Moreover, other two circular geomagnetic anomalies, *C* and *D*, are detected at X = 1.5 m and Y = 18.5 m and at X = 7 m and Y = 2.5 m, respectively. Finally, a large anomaly, E, with a regular shape, is between X = 4 and 10 m and Y = 4 and 10 m. So, two anomalies of possible archaeological interest have been detected by both geophysical methods (A_1, A_2, B_1 and B_2). Geomagnetic method shows further anomalies not surveyed by georadar (see *C* and *D* in Fig. 20.20c–d). Moreover, the enlargement of geomagnetic prospection enabled us to identify another anomaly, indicated as *E* in Fig. 20.20c.

[15]The data were acquired on a regular grid 20 m × 20 m along an interspaced line of 0.5 m and a sampling rate of 10 Hz. The data were filtered to obtain the best signal/noise ratio, and then processed, using a kringing interpolation. The result was visualized as a shaded-relief image, enabling highlighting of some geomagnetic anomalies.

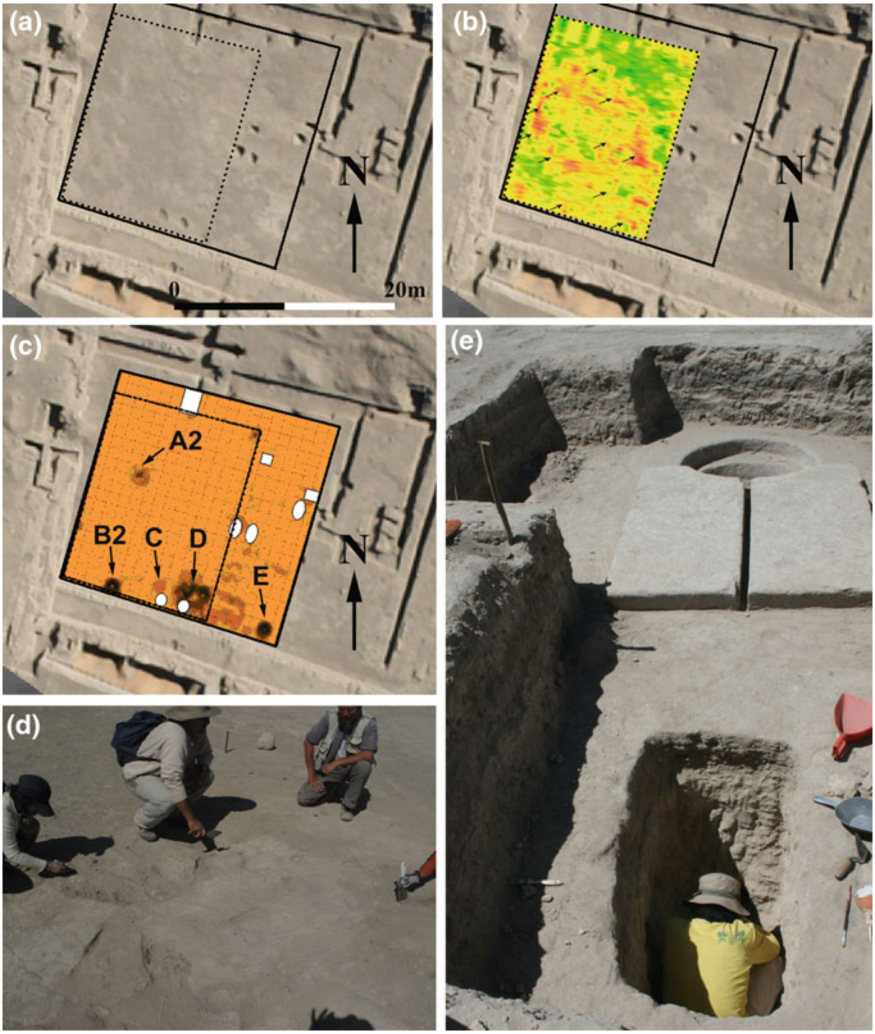


Fig. 20.20 **a** Location of the investigated area near *Templo del Escalonado*: the image is given by an orthorectified photo on WW-1 satellite panchromatic image. *Black* continuous and *dashed line square* denote the areas investigated by geomagnetic and GPR method, respectively. **b** GPR time slice 60 cm deep: *black arrows* indicate areas of possible archaeological interest. **c** Geomagnetic maps: *A2*, *B2*, *C*, *D*, and *E* indicate magnetic anomalies. **d** Area A2 characterized by a magnetic anomaly thought to be of possible archaeological interest; the excavations revealed a ritual fire. **e** Result of the excavations carried out nearby the anomaly D, revealing an altar

On August 2009, a trial excavation was carried out in correspondence with the anomaly *A2*, detected by both GPR and geomagnetic methods (see Fig. 20.20c–d). A ceremonial offering was unearthed. It was characterized by the presence of coal and the remains of a ritual fire made with fluvial stones. From the archaeological perspective, this ceremonial offering was very significant, because the hearth was located below a floor dated back to the end of the Phase IV (known as Phase IVc), archaeologically associated to a platform built after an earthquake and two mudslides described (see Chap. 19 by Orefici). The Phase IV (350–400 A. D.) of Cahuachi was characterized by several offerings and sacrifices, as a consequence of a crisis determined by the above-said devastating natural disasters which caused profound and sudden changes. The finding of this ritual fire and its archaeological implications motivated the archaeologists to conduct further analyses nearby of other anomalies indicated in Fig. 20.20c. In particular, excavations conducted in an area, including the geomagnetic anomaly *D,* unearthed a ceremonial altar (Fig. 20.20d–e) dated back to Phase IV and composed of two large platforms. Therein the archaeologists found four gold bars (which likely caused the magnetic field change) and additional offerings, such as necklaces and animals (bird and cuy or guinea pig) sacrificed to the divinities.

20.4.2.3 Site S5: Pyramide Sur

Since 2011, in the mound named *Templo Sur*, east of *Gran Piramide*, a four-year archaeogeophysical campaign was started and is today ongoing to obtain predictive maps for planning archaeological excavations. Geophysical prospecting activity was carried out on three zones, at the bottom of, on the north slope of, and on the top of Templo Sur. The results, especially those obtained on the slope of the mound, enabled us to detect the pyramidal structure of the mound.

Bottom of Templo Sur

The investigated area was characterized by its square shape of a size equal to 18 m^2 with irregular and rough surface and several looting holes. The horizontal spacing chosen between parallel profiles at the site was fixed at 2.0 m. Along each profile, markers were spaced every 2.0 m to provide spatial reference and reduce potential uncertainties. GPR data showed quite limited penetration caused by the presence of clay in the sand matrix. The estimated velocity was 0.12 cm/ns corresponding to a dielectric permissivity value of 6.25.

For the GPR data acquisition and processing, taken into account was the fact that the investigated surface was not flat. However, as the average curvature ray of the holes was quite large with respect to the central wavelength, the expected GPR results were considered reliable. Several slices were generated at 0.25 cm intervals to identify archaeological features. Figure 20.21 shows two time-slice images extracted from the 3D model created with radargrams acquired at 200 MHz frequency, at estimated depths of 0.50 and 1.25 m, respectively. The strong attenuation of the EM signal caused by the high conductive soil did make it possible to investigate the soil at depth higher than 1 m with the 600 MHz antenna.

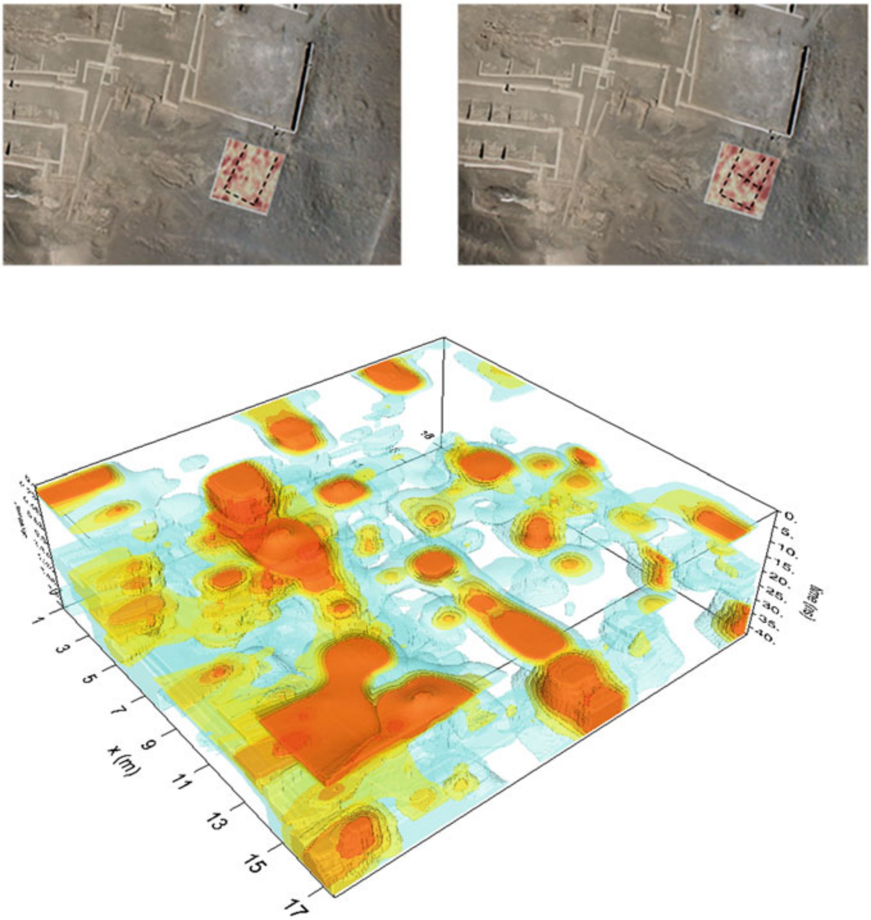


Fig. 20.21 Georadar prospecting at the bottom of *Templo Sur*. *Top* Two different georadar timed slices extracted by 3D model acquired with 200 MHz antenna placed at an estimated depths respectively of 0.50 (*left*) and 1.25 m (*right*). *Bottom* 3D visualization of iso-amplitudes that reveal the presence of linear anomalies referable to two buried walls, which have been unearthed by archaeologists

The georadar time-slices, overlapped on an satellite image, placed into evidence the presence of two linear parallel anomalies (Fig. 20.21 upper), enhanced by the 3D- visualization of GPR iso-amplitudes (Fig. 20.21 bottom). The strong reflectors referable to buried walls are at the depth of 1.20 m. At the same depth, two further high-reflective areas referable to structures are visible. The presence of multiple irregularities on the surface do permit easy interpretation of the data. However, the subsequent excavations performed in this area confirmed the presence of two large walls corresponding to the two major alignments identified in the two time-slices.

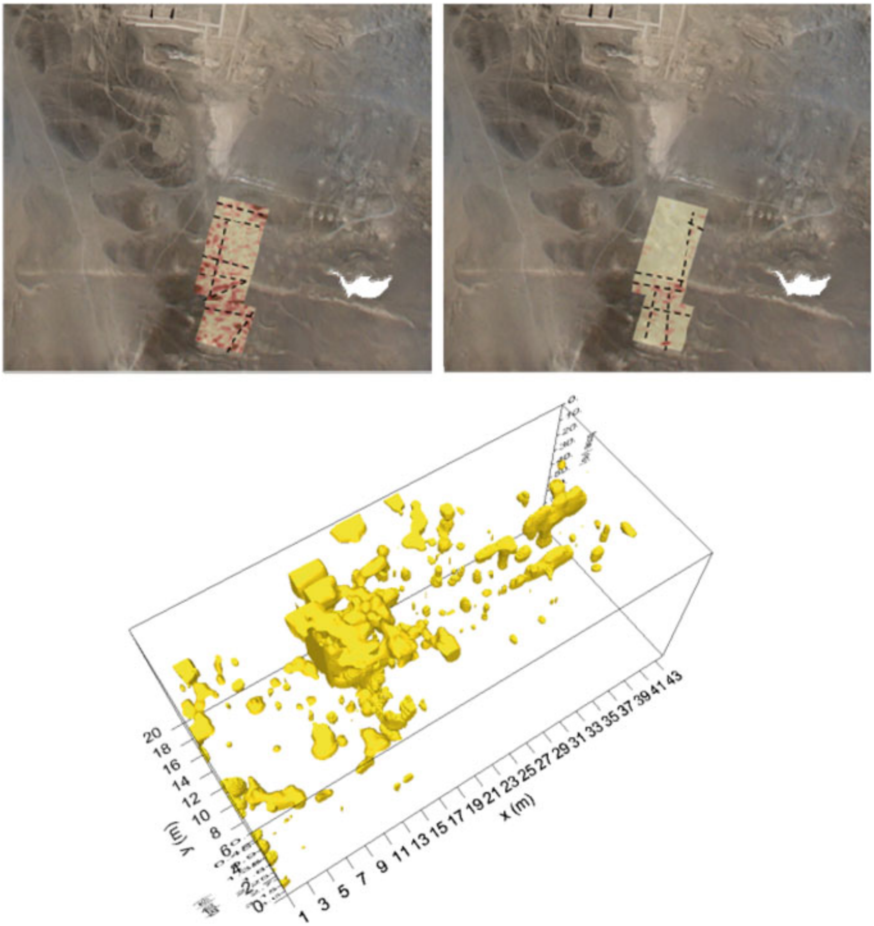


Fig. 20.22 Georadar prospecting at the top of Templo Sur. Time slices extracted by 3D models acquired with 600 (*left*) and 200 MHz (*right*) antenna placed respectively at an estimated depths of 1.0 and 1.5 m. *Bottom* 3D visualization of data iso-amplitudes, acquired with the 200 MHz antenna, which depicts the linear anomalies visible from the time slices

Top of Templo Sur

The second investigated site was on the top of *Templo Sur*. The site of about 19 × 40 m was surveyed along the N-S direction with profile separation fixed at 1 m. The area is characterized by a regular and flat surface, and the physical characteristics of the soil enabled us to survey down to a maximum depth of 2.00 m with the 200 MHz antenna. The Fig. 20.22 (left) shows the horizontal slice extracted at a depth of about 0.75 m by the 3D model built with the data recorded at 600 MHz frequency that provides better resolution than the 200 MHz antenna. The time slice shows several highly reflective zones that, by their regular distribution,

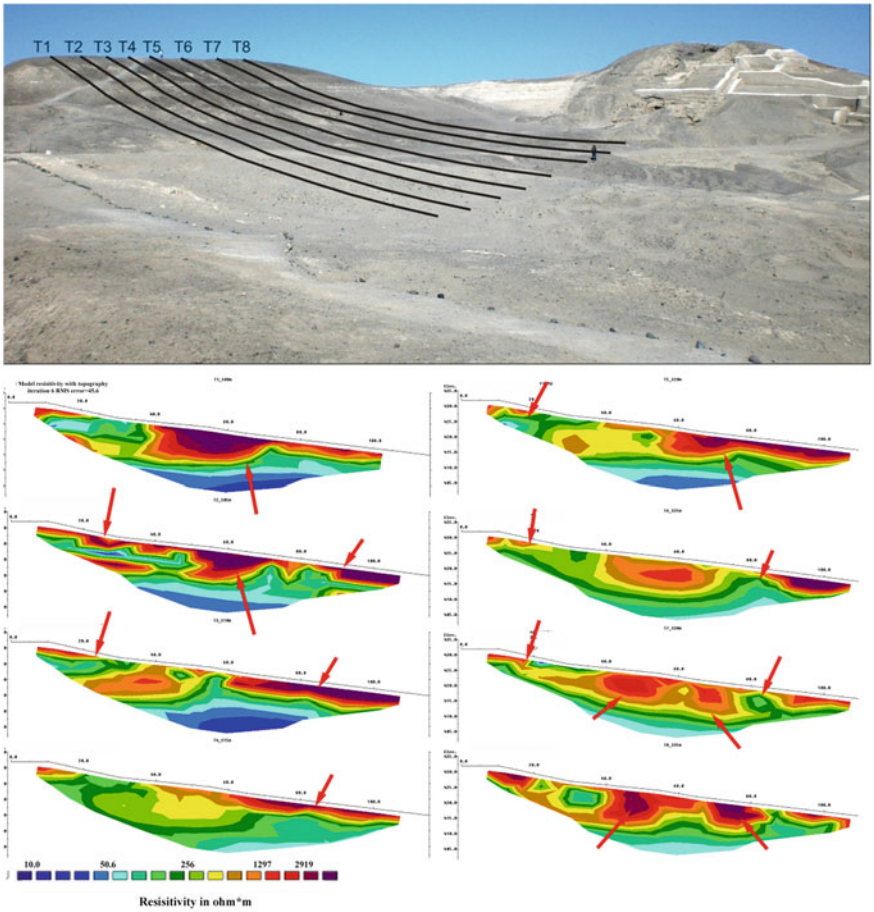


Fig. 20.23 *Up* Electrical resistivity measurements (indicated with *black lines*) acquired along the slope of Templo *Sur*. *Bottom left* and *right* Electrical resistivity tomographis along the profiles T3 and T5. *Red arrows* indicate highly resistive areas

suggest the presence of walls. The time slice analysis in Fig. 20.22 shows the results obtained in the same survey with the support of the 200 MHz antenna. Exploiting its greater penetration capability, it was possible to measure the depth of the reflectors referable to buried remains. Finally, the excavations confirmed the interpretation of GPR results.

Slope of Templo Sur: Discovery of the Pyramid

The north side of the mound was investigated integrating GPR and ERT methods to characterize the subsoil, from possible structures to geological layers. ERT was

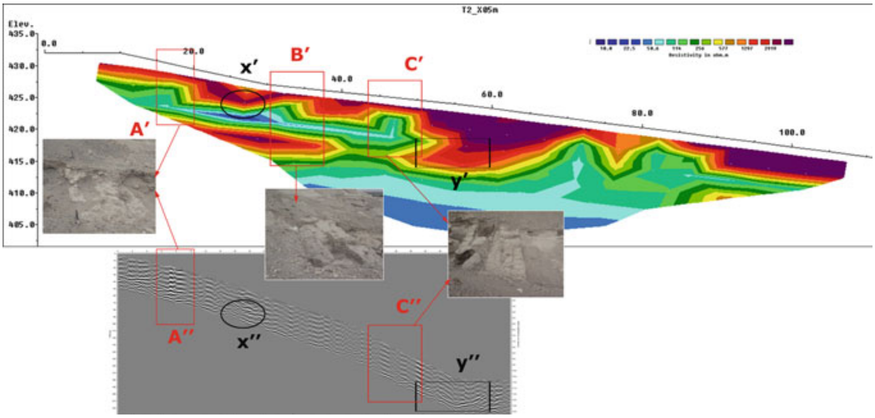


Fig. 20.24 Comparison between archaeological findings and features detected from ERT profile and corresponding radargram

performed by 24-channel Syscal Kid georesistivimeter. Eight electrical tomographies were acquired with an electrode spacing of 4.00 m arranged with Wenner and Dipole-Dipole arrays in multielectrode mode, for a total length of the profiles of 92 m. The results are depicted in Fig. 20.23, indicating high values of resistivity due to the presence of cavities, fillings, or areas delimited by structures in adobe located at the center of the tomographies. Further, on the upper part of the profiles (very near the top), low values of resistivity have been measured. These could be due to the presence of heterogeneous sediments transported by the weather that have covered the ancient structures over the centuries. The ERTs proved to be capable of detecting buried adobe structures notwithstanding the low geometric resolution, due to the great distance of the electrodes (5 m), and the poor contact of electrodes caused by very dry conditions of the soil. This made necessary the integration of the ERT data from GPR prospecting.

The GPR results match well with the ERTs. Generally, zones characterized by strong variations of electrical resistivity correspond to the reflectors of radar pulses. GPR prospecting enables us to characterize the soil at a depth of 1.5 m, as well as to identify reflectors indicating walls and the interface between walls and geological layer. The comparison between radargrams and ERTs corresponded with high resistivity areas and the radar reflectors, revealing in some cases the presence of very large, compacted walls, and, in other cases, voids or filling between walls (Fig. 20.24). The comparative interpretation of ERT profiles and radargrams enabled a rough reconstruction of the pyramidal structure of the mound, later confirmed by archaeological excavations (Fig. 20.24).

Site S6: The Top of Great Pyramid

The top of the Gran Pyramid was investigated by geomagnetic prospecting. The site was divided in three areas separated by walls and with the following dimensions: 9 × 7 m, 7 × 7 m and 15 × 700 m. Figure 20.25 shows two geomagnetic maps

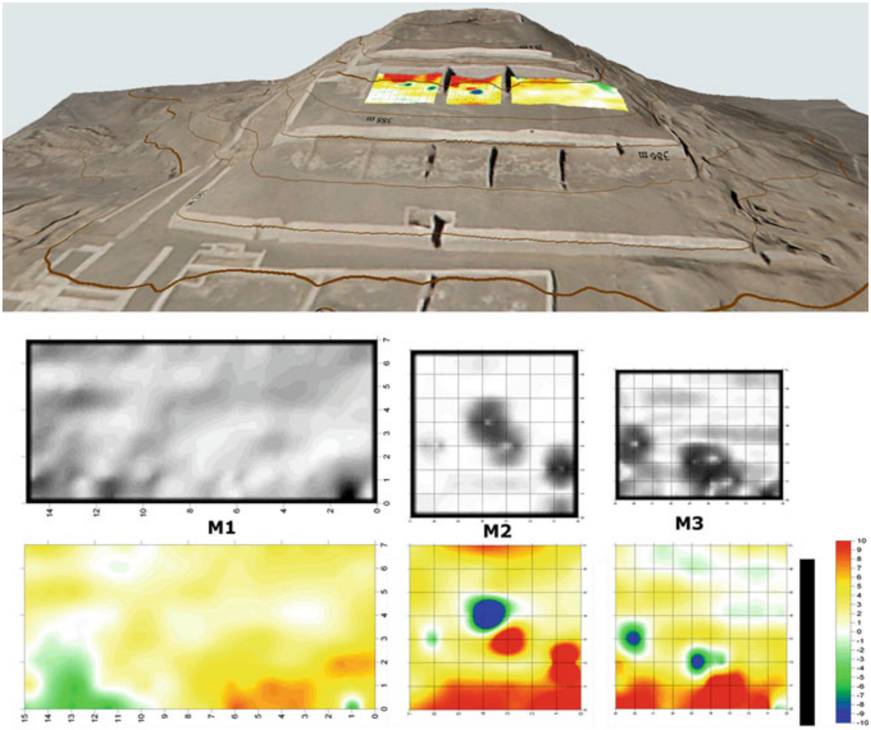


Fig. 20.25 Geomagnetic prospecting on the *top* of *Gran Piramide*

(with color and shaded relief) which revealed several dipolar magnetic anomalies, likely referable to a tomb and some sacrificial fires that are typical in that area of the pyramid.

20.4.2.4 Remote-Sensing Approach for Site Detection in Vegetated Areas: Site S7 in the Nasca Riverbed

The same approach adopted for the bare-ground site was applied also to the vegetated areas. In addition, different vegetation indices including the NDVI were used to obtain good results in terms of signal enhancement related to possible archaeological features.

The focus of our investigations was the Nasca riverbed, in order to study and map palaeoriverbeds and possible underground channels. Then, the field of investigation was enlarged for the identification of buried settlements. Some aerial photos taken in April 2007 had placed into evidence the presence of several damp marks, some of them related to recently buried infrastructures, other referable to palaeoriverbeds. In particular, our attention was focused on an area about 2 km NW of Gran Piramide where adobes and ceramic fragments were found.

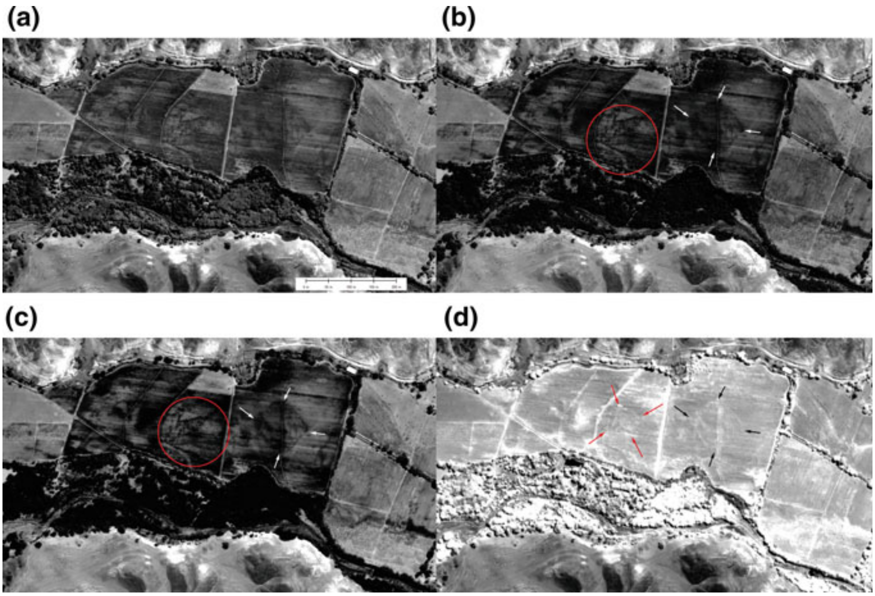


Fig. 20.26 Nasca riverbed: identification of a buried settlement, including the basement of a pyramidal structure. **a** QuickBird panchromatic image acquired on 2005 March. **b** Green pan-sharpened image. **c** Red pan-sharpened image. **d** NIR pan-sharpened image. *White arrows* in **b–c** denote the marks related to the basement of a pyramidal structure, whereas the *red circles* indicate other features, including a palaeoriverbed. **d** The *red* and *black arrows* indicate the features emphasized by NIR

The processing of a QuickBird image acquired on September 2002 enabled us to identify some features characteristic of the geometric shapes of possible archaeological interest. In particular, the NDVI map showed more information than panchromatic and multispectral pan-sharpened images.

Then, another QuickBird image, acquired in a period with great moisture content on the ground surface (2005 March), was selected and acquired from the Digital Globe Archive. The expected result was an improved visualization of damp marks, as it really existed. In particular, panchromatic (Fig. 20.26a), and even more red and NIR bands, highlighted some vegetation marks, partially covered by grass and cotton plants at the time of satellite-image acquisition. The same bands enabled visualization of damp marks on bare-ground areas at the site.

Different pan-sharpening algorithms were used to exploit the higher spatial resolution of panchromatic image and the spectral content of satellite imagery, thus enabling enhancement of the vegetation marks (Fig. 20.26b–d).

Graham-Schmidt algorithm was considered the most effective image fusion algorithm in terms of discrimination of marks, for the green, red, and NIR bands. The green and red pan-sharpened channel provided most of the r content of information. In particular, a quadrangular-shaped signal and other linear marks on the west of it are easily visible (indicated by white arrows and a red circle in

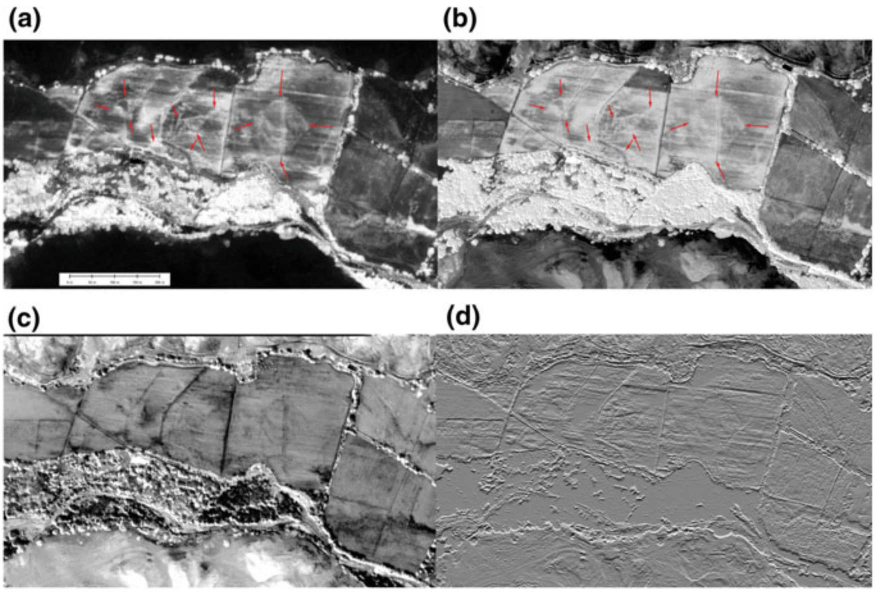


Fig. 20.27 Processing of 2005 QuickBird imagery **a** NDVI map. **b** PC1. **c** PC2. **d** Convolution-filter angle applied to applied to red pan-sharpened image

Fig. 20.26b–c). NIR band enabled better discrimination with respect to the green and red bands of the linear features related to crop marks (Fig. 20.30d).

A further improvement was achieved by computing PCA and NDVI (see Fig. 20.27a–c). The latter performed edge thinning of the pattern of archaeological features. Finally, directional-filter angle was applied to enhance selectively the image features having specific directional components (Fig. 20.27d).

The identification of marks reported on the RGB composition of NDVI, PC2, and directional-filter angle applied to red pan-sharpened image, placed into evidence three different patterns of features named with letters A, B, and C (Fig. 20.28a)

Pattern A is composed of several linear features suggesting the edges of platforms, consisting of quadrangular shapes intersected by oblique lines, for a total area equal to 1 Ha.

Pattern B has a rectangular shape with dimensions 100 × 90 m and an orientation of about 45° with respect to the North. The shape and parallel segments inside the rectangle suggest that they are traces related to the basement of a pyramidal structure.

Feature C is a typical palaeoriverbed which along with other similar features indicate changes of the river over time. Finally, subtle marks east of pattern B, visible from RED and NDVI images, seem to reveal a quadrangular shape related to similar buried structures as the above mentioned A.

Pattern B was investigated by geomagnetic method and infrared thermography (Fig. 20.28b–c). The magnetic prospecting (Masini et al. 2012) were conducted

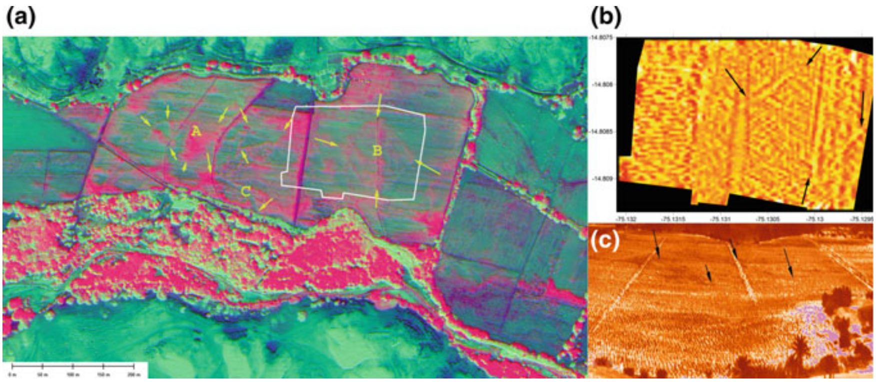


Fig. 20.28 Nasca riverbed: data integration. **a** RGB composition of NDVI, PC2 and directional filter angle applied to red pan-sharpened image; **b** geomagnetic map; **c** aerial infrared thermography

over an area of 2.2 ha, on 2009 August. Linear magnetic signals oriented in correspondence to the four sides of the quadrangular pattern were identified. Finally, infrared thermography provided thermal anomalies that matched the features obtained by the processing of satellite and geomagnetic data.

From the archaeological point of view, the discovery of this buried settlement opened new perspectives of research and new questions regarding its function and its spatial and temporal relation with the near Ceremonial Center of Cahuachi (Orefici 2009b).

20.4.2.5 Paredones

Finally, we show some results of integrated geophysical investigations performed in Paredones. Three platforms were investigated by GPR, ERT, and magnetometry. For the sake of brevity, we describe only the results obtained on one of the three platforms by using GPR and magnetometry. The map of Paredones was obtained by processing aerial images taken from a drone by means of the SfM technique which enabled us to provide a very detailed digital elevation model at a spatial resolution of 10 cm. GPR prospecting was performed by using a Hi-MOD IDS instrument with two antennas of 200 and 600 MHz frequencies.

For the conversion of the GPR time profiles at that depth, a velocity value 0.13 m/ns was adopted. The investigated area is characterized by a flat and regular surface with size 44 × 18 m, for which a total of 23 profiles have been acquired. The profiles were spaced at 2.00 m intervals and were performed only along the longer direction. Based on the acquired profiles, 3D volumes were generated. A number of time-slices at different depths were extracted, thus enabling identification of some features of possible archaeological interest. Figure 20.29 a–c shows three GPR time slices at 1.40, 2.00, and 2.50 m, respectively. The comparative

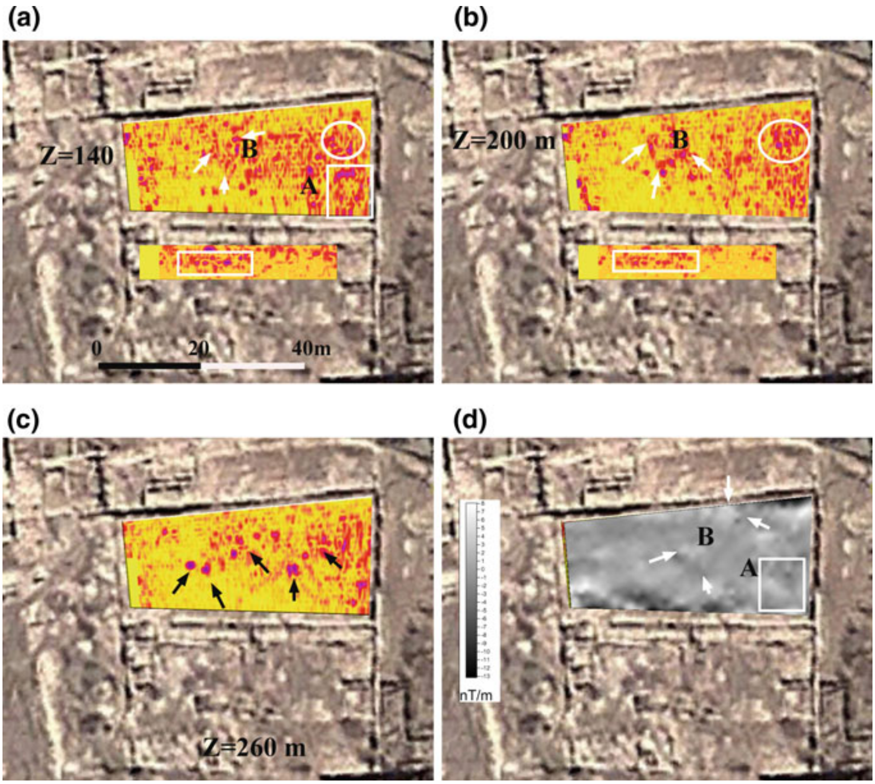


Fig. 20.29 **a**–**c** The GPR time-slices (acquired with 200 MHz antennas) at the depth of 1.40, 2.00, and 2.60 m revealed the presence of strong reflectors of possible archaeological interest (A and B). They matched some magnetic anomalies. **d** The feature A was confirmed by archaeological findings

analysis of the maps enabled us to detect reflectors related to the presence of buried earthen walls, with or without the stone foundations that typically characterize most of the structures in Paredones. In particular, from 1.40 to 2.00 m (Fig. 20.29a–b), GPR results placed into evidence a number of anomalies, some of them were linearly oriented (A in Fig. 20.29a–b and 20.30c) and other characterized by irregular shape (indicated by B and the circle in Fig. 20.29a–b; see also Fig. 20.30c). At the depth of 2.60 m (Fig. 20.29c), linearly aligned strong reflectors can be observed in the center of the rectangular platform (Fig. 20.29c).

In the same area, geomagnetic investigations were carried out by using a cesium–vapour magnetometer G-858 Geometrics in gradiometric configuration, with two magnetic probes set in a vertical direction at a distance of around 1 m from each other. The data were acquired by a sampling rate of 10 Hz for an interspaced line of 0.5 m. In order to obtain the best signal/noise ratio, the magnetic data were filtered and then processed, using a k ringing interpolation. The shaded-relief visualization facilitates the identification of some magnetic anomalies,

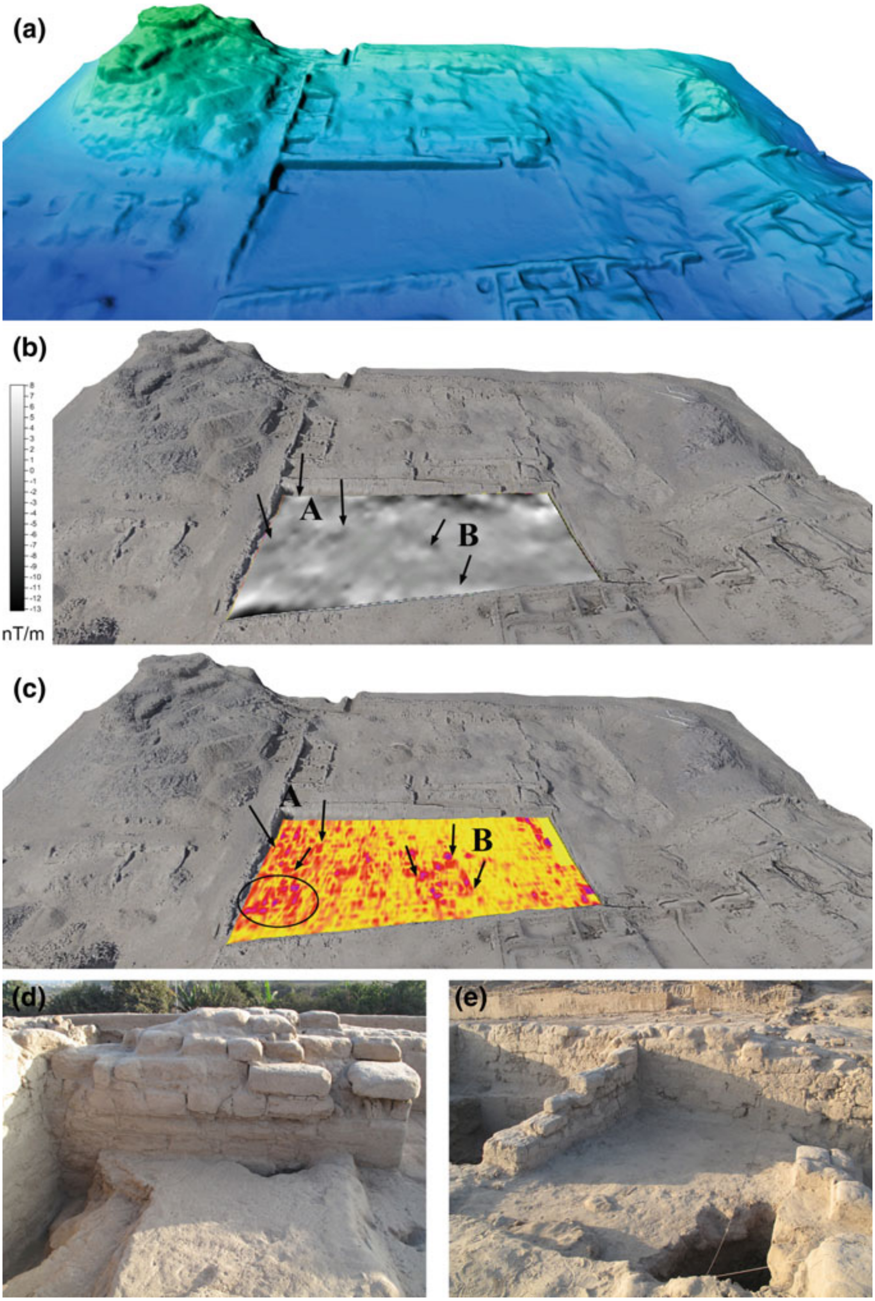


Fig. 20.30 **a** 3D visualization of DEM provided by SfM-based processing of images taken from UAV. **b** 3D visualization of a magnetic map which indicated two areas characterized by magnetic anomalies that matched GPR anomalies at depth of 1.4 m. **c**. Archaeological excavations unearthed. **d–e** Some walls and a floor that confirmed the archaeological nature of the observed geophysical features

some of which fit well the GPR anomalies (A and B in Figs. 20.29b–d and 20.30b). Nearby, the detected anomaly A archaeological excavations were carried out revealing some adobe structures confirming the archaeological nature of the features detected by GPR and geomagnetic prospecting.

20.4.3 Conclusions

An overview of the results obtained by the ITACA Mission by means of multiscale and multisensor integration of remote-sensing methods, including geophysics, in Cahuachi and its surrounding from 2007 to 2015, has been presented here and discussed. Most of the applications were aimed at preventive archaeology, that is, to provide information on the presence of buried sites and structures for various different surface characteristics: from arid bare ground to vegetated areas in the river oases.

The ITACA mission was also intended to build prediction models useful to support decision making and to plan archaeological excavations. The investigations were also the occasion to develope ad hoc approaches based on remote sensing and geophysics (data acquisition/pre-processing, processing, post processing and interpretation) to improve the detection of buried earthen structures. This is a crucial issue because earthen archaeological remains are widely present throughout the world (e.g., South America, Asia, Africa), and their identification is a challenge due to the subtle physical contrast between earthen remains and their surrounding subsoil.

In Cahuachi, almost all of the temples are truncated pyramids built in adobe upon pre-existing natural mounds with the construction of embankments, adapting to the natural contours of the land, building on, and levelling out, the natural strata of clay to use them as a base for the adobe walls (see Chap. 15 by Orefici). Therefore, regarding the sensitivity of optical/electromagnetic sensors, we are dealing with building materials with physical parameters not very different compared to those of the mound subsoil and ground covering the walls of the temples.

This requires testing the various techniques to investigate the subsoil by geophysical methods, working side by side with archaeologists, involved in the interpretation of the results. For a rapid validation of the methodologies, it was fundamental to check the processed data with the archaeological evidences quickly.

This was the approach employed in various contexts and areas of Cahuachi and Nasca territory, herein presented and discussed. The studied sites were *Piramide Naranja*, *Templo del Escalonado*, *Templo Sur*, sector B of Cahuachi, and Paredones. The same approach was also adopted for the research conducted on the *puquios* (see Chap. 22 by Lasaponara et al. (2016a, b, c)). These sites were investigated using the most capable tools available today, from earth-observation technologies and science, including satellite, optical, and SAR sensors, aerial prospecting, UAV-based surveying, GPR, Geomagnetic methods, and ERT.

In particular, a multiscale and multisensory approach was adopted for the archaeogeophysical investigations in *Piramide Naranja,* on the north-eastern and eastern sides. On the north-east side, the satellite data processing helped to identify micro-reliefs related to terraced steps which composed truncated pyramidal structure. They were confirmed by geomagnetic techniques, which also enabled the detection of magnetic anomalies, one of these investigated by GPR revealing some reflectors referable to the presence of tombs or filling spaces (Lasaponara et al. 2011). The subsequent excavation confirmed this interpretation and unearthed a rich ceremonial offering, including ceramics, painted textiles, precious metal objects, and painted pumpkins. The same approach was also used in *Templo del Escalonado*. GPR and geomagnetic prospecting, performed in two different field investigations, captured spatial anomalies, which have been later confirmed by archaeological excavations (Rizzo et al. 2010). In particular, archaeologist unearthed an altar and a ceremonial offering, characterized by the presence of coal and the remains of a ritual fire on a floor dated back to the end of the Phase IV (known as Phase IVc), indicating the "last ritual offering" before abandonment of the pyramid. The excavation also placed into evidence a ceremonial altar, dated back to Phase IV, composed of two large platforms and enriched by gold bars and offerings.

All the three geophysical techniques were applied to the Inca site of Paredones. GPR, ERT, and geomagnetic prospecting have been performed to obtain some predictive maps for three distinct areas. Trial excavations confirmed the archaeological interest of the anomalies.

The most import result of archaeogeophysical investigations was obtained in *Templo Sur*, connected with the eastern side of *Gran Pirámide.* ERT and GPR prospecting enabled the reconstruction of the geometry of a truncated pyramidal structure. The comparison between the excavated walls and geophysical anomalies enabled an important advance in interpreting ERT and GPR data for the detection of buried earthen walls and filling structures.

Beyond the archaeological area, some investigations focused on the Nasca River oasis. Herein, at about 2 km NW of *Gran Piramide,* a buried settlement (covering 4 Ha), including platforms and likely a pyramidal structure, was identified by satellite images, with indirect validation by infrared thermography and magnetic maps. From the archaeological point of view, the discovery of this buried settlement opens new perspectives of research (Orefici 2009a, b), posing new questions regarding its function and its spatial and temporal relation with the near Ceremonial Center of Cahuachi and the nearby geoglyphs in Pampa de Nasca. As a whole, our results pointed out that the integrated use of various remote-sensing technologies represents a valuable source of information for the study of past landscapes, as well as an operational tool for preventive archaeology and for the monitoring and management of the fragile Nasca archaeological heritage.

In the future, in the Nasca drainage basin, the earth observation and mapping technologies will be ever more oriented to an operative use for both site detection and the monitoring of the archaeological heritage and its protection from natural and man-made risks.

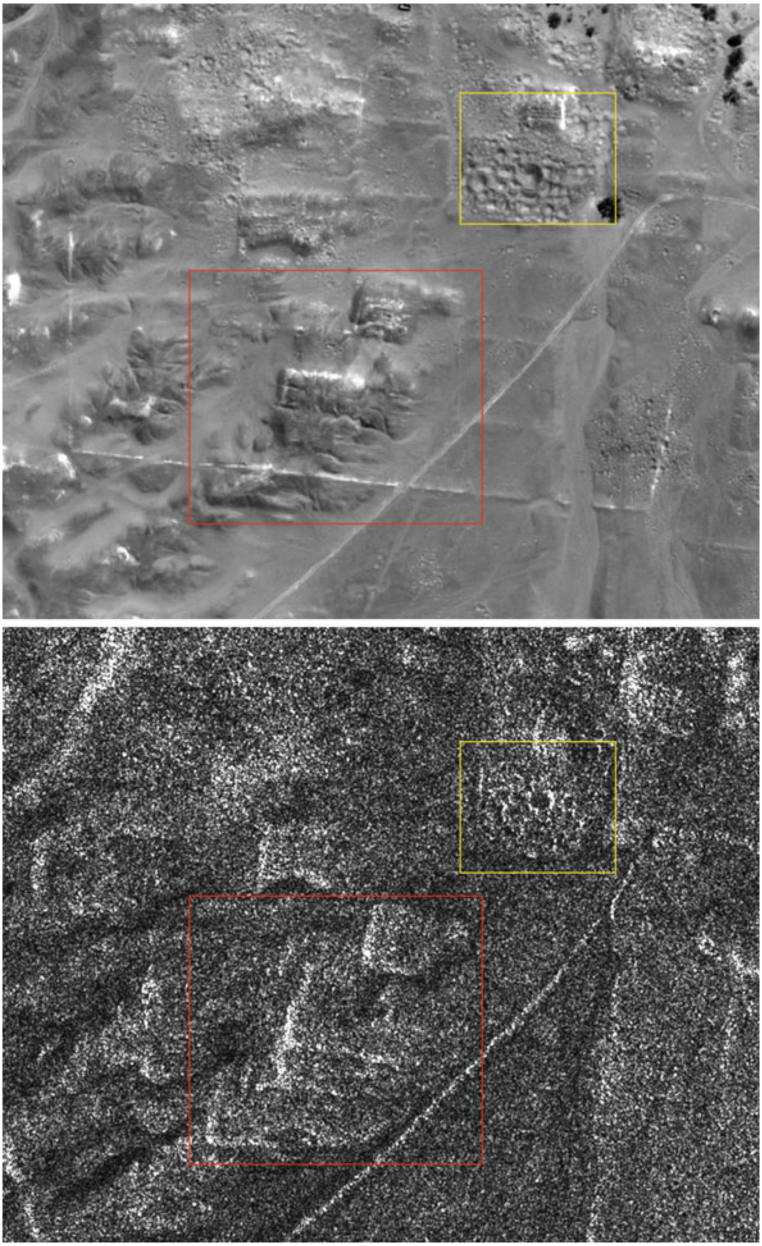


Fig. 20.31 *Top* Cahuachi, detail of sector B observed from an optical satellite image (GeoEye). *Bottom* SAR satellite data (COSMO SkyMed Spotlight). The SAR data provide complementary information respect to optical imagery

The first aim will be pursued by means of an integrated use of geophysical prospecting with low-cost mapping techniques, including those based on the processing of images taken from UAVs. Active remote sensing including SAR will be also applied for the identification of features of cultural interest in the arid Nasca landscape: from the mounds, which conserve pyramidal structures, to the geoglyphs (Fig. 20.31).[16]

The second aim will be addressed by means of a multisensor approach based on space technologies, exploiting the best temporal resolution available from optical and SAR satellite data (Sentinel) for operative monitoring of the fragile cultural heritage in the Nasca drainage basin.

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[16]Recently UAVSAR of Jet Propulsion Laboratory flew over the Nasca lines providing valuable information about damage to the geoglyphs. The promising results obtained by Bruce Chapman motivate operational use for the study and protection of the geoglyphs (http://www.sci-news.com/archaeology/nasa-airborne-radar-nasca-lines-03600.html). In the future C-bad and L-band satellite radar data will used in order to exploit the penetration capability in the arid setting of Nasca: promising results have been recently obtained in Xinjiang region along the Silk Road Coridor by using C-band Sentinel-1 and L-band PALSAR imagery (Chen et al. 2016).

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Chapter 21
Satellite SAR Remote Sensing in Nasca

Francesca Cigna and Deodato Tapete

Abstract In 2012, a research project initiated at the British Geological Survey used space-borne Synthetic Aperture Radar (SAR) imagery to investigate the environmental changes affecting the drainage basin of Río Grande and its tributaries, in Southern Peru. Our research has provided evidence of the effects due to natural and anthropogenic processes on the cultural landscape where the Nasca Civilization flourished centuries ago. This chapter provides an overview of the new insights brought by satellite SAR technology to the understanding of land use and changes in the fertile river valleys, condition of local water resources, and archaeological heritage. Impacts of this research are discussed in relation to the rejuvenation of the water supply system and preservation of cultural identity.

Keywords Synthetic Aperture Radar · Change detection · Backscatter · Coherence · Geoglyphs · Puquios · Looting · Cahuachi · Nasca · ENVISAT · TerraSAR-X

21.1 SAR in Nasca

As widely described in previous chapters of this book, the catchment area of Río Grande in Southern Peru was the home of the Nasca Civilization (Fig. 21.1), with evidence of human occupation since 2000 BC, that was concentrated mostly along its tributaries Río Ingenio, Río Nasca, and Río Taruga. After several millennia, local communities still reside and cultivate the alluvial valleys, and their subsistence depends on the available soil and water resources. A long-standing connection therefore exists between the environment and local population, and exposure to

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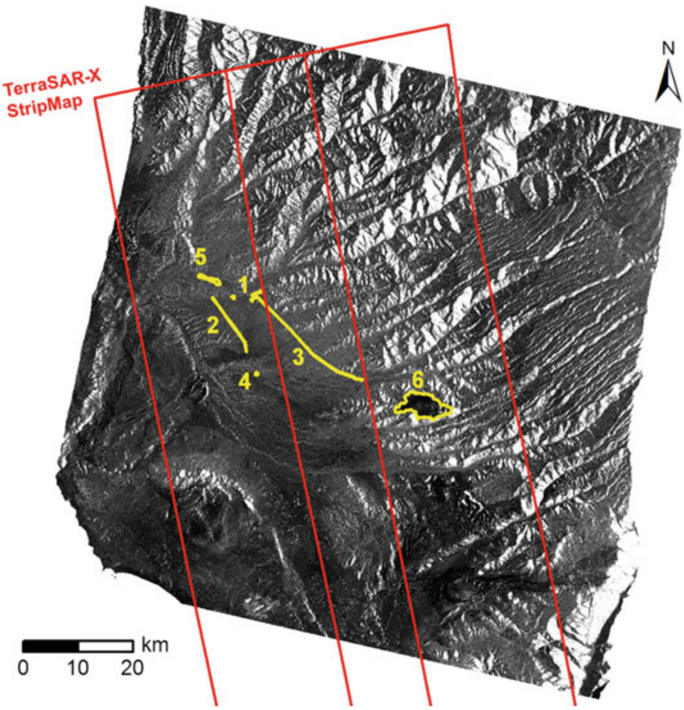


Fig. 21.1 ENVISAT ASAR IS2 image acquired in descending mode on 15/11/2005 and covering the Nasca region, Southern Peru, with 2012 TerraSAR-X StripMap footprints in ascending mode and indication of areas of interest: (*1–2*) Nasca Lines; (*3*) Panamericana Sur road; (*4*) Cahuachi; (*5*) Río Ingenio valley and agricultural fields; (*6*) Cerro Blanco sacred mountain

climate and natural processes needs to be accounted for in the perspective of maintaining this equilibrium.

Historically, the region was repeatedly impacted by flash floods and run-off of sandy materials from unstable slopes. Archaeological stratigraphic evidence testifies that in AD 400–450 the Ceremonial Centre of Cahuachi declined due to a series of mudslides and severe earthquakes (Tapete et al. 2013).

More recently, the scientific community has started debating whether climate events such as El Niño can be considered among the natural threats affecting the Peruvian dry valleys and, if so, how we can measure their impacts (Lefort et al. 2004).

In this context, Synthetic Aperture Radar (SAR) data from space have been increasingly accessed by researchers to retrieve surface evidence related to natural surface processes such as soil erosion and degradation (Lefort et al. 2004). It is well known that one of the advantages of SAR is the wide availability of historical datasets, such as the ERS-1/2 and ENVISAT catalogues of the European Space Agency (ESA), providing C-band (4–8 GHz) images that were acquired almost uninterruptedly from 1991 to 2012. In particular, the historical coverage over Nasca (Fig. 21.1) enabled us to source a consistent data stack over the years, with spatial resolution of 25–30 m and swaths of 100 km. These data are suitable for wide-area and regional assessments to identify trends of change or stability, alongside investigation of sites as wholes and contextualized within their surrounding environments. To this purpose, our research project focussed on a retrospective investigation of the regional to local-scale changes due to both natural hazards (mass movements and flooding) and anthropogenic activities (agriculture and archaeological looting).

For local-scale assessment, our research also benefitted from the availability of X-band (8–12.5 GHz) images acquired by the German Aerospace Center (DLR) TerraSAR-X mission since 2008. The range of spatial resolutions varying from 16 to 1 m and scene size from 100 km (width) by 150 km (length; extendable to 1650 km) in ScanSAR (SC) mode to 5–10 km (width) by 5 km (length) in High Resolution SpotLight (HS) represented a technical improvement with respect to ERS-1/2 and ENVISAT medium-resolution imagery for the detection and delineation of subtle features spread across the landscape including the famous UNESCO World Heritage List geoglyphs of Nasca (Lines and Geoglyphs of Nasca and Pampas de Jumana).

Technique-wise, the region of Nasca was studied by means of interferometric coherence (Ruescas et al. 2009) and analysis of its spatial variation at the micro- and meso-relief scale (Baade and Schmullius 2010). Our project provided an occasion to develop a methodological approach to the quantitative assessment of radar backscatter variations to investigate land use, soil moisture, and morphological changes (Cigna et al. 2013) and to demonstrate the potential for operational use to detect and monitor archaeological looting (Tapete et al. 2013).

21.2 SAR Input Data and Processing

SAR stacks from the archive of the European Space Agency (ESA) were accessed and exploited in the framework of Category-1 project Id.11073 to cover the whole natural and cultural landscape of the Nasca region (Fig. 21.1). These sets included: eight ENVISAT Advanced SAR (ASAR) IS2 scenes acquired along descending orbits between 04/02/2003 and 15/11/2005; and five ENVISAT ASAR IS2 scenes acquired along ascending orbits between 24/07/2005 and 11/11/2007.

SAR-based results were also integrated and cross-validated with multispectral Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data acquired on 30/05/2003, 01/06/2004, and 10/06/2007 in the visible–near-infrared (VNIR), shortwave infrared (SWIR), and thermal infrared (TIR), with spatial resolutions of 15, 30 and 90 m respectively, and the derived Normalized Difference Vegetation Index (NDVI) and Water Index (NDWI).

For the multi-scale observation of the Nasca Lines, we analyzed the following X-band TerraSAR-X and TanDEM-X images: (i) ScanSAR, HH polarization, ascending mode, range resolution 17.0–19.2 m; (ii) StripMap, HH polarization, ascending mode, range resolution 3.3–3.5 m (Fig. 21.1); (iii) SpotLight, VV and HH polarization, ascending and descending mode, range resolution 1.7–3.5 m; and (iv) High Resolution SpotLight, HH polarization, descending mode, range resolution 1.1–3.5 m.

These images were accessed via the TSX-Archive-2012 LAN1881 project with DLR.

We mainly exploited the amplitude information to investigate the spatial and temporal changes of the backscattering coefficient σ^0. This indicates the radar signal backscattered to the sensor, normalized–to a first approximation–to the horizontal ground surface and referred to as per unit area on the ground.

The workflow to extract σ^0 values from raw SAR data and convert these to decibel (dB) and multi-temporal change detection analysis is described in Cigna et al. (2013). Nevertheless, it is worth mentioning here how ratios between SAR pairs are computed, as they are the basis for our interpretation of the recent environmental changes we observed across the Nasca region. Two SAR images k and j, acquired by using the same acquisition mode and geometry at the times t_k and t_j respectively, are spatially filtered to reduce the effects of radar speckle and increase the signal content of the image pixels. Their backscatter ratio ($R_{\sigma 0}$) is then computed, pixel by pixel, as follows:

$$R_{\sigma_i^0} = \frac{\sigma_i^0(t_k)}{\sigma_i^0(t_j)}$$

R is dimensionless and takes on values between 0 and 1 when the considered pixel i has a higher backscattering coefficient at time t_j with respect to time t_k, while values exceeding 1 occur when the pixel i has lower backscattering coefficient at the time t_j with respect to time t_k.

The result is a map showing the spatial patterns of σ^0 increase and decrease (Sect. 21.3) that can be correlated to changes in soil moisture content, vegetation coverage, or morphology (Cigna et al. 2013), the latter being for instance due to legal or illegal excavations (Sect. 21.5).

We also exploited multi-temporal coherence. Coherence (γ) is a measure of interferometric phase correlation, and can be computed as the cross-correlation coefficient of two SAR images. This is estimated over a small window of a few pixels in range and azimuth, once all the deterministic phase components (mainly due to the terrain elevation) are compensated for. Computation of the absolute value of γ, using a moving window over the whole SAR image, results in a coherence map of the observed scene, where values can range from zero to one, i.e., from no correlation to perfect correlation. Strong coherence means high homogeneity with no change of land surface properties or geometric conditions, while low γ values are found over altered surfaces. As demonstrated in Sect. 21.3.1, the patterns found in the multi-interferometric coherence map can complement those retrieved based on amplitude change detection.

21.3 Regional-Scale Environmental Assessment

21.3.1 Land Use and Soil-Moisture Changes

A demonstration of how valuable SAR can be to track environmental impact due to agricultural activities is here reported with regard to the floodplain of Río Ingenio, on both yearly and seasonal bases (Fig. 21.2).

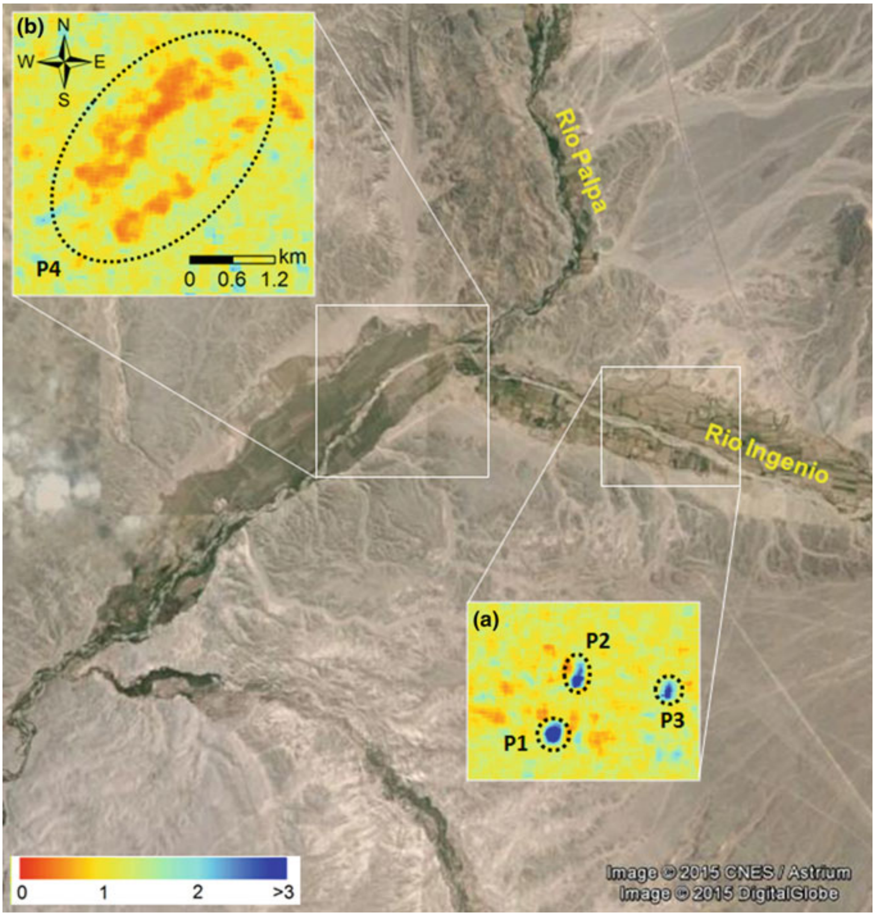


Fig. 21.2 Optical image of the floodplain of Río Ingenio from Google Earth (© 2015 CNES/Astrium/DigitalGlobe) with amplitude change detection maps by ratioing the backscattering coefficient ($R_{\sigma 0}$) in: **a** November 2004 and November 2005 (yearly basis), and **b** May 2005 and November 2005 (intra-year assessment). Blue areas indicate increased backscatter (e.g., P1, P2, P3) likely due to an increase in soil moisture between 2004 and 2005, while the red-orange areas (e.g., P4) indicate a decrease in the backscatter from May to November 2005

Two ENVISAT scenes acquired during the same month of two consecutive years (November 2004 and 2005) were compared to detect changes over one year, and amplitude change was detected (Fig. 21.2a). While orange to dark red areas over agricultural fields indicate a decreased backscatter from 2004 to 2005, three localized areas in blue show σ^0 increase up to 4–5 times the initial values (P1–P3 in Fig. 21.2a).

ASTER images acquired in June 2003 and 2004 highlight a general decrease in the reflectance in the NIR band and the vegetation cover over the eastern part of this area, even where increased backscattering is found.

On the other side, the ratio November–May 2005 (Fig. 21.2b) shows the difference in backscatter recorded between two opposite seasons. Decrease of σ^0 is apparent in agricultural areas to the west (P4).

The lower radar backscatter is probably due to an overall decrease of soil moisture and possibly to an associated decrease of vegetation, which correspond to a decrease in the reflectivity of the observed ground surface (Cigna et al. 2013). This suggests that variations of radar could be used as an indicator of land surface changes (vegetation and soil moisture) due to the agricultural cycle. Further analysis of environmental monitoring data could confirm this hypothesis. In the perspective of a regular and repeated monitoring, such a baseline mapping helps to enhance anomalies of radar backscatter.

Unlikely to be associated with human activities of seasonal or yearly frequency, these anomalies might also appear in situations of flooding events, unexpected alteration due to land-use or land-cover change or, in some circumstances, surface indicators of buried features (e.g., anthropogenic or paleo-channels).

As mentioned in Sect. 21.1, regional-scale assessment based on amplitude change detection maps can be complemented with corresponding multi-temporal interferometric coherence analyses.

Figure 21.3 shows $R_{\sigma 0}$ patterns observed between 2005 and 2007 in association with loss of coherence in the floodplain of Río Nasca, Peru, in proximity to the ceremonial center of Cahuachi. As discussed earlier in this book, the whole area was affected by flood events to the extent that the settlements were heavily damaged or destroyed. Although the river brings fresh mud yearly and creates a fertile strip for agriculture, it still represents a potential treat for the local archaeological heritage, which could be damaged by floods due to extreme weather conditions, also in relation to El Niño. Alteration of the radar backscatter between dry, wet, and flooded un-vegetated surfaces can therefore be also used to infer the impact in the recent past and assess flood hazard and susceptibility.

In addition to their scientific value, the findings of this research may generate impacts for the benefit of the local community and natural environment. The retrospective analysis we have undertaken with ENVISAT suggests that the radar backscatter can be used as a proxy to measure and spatio-temporally contextualize the anthropogenic impact on the landscape in Nasca, and that there is scope to extend this type of monitoring. Therefore, the observed patterns not only represent the basis that future change detection analyses of more updated SAR data should be compared with, but also may encourage local authorities to review the current

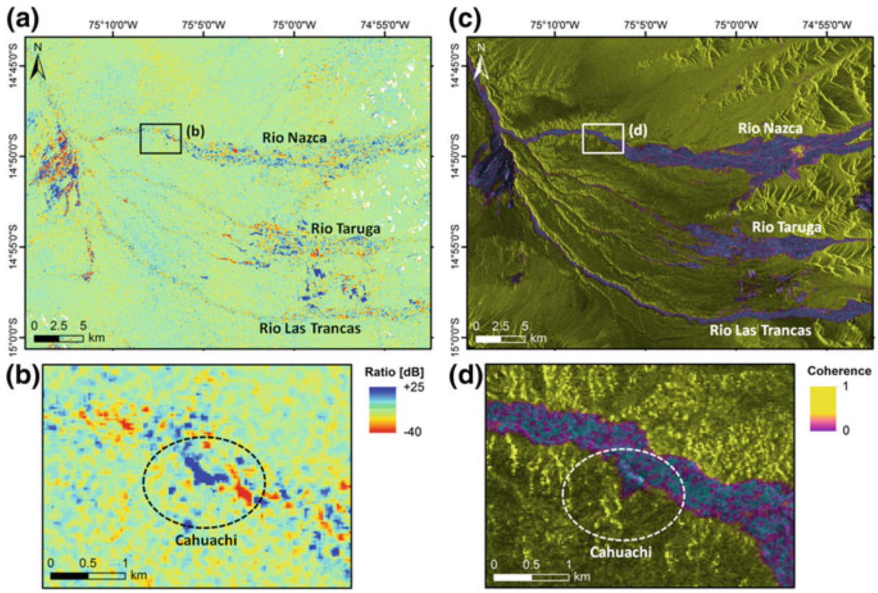


Fig. 21.3 Change detection maps based on **a**–**b** the ratio of the backscattering coefficient between ENVISAT ascending mode images acquired on 2 February 2005 and 7 October 2007, and **c**–**d** the corresponding coherence maps (Bperp 4 m) over the Nasca Civilization region in Peru and the archaeological site of Cahuachi (Tapete and Cigna 2016). The dotted circles highlight areas where changes in the ratio (*blue-red* patterns) are associated with loss of coherence (*pink-purple* patterns) likely due to soil moisture and vegetation changes along the river plain as seen in (**a**, **c**) for the Río Nasca, Taruga and Las Trancas plains, and (**b, d**) archaeological excavations in the area of the ceremonial centre of Cahuachi

practice of land management, as they suggest where major changes of soil properties and land use occurred in recent years.

21.3.2 Monitoring Landforms and Mass Movements

Wind-driven dynamics of sand-dune displacements and mass movements triggered by sudden rainfall events are common land-surface processes in the arid areas of the Nasca region (Cigna et al. 2013) and might impact the preservation of archaeological features of this cultural landscape.

We tested our approach described in Cigna et al. (2013) to investigate surface evolution of a sand dune area located 30 km south of Cerro Blanco (a mountain considered sacred by the inhabitants of Cahuachi). Figure 21.4a shows a multi-year RGB color composite of three ENVISAT scenes acquired on 04/02/2003, 30/11/2004 and 15/11/2005. Green areas are related to greater radar reflectivity in November 2004 while blue and magenta areas indicate higher backscattering in

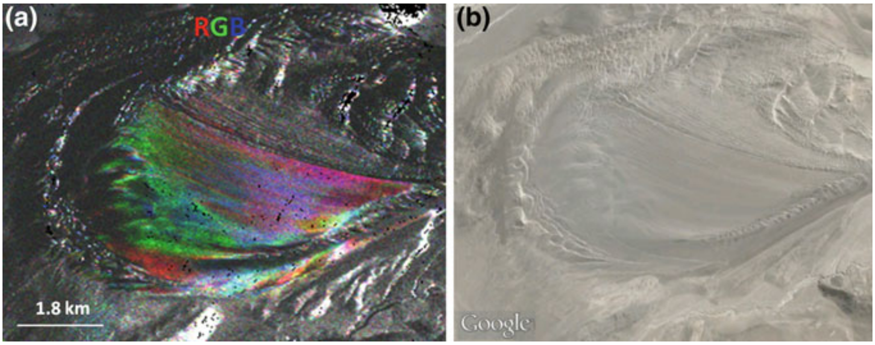


Fig. 21.4 **a** RGB color composite of a sand dune south of Cerro Blanco obtained by comparison of ASAR descending scenes acquired on 04/02/2003, 30/11/2004, and 15/11/2005; and **b** corresponding Google earth (© 2013 DigitalGlobe)

2003 and 2005, suggesting the occurrence of movements of sandy material that significantly modified the local surface morphology and the related radar backscattering. Comparison with Google Earth imagery clarifies the nature of the processes affecting the sand-dune surface, the morphology of which varies significantly with the season and the year (Fig. 21.4b). This example provides a proof-of-concept of what image analysts and archaeologists can do using regular SAR acquisition to monitor the evolution of natural landforms and prevent potential impacts on archaeological and landscape features nearby.

21.4 From Natural Environment to Anthropogenic Features

One of the strongest linkages between the natural environment and the civilizations that populated Nasca is the ensemble of infrastructure built to make this region more liveable. Systems to supply water fall within this category.

Further elements of connection are represented by the religious structures and infrastructure, above all the geoglyphs of Nasca, the function of which is still under debate within the scientific and archaeological communities.

21.4.1 (Re-)Discovering Ancient Water Systems: Puquios of Nasca

Rainfall is very limited on the southern coast of Peru, and rivers in Nasca are affected by water deficiency throughout the year. Therefore, water availability and accessibility are a real constraint in this region. Hydrological conditions in past centuries were probably comparable with the present ones, if the inhabitants of Nasca at the time needed to create systems of aqueducts called *puquios* to store and supply water (Schreiber and Lancho Rojas 2003; Lasaponara and Masini 2012).

These horizontal wells exploited the natural topographic gradient to collect water and were typically formed by an open trench and/or a subterranean gallery connecting the surface with the subsurface water (Fig. 21.5). The need to understand these partially or totally hidden structure, and the conservation history by which some of the *puquios* were abandoned if not even destroyed, now make desirable the development of investigation methods that would enable the (re-)discovery of these features from the surface.

From the radar point of view, discrimination of σ^0 properties over the monitored scene can lead to the recognition of morphological features which may be attributed to archaeological remains and traces of ancient *puquios*. Besides geometry and surface roughness, soil moisture content and material composition also have an effect on radar brightness. This aspect was used to distinguish still functioning *puquios* from those abandoned in the valley of Río Taruga belonging to the southern group of tributaries of Río Grande (Fig. 21.5a; Tapete et al. 2013).

RC color composites of two scenes acquired on 30/11/2004 and 15/11/2005 and ASTER-derived 2003–2004–2007 NDVI and NDWI indices suggest changes of soil moisture and vegetation over a large, dry, hydrographic reticulum lying within the desert between the Río Nasca and the Pampa de Chauchilla. Among other features, one was found in correspondence with the track of a younger *puquio* (for further detail, the reader can refer to Tapete et al. 2013, 2014).

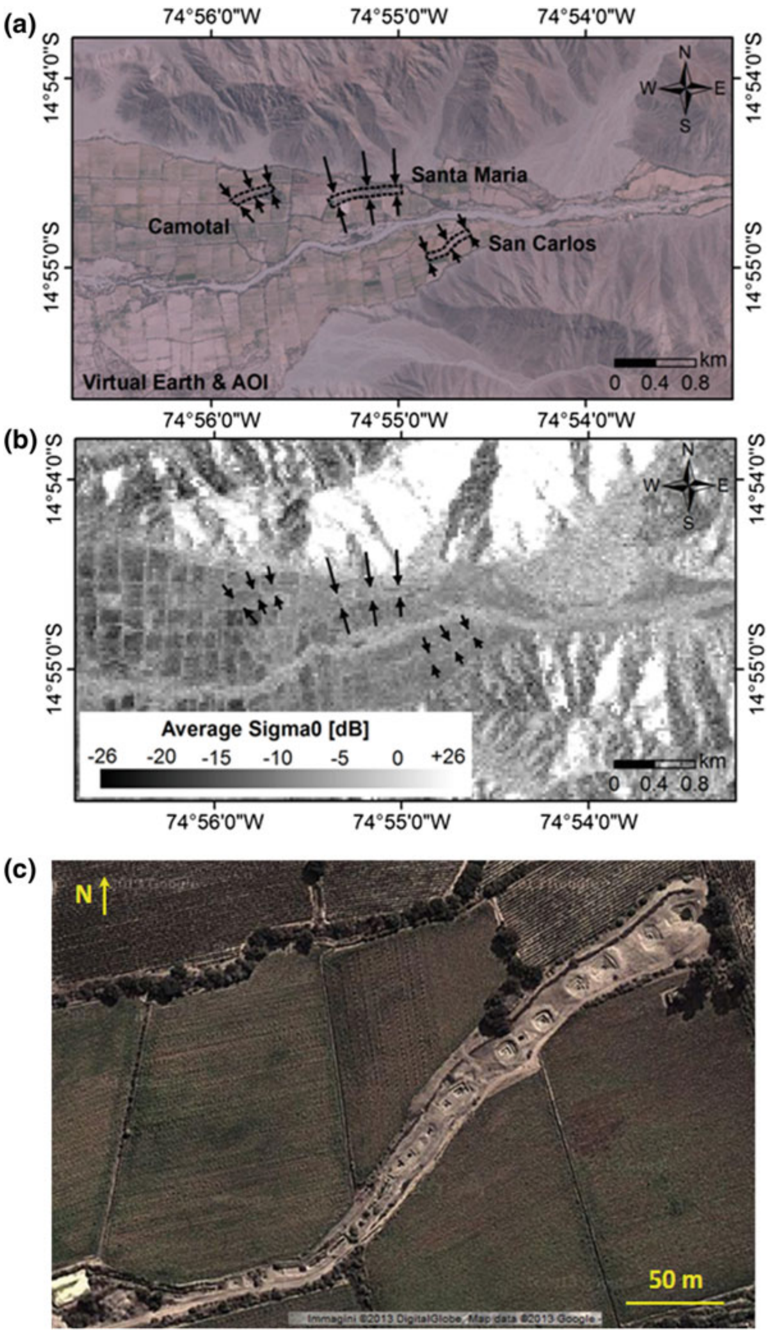
The multi-temporal ENVISAT scene over the Taruga Valley enables us to identify the still-functioning *puquios* Santa María and San Carlos, as well as the disused *puquio* Camotal. The latter is distinguished based on different σ^0 possibly due to its condition of abandonment (Fig. 21.5b).

The capability of SAR imagery to support the recognition of ancient hydraulic systems opens new perspectives in water resource management from space. Impacts on arid cultural landscapes facing drought can be enormous for local communities. Furthermore, the assessment of the current condition of archaeological features such as the *puquios* can inform about the potential impacts of climate change and desertification.

Among the implications that such research and improved knowledge can generate, it is worth mentioning the possible social and economic benefit to local communities that might be supplied with more water by rejuvenating these past water systems or by building new infrastructure following similar, environmentally sustainable designs.

21.4.2 Delineating Subtle Features: Geoglyphs of Nasca

As mentioned in Sect. 21.1, a multi-scale approach has been tested over the geoglyphs of Nasca located near the Panamericana Sur road (Fig. 21.6).


(a)
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km
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(b)
Average Sigma0 [dB]
-26 -20 -15 -10 -5 0 +26
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N
50 m
Immagini ©2013 DigitalGlobe, Map data ©2013 Google

◀ **Fig. 21.5** **a** Google Earth image (© 2015 CNES/Spot Image) and **b** 2003–2005 average ENVISAT scene of Río Taruga and the three *puquios* Camotal, Santa María, and San Carlos. **c** Google Maps view of *puquio* San Carlos (© 2013 DigitalGlobe Map data). *Dashed rectangles* in (**a**) and *arrows* in (**a**–**b**) indicate the location of the *puquios* in the optical and radar data

The full range of beam modes and incidence angles offered by the TerraSAR-X satellite mission proved beneficial in improving the detection and delineation of such subtle archaeological features, while relating them to the landscape over a wide swath. Figure 21.6 demonstrates the stunning improvement in SAR imaging from ScanSAR to High Resolution Spotlight modes to discriminate the UNESCO World Heritage List Nasca Lines (see also Tapete et al. 2015a).

It is well known that these 'negative geoglyphs' are low-relief drawings made by exposing unpatinated and lighter-colored ground (Cigna et al. 2013). Within SAR images, the geoglyphs typically appear darker compared to the surrounding soil. Such a radar property is evident, even in the images with the lowest resolution (about 17 m; Fig. 21.6b), although the boundaries with the neighboring pixels are expectedly vague and not well defined.

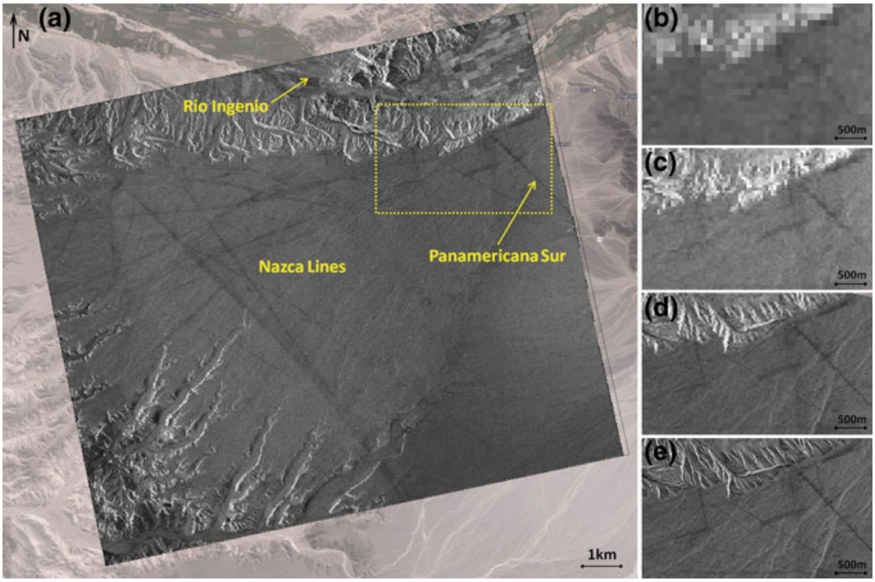

Fig. 21.6 X-band SAR images of the Nasca Lines (Tapete and Cigna 2016): **a** TerraSAR-X SpotLight 13 August 2008 ascending mode with VV polarization, 32.5°–33.6° incidence angles over the Nasca Lines (© DLR 2016), overlapped onto optical imagery (© 2013 Google Imagery © Cnes/Spot Image, DigitalGlobe, Map data © Google). Comparison of: **b** ScanSAR TerraSAR-X, HH polarization, ascending, range res. 17.0–19.2 m; **c** StripMap TanDEM-X, HH polarization, ascending, range res. 3.3–3.5 m; **d** SpotLight TerraSAR-X, HH polarization, descending, range res. 1.7–3.5 m; **e** High Resolution SpotLight TanDEM-X, HH polarization, descending, range res. 1.1–3.5 mm (© DLR 2016)

The distinctive radar signature of the geoglyphs can be analyzed by drawing a backscatter profile from the feature to the nearby soil (darker gravels) and checking its consistency or variations by year or by season. Full descriptions of this method and the outcomes achievable are reported in Tapete et al. (2013).

The improved spatial resolution of the images makes space-borne SAR a useful resource for archaeologists and conservators to complement optical data in assessing the condition of these subtle features.

21.5 Protection of Archaeological Heritage: Looting in Cahuachi

Decades of archaeological research in Peru have proved that this region has a wealth of ancient buried remains that, unfortunately, are also the target of looters (refer to previous chapters of this book). Looting manifests in the form of large holes, of meter to decameter size, which destroy irreversibly the archaeological context and its former morphology and appearance.

No attempts to use SAR for detection of looting had been undertaken prior to our project, and probably this technique had been neglected due to the resolution offered by ERS-1/2 SAR and ENVISAT ASAR sensors, compared with optical satellites. Our idea, instead, was that, if 30 m resolution images were sufficient to detect buried and abandoned *puquios*, they might also provide surface evidence of changes in radar backscatter as a consequence of morphological alterations due to looting.

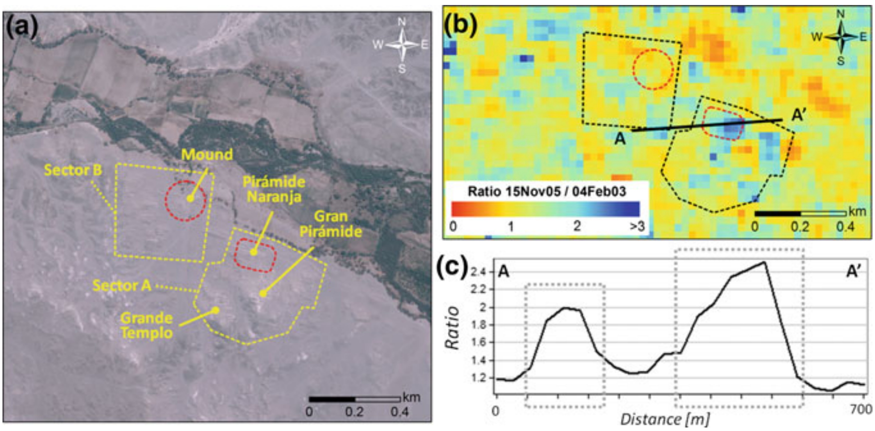

Fig. 21.7 **a** Google Earth image (© 2015 CNES/Astrium/DigitalGlobe) of Cahuachi Sectors A and B enclosing archaeological mounds. **b** Corresponding amplitude-change detection map based on $R_{\sigma 0}$ in February 2003–November 2005. **c** A–A′ ratio profile. The *blue* patterns in (**b**) refer to morphological alterations over the southeast corner of Sector B and Pirámide Naranja

With this concept in mind, we performed a multi-temporal analysis to measure σ^0 changes recorded in the ceremonial centre of Cahuachi (Fig. 21.7a).

Looking at the whole period covered by the descending mode data (04 February 2003–15 November 2005), two blue-colored patterns indicate an increase in the radar backscatter over the Pirámide Naranja and the south-eastern corner of Sector B (Fig. 21.7b). These patterns coincide with the adobe structures that were exposed by the archaeological excavations done by the ITACA mission. Thus, the second peak in the 'A–A' ratio profile in Fig. 21.7c relates to authorized archaeological excavations, whereas the first one cannot be attributed to legal excavations. Integration with ground truth and records of archaeological excavations also enabled us to exclude effects of surface erosion or other types of disturbance. Other radar backscatter changes that were observed to the north and west of the center are not related to the ceremonial center but to variations in soil properties (e.g. moisture content) across the river plain.

This type of analysis is a retrospective investigation, at site-scale, of past events of looting and has the added value of evidencing issues of the recent history of the archaeological structures. If applied to newly acquired imagery with higher spatial resolution, this change-detection method could be suitable for operational monitoring of looting on a regular basis, even at the scale of individual structures, as it is currently successfully tested in the Middle East (Tapete et al. 2015b, 2016).

21.6 Concluding Remarks

Our satellite studies in Nasca demonstrated that SAR remote sensing and imagery can be exploited to identify changes in surface morphology, soil moisture, and vegetation across this arid region. These data are particularly useful for regional assessment of landscape changes and evolution and to plan further ground investigations and archaeological missions. In this role, information derived from multi-temporal analysis of radar backscatter signals and changes need to be interpreted in relation to land-use changes and management, environmental monitoring data, and the recent history of the sites, including activities of the archaeological missions and, in some cases, illegal excavations by looters.

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Chapter 22
Puquios: New Insights from the Integration of Remote Sensing, GIS-Based Analyses and Geophysical Investigations

Rosa Lasaponara, Gabriele Nolè, Enzo Rizzo, Luigi Capozzoli, Gerardo Romano, Maria Danese and Nicola Masini

Abstract The investigations conducted previously on the Nasca puquios, with particular reference to those systematically performed by Schreiber and Lancho Rojas (1995), Schreiber and Lancho Rojas (Los *puquios* de Nasca: un sistema de galerías filtrantes. Editorial Los Pinos, Lima, 1998), Schreiber and Lancho Rojas (Aguas en el Desierto. Los *puquios* de Nasca. Fondo Editorial, Lima, Perú, 2006), have had the merit of placing the theme of Nasca water management in the center of debate on the ancient Nasca world. Water has become the crossroads of all the other research lines focused on the influence of environment and climate on the Nasca culture, as well as on the geoglyphs, ceremonial architecture, and settlements. In this cultural framework, some studies based on multitemporal, multiscale, and multisensor analyses have been performed in the Río Grande de Nasca drainage in

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order to investigate the interaction between the *puquios* and environmental conditions, as well as to improve knowledge of the local environmental settings. Herein we present and discuss the investigations, based on the integration of remote sensing, GIS-based analyses, and geophysical prospecting, in the framework of the ITACA mission of the Italian CNR. Outputs from satellite-based investigations, along with all the information already available from previous studies, were the input data used in the statistical spatial analyses and geophysical prospecting. The main findings provided information useful to: (i) improve the current knowledge on the *puquios* at both intra-site and inter-site levels and their relationship with environmental and human settings, (ii) identify unknown *puquios*, (iii) and support planning for subsequent archaeological excavations. As a whole, the investigations based on the adopted integrated approach provided new insights into this hyper-arid area which has been the homeland for numerous civilizations, despite the extreme physical environment that presents serious obstacles to human occupation.

Keywords *Puquios* · Groundwater · NDVI · MNDWI · Satellite remote sensing · GIS based analyses · ERT

22.1 Introduction

Over the years, archaeological investigations on the ancient Nasca civilization have been oriented towards answering important basic questions such as: How did the Nasca come about?; What were the strategies, and how were they devised, to effectively face adverse environmental conditions (drought, flood, *El Niño*)? and What were the main reasons for their decline? To address these questions, one important key factor is the issue of water management that has generally strongly influenced the rise and collapse of civilizations through the world (Hassan 2003). Over the millennia, water has been the mainspring of civilization, and water shortages have been an engine of human innovations since the scarcity of water has propelled innovative technical solutions and social transformations. In this context, the Nasca aqueducts, known as *puquios*, are recognized as one of the most precious jewels of the Prehispanic cultures in Peru (Schreiber and Lancho Rojas 2006) and one of the most enduring legacies of the ancient Nasca culture.

Today, around 36 *puquios* still function, bringing fresh water into this hyper-arid desert area (Fig. 22.1). In general, the existing *puquios* are located in the three southern valleys: 29 have been recorded in the Nasca Valley, two in Taruga Valley, and five in the Las Trancas Valley (Schreiber and Lancho Rojas 2006). It is assumed that the aqueduct system must have been much more developed than it appears today and contributed to an intensive population of the valleys, exploiting an inexhaustible water supply throughout the year. Some answers to the many questions and open issues relating to the *puquios* may come from the analyses of multispectral satellite images, from medium- to high-spatial resolution, along with digital terrain models. The recent increasing advances in multi-sensor and

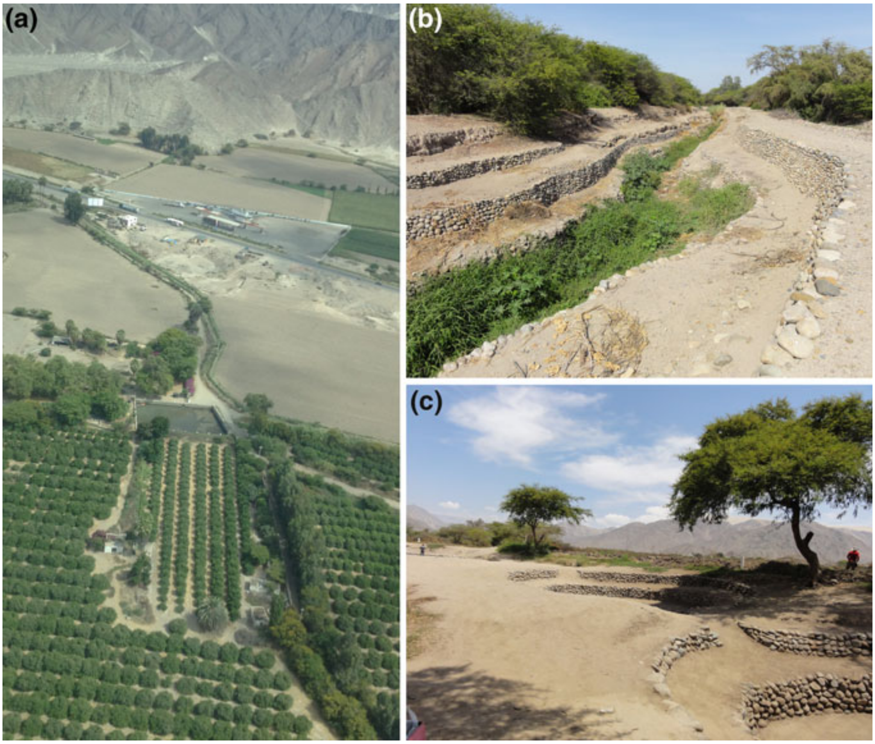

Fig. 22.1 *Left* An aerial view of the landscape close to the modern Nasca town including an area irrigated by an aqueduct and a reservoir. *Top right* The trench-shaped *puquio* of Ocongalla in the Río Nasca valley. *Bottom right* The aqueduct of Cantalloc known for its circular chimneys (ojos)

multi-source technologies, mainly based on the integration of space and airborne sensors with in situ measurements, opens new challenging perspectives in the field of archaeology and palaeo-environmental studies.

The integration of diverse data sources can greatly improve our capacity to uncover unique and valuable information in the Nasca drainage basin–from the detection to the management and preservation of cultural resources and landscapes. In particular, the integration of the diverse, powerful, technical tools today available in the field of statistic analysis, space technology, and geophysical prospecting can provide new opportunities to explore the fascinating past of the Río Grande de Nasca drainage. This investigation approach is important especially in those areas as Peru where human frequentation has been strongly conditioned by environmental setting and changes (for additional details, the reader is referred to Orefici and Lancho Rojas in Chap. 2). To expand on this issue, herein we focus on the following main points:

(i) The dynamic characterization of the hydrologic regime of the area, performed using a rich data set of satellite time series, collected over more than 30 years from 1980s up to today.
(ii) Statistical spatial analyses to characterize the spatial and temporal relationship at various scales from intra- to inter-sites level.
(iii) Detail 3D maps for some *puquios* as obtained from the DTM based on satellite data and geophysical prospecting.

In particular, relating to point (i), diverse, satellite-derived parameters, such as temperature and moisture, were analyzed based on their spatial and temporal patterns. This can help us to extract precious information to reconstruct traces of ancient environmental changes still present today, fossilized within the present landscape. One of the most significant parameters is the surface-moisture content, because the Nasca exploited water predominately from subsurface canals and the ground-water table to cope with their basic survival needs, agriculture, and ritual and domestic uses.

The modern land use and landscapes can obscure the ancient water ways and hidden important information on the distribution and organization of the filtration-gallery system. The identification of palaeo-environmental features and characteristics may help us to (i) improve our current knowledge about the *puquios*, (ii) discover new and unknown ancient settlements, and (iii) advance knowledge about the social organization, agricultural production, survival strategies, and settlement distribution. In fact, the use of satellite-derived moisture content may facilitate the identification of areas involved in early environmental manipulation, mainly addressed to set up irrigation and artificial wet agro-ecosystems where the natural rainfall was insufficient to support agriculture.

One of the main advantages of satellite based observations is the possibility to search large areas using non-destructive technology and extract new information on the complex environmental conditions that have characterized the Río Grande de Nasca drainage basin. Moreover, results from satellite-based investigations, along with all the other information available from previous studies, can be used to create predictive models. They are useful tools for archaeological investigations (see Chap. 20) being that they can provide an acceptable compromise between the effectiveness of results and the reduction of time and costs needed to conduct field surveys in large areas. Both satellite and predictive models can also contribute to (i) preventive archaeology for an operational use and (ii) to identify the factors that conditioned the location of the settlements in the past (e.g., Danese et al. 2014). This is particularly important for the area of interest characterized by the presence of geoglyphs which are one of the most fragile heritage of the entire world, due to the particular constructive technique based on the removal and piling of shallow-soil layers (see Chaps. 11 and 12). The geoglyphs are not only located in the area already inscribed in the UNESCO list but also in other vast areas of the valleys, exposed to threats mainly arising from flash floods and off-road vehicles. The potential existence of yet-unknown ground drawings (that are not visible in situ but only from a bird's-eye view) strongly prevents and limits the field surveys that first require preliminary assessment from remotely-sensed data.

After the satellite-based investigations, we also conducted geophysical prospecting which consisted of the measurement of some physical properties of the soil (such as anomalies in magnetic, electric, or radio signal) that can reveal its structure, as well as the presence of buried objects (for additional details on geophysical methods applied in the Nasca region, see Chap. 20). In the case under investigation, the resistivity method was used. The purpose of this technique is to determine the subsurface resistivity distribution by making measurements on the ground surface. The differences in relative resistance is generally used to map features including ditches, pits, voids, and structural features such as walls, as well as the presence of aquifers. Compared to other geophysical techniques (such as ground-penetrating radar or magnetometry), resistivity is more time consuming, but can provide detailed information useful to characterize the relationship between the vadose zone and the deep groundwater at subsurface levels, deeper than those obtained from other geophysical surveys (Zhdanov and Keller 1994).

22.2 Remote Sensing: Rationale and Results

22.2.1 Rationale

Modern satellite data can provide unparalleled views of ancient landscapes through the exploitation of active and passive sensors with their multispectral information available at different spatial resolutions, including sub-metric details (Andrew et al. 2006). Moreover, the availability of historical archives for both satellite data (Fig. 22.2) and aerial photographs enables us to carry out new exploratory approaches, making it possible to view the entire region of the Nasca over time. The synoptic spatial perspective offered by a “bird’s-eye view” facilitates the identification of man-made features and their discrimination from those due to natural processes that also contributed to the transformation of the landscape.

Remote-sensing technologies enable us to categorize and contextualize features and patterns even over remote and broad areas. Moreover, satellite-based information and GIS tools enable us to model and map complex concepts, also including social behaviors and decision-making processes. Satellite pictures are sensitive to presence/absence of vegetation (type and status), soil compositions and conditions, moisture content, and their spatial and temporal variations, which can be visually appreciated as tonal differences in pixels. These differences can be further emphasized by using statistical time-series analyses and enhancement techniques, such as, for example, filtering, mathematical combinations of different bands, pan-sharpening of panchromatic and multispectral imagery, fusion of active and passive sensors, supervised and unsupervised classifications, principal component analysis (PCA), Tasseled-Cup transformation (TCT) (Kauth and Thomas 1976), statistical analysis such as those based on local indices of spatial autocorrelation (LISA), e.g., Moran, Geary and Getis indices (Lasaponara and Masini 2012c; see

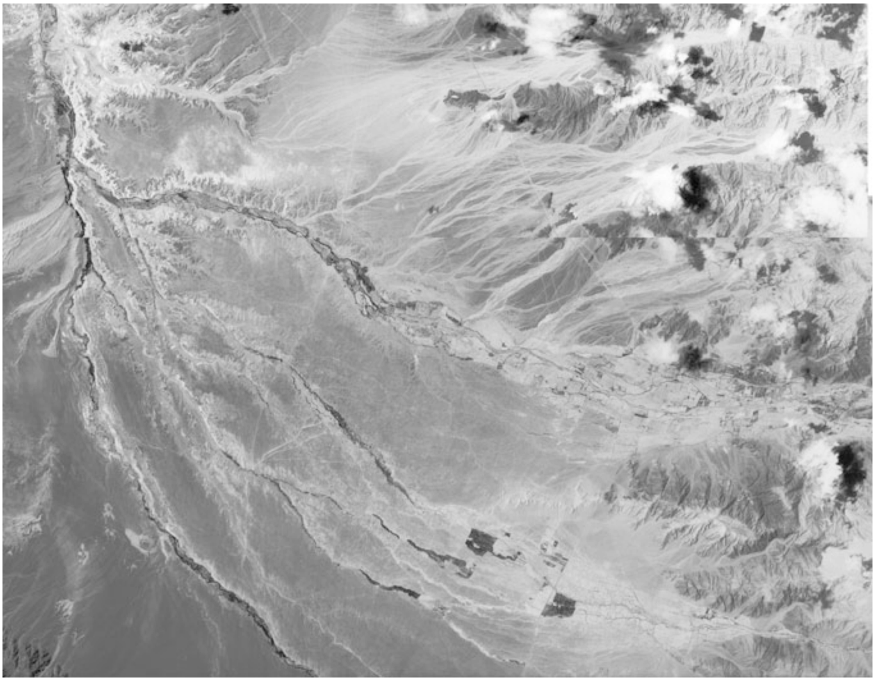

Fig. 22.2 Corona image acquired on 11 March 1966 (satellite declassified image S FWD 1030-1)

Chap. 20 by Masini et al.). Using suitable data-processing techniques, environmental manipulations as well as archaeological settlements and "anthrosols"[1] can be distinguished from other soils because of the expected differences in variations in the grain size and soil moisture retention (due to differences in drainage capability), which generally results in darker pixels in optical pictures or brighter ones in radar scenes (see Chap. 21; Cigna et al. 2013).

As a whole, the use of remote sensing offers a variety of advantages when compared to other forms of data acquisition, and they can be briefly summarized as follows:

(i) It offers synoptic views and wide regional coverage which are priorities for spatially distributed sites as in the case of the filtration galleries.
(ii) It is a unique, valuable data source for obtaining information on the past decades thanks to the available huge archive of historical datasets available since the 1960s.
(iii) It enables continuous acquisition of up-to-date information since satellite remote sensing provides systematic acquisition or can be programmed to enable regular, periodic surveys of the area of interest.

[1]Anthrosols indicate soil formed, or heavily modified, by long-term human activity.

(iv) It offers accurate data for information and analysis in a non-invasive, non-destructive manner.

Data collected using satellite remote sensing can be used for many purposes, as for example, the construction of thematic maps of land use-and land cover, vegetation conditions, soil characteristics, water resources, Digital Elevation Models (DEM), etc.

In the current study, in order to exploit as much as possible the large quantity of data sources and information that can be extracted from satellite data, a long-time series was used to map the modern land use and landscape features, as well as to reconstruct the ancient environmental changes that have occurred in the Nasca drainage. In particular, satellite-derived moisture-content and moisture-pattern variations over the seasons and years have been used to facilitate the identification of the intra and inter-annual dynamics of vegetation and of the hydraulic regime (perennial, ephemeral, dry) of the rivers in the area of interest. This area, i.e., the alluvial valley bottom in the lower Andean foothills, tends to exhibit moderate-to-high infiltration capacities which reduce the volumes of superficial water in the rivers. In other words, rivers tend to flow partially on the surface and then to completely drop below, reaching the phreatic layer at various points that vary over the seasons and years according to the water availability (see Chaps. 2 and 13). The added value of using the multitemporal satellite data is the possibility to dynamically detect and monitor vegetation conditions and water availability, with particular reference to the identification of the initial points at which (in the zone of infiltration) the rivers drop below the surface and flow underground, to re-emerge several kilometers away in the lower valley.

22.2.2 Data Processing

The identification of vegetation variations, as well as the variations of the point at which the water disappears, may be profitably enhanced by a suitable data processing of multi-date observations. Moreover, it should be considered that the satellite scenes provide signals related not only to soil conditions and compositions but also to a combination of multiple parameters ranging from the acquisition geometry to the atmospheric conditions that must be suitably quantified and removed. The reduction of noise (including calibration and inter-calibration issues) improves the signal-to-noise ratio and the visibility of the targets. In this way, it is possible to qualitatively assess the amount of vegetation and the availability of surface-moisture content related to the complete time period investigated, along with the inter- and intra-annual variations of past decades and also to infer and extract information about the future trends.

The satellite data sets used for these investigation were pre-processed using calibration, inter-calibration, atmospheric, and geometric correction in order to minimize sensor degradation, atmospheric contamination, and geometric distortion that would otherwise strongly affect the satellite pictures.

Various data processing methods were applied in order to: (i) enhance details, (ii) improve edge detection, (iii) extract and quantify features and shapes in a semiautomatic and/or automatic way, (iv) detect changes over time (based on the multitemporal dataset), and (v) emphasize spectral responses of various surface/target/indicators, such as vegetation, moisture, etc.

Among the diverse data-processing techniques, we briefly highlight here the use of digital filtering, geospatial analysis including Principal Component Analysis (PCA), and the classification adopted to further improve the visibility of subtle signals, linked to the targets above described, and to extract and map the features of interest. In particular, we briefly summarize PCA, which removes the correlation between the multitemporal maps and transforms them into new uncorrelated Principal Component (PC) maps. Generally, the number of the PC is equal to the number of the original images used as input data.

The PCA depends on the given statistic of the processed data set and, therefore, also the interpretation and meaning are in turn data-set dependent. As a general role, we can consider that the first component (this has the biggest variance) provides an average of all the multitemporal maps used as input, in our case, NDVI or MNDWI maps. Therefore, it does not provide information about potential changes. The following components (that are orthogonal to each other and have less variance) inform us about the variations occurring during the investigated time window. In particular, it is expected that the second component should be more supportive and informative about the spatial distribution and the amount of change (decorrelations) occurring in the investigated area. The components following the second one refer about less variance. This means smaller variations compared to the second component, but it should be considered that these variations may be significant if correctly interpreted also with the support of the eigenvectors. Later components can identify noise such as the radiometric and other type of errors.

The categorization of diverse classes is herein made by using unsupervised classification because it requires a limited human intervention in setting up the algorithm parameters. The importance of applying unsupervised classification in archaeological applications is that: (i) it is an automatic process, namely, it usually requires only a minimal amount of initial input compared with a supervised data set; (ii) classes do not have to be defined a priori; and (iii) unknown feature classes may be discovered. A number of unsupervised classification algorithms are commonly used in remote sensing, including thresholds based on (i) K-means clustering, and (ii) ISODATA (Iterative Self-Organizing Data Analysis Technique) (Lasaponara et al. 2016; Lasaponara and Masini 2012b, c).

22.2.2.1 Results: Multitemporal Characterization of the Fluvial Oasis

The availability of a declassified satellite image (Corona) acquired on March 1966 enables us to identify and map the most dramatic changes that occurred during the last 50 years.[2] Figure 22.3 shows the Corona image georeferenced and implemented in a GIS. It covers an area of 600 km^2, including the lower and medium valleys of the Río Nasca and Río Taruga.

The overlap of this image on more recent Aster and Landsat TM data enables us to map and measure the changes related to cultivated land, the river paths, and the vegetation cover, not only in the arable lands but also along the ravines (*quebradas*) not used for farming. The most significant changes are observed in the Río Taruga, in particular where the land is used for farming. In Río Nasca, only small changes in cultivated areas are observed in the lower valley from altitudes of 390–440 m. An interesting aspect is related to vegetation cover in the ravines of the lower valleys, in particular in the Río Taruga, which seems to have increased from 1966 to date. This is important because the ravines are not cultivated areas, due to the difficulty of farming them. Therefore the greater vegetation cover is an indicator of the greater availability of water.

The Nasca and Taruga riverbeds have been affected by some changes in both their courses and widths, which, in some cases (Aja and Tierra Blancas), have increased by 100–150%.

In order to dynamically characterize the environmental conditions of the study area, the NDVI index was calculated by using a Landsat Thematic Mapper dataset, acquired 1985–2010. The NDVI, computed according to the formula $NDVI = ((NIR - R)/(NIR + R))$, provides information on the presence and status of vegetation, along with seasonal and annual variations over the considered time series.[3] The computation of the maximum NDVI (monthly, seasonal, and annual) enables the minimization of the residual cloud contamination and the identification of the most intensely green and healthy pixels, which vary from one season to another, according to the specific phenology of the given crops, and can vary from one year to another according to the meteorological conditions and the water availability.

To have an additional source of information, we also computed the median, which is shown in Fig. 22.4 obtained by using the whole time series. A visual inspection of Fig. 22.4 highlights the fluvial oasis, characterized by higher NDVI values and clearly discriminates them from the surrounding desert areas, which exhibit very low NDVI values. This image can be better interpreted using also the PCA components. Herein the unstandardized PCA was computed, because we were more interested in the enhancement of the changes over time. Using the

[2]Some Corona images of the Nasca region are available and downloadable from http://earthexplorer.usgs.gov/. Corona images are satellite images acquired from 1960 to 1972 for reconnaissance to produce maps for U.S. intelligence agencies. Since 1995, Corona images have been declassified and can be used for civil applications, including environmental analyses and archaeological investigations. A mosaic of Corona satellite images acquired on March 1966 has been used for detecting changes in arable lands and hydrography, as well as unknown puquios, in the Nasca drainage.

[3]NIR is near infrared band; R is red band.

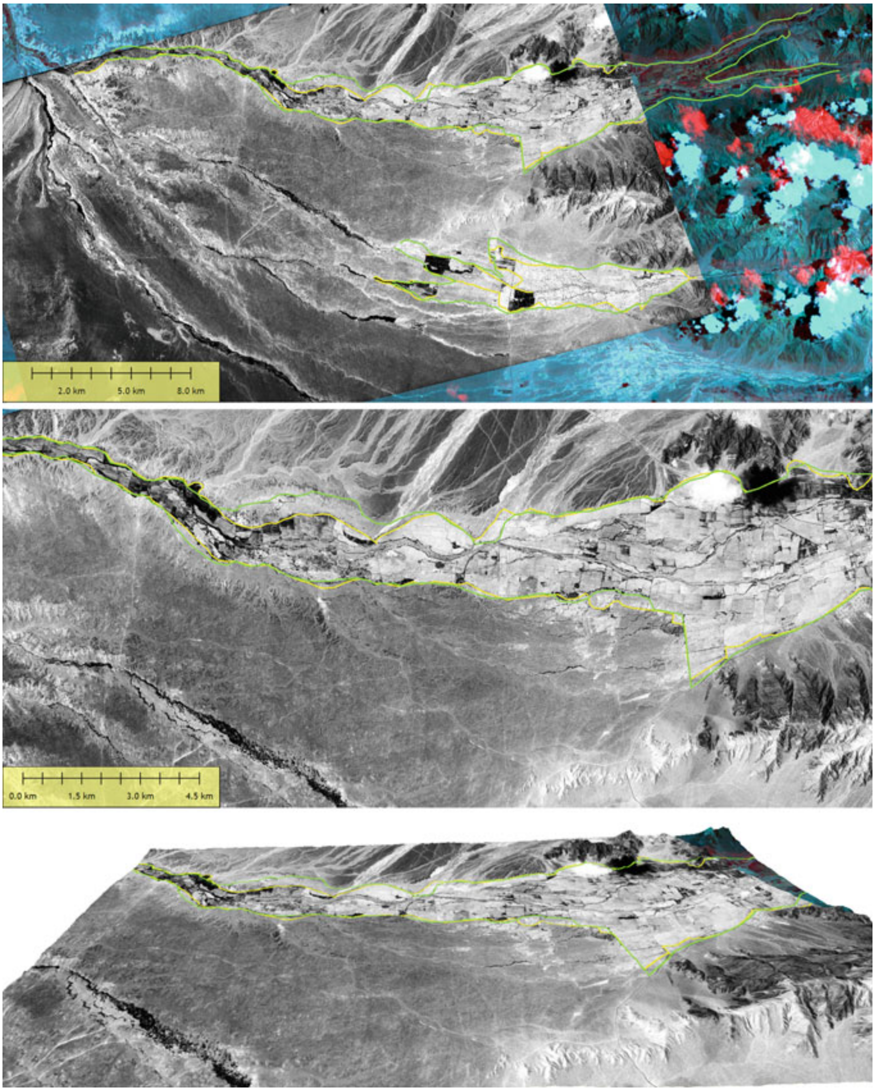

Fig. 22.3 *Top* Corona satellite image acquired on 1966. The overlap on an Aster satellite image acquired on 2013 of the Río Nasca drainage enabled us to detect changes in the land use, vegetation cover and the hydrography. *Middle* Detail of the Río Nasca valley including Aja and Tierra Blancas tributaries. *Bottom* 3D of the Río Nasca valley. The *yellow* and *green line* denote the borders of the areas used for farming in 1966 and 2013, respectively

standardized PCA, the components are computed on the basis of the correlation matrix; whereas using the unstandardized PCA the components are computed using the variance/covariance matrix. It is important to note that the PCA is highly dependent on the statistics of the processed data set, and, therefore, the

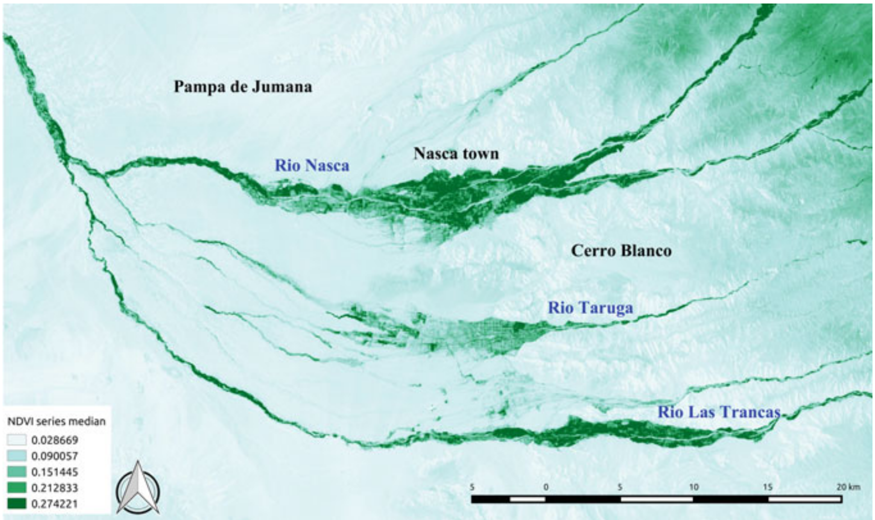

Fig. 22.4 Landsat TM based map of the median of NDVI yearly maximum values computed from 1985 to 2010

interpretation cannot be universal, but must be interpreted with caution and carefully verified with independent data set and information.

In the current case under investigation, the unstandardized PCA was applied to the yearly maximum of NDVI computed for a time series spanning 1985–2010 and therefore, for each pixel, the results must be interpreted as follows. High values in the first component inform us about the variance over time. As a result, the inter-image variance will be (i) extremely high where there are agriculture lands due to the seasonal and inter-annual variability of the given crops and (ii) extremely low where there is desert which tends to be stable. Figure 22.5 depicts the first component of unstandardized PCA. It is possible to see that the areas characterized by the greater greenness and health of vegetation are exactly inside the three valleys and where the *puquios* are located (see hap. 13, infra).

Figure 22.6 shows the yearly NDVI maps computed for 1996 and 2010. The comparison between the two maps clearly shows the differences from one year to another in the vegetated area. In the map of 2010, the yearly maximum NDVI, the vegetation distribution, is sparser and less "green" compared to 1996. The fact that the vegetation is less green is evident by the differences in the NDVI ranges: (i) the NDVI maximum value was 0.60 in 2010 and 0.80 in 1996. The different range values clearly refer on the variations from one year to another of the vegetation cover and also to its spatial distribution. As evident, the areas with relatively high NDVI were significantly smaller in 2010 compared to 1996. This means that the crop were significantly reduced over time, and this difference was likely due to meteorological conditions in general and to the water availability in particular. In other words, the year 2010 was characterized by drier conditions compared to those

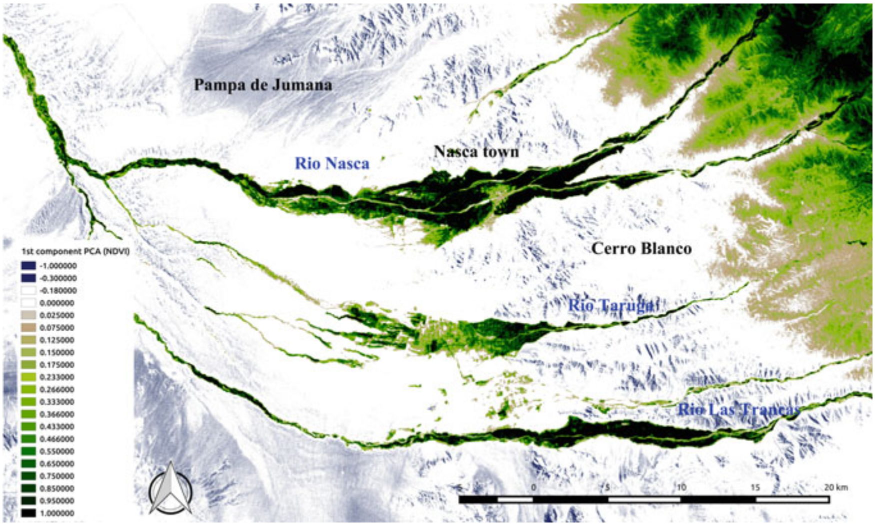

Fig. 22.5 First component of the PCA calculated using a satellite time series data set of yearly maximum of NDVI computed from 1985 to 2005. It provides information about the strength of the temporal covariance of yearly NDVI maximum for each pixel. As a result, the inter-image variance is (i) *high dark green* in the pictures where there are agriculture lands due to the seasonal and inter-annual variability of the given crops, and (ii) *low light green* in the pictures where there is a desert area that tends to be more stable compared to the vegetation cover

of 1996 year. These fluctuations can be considered as normal even, if, in the extreme arid conditions of the area of interest, the also small decrease in water availability may have strongly amplified effects on vegetation.

22.2.2.2 Arable-Land Extraction

In order to map the arable land, the whole time series was considered by analyzing the NDVI maximum maps computed for each year. This was important in order to limit the yearly fluctuations that can take place and can be evident from one year to another. The information inside the whole temporal window was taken into consideration by using the PCA. In this way, a synthetic view over the whole analyzed period was obtained from the whole NDVI time series. In particular, the extraction of arable land was made by using the first component of the PCA (shown in Fig. 22.5), computed using a dataset composed of satellite images acquired 1985–2005. The first component of the PCA was classified into five quintile classes, and the identification of the arable land was made by considering the higher class (Fig. 22.7).

Important considerations arise from the visual inspection of Fig. 22.7 which shows the overlay of NDVI, rivers, *puquios,* and arable lands as obtained from satellite data:

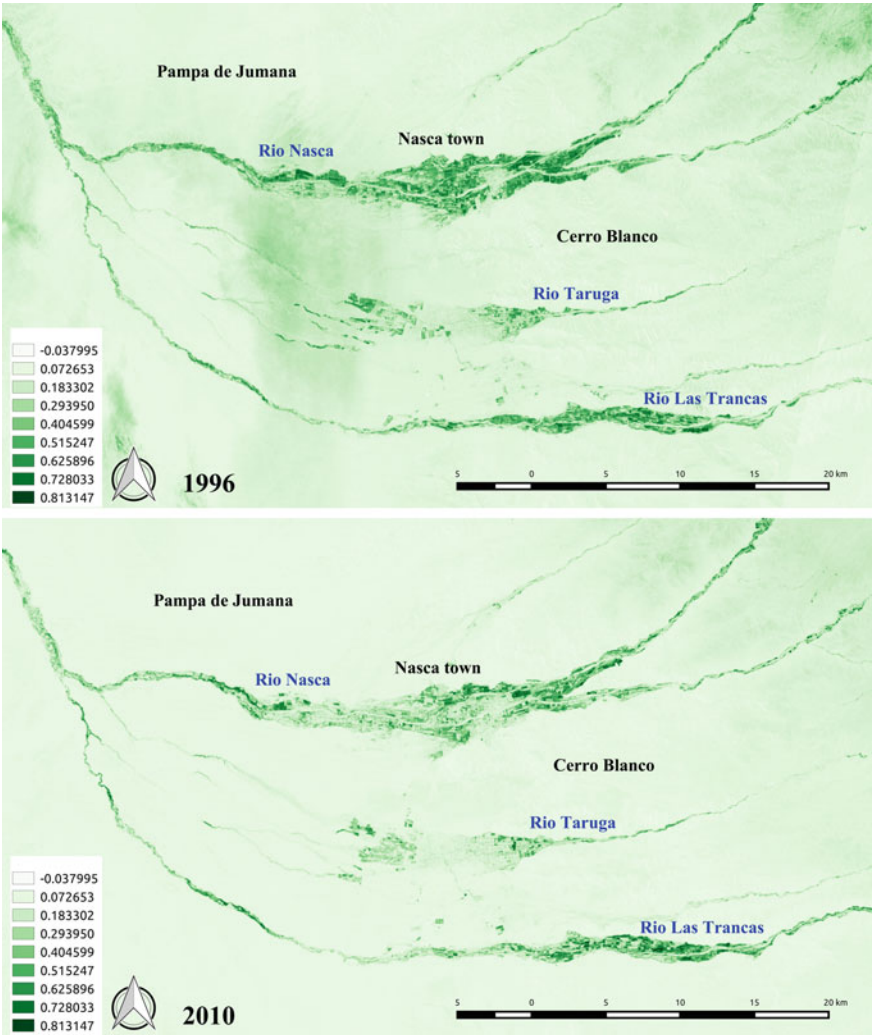

Fig. 22.6 *Top* Satellite Landsat TM map of yearly maximum NDVI for 1996. *Bottom* Map for 2010

1. All the filtration galleries are distributed very close to the rivers, thus showing that, for many of them, the main source of water the subsurface rivers.
2. All the known *puquios* are located inside the arable land, as expected, and what is evident is that, in the Taruga valley, the number of recorded *puquios* and their spatial distribution is lower compared to the other valleys Aja, Tierra Blancas (Fig. 22.8), and Las Trancas. This is due, as expected, to the lower water charge of the Taruga river compared to the other rivers, but, at the same time, this may also suggest that, in the Taruga valley, additional lost *puquios* may be found.

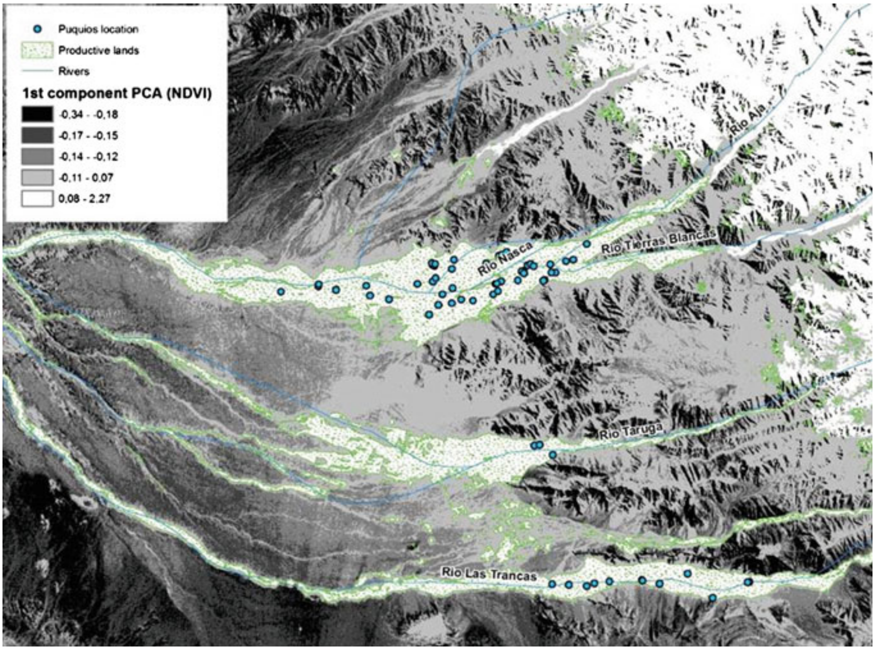

Fig. 22.7 The first PCA of NDVI computed on Landsat time series from 1985 to 2005. The map also shows the location of *puquios* and arable lands

Fig. 22.8 3D satellite view (Pleiades acquired on 28.11.2012) of Nasca town, where Aja and Tierra Blancas tributaries join the Nasca River

This hypothesis is mainly based on the consideration that (i) an additional water source may be the water table, and (ii) the arable land seems to be large enough to host additional *puquios* (see also Sect. 22.4)

3. Additional investigations based on higher-resolution satellite data can provide new insight into this analysis (see Sect. 22.3)
4. GIS-based analyses of the statistical correlation and spatial distribution of ancient villages and settlements can be considered to further investigate inter- and intra-relationships between *puquios* and settlements (see Sect. 22.4).

22.2.2.3 Satellite-Based Characterization of the Rivers: From Surface Flow to the Underground Drop Points

In order to dynamically characterize the river flow in the specific conditions of the study area, moisture-index maps were calculated from a Landsat TM dataset, acquired from 1985 to 2010, according to the formula: MNDWI = ((Green − SWIR)/(Green + SWIR)), where Green and SWIR (short wave infrared) correspond to bands 2 and 5, respectively (Xu 2006). MNDWI is capable of identifying water bodies and soil-moisture content (see also Rokni et al. 2014). The application in areas characterized by vegetation cover, built land, and water bodies (e.g., lakes) places generally into evidence positive values for water bodies, values around 0 or little less than 0 for built-up areas, and lower values to built-up areas for vegetation cover. In our case, the spectral behavior of the arid pampas of the Nasca drainage is expected to be similar to those typically observed for built-up areas. Therefore, the MNDWI values for vegetation cover will be less than those for the bare surfaces of the *pampas* and the slopes of the *Sierra*. With respect to the oases rivers of the Nasca drainage, the extension of riverbeds and the water charge are not so significant.[4] Therefore the range of MNDWI values must be carefully interpreted according the specific characteristics of the study area.

The MNDWI average and standard deviation (Std), computed using a time series from 1985 to 2010 of cloud free TM images, put in evidence four different behaviour according to the different ranges of altitudes for the three river valleys.

Figures 22.9 and 22.10 show the MNDWI average and Std respectively, considering a buffer of 250 m along the axes of the rivers. In particular, the considered altitude ranges are the following: less than 400 m, from 400 to 750 ÷ 850 m, from 750 ÷ 850 to 1000 ÷ 1200 m., and, finally, higher than 1000 ÷ 1200. These altitude ranges approximately correspond to those identified by Schreiber and Lancho Rojas (2006, 2009), and indicated as: lower valley, middle valley, middle-up valley (thought be the infiltration zone of water), and up valley, respectively.

The joint analysis of the MNDWI average and standard deviation (Figs. 22.9 and 22.10) provides information on the flow regime related to the considered time window (1985–2010). In particular, the average values provide indirect information pixel-by-pixel on the presence-absence of surface water, whereas the standard deviation estimates its variation over time, which is particularly important for the identification of the river sections characterized by perennial, or on the contrary, ephemeral flow regime.

The extreme ranges of the computed MNDWI indices are −0.14 and −0.37. The standard deviation varies from 0.065 to 0.16. On the basis of the estimated values from satellite time series and direct observation from in situ investigations

[4]In the Río Grande drainage basin, the annual rainfall is around 10 mm in the lower and middle valley (less than 800 m of altitude). The precipitation strongly increases with altitude, reaching 200 mm/year above 2500 m a.s.l. and 400 mm/year above 3500 m a.s.l. (Baade and Hesse 2008).

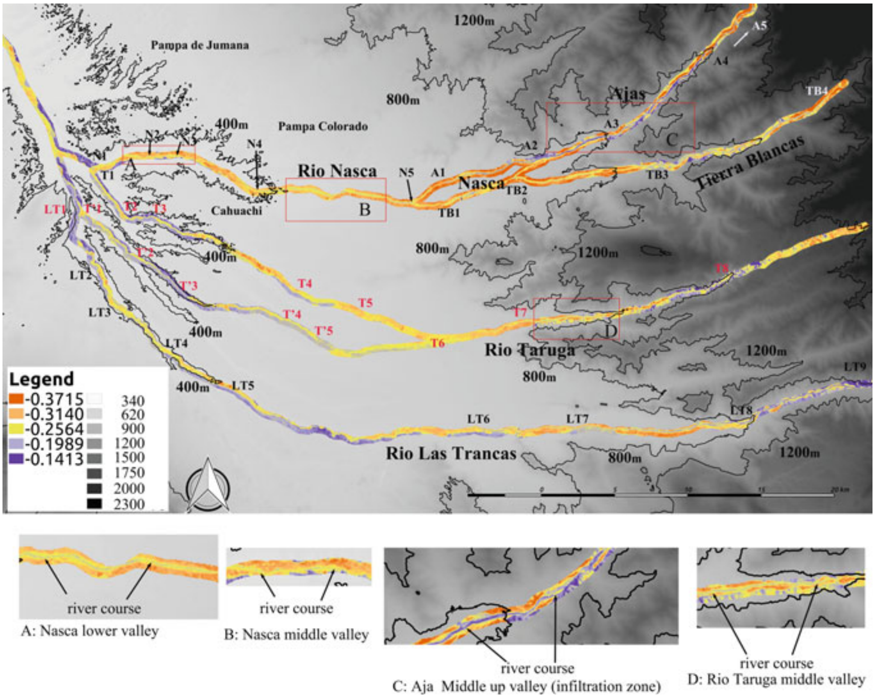

Fig. 22.9 *Top* MNDWI average of Landsat data acquired from 1985 to 2010 for the characterization of the Pampa, vegetation areas and for the river courses. *Bottom row* Images depict some detail of rivers tracing the river course extracted from the MNDWI average value

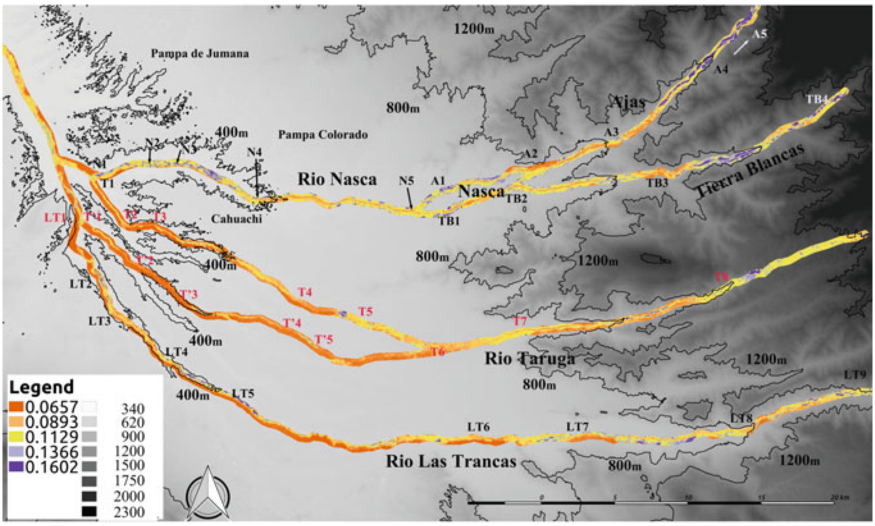

Fig. 22.10 MNDWI standard deviation of Landsat data acquired from 1985 to 2010

performed in some test sites in the Nasca drainage,[5] we consider the MNDWI values higher than −0.2 as significant for the presence of superficial riverine water. With the respect of time variation, we assume ***Std*** values ranging from 0.06 to 0.08 as significant for stable conditions (presence/absence of water along the river course), which typical are observed in the middle valley. ***Std*** values greater than 0.11 are considered significant for dynamic variations of river flow. In particular, we observe ***Std*** values ranging from 0.11 to 0.12 in the lower valleys, where water tend to re-emerge in some critical points, varying seasonally and yearly according to the rainfall. Finally, ***Std*** values in the range from 0.13 to 0.14 are observed in the middle-up valley (the so-called infiltration zone; Schreiber and Lancho Rojas 1995) where the water drops into the subsoil.

On the basis of the above assumed values of MNDWI and Std, we identified the different flow regimes pixel-by-pixel for the three rivers (see Tables 22.1, 22.2 and 22.3 and Figs. 22.9 and 22.10).

Figure 22.11 shows the maps of the yearly average MNDWI for 1985, 1996, and 2005. It is important to highlight, as expected, that the values of MNDWI in the arid

Table 22.1 Flow regime of Nasca River and its tributaries on the basis of multitemporal observation of MNDWI

River	Sector	Flow regime
Nasca	N1-N2; N4-N5; N5-A1	Ephemeral
	N2-N3	Perennial
	N3-N4; N5-TB1	Dry
Aja	A1-A3; A4-A5	Perennial
	A3-A4	Ephemeral
Tierra Blancas	TB1-TB3; TB3-TB4	Ephemeral

Table 22.2 Flow regime of Taruga River on the basis of multitemporal observation of MNDWI

River	Sector	Flow regime
Taruga	T1-T2; T4-T5; T7-T8; T′1-T′2; T′4-T′5	Ephemeral
	T2-T3; T′2-T′3	Perennial
	T3-T4; T5-T7; T′3-T′4; T′5-T′6	Dry

Table 22.3 Flow regime of Las Trancas River on the basis of multitemporal observation of MNDWI

River	Sector	Flow regime
Las Trancas	LT1-LT3; LT6-LT7	Ephemeral
	LT4-LT5; LT7-LT9	Perennial
	LT3-LT4; LT5-LT6	Dry

[5]The ground observation were made in several test sites located in the valleys of Río Taruga (Camotal, Santa Maria, San Carlos, Pajonal Alto, and Bajo), Río Nasca (Ocongalla, Las Cañas), and Tierra Blancas (Cantalloc, Bisambra).

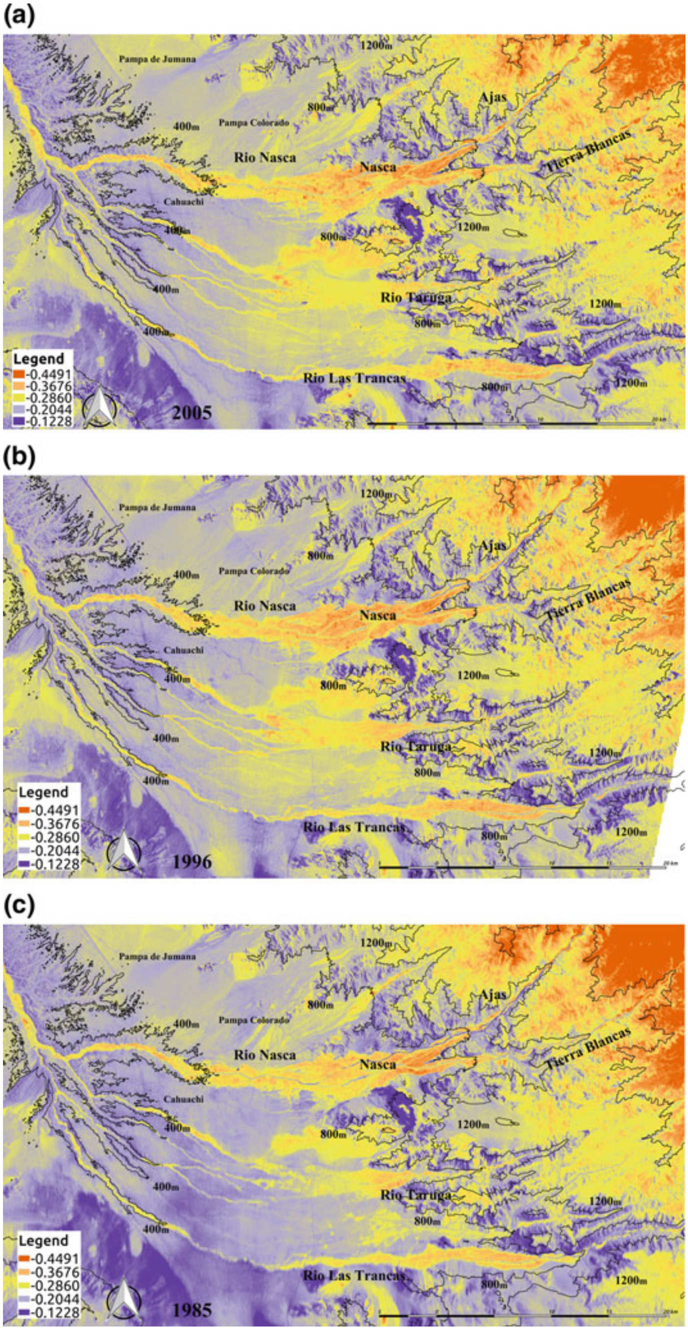

Fig. 22.11 Río Nasca drainage: yearly average of Landsat TM MNDWI computed for 2005 (*top*), 1996 (*middle*) and 1985 (*bottom*)

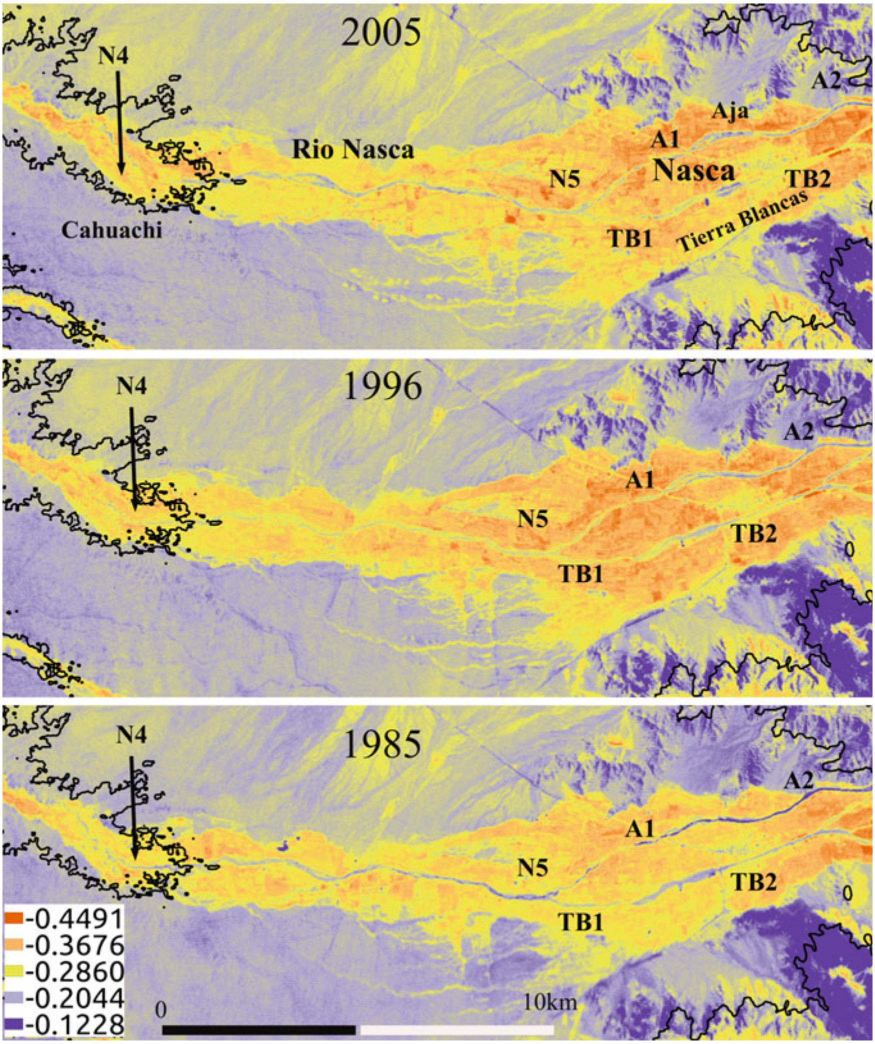

Fig. 22.12 Río Nasca valley: yearly average of Landsat TM MNDWI computed for 2005, 1996, and 1986

surfaces of the pampas and of the *Sierra* are higher than the vegetation cover of the river valleys due to the spectral characteristics of these surfaces. In order to overcome this drawback, the analysis is performed jointly with NDVI maps which enable us to leave out the bare areas and focus only on the river oasis. The water surface is always characterized by negative values of MNDWI ranging from −0.26 to −0.12, due to the fact that the water charge of the rivers and their tributaries is very low. Nevertheless, the difference of MNDWI values of water with respect to vegetation (from −0.44 to −0.28) is enough to discriminate and extract the river course. The annual observation, such as, e.g., those shown in Fig. 22.11, enables refinement of the characterization of the flow regime and the identification of the critical points where the rivers drop below the surface, especially in the middle-up valley. Figure 22.12 shows the variation of MNDWI observed for the years 1985, 1996, and 2005 in the Río Nasca Valley. In particular, it is important to note the prevailing ephemeral flow regime, which is interrupted by some sections of the rivers with a small amount of constant superficial water.

22.3 GIS-Based Analysis for Archaeology: Rationale and Results

22.3.1 Rationale

Predictive models were introduced for landscape archaeology studies from various authors over the last thirty years (see, e.g., Danese et al. 2014 and references therein quoted). Landscape archaeology focuses on the relationships between man and natural environment. Landscape is considered as a number of diverse phenomena, with each of them indicating cultural transformations in the investigated region. Consequently, as assumed by predictive models, starting from our knowledge of well-known archaeological sites, it is possible to use them as test-sites to understand which factors influenced their positions in the space. Existing relationships between the natural and social environments are studied, together with the location of sites, with the aim to find settlement rules to use inside the model.

Two main uses are made of predictive archaeology. The first is practical: its goal is to sensibly map areas and use this information to protect archaeological heritage. The second is scientific, and it is linked to the will to reconstruct the past, i.e., to better understand settlement patterns on the basis of parametric models.

Concerns the methods, most of the literature commonly use statistical ones, in particular: Markov's chain; Dempster-Shafer's belief theory; logistic or linear regression; and multi-fractal analysis. However, simpler methods such as map algebra functions are also used. Another important aspect in predictive models is the choice of parameters. In the literature, there is a great variability of considered factors, but just a few of them are always present. These are land use, elevation, and water bodies. Other parameters, both environmental and social, are less often employed.

The selection of parameters depends on the historical period to investigate and could be done in an inductive or deductive way. On the basis of the deductive approach, location rules derive from a theoretical approach and from the consequent theoretical knowledge of archaeological sites. From these elements, settlement patterns and land use criteria in the past are understood. Using the inductive approach, rules inserted in the predictive model are extracted on the basis of a dataset, composed by information of well-known sites or from data picked up from archaeological surveys and remote-sensing images.

In our investigations, the Kernel Density Estimation was used to obtain objective information about the spatial distribution and relationships between aqueducts, ancient settlements, and arable lands as calculated from the available satellite dataset. The analysis of the relationships between the spatial distribution of *puquios* and the settlements considered for diverse given periods can provide insight and indirect information about the dating of the *puquios*.

22.3.2 Method: Kernel Density Estimation

Kernel Density Estimation (KDE) is a spatial-analysis technique, used in the statistical field and applied to many application fields (for a deeper review, see Danese et al. (2008a, b) and reference therein) such as social and economical studies, physics and astronomy, agriculture, public health, epidemiology, crime analysis, and archaeology [see, e.g., Krist and Brown (1995), Fisher et al. (1997), Charlton et al. (2012)].

KDE is mainly useful to investigate the local-density properties of a spatial distribution. A classical, "global" density tells us how many events (for example, how many sites) there are per surface unit, with a unique number for the whole study area, whereas KDE is able to inform us on how density varies locally above the studied region, where there are high (hot spots) and low density zones (cold spots), and how high and low they are.

In human spatial phenomena, usually, hot spots and the closeness between similar geographical objects means a stronger relationships between them, and this is important also in archaeological study, in particular for what concerns the settlement pattern and the distribution of archaeological sites over the landscape.

In spite of this, KDE and its geographical version are still not widely used in archaeological research, in fact, just a few works exist in the literature (Danese et al. 2014).

From the analytical point of view, KDE (*l* function) is defined by the following expression.

$$\hat{\lambda}_{\tau}(s) = \frac{1}{\delta_{\tau}(s)} \sum_{i=1}^{n} \frac{1}{\tau^2} k\left(\frac{(s - s_i)}{\tau}\right). \quad (22.1)$$

The kernel k is a three-dimensional window that goes over each event of the studied point pattern and calculates the density around it. The dimension of the window (width) is defined by the bandwidth (t), while its height is defined from the intensity of events (s_i), that is, a quantitative attribute that characterizes it (e.g., in the archaeological field, it could be the number of findings or sites of archaeological interest). The window can have various three-dimensional shapes, according to the chosen kernel (k) function (Gaussian, etc.). Among all these parameters, the most important for a correct estimation is the bandwidth. Nowadays, no perfect method yet exists to define it. In this work, the nearest- neighbor, average distance between events (first or higher orders) is used as a representative distance between events and consequently as the bandwidth.

22.3.3 Relationships Between Archaeological Sites and the Puquios

To investigate the spatial distribution and relationships between aqueducts, ancient settlements, and spectral indices, KDE was applied. *Puquios* and ancient-sites distributions were compared to assess the degree of their spatial autocorrelation as calculated from the available satellite dataset, summarized in Fig. 22.13. In particular, the spatial distribution of the *puquios* were compared with the settlements belonging to four different periods: (i) Early Nasca (Phases 2–4, 1–450 AD), (ii) Nasca Phase 5 (450–550 AD) Late Nasca (550–750 AD) and (iii) Late Intermediate Period (1000–1476). The location of the sites had been obtained by data available from the literature, in particular from Schreiber and Lancho Rojas (1995), Silverman (1993), Silverman and Proulx (2002), and Proulx (1998).

Figure 22.14 shows the results of comparative pattern analysis based on KDE of *puquios* and settlements in Early Nasca, Nasca 5, Late Nasca, and Late Intermediate periods. In the Early Nasca, no overlapping of patterns of *puquios* and settlements are visible. In Nasca 5, high-density values of KDE of *puquios* and settlements are

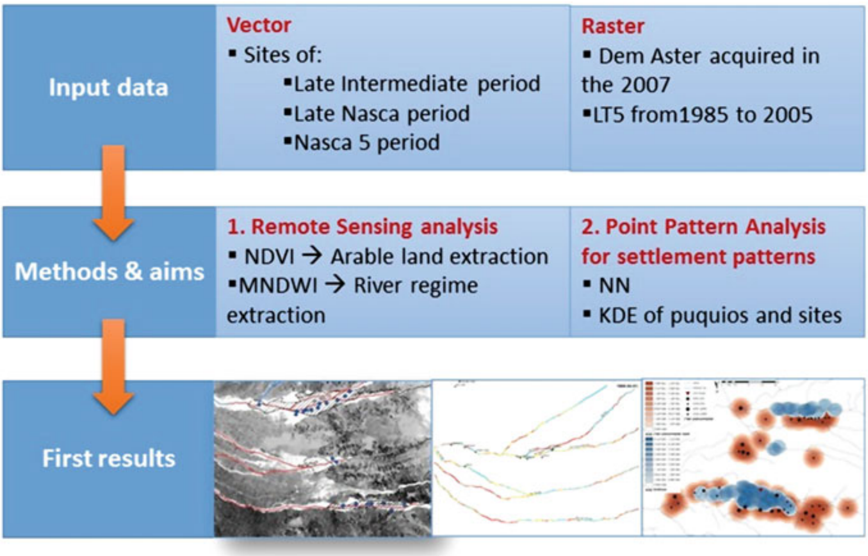

Fig. 22.13 Flow chart of the methodological approach used for analyzing the relationship between *puquios* and settlements over time

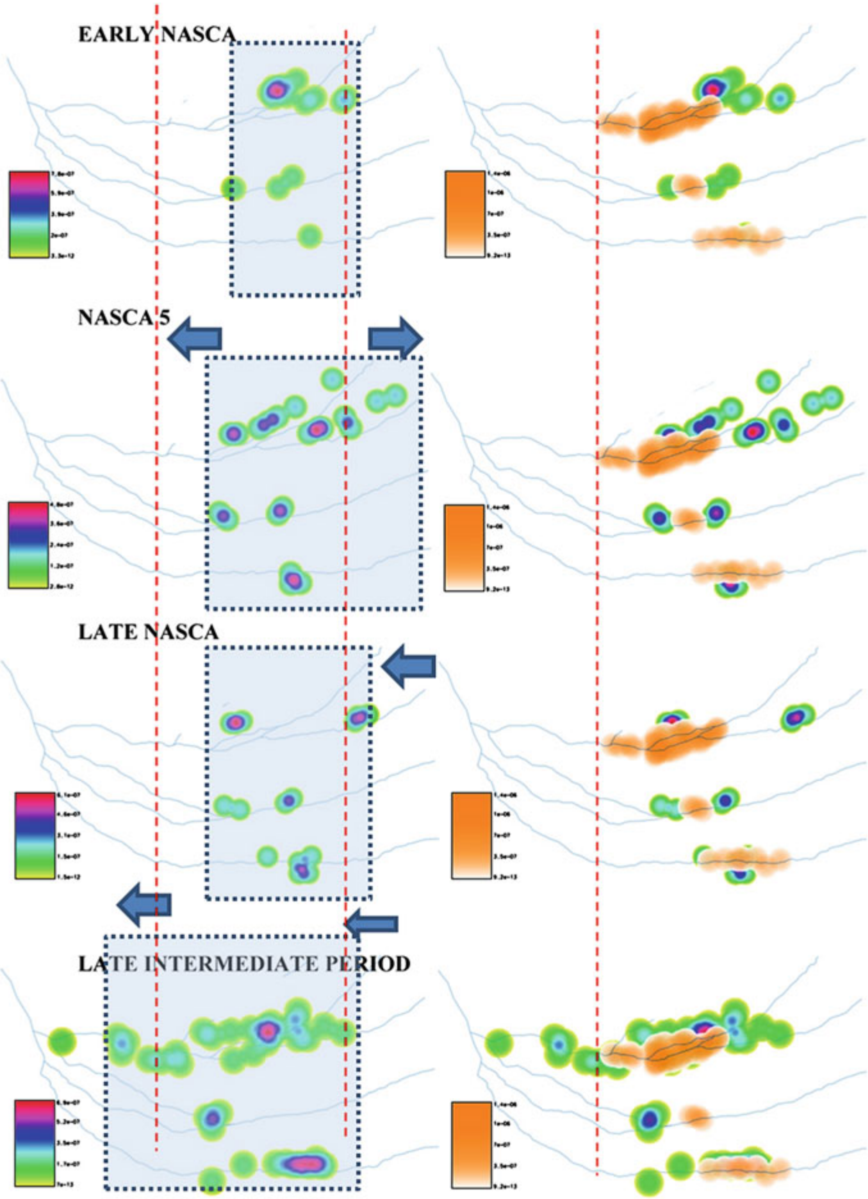

Fig. 22.14 Comparative pattern analysis based on KDE of *puquios* and settlements in Early Nasca, Nasca 5, Late Nasca and Late Intermediate periods

partially overlapped in the Río Nasca Valley (from the Nasca River to the beginning of Aja and Tierra Blancas tributaries) and the Río Las Trancas Valley. This indicates an increase of settlements compared to Early Nasca period and a first phase of coexistence of aqueducts and habitation sites. In Nasca 5, a significant expansion of the settlements, in particular eastward, occurs. In Late Nasca, a contraction of the settled area and a reduction of the number of settlements take places. This was mainly due to the changes occurring in the number and size (minus and plus compared to the previous phase, respectively) of settlements coupled with a more complex social organization. The areas, characterized by the overlap of high-density values of KDE of *puquios* and villages, are located in Río Nasca and Río Las Trancas.

In the Late Intermediate Period, a significant expansion of the settled area, both eastward and westward, and an increase in the size of settlements (Schreiber 2003) takes place.

In particular, a high correlation is found between settlements and *puquios* in the valleys of Las Trancas and Río Nasca, including its tributaries Tierras Blancas and Aja. It is interesting to note that the areas with a high density of *puquios* are similar to areas characterized by higher values of NDVI.

Pattern analysis based on KDE seems to confirm the hypothesis of Schreiber and Lancho Rojas (2006) about the origin of *puquios* in the Nasca 5 period as a response to the prolonged drought that occurred on a global scale. To cope with this adverse situation, the population moved towards both (i) the higher areas (east) where they easily found the water available from superficial rivers and (ii) down to the medium valley (west) where they started to systematically exploit the available subsurface water by building the *puquios*. Additional confirmations of this hypothesis are provided by artifacts found during the field survey by Schreiber (1995–2006) in at least two *puquios*: the Pangaravi puquio in the Tierra Blancas Valley and Totoral puquio in the Las Trancas Valley. Settlements dated to the Nasca 5 in the medium valley could only have been possible with the *puquios* which enabled human life and made productive a desert land where the only source of water was provided by the subsurface rivers and the water table.

In Late Nasca, no particular changes with respect to Nasca 5 seems to have occurred, partly a contraction of the settled area due to the increase in size of the settlements. Finally, a stronger expansion of settlements and a larger overlap between settlements and *puquios* could be observed in Late Intermediate period.

This is also confirmed by many archaeological finds and clues, such as, e.g., Silverman (1990) who theorized that, in the Nasca Valley, the presence of late sites, such as the Middle Horizon Pacheco (Paulsen 1983) and Late Horizon Paredones, were likely linked to the availability of the pre-existing Nasca water-supply system.

22.4 Río Taruga Valley: The Contribution of Geophysical Prospecting

Compared to the other valleys of the Río Nasca drainage, the Taruga one that is characterized by having very a few puquios compared to its potential arable surface: five puquios on about 26 km^2, considering its eastern and western borders as

Travesia and *Pajonal Bajo*, respectively. Among these five puquios, two are still functioning (Santa Maria and San Carlos), one is abandoned in Camotal, and the other two are "puquios *perdidos*", which have been herein located (following Josue Lancho indications) and mapped using high-resolution satellite data (see Sect. 22.5). The Río Nasca Valley, including the tributaries of Aja and Tierra Blancas, is characterized by 29 functioning puquios for a potential arable land of about 52 km^2, having as eastern and western borders Orcona and Ayapana, respectively. Finally, in the Las Trancas Valley, the potential arable land has a surface of about 12.5 km^2 and in the past was irrigated by a water catchment system composed of eight puquios, according Schreiber and Lancho Rojas (1995), plus two more recently discovered by the ITACA mission (as discussed in Sect. 22.5).[6]

In summary, the ratio between potential arable land surface and puquios for the three valleys of Nasca, Taruga, and Las Trancas are 1.8, 5.2 and 1.25 km^2/puquio, respectively. From the highest value of this ratio, for Taruga valley with respect to the others arises the question whether in the past there were more puquios than those known today.

The state of our knowledge does not make it possible to answer the above question. However, it is reasonable to think that, in the past, there was a greater number of water-supply systems, including puquios, that were able to irrigate the extensive areas of Pajonal Alto and Bajo (though in the past they were smaller than today, but still significant) where we do not have any information about the presence of puquios.

In 2016, a joint scientific and archaeological research campaign by Proyecto Nasca and ITACA mission is starting. The aim is to investigate an area of great interest because of the presence of a habitation site, some geometrical geoglyphs (mainly lines and trapezoids), and three puquios in a radius of 1.0–1.5 km.

In 2012–13, a geophysical prospecting campaign took place to characterize the subsoil from the unsaturated zone to the top of the groundwater table. To this aim, two areas had been selected. The first one is nearby to the functioning puquio of Santa Maria, which takes the water from the river. The second investigated area in Camotal, where a buried *puquio* had already been roughly identified and investigated by Lasaponara and Masini (2012b, c).

The geophysical method employed was electrical-resistivity tomography (ERT), which consists of the measurements of the resistivity of the subsoil to characterize the relationship between the vadose zone and the groundwater. The vadose zone is the part of the subsoil between the ground surface and the top of the phreatic zone, where the water is at atmospheric pressure.

The ERTs were carried out by a georesistivimeter (Syscal) connected to a multichannel electrical cable, consisting of two multichannel cables of 24 channels with an electrodes spacing of 5 m. A Schlumberger automatic-array configuration was used, which transmits an electric current (I) into the ground via two contiguous

[6]The considered arable land is delimitated on the eastern side by the Joya puquio and on western side by the Huayurì puquio.

electrodes (AB), and the potential drop (ΔV) is measured between several sets of coupled electrodes (MN). In order to obtain a 2D-real resistivity model, the apparent resistivity values were inverted by means of inversion algorithms.[7] The step were the following: (i) arrangement of the data for the inversion; (ii) selection of the inversion type and parameters; (iii) application of the Occam method[8] capable of transforming the apparent resistivity pseudo section into a model that represents the distribution of the calculated electrical resistivity in the subsurface (Constable et al. 1987).

The smoothness method adjusts the 2D-resistivity model trying to iteratively reduce the difference between the calculated and measured apparent resistivity values. The root mean-squared (RMS) error provides a measurement of this difference. In all, the difference between ERT the RMS was <7%.

22.4.1 Geophysical-Data Analysis and Interpretation

In the Taruga valley, nearby the *puquio* of Santa Maria, the measurements were performed to obtain information about the diverse parts of the aqueduct (Fig. 22.15). The latter is located on the north side of the Taruga River (the source of water) and flows parallel to it. The survey conducted during the geophysical prospecting placed into evidence an articulated structure composed of a tunneled gallery, followed by a filled gallery with 28 square chimneys (*ojos*), and, finally, an open trench which pours water into a concrete walled reservoir (Fig. 22.16).

Two ERT profiles were carried out (Fig. 22.15). One named T1 is north-east oriented, the second (T2) is east-west oriented, located at south of the puquio (Fig. 22.15). The ERTs were acquired by a multichannel system (48 electrodes) with an intermediate electrode distance of 5 m. This configuration made possible a 230-m section and an investigation depth of about 30 m (Fig. 22.17).

The resulting resistivity images depict two main electro-layers (Fig. 22.17): a shallow one is a relative resistivity layer (>300 O.m) with a thickness of about 8–11 m; on the contrary, the deeper one is a relative conductive layer (<150 O.m). From a hydrogeological point of view, the resistive shallow layer can be interpreted as a vadose zone, the deep conductive layer as an aquifer zone (or saturated layer). Moreover, the ERT T1 (Fig. 22.17 top) highlights an increased thickness of the relative resistive layer in the direction of the river, while the ERT T2 (Fig. 22.18 bottom) indicates a constant vadose layer. Figure 22.18 also contains a 3D-ERT image of the investigated area depicting the interpreted aquifer level.

Higher conductivity values, likely referring to water's presence, are observed around 15 m deep, along the east-west profile (T2, Fig. 22.17 bottom) parallel to

[7]For the processing of ERTs, the software ZondRes2D was used.

[8]It is an inversion by the least-squares method, using a smoothing operator and additional contrast minimization.

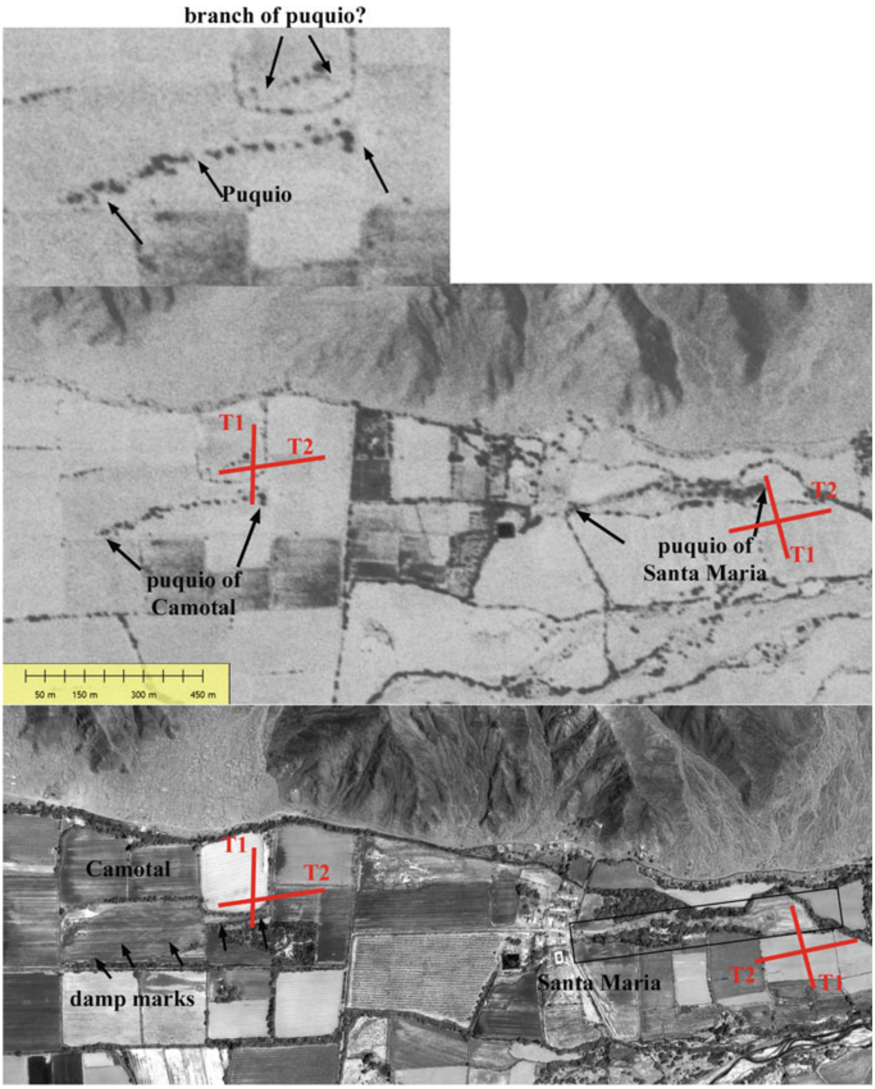

Fig. 22.15 Detail of the Río Taruga Valley observed from a 1966 Corona declassified satellite image (*middle*) and 2013 Pleiades image (*bottom*). A detail of the Corona image is showed up on the left. *Red lines* indicate the ERT profiles acquired nearby the puquios of Camotal and Santa Maria. The Camotal one has been identified from the 1966 Corona image where shrubs and trees are visible along the possible path of the buried aqueduct. In the 2013 satellite image, some damp marks are the only traces indicating the presence of the puquio. The image up (*left*) shows some vegetation markers suggesting the presence of a buried branch of the puquio, which has been confirmed by geoelectrical prospecting

Fig. 22.16 Puquio of Santa Maria. General view of the aqueduct and details of chimneys surrounded by a square, stepped structure built with pebbles

the river, and 14–16 m deep along the north-south profile (T1, Fig. 22.17 top) perpendicular to Río Taruga. The ERTs were not able to detect the geometry of the gallery because they are too small compared with the resolution of the technique for deep targets.

Camotal is located about 1 km west of the Santa Maria puquio, on the north side of the Taruga River. A 1944 aerial photograph clearly shows it (Schreiber and Lancho Rojas 2006). A precise identification of the path was possible by using a Corona image acquired on 1966 (Figs. 22.15 and 22.19 top), where it is possible to observe some trees of willows (*Salix Humboldtiana)*[9] and shrubs along the route of the puquio. The Pleiades image acquired in 2012 shows also some damp and/or crop marks along the path identified from the Corona photo of 1966. Today it is no longer functioning and appears as an open trench. However, some traces observed by satellite data reveal the presence of a buried gallery.

In Camotal, two geoelectrical profiles were acquired (Fig. 22.19, middle). One (T2) is east-west oriented and located 60 m north of the puquio. The second one (T1) is south-north oriented, crossing the buried puquio. In Camotal, ERT were acquired with the same configuration as in Santa Maria.

Two main electro layers are depicted: a shallow relative resistivity layer (>300 O.m) related to the vadose zone with a variable thickness (6–10 m) and a deep relative conductive layer (<150 O.m). The two profiles provided interesting

[9]*Salix humboldtiana* is a tree species of willow which is found along watercourses and puquios in the Nasca drainage. In some cases, they represent a proxy indicator of the presence of surface-water aquifers and abandoned *puquios*.

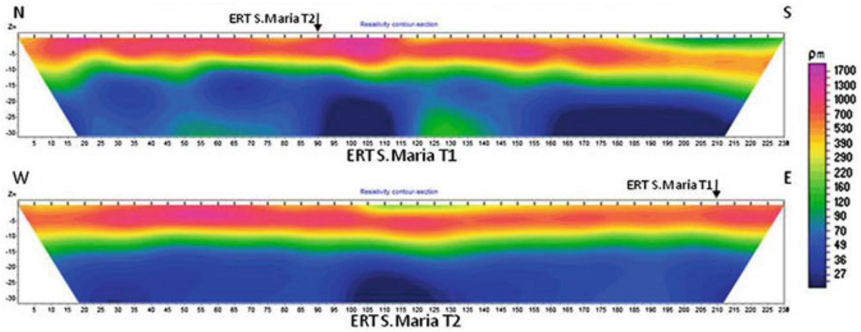

Fig. 22.17 Puquio of Santa Maria: ERTs acquired along the profiles (*top*) T1 and (*bottom*) T2

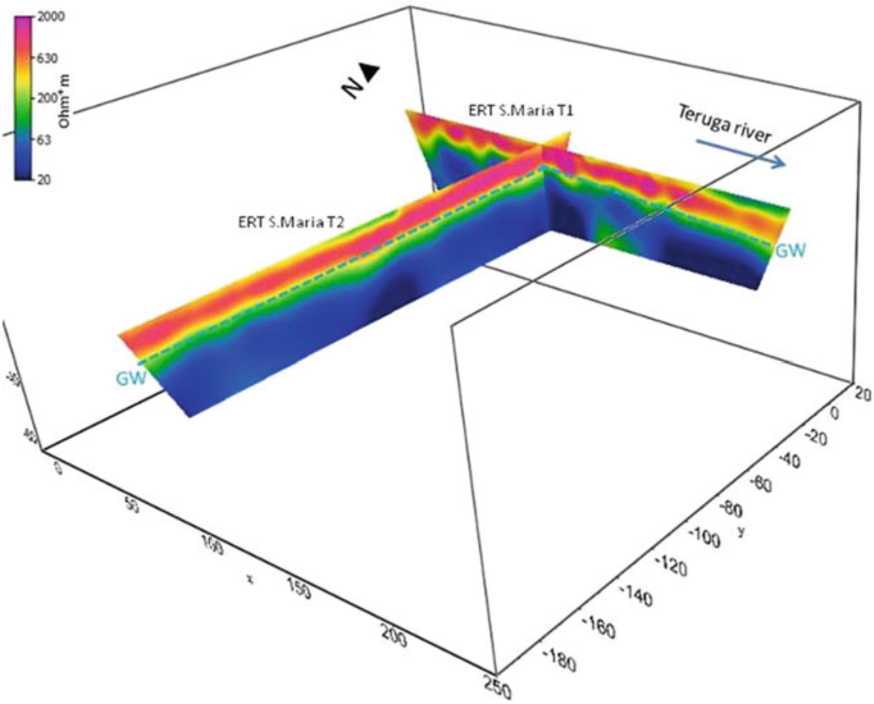

Fig. 22.18 3D visualization of the two ERT profiles in Santa Maria (the *blue dot* line indicates the hypothetical piezometric level at depths ranging from 13 to 20 m)

results not only for the water-table characterization but also for the identification of the ancient puquio. In particular, T1 profile shows clearly indicates a shallow conductive layer with a length of 20 m (Fig. 22.19 middle), corresponding to the puquio. At abscissas 90–120 m, a morphological conductive feature suggests the presence of another gallery, probably a branch of the puquio, as already partially

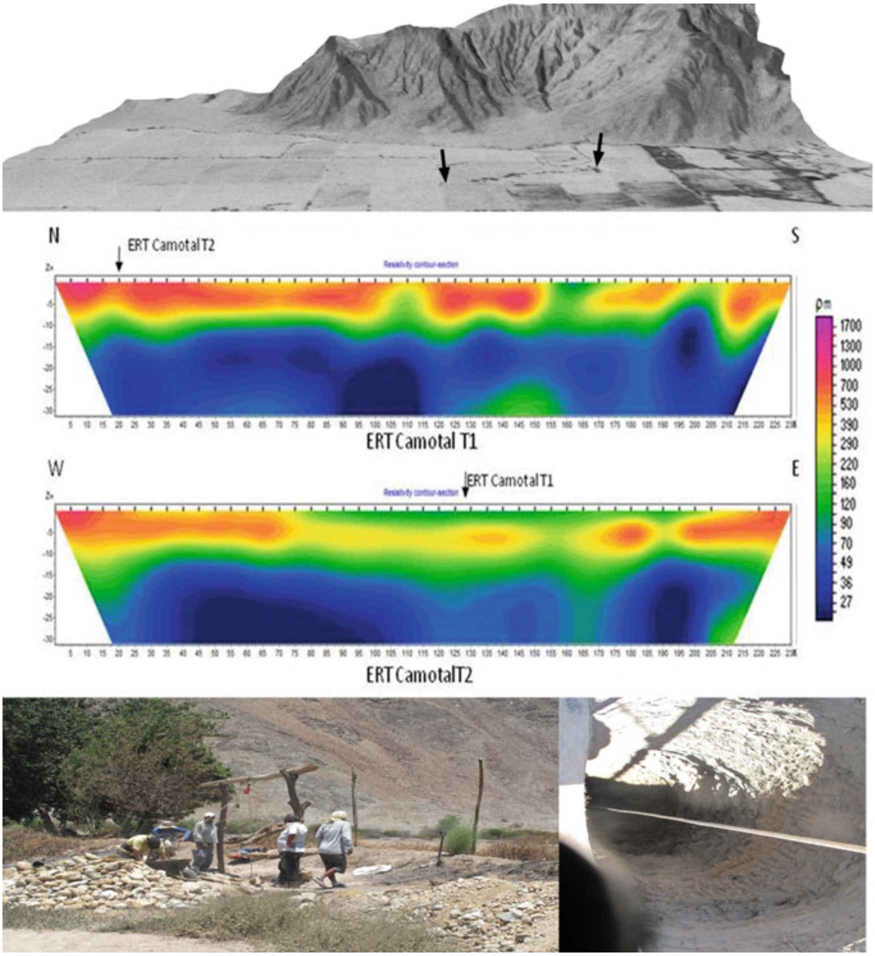

Fig. 22.19 *Top* 3D-Corona image of 1966 of the puquio of Camotal in the Río Taruga valley. *Middle* In geoelectrical profiles, *red circles* denote the points where the profile south-north crosses the puquio and a buried branch of the same puquio. *Bottom* A well nearby the investigated area

visible from the Corona image (Fig. 22.15 top left). The above mentioned conductive elements are at depths of 8 and 10 m, respectively. The direct measurement of the depth of the water level, in a well nearby the geoelectrical profile well, fit with ERT results (Fig. 22.19).

T2 profile confirms the depths related to the top of conductive layer ranging from 10 to 12 m. Moreover, the ERT highlights an interrupted shallow resistive layer in the middle part (abscissas 75–160 m). Finally, we can notice also an interruption of the conductive layers. This, along with the lack of maintenance, was probably the cause of the abandonment of the puquio. As a whole, comparing the ERT results obtained in Santa Maria and Camotal, we can say that the first exhibits a homogeneous pattern for both the resistive and conductive layers. The second shows some interruptions in the resistive layers (vadose zone) as well as in the conductive layers related to the presence of water.

22.5 Detecting Lost and Abandoned *Puquios* Using High-Resolution Satellite Imagery

The crossed observation of MNDWI and NDVI maps documents evidence of areas where it is very likely to find *puquios* or abandoned branches of still functioning puquios. These areas were further investigated using very-high- resolution satellite data able to detect changes in surface parameters due to the physical/chemical interactions between structures and filled-trench galleries and their neighboring soils. In the areas covered by vegetation, these changes appear as subtle spatial discontinuities or variations in the reflectance values (i.e., tones or colors) of vegetation and soil surface. Moreover, the visibility of these subtle traces (that are generally not visible in situ) appearing as crop/weed and soil marks, having a intra- and inter-year variability due to changes in crop types and phenology, soil-moisture content, and other surface parameters. This means that the visibility of traces linked to potential lost *puquios* can be profitably enhanced by multi-date observations.

In the desert areas, the identification of marks related to lost *puquios* based on remote sensing can be improved also by taking into account additional characteristics, such as the geometric pattern, i.e., the morphology linked to the presence of chimneys and the berm. Following this approach, several traces of sections and branches were identified for both known and unknown *puquios*.

Starting from known *puquios*, Fig. 22.20 shows the 2D- and 3D-views of the Conventillo *puquio*, located on the west side of the Nasca River (Fig. 22.20a–b). From (c) to (f), note the multitemporal observations related to various years and months, respectively in August 2002 (Fig. 22.20c), September 2009 (Fig. 22.20d), May 2011 (Fig. 22.20e), and June 2013 (Fig. 22.20f). In particular, the traces of surface-moisture changes are more evident in May, in accord with the fact that this period is generally characterized by greater water availability, thus making visible some buried irrigation canals (Fig. 22.20e).

The multitemporal space observation of Cuncumayo and La Joya, located in the Aja and in Las Trancas irrigation sectors, respectively, show old, buried channels and branches of *puquios* (Figs. 22.21 and 22.22). In particular, Fig. 22.21 shows two satellite images of Cuncumayo, acquired on May 2002 and August 2013. Some notes on this puquio are in a report of field surveys made in 1934 by Gonzalez Garcia (Schreiber and Lancho Rojas 2006) who described it as an open trench, flowing alongside a bedrock outcropping that forms a ridge extending into the valley. The 2002 satellite image shows an open-trench puquio 560-m long. At south of this *puquio*, we observe sparse vegetation, and damp and crop marks aligned along a path which reasonably could refer to the presence of a buried puquio.

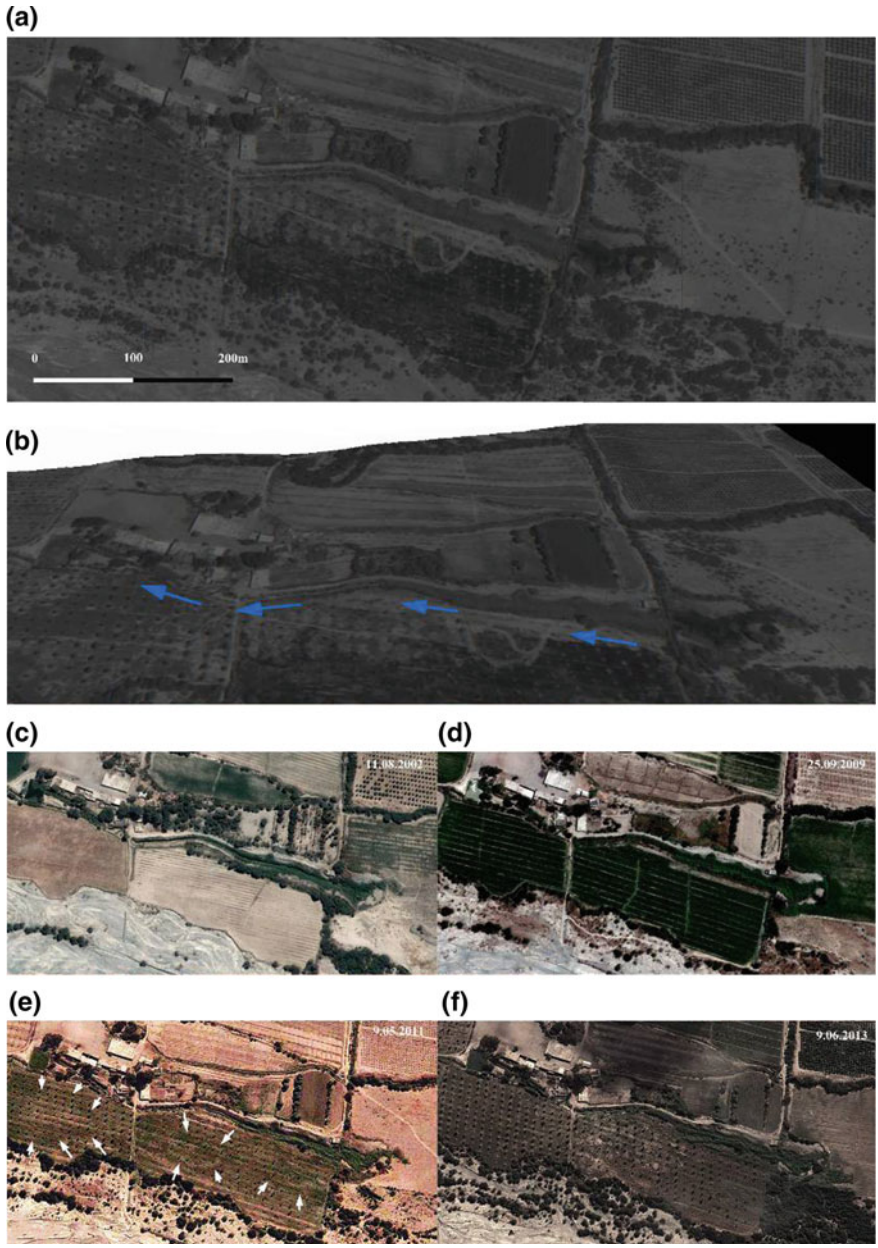

Fig. 22.20 **a** and **b** show 2D and 3D space views of a section of the Conventillo puquio, respectively (from satellite Pleiades data acquired on 28.11.2012). **c–f** Multitemporal view of the same section as in parts (**a**) and (**b**) (Google Earth images). In particular, the pictures show inter- and intra-year changes in surface moisture and vegetation, due to the subsurface-water availability. **e** The scene acquired on May 2011 documents the presence of buried irrigation channels

Fig. 22.21 Multitemporal space view of the Cuncumayo puquio located in the Aja irrigation sector and abandoned more than 30 years ago. It was a deep, open-trench type flowing alongside a bedrock outcropping that forms a ridge extending into the valley. The two images, from Google Earth, were acquired in August 2002 and December 2013, respectively

The question is: did the two *puquios* coexist? or was only one of the two functioning in the past (the 'buried *puquio*'), and then, after being abandoned, a new puquio was built. In our opinion, considering that the path of the old puquio seems to converge in the same point where the current puquio ends, we exclude the hypothesis that it was only a branch but conclude it is the old section of the aqueduct.

Figure 22.22 is related to La Joya puquio. It was well depicted in an aerial photo acquired in 1944 that clearly showed six large conical *ojos* (Schreiber and Lancho Rojas 2006). The puquio was filled in 1950. Thanks to satellite images, it has been possible to map it and to observe phases of the construction of the aqueduct. In particular, shrubs, trees, and damp and cropmarks are aligned along one of the two paths which indicate the presence of subterranean galleries, as branches of the main

Fig. 22.22 Multitemporal space view of the Joya puquio, located in the *Las Trancas* irrigation sector. The two images were acquired in August 2002 (*top*) and June 2013 (*bottom*)

puquio section. Other marks seem to refer to some changes in the path of the same puquio. Finally, some crop marks (denoted by red arrows) indicate the presence of a buried canal for irrigation.

The availability of a 1966 Corona image provides information on the presence of potential puquios or past branches later modified and not anymore visible in the modern satellite pictures, as in the case in Camotal.

By integrating the 1966 Corona photo with the 2012 satellite image and ERT prospecting results, it has been possible to reconstruct the original pattern of the puquio in Camotal, which, along with those in Santa Maria and San Carlos, made possible agricultural development in the upper part of the Río Taruga Valley.

Finally, the processing of Pleiades multispectral imagery enabled the discovery of two filtration galleries, on the left border of the Las Trancas riverbed. The first, named LT9, is located between the *puquios* of Pampon and Totoral. It seems to have been built as tunneled and filled-trench galleries, characterized by a number of

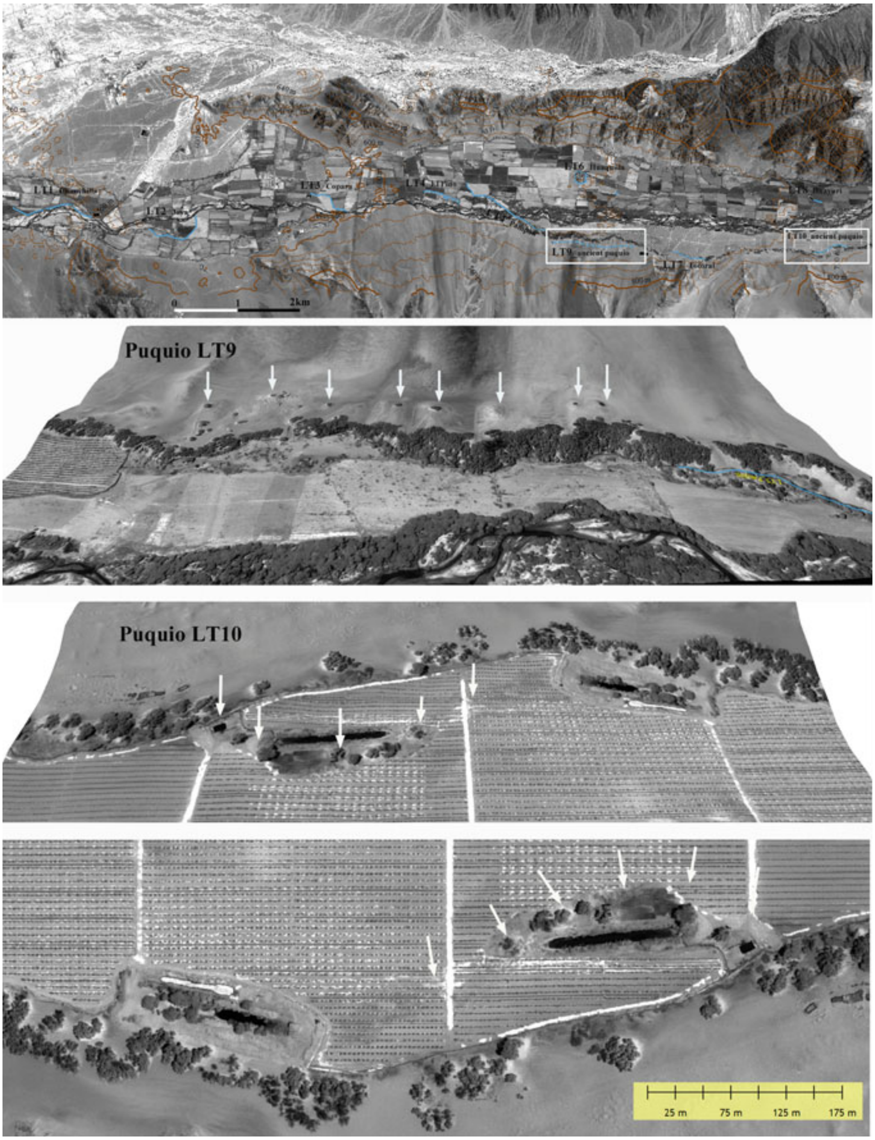

Fig. 22.23 *Las Trancas* valley: discovery of two *puquios* located along the southern border of the river and named LT9 and LT10 (see Table 13.4 in Chap. 13). The latter could refer to a puquio hypothesized by Josue Lancho (named *La Marcha*) thought to be in front of the puquio of Huayurì

chimneys. The second, named as LT10, is located east of the Totaral puquio, in front of the Huayuri one.

It could refer to a puquio hypothesized by Lancho and named as *la Marcha*. Unfortunately, the presence of vegetation makes difficult the identification of building techniques (Fig. 22.23).

22.6 Conclusion

From the analysis of time series of Landsat maps from the 198n0 s up to now, it has been possible to spatially characterize the intra- and inter-annual variations of both NDVI and MNDWI. In particular, the analysis of NDVI, a proxy of vegetation cover, and MNDWI, an indicator of moisture content, enabled us to assess the intra and inter-year water availability, as well as to estimate with high spatial and temporal detail the hydraulic regime (perennial, ephemeral, dry) of the rivers and tributaries of the Nasca drainage. Moreover, the multitemporal analysis enabled us to dynamically identify the critical points where in the 'infiltration zone' of each river drops below the surface, to remerge several kilometers away in the lower valley.

The arable land was also calculated by an unsupervised classification performed on the first component of the PCA applied to a time series of yearly NDVI maps computed for 1985–2010. This important information is useful to understand the ability of the ancient Nasca populations in developing effective and complex agro-ecosystems to meet the demands of a large population.

Combining the archaeological information, data, and dating hypothesis reported in the scientific literature, with the results of satellite multitemporal analyses, in a GIS environment, it was possible to obtain a first rough predictive tool for recognition of the presence of *puquios*. GIS analyses based on KDE showed the spatial and temporal dynamics of settlements and *puquios* from the Early Nasca to Late Intermediate periods. This established two main periods of development: one in Nasca 5/Late Nasca; the second in the Late intermediate Period; these were results of settlement expansions eastward, in the first case, and westward, in the later period (Fig. 22.14).

In Río Taruga, geoelectrical investigations were carried out near two *puquios*: Santa Maria and Camotal. The first is still functioning; the second is abandoned. The ERTs proved to be capable of characterizing the subsoil, from the vadose zone to groundwater, as well as in providing information useful to detect buried galleries.

The availability of historical, declassified satellite pictures enabled us to precisely locate known *puquios*, characterizing them by their articulated structures composed of branches.

Finally, unknown *puquios* and abandoned branches of galleries have been detected in the Las Trancas and Aja Valleys by VHR satellite imagery, using some proxy indicators such as linear or curvilinear alignment of vegetation (shrubs and trees), and damp and weed marks, which in many cases are the only traces which typically remain of abandoned and buried trench galleries.

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Chapter 23
Geomatics Applications in Cahuachi and Nasca Territory

Gabriele Bitelli and Emanuele Mandanici

Abstract Several geomatics techniques were applied and integrated for the ceremonial center of Cahuachi and the Nasca territory, including GNSS surveys, digital-elevation-model generation from satellite imagery, and close-range photogrammetry. Accurate 3D models of the landscape in which the archaeological site is set and, at different scale, of structures and individual archaeological finds constitute a powerful means of documentation and study.

Keywords Geomatics · Remote sensing · Digital Elevation Model (DEM) · Close-range photogrammetry · 3D modelling

23.1 Introduction

The application of the techniques and methods of Geomatics Engineering is becoming more and more a standard approach in archaeology for documentation, surveying, and monitoring at different levels and scales: cultural landscapes and territories, entire sites, single buildings or monuments, and single objects. The integration of diverse modern surveying instruments is in fact a key factor for conservation, maintenance, and restoration work requiring accurate and complete documentation (Bitelli 2008).

At Cahuachi and in the wider Nasca territory, in the context of the scientific activities of the Itaca Mission of CNR, several geomatics techniques were applied with different aims, from Global Navigation Satellite System (GNSS) to satellite remote sensing, from digital photogrammetry to modern topographical techniques. Georeferencing all the data in a common geographic/cartographic frame enables integration of the various results in the context of a GIS (Geographical Information System), able to support the current archaeological work and to plan future developments.

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The chapter summarizes some examples of geomatics activities carried out for the area, focusing on activities performed during a field campaign conducted in 2013.

The chapter is organized according to the techniques applied.

23.2 GNSS Surveying

The use of various geospatial data, encompassing satellite imagery, digital elevation models, and existing maps, requires the definition of a common spatial reference system, in order to integrate all the information coherently (Bitelli et al. 2013).

Since many satellite platforms are designed to provide data worldwide and these data are referred to a global reference system, the adoption of an international frame can be the most current convenient choice[1]. The ITRF2008 (International Terrestrial Reference Frame), which is the most recent realization of a world spatial reference system, was therefore adopted.

A reference point was established on the roof of the Antonini museum at Nasca, and its position was measured using a dual frequency GNSS receiver. The acquisition process lasted several hours, and the recording was processed by precise point-positioning (PPP) techniques (Zumberge et al. 2004), making possible a precision in absolute positioning of about ten cm (Barbarella et al. 2009). In order to obtain the a.m.s.l. altitude, the geoidal undulation computed by the EGM2008 model was applied (see discussion below). The reference point served as master station for the surveying activity inside the archaeological area of Cahuachi (Fig. 23.1) and in the Nasca river valley. In particular, some ground-control points were measured at Cahuachi, adopting the rapid-static technique, to be used for accurate georeferencing of satellite imagery.

Using the same rapid-static technique, three points were measured also in the archaeological site of Paredones, near the modern Nasca town (Fig. 23.2).

All these points may be of course used also to frame existing surveys and maps within the international reference system.

Some kinematic surveys, yielding the positions of a moving GPS antenna in respect to a fixed one (master station), were furthermore carried out in order to georeference geophysical prospecting sites (see Chap. 20) and to topographically correct them. This enables an accurate reconstruction of the geometry of the underground stratigraphy. Figure 23.3 shows the measurement of the elevation profiles of the terrain along the lines of the geoelectrical survey in Cahuachi. The same activity was conducted in one area near Río Taruga valley.

GNSS techniques can be applied also to describe the morphology and the micro-relief of topographic features of archaeological interest. Figure 23.4 shows a highly detailed Digital Elevation Model (DEM) of a small mound inside the area of

[1] In addition to the standard UTM grid, four Transverse Mercator Grid systems were used in Peru in the past

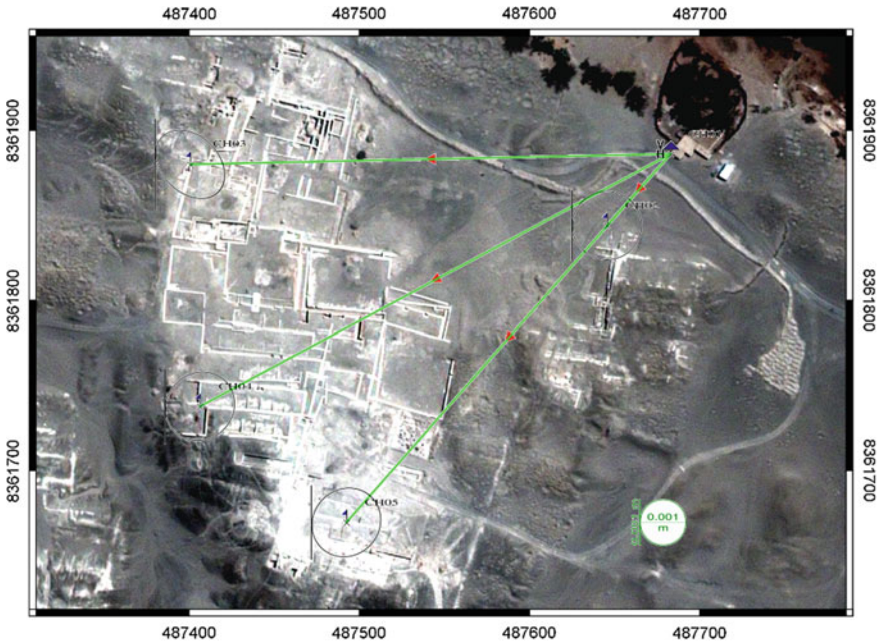

Fig. 23.1 Cahuachi, computation of Ground Control Points. The ellipsis and vertical bar for each point refers to the planimetric and vertical accuracy of the retrieved position; the rightmost vertex was connected with the reference point at the Antonini museum

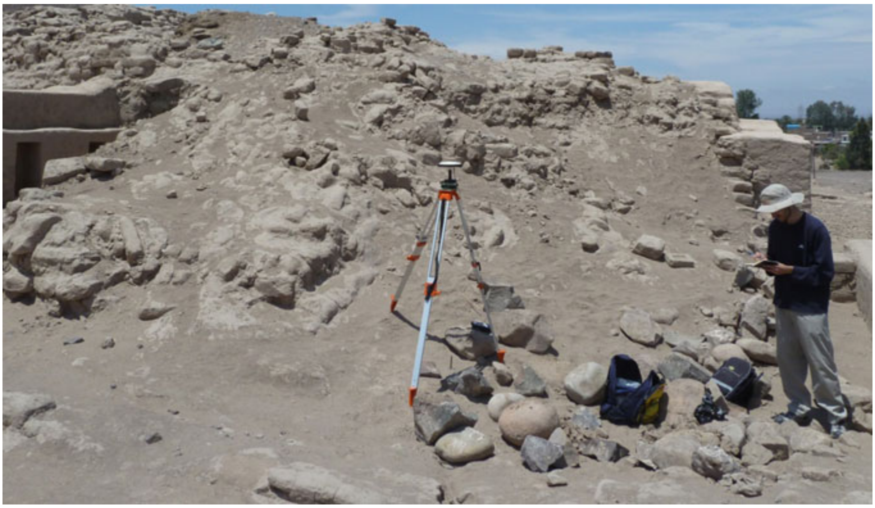

Fig. 23.2 GNSS acquisition in Paredones

Fig. 23.3 GNSS kinematic survey along a geoelectrical line in Cahuachi

Cahuachi, generated by a kinematic survey; the dense three-dimensional point cloud obtained was interpolated using a kriging technique. The final product has a spatial resolution of 0.3 m; vertical accuracy is less than 10 cm. GNSS techniques have been also used for mapping looted areas already investigated by satellite remote sensing (see Chap. 25 and also Lasaponara and Masini 2010).

23.3 Remote Sensing and Digital Terrain Modelling

Satellite and aerial images are now commonly used for site exploration and landscape archaeology, because of their capability to provide information covering large areas with an increasing spatial resolution.

Among the most important base products that can be obtained are Digital Elevation Models (three-dimensional surfaces describing the morphology of the

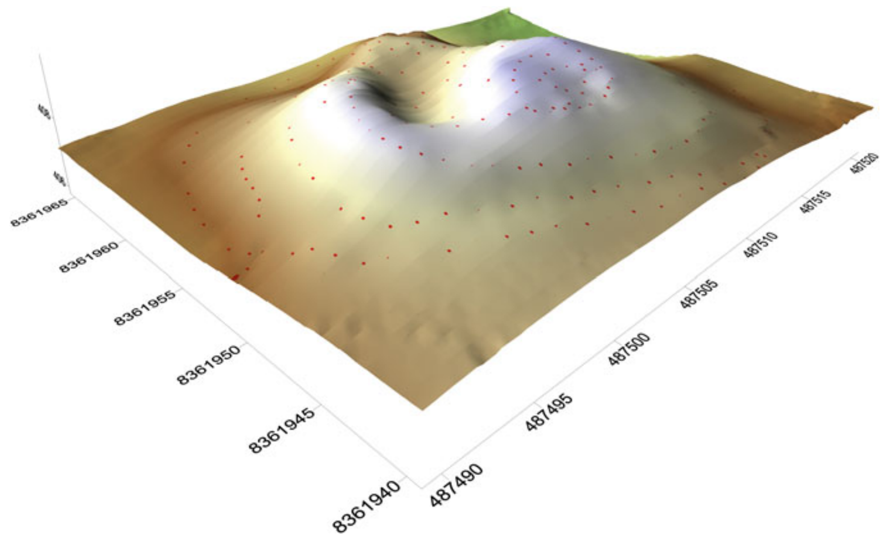

Fig. 23.4 Digital elevation model obtained by GNSS kinematic survey of a small mound inside the archaeological site of Cahuachi

terrain) and orthophotos. Through photogrammetric techniques, it is possible to derive a DEM of a portion of terrain from a stereo pair of images acquired from different points of view (Bitelli et al. 2013). Among the satellite platforms that offers this kind of products, a GeoEye-1 stereo-pair was chosen to generate a model of a portion of the Río Nasca Valley including the ceremonial center of Cahuachi (Orefici 2012; see also Chap. 15) and the geoglyphs of Pampa de Atarco (Fig. 23.5; see also Chap. 12). GeoEye-1 is able to collect images at 0.41 m spatial resolution for panchromatic band and 1.65 m for multispectral bands at nadir, with a revisiting time of three days.

The process requires some ancillary data, including the coordinates of a set of control points. The generated elevation model covers an area of about 60 km^2 with a spatial resolution of 5 m. The same model can be used to produce a high resolution orthophoto, which is an undistorted image having the same geometric properties as a map. The georeferencing accuracy of this product is largely influenced by the accuracy of the coordinates of the ground-control points and by the number of points used. However, it can rarely be better than once or twice the 0.5-m spatial resolution of the original image (Meguro and Fraser 2010).

The height measurements of the terrain, which can be obtained by satellite imagery, are usually ellipsoidal heights, because the position of the satellite and the orientation parameters of the images are expressed in a global reference system, i.e., WGS84. The difference between ellipsoidal height and orthometric height, which is the one commonly used, is the geoid undulation. When site specific data are not available, this value can be derived from global models, such as the EGM2008 (Earth Gravitational Model) (Pavlis et al. 2012), and must be subtracted from the ellipsoidal height.

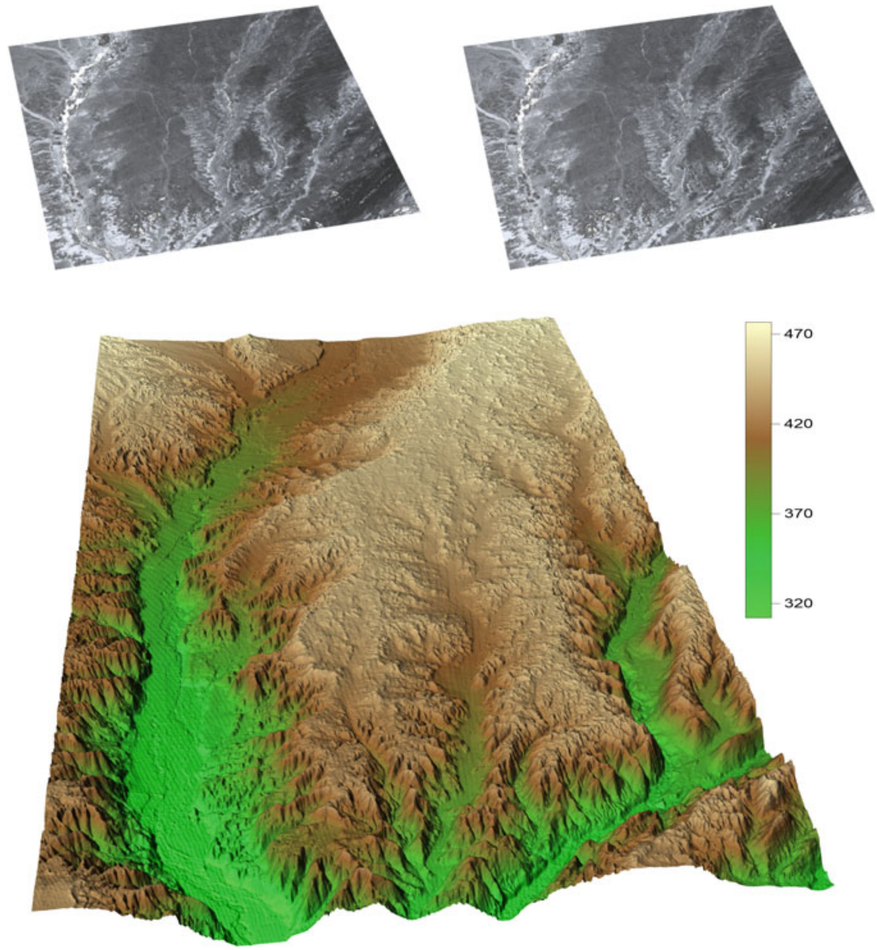

Fig. 23.5 Perspective view of the digital-elevation model of a portion of the Nasca River, derived from a GeoEye-1 stereo-pair

Very often the undulation can be assumed constant over the area covered by a single image. However, this is not actually the case, since the tectonic setting of the area (see Chap. 3) determines gravity anomalies and, in turn, strong undulation gradients. Considering the area covered by the GeoEye-1 images (about 10 km in east-west direction), the undulation ranges from 28.5 to 30.5 m (Fig. 23.6); thus, if a constant value were used, a differential error up to 2 m would be introduced in the model.

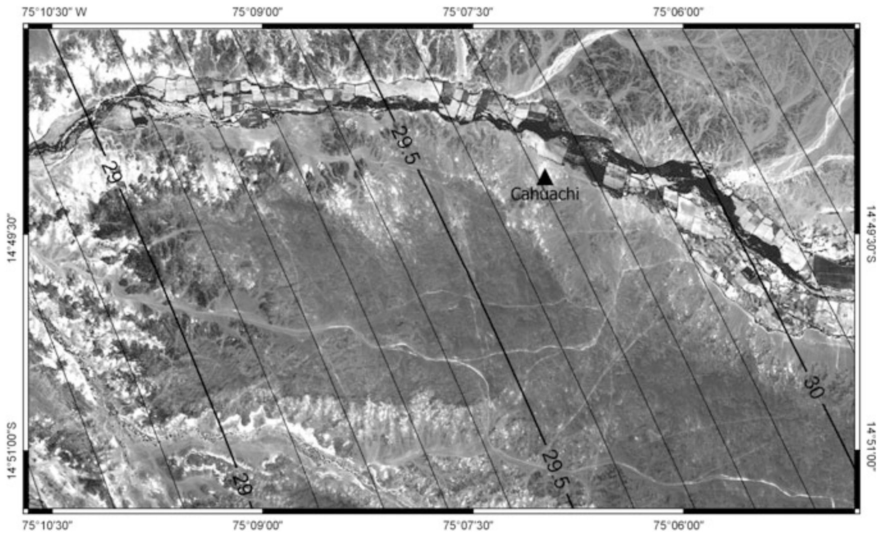

Fig. 23.6 Geoid undulation in the area covered by GeoEye-1 images, according to the EGM2008 model

23.4 Close-Range Photogrammetry

3D modelling, intended to produce three-dimensional products starting from surveyed data (Remondino et al. 2012), was applied to structures and single objects in the archaeological area of Cahuachi. Data required for this operation can be recorded with passive or active sensors, leading to image-based or range-based approaches, respectively. The image-based approach is normally performed with digital cameras, and, for this reason, it can be considered a low-cost, portable, and flexible method for archaeological surveying. Range-based techniques use instead different kinds of scanners, obtaining very accurate 3D models, but with high cost and the need for complex processing. Either of the approaches can produce today 3D representations in terms of cloud points and surfaces (meshes).

In recent years, various software solutions have become available for the processing of images and the derivation of 3D models by photogrammetric approaches, with a high level of automation. In this context, while the core of the process belongs to classical photogrammetry adapted to digital environment (e.g., camera calibration and reconstruction of interior and exterior orientations of the images), some algorithmic solutions derive from computer-vision research. The elaboration includes simultaneous determination of camera parameters and orientation of the images, cloud point generation and subsequent densification, editing of the models, and finally, when required, a texturization phase to produce a realistic 3D model with all the color data.

Figure 23.7 represents the textured 3D model of an aqueduct (*puquio)* in the San Carlos area, Río Taruga Valley, together with the corresponding orthophotos, with

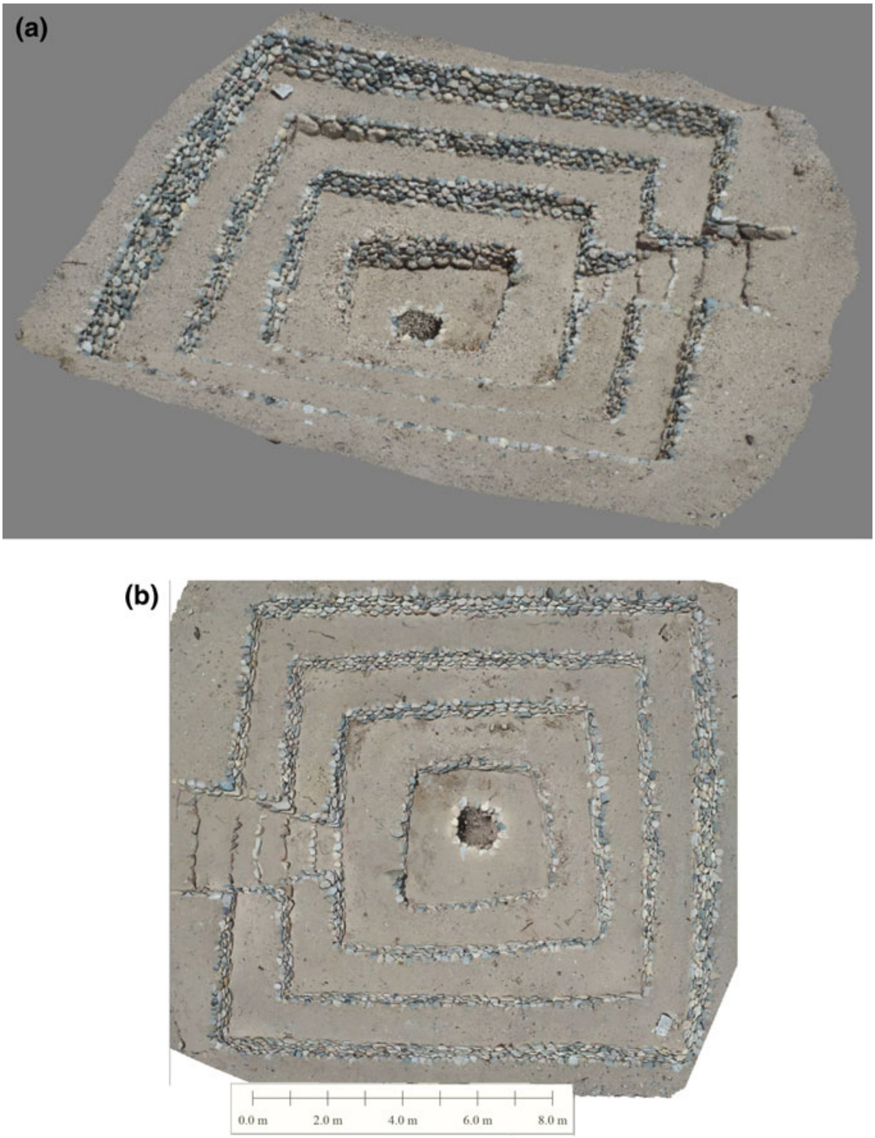

Fig. 23.7 Detail of *puquio* of San Carlos: **a** 3D textured model and **b** orthophoto. The images show a stepped structure around a well, named in Spanish ‘ojo’ (eye), enabling access to the aqueducts for their annual cleaning

pixel size 0.02 m (for additional details on *puquios*, the reader is referred to Chaps. 13 and 22; Schreiber and Lancho Rojas 1995; Lasaponara and Masini 2012). The model was realized by a block of 112 images, appropriately positioned in space. These products make possible an interactive exploration of the object, which can be

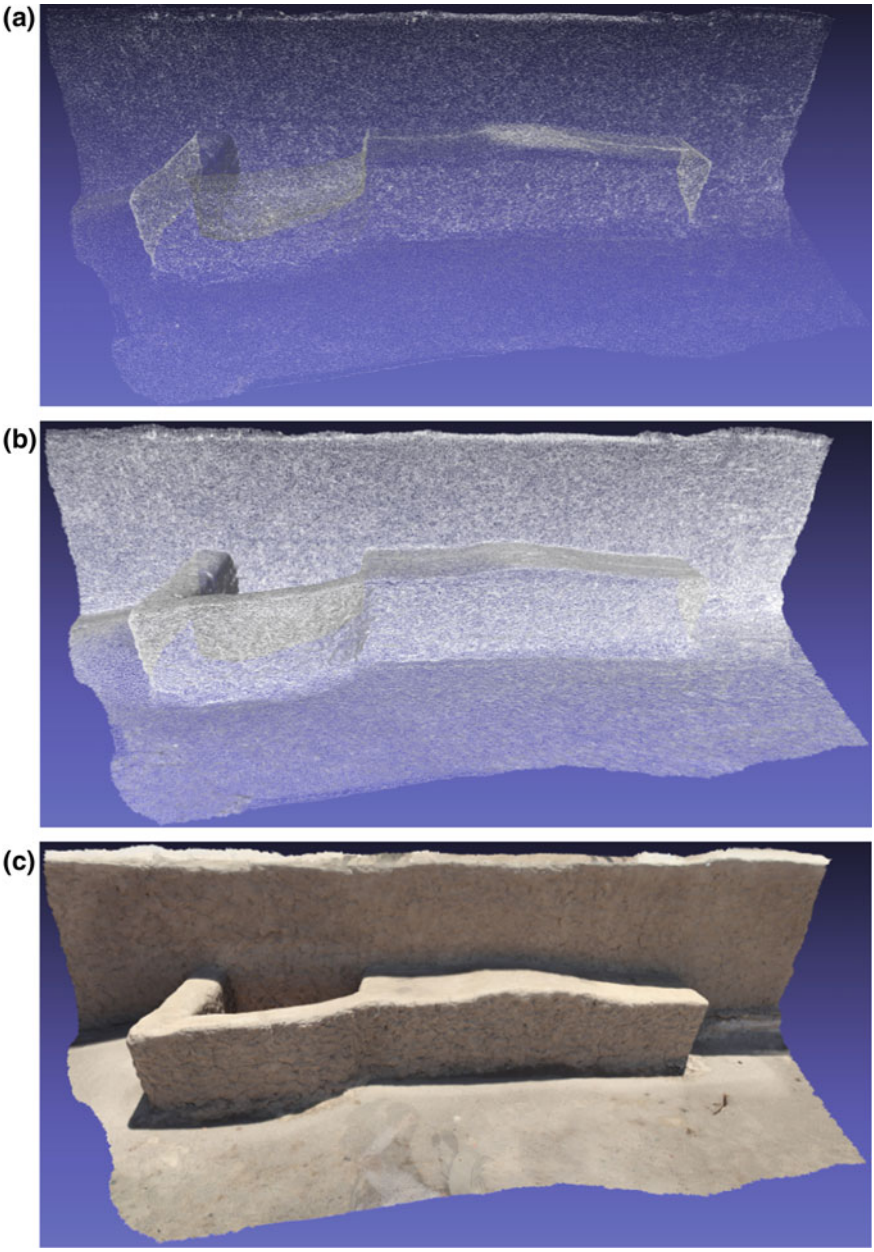

Fig. 23.8 A particular structure built in adobe in Cahuachi: **a** cloud point, **b** mesh, **c** textured model

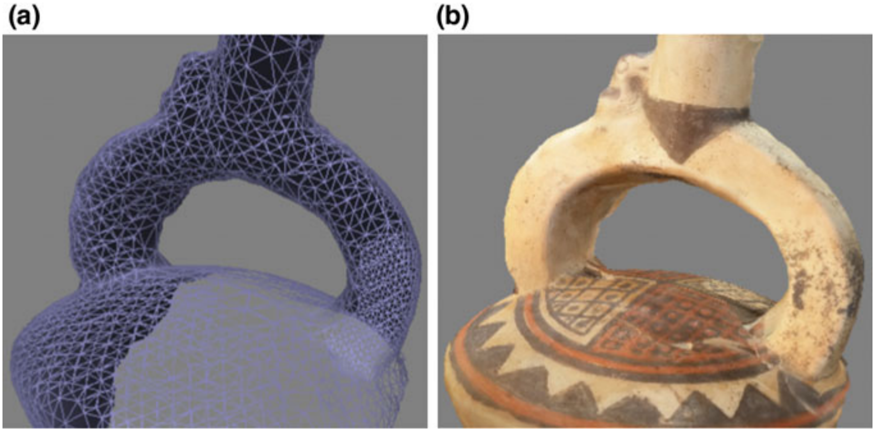

Fig. 23.9 Detail from a 3D model of a Nasca painted vessel from the Antonini museum: **a** wireframe and **b** 3D textured representations

used to study its geometry in detail and to take every kind of measurements; of course, it can support also the realization of traditional vector drawings.

Figure 23.8 refers instead to a detail of a structure of Cahuachi site, reconstructed in detail by about 50 images in 9 million points (Fig. 23.8a), then triangulated in a fine mesh (Fig. 23.8b) and finally textured in true color (Fig. 23.8c).

Finally, a portion of the model realized for a small archaeological find, held at the Antonini museum, is shown in Fig. 23.9, as wireframe and texturization.

The availability of accurate 3D models of the archaeological finds, realized by scanning or digital photogrammetry, constitutes a powerful means of documentation and study (Bitelli et al. 2014), even in remote areas; furthermore, it can be used —where appropriate—for the realization of replicas of the objects themselves.

23.5 Conclusions

The application of geomatics methods at Cahuachi and in the Nasca territory is part of interdisciplinary research and involved almost all the major techniques currently available. The significance of the examples provided is not only evident in the final digital products, useful for a number of studies, but also in the demonstration of the integration of various georeferenced datasets.

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Chapter 24
The Polychromy of Nasca Pottery: A Nondestructive Analytical Approach for Compositional and Mineralogical Investigation of Pigments

Lighea Pappalardo, Nicola Masini, Francesca Rizzo and Francesco Paolo Romano

Abstract Some new considerations about the characterization of pigments on polychromatic Nasca pottery by the use of PIXE-alpha and XRD nondestructive and in situ techniques are presented. The investigation, in particular, is focused on the compositional study of painted surfaces on selected archaeological Nasca fragments coming from the ceremonial center of Cahuachi in Southern Peru. Quantitative data are also discussed, with the aim of identifying the raw materials. A review of the nondestructive instruments and methods developed at the Laboratori Nazionali del Sud (LNS) of the Istituto Nazionale di Fisica Nucleare (INFN) and at the Istituto per i Beni Archeologici e Monumentali (IBAM) of Consiglio Nazionale delle Ricerche (CNR) is given. In particular, this article revisits the PIXE-alpha (Particle Induced X-ray Emission) system, based on the use of a ^{210}Po radioactive-source-emitting alpha particles, the XRF (X-ray Fluorescence), and the micro XRF and XRD portable spectrometers. It also describes an analytical protocol for fully quantitative data, based on the combined use of the portable PIXE-alpha and XRD nondestructive techniques.

Keywords Nasca pottery · PIXE-alpha · XRD · XRF · Pigments

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24.1 Introduction

Color, one of the main manifestations of art, can be considered as a developing aspect of human society (Jones 2004). Also, one can attribute symbolic meaning, pertinent to a specific period, to the choices and use of colors in arts and crafts (Silverman and Proulx 2002).

However, its use is strictly related to the availability of the raw material and to the level of the production technology. For instance, in the early prehistory (Paleolithic and early Neolithic) people used, mainly in mural paintings, black, red and yellow colors probably because the row materials (carbon and red or yellow ochre) were readily available. Due to this very limited choice of materials, no particular artistic or symbolic meaning could be attributed to the used colors. However, with time, more possibilities became open to the artisans.

Blue, green, various types of black, and red of different tonalities, obtained after elaborated technological procedures, were mostly used. This large variety of possibilities has stimulated the discussion about the artistic and symbolic value of the colors. However, even in these favorable cases, it needs to be taken into account to what extent the choice of a given color by the artisan/painter is conditioned on the ease of finding the raw material and how much on the know-how related to its technology of production.

It should be also stressed that the ancient painters produced various tonalities of colors by mixing various pigments and clays: this implies the necessity to develop quantitative methods to determine the concentration of the above constituents (Maniatis et al. 1993; Romano et al. 2011). Recently, a large quantitative investigation on Nasca pigments has been carried out by using LA-ICP-MS destructive methods (Vaughn et al. 2005; Vaughn and Neff 2004; Vaughn and Van Gijseghem 2007). This study proved that these methods are very appropriate for the task; in particular, the authors identified various compositional groups that are present in a bivariate plot of manganese and iron oxide concentration. In particular, group Black 1 is comprised entirely of sherds from the Nasca culture (primarilyEarly Nasca).

Other studies (Shimada and Wagner 2007) have been carried out in the field of the chemical and mineralogical characterization of Nasca pottery: thin sections, X-ray spectrometry, and NAA have been conducted to study the provenance, as well as an investigation into the reconstruction of pre-hispanic procurement of raw materials and techniques for craft production.

Other approaches based on Mossbauer spectroscopy, together with INAA and XRD (Shimada et al. 2003), have been employed to investigate the production process and the composition of the clays of pre-hispanic ceramics.

A comparison between LA-ICP-MS and INAA techniques applied to Nasca ceramics has been also carried out (Vaughn et al. 2011).

At the LANDIS laboratory of IBAM/CNR and LNS/INFN of Catania, a number of instruments and methods suitable for nondestructive and quantitative study of painted surfaces were developed. In Sect. 24.2, we will present them and their applications to the characterization of the colors on ancient surface of pottery.

Section 24.3 will describe the analysis of Nasca polycrome pottery (Romano et al. 2011), and new considerations will be presented.

24.2 LNS-IBAM Noninvasive Instruments and Methods for Compositional and Mineralogical Investigation of Pigments

In recent years at the LANDIS laboratory of the LNS-INFN and IBAM-CNR of Catania (Italy), many efforts have been dedicated to realizing innovative portable PIXE-alpha and XRD systems for in situ applications in the field of cultural heritage.

The PIXE-alpha technique (Pappalardo et al. 2003), due to its analytical depth of a few microns (about 15–20 μ in a clay-based matrix, as is the case of most archaeologically relevant clay pigments) is particularly suited for the elemental analysis of the painted surface: in fact, the investigation into the pictorial layer and the substratum contribution is thus greatly simplified. In addition, the mineralogical nature of pigments can be investigated by the use of our portable XRD spectrometer (Romano et al. 2006).

By combining the results obtained by these techniques, it is possible to determine quantitatively the composition of the paints (Pappalardo et al. 2008; Gatto Rotondo et al. 2010): in fact, PIXE-alpha data provide a qualitative indication about the chemical elements present in the sample; this indication is, in turn, useful to limit the XRD search only to those phases containing the elements individuated by the PIXE. The XRD qualitative information on the compounds is then used as the input to a dedicated software (GUPIX) to generate the stoichiometric information which enables extraction of quantitative concentrations (Maxwell et al. 1995).

More recently, low-energy/high-power X-ray beams, at grazing incident angles, have been used (Romano et al. 2012a). Also, microfocus systems associated to polycapillary optics have been used in XRF scanning mode, as well as in XRD analysis to obtain information on the sub-millimetric chemical or mineralogical composition of the painted surfaces (Romano et al. 2012b).

Since 2011, a nondestructive study of Nasca polychrome pottery to compositionally and mineralogically characterize various pigments has been conducted, and the first results have been published in Romano et al. (2011). This chapter shows the results of some analyses performed on black and white pigments.

24.3 Some Considerations About Nasca Polychrome Pottery

The Nasca site, on the south coast of Peru, is well known for the polychrome pottery that was produced mostly in the intermediate period 1–800 A.D. (Silverman and Proulx 2002; Vaughn et al. 2005). The pottery surface was decorated with a large number (in some cases as many as 15) of colors of various tonalities. The ceramists' painted characteristic figures and geometrical lines which are interpreted as having religious or symbolic meanings. The iconography has been intensively studied (Proulx 2006). A Nasca ceramic seriation has been based on the studies of L. Dawson, who established a sequence of nine phases, described in detail by Rowe (1960), Menzel et al. (1964), and Proulx (1968, 2006).

Undoubtedly the pottery painters possessed the necessary knowledge of the raw materials, the ability to mix the various minerals, and the experience to control the firing process in order to obtain a given color of a given tonality. This ability is the result of a sophisticated culture and gained through both external contacts with different people or internal development due to well-organized social and political structures.

A systematic study of the "materiality" (composition, firing, raw materials, etc.) of the surface colors would be of great importance in exploring the above-cited social relationships. One of the most complete analysis devoted to the study of the Nasca pottery pigments is presented in the work of Vaughn et al. (2005), who analyzed 130 sherds with painted surfaces by means of the LA-ICP-MS method. For the black pigments, the results on the absolute concentrations of Mn and Fe were reported and grouped in a bivariate plot. The data of each group are limited by an ellipse representing the 90%-confidence interval for group membership.

In the contexts of the ITACA Mission for scientific research in Cahuachi, a study conducted by the Laboratory of CNR/IBAM on five fragments belonging to Nasca culture was performed (Romano et al. 2011).

In the present paper, we focus our attention on further, more-detailed examination of the results on black and white pigments. Figure 24.1 comprises photos of the five analyzed sherds.

All five pottery sherds date back to Early Nasca. They are typical ceremonial pottery characterized by various motifs. N1 is part of a figure depicting a feline; N2 belongs to a decorative band with geometrical and figurative elements, including garlic; N3 is the representation of a bean, framed in a band divided into panels; N4 is part of a "tarrabo" (loincloth) of a male; and, finally, N5 depicts the feet of an anthropomorphic feline, whose tongue appears on the left side, with the two legs on the same sherd. According to the ceramic seriation (Proulx 1968), the samples N1, N3–N5 belong to Nasca 3, whereas the sample N2 seems to belong to Nasca 2.

In order to have information on the thicknesses of the surface pictorial, we performed two microdestructive tests on a small portion of two of the studied samples (N2 and N3).

In Figs. 24.2 and 24.3, the thin sections related to the above fragments are shown.

In order to elucidate the method used in (Romano et at. 2011) for the concentration measurements, we illustrate it with the following two examples.

In Fig. 24.4, the PIXE-alpha spectrum and the XRD diffraction pattern taken of the black pigment (M2) of the N2 sherd of Fig. 24.1 are presented.

In Fig. 24.5, the PIXE-alpha spectrum and XRD diffraction patterns of the white pigment on the N2 sherd are reported.

Fig. 24.1 The Nasca sherds' painted surfaces studied in Romano et al. (2011). The measurement points are indicated

Fig. 24.2 Thin section on fragment N2. The black pigment, about 20 µ thick, is imposed on a white one of about 120 µ

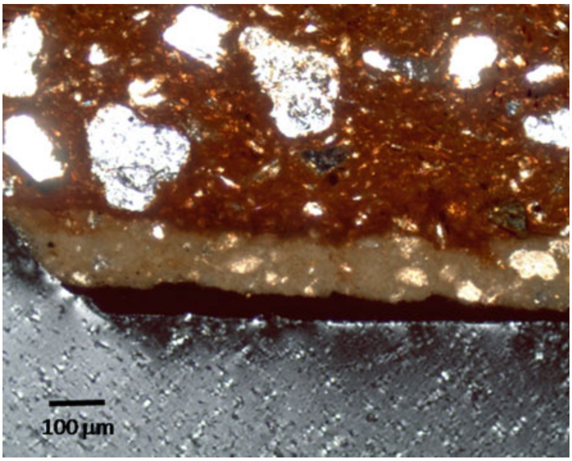
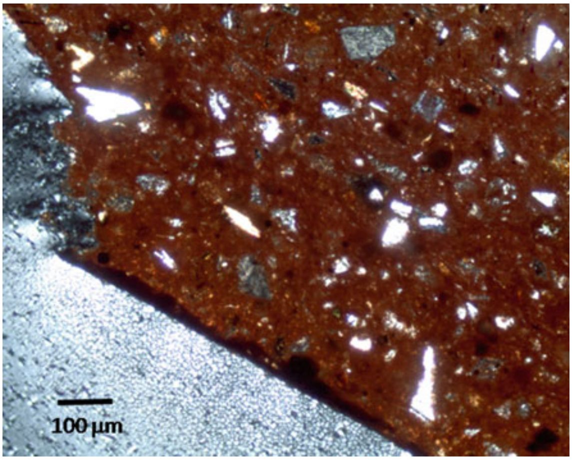


Fig. 24.3 Thin section on fragment N3. The black pigment, about 15 μ thick, is directly deposited on the ceramics surface



24.4 Quantitative Results of the Composition of the Analyzed Pigments

24.4.1 Black-Pigments Analysis

It is interesting to note, in the spectrum of Fig. 24.4, the presence of manganese. Quantitative data taken by using the GUPIX code give a MnO/FeO ratio of about 0.1. No significant presence of fluxing elements such as potassium is found. The MnO and FeO concentration data are displayed in Table 24.1.

The diffraction pattern reveals the presence of Mn and Fe oxides. This is consistent with the conclusion that the black color is produced by the presence of Mn and Fe oxides.

In Fig. 24.6, the data of Table 24.1 are plotted on the diagram from J. Vaughn (LA-ICP-MS) paper (Vaughn et al. 2005) in which every ellipse represents a well-defined compositional field for different black pigments of Nasca pottery. Our data, reported in the same graph, fall within the group called "group Black 1" which is constituted entirely of sherds from the Nasca culture, primarily Early Nasca (Vaughn et al. 2005).

24.4.2 White-Pigment Analysis

From Fig. 24.5, the presence of Al_2O_3, SiO_2, K_2O, CaO, and Fe_2O_3 in the PIXE-alpha data, together with the mineralogical XRD results, can be explained as the result of the firing process of kaolin. As an example, Table 24.2 reports the obtained concentrations.

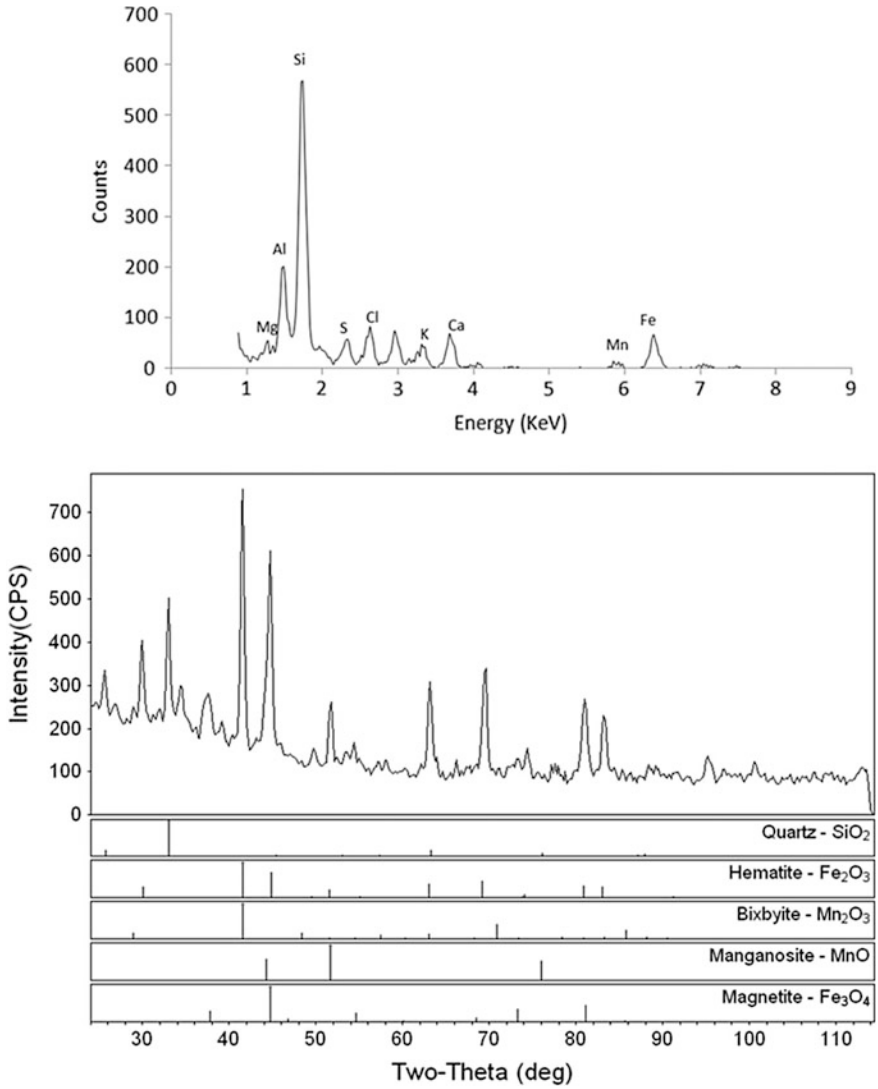


Fig. 24.4 *Top* PIXE-alpha spectrum and (*bottom*) XRD diffraction patterns of the black pigment M2 on the N2 sherd. The presence of Mn and Fe as elements (from PIXE) and as oxides (from XRD) is confirmed

Note that, in the Gehlenite ($Ca_2Al_2O_7$), the ratio of Al_2O_3/CaO is 0.91. The same ratio is found for the analyzed M3 pigment, supporting the assumption that Al_2O_3 and CaO concentration data are due only to the presence of Gehlenite.

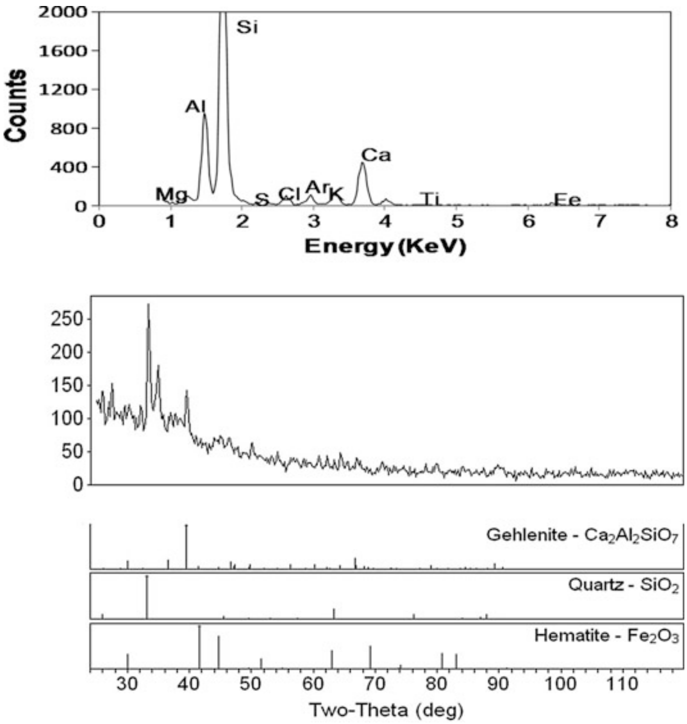


Fig. 24.5 *Top* PIXE-alpha spectrum and (*bottom*) XRD diffraction patterns of the white (M3) pigment on the N2 sherd. The presence of Al, Si, and Ca as elements (from PIXE) and as mineral constituents (from XRD) is documented. Gehlenite and quartz are also indicated

Table 24.1 The MnO and FeO content for the black pigments obtained by PIXE-alpha analysis are shown together with the corresponding values of the Log10 (ppm)

	MnO		FeO	
	(%)	Log (ppm)	(%)	Log (ppm)
M2	4.3	4.63	35.5	5.55
M5	3.5	4.54	34.6	5.54
M11	3.4	4.53	33.8	5.52
M15	2.5	4.40	39.3	5.59
M16	2.8	4.45	37.2	5.57

With the above assumption, it is possible to estimate the percentage of SiO_2 coming from the Gehlenite (9%) and the one coming from the presence of quartz (41%).

In conclusion, the quantitative composition of the white pigment will be:

Gehlenite 43.2%, quartz 41.0%, K_2O 2.6%, Fe_2O_3 5.1%.

As concerns the precursor material, it is known that Gehlenite is a product of the firing transformation of kaolin.

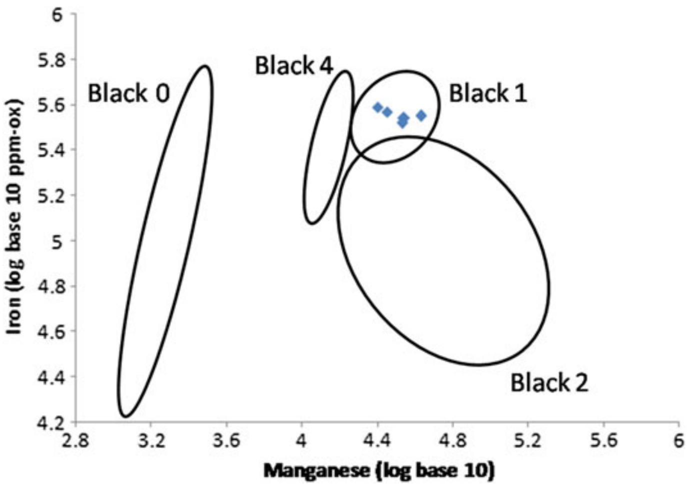


Fig. 24.6 Quantitative data on Fe and Mn oxides (shown in Table 24.1) reported as "log ppm" in the Vaughn et al. (2005) bivariate plot

Table 24.2 The quantitative PIXE–alpha data on the white pigment M3

M3	Al_2O_3	SiO_2	K_2O	CaO	Fe_2O_3
Conc. (%)	16.6	51	2.6	17.6	5.1

24.5 Conclusions

The complementary use of PIXE-alpha and XRD portable systems has given the possibilities, in some selected cases (e.g., black and white colors), to recognize the level of technology reached by the artisan/painters: certainly they were familiar with the procurement of the raw materials to build the palette with the correct proportions and to control the firing temperature.

Concerning the black pigment, it would be very interesting to know if Mn is associated with Fe in a natural deposit present in the Nasca region, or if the Mn and Fe oxides are only separately available.

Concerning the white pigment, it would be also useful to know if the kaolinite (which is known to be present in the region) is naturally associated with calcium carbonate in the correct composition to supply the Gehlenite.

Finally we would stress that it seems that, when the Nasca artisans and painters wanted to obtain a given color, they were able to prepare the correct palette to obtain it. This ability supports and reinforces the attribution of artistic and symbolic valence to the Nasca culture.

An important result is that, using the above described nondestructive analytical approach, it has been possible to attribute the analyzed sherds to a very precise period of Nasca culture: in particular "early Nasca" (Vaughn et al. 2005). Also, concerning the white pigment, a quantitative analysis of the pigments has been done.

Finally and further, this work has shown that the portable instruments and the nondestructive methods of quantitative analysis developed at the laboratories of LNS/INFN and IBAM/CNR are valid tools for the investigation of the production technologies of the Nasca polychrome pottery. In particular, their portability enables invesitigators to examine a large quantity of museum objects giving the possibility also to study small variations within the various phases of Nasca culture, as well within the different settlements (Silverman 2002).

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Chapter 25
Combating Illegal Excavations in Cahuachi: Ancient Problems and Modern Technologies

Rosa Lasaponara and Nicola Masini

Abstract Illegal excavations represent one of the main risk factors which affect the archaeological heritage in Peru, in general, and in Nasca region, in particular. Looting in Peru has an ancient "tradition", starting from the Spanish Conquistadors (and before); but since the 1960s, it has been strongly intensifying to supply the growing national and international markets. After the famous plundering of Sipán, an agreement was reached with the United States in 1997 to restrict the import of Pre-Columbian and ethnographic material from Peru. But, unfortunately, since the signing of the bilateral agreements with the United States, the traffic has shifted and been directed more towards Northern and Central Europe. Steps were taken to prevent illegal excavations through the forced return of looted archaeological objects; but this only partially addressed the problem because, even if the objects have been returned, the archaeological context from which they were stolen cannot be recovered. To stop, or at least limit, the illicit trade, it would be necessary to improve the present national and international laws and make available the resources necessary for their enforcement and for a wider understanding and systematic monitoring of the archaeological areas by using effective techniques of surveillance, including remote sensing. This chapter deals with the results obtained by using an automatic procedure applied to multitemporal satellite images of some areas in the Río Grande de Nasca Drainage for the detection of looted areas. The rate of success in detecting changes related to the archaeological looting has been successfully tested in significant selected areas using complementary tools such as Unmanned Aerial Vehicles (UAV), a Global Positioning System (GPS), Ground-penetrating radar (GPR), and field surveys. Satellite technologies can provide reliable information: (i) to quantify the looting phenomenon even if it is on

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an “industrial scale” over large areas, and (ii) to set up a systematic monitoring tool to trace the illicit trade in antiquities. This study has implications for the protection of archaeological sites, not only in Nasca but also across the world.

Keywords Archaeological looting · Spatial autocorrelation · Automatic classification and mapping, GPR, UAV, Cahuachi

25.1 Introduction

Peru has an extraordinarily rich archaeological heritage with more than 100,000 archaeological sites–as estimated by the Peruvian government–twelve World Heritage sites already listed, and other seven under consideration. Today, only a few percentage (less than 10%) of the Peruvian archaeological sites have been uncovered and, unfortunately, they often come to public notice because of acts of vandalism or looting. Looting is an “ancient” problem in Peru, beginning in the first colonial period (16th–17th century), as the result of trade of pre-Hispanic objects during the Spaniards’ “search for gold” (Doering 1958), coupled with the “policy of eradicating ancestor” veneration and destroying mortuary evidence in a bid to “extirpate idolatry” (Gerdau-Radonic and Herrera 2010).

Peru was of the first countries of America to adopt legislation to confront looting and to protect cultural property. In 1882, the Peruvian state approved a law (Supreme Decree 89 from 2 April 1882) that prohibited the exportation of archaeological objects without previous governmental authorization (Batievski and Velarde 2006) and, moreover, established that all the ancient monuments belong to the Peruvian Nation. Despite this, in the 20th century, illegal excavations increased throughout all of the Peruvian territory. As an example, we cite the sacking of the archaeological sites of Paracas, recorded and described by Julio Tello in the 1920s.

To cope with this issue, amendments to the legislation were undertaken. The new law (6634 approved in 1929), established that undiscovered pre-Hispanic artifacts and monuments belonged to the State, whereas the private ownership (of pre-Hispanic movable cultural goods) could only be recognized if they were inscribed in a register within one year. However, the expected effectiveness of this law was strongly reduced by: (i) numerous exceptions aimed at increasing private ownership rights (over immovable pre-Hispanic artifacts and the land where archaeological artifacts were found), and (ii) the opportunities granted to persons in charge of the archaeological excavations to acquire property rights for the duplication of objects they found (Martorell-Carreño 2006). Actually, this registration never worked, nor did the legislated protection measures.

After conciliating the Civic Code with cultural-heritage legislation, the following laws (24047 and 28296) defined a more extensive concept of cultural heritage. It was to be fundamentally protected by the assumption that cultural property belonged to the nation, and this reinforced the need to control findings from official archaeological excavations. Unfortunately, once again, the legislation has not "resolved the Peruvian heritage problem" (Martorell-Carreno Martorell-Carreño 2006).[1]

From the anthropological point of view, looters have highly variable characteristics, such as: (i) small-scale looters, who are generally hikers or hunters, are considered unpremeditated looters, (ii) artefact collectors who damage sites to build their own collections of ancient artefacts, and (iii) "professional" looters who may be poor native people or relatively educated, non-indigenous individuals motivated by money, feeding into a well-established, international market (Smith 2005). Until the early 20th century, the grave robbers, named huaqueros in Peru, normally worked mainly individually, but, later in the subsequent decade, they started to work in teams for their own gain or for second parties.

Clandestine excavation activity is mainly linked to illicit trade of antiquities in Europe and North America (Brodie and Renfrew 2005; Luke 2006). To contrast this phenomenon, since 1956 the General Conference of the United Nations Educational, Scientific and Cultural Organization recommended all the Member States to take "all necessary measures to prevent clandestine excavations and damage to monuments and also to prevent the export of objects thus obtained" (UNESCO 1956)". To confront the looting, repressive measures were adopted in many countries, along with restrictive laws to enforce the return of objects derived from clandestine excavations or theft to their countries of origin. In 1970, UNESCO promulgated the Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property (UNESCO 1970; Forrest 2010). The restitution of stolen or illegally exported cultural objects is treated in the UNIDROIT Convention which was approved in Rome on 1995 (UNIDROIT 1995).

This was another important advancement made by the international community to address site looting and the illegal trade in archaeological objects.

At present there are several international conventions that together provide a framework to support international cooperation to prevent looting, including the underwater archaeological heritage (UNESCO 2001). Additional actions have been adopted recently to condemn and prevent the looting and illegal excavations that have exponentially increased in the Middle East since the beginning of the conflict in Syria. The United Nations Security Council, on 12 February 2015, adopted Resolution 2199 that condemns the destruction of cultural heritage and adopts legally binding measures to counter illicit trafficking of antiquities and cultural objects.

[1]Summarizing, the current legislation on the protection of cultural heritage, it "expresses an interest superior to private property rights" (Karlzén 2010; Martorell-Carreño 2006). However the Constitution assures the right of private ownership over movable objects, belonging to cultural heritage, which can be traded domestically. Unauthorized excavation, extraction, and export are forbidden and criminalized by the Penal Code. Excavations can made only by archaeologists if authorized, following a complex procedure. New findings belong to the state and never can come legally into the hands of a private person.

Nevertheless, in spite of these additional restrictions, looting and artefact trafficking remain a major problem throughout the world, and important cultural property has disappeared from many countries to end up in lucrative trade for unscrupulous dealers operating both locally and internationally. As revealed from the survey conducted by Proulx (2013), the looting at archaeological sites is a pervasive, broad-based phenomenon.

Currently in Nasca and in Peru, as all over the world, numerous archaeological sites are systematically targeted for clandestine excavations that not only cause the loss of the artefacts themselves, but also the loss of information about the civilizations or human settlements they represent. This constitutes irreversible losses of knowledge about the human past, since, from the archaeological, historical point of view, the real value of the looted artefacts is actually what they say about the context, or ancient site, in which they were found.

In the last decades, the international cooperation among cultural organizations and museums proved to be effective in preventing illicit import and export of artefacts. However, the global dimension of the problem makes necessary further methods and strategies to face the plundering of cultural sites in situ. To this end, remote sensing can be a useful tool to systematically monitor, to quantify the damage, and to support mitigation strategies.

The preservation of cultural heritage and landscape is today a strategic priority not only to assure cultural treasure and evidences of the human past for future generations, but also to exploit them as a strategic and valuable economic asset–especially if inspired by sustainable development strategies. This is an extremely important key factor the countries, such as Peru, which are owners of an extraordinary cultural legacy that is particularly fragile due to its specific characteristics (think about adobe as a building material, or about the “construction techniques” of the Nasca Lines) and to the specific risks to which it is exposed (El Niño, floods, etc.).

Taking advantage of broad spatial coverage, high-spectral, and sensitivity, satellite remote sensing can be usefully adopted for controlling looting. Satellite technologies offer a suitable chance to quantify and analyze this phenomenon, especially in those countries, from Southern America to Middle East, where the surveillance on site is not very effective and is very time consuming or impracticable, due to military or political restrictions.

In this paper, we focus on the use of high-spatial-resolution satellite and aerial images to quantitatively assess looting in Nasca. In particular, multitemporal satellite images have been acquired for the study area and processed by using both autocorrelation statistics, unsupervised classification, and segmentation to highlight and extract looting patterns. The rate of success in detecting changes related to archaeological looting has been successfully tested in significant selected areas using drone survey and complementary tools such as GPS and field surveys. The mapping of areas affected by looting was also used to investigate areas not systematically documented previously.

25.2 Archaeological Looting in Cahuachi

The ceremonial center of Cahuachi[2] is an emblematic case of massively looted sites since the Colonial Period (Doering 1958). Illegal diggings linked to illicit trade of Nasca pottery with European museums probably started in the 19th century (Silverman 1993).

The phenomenon of looting increased in the 20th century and assumed the dimensions of large-scale plundering. An indirect cause of this was paradoxically the attention of the first archaeologists in investigating Cahuachi and its surrounding.

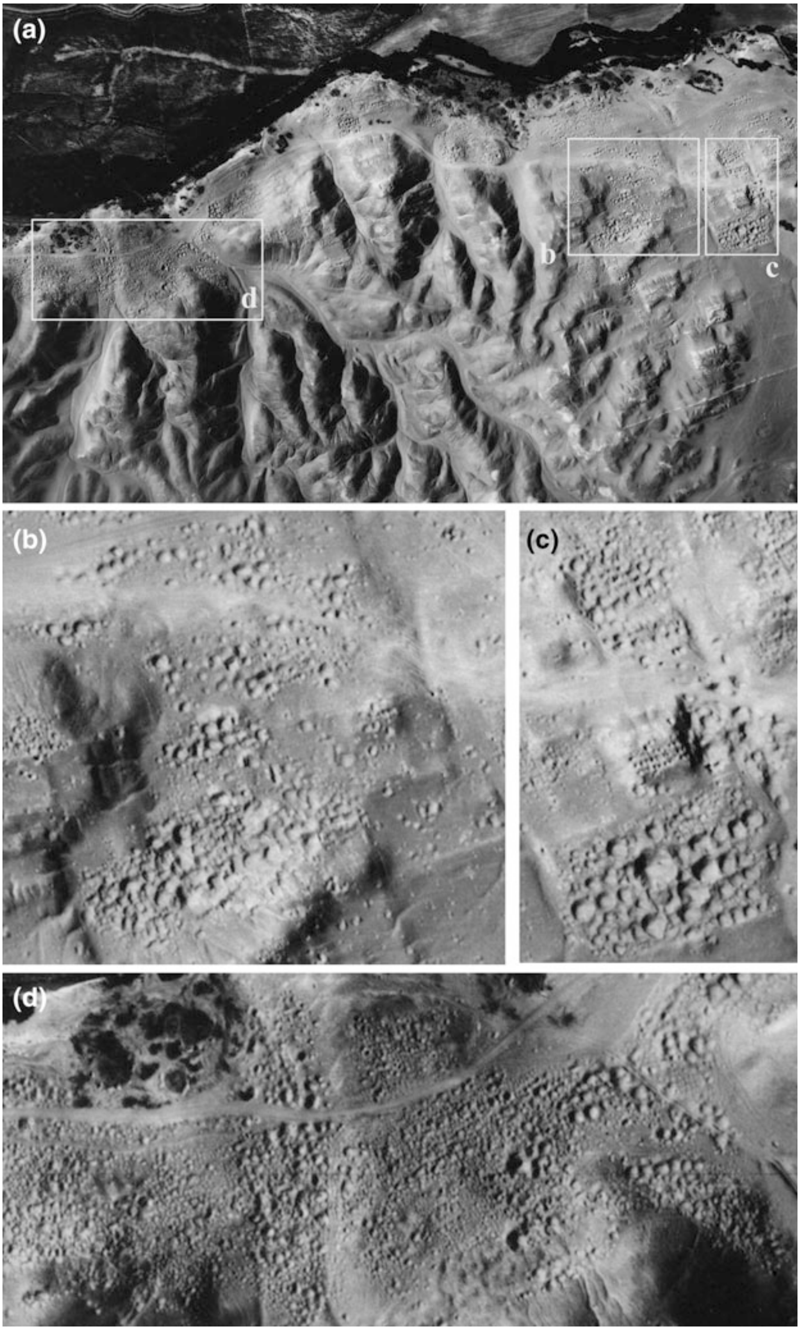
Some workingmen trained by Max Uhle during his field survey in 1905 "continued alone and in secret" to search for Nasca pottery which they sold to some dealers (Uhle 1914; Silverman 1993). The destructive aftermath of the archaeological investigations continued with Tello, Kroeber, and Doering.

A well-organized system of clandestine excavations that sold to dealers of Lima was directed by one of the Max Uhle's collaborators. It is estimated that, over 25 years, about 30,000 tombs were plundered, with an invaluable loss of context not only in the cemeteries but also in habitation sites and ceremonial architecture, where many rooms were deprived of floors and walls, thereby confusing subsequent archaeological interpretation (Silverman 1993).

Silverman (1993) was the first who studied the phenomenon of the *huaqueros* in Nasca, also from the social viewpoint. To this end, she interviewed some famous *huaqueros* of Nasca. The dynamics were always the same: when a tomb or an offering was found, a 'treasure rush' ensued: surrounding the finding, a number of holes were excavated. This explains why some areas, such as mounds or cemeteries, were so thoroughly looted with regularly spaced patters of holes. By regular, we mean holes made along two orthogonal directions, generally with the same diameters and spaced at the same distance. Probably the area had been previously parcelled to be excavated. This is the case for some of the mounds plundered in sector B of Cahuachi (Fig. 25.1, in particular Fig. 25.1b–c). In other cases, the holes do not exhibit regular patterns, but rather a scattered distribution with highly variable sizes. This could be due to periodical revisits to the areas by the *huaqueros*.

About the social profiles of the *huaqueros,* in the period in which Silverman worked (1980–90s), the grave robbers plundered not for professional collectors but for some local persons, such as the owners of lands where they usually worked for farming activity or for their own individual profit (Silverman 1993). At that time (maybe even currently), there were two categories of grave robbers: the professionals or "looter of finesse" (!) and the profaners. The first worked carefully with various probes, "to disturb the minimum possible" (!), in order not to compromise the integrity of the expected treasure. The second type of looter were "blinded by

[2]About Cahuachi, the reader is referred to Chaps. 14, 15, and 19 by Orefici (2016a, b, c).


(a)
b
c
d
(b)
(c)
(d)

◀ **Fig. 25.1** **a** Aerial view taken in 1955 of sector B of Cahuachi which indicates a vast area affected by illegal diggings south of the Río Nasca (photo taken on 1955.08.05). **b**, **c** The scenes are zooms depicting two looted areas characterized by regular patterns of deep holes whose diameters range from 5 to 12 m. **d** Picture shows irregular patterns of smaller holes (3.5–6-m wide)

ambition and brutality".[3] They worked "like pigs that sniff out the ground in search of food" (Silverman 1993).

Probably these latter looters worked with less care. This is reflected by an irregular or random pattern of holes, most of them shallow and with small diameters (see Fig. 25.1d and compare with Fig. 25.1b, c).

It must be said that the excavation depth depends on the dimensions of the holes. For the stability of the excavation, the deeper the hole, the greater must be the diameter, thus requiring some technical skills. On the basis of the diameter of the hole, it is possible to estimate the excavation depth. Considering a radius of action of the *huaqueros* of around 1.50 m, for a soil such as that of Cahuachi, composed of silt matrix, clayey sand, and slightly cemented gravels[4] [see also Chap. 3 by Delle Rose (2016)], the angle of the trench walls under which they could work safely, was likely about 60°. This means that, with diameters of excavations ranging 5–12 m, the reachable depth varied 2–8 m, respectively; those are the depths where it was possible to find tombs and ritual offerings.

Figure 25.1b, c show some platforms and mounds characterized by holes with diameters ranging 6–9 m, linearly aligned along two orthogonal directions, interrupted by single hollows of diameter greater than 10 m (see Fig. 25.2). In some cases, the holes have the same size and are equally spaced. Figure 25.1d depicts an area characterized by smaller (3.5–6 m) and shallower holes arranged in a chaotic way with variable shapes, not only circular but also irregular. Probably the 'looters of finesse' excavated according to regular patterns with sizes 6–12 m, reaching depths up to 8 m. The excavation ended not before having partially filled the hole for safety reasons.

The 'brutal profaner', using only ordinary iron with factory flaws, could not dig deeply enough (Silverman 1993).

Actually, the holes excavated before 1955 are still recognizable on the ground and remotely, though their edges that are less marked due to the erosion and the filling of the holes by sand carried by the wind. The depth measured by GPS and UAV (see Sects. 25.6.1 and 25.6.2) ranges from 30 cm to 2 m.

Figure 25.3 shows an area in sector B, on the western side of the excavated temples, observed from the aerial photographs (top), taken in 1955, and a satellite image acquired on 2011 (bottom), respectively. The comparison puts documents the effect of the erosion and the sand, carried by wind, covering the circular holes.

[3]According to the derogatory comments of witness to some "looters of finesse" interviewed by Helaine Silverman.

[4]Soil generally characterized by angles of friction ranging 28–32° and cohesion of 5–10 kPa (Cestelli Guidi 1987).

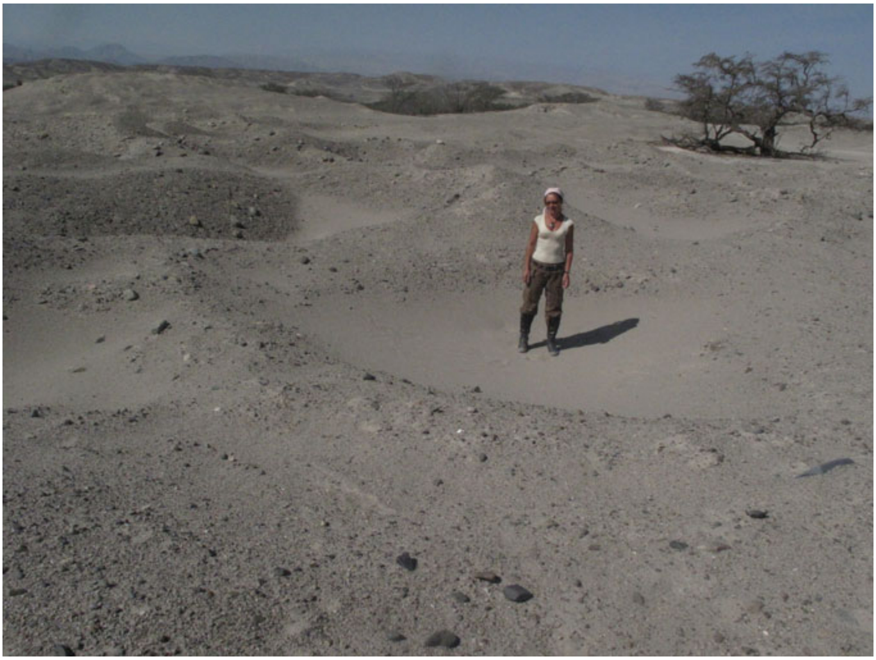


Fig. 25.2 Large holes indicate past looting activity in sector B of Cahuachi (photo by N. Masini)

Moreover, we can also notice a significant increase of illegal diggings between 1955 and 2011, which struck the few areas not affected by grave robbers of the 50s.

Similar patterns can be also observed on the eastern side of the monumental core of Cahuachi, as evident from Fig. 25.4. However, some new looted areas, bordered by a dark line, are evident from the 2011 satellite picture (bottom).

Finally, another phenomenon not always visible remotely is given by the digging into already-looted tombs, which can be found in both irregular and regular looting patterns. They are related to post-depositional processes, currently investigated by anthropologists (see, for example, the study conducted by Gerdau-Radonic and Herrera (2010) on looted tombs in Ancash).

25.3 Aerial and Satellite Tools for Monitoring and Quantification of Looting

The effectiveness of monitoring depends on the capability to perform systematic surveillance, exploiting various tools, such as, for example, satellites, manned aircraft, and aerial drones. Nevertheless, aerial and drone surveillance is impracticable in several countries due to military and/or political restrictions, or due to

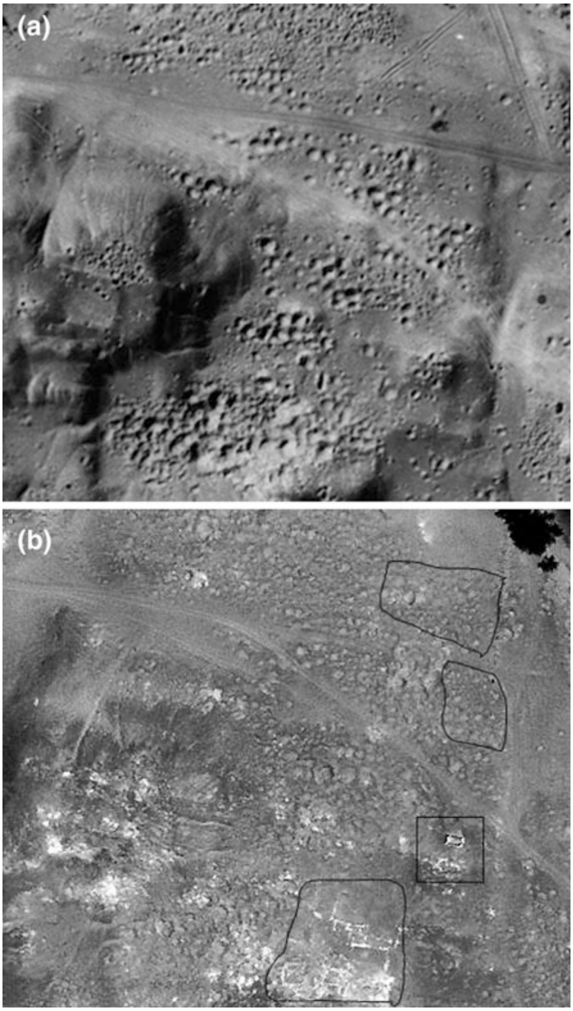
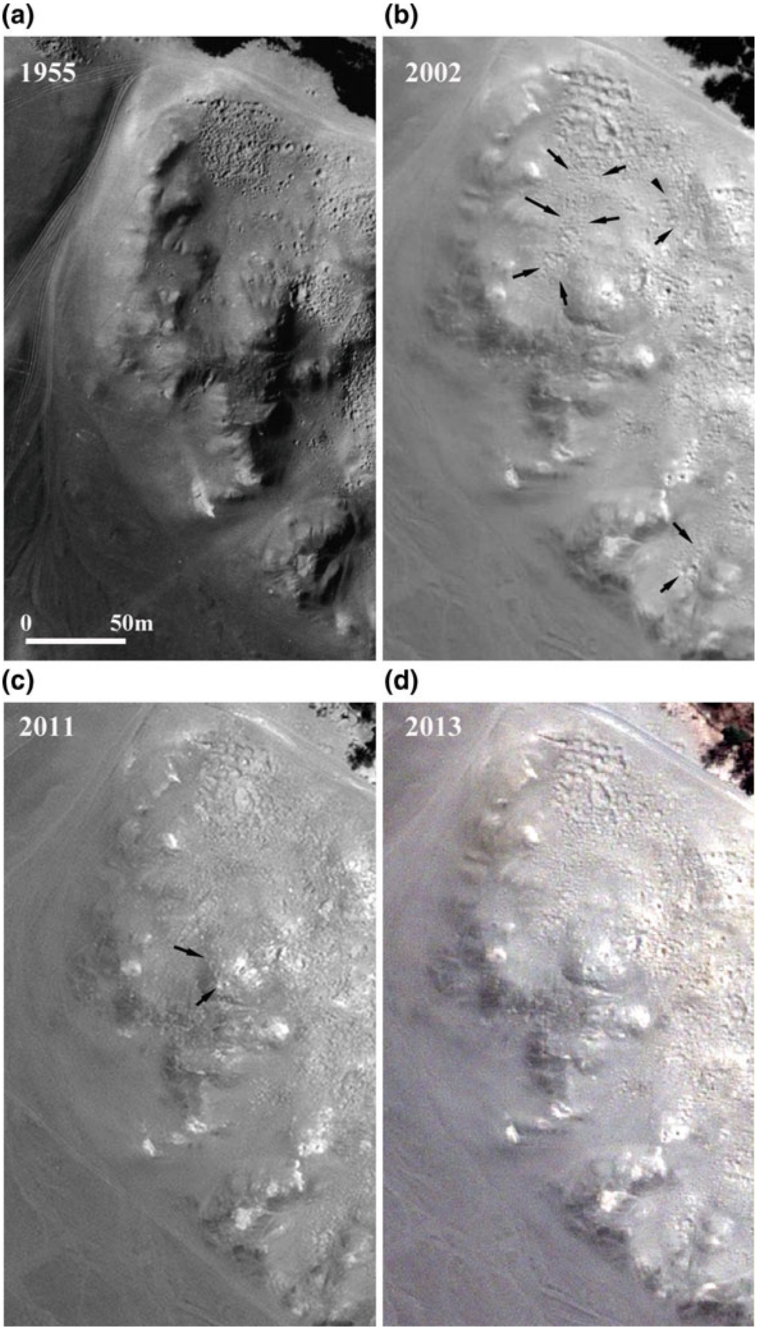


Fig. 25.3 Detail in sector B observed from (*top*) an aerial photo taken in 1955 and (*bottom*) a satellite image acquired in 2011. The comparison documents that most of the holes excavated before 1955 are barely visible in 2011, due to erosion and the sand carried by wind

ongoing conflicts and wars. Moreover, aerial surveillance is not very effective for huge areas and for difficult environmental settings (deserts, rain forests, etc.).

In these contexts, the use of satellite imagery with spatial resolution less than 1 m, generally known as very-high-resolution (VHR) data, can offer a suitable capability, thanks to their global coverage and re-visitation times.

Some recent applications have shown that VHR satellite imagery are of great help in the remote surveying of archaeological heritage and for documentation, and monitoring of looting damage. Examples can be found in Peru (Lasaponara and Masini 2010; Contreras 2010; Lasaponara et al. 2012, 2014) or in areas of ongoing conflicts such as Iraq and Syria (Parcak 2007; Casana 2015; Casana and Panahipour 2014, Stone 2008; Van Ess et al. 2006; Tapete et al. 2016), and other sites of the Middle East, including World Heritage sites, such as Petra (Vella et al. 2015).


(a)
1955
0
50m
(b)
2002
(c)
2011
(d)
2013

◀ **Fig. 25.4** Multitemporal data set of an area (named L7 in Fig. 25.6) east of the monumental core of Cahuachi and strongly affected by looting. **a** Aerial photo taken on 5.08.1955. **b** Satellite QuickBird panchromatic image acquired on 16.09.2002. **c** Satellite GeoEye panchromatic image acquired on 29.02.2011. **d** Satellite Pléiades true-color image acquired on 26.01.2013. The comparative observation of the four pictures, documents that, in this zone of Cahuachi, most of the area devastated by looters date back to pre-1955. However, some newly looted areas are visible from the more recent satellite pictures, denoted by *black arrows*. In particular *black arrows* in (**b**) and in (**c**) denote areas illegally excavated between 1955 and 2002, and between 2002 and 2011, respectively. In this area, no significant changes due to huaqueros between 2011 and 2013 are visible

Focusing on Peru, Contreras (2010) used remote-sensing imagery from aerial and space platforms to assess looting damage via photointerpretation in the Virù Valley. In Nasca, inn thge context of ITACA mission investigations, Tapete et al. (2013) demonstrated the potential of SAR data to detect and monitor illagal diggings.

From the data analysis point of view, just in Peru, Lasaponara and Masini (2010) have provided a significant contribution from both data processing and remote monitoring, specifically in the Nasca area of Cahuachi (see also http://www.bbc.com/news/world-latin-america-16190824). They devised a semiautomatic, data-processing approach on local indices of spatial autocorrelation (LISA) used to enhance spatial patterns of looting, typically characterized by circular holes. The highly satisfactory results, further validated by ground surveys (Lasaponara et al. 2012), encouraged the authors to improve the semi-automatic approach and finally to develop a fully automatic procedure (Lasaponara et al. 2014) that was applied and tested in Ventarron (Lambayeque, Peru), one of most important archaeological sites in Southern America and one historically strongly affected on an industrial scale by illegal digging. Focusing on the Middle East and areas of ongoing conflicts, Van Ess et al. (2006) were able to identify looted areas near Uruk-Warka, situated c. 300 km south of Baghdad, by comparing pre-war and post-war IKONOS images. They located looting activities by using supervised classification methods. Stone (2008) estimated the extension of the damaged areas and the chronology of looting by using a QuickBird time series.

Casana and Panahipour (2014) worked for several years, within the framework of a NASA-funded research project, to develop a comprehensive, archaeological-site database for Syria and surrounding regions. The database includes 15,000 sites in Syria and, therefore, provides a highly significant basis for a robust analysis. This works has been updated by Casana (2015), who enabled detection and mapping of archaeological damage of cultural heritage sites in Syria, caused by vandalism and looting made by Islamic State militants.

Finally, Tapete et al. (2016) demonstrated the capability of very high resolution satellite SAR data in extracting and monitoring archaeological looting by using an approach based on the analysis of interpretation keys of looting marks.

Fig. 25.5 Satellite Pleiades true-color image of Cahuachi acquired on 13.03.2013. *Red rectangular blocks* denote some areas strongly affected by archaeological looting. Most of them are located at west of the monumental core of Cahuachi, named L1, L2, and L3. L1 is near Estaquería, L2 nearby Gran Piramide 2 (**z**), and L3 is north of Zone B. In Zone A, where the archaeological excavations are ongoing, box L4 includes some small looted areas located north of Grande Templo (**w**), Grande Piramide (**y**) and Templo Sur (**x**). Finally, two areas plundered by grave robbers are located north-east and east of Zone A, respectively

25.4 Remote-Sensing-Based Approach in the Nasca Drainage

In Cahuachi and other sites of the Nasca drainage, the same technologies and methods of investigation used for site detection, discovery of archaeological remains, and documentation of sites and monuments have been applied to observe, analyze, and monitor the illegal diggings. Given the vastness of the territory and its difficult accessibility, satellite remote sensing, mainly optical, can be usefully adopted for the quantification of the looting phenomenon. Figure 25.5 shows an ortho-rectified satellite image where the main looted areas herein investigated are depicted in red boxes. There are six sectors, each of which includes, or is close to, an area of archaeological interest, from Estaquería at the east to Zone A of Cahuachi at the west.

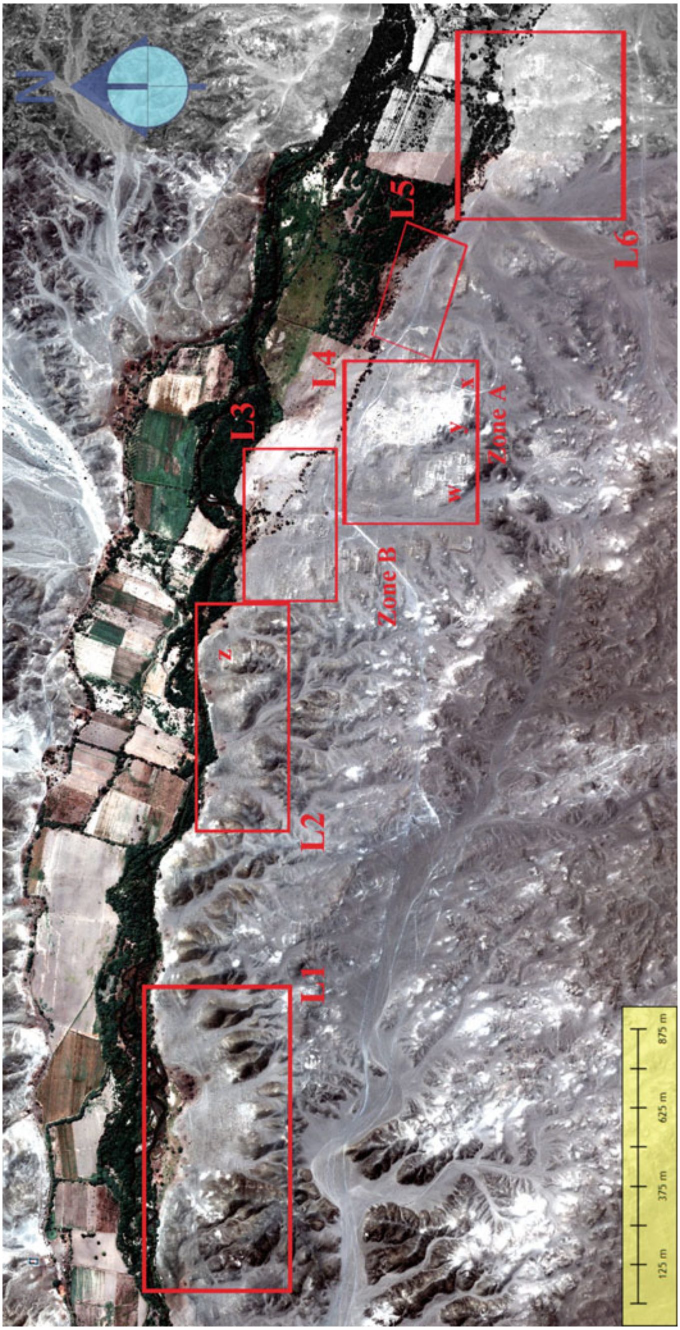
The scope of our activities, still on ongoing, have been two-fold: (i) operational, aimed at evaluating the state of conservation of Nasca archaeological heritage; and (ii) scientific, aimed at developing new scientific methodologies and approaches.

In this chapter, we focus solely on the scientific and methodological approach. In particular, remote-sensing technologies have been exploited for assessing features and patterns linked to looting activity, in a multitemporal perspective using a semi-automatic, extraction-processing method. This will be described and discussed in Sect. 25.5.

Moreover, for future operational use, a number of surveying techniques, including UAVs, GPS, and GPR, have been tested on some test sites. UAVs have been used for the 3D highly-detailed modelling of archaeological surface, at the scale of the single ‘hole’. To the same end, GPS has been also used, as a complimentary tool. Finally, GPR prospecting has been applied over looted sites to understand the state of disturbance in the subsoil produced by grave robbers.

25.5 Satellite Data Processing and Results

The automatic identification and quantification of looted areas from space may pose serious challenges related to data processing and interpretation. This is mainly due to the fact that the areas affected by looting may appear different from one image to another and even quite different within the same image due to their diverse physical


N
L1
L2
L3
L4
L5
L6
Zone A
Zone B
w
x
y
z
125 m
375 m
625 m
875 m

characteristics. This complexity is more evident for looting features that are characterized by weak spatial/spectral signals with no clear edges or patterns. Moreover, there are numerous factors, such as, atmospheric contamination, seasonal variability, noise, etc. that tend to distort subtle signals such as the edges and feature patterns linked to looting. To overcome this drawback, the use of statistical spatial analyses may be quite effective because they take into account not only the spectral values of the given pixel but also the spatial relationships among pixels (Lasaponara and Masini 2012).

The data-processing chain herein employed is mainly based on the approach specifically developed by Lasaponara et al. (2014) for the assessment of looting from satellite, as is shown in Fig. 25.6. It can be summarized in five steps: (i) filtering of vegetation to reduce false alarm; (ii) extraction of spatial patterns linked to illegal excavation using geostatistical analysis; (iii) automatic classification; (iv) segmentation, mapping; and (v) validation.

To make the procedure more general, the unsupervised classification is used to obtain a first 'rough' categorization of pixels. The refinement of the categorization is obtained by the segmentation applied in order to extract the roughly geometric, circular shape of the previously clusterized pixels (Lasaponara et al. 2016).

Over the years, some standard global and new local spatial statistics, such as, e.g., Moran's I, Geary's C, G statistics (Getis et al. 1992), LISA (Anselin 1995), and GLISA (Bao and Henry 1996), have been developed to detect the spatial patterns. All these spatial analytical techniques usually derive the spatial pattern, spatial structure, and form of spatial dependence from the data (Bao 1999). For this paper, we have applied LISA approach being which it has already been successfully adopted to enhance and investigate looting from space (Lasaponara et al. 2014). In particular, local indices should allow us to uncover hidden, local patterns that may be lost using global statistics. Results from these indices provide diverse maps which, for each pixel, inform us about the presence of a local cluster, as well as variations in texture or the presence of an edge. In particular:

- Getis-Ord Gi index facilitates the identification of the so-called hot spots, namely areas characterized by significantly higher or lower values compared to those of neighbouring pixels.
- Moran's I detects both positive and negative spatial correlations. It has values that typically range from approximately +1 to −1 representing complete positive negative spatial autocorrelation, respectively.
- Geary's C index identifies edges and areas characterized by discontinuities

In order to automatically detect the areas affected by looting, the results from the three LISA indices are classified using the K-means unsupervised classification algorithm. This classification requires limited human intervention in setting up the algorithmic parameters.

In the K-means algorithm, the cluster variability is optimized by a least-squares minimization of the cost functional relating to Eq. (25.1):

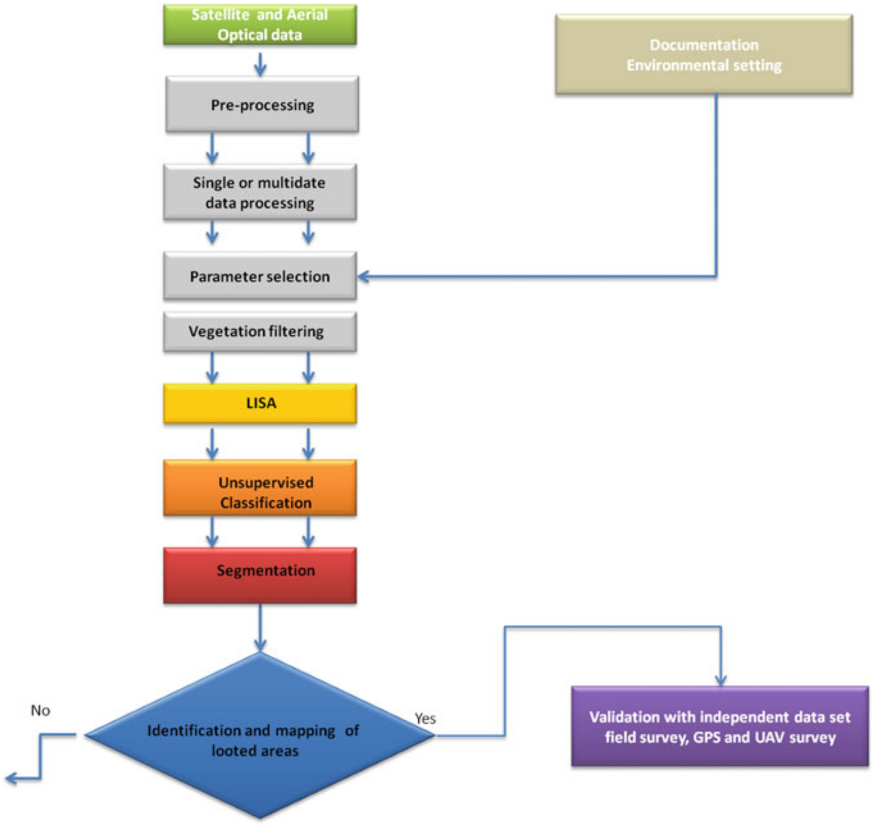


Fig. 25.6 Flow chart of the data-processing chain

$$MSE = \frac{\sum [x - C(x)]^2}{(N - c)b} \quad (25.1)$$

where MSE is Mean Squared Error, N is the number of pixels, c indicates the number of clusters, and b is the number of spectral bands, C(x) is the mean value of the cluster that pixel x is assigned to.

Equation (25.1) clearly shows that the minimization of MSE implies that K-means works best for spherical clusters that have the same variance. This indicates that the K-means algorithm tends to perform better for homogeneous surfaces/objects, such as, in particular desert areas such as in Cahuachi.

The choice to perform first the classification (unsupervised) and then the segmentation was made herein to reduce the parameters to be selected in order to extract geometric features that are obtained by setting only: (i) the minimum number of pixels to be considered in a region for building a segment; and (ii) the

Fig. 25.7 Looted area L1 (see Fig. 25.6). **a** Pléiades true-color image (the same as Fig. 25.6). ► **b** K-means classification of (**a**) with 5 classes. **c** Result of Local Moran'sI. **d** Image (**c**) classified by using K-means method. **e** Result of Local Geary's C index. **f** Image (**e**) classified by using K-means. The *red rectangular boxes* in (**a**), (**c**), and (**e**) are the classified areas shown in (**b**), (**d**) and (**f**), respectively

number neighboring pixels which determines the separability/connectivity of the segments.

The above-described satellite-based approach has been herein applied to a large area (about 4-km long and 300-m wide) south of Río Nasca, which includes the monumental core of Cahuachi (Fig. 25.5). In particular, six test areas have been selected because most of them are located close to and surrounding he pyramids and other evident archaeological features.

L1 is the largest sector, located to the east of Estaquería and characterized by various irregular and regular looting patterns (see Sect. 25.3), with a great variability of the dimensions of the hole diameters (around 4–10 m) and depths.

L2 is to the west of L1 and includes Gran Piramide II. It is characterized by irregular patterns of shallow holes with small diameters (a zoom, named 'd' and related to an aerial photo taken in 1955, is shown in Fig. 25.1).

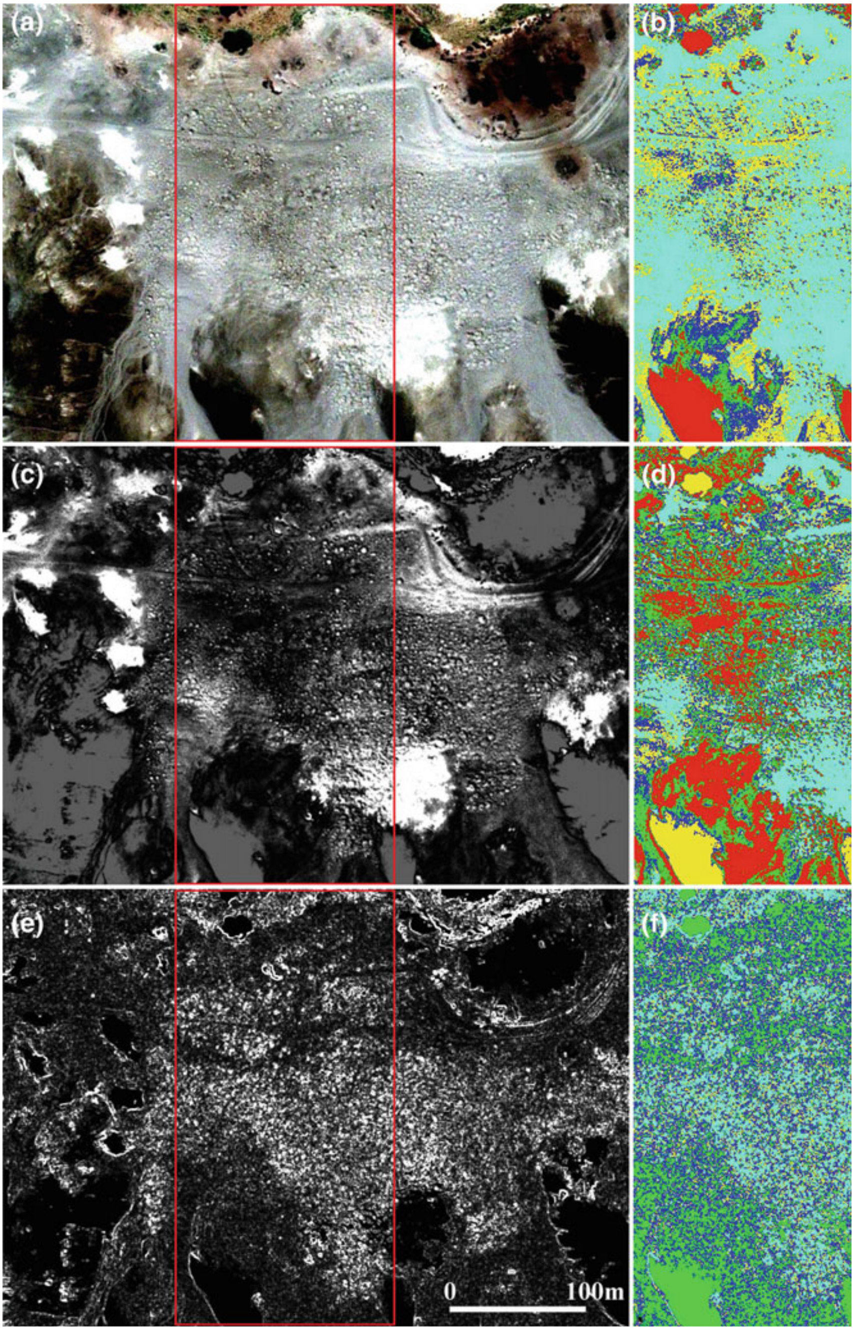
East of Gran Piramide II and north of Zone B (including a number of mounds and platforms), there is a sector named L3. It had been severely plundered by 'professional' *huaqueros* before 1955, as confirmed by regular pattern of holes, whose diameters are mostly larger than 7 m, and, in some cases, up to 12 m^2. It has already been investigated by using LISA applied to satellite data (Lasaponara et al. 2012).

L4 includes part of Zone A and is to the north of *Grande Templo* and *Grande Piramide*. It is characterized by irregular patterns of small and medium size holes (around 3–7 m).

Finally, L5 and L6 sectors are located northeast of Zone A characterized by irregular and regular patterns with highly variably sized holes.

As a whole, it is important to highlight that the dimensions of the holes (diameters and depths) are larger on mounds than on flat areas. This may be due to two reasons: the first is given by the expected presence of deeply located ritual offering and tombs, the second is linked to the presence of fills, used as 'final seal' after the abandonment of Cahuachi (see Chap. 19 by Orefici 2016c).

The applied methodology is mostly based on data-processing procedures already used in 2011 for L3 sector as described above (Lasaponara et al. 2012). In that case, LISA was exploited to enhance the spatial patterns linked to looting disturbance. To automatically extract the spatial anomalies in Lasaponara et al. (2014), the LISA was jointly used with unsupervised classification and applied to another case study (Ventarron in Northern Peru). To limit the false detection of looting features, the segmentation has been herein applied as an additional refinement of the data-processing step. The improvement achieved by using the diverse proposed data-processing steps (LISA, unsupervised classifications, and segmentation, respectively) are shown in Figs. 25.7, 25.8 and 25.9, where the intermediate and


(a)
(b)
(c)
(d)
(e)
(f)
0
100m

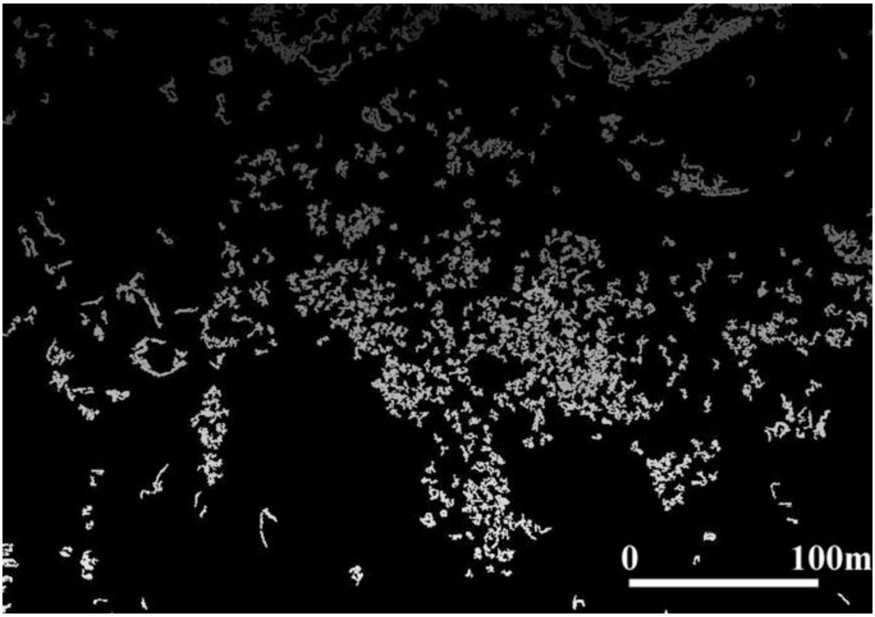


Fig. 25.8 Looted area L1. Segmentation of Fig. 25.7f which the K-means classification of Geary's C index result applied to satellite Pléiades true-color image in Fig. 25.7a. The segmentation has been performed with a population minimum (minimum number of pixels that must be contained in a segment) of 30 and a number of neighbors of four

final results are depicted, respectively. For brevity's sake, we only show L1 sector, selected because it is characterized by irregular and regular patterns of circular looting features of highly variable dimensions.

Figure 25.7a shows, for the looted area L1, the Pléiades true-color picture acquired on 26.01.2013. LISA has been applied to enhance the looting features. The best results have been obtained from Moran's I and Geary's C index (see Fig. 25.7c, e). The classification step applied to both of them and the true-color image suggest that the best categorization of surface patterns, including the looting one, is provided by Geary's C index (see Fig. 25.7b, d, f).

Consequently the segmentation has been applied to the results of Geary's C index, considering only one class, related to the shadowed part of the hole (in cyan color in Figs. 25.7f and 25.9) by setting the following parameters: population minimum (minimum number of pixels that must be contained in a segment) of 30 and number of neighbors of four. The final result exhibits a high rate of success of around the 90%. The false detection mainly regards natural features easily recognizable from the optical image, such as trees of *huarango* and geomorphological signs.

The satellite-based analysis was used to map and quantify the looted areas in the six sectors investigated (Fig. 25.5). Figure 25.10 shows the Archaeological Looting map (ALM) of Cahuachi. As a whole, in the six investigated sectors, the total area

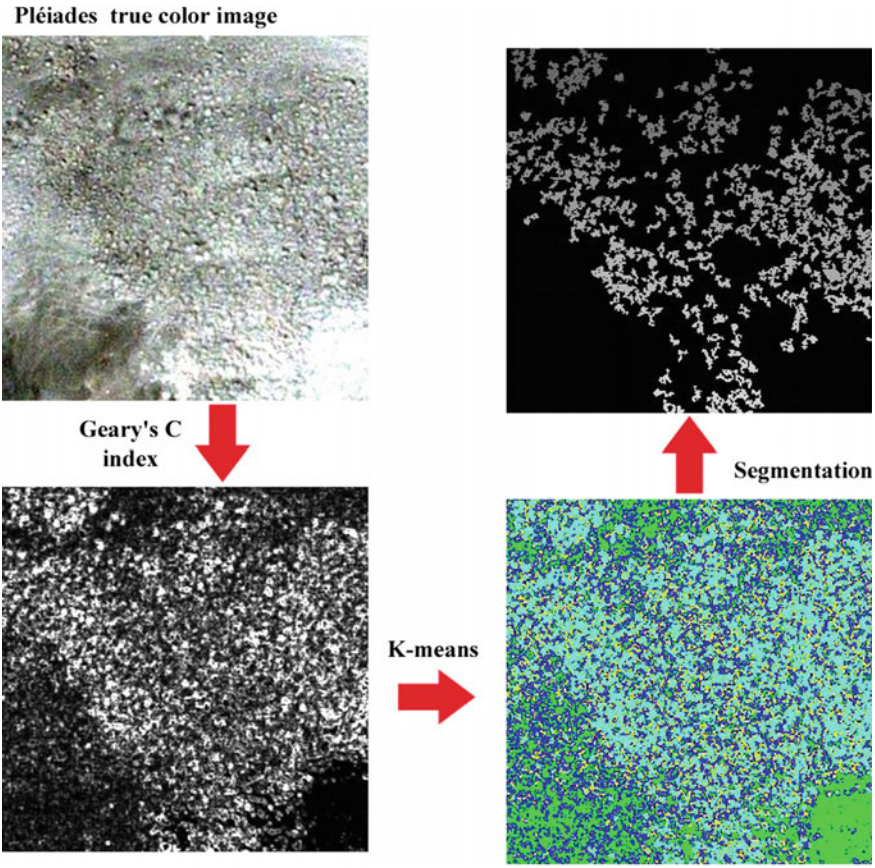


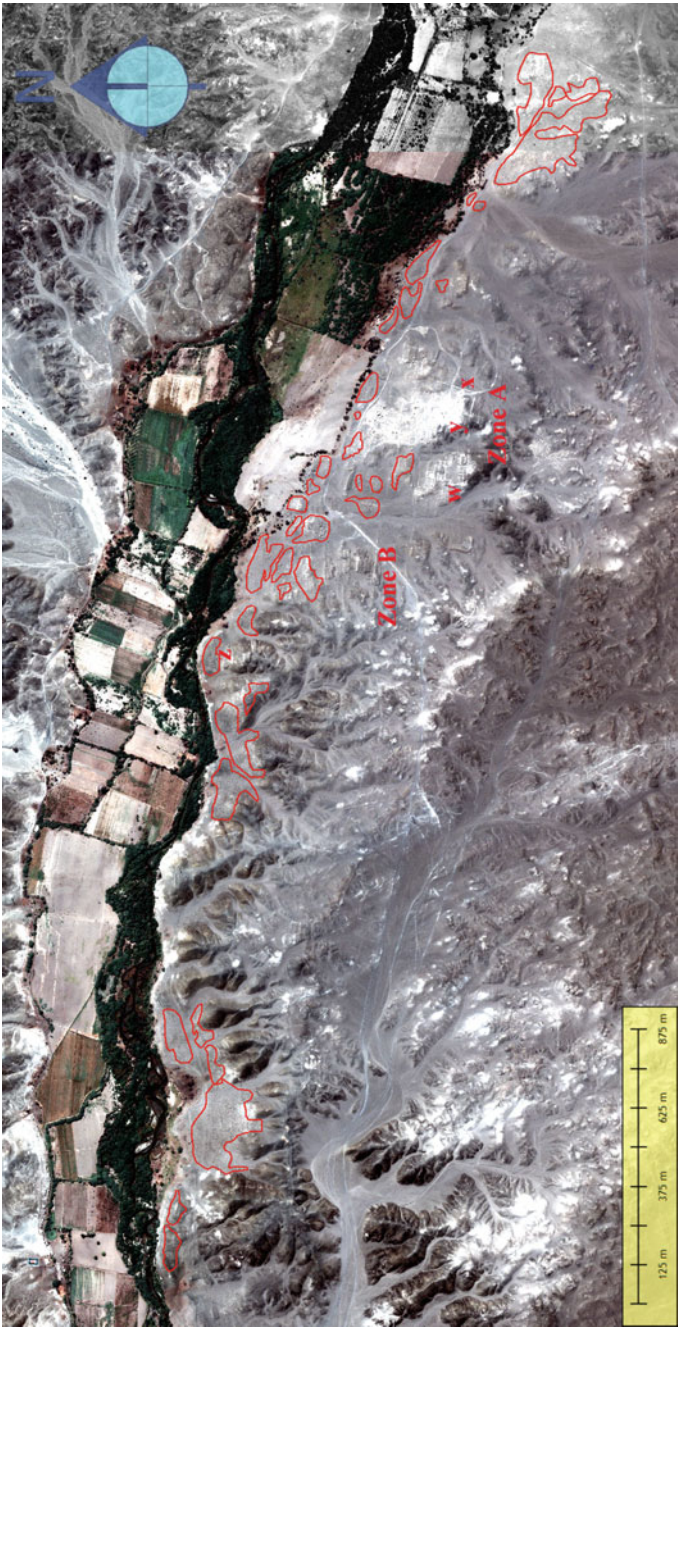
Fig. 25.9 Workflow of satellite data processing of a detail of looted area L1

affected by plundering is around 25 ha. The ALM is part of the dataset of the GIS-based prediction model of Cahuachi which includes also the Archaeological Atlas of Cahuachi currently in preparation.

25.6 Estimation of Looting Damage Using UAV, GPS Survey, and GPR

25.6.1 High-Resolution Aerial Survey

Very highly detailed surveys based on aerial images have been performed with two-fold aims: (1) to assess the rate of success of the automatic extraction of looting features based on the use of satellite imagery, as described in Sect. 25.5; and (2) to


Zone A
Zone B
x
y
w
z
125 m
375 m
625 m
875 m

◀ **Fig. 25.10** Archaeological looting Map of Cahuachi. The areas affected by illegal diggings have been identified and mapped by means of visual reconnaissance along with semi-automatic extraction of looting features based on the satellite-based data-processing approach described in Sect. 25.5

document and analyze the metrical and morphological characteristics of the looted areas. To these ends, images have been taken from tourist ultra-light aircrafts and unmanned aerial vehicles (UAVs) by using consumer-grade digital cameras and processed by imaging techniques which enable the estimation of three-dimensional objects from two-dimensional image sequences.

Compared to aircraft, the UAVs offer several advantages: particularly low cost and the ability to cover large areas in a short time. There are currently a wide range of UAVs. A classification of these systems based on size, weight, endurance, range, and flying altitude, is contained in Nex and Remondino (2013). For the purpose of our investigation, we adopted a low-cost drone Dji Phantom Vision 2 plus which is a radio-controlled quadcopter able to take off and land vertically on any surface. The propulsion is supplied by four electric motors powered by a battery which provides flying times of 20–25 min in standard conditions. The remote control is performed up to a maximum distance of 700 m.[5] The Phantom 2 Vision Plus is equipped with a two-axis, very stable gimbal, and a mounting for a DJi camera which can shoot video in full HD and take 14-megapixel photos.

Aerial surveys were conducted over Zone A of Cahuachi, as well as on the Inca site of Paredones, near Nasca town. The surveys aimed at providing orthophotos and DEMs for mapping and characterizing the looted areas with centimetric detail, including the holes made by *huaqueros*. For the first aim, the images were acquired from UAV in automatic and zenith mode at 30-m altitude. For the second, one the images were captured in manual, oblique, and nadiral mode, at altitudes from 8 to 20 m.

The orthophoto and the digital models have been obtained by processing the aerial images by using Structure from Motion (SfM), a range-imaging technique which enables estimating three-dimensional objects from two-dimensional image sequences and which may be coupled with local-motion signals. With respect to conventional photogrammetry, which requires a single stereo-pair, SfM needs multiple, overlapping photographs as input for feature extraction using 3-D reconstruction algorithms.[6]

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[5]With horizontal, vertical and rotation speed ranging from 0.1 to 15 m/s, 0.1 to 6 m/s and 200 °/s, respectively.

[6]The photogrammetric processing of digital images for generating 3D spatial data was performed by using Photoscan software (Agisoft PhotoScan User Manual 2014). The processing includes the following steps: (i) the selection and loading of photos, captured with correct overlap requirement (60 % of side overlap +80 % of forward overlap) aimed at minimizing blind-zones; (ii) computation of camera position and orientation for each photo, alignment of photos and building of a sparse point cloud; (iii) generation of a dense-point cloud model which enables calculating the depth information for each camera position; (iv) building 3d model polygonal mesh; and (v) and, finally, building model texture.

Figures 25.11 shows the DEM and the orthophoto of Inca site of Paredones derived from the SfM based processing of images taken from a UAV in September 2015. The two cartographic products made possible surveying in the areas affected by illegal diggings as well as identifying further remains and artifacts unearthed by *huaqueros*. The same use of aerial images, taken from ultralight aircrafts, has been made in Cahuachi for Zone A (Fig. 25.12). In addition, the digital models enabled the study of the diverse phases of illegal excavations and, finally, the assessment of the rate of success of satellite-based automatic extraction of looting features.

25.6.2 Global Positioning System

In order to provide additional complementary data to support the validation of the results obtained by satellite-based investigations, some GNSS kinematic surveys were performed. This technique consists of measuring the positions of a moving GPS antenna in respect to a master station (fixed station). This enables us to verify the single holes extracted by satellite-based analyses, as well as to obtain accurate digital models with a spatial resolution of 0.3 m and centimetric vertical accuracy. Figure 25.13 shows a couple of examples of GNSS applications on allegedly looted areas which enable us to study the morphological and dimensional characteristics of the looted areas [for additional detail, see Chap. 23 by Bitelli and Mandanici (2016)].

25.6.3 Ground-Penetrating Radar

In order to explore the subsoil of areas in Cahuachi affected by illegal digging, geophysical investigations by using Ground Penetrating Radar (or GPR) were performed. GPR is a nondestructive active technique that provides high-resolution detection, imaging, and mapping of subsurface soils and rock conditions. The basic system is made up of a transmitting antenna that emits an electromagnetic impulse which is gathered by the receiving antenna after being reflected or scattered by the presence of a dielectric discontinuity. GPR data were acquired with a Ris-Hi mode system equipped with a double couple of antennas with central frequencies of 200 and 600 MHz (for additional information on GPR applied to archaeology in Cahuachi, see Chap. 20 by Masini et al.).

The typical outputs of GPR prospecting are radargrams, the time slices, and 3D visualization of iso-amplitudes. The radargram is a measure of the reflection amplitudes and the travel time that the reflections take. Multiple radargrams collected over an area may be used to build 3D-tomographic images, displayable as 3D blocks or as horizontal slices. The latter, known also as depth slices or "time slices, are maps obtained

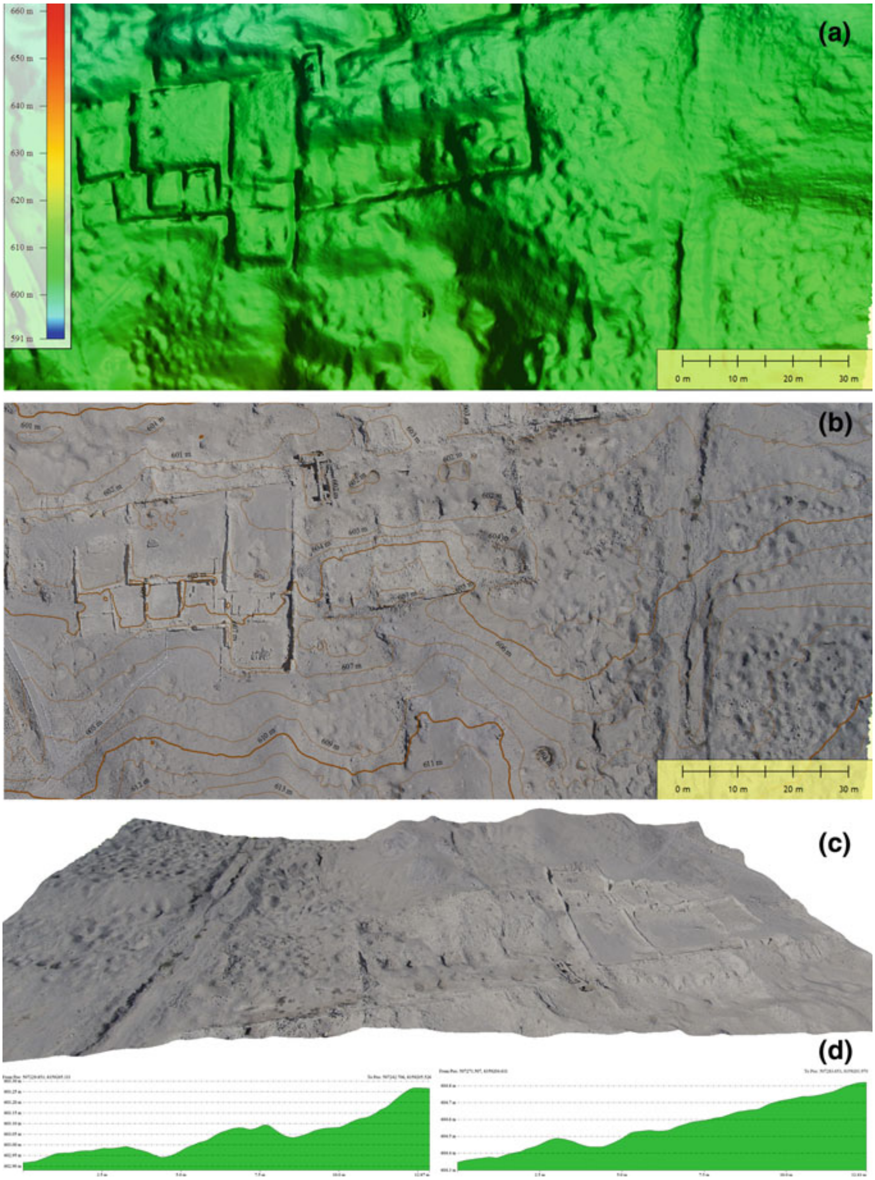


Fig. 25.11 Inca site of Paredones: looting survey derived from the SfM-based processing of aerial images taken from UAV in September 2015. **a** DEM **b** Orthophoto. **c** 3D image of the looted area. **d** Profiles over the looted area

for specific depths and enable spatial visualization of reflectors or discontinuities in the subsoil linked to the presence of archaeological remains. The 3D representation of iso-amplitudes makes the interpretation of GPR results easier.

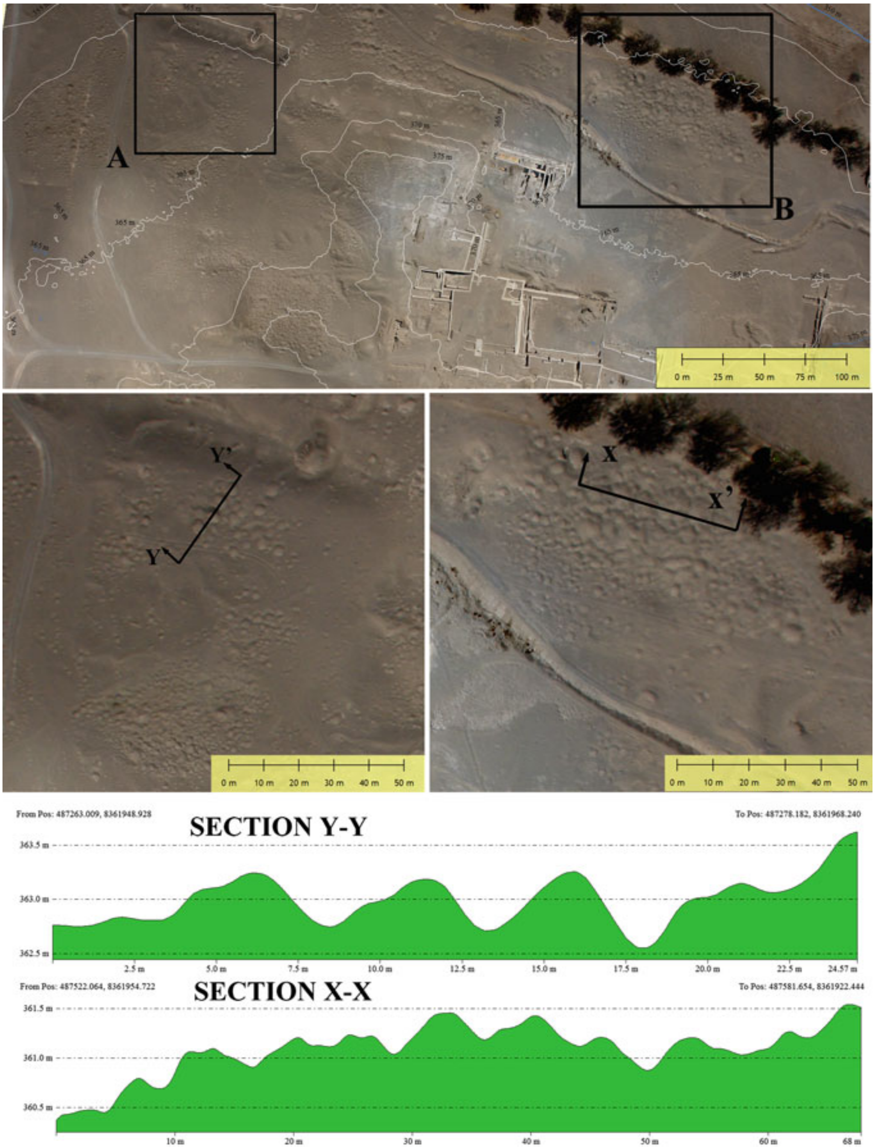


Fig. 25.12 Cahuachi, zone *A*: looting map derived from the SfM-based processing of aerial images taken from aircraft in April 2007. (*top*) Orthophoto of an area affected by looting including Piramide Naranja, Templo del Escalonado. (*middle*) From *left* to *right*, zooms of two areas named *A* and *B*, respectively, indicated in figure up *black square blocks*. (*bottom*) Profiles *Y-Y'* and *X-X'* along linearly aligned holes in the areas *A* and *B*, respectively

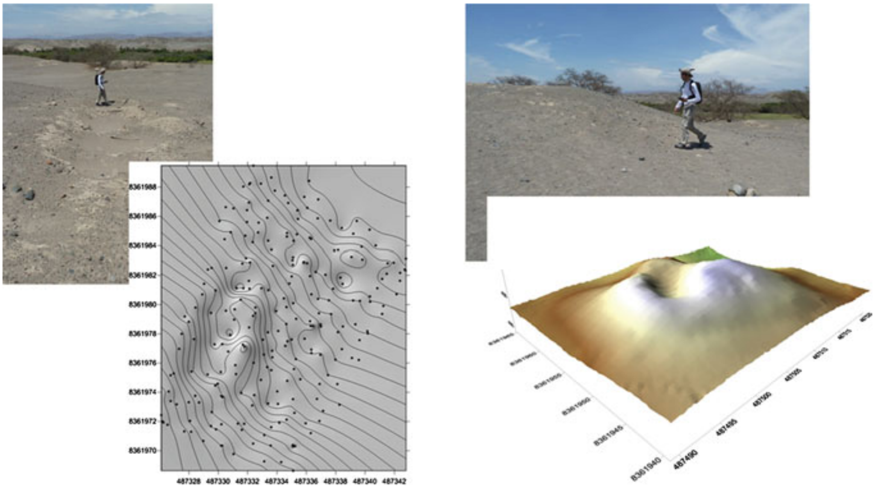


Fig. 25.13 GPS survey of looted areas

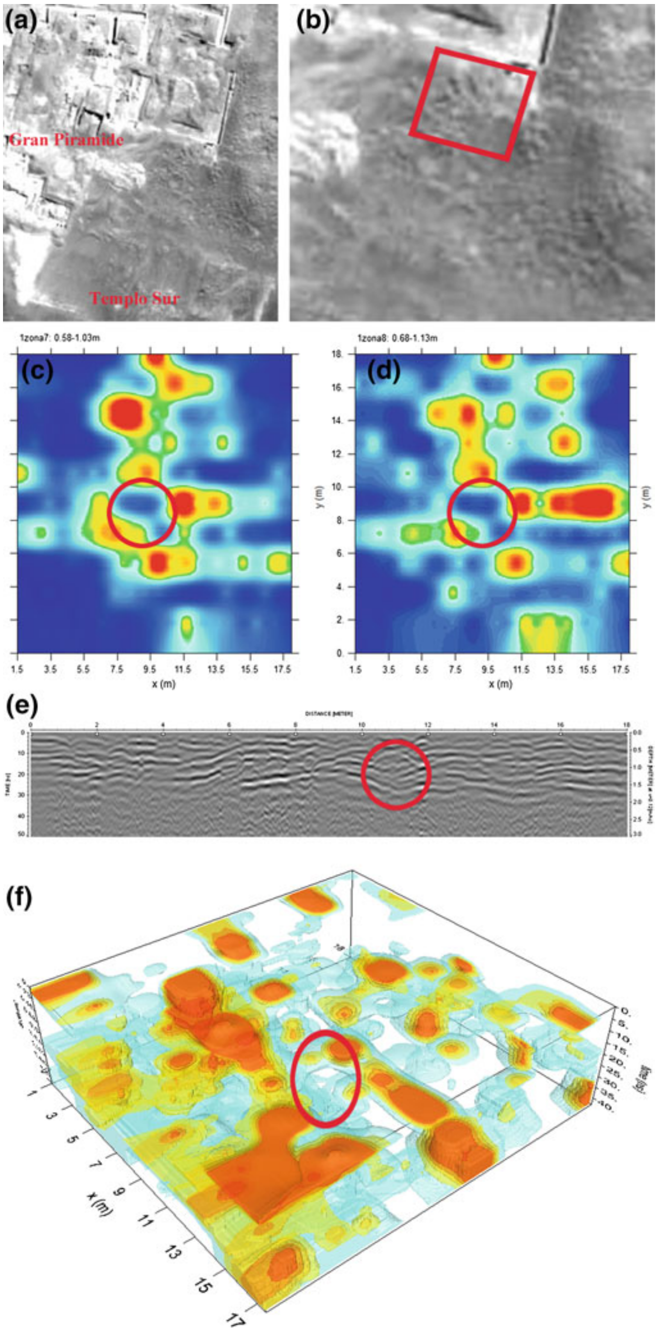
In Cahuachi, GPR was applied to explore from 1 to 2.5 m of the subsoil, depending on dielectrical characteristics of the soil and the frequency of the antenna used, with the aim to measure the depths of illegal excavations and to detect possible reflectors of archaeological interest not disturbed by *huaqueros*.

Figure 25.14 shows the results of GPR prospecting performed on a quadrangular area of about 20 × 20 m, located to the north, and at the foot, of *Templo Sur* (Fig. 25.14a, b), and characterized by the presence of some holes made by *huaqueros*.

The radargram (Fig. 25.14e) places into evidence, at the center of the investigated area in correspondence to one of the holes visible from satellite images, the reflection of a target clearly referable to the filling of a possible tomb or ritual offering at depths of 1–2 m. The morphology of the reflections suggest an insignificant disturbance caused by the grave robbers, even if the surface appears strongly modified by *huaqueros*. The reflections have been also visualized by means of time slices and a 3D representation of iso-amplitudes which enable us to provide additional information about the presence of buried structures around the possible tomb.

25.7 Final Remarks

In Peru, in general, and in Nasca in particular, archaeological looting is recognized as one of the most serious threats to cultural resources in both recorded and unrecorded sites. “It is ironic that the fascination with the past, which motivates all


(a)
Gran Piramide
Templo Sur
(b)
1zona7: 0.58-1.03m
(c)
x (m)
1zona8: 0.68-1.13m
(d)
y (m)
x (m)
(e)
DISTANCE [METER]
(f)
x (m)

◀ **Fig. 25.14** Cahuachi: test performed by using GPR to investigate the state of disturbance of the subsoil of area between Grande Piramide and Templo Sur which is characterized by holes of grave robbers. **a, b** Location of the investigated area in a satellite image and a zoom. **c, d** two time slices at depths 0.58–1.03 and 0.60–1.13 m, respectively. **e** radargram. **f** 3D representation of iso GPR amplitudes. The *red circle* denotes the presence of the anomaly indicative of a possible tomb or ritual offering

possible public behaviour toward archaeological resources, also causes so much damage and destruction" (McAllister 1991).

Many problems are associated with illegal excavations, among them: (i) damaging of archaeological sites, (ii) loss of artefacts, (iii) destruction of the context of artefacts and therefore irreplaceable loss of valuable information, and (iv) denying this cultural heritage to new generations (Atwood 2006).

To highlight and limit this phenomenon, systematic monitoring is required. Up to now, the protection of archaeological heritage from illegal digging has generally been very complex, to be done by both direct (in situ) and/or aerial surveillance, because this monitoring is expensive, time consuming and not operatively applicable for extensive desert areas, such as the Southern Coast of Peru. VHR satellite images can adequately offer operative monitoring tools, thanks to their global coverage and frequent re-visitation times.

This chapter briefly describes the emblematic case of Cahuachi, massively plundered since the 1930s. An overview on the state of the art of the satellite remote sensing for archaeological looting is briefly discussed. Even if remote sensing for the looting monitoring is a quite recent application, the results from many papers (Lasaponara and Masini 2010; Lasaponara et al. 2012, 2014; Casana and Panahipour 2014) clearly pointed out that satellite VHR images can suitably provide operative tools for the remote surveillance of looting phenomena.

This is further confirmed by the satisfactory results we obtained from the automatic procedure herein developed and applied to the Nasca area. The data processing we devised, mostly based on statistical analysis and classification, automatically identifies and extracts the changes linked to illegal excavations, thus offering useful information for both the monitoring and quantification of looting activities.

Finally, it is important to highlight that the recent ESA missions, denoted as Sentinel 1–2, provide active and passive data available completely free for charge. Even if their spatial resolution is worse than those offered by the commercial VHR satellite missions, they can offer (if also adequately processed at the sub-pixel level) an effective complementary data source for a systematic monitoring of the most vulnerable areas.

Acknowledgments The DEM in Fig. 25.11 has been processed by Antonio Pecci of CNR/IBAM. The GPR prospections have been performed and processed by Luigi Capozzoli, Enzo Rizzo of CNR-IMAA and Gerardo Romano of University of Bari (Fig. 25.14c–e). The 3d visualization of GPR iso-amplitude in Fig. 25.14f has been made by Giovanni Leucci of CNR-IBAM. GNSS kinematic surveys have been performed by Gabriele Bitelli and Emanuele Mandanici of University of Bologna.

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Chapter 26
Nasca Lines: Space Tracking of Vandalism

Nicola Masini, Maria Danese, Antonio Pecci, Manuela Scavone and Rosa Lasaponara

Abstract The Nasca Lines are one of the most impressive examples of cultural heritage throughout the entire world. Their exposure to damage and overall vulnerability are very high, much more than any other elements of cultural heritage, due to their intrinsic fragility and also because they are strongly threatened by several anthropogenic factors such as vandalism, ignorance, and urban sprawl. Moreover they are sparsely spread over large areas with easy and general access, which make their destruction almost effortless and their protection very challenging. This chapter is focused on the capability of remote-sensing technology capability for identifying and quantifying spatially-distributed damage to the geoglyphs, primarily caused by vandalism.

Keywords Nasca geoglyphs · Satellite remote sensing · Monitoring · Vandalism

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26.1 Introduction

Our archaeological heritage has been, and still is, critically threatened and frequently damaged (probably much more than any other cultural heritage, from artistic to architectural property) by several anthropogenic factors, such as vandalism, ignorance, urban sprawl, and, of course, looting.[1]

The exposure to these kinds of risk is huge. Just consider the number of archaeological sites, or potential archaeological areas located in countries where economic progress does not meet the aspirations of the present, without perhaps compromising the ability of future generations to meet their own needs, among which is the maturation of their own ancient cultural heritage. Consider also that a significant part of the archaeological heritage is located in countries affected by armed conflicts or civil wars. In recent years we are experiencing a resurgence of the phenomenon of ideological vandalism, such as that implemented by the Islamic State in Iraq and Syria.

Also, the vulnerability of archaeological heritage to anthropogenic risks, with particular reference to vandalism, is greater than that for other cultural resources. This is due to: (i) its intrinsically high material fragility which makes it easily damageable or destructible (it is very easy to demolish with mechanical actions columns and statues), and (ii) the lack of surveillance of archaeological sites and of (even more) potential archaeological interest areas, being that it is quite expensive and not feasible in all cases. This has always favored the use of surveillance techniques based on aerial and satellite remote sensing.

In Peru, devastating human actions have an ancient history, largely linked to *damnatio memoriae*, i.e., the initiative to impose the newly introduced European culture and the Christian religion on the Andean civilization and its world view. Inca and pre-Inca temples were destroyed, used as foundation for palaces, convents, and churches or as quarries of general construction materials. One of the most emblematic cases is the Coricancha, the most important Incan temple dedicated to the Sun God.

In the 20th century, the greatest damage to pre-Hispanic archeological heritage was due to the plundering of vast areas along the coast, from South to North, linked to illicit trade of antiquities in Europe and North America. A further anthropic damage factor to Peruvian archaeology is vandalism, particularly destructive where the heritage is inherently fragile and difficult to monitor and protect, as in the case of geoglyphs of Nasca.

[1]About the risks threatening archaeological heritage, this chapter mainly focuses on vandalism and briefly on urban sprawl, whereas for looting the reader is referred to Chap. 25 by Lasaponara and Masini (2016).

This chapter deals with some issues related to the crucial problem of the protection of Nasca lines, which can be, at least partially, addressed by using the most recently implemented earth-observation technologies. A short overview on the use of remote sensing for the monitoring of vandalism is described. Finally, some operative applications are herein presented and discussed.

26.2 Protection of Nasca Lines: Brief History and Regulations

"The Nasca Lines are one of the most impressive archaeological monuments in the world" (UNESCO 1994) and are also undoubtedly the most fragile due the specific characteristics of these magnificent drawings. They were obtained using two techniques (i) removing and pulling the gravel inwards to the drawn lines, to obtain the figures' lines in slight relief or (ii) through the removal of the gravel from within figure's lines, obtaining a solid figure by the resulting contrast with its surroundings. They could be severely damaged or completely destroyed simply by stepping on them. Therefore, the protection of this vast area is a mandatory step to reduce threats to the geoglyphs mainly "from tourism and vandalism" (UNESCO 1994).[2]

The first measures of protection were undertaken under the terms of Law No. 24047/19, which conferred on the National Institute for Culture the responsibility for the protection, also by forbidding access to the geoglyphs themselves and limiting planning for urban and rural development. Severe restrictions and penal sanctions as punishment were imposed as complementary actions, in the case of transgressions.

Despite this, unfortunately, over the years, due to easy access to the whole area, numerous disturbances have left indelible traces on the landscape as, for example, tracks made by vehicles or feet, including those linked to the Dakar auto rallies of 2012 and 2013.

In 1993, the Departmental Resolution No. 421/INC declared the Lines and geoglyphs of the Pampas of Nasca an Archaeological Reserve Area. In 1994, the Lines were inscribed on the World Heritage List on the basis of criteria IV (http://whc.unesco.org/archive/advisory_body_evaluation/700.pdf) "This system of lines and geoglyphs, which has survived intact for more than two millennia, represents a unique form of land-use which is especially vulnerable to the impact of modem society, and especially mass tourism". The area that was declared as included and mapped in the World Heritage List covers more than 700 km^2 (see Fig. 26.1) along low foothills and over desert terrain. Obviously, this further highlights the conservation issues and challenges.

[2]On the interpretation and dating issues of Nasca geoglyphs, see Chap. 11 by Masini et al. (2016a) and Lambers (2006).

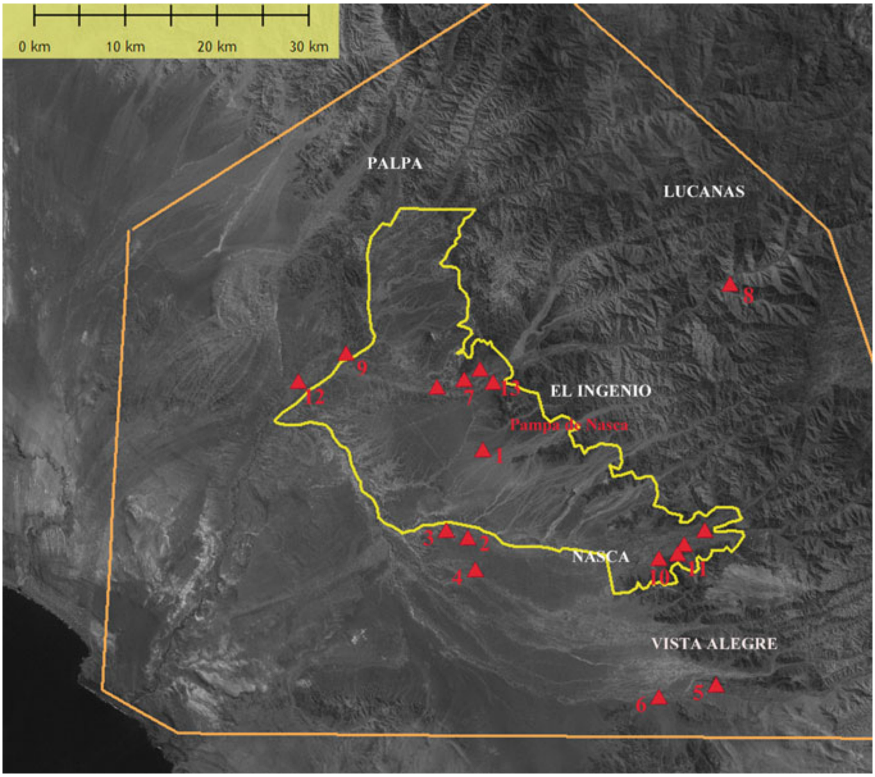

Fig. 26.1 Río Grande de Nasca drainage in a Landsat image. The *yellow polygon* indicates the perimeter of the area included in the World Heritage List. The *Orange lines* denote the perimeter of the reserve area established by the Management System Cultural and Natural Heritage in the territory of Nasca and Palpa. The *numbers* indicate the most important archeological sites in the Río Grande de Nasca drainage: *1* Nasca Lines, *2* Estaquería, *3* Cahuachi, *4* Geoglyphs of Pampa de Atarco, *5* Huaca del Loro, *6* Chauchilla, *7* San Jose, *8* El Tajo, *9* San Juan, *10* Paredones, *11* Cantalloc, *12* Cabildo, *13* Ventilla

In 2000, Luis Guillermo Lumbreras published, with the National Institute of Culture, a document entitled “Formulation of guidelines for the development of a management plan for the Nasca lines”. This included an appropriate register, cataloging and delimitating the area inscribed in the UNESCO World Heritage Site.

Later, on the 13th August 2004, a National Resolution (Directorial n. 654/INC) provided more precise details in respect to Article 1 of the previous Resolution (Jefatural n. 421/INC), specifying the location of the Nasca geoglyphs that included the streams Santa Cruz, Magallanes, Piedra Blanca, as well as the valleys of Santa Cruz, Río Grande, Palpa, and Ingenio, and the pampas of Jumana, Nasca and Las Trancas (in the departments of Ica and Ayacucho).

In 2009 the "Management Plan Lines and geoglyphs of Nasca and Pampas de Jumana" designed the system for the management of the cultural territory of Nasca and Palpa, considering the conservation of cultural and natural heritage as a key factor for Peru's social, economic, and environmental development.

According to the UNESCO report made in 2013, the factors affecting the property (as identified in previous analyses http://whc.unesco.org/en/soc/1994) are mainly:

- Damage caused by illegal excavations and farming activities;
- Continued vehicular traffic through the geoglyphs;
- Damage caused by flooding
- Lack of systematic monitoring of the property;
- Insufficient air-traffic security measures;
- Lack of a management plan;

On January 16, 2015, the Ministerial Resolution No. 019-2015-MC approved the "Management System for Cultural Heritage Nasca and Palpa Territory" plan, entrusting to the Decentralized Cultural Department of Ica the plan's implementation. The Management System covered not only the areas registered as world heritage sites by UNESCO but also areas with geoglyphs, petroglyphs, aqueducts, ceremonial sites, and urban roads, burial areas, churches, houses, house estates, and particularly important ecosystems that enable the understanding of the interrelationship between human beings and nature, as well as paleontological areas.

The area considered in the management system of cultural and natural heritage of Nasca and Palpa territory covered the territories of the Ica and Ayacucho regions, extending over 5627 km^2.

This territory includes the districts of Santa Cruz, Río Grande, Llipata, and Palpa District, located in the province of Palpa; part of the district of Santiago in the province of Ica; Changuillo districts, El Ingenio, Vista Alegre, Nasca District, and the district of Marcona, located in the province of Nasca; and part of the districts of Ocaña, Leoncio Prado, and Santa Lucia in the Ayacucho region. The polygon includes the basins of the following rivers with their respective sub-basins: Río Grande north to south, with the sub-basins of the rivers Santa Cruz, Río Grande, Palpa, Viscas, Ingenio, Nasca, Aja, Tierras Blancas, Taruga, and Las Trancas. Within the sub-basin of the Nasca River, from north to south, they are the micro basins of the streams Cruz del Chino, Las Animas, Urpalla, and Socos.

The Nasca Lines have been preserved over time due to the lack of rain, limited erosion processes, and also thanks to the air humidity which fostered the development of a thin crust on top of the reliefs, thus protecting the drawings from wind erosion. Unfortunately today, they are affected by several risks, mainly anthropic, such as vandalism, off-road tracks, and urbanization which are the cause of their deterioration and, in some cases, total destruction.

26.3 Satellites to Focus on the Nasca Lines

Presently, the great number of multispectral VHR satellite images, even available free of charge in Google Earth, have opened new strategic challenges in the field of remote sensing in archaeology. The importance of applying space technology to archaeological research has been paid great attention worldwide, due to the following aspects:

(i) the improvement in spectral and spatial resolution reveals increasingly detailed information for archaeological purposes;
(ii) the synoptic view offered by satellite data helps us to understand the complexity of archaeological investigations at a variety of different scales;
(iii) satellite-based digital elevation models (DEMs) are widely used in archaeology, for several purposes, to considerably improve data analysis and interpretation;
(iv) the availability of long satellite time series enables monitoring hazards and risks in archaeological sites over time;
(v) remotely-sensed data enable us to carry out both inter- and intra-site prospecting and data analysis.

In particular, the use of satellite remote-sensing technologies over the large area covered by the Lines can trigger significant improvements in the establishment of a systematic monitoring for improving knowledge and documentation and for supporting preservation strategies.

Satellite can offer strategic tools useful to cope with the lack of systematic monitoring of the property as remarked many times in the UNESCO reports (http://whc.unesco.org/en/list/700/documents/). One of the most important points is that most of these technologies are available at varying costs for different purposes and needs, so, even with a small budget, it is possible to implement very effective solutions. Of course, an optimized integrated approach, based on diverse space technologies and data analyses, can combine the available data at very-high spatial resolution with those available at higher temporal resolution. Moreover, active and passive satellite sensors are ideally suited for observing the Nasca site being that this region has virtually no vegetation and rainfall–so that natural disturbances are minimal.

Nevertheless, despite the anticipated high potential, up to now, only a few attempts have been made to evaluate the performance of satellite technologies for the monitoring, protection, and preservation of the Lines. ESA and NASA made a preliminary assessment of the capability of satellite and airborne SAR, respectively, for the characterization of radar imaging capability on Nasca Lines (http://www.esa.int/Our_Activities/Observing_the_Earth/Ancient_desert_markings_imaged_from_orbit). Ruescas et al. (2010) used the radar coherence to assess changes of the Nasca Lines from 1997 to 2004. In particular, they considered both SAR amplitude and coherence. The latter informs us about the mechanical stability of the Lines, whereas the former about their electromagnetic structure. Results from this investigation shown that the highest coherence, and in turn the unchanged areas, was found in correspondence of the Lines and roads; whereas the lowest coherence was observed in correspondence with the agricultural areas, which was as expected due to the temporal phenological changes occurring over them.

More recently, NASA performed an aerial survey of the Lines using Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR), developed and managed by the Jet Propulsion Laboratory, Pasadena, California, (http://www.jpl.nasa.gov/news/news.php?feature=4834). To this end, multiple flights were performed on March 2015 to identify damage on the ground beneath the aircraft that occurred after the Green Peace demonstration that caused significant disturbance around the Hummingbird.

Finally, a time series of Landsat TM data was recently used by Hesse (2015) to identify disturbances of the Lines during the study period 2009–2013. This change detection highlighted that the most extensive surface disturbances occurred between 06 January 2012 and 22 January 2012, due to intense off-road vehicle activity linked to the Nasca–Pisco stage of the 2012 Dakar rally which passed through the area.

26.4 Protection and Monitoring of Geoglyphs: Remote Sensing Perspectives for Operational Use

Nowadays, the availability of satellite data at various spatial and temporal resolutions enables various ways and strategies for the "remote safeguard" of geoglyphs, depending on their size and shape, as well as on the expected type of damage factors ranging from tracks of off-road vehicles and pedestrian to damages caused by urban expansion. To this end, it is important to highlight that the sizes of geoglyphs greatly vary, from biomorphic figures of about 50–100 m to straight lines that are longer than 1 km.

For operational use of satellite remote sensing, several factors have to be considered, including the costs of obtaining the images, their temporal resolution (which depends on the revisit time of the satellite), their spatial and spectral resolutions, and, in turn, their capability in discriminating geoglyphs and traces of damage.

The choice of technologies and satellite data also depends on the purposes that may include:

1. the creation of topographic and thematic maps for typological studies also oriented to the **analysis of the state of conservation**. In this regard, some applications by the authors will be described in Sect. 26.4.1.
2. the **change detection and assessment of damages** caused by known and unknown events, as, e.g., the most recent cases of damage caused by specific events such as the Dakar rally, Green Peace activists, and "ordinary" acts of vandalism. In Sect. 26.4.2, some examples will be reviewed.

3. the setting up of **systematic monitoring** of the state of conservation of geoglyphs with a temporal resolution adequate for safeguard activities. In this regard, a starting point is the approach proposed by Hesse (2015) which, adequately readapted, could be used not only for the multitemporal observation of past damage events but also to monitor and follow events in order to put into action protection measures.
4. integrated **management** of data provided by remote-sensing-based activities and in situ surveillance aimed at updating thematic maps (monthly, yearly and multi-yearly), improving the understanding of risk factors, at supporting decision makers for the planning of actions to eliminate vandalism and the drafting of the periodic report for the UNESCO.

26.4.1 Analysis of the State of Conservation

In the context of the activities of the ITACA Mission in the Nasca drainage basin, some applications have been developed to provide tools for assessing the state of conservation of geoglyphs, with particular reference to the Pampa de Atarco.[3]

Specifically, our approach sought to survey all the known geoglyphs (and possibly to detect unknown ground drawings), to map damage caused by anthropic and natural factors, as well as to evaluate their integrity with respect to a presumed original state of the geoglyphs. The results have been products useful for investigation projects as well as for planning and managing activities of surveillance and control.

For this task, very-high-resolution satellite imagery (with geometric resolution of panchromatic band ranging from 1 to 0.30 m) offers a good compromise between the needs to cover large areas and the great detail obtainable for both geoglyphs and damage features. However, some problems make this technology not always operational and so practicable. One is the high cost (see for example http://www.e-geos.it/products/pdf/prices.pdf) for both new acquisitions and archived data (around \$750–1500 for 100 km^2). The other limit is the spatial resolution which does not enable appreciation of all the details of geoglyphs, especially the biomorphic ones.

In order to reduce the costs of satellite data without reducing the quality of information, the choice of the satellite dataset must be done considering that:

- the costs increase with spatial and spectral resolution and the number of spectral bands;
- the cost ratio between archived and new acquisition data is 0.5;[4]

[3]On the scientific activities performed in Pampa de Atarco by the ITACA mission of Italian CNR, the reader is referred to Chap. 12 by Masini et al. (2016b).

[4]Moreover, the minimum areas are 25 and 100 km^2, respectively.

- most of the archived images are available free of charge on Google Earth;[5]
- the geoglyphs are located only in the pampas of Río Grande drainage basin;
- biomorphic geoglyphs which require higher-resolution imagery are not spread uniformly over all the pampas.

There are three strategies to improve the information content, in case the satellite images do not provide the details necessary to analyze the morphological features, as well as to identify small traces of vandalism:

(i) integration of satellite remote-sensing data with high-resolution images taken from aircrafts and UAV with centimetric (5–20 cm) spatial resolution, useful also to obtain accurate digital elevation models (DEMs) (see for example Lasaponara et al. 2016b);
(ii) enhancement of satellite imagery by using suitable data processing, such as, e.g., convolution and morphology filtering, etc. (see Lasaponara and Masini 2012).
(iii) statistically-based extraction of features related to geoglyphs and vandalism marks by using unsupervised classification and segmentation.

As an example, we show some outputs to address points (i), (ii) and (iii) (in Figs. 26.2, 26.3 and 26.4).

Figure 26.2 shows a detail of the geoglyphs of Pampa de Atarco observed from a satellite image of 2011 (a, d); an orthophoto, and a DEM derived from the processing of aerial photos taken from a drone in 2015 (b and c, respectively). The added value of aerial images is given by the capability to discriminate, with higher detail with respect to satellite picture, geoglyphs and small traces of vandalism. Moreover, the DEM enables us to improve knowledge about the microtopography useful to better understand the drawing techniques, study the relative chronology of overlapping lines and figures, and identify all the vandalism tracks, including not only those caused by vehicles but also by incautious pedestrians (walking even with appropriate shoes), as in the case shown in Fig. 26.2e, f.

Figure 26.3 show the results of two-edge enhancement filters of the same scene as in Fig. 26.2. They are the directional and Laplacian filters (Fig. 26.3b, c, respectively). The directional is a first derivative filter that enhances features having specific direction components (or gradients), and consequently operates with regard to edge direction. On the contrary, Laplacian is a second-derivative edge-enhancement filter and operates without regard to edge direction. The enhancement filters improve the information content and so the highlighting of the geoglyphs and damage traces.

Figure 26.4 shows a satellite image and its elaborations specifically made to enhance traces of vandalism over, and close to, the geoglyphs of Pampa de Atarco. In particular, Fig. 26.4a shows the satellite picture acquired from the GeoEye in 2011. Figure 26.4b depicts the results obtained from the statistical elaboration of

[5]It should be taken into account that the images available in Google Earth have a lower quality and reduced elaboration opportunities.

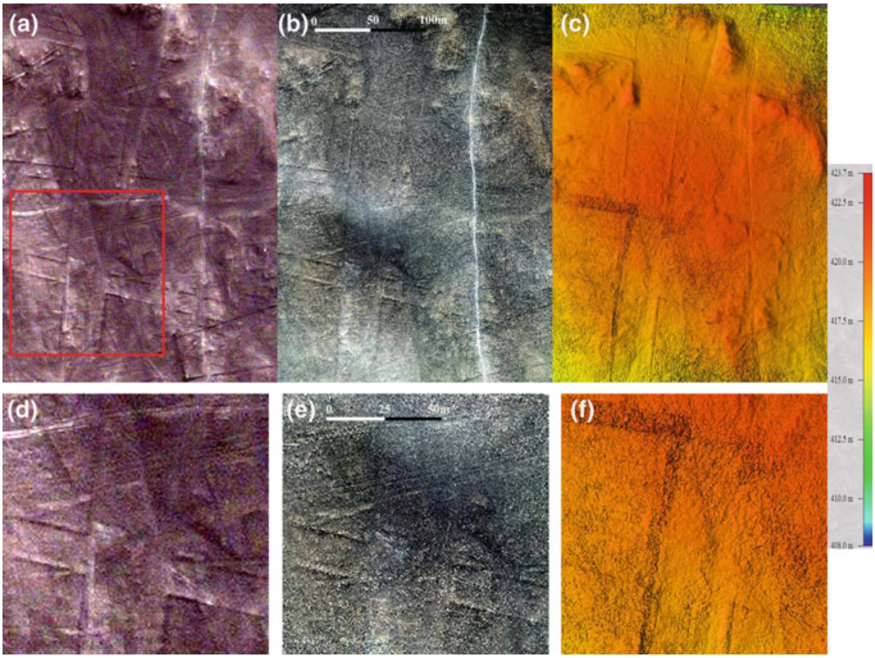

Fig. 26.2 Geoglyphs of Pampa de Atarco: detail of a trapezoid and a meandering motif from a satellite image. **a** Orthophoto and **b–c** DEM obtained by processing aerial images taken from a drone in 2015; **d** Zoom of **a**. e Zoom of **b. f** Zoom of **c**. The *red box* in **a** indicate the subset of the zooms in **d**, **e**, and **f**

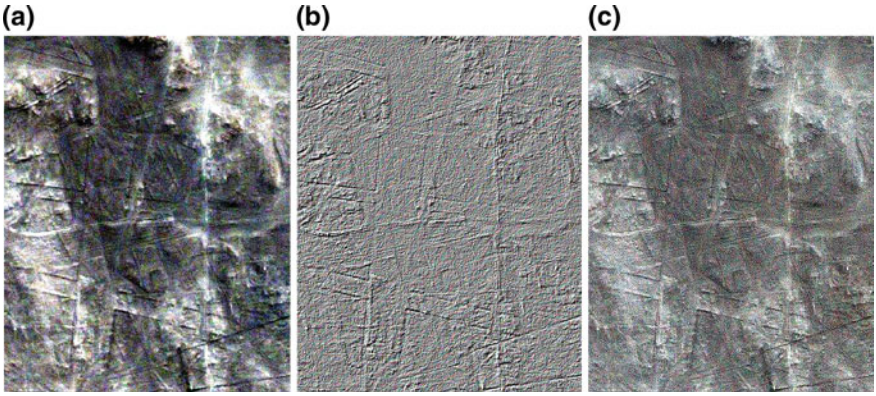

Fig. 26.3 Enhancement of **a** the same scene as in Fig. 26.2a by using **b** convolution directional and **c** Laplacian filtering

the panchromatic picture performed using the unsupervised classification based on the Kmeans method. The diverse colors document the different classes obtained. The yellow class is clearly related to the traces of vandalism that are well

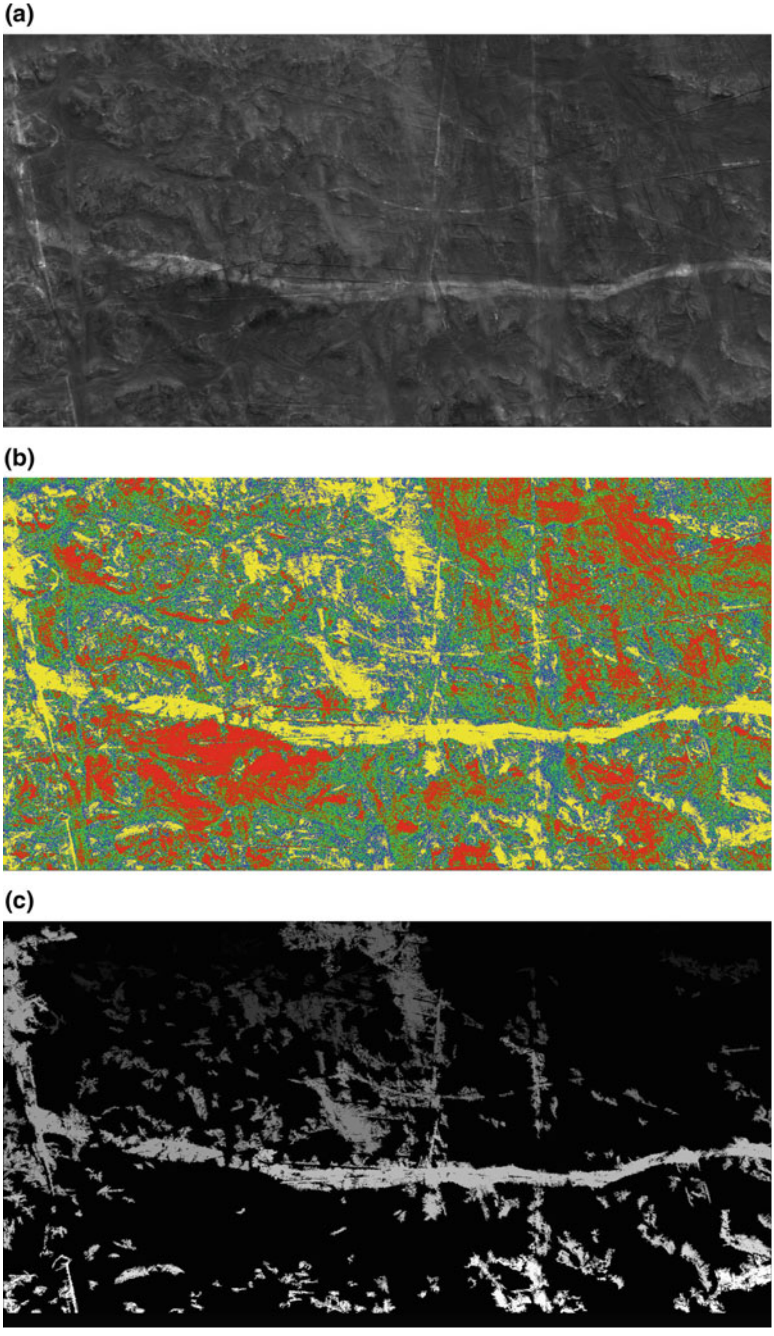

Fig. 26.4 **a** Detail of the geoglyphs in Pampa de Atarco from GeoEye panchromatic image acquired in 2011. **b** Unsupervised classification performed by Kmeans method of **a**; **c** segmentation of **b**. The class with *yellow color* is related to damage caused by vehicles and motorcycles

categorized because they are more recent than the geoglyphs. This temporal sequence is evident by the different reflectance values that characterize the pixels involved in recent changes. They tend to be brighter than the others. The contrast is evident by a visual comparison of areas affected and area unaffected by disturbance in the panchromatic image. The most interesting point is the statistically significant difference between the unchanged areas and those involved in the landscape disturbance. This is clearly pointed out by the high discrimination capability of the Kmeans which clearly identifies and well categorizes pixels adversely affected by change due to damage caused by vehicles and motorcycles. To make the damage clearer and the assessment of their impact easier, a segmentation is carried out on the output of the classification (similar to what done for the enhancement of the looting in Chap. 25 by Lasaponara and Masini 2016). The yellow class has been segmented in order to isolate, and better characterize, the area identified as changed, thus facilitating the interpretation process as well as the damage quantification (see also Lasaponara et al. 2016a).

Satellite-based analysis has been also adopted to evaluate the state of conservation or, better to say, the degree of 'integrity' with respect to a 'presumed' original state of the geoglyphs of Pampa de Atarco. These geoglyphs are located at the south, west and southeast side of the ceremonial center of Cahuachi, and cover an area of about 3500 ha. They are mainly composed of geometric figures such as, straight, and U-shape lines, trapezoids, triangles, zig-zag, and meandering motifs, made by using three different engraving techniques. The first is based on the removal of sand and gravels to expose the underlying lighter dust and the use of the removed material to create lines. The second is an additive technique, consisting of placing dark color gravels along the lines to be drawn. The third is aimed at creating slight microrelief by scraping sand and gravels and adding some darker gravels along the lines (for additional detail, see Chap. 12 by Masini et al. 2016b).

The state of conservation (or integrity) of each geoglyph has been made detecting possible *lacunae* with respect to its presumed original shape and dimension (Fig. 26.5). This has been relatively easy for straight lines and trapezoids, but more difficult for other figures such as meandering and zig-zag motifs.

The computation of the conservation index has been made for both the straight lines and the areal figures (such as trapezoids, meander, zig-zag, etc.). For the areal figures, the indices have been calculated for the lines and the curves bordering them.

The conservation degree, expressed as a percentage, was calculated on the basis of the GeoEye satellite image acquired on 28.02.2011 (Fig. 26.5), by computing the ratio between the current observed length of each geoglyph and the presumed original length of the geoglyph.

The computation of the conservation indices (Fig. 26.6 and Table 26.1) places into evidence that about the 20% is almost completely lost or severely damaged, thus making very difficult any restoration actions based on the removal of signs of vandalism, mainly due to off-road vehicle tracks. Almost 30% is affected by significant disturbance, which makes the reconnaissance and recognition of the figures difficult. For this class, the state of decay does not compromise the effectiveness of

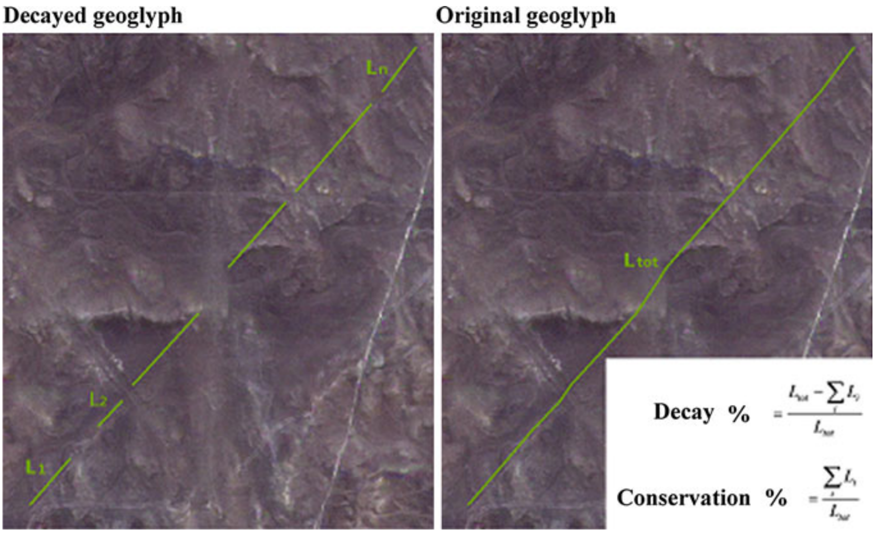

Fig. 26.5 Conservation and decay index

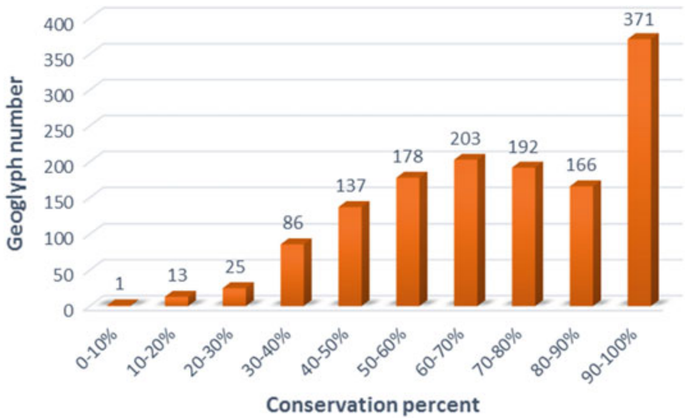

Fig. 26.6 The conservation percentage computed for the geoglyphs located in Pampa de Atarco

any restoration interventions, which should be addressed to make more visible the conserved geoglyphs only (!) removing the traces of disturbance. Finally, 26 and 27% of geoglyphs are well and very well conserved, respectively. They do not need significant restoration.

Figures 26.7 and 26.8 show the spatial distribution of the above-said conservation percentage classes in the Pampa de Atarco. The red color corresponds to severely damaged geoglyphs, the yellow denotes the lines damaged, and finally, the green indicates the well preserved geoglyphs (Table 26.1). As a whole, we can observe that most of the severely damaged line are concentrated in the figures

Table 26.1 Damage classes identified for the geoglyphs located in Pampa de Atarco according to the computed conservation indices

Conservation percentage	N. Geoglyphs	% Geoglyphs	Comment
<30	39	2.8	Almost disappeared
30–50	223	16.3	Severely damaged
50–70	381	27.8	Damaged
70–90	358	26.1	Well conserved with localized lacunae
90–100	371	27.0	Very well conserved
	1372	100.0	

linked to a ceremonial function such as meanders, zig-zag, and spiral motifs (probably due to a greater wear over time caused by processions and other ritual activities?). A very good state of conservation is mainly observed in long lines bordering trapezoids and irregular figures.

For the rest, the spatial distribution of damage level depends on the presence of the tracks of vehicles that have crossed the Pampa of geoglyphs. In this respect, Fig. 26.9 shows the map of the geoglyphs of Pampa de Atarco with the indication of roads and tracks produced by motor vehicles and motorcycles which have crossed the geoglyphs in east-west and north-south directions.

26.4.2 Change Detection and Assessment of Damage

For change detection, the same consideration are valid with respect to the choice criteria of the remote sensing data, as in Sect. 26.4.1. In addition, the need to identify and quantify differences between images acquired for the same area at different times by using appropriate change- detection methods should be taken into account (Hussain et al. 2013). Change detection must be preceded by a precise geometric co-registration of the multidate scene, in order to avoid false changed areas, as well as radiometric, atmospheric, and topographic corrections, in order to minimize their impact on the effectiveness of the change detection method, whose accuracy must be assessed.

This approach based on remote-sensing change detection can represent an operational tool for: (i) drafting of the periodic report to submit every six years to the World Heritage Committee[6]; and (ii) supporting decisions related to the protection and management of the intangible Archaeological Zone of Nasca Lines.

[6]Every six years, Peru, as well as the other States Parties, have to provide to the World Heritage Committee a report related to the application of the *World Heritage Convention*, including the state of conservation of the properties. The periodic reporting is required in order to: (1) provide an "assessment as to whether the World Heritage values of the properties inscribed on the World

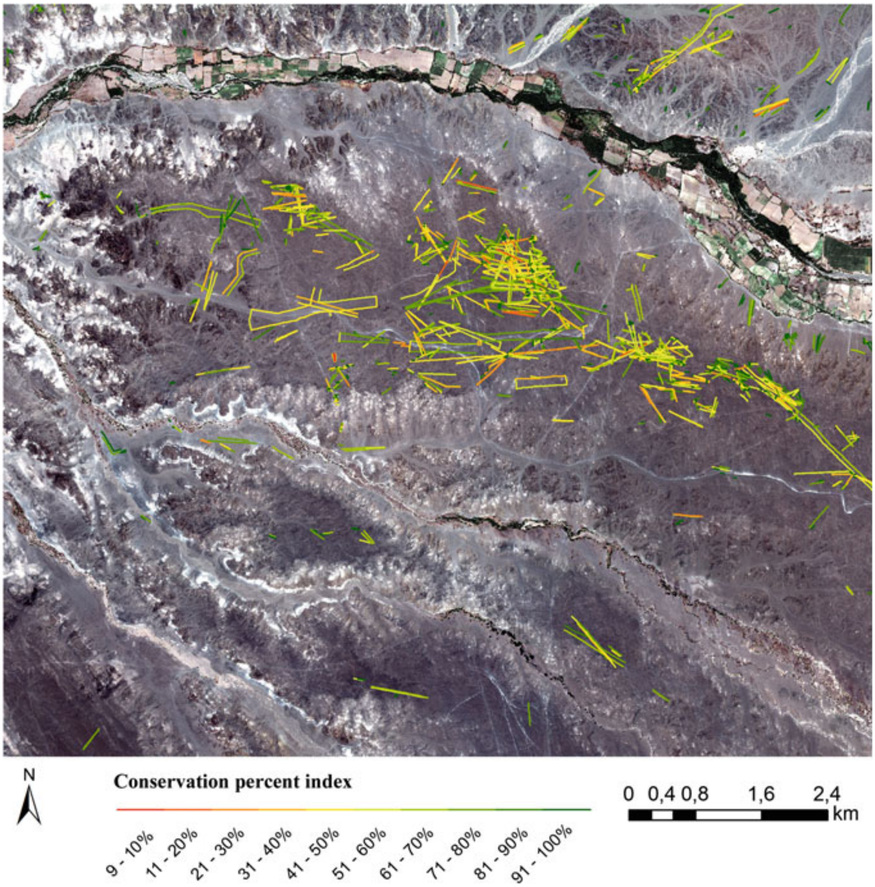

Fig. 26.7 Pampa de Atarco geoglyphs from GeoEye satellite image (28.02.2011). The map also includes the geoglyphs with color indicating the conservation index. The *lines* with a low conservation index (with colors between *orange* and *red*) are mainly located nearby the geoglyphs, such as meanders, spiral and zig-zag, where ceremonial activities (such as processions, etc.) took place

To this end, the use of satellite images can enable the observation of a given phenomenon in order to prepare the protective actions. A further and more challenging aim is to apply space-based earth observation to intensify surveillance: (i) inside the intangible Zone protected by UNESCO (consider the recent case of Colibri damaged by Green Peace); and, also outside the intangible Zone, such as the

(Footnote 6 continued)

Heritage List are being maintained over time"; (2) "to record the changing circumstances and state of conservation of the properties" (http://whc.unesco.org/en/periodicreporting/).

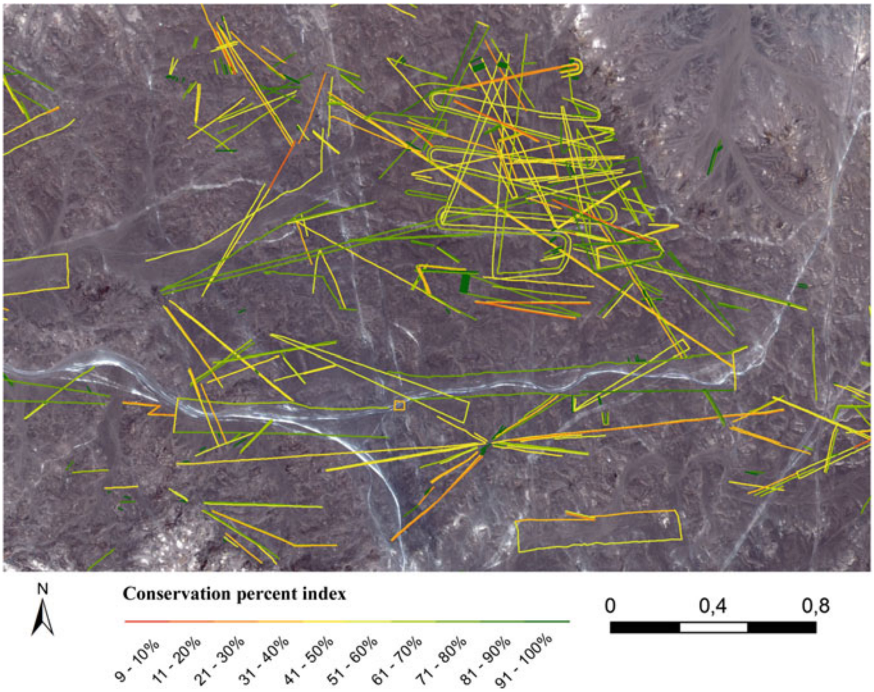

Fig. 26.8 Zoom of map in Fig. 26.7 centered on a group of geoglyphs characterized by the presence of a large meander and a radial center

geoglyphs of Atarco and Usaka which are particularly exposed to damage caused by cars and motorcycles.

Several site in the Nasca drainage have been observed and investigated with the object to assess the reliability of the current available satellite data and processing methods, also from a multitemporal perspective. For example, Fig. 26.10 shows the changes that occurred 2002–2011 and 2011–2013, in an area of Pampa de Atarco (about its location, see Fig. 25.9). It is an emblematic example of how such a fragile cultural heritage could be severely damaged in a short time. In fact, the variations that occurred during nine years (2002–11) seem to be less than those recorded in just two years (2011–13), likely due to Dakar Rally event which attracted many people, directly and indirectly related to car race event, who consequently travelled in the desert of Nasca.

Starting from this evidence, we compared two satellite images acquired before and after the Dakar Rally (acquired on 29.02.2011 and 13.03.2013). The analysis shows the dramatic scenario depicted in Fig. 26.11. In particular, in red are the curves and lines related to vehicles tracks and roads visible from the 2011 satellite image. In the two following years, several new tracks of motor vehicles and motorcycles, severely damaged the geoglyphs of Atarco, even reaching some mounds and platforms in Cahuachi.

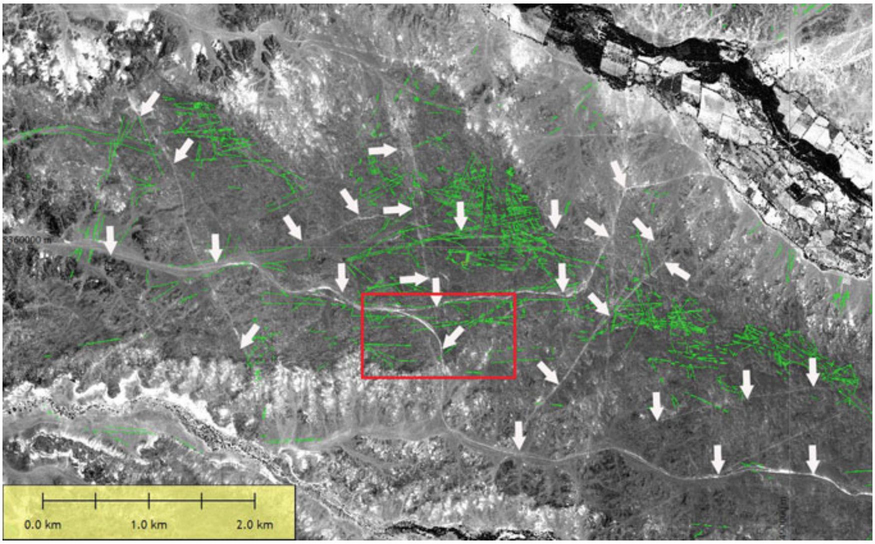

Fig. 26.9 Map of the geoglyphs of Pampa de Atarco from GeoEye acquired on 28.1.2011. The *white arrows* indicate the tracks and roads which cross the geoglyphs, damaging them. The *red box* indicates a subset reported in Fig. 26.10

This event had the merit of increasing the awareness of people about the importance of protecting and preserving such a fragile cultural heritage, as evident by the most recent ‘Greenpeace’ accident which created a large debate involving not only experts and institutions, but also common people.

We wonder if the interest aroused by the Greenpeace and the Dakar race cases can be sufficient to create a new culture and new attitudes regarding the cultural heritage of Peru. This could conceivably even result in urban planning more attuned to the protection of cultural heritage, also outside the intangible area, and thus avoiding the destruction that occurred in the last decade due to then uncontrolled urbanization processes (Fig. 26.12).

26.5 Conclusions and Future Perspectives

The Nasca Lines are one of the most fragile and impressive evidences of an ancient civilization of the entire world. Their exposure to damage, mainly anthropic, is very high. They could be severely damaged or completely destroyed simply by incautious footsteps.

Their sparse distribution over large areas and their specific material characteristics make their destruction easy and their protection very challenging.

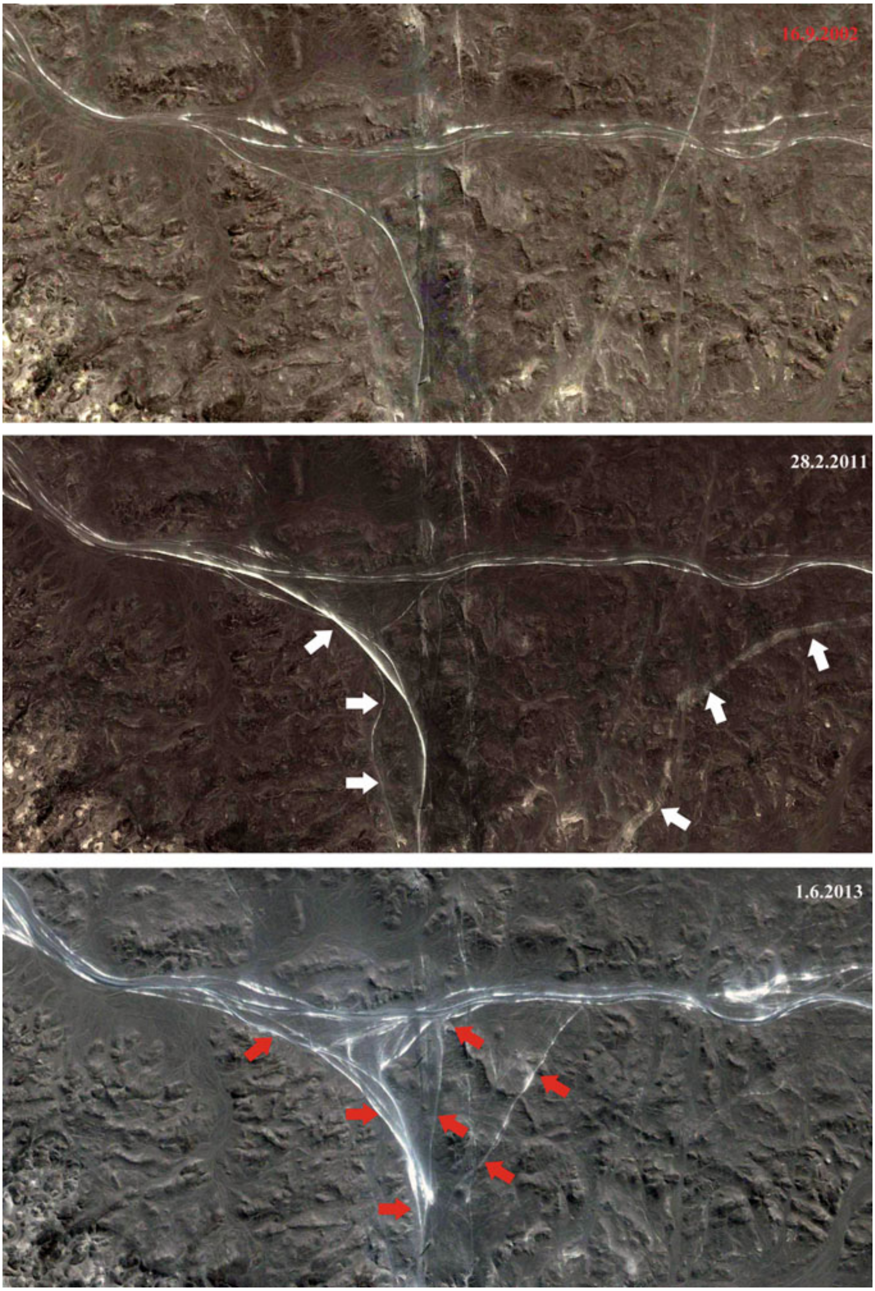

Fig. 26.10 Detail of Pampa de Atarco geoglyphs (for its location, see Fig. 26.9). Change detection made on satellite images acquired in 2002, 2011, and 2013. The *white* and *red arrows* show that the most significant changes occurred 2002–2011 and 2011–2013

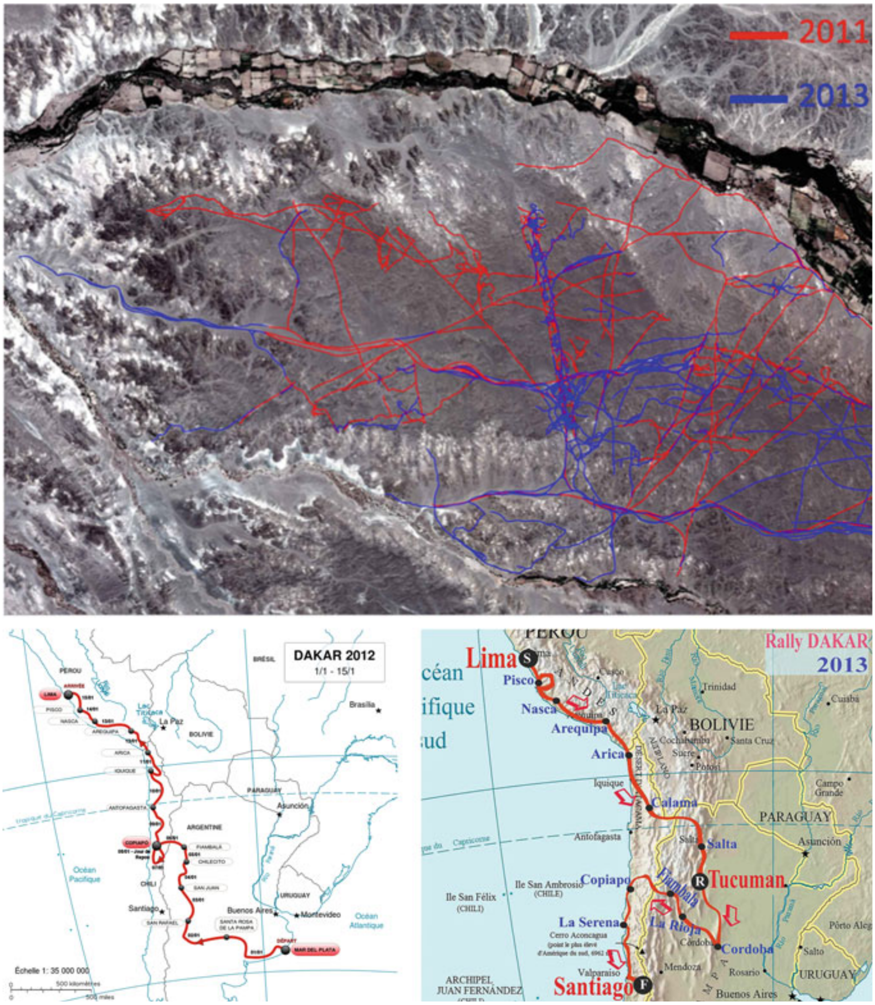

Fig. 26.11 Pampa de Atarco. *Top* Change detection computed between two satellite GeoEye images acquired on 29.02.2011 and Pleiades images acquired on 13.03.2013. The *curves* and *lines* in *red* are the vehicles tracks and roads visible from the 2011 satellite image. In the two following years, several new vandalism tracks, in *blue*, have been caused by off-road vehicles. This dramatic increase in vandalism damage could have some direct or indirect link with the two Dakar Rally events held in 13–14 January 2012 and 7–8 January 2013. *Bottom* Maps of the Dakar Rally Races in 2012 and 2013 (from Wikipedia)

A higher awareness of the values of protection and the risks needing consideration, along with operational use of observational technologies, in particular space-based-sensor satellites, can reduce threats to the geoglyphs.

In this chapter, we have showed that remote sensing is capable of identifying and quantifying widely spatially-distributed damage, caused by vandalism, ignorance, uncontrolled urban expansion, and mining.

Fig. 26.12 Vista Alegre at South of Nasca town. In this case, uncontrolled urbanization destroyed completely some lines and trapezoids as showed from the satellite dataset 2002–2013 (Courtesy of Google Earth)

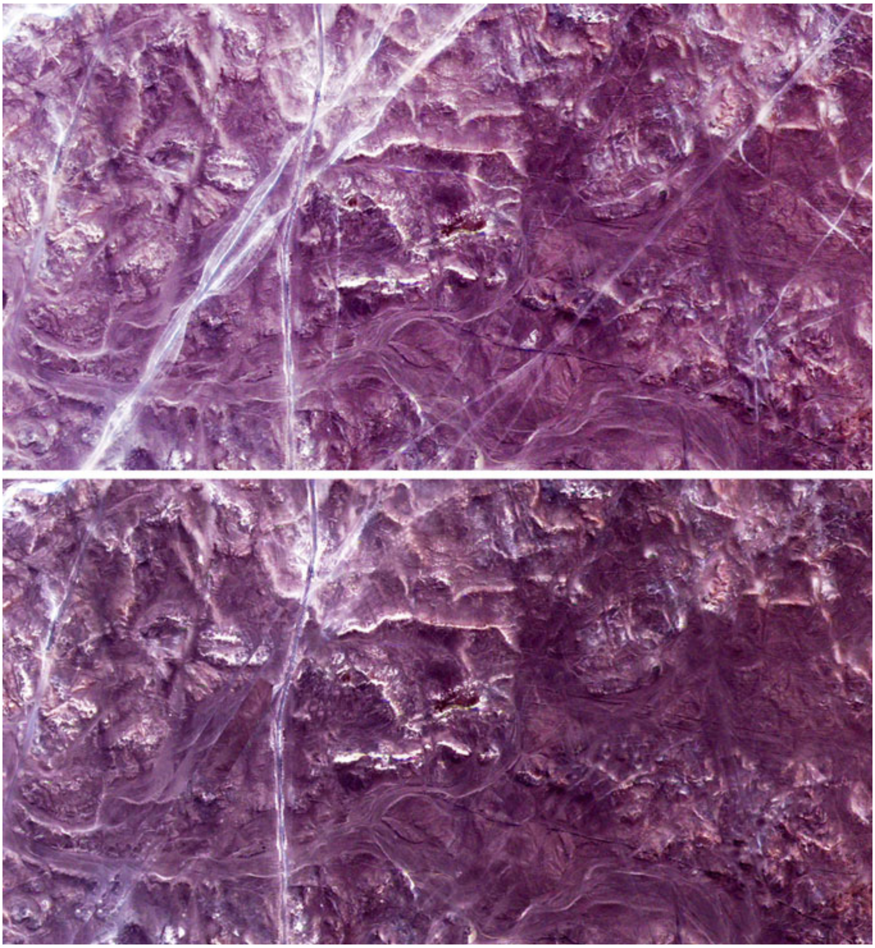

Fig. 26.13 Digital restoration of a desert terrain drawing by removing vandalism traces and off-road vehicles tracks (map by Manuela Scavone, CNR-IBAM)

In the future, the technologies should be ever more focused, through regular, operational use, on both planning intervention strategies for the safeguard of geoglyphs and supporting the management of crisis situations linked to vandalism and natural disasters, including flashfloods. The recent availability of Sentinel data, free of charge and with a short revisiting time, can open new scenarios for risk prediction, prevention, and mitigation.

Moreover, the digital remotely-sensed data can offer new opportunities for the conservation of geoglyphs by means of the virtual simulation of landscapes after removal of vandalism damage. An example can be seen in Fig. 26.13, depicting a possible use of the digital virtual restoration in Pampa de Atarco.

Finally, the increasing awareness of citizens about the importance of the preservation of cultural heritage, along with the technologies and social media, can promote in the future citizen-friendly scientific activities and projects, such as crowd-sourced science, civic science, volunteer monitoring, offering more effective and low-cost tools for the safeguard of Nasca Lines heritage.

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