The Geoglyphs of Palpa (Peru): Documentation, Analysis, and Interpretation

Thesis

presented to the Faculty of Arts

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by

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Accepted on the recommendation of

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Technical note

This study consists of two parts: the main volume, containing text and illustrations, and a supplement, including large format maps and a DVD. The DVD contains a database with the geoglyph data on which the results of this study are based, a virtual flight over the geoglyphs of Palpa, and the text of the main volume.

Main volume:

Illustrations referenced in the text as “Figure” are included in the main volume, whereas illustrations referred to as “Map” can be found in the supplement. All maps in this study are oriented towards true north. Coordinates, where present, are given in UTM projection, zone 18 S, WGS 84. Since UTM coordinates are given in meters, they provide the map scale at the same time.

All photographs used to illustrate this study have been taken by team members of the Nasca-Palpa project. On some photos taken in the field as well as on excavation drawings, geoglyph and site numbers are shown according to a preliminary system used for fieldwork. During analysis, the numbering system has been changed. Definite geoglyph and site numbers are given in the figure captions.

DVD:

The geoglyph database (*palpa_geoglyphs.mdb*) has been generated in MS Access 2000 and requires this or a compatible software program to be opened.

The virtual flight over the Palpa geoglyphs (*virtual_palpa.avi*) has been recorded in AVI format and is best viewed with Apple´s freely available Quicktime Player. Due to its size, it is recommended to copy the file to your local hard disk before opening it.

The main volume of the thesis is also included on the DVD (*lambers_palpa_thesis.pdf*). It is stored in PDF format, which can be opened using the freely available Adobe Reader.

Acknowledgments

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1. Introduction

The geoglyphs on the Nasca *pampa*, a flat plateau in the desert on the south coast of Peru, rank high among the most famous cultural heritage sites in the world. Thousands of tourists visit Nasca every year, and a wide variety of literature on the Nasca geoglyphs (often simply called "Nasca lines") is available in bookshops around the world. So why another book? Persis Clarkson, one of the few archaeologists who conducted serious fieldwork on the Nasca *pampa*, states that

> "... much of the literature on the Nazca geoglyphs is shrouded by presuppositions that have not been adequately verified in the field." (Clarkson 1990:117)

In the present study, the results of an extensive field study of the geoglyphs of Palpa, in the northern part of the Nasca drainage (Figure 1.1), are presented. Here, the second largest concentration of geoglyphs in the Nasca region is located on the slopes and plateaus along Río Grande, Río Palpa, and Río Viscas. The thorough investigation of these geoglyphs is intended to fill some of the many, and vast, gaps in our scientific knowledge on the geoglyphs of the Nasca region.

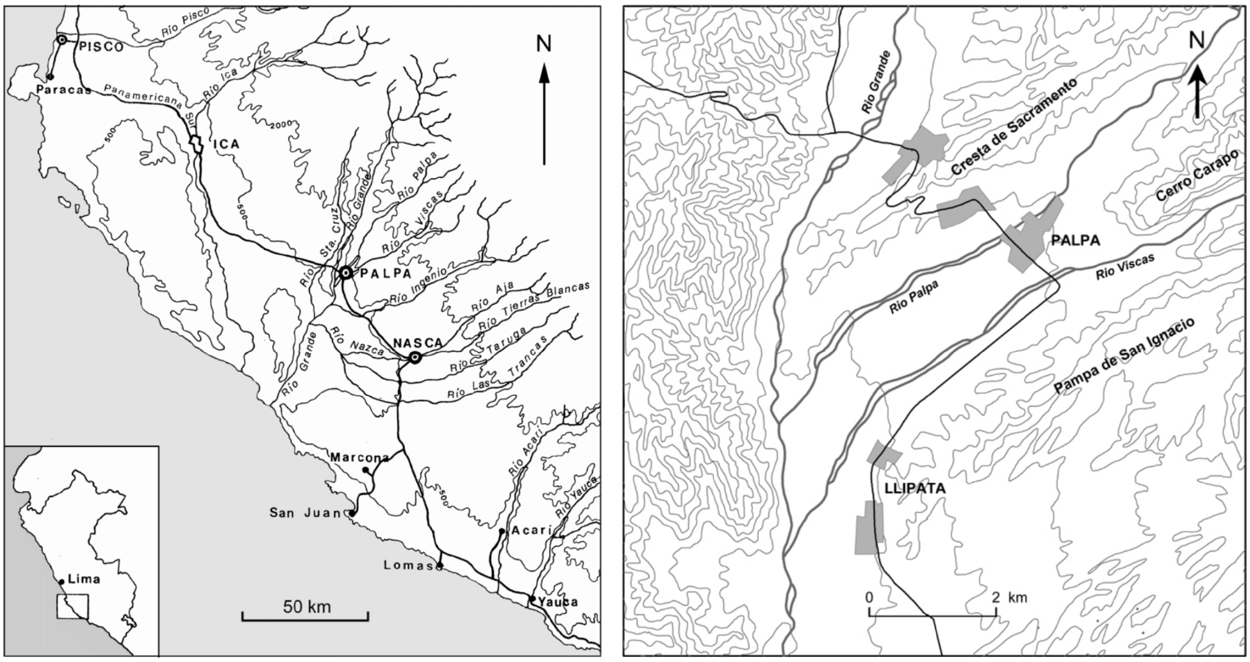

Figure 1.1: The study area around Palpa in the Rio Grande basin on the south coast of Peru

The Nasca geoglyphs have for a long time been understood in terms of astronomy. Maria Reiche, life-long keeper of the geoglyphs, promulgated the idea that lines were oriented towards points on the horizon where the sun or certain stars rose or set on significant dates, and that figures represented astral constellations. Since 1980, however, a new hypothesis has emerged from archaeological, anthropological, and ethnohistorical research in the Nasca area and elsewhere. The Nasca geoglyphs are now understood as manifestations of persistent Andean traditions of social organization, religious practices, and cultural concepts. They are interpreted as sacred spaces made and maintained by social groups in common labor who performed rituals on the geoglyphs in the framework of a mountain, water, and fertility cult. However, archaeological evidence from geoglyph sites to support this new interpretation is still sparse. The investigations at Palpa provided a good opportunity to confront it with archaeological data.

In order to do so, a suitable database had to be established beforehand. A basic problem encountered by anyone who intends to study the Nasca geoglyphs is the lack of a good documentation. Most available geoglyph maps do not meet the standards for the recording of archaeological features. Furthermore, only a small fraction of existing geoglyph sites are covered. Thus, the documentation of the geoglyphs was of crucial importance before any new interpretation could be attempted. Since previous efforts had largely failed, a new approach to document the geoglyphs was indispensable. By applying modern methods of analytical aerial photogrammetry at a large scale, it was possible to produce a detailed, accurate, and complete 3D recording of more than 1 500 geoglyphs in the Palpa area. Solving the documentation issue thus constituted a significant part of the research described in this study.

The Palpa area of the Nasca basin has for a long time been largely ignored by archaeological researchers as have the Palpa geoglyphs, even though they are comparable in quality and complexity to the better known ones on the Nasca *pampa*. There has also been a lack of public interest in them, and worse yet, little or no protection. Such negligence notwithstanding, Palpa provided an excellent starting point to learn more about the geoglyphs, and the Nasca culture in general.

In 1997, the Swiss-Liechtenstein Foundation for Archaeological Research Abroad (SLSA, Zurich) initiated a long-term archaeological research project at Palpa that provided the framework for the research described in the present study. It comprised three main fields of activity. Firstly, a regional settlement survey of the middle and lower parts of Río Grande, Río Palpa and Río Viscas was undertaken to register all prehispanic sites around Palpa. Secondly, extensive excavations were carried out at Los Molinos and La Muña, two Nasca sites along Río Grande, as well as at several other sites. The third field of activity, which is the one described here, was the detailed documentation, analysis and interpretation of the geoglyphs of Palpa. The

SLSA project was jointly directed by Markus Reindel, of the Commission of General and Comparative Archaeology (KAVA, Bonn) of the German Institute of Archaeology (DAI, Berlin), Johny Isla, of the Andean Institute of Archaeological Studies (INDEA, Lima), and Armin Grün, of the Institute of Geodesy and Photogrammetry (IGP) at the Swiss Federal Institute of Technology (ETH, Zurich). The geoglyph study was undertaken between 1999 and 2004 by the author as part of his PhD research at the Department of Pre- and Protohistory of the University of Zurich. It was jointly supervised by Philippe Della Casa, head of that department, and Armin Grün, head of IGP.[1]

The study area around Palpa encompassed approximately 89 km^2 defined by the limits of a series of aerial images taken especially for the intended geoglyph research (Maps 1, 2). This zone comprises in its center the wide floodplain formed by Río Palpa and Río Viscas shortly before they coalesce with Río Grande. This is also where the modern town of Palpa is situated. The alluvial plain is framed to the northwest by Cresta de Sacramento, to the northeast by Cerro Carapo, and to the southeast by Pampa de San Ignacio and Pampa de Llipata. To the southwest, Río Grande flows along a steep undercut slope towards its junction with Río Ingenio, after having taken up both Río Palpa and Río Viscas. The aerial images were taken in such a way that the mentioned ridges, plateaus and dry valleys lacking in vegetation along and in between the river valleys were covered, since this is the place where the geoglyphs are located.

The geoglyphs of Palpa were the actual object of investigation of the present study. They are evidently part of the same cultural phenomenon as the famous lines and figures on the Nasca *pampa*. The geoglyphs in both areas share the basic shapes, motifs, and construction techniques. Interestingly, however, there are some peculiarities in the Palpa geoglyph repertoire. For example, on Pampa de San Ignacio we have probably the densest concentration of geoglyphs and at the same time the largest trapezoid known in the whole Nasca drainage. There are considerably less zoomorphic figures in Palpa than in Nasca, but many more small

1 Currently the second phase of the Nasca-Palpa project, which started in 2002 and is now co-sponsered by SLSA, ETH Zurich, the German Federal Ministry of Education and Research (BMBF, Bonn), and the German Research Foundation (DFG, Bonn), comprises four major fields of activities: excavations at Paracas sites in the Palpa area, investigations of the paleoclimate and -ecology of the Nasca region, the application and improvement of novel methods of archaeological prospection and chronometric dating of archaeological remains, and finally the study of the geoglyphs on the Nasca *pampa* using and enhancing the latest digital photogrammetric technologies (for an overview see Reindel, Wagner eds. 2004). People in charge of the second phase of the project include, in addition to the above mentioned researchers, Günther Wagner, of the Archaeometry Research Group of the Heidelberg Academy of Sciences, Bernhard Eitel, of the Institute of Geography of the University of Heidelberg, and Jussi Baade, of the Institute of Geography of the University of Jena. The second phase of the Nasca-Palpa project will not be concluded before 2006. The present study therefore refers mainly to results of the first phase.

anthropomorphic figures. Due to the topography of the Palpa area, which lacks the vast plain of the Nasca *pampa*, the geoglyphs are mainly located close to the valleys, *i.e.* in conjunction with settlements from the same epoch. This factor makes it easier than in Nasca to study the relationships between the two classes of cultural remains, which was one reason why Palpa was chosen for new archaeological investigations.

As a first step of the work in Palpa, all geoglyphs were recorded photogrammetrically by using the high resolution aerial images mentioned above. Furthermore, most of them were documented by on site field observations. This work resulted in a comprehensive geoglyph database containing 3D models, 2D maps, as well as detailed descriptions of the geoglyphs. All data was then integrated on a GIS platform (geographical information system). That accomplished, the actual archaeological analysis was undertaken, combining standard archaeological methods and new possibilities provided by database and GIS functionality. Spatial analyses were performed to understand the role of the geoglyphs in the Nasca cultural landscape. Recent hypotheses on geoglyph function were confronted with the archaeological record of Palpa. The result of this investigation is a cultural-historic interpretation of the geoglyphs of Palpa solidly based on archaeological evidence.

When compared to other recent investigations of the Nasca lines, the research presented here is in several regards a new contribution. Apart from studying the Palpa geoglyphs for the first time, three novel approaches were pursued:

- the consistent application of modern aerial photogrammetry to Nasca archaeology, which allowed for the first time the generation of a comprehensive geoglyph database,
- the testing of a recent hypothesis that explains the Nasca geoglyphs in terms of Andean traditions of social organization and religious practices,
- the first-time use of GIS technology, integrating all available information on a multi-data platform, in order to investigate the ordering principles that guided the geoglyph making and use.

The structure of this study follows the process of the research described herein. In chapter 2, the Nasca area and the geoglyphs are described, and a brief overview of their cultural background is given. In chapter 3, by reviewing recent contributions to Nasca geoglyph research, basic issues are identified that have to be addressed when investigating the Palpa geoglyphs, and the approach pursued in the present study is detailed. After presenting the background of the Nasca-Palpa project in chapter 4, the documentation of the geoglyphs is then described in chapter 5.

Together with chapter 6, which comprises the archaeological analysis of the Palpa geoglyphs and the corresponding results, this is the main part of the present study. In chapter 7, the results are discussed and interpreted in the light of current knowledge on the Nasca geoglyphs. In chapter 8, results as well as applied methods are summarized and reviewed. Detailed descriptions of archaeological contexts are grouped in a final appendix together with a glossary and bibliographic references.

2. The geoglyphs in the Nasca region

In this chapter, the geoglyphs and their environment are described, and current knowledge regarding their cultural context is briefly summarized.

2.1 Definition and description

The commonly used term “Nasca lines” refers to ground drawings or markings that cover many slopes and plateaus in the desert of the Nasca drainage, along the Andes foothills (Figure 2.1).

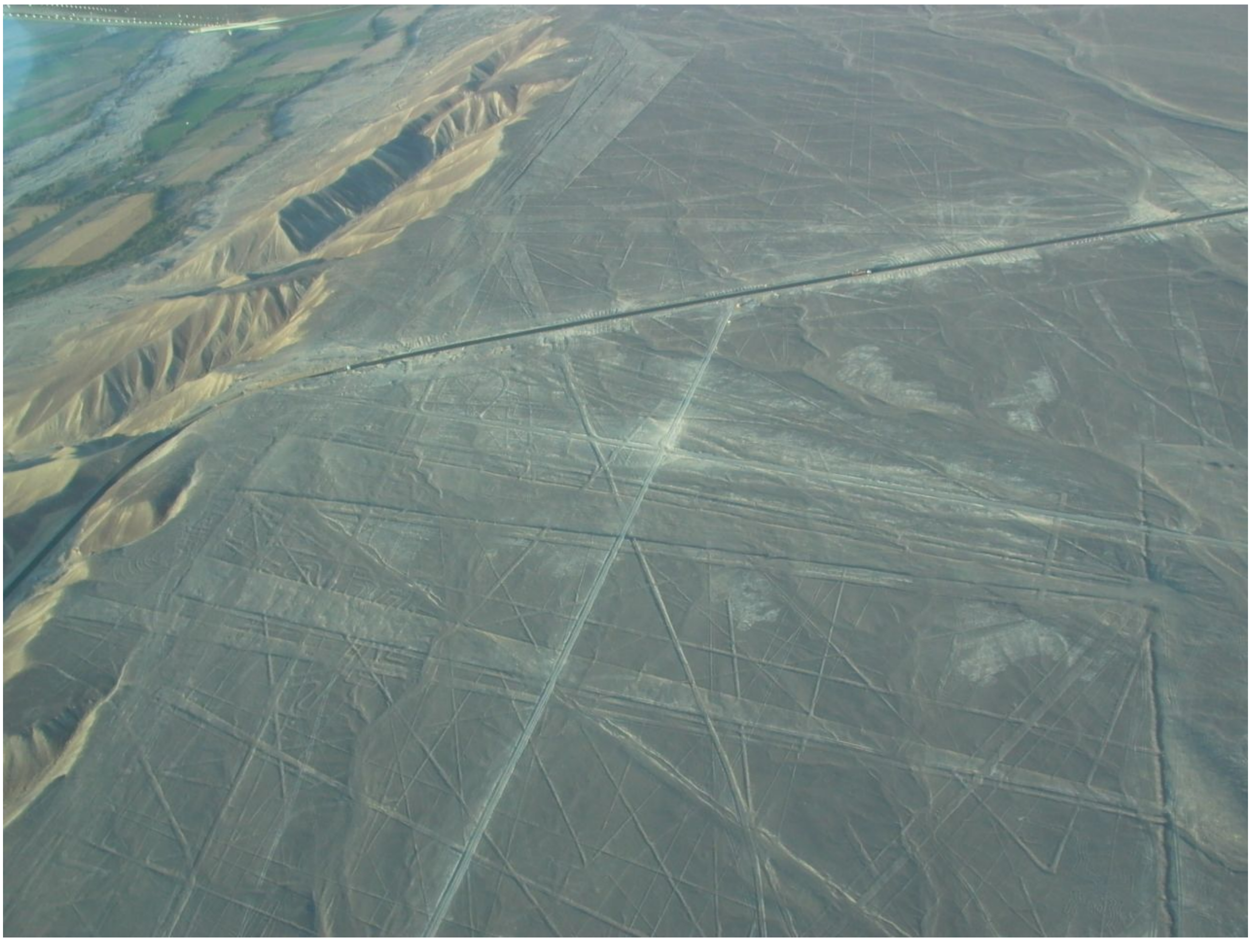

Figure 2.1: Geoglyphs along the northern edge of the Nasca pampa (center: Panamerican Highway, upper left: Rio Ingenio)

Archaeologically these peculiar features are called “geoglyphs”, a modern composite based on Greek *gē* = “earth, ground” and *glyphō* = “carve, cut out, engrave” (Liddell, Scott 1996:347, 353). Thus, literally “geoglyph” means “ground carving”. As will be shown later, this designation is not altogether fitting, since the geoglyphs were not really carved into the ground surface. Nevertheless, the term is widely used nowadays and is at any rate more appropriate than the term “Nasca lines” that misleadingly implies a linear shape of all geoglyphs. Geoglyphs can be found in many arid environments along the pacific coast of the American continent, from California to northern Chile (Clarkson 1999). However, the densest concentration and the highest number of geoglyphs is located in the Nasca area on the south coast of Peru. In this study, the term “Nasca geoglyphs” is used to denote all prehispanic ground carvings in the Nasca drainage, while “Palpa geoglyphs” refers to the subset of geoglyphs located in the area around the modern town of Palpa.

Geoglyphs are usually located in a rocky desert environment due to their construction technique. The Nasca drainage provides many suitable spots to place geoglyphs. It is circumscribed by the Andes foothills to the northeast and the coastal cordillera to the southwest (Eitel et al. 2005). This coastal cordillera is a unique topographic feature which distinguishes the Nasca area from other coastal valleys to the north and south. Its presence lead to the development of a large basin filled in during the Pleistocene with alluvial sediments composed of sands of different grain size, small to middle-sized stones and rocks, and large boulders. During the Upper Pleistocene, this pediment was dissected by rivers running from the Andes to the sea, forming the green oases still visible today. Since the coastal cordillera blocks the rivers from the seashore, they coalesce on its eastern flank into one river, Río Grande. This is the only river in the Nasca basin with perennial runoff and therefore the only one that dissects the coastal cordillera. The beige ridges and plateaus that form a sharp contrast to the green river oases are usually called *pampas*. On their surface, the loose sand between the stones has been blown away by wind erosion, leaving behind a thin, but dense layer of oxidized stones, a so-called desert pavement. The vast *pampas* covered by this pavement are ideal drawing grounds to create geoglyphs. Thus, the dense concentration of geoglyphs in the Nasca basin in contrast to other valleys to the north and south can be explained, among other things, by the unique topographic setting in that region.

To create a geoglyph on the flat plateaus, the stones of the desert pavement were removed from one place, revealing the bright sandy layer below (Figure 2.2). Piling the dark stones up at another place, usually along the outlines of the cleared areas, further enhanced the contrast in color and brightness between the original and the altered surface. On the valley walls, where the rivers have cut through the sediments, the creation of geoglyphs often required more labor investment since the stone cover is in many cases discontinuous. Here, in order to mark a geoglyph, sometimes a part of the sediment had to be removed, too – which comes closer to engraving or carving than the geoglyphs on the plateaus –, and the excavated melange of sand and stones was heaped up along the furrow. In any case the making of a geoglyph was technically a relatively simple task requiring mainly a certain amount of labor investment. That is why at least smaller geoglyphs are still made today: the most prominent geoglyphs along the valleys nowadays are advertising drawings promoting private companies, political parties, or government agencies. The plateaus close to the valleys are equally covered with modern graffiti: names of individuals, imitations of ancient geoglyphs, etc. Those modern geoglyphs are easily distinguishable from the prehispanic ones, however, since their symbology is easily accessible to the modern viewer.

Figure 2.2: A straight line marked into the desert pavement of the Nasca pampa

The predominate kind of prehispanic geoglyphs on the flat plateaus is a large cleared area, often in trapezoidal or rectangular form. It is in most cases accompanied by lines running straight or bending several times, forming zigzags, meanders or spirals. Lines and (smaller) trapezoids are also common features on the slopes of valleys and hills. Biomorphic figures like birds, whales, human beings, etc. constitute by far the smallest fraction of the whole corpus, yet at the same time they are the most famous geoglyphs. Larger, zoomorphic figures are usually found on flat plateaus, while smaller, anthropomorphic figures are mostly located on slopes. A common trait of the majority of geoglyphs is that they occur together in complexes (Figure 2.3), often crosscutting each other, with older geoglyphs obliterated by younger ones.

The geoglyphs are located in a relatively stable environmental setting. The desert pavement exists, if not anthropogenically altered, since the Upper Pleistocene (Eitel et al. 2005). Where in the process of creating a geoglyph the underlying sandy layer was exposed, the silty elements of this layer, along with the always present air humidity, fostered the development of a thin crust on top of this layer. Such a crust, which is able to largely prevent wind erosion of the exposed surfaces, can only develop, however, if the surface remains undisturbed over a long period of time, *i.e.* after human activity on the *pampas* had ceased. Thus, the abandonment of the geoglyph sites permitted their preservation, which is why many geoglyphs are still well visible today. Modern anthropogenic activity on geoglyph sites, or on the *pampas* in general, is hence the major threat to which the geoglyphs are exposed. Geoglyphs close to inhabited zones are nowadays often affected by houses or roads built along the valley margins, by hurdlings constructed on slopes, or by informal soccer fields build on trapezoids, etc. This is the case at least in areas where the geoglyphs are not protected. So far, only the Nasca *pampa* between Río Ingenio to the north and Río Nasca to the south and west has been declared *zona intangible* by the Peruvian government, and later also World Cultural Heritage by UNESCO. In most other parts of the Nasca area, access to geoglyph sites is unrestricted. That means that today many geoglyphs close to modern settlements are in imminent danger of being destroyed, and old aerial photos indeed reveal that many have already vanished during the last decades (*e.g.* Aveni ed. 1990: appendix II fig. 6; cp. Fischer, Künstle 1999).

Figure 2.3: A geoglyph complex on the northeastern edge of the Nasca pampa

The geoglyphs on the Nasca *pampa*, specifically those along the south bank of Río Ingenio, are nowadays world famous and are constantly flown over by tourists in small airplanes starting from the Nasca airstrip. Thus, the geoglyphs have become an important economic factor in the city of Nasca where many hotels and restaurants have been established in recent decades to host tourists from all over the world. However, geoglyphs in other zones of the Nasca basin are often poorly known, in many cases not even by the local population. They are therefore usually not taken care of. Stone cairns associated with geoglyphs have been looted in most cases. In general, protecting the geoglyphs off the Nasca *pampa* is a problematic task, since they are distributed over a wide area, difficult to access, and not easily discernible on the ground. Furthermore, today's population is claiming parts of the terrain covered by geoglyphs as building zone, quarry, waste dump or agricultural zone.

All in all, the Nasca geoglyphs are even today a prominent feature in the Nasca landscape, but their preservation is a challenging task. The Peruvian national cultural authority, the *Instituto Nacional de Cultura* (INC, Lima) has therefore recently commissioned a study of this issue in close cooperation with UNESCO. In that study (Lumbreras 2000), the geoglyphs, their preservation, their history, their investigation, their importance today, and the threats they are exposed to are surveyed, and a master plan is proposed that aims at the protection and sustainable use of this important cultural resource. Since this master plan is new, it has had as yet only limited impact, but the research described herein follows its guidelines closely.

End date	***Period***	***Archaeological Culture***	***Phase***
1 532 AD	LATE HORIZON	Inca	
1 400 AD	LATE INTERMEDIATE PERIOD	Ica / Chincha	
1 000 AD	MIDDLE HORIZON	Wari	
600 AD	EARLY INTERMEDIATE PERIOD	Nasca	Late
450 AD			Middle
250 AD			Early
1 BC/AD		Initial Nasca	
200 BC	EARLY HORIZON	Paracas	Late
400 BC			Middle
600 BC			Early
800 BC	INITIAL PERIOD		
1 800 BC	ARCHAIC		

Table 1: Chronology and cultural history of the Nasca basin (dates corresponding to preliminary results of the Nasca-Palpa project)

2.2 Chronology and cultural context

The geoglyphs are generally associated with the Nasca culture (Table 1), which flourished between the 2nd century BC and the 7th-8th century AD in the Nasca region and in the Ica valley further to the north (Rickenbach ed. 1999; Silverman, Proulx 2002). It emerged out of the preceding Paracas culture (Paul ed. 1991), apparently in a rather smooth transition mainly marked by technological and stylistic innovations reflected in ceramics and textiles. Those two categories of finds are still the best known manifestations of both cultures, and a good part of what we know today of Paracas and Nasca is still mainly based on stylistic, technological and iconographical studies of ceramics and textiles distributed over museums around the world (Kroeber 1956; Rowe 1960; Menzel et al. 1964; Sawyer 1997). Another source of information are excavations of cemeteries of both cultures, in many cases undertaken early in the last century (Uhle 1913; Tello 1959; Tello, Mejía 1979; Kroeber, Collier 1998; Isla 2001a; Mejía 2002).

For a long time, practically no other solid information was available on both Paracas and Nasca. In recent years, however, a growing number of research projects have been undertaken, including regional settlement surveys covering all tributaries of the Nasca drainage (Browne 1992; Schreiber 1999; Silverman 2002a) and further valleys to the north and south (Massey 1992; Cook 1999; Velarde 1999; Valdez 2000), as well as excavations at important sites like Cahuachi, the biggest site from Nasca times (Silverman 1993a; Orefici, Drusini 2003) and several smaller sites (Isla et al. 1984; Vaughn, Neff 2000; Vaughn 2004). Data from many of these projects is still under study, and little substantial results are available so far. However, significant new contributions to the investigation of both cultures can be expected for the years to come.

Based on current knowledge, it seems that the Nasca culture during most of its course developed rather undisturbed by foreign intrusions (save for its late phase), although it maintained far reaching trade connections, and its influence can be recognized in the material culture of adjoining regions, like Pisco and Chincha to the north, Acarí to the south, and the highlands to the east (Moseley 2001:197ff). Nasca economy was essentially based on agriculture, for which an efficient water management in the valleys was developed (Schreiber, Lancho 2003). Field crops and food procurement played a prominent role in Nasca iconography as depicted on fineware ceramics, along with a pantheon of mythical beings that often showed a combination of human and animal traits (Makowski 2000). During the course of its evolution, Nasca society was always a complex one, with social and economic hierarchies clearly discernible in the archaeological record. The level of complexity, however, changed through time. In Early Nasca times, Cahuachi in the middle Nasca valley assumed the role as spiritual and ritual, if not political center of the Nasca drainage (Silverman 1993a). Later, the Nasca sociopolitical landscape became more fragmented, and an increasing concern with (internal and external) warfare, foreign influence, and climatic conditions becomes evident in the archaeological record. Through all these changes, the inhabitants of the Nasca region maintained a high technological level in irrigation and water management, production of fineware ceramics, adobe architecture, etc. (Carmichael 1994; Clarkson, Dorn 1995; Orefici 1999; Biermann 2001). When at the end of the Early Intermediate Period the Wari empire from highland Ayacucho (Schreiber 1992) extended its area of influence to the south coast, the transition from Nasca to Wari seems to have caused more disruptions than the previous transition from Paracas to Nasca, although some cultural traits seem to have persisted well into the Middle Horizon (Isla 2001b).

Whether this is true for the geoglyphs as well is still a matter of debate. This cultural phenomenon is generally closely associated with the Nasca culture, while its origins, like that of many Nasca cultural traits, are traced back to the preceding Paracas culture (Silverman, Browne 1991). This cultural affiliation is based on iconographic parallels between biomorphic figures and motifs on ceramics and textiles on the one hand, and potsherds found on geoglyphs on the other hand. Some geoglyphs, mainly lineal and trapezoidal ones, have also been tentatively dated to the Middle Horizon or even to the Late Intermediate Period, but based on shaky evidence (Clarkson 1990). Thus, there is a general consensus that most of the Nasca geoglyphs were made during the time of the Nasca culture and by the society that sustained that culture.

3. Geoglyph research in the Nasca region

In this chapter, previous research of the Nasca geoglyphs is summarized and critically reviewed in order to define a baseline for the present study. Starting from the premise that a precise documentation is a prerequisite for any analysis and interpretation, both fields of work will be treated here in separate subchapters. For both documentation and analysis/interpretation, starting points for investigating the Palpa geoglyphs are identified, and own approaches are developed building on previous research and additional premises. The research in Palpa will then be described in the next chapters.

3.1 Geoglyph documentation

3.1.1 Previous research

Anybody who intends to study the Nasca geoglyphs will soon discover that finding suitable data on them is a difficult task. This is somewhat surprising, considering the amount of available literature on the topic. However, as Anthony Aveni, who directed an important research project on the Nasca *pampa* in the 1980s, rightly states,

> "... much that has been written about the Nazca lines is too long on speculation and too short on documentation." (Aveni ed. 1990:iii)

Indeed, descriptive data on specific geoglyphs is rarely presented in the literature (*e.g.* Ravines et al. 1995), and photos as well as sketches of geoglyphs are often shown without information about their precise location. The situation is somewhat less problematic with regard to maps of the geoglyphs, of which a fair number is available. However, the quality of most of them is far below common standards for the documentation of archaeological features. The maps can be grouped into five categories:

- overview maps, showing the general location of geoglyphs in a large area, but not the precise shape and location of specific geoglyphs (*e.g.* Kern, Reiche 1974: figs. 1-3; Aveni ed. 1990: fig. II.1b; Reiche 1993:568-569; Reinhard 1996: hoja 1; Lumbreras 2000:142);
- maps showing some, but usually not all, geoglyphs of a certain area, based on terrestrial measurements of the orientation and length, but not the precise shape, of selected geoglyphs (*e.g.* Kern, Reiche 1974: figs. 4, 37; Reiche 1993: *passim*);

- sketch maps of geoglyph sites usually based on aerial images and/or observations made in the field, often showing the basic components of geoglyph complexes, their relation to each other and to their environment, but neither their precise shape nor their exact location (*e.g.* Silverman 1990b: figs. 11-17; Aveni 1990b: fig. II.3; Lumbreras 2000: *passim*; Mejía 2002: fig. /P8:3200(1)/);
- maps showing as complete as possible the geoglyphs existing in a certain area, based on a photogrammetric analysis of aerial images, with the completeness of the map constrained by the scale of the images used (Hawkins 1974: figs. 3-6; IGN 1993; Nikitzki 1993);
- compilations of maps combining data from several of the above mentioned sources (*e.g.* Reiche 1993: encarte 9.1; Reinhard 1996: hojas 2-6) or for which no sources are detailed (*e.g.* Lumbreras 2000: *passim*).

As the overview indicates, all available maps of geoglyphs show certain deficiencies regarding their accuracy or completeness. This becomes especially evident in the case of the northern part of the Nasca *pampa* for which several maps from different sources are available: they show differences not only in scale, coordinate system and graphic rendition, but also in content.[2] Their suitability for archaeological research is therefore limited. Many other parts of the Nasca drainage are not covered by archaeological maps. Thus, the state of documentation of the geoglyphs is insufficient. A review of the techniques employed to map the geoglyphs can help understanding the reasons for this unsatisfactory situation.

Terrestrial measurements

The first one to map geoglyphs on the Nasca *pampa* was Maria Reiche. Starting in the late 1940s, she used measuring tape and a compass for surveying (Reiche 1993). Later, she also measured arcs of lines with paper templates (Reiche 1993: fig. 11.5). Her main tool, however, was a theodolite, which she used for mapping outlines of figural geoglyphs (Reiche 1993:467ff). Theodolites have furthermore been used by Reiche and others to determine the azimuth orientation of straight features, like lines, straight sections of figures, or borders of trapezoids (Reiche 1976; Hawkins 1974; Aveni 1990b). On the resulting maps, geoglyphs surveyed this way are usually depicted as standardized lines, without information about their precise width,

2 Some maps are even obviously incorrect. For example, on Nikitzki's map some well known figural geoglyphs that are actually located outside the area covered by the map are depicted in arbitrary places among correctly mapped geoglyphs (Nikitzki 1993).

length, or shape. It is generally possible to measure the location, shape and size of a geoglyph using a theodolite (*e.g.* Reindel et al. 1999: figs. 11-13). However, the amount of work required to do so is prohibitive considering the number of existing geoglyphs, which is why the use of theodolites has largely been restricted to determine geoglyph orientation.

AERIAL PHOTOGRAPHY

Aerial images are a common tool for archaeological research on the Peruvian coast. Due to the lack of vegetation in the coastal desert, archaeological remains lay open on the surface and can be recognized to a certain degree in aerial images (depending on image scale). The aerial photographic service of the Peruvian air force (*Servicio Aerofotográfico Nacional*, SAN, Lima) has systematically produced high quality aerial photos of many parts of the country since the 1940s. All coastal valleys have been covered several times at different image scales during the last decades. The images were usually taken for cadastral, agricultural, or planning purposes. Therefore, often only inhabited or economically used zones are covered, like the irrigated and settled valley floors. Empty desert zones are often only covered in small scale, if at all. The images can be purchased at reasonable prices from the SAN or IGN (*Instituto Geográfico Nacional*) offices in Lima.

Since SAN images are easily available and affordable for archaeological projects, many researchers use them as a natural starting point for their investigations. In the Nasca region, the SAN was furthermore commissioned on several occasions to perform special flights to take photos of geoglyph concentrations on the Nasca *pampa* (*e.g.* Reiche 1976:21; Hawkins 1974). Many well known and often published photographs of Nasca geoglyphs have been taken during these flights. Thus, SAN aerial images are a widely used tool in Nasca archaeology. Archaeological sites are located, and sometimes classified, based on what can be discerned in the SAN photos. Often, sketch maps are produced with the aid of these images, and they are used in publications to illustrate archaeological contexts.

However, in spite of these efforts SAN images do not cover all areas with geoglyphs, nor at a scale that enables the recognition of the narrow lines. Therefore, additional aerial images were taken by some projects. In 1984, in the framework of Anthony Aveni's project (see chapter 3.2.1), an unmanned, tethered balloon to which a small format camera was attached was used. The aim was to take low altitude, vertical images of several line centers. However, only one picture of a line center in the southern part of the *pampa* could be taken due to technical problems (Johnson et al. 1990:278, fig. VII.2, 4; Aveni 2000a:156-159, figs. 40, 41). Thus, the contribution of balloon photography to the documentation of geoglyphs is so far quite limited.[3] In Aveni's project, after balloon photography had largely failed to deliver the desired results, it was decided to rent a small aircraft to take a series of vertical aerial images of a part of the Nasca *pampa* (Johnson et al. 1990:278) with an aerial camera. The image flight covered the northern bank of Río Nasca well into the *pampa*. The resulting images had a scale of 1 : 24 000 and were combined into a photomosaic (Aveni ed. 1990: supplement). However, the film supply, originally calculated only for a limited number of shots to complement the balloon flights, was not enough to cover the whole *pampa*, to achieve a greater scale, or to allow a general overlap of the images that would have enabled full stereo processing (Gerald Johnson, personal communication 2003). Thus, while being helpful for general orientation in the southern section of the Nasca *pampa*, the photomosaic allows only the largest geoglyphs to be discerned.

PHOTOGRAMMETRY

Aerial photography is usually only used for orientation and illustration. Some researchers, however, have gone beyond this point by analyzing aerial images with photogrammetric means. Photogrammetry allows accurate 3D measurements of objects based on two or more images of them. Its application is therefore a qualitative step further compared to the simple sketch maps produced from single aerial images. In the Nasca area, there are three published geoglyph maps elaborated with photogrammetric means (see above). All of them cover the same area: the northern edge of the Nasca *pampa* along the southern bank of Río Ingenio, *i.e.* the area with the largest concentration of geoglyphs and with most biomorphic figures. British-American astronomer Gerald Hawkins was the first to introduce photogrammetry into Nasca archaeology. His map is the only one for which specific information on the database is given:

> “We decided to extend the stereographic and standard photogrammetric method used at Stonehenge and Callanish in Britain. This method provides contours above mean sea level and a rapid and accurate mapping of all surface features. We cooperated with the Geophysical Institute of Peru and the Servicio Aerofotográfico Nacional (SAN) of the Peruvian Air Force. On August 1, 1968, SAN obtained 30 overlapping, high-resolution photographs of the area. These were used to make a ground plan to the scale of 1:2000, so that 10 centimeters on the chart represented 200 meters on the ground.” (Hawkins 1974:125)

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3 Balloon photography has also been used outside the Nasca area by Rodríguez to document a figural geoglyph in the Chillón valley (Rodríguez 1999: figs. 7, 8, 16).

Unfortunately, no information as to the scale of the aerial images is given in Hawkins's report. The map is published at a reduced scale, and the geoglyphs are depicted as dashed lines, which affects the overall comprehensibility of the map. According to Hawkins, all geoglyphs wider than 30 cm are depicted, whereas the narrowest lines encountered in the field had a width of 10 cm (Hawkins 1974:119, 125). Thus, although Hawkins' map is an important qualitative step forward in the documentation of the geoglyphs, it has still certain deficiencies.

After Hawkins's efforts, two other maps were elaborated by photogrammetric means (IGN 1993; Nikitzki 1993). They were published without accompanying notes, and no information is given on either of them as for the photos used. It seems possible that both of them were elaborated based on the same set of aerial images used by Hawkins. However, the three maps have different scales, very different graphic styles, and show also discrepancies in their content, *i.e.* the geoglyphs depicted on them. It is not clear if archaeologists contributed their expertise to the elaboration of either of the three maps.

3.1.2 Review and own approach

Considering the delicate situation of the geoglyphs today, their documentation is of utter importance as a contribution to their long-term preservation. Moreover, without a good documentation any attempt to analyze and interpret the geoglyphs in terms of cultural history must remain futile. Hence, any new study of the geoglyphs has necessarily to start with the elaboration of a reliable and accurate documentation. The deficiencies of available maps are on the one hand due to the fact that the focus of most research projects has so far been on explaining the geoglyphs rather than on recording them. On the other hand, hitherto applied methods of geoglyph recording have not proven efficient enough, as the above review clearly shows. In order to overcome these shortcomings, it is necessary to take advantage of the manifold tools offered by modern mapping methodology.

Topographical surveys are nowadays usually based on remote sensing techniques. In remote sensing, information about an object – in this case, the geoglyphs on the earth's surface – is obtained by sensors that capture electromagnetic radiation emitted or reflected by the object, *e.g.* sunlight or radar rays. Different types of sensors allow to obtain information on the geometry, composition, temperature, use, etc. of the earth's surface or objects upon it. To record the Nasca lines, optical airborne or spaceborne sensors are possible candidates since they provide information about the location, size, and shape of the geoglyphs, as well as the surrounding terrain.

Satellite remote sensing

So far, data obtained by spaceborne sensors has not been used for documenting the Nasca geoglyphs. This is due to the fact that high resolution satellite imagery has become available only recently. The level of detail visible in an image depends on its spatial resolution, which can be expressed in pixelsize. A resolution of 1 m pixelsize means that a square of 1 m edgelength on the ground has a unique color, or gray value, in the digital image. If, like in Palpa, a complete geoglyph recording is aimed at, imagery is needed that allows to discern even the narrowest lines, which have a width of approx. 10 cm. To show such geoglyphs with enough detail to map them accurately, the pixelsize should at least come close to their minimal width. Ideally, it should be even smaller.

Such high spatial resolution is so far not commercially available from spaceborne sensors, even though over the past few decades image resolution has increased considerably. When the last well documented fieldwork on the Nasca *pampa* was carried out in 1984 under the direction of Anthony Aveni, the best available images were those taken by NASA's analog Large Format Camera (LFC) mounted on the Space Shuttle during mission STS-41G (Doyle 1985). Depending on orbit, film, and atmospheric conditions, spatial resolutions from approx. 5 to 20 m were achieved. Furthermore, images taken by the Landsat 4/5 Thematic Mapper sensor with a spatial resolution of 30 m were available at that time (Lillesand et al. 2004: tables 6.1, 6.2). In 1997, when the first photo flight over Palpa and Nasca was performed in the framework of SLSA's project with airborne sensors, the best available resolution of civil spaceborne sensors was 5.8 m, provided by the Indian IRS-1C and D satellites (Lillesand et al. 2004: table 6.8). By then, the Russian government had furthermore made available selected images taken by the analog KVR-1000 camera mounted on several satellites of the military COSMOS series (Lillesand et al. 2004:463). These panchromatic images offer a spatial resolution of 2 m but cover mainly parts of Europe, Asia, and North America.

At the time of writing (2004), panchromatic sensors mounted on satellites launched by private companies capture imagery with a spatial resolution that comes closer to the useful range for geoglyph mapping yet is still not high enough. The recently launched EROS-A satellite provides digital imagery with a spatial resolution of 1.8 m. The Ikonos 2 as well as Orbview 3 satellites deliver a spatial resolution of 1 m, while Quickbird 2 even achieves 0.61 m pixelsize (Lillesand et al. 2004: table 6.14). As of May 2004, the Nasca *pampa* is covered by four Quickbird images and several series of Ikonos images, whereas no high resolution EROS A or Orbview images have so far been taken over that area. For Palpa, only one Quickbird image covering the eastern half of the area of investigation is currently available.[4] In the years to come, new civil sensors with a panchromatic resolution of 0.5-0.4 m are likely to be launched.[5] It is to assume that in the military realm the best available spatial resolution is already much higher, probably in the centimeter range. However, due to legal and other constraints (Fritz 1999), such imagery is unlikely to become available to civil users in the foreseeable future.[6]

Table 2 gives an overview of the characteristics of several sensors that currently offer the highest available spatial resolution in panchromatic imagery. The actual availability of images over specific areas can be checked via the company websites.

Satellite / Sensor	***Swath width (km)***	***Spectral band Pan (µm)***	***Spatial resolution (m)***	***Website***
COSMOS KVR-1000	40	0.51-0.76	2	www.sovinformsputnik.com
EROS-A	13.5	0.50-0.90	1.8	www.imagesatintl.com
IKONOS	11.3	0.45-0.90	1	www.spaceimaging.com
OrbView-3	8	0.45-0.90	1	www.orbimage.com
QuickBird-2	16.5	0.45-0.90	0.61	www.digitalglobe.com

Table 2: Satellites and sensors providing high resolution panchromatic imagery (as of May 2004)

All in all, imagery from spaceborne sensors is currently not available at a spatial resolution that would allow a complete recording of the Nasca geoglyphs including the narrowest lines, which was the aim of the Nasca-Palpa project. Nevertheless, if the focus is put on other aspects, then data provided by satellite sensors can be helpful in many ways. A partial geoglyph mapping is only one example. Virtually all areal geoglyphs, like trapezoids and rectangles, as well as the wider lines (yet not the famous biomorph figures), are visible in existing IKONOS and

4 Information based on survey of online image databases of the respective companies conducted on May 13, 2004. For up-to-date results see company websites as given in Table 2.

5 See press releases "DigitalGlobe unveils plans for next-generation spacecraft constellation" (March 23, 2004) at www.digitalglobe.com and "Space Imaging reacts to new White House remote-sensing policy" (May 13, 2003) at www.spaceimaging.com.

6 See also fact sheet on "U.S. commercial remote sensing policy" (April 25, 2003), available as PDF at www.licensing.noaa.gov.

Quickbird images. By mapping these larger geoglyphs, a basic documentation, which for many geoglyph sites is not yet available, could be elaborated. Satellite images can be ordered in georeferenced form and used for mapping in 2D or even stereoscopically in 3D, provided that stereo coverage is available. Considering the delicate situation of the geoglyphs today, such an approach would already be helpful in many cases, and the resulting maps could be used as starting point for further studies.

The generation of DTMs or maps of large areas, *e.g.* the whole Nasca basin, is another task for which satellite sensors offer suitable data. In Peru, governmental agencies like SAN or IGN use combinations of images taken by airborne and spaceborne sensors to produce and update maps and DTMs of the whole country, though so far only at small scales. Other sources offer DTM data based on spaceborne sensor imagery as well. As an example, stereo imagery acquired by NASA's ASTER sensor mounted on the TERRA satellite (Lillesand et al. 2004: 481ff, table 6.21) is used to generate DTMs with up to 7 m horizontal accuracy. Stereoscopic imagery with different resolution from other sensors (*e.g.* SPOT, JERS-1, ADEOS, IKONOS etc.) is likewise suitable for DTM generation.

Another source for height information of the earth's surface is SAR (synthetic aperture radar) interferometry. Phase difference of microwaves emitted and received by two radar sensors arranged along a known baseline allows to calculate the elevation of the point on the surface from which the waves are reflected. A large-scale application of this method to generate DTMs was NASA's Shuttle Radar Topography Mission (SRTM) flown in 2000. During this mission, approx. 80% of the surface of the earth were covered by radar interferometry. SRTM data enables the elaboration of DTMs with an accuracy of better than 20 m (horizontal) and 16 m (vertical), respectively (Lillesand et al. 2004:712ff). On a smaller scale, SAR interferometry has recently been applied to detect geomorphological change in the desert surface of the Nasca *pampa* between 1997 and 1999 (Lefort et al. 2003; Lefort et al. 2004). Although the results show that a good part of the vast plain is relatively stable and does not show any change, erosion channels coming out of the Andes foothills and crossing the *pampa* are clearly locatable. The monitoring of geoglyph sites and especially the identification of areas where natural erosion is likely to occur is important for efficient geoglyph preservation (cp. Lumbreras 2000).

Aerial photogrammetry

The many benefits of satellite imagery notwithstanding, if an accurate and complete 3D mapping of all geoglyphs of a given area is needed, aerial images are still the best choice. They potentially offer a spatial resolution high enough to discern even the narrowest lines. Depending on flight height, the camera used, and the area to be covered, images at a scale of up to 1 : 2 500 can easily be obtained during standard photo flights, with a larger scale meaning more images to cover a given area. 3D object extraction and DTM generation require the taking of overlapping images in order to obtain stereopairs suitable for a photogrammetric analysis. In order to map the Nasca geoglyphs in the Palpa area, it was decided to focus on an analytical photogrammetric analysis of large scale aerial images. Photogrammetry has so far seldom been applied to Nasca archaeology, and the results are rather mixed. This, however, seems largely due to the fact that the scale of the images used did not allow a complete mapping that would have included the many narrow lines. Furthermore, the mapping efforts seem to have been accomplished largely without archaeological expertise involved. Thus, the potential of modern photogrammetry for geoglyph recording should not be judged from previous efforts alone. Rather, a survey of recent applications in cultural heritage recording shows that modern analytical and/or digital photogrammetry is a powerful tool if applied correctly. In Europe, Asia, and Australia, it has successfully made its way into every-day archaeological research. In New World archaeology, however, it has so far rarely been employed. Some recent exceptions include the documentation of Maya architecture in Honduras and Mexico (Gray, Boardman 2002; Desmond, Bryan 2003), the recording of monumental *adobe* architecture on the Peruvian north coast (Reindel 1993; Sauerbier et al. 2004), and the documentation of terraces and other structures in the northern Peruvian Andes (Capra et al. 2002). Photogrammetry, like laser scanning, allows for high accuracy 3D recording at relatively low cost. In the following part, the procedures, chances, and requirements of photogrammetry are briefly outlined. Detailed introductions into the principles of photogrammetry are available elsewhere (Mikhail et al. 2001; Lerma 2002; Luhmann 2003; Kraus 2004).

According to the official definition by the American Society for Photogrammetry and Remote Sensing (ASPRS),

> "Photogrammetry is the art, science, and technology of obtaining reliable information about physical objects and the environment, through processes of recording, measuring and interpreting images and patterns of electromagnetic radiant energy and other phenomena." (www.asprs.org/asprs/society/about.html, accessed May 27, 2004)

In other words, photogrammetry allows to obtain metric information about the size, shape, and position of a given object – *i.e.*, data that allows the geometric reconstruction of that object – by measurements not performed at the object itself, but in images of it. In this sense, photogrammetry is a subfield of remote sensing, in which information about an object is obtained by sensors that do not touch the object itself, but rather record electromagnetic radiation emitted by the object. In photogrammetry, optical sensors like cameras are used to capture lightwaves reflected by the object, on the base of which an image is generated. This accomplished,

> “[t]he fundamental task of photogrammetry is to rigorously establish the geometric relationship between the image and the object as it existed at the time of the imaging event. Once the relationship is correctly recovered, one can then derive information about the object strictly from its imagery.” (Mikhail et al. 2001:1)

Photogrammetry allows to survey and measure a wide range of objects, from microscopic particles to whole planets (see Luhmann 2002 for an overview of recent research). In the case of cultural heritage, the advantages of measuring in images instead of at the actual object become easily evident:

- taking images of an object is usually faster and easier than undertaking accurate measurements at it,
- in the case of sensitive objects, measuring in images helps avoiding potential damage caused by surveying activities,
- an object can be recorded even if it has vanished or considerably changed since the images were taken.

Photogrammetric measurements in images basically require suitable images, information on the camera, and control data:

- Images: From a single image of an object, only 2D data can be easily derived. For measurements that aim at the recovery of metric 3D data, at least two different images of the object are usually needed. Similar to the way human vision works, two views of an object from slightly different viewpoints allow to see the object in 3D. This basic procedure of photogrammetry is called stereoscopic viewing. In order to record an object in 3D, a series of images has to be taken in a way that every part of the object is covered by at least two adjoining images. The overlapping areas of the images allow not only stereo viewing, but also 3D measurements.

- Camera: The way an image of a real-world object is generated depends on technical characteristics of the camera like focal length, used lens, etc. These parameters determine the distortion of the image when compared to the real-world object. The determination and modeling of these factors is called calibration. The camera can be calibrated by taking photos of a testfield of points whose spatial positions are known.
- Control data: To enable the correct scaling or positioning of recorded objects, the precise location of certain points, or the precise length of certain ranges visible in the images needs to be established by independent measurements.

Thus, images and control data have to be acquired at the object itself, while calibration data on the camera can either be obtained in the office or, simultaneously, during the process of image acquisition (self calibration). The time necessary to acquire data is usually much shorter than data processing and analysis, which has to be carried out in the office. Once the camera has been calibrated, the images can be oriented relatively to each other and, incorporating also control data, absolutely in space. In the overlapping area of two adjoining, oriented images (stereopairs), 3D measurements can be carried out, the results of which are then digitally recorded. Based on this data, the geometry of the object can be virtually reconstructed. If photorealism is needed, texture is generated from the images and draped over the geometric model. Different products can be derived from the model, like maps and plans. The digital 3D data is especially well suited to be integrated on a GIS platform, where it can not only be managed and edited, but also analyzed as for inherent spatial relations between its components.

Given that these prerequisites are complied with, modern aerial photogrammetry seems a powerful tool to accurately record the Nasca lines in 3D. The geoglyphs are distributed over wide, largely flat terrain and lay open on a surface not covered by vegetation. These are ideal conditions for aerial photogrammetry, since the geoglyphs can be completely recorded by taking vertical aerial images organized in parallel strips with a calibrated aerial camera mounted on a low altitude aircraft. Control data can nowadays easily be obtained by determining the absolute position of certain points clearly identifiable in the aerial images with GPS (global positioning system). That way, the photogrammetric fieldwork can be reduced to a photo flight and some GPS measurements. The actual mapping can then be done in the office using photogrammetric hard- and software.

Complementary archaeological fieldwork

The great potential of photogrammetry notwithstanding, it cannot substitute archaeological fieldwork completely. The geoglyphs were made, used, and perceived on the ground and should also be studied on the ground. Only a certain familiarity with the geoglyphs allows to correctly identify and map them using aerial images, and only verification of the resulting maps in the field allows to assess the quality of the mapping procedure. Furthermore, there are several aspects that are elusive for image-based recording. Associated cultural remains like ceramics or lithics, stratigraphic relationships between geoglyphs, and alterations of geoglyphs are important aspects that can hardly be documented in images alone. Thus, the potential of a photogrammetric recording should be combined with a thorough archaeological recording. Since the actual mapping of the geoglyphs can be done in the office, fieldwork may be dedicated entirely to the description of geoglyphs and associated cultural remains, which is an important advantage compared to previous project.

Geographic Information System (GIS)

To store, manage, analyze, and visualize hybrid data in an efficient and sustainable way, the versatile functionalities of modern Geographic Information Systems (GIS) are especially suitable. GIS has become an important tool in archaeological research since the 1990s (Baena et al. 1997; Kvamme 1999; Gourad 1999). This is due to the capability of GIS to make use of the inherent spatial component of archaeological data, as stressed by the authors of the recently published first textbook on archaeological applications of GIS:

> "Artefacts, features, structures and sites, whether monument complexes, chance finds of individual objects, scatters of ploughsoil material or rigorously excavated structural and artefactual remains, are all found *somewhere*. As well as the position of the feature or artefact itself there may also be a series of *relationships* between the locations of features and artefacts, revealed by significant patterns and arrangements relative to other features and things." (Wheatley, Gillings 2002:3; emphasis in original)

A strong point of GIS is that it allows to put archaeological features and finds in a topographic and environmental context and to systematically analyze patterns and interdependencies between different types of data. This ability is partially responsible for the boost of landscape archaeology in recent years (Gramsch 1996; Gillings et al. eds. 1999; Anschuetz et al. 2001). However, GIS is a useful tool not only on a regional scale, but also on the site level, *e.g.* for managing and analyzing data resulting from geophysical prospection or excavation (Neubauer 2004).

A GIS is mainly composed of tools for data storage, analysis, and visualization (cp. Wheatley, Gillings 2002: fig. 1.2). Its core is a database management system (DBMS) in which archaeological as well as other data is stored (Ryan 2004). A careful structuring of the database is decisive for efficient data retrieval, editing, and querying. A second element of a GIS is the one which is often regarded as the GIS itself: it comprises tools for manipulating and analyzing the stored data and for interrelating different types of data. A third important element is finally the visualization and output of data and results of analysis, be it on-screen or in other forms, *e.g.* as maps.

In the Nasca region, the capabilities of GIS could not yet be exploited due to a lack of suitable data. Concerning the geoglyphs, which occupy a prominent place in the Nasca landscape, a GIS-based analysis has been a desideratum for some time to help understanding ordering principles that guided their creation:

> "In the future, perhaps GIS analysis will reveal systematic spacing of geoglyphs that we do not perceive from ordinary examination of aerial photographs and maps." (Silverman, Proulx 2002:179)

The intended photogrammetric analysis of the Palpa geoglyphs in combination with their thorough recording in the field was expected to result in exactly the kind of hybrid data GIS is designed to analyze. Thus, GIS should be utilized for data storage, analysis, and visualization as important complementation of fieldwork from the beginning of the project.

All in all, in order to document the geoglyphs of Palpa in an efficient and accurate way, a new approach combining procedures of modern aerial photogrammetry, archaeological field survey, and GIS technology seemed most promising. Such an approach should allow the establishment of a suitable database indispensable for any further cultural-historic investigation into geoglyph function and meaning.

3.2 Geoglyph analysis and interpretation

3.2.1 Previous research

The search for the function and meaning of the Nasca geoglyphs has been the driving force behind their investigation ever since they were first spotted from a hill east of Nasca by Peruvian archaeologists Julio C. Tello and Toribio Mejía in 1926 (Mejía 2002:182). Many people, among them surprisingly few archaeologists, have since contributed to the topic. The most prominent hypothesis among the public is still that of Paul Kosok and Maria Reiche, who considered the geoglyphs "... the largest astronomy book in the world" (Kosok 1965:49). Down to the present day, the notion that lines point toward stars and figures depict astral constellations is repeated in newspaper articles and tourist guidebooks. The main reason for the persistence of this explanation is that Maria Reiche, who sustained the astronomic hypothesis, had for a long time a quasi monopoly in the interpretation of the geoglyphs and was a media favorite. Although the geoglyphs were first associated with astronomy by Paul Kosok in 1941, it was Maria Reiche who promulgated and expanded his explanation throughout the following decades.

The origin of the astronomic hypothesis and its basic elements have been described in a series of publications by its main protagonists (Kosok, Reiche 1947, Kosok, Reiche 1949; Kosok 1965; Reiche 1976, Reiche 1993). They are well known and will not be repeated here. The main aspect of the hypothesis, *i.e.* the alleged orientation of lines or straight elements of other geoglyphs towards the rising, setting, or zenith point of the sun and other stars at calendrically important dates (*e.g.,* solstice or equinox days), has been thoroughly tested on several occasions by researchers with a professional background in astronomy (Hawkins 1974; Aveni 1990b; Ruggles 1990). Although the premises and methods of these tests differed, and their results are not identical, all of them show that astronomic orientation can be ruled out as main ordering principle of the Nasca lines. In spite of these results, the astronomic hypothesis is even today the starting point of current research, as a recent project directed by geodetic engineers from Dresden, Reiche's hometown, shows (Teichert, Richter 2001, Teichert, Richter 2003; Teichert et al. 2002). Therefore, a few critical comments on some often overlooked aspects of Kosok's and Reiche's hypothesis seem appropriate.

The famous story of Kosok being "... struck with the thought that these remains could have had some connection with early calendrical and astronomical observations" (Kosok 1965:52) is often associated with a picture of him standing beside a line that points to the sunset above the flat horizon. This picture, which is not, although often cited as such, reproduced in his 1965 publication, was reportedly taken by his wife Rose (Aveni 2000a:91), probably someplace on the Nasca *pampa*. If this is true, then it cannot have been taken on June 22, 1941, because on that day, Kosok and his wife were standing on the edge of a plateau near Llipata, in the vicinity of Palpa, as clearly stated in Kosok's original report (Kosok, Reiche 1947:202). The specific line that pointed to the sunset on that day, a photo of which is shown in the report, runs down the hill and crosses a wide *quebrada* that opens up to the Río Grande valley. The line is part of a set of lines radiating out in different directions from the point where Kosok was standing, an arrangement today called a line center. To the west, it ended in a large trapezoid (now destroyed) on the east bank of the Río Grande, on the west bank of which a range of rocky hills sharply rises, forming a jagged horizon high above the valley. Thus, from where Kosok was standing, the line can only roughly indicate a point on the horizon, since the horizon is on a considerably higher level than the visible end of the line.[7] What Kosok saw on that decisive day was not a flat horizon where the sun could neatly set over the distant end of a line, but instead a high range of hills, its characteristic peaks and gullies clearly visible against the setting sun. It has been cogently proposed by other researchers that such a setting could have easily served for astronomic observations, since the sunset can be observed over different, easily distinguishable points during the course of the year (Reinhard 1996:32; fig. 29). For reliable calendric observations in such a setting, a fixed viewpoint for comparable observations is the only requirement. Lines or markings on the ground, however, are not needed in such a scenario. Thus, although astronomic observations may have been undertaken, there is no reason to assume that the geoglyphs were related to them, at least not in the way proposed by Kosok.

It may be argued that in a setting like the one visible in the famous photograph mentioned above, with a flat horizon like that to the west of the Nasca *pampa*, lines made up for the lack of a distinctive row of hills, indicating the position of the sun and starts on important dates. If this was true, there should be an observable difference in the formal repertoire of geoglyphs between areas with a flat horizon and others with a hilly horizon. On the basis of available data, this question cannot be decided, but there seems to be a high degree of similarity between geoglyphs of different parts of the Nasca region.

According to the astronomic hypothesis, lines are not only associated with sunsets, but also with the position of certain stars in the night sky. If this was the case, then ancient observers on the *pampa* would have encountered a practical problem that has rarely been mentioned: the lines on the ground are hardly visible by night, if at all. They could therefore not have fulfilled their alleged function. So far there is no evidence whatsoever that the course of the lines was being illuminated. Such an illumination, on the other hand, would have affected the visibility of the stars. Even in the daytime, the visibility from the ground along a line towards the horizon is often limited, for example due to afternoon haze that makes the horizon appear fuzzy. Thus, from a practical point of view, lines could most likely not have indicated the position of stars, and do

7 Kosok´s view on that day can be appreciated in pictures published by Morrison and Mosely (Morrison 1987:39; Moseley 2001: fig. 67). The combination of lines and trapezoids south of Llipata on which Kosok was standing has since been sketch-mapped by Horkheimer and Rossel (Horkheimer 1947: fig. 11; cp. fig. 5; Rossel 1977: fig. 44) and was interestingly labeled "Línea Sirius" by Reiche (Reiche 1993:568-569). It has also been mapped by the Nasca-Palpa project (Map 1).

not even seem especially well suited to indicate sunsets over flat terrain. Furthermore, though lines may be clearly visible over a certain distance, they are in many cases much longer than observable from a ground perspective, a fact that cannot be explained with astronomical observations. Besides, especially on the Nasca *pampa*, a major part of lines are organized around line centers from which they radiate in all possible directions. Thus, the existing range of line orientations covers practically the full circle. If specific points on the horizon were to be highlighted by the orientation of lines, such an arrangement would not have made any sense.[8]

All in all, lines on the ground seem of little value for celestial observations due to practical considerations. This questions the plausibility of the astronomic hypothesis even without touching the issue of prehispanic astronomic knowledge. Astronomy may well have played an important role in ancient times in the Nasca region. It seems, however, misleading to relate astronomical activities to geoglyphs. The often repeated notion that the Nasca geoglyphs can only be understood when viewed from above has rightly been criticized. Yet the converse line of vision seems equally misleading: looking up into the sky from the *pampa* does not seem to help understanding the geoglyphs either. A ground perspective, standing on the ground and looking on the ground where the geoglyphs are, seems more promising to find out more about the Nasca geoglyphs.

The astronomic hypothesis plays only a marginal role today, at least in scientific research, because its astronomic aspect has been tested and largely rebutted. The above listed practical issues further question its plausibility. However, fifty years ago, following Kosok's and Reiche's early publications, the notion of advanced astronomic knowledge from prehispanic times manifest in spectacular drawings in the desert made the Nasca geoglyphs world famous. By the 1960s, they attracted *aficionados* from all over the world who tried to explain the geoglyphs from very different viewpoints that were often only loosely, if at all, related to Andean cultural history. Some of these rather unscientific hypotheses are listed in recent reviews (Aveni 1990a; Silverman, Proulx 2002: chapter 7). Rostworowski comments that

> “[a]lgunas hipótesis son extravagantes por la necesidad humana de buscar lo maravilloso, que desligue a la persona de su monótono diario vivir y la haga soñar con extraterrestres y un aeropuerto espacial.” (Rostworowski 1993:190)

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8 The objections mentioned here address straight lines, which Kosok and Reiche originally based their reasoning upon. Apart from straight lines, Reiche and others also checked borders of trapezoids and rectangles, as well as straight portions of bended lines and figures for possibly meaningful orientations. The above mentioned issues apply to them as well.

Hence, we face a wide range of hypotheses concerning the function of the geoglyphs, running the gamut from landing strips for spacecrafts to Olympic runways to pieces of art. Of all these ideas, however, relatively few are based on actual scientific research in, or into, the Nasca region.

The situation has fortunately changed since 1980. In the last two decades several serious investigations of the Nasca geoglyphs have been carried out that eventually brought about an actual paradigm shift in their interpretation. A review of the results of these recent efforts shows that a general consensus has emerged from them concerning the basic function and significance of the Nasca geoglyphs. For the purpose of the present work, it seems therefore fruitful to review these recent serious contributions in order to identify a starting point for the research presented here. Several overviews of the long history of geoglyph research since 1926 exist, in varying detail, elsewhere (Morrison 1987; Aveni 1990a, Aveni 2000; Lumbreras 2000; Makowski 2001; Silverman, Proulx 2002) and may be consulted as background information. In what follows, important investigations of the Nasca geoglyphs carried out by different researchers since 1980 are reviewed, and the implications for the present study are summarized.

Johan Reinhard

American anthropologist Johan Reinhard studied the Nasca geoglyphs in the early 1980s as part of a broader investigation into Andean religious concepts and practices (especially mountain worship) as manifest in archaeological and ethnographic contexts. His fieldwork in Nasca was limited to the localization of shrines on mountain tops around Nasca (Reinhard 1988, Reinhard 1996). Basing his arguments on historic sources and ethnographic reports, Reinhard shows that in Andean religious traditions mountain deities played a prominent role and were closely associated with water, weather, and fertility, while their veneration often involved ritual processions along straight lines. Since oral traditions in the Nasca region also speak of mountain deities (namely associated with Cerro Blanco, on the south bank of Río Nasca), he relates the lineal geoglyphs to mountain worship and a cult revolving around water and fertility, a context into which also the motifs of the figural geoglyphs would fit neatly (Reinhard 1996:36ff). According to Reinhard,

> "... lines played a role in a water ritual by connecting a central place of worship (the mound) with critical places in the irrigation system ..." (Reinhard 1996:25)

He explains the great number of lines with them being made by kin groups and assumes that line centers on elevated points were places where offerings were deposited (Reinhard 1996:29f).

Reinhard's attempt to interpret the geoglyphs on the basis of Andean religious traditions marks, together with the research undertaken by Aveni and his team (see below), the beginning of a reconsideration of the cultural background of the geoglyphs that had long been neglected. He shows that persistent Andean religious concepts and social organizing principles can potentially explain the Nasca lines. However, the archaeological evidence that Reinhard offers to support his view is largely restricted to unspecific references to common finds on and around lines, like ceramic vessels or seashells.

Anthony Aveni

American archaeoastronomer Anthony Aveni has investigated a wide range of archaeological contexts throughout the Americas with regard to their astronomic significance (for an overview see Aveni 2003). His interest in the Nasca geoglyphs was sparked when he noticed formal similarities between the geoglyphs and the *ceques*, imaginary connecting and dividing lines from Inka times in highland Cusco described by Spanish chroniclers that he had been investigating before together with Tom Zuidema (Zuidema 1964; Bauer 2000). In the early 1980s, Aveni led a team of archaeologists, anthropologists and astronomers to study the lineal geoglyphs on the Nasca *pampa*, which until then had received less attention than *e.g.* the figural ground drawings (Aveni ed. 1990; Aveni 1990a, Aveni 1990b, Aveni 1999, Aveni 2000a, Aveni 2000b). They found that on the Nasca *pampa*, more than 700 straight lines are grouped around approx. 70 line centers from where the lines emanate radially, many of them interconnecting several such centers. Thus, a possible order in the lineal geoglyphs on the Nasca *pampa* became discernible (Aveni 1990b). The radial character of the system of lines that connect centers established on naturally elevated points bears, following Aveni, strong formal, and maybe functional resemblance with the Cusco *ceque* system. The radial *ceques* divided and organized the terrain, connected places of religious importance (*huacas*), and were often walked upon in spite of their straightness in rugged terrain. Aveni and his team found ample evidence that the Nasca lineal geoglyphs were equally walked upon, many of them showing signs of having been used as footpaths, and that many of them connected

> "... important points that delineate the flow of water across the pampa: e.g., bends in rivers, dunes overlooking the banks of the rivers and their tributaries, or the last hill by which one descends down onto the pampa as one approaches from the Andes." (Aveni 1990b:110)

Taking the analogy to *ceques* and *huacas*, which in highland Cusco were closely associated with certain social groups (*ayllus*), even further, Aveni (Aveni 2000a:180) speculates that Nasca social organization may be reflected in the Nasca line system. Concerning a possible orientation of certain lines towards astral constellations, Aveni (Aveni 1990b) and Ruggles (Ruggles 1990) put the astronomical hypothesis to a rigorous statistical test. As a result, they suggest that astronomy might have played a certain role in the construction of some lines, but clearly rule out that it could have served as general organizing principle underlying the system of lines. Summarizing his team's research, Aveni concludes that

> "... the Nazca lines ... were intended, at least in part, to be walked over in some complex set of rituals that pertained most likely to the bringing of water to the Nazca valley and perhaps to associated mountain worship." (Aveni 1990b:112)

As already mentioned, the work accomplished by Aveni and his team marks, together with Reinhard's and Silverman's research (see above and below, respectively), the beginning of a new era of scientific investigation into the Nasca lines after the dominance of Maria Reiche's ideas and redirected the research agenda toward an Andean cultural framework in which to interpret the geoglyphs. His fieldwork showed that a thorough investigation of the lines on the ground, hardly attempted before, can reveal important insights into the nature of the Nasca lines. However, some shortcomings should not be overlooked. His research on the *pampa* did not help establishing the missing link to the contemporary, largely unstudied settlements in the valleys – probably one of the reasons why Aveni relies heavily on ethnohistoric and ethnographic parallels to interpret the geoglyphs. Furthermore, like many of his colleagues, he treats the alleged system of lines as a single context, without differentiating chronologically. Finally, he does not present any specific evidence recovered in the field that would clearly support the idea of rituals being performed on the geoglyphs, the nature of which therefore remains unspecific. The same applies to his references to Nasca social organization. Nevertheless, the publication of the results of the investigations of Aveni's team (Aveni ed. 1990) is still, though containing little raw data, the most comprehensive study on the Nasca lines available.

Persis Clarkson

Canadian archaeologist Persis Clarkson specialized in geoglyph research in the Americas, her area of interest ranging from the southwestern US to southern Peru and northern Chile (Clarkson 1999). In the early 1980s she took part in Aveni's project, conducting an extensive survey of cultural remains on the Nasca *pampa*. She documented archaeological features like stone circles, cairns, structures and artifacts on and nearby the ground drawings, trying to establish a cultural and environmental framework for the study of the geoglyphs (Clarkson 1990). Later on, she continued her work in own projects (Clarkson 1996, Clarkson 1998). Among other topics, she investigated the relative as well as absolute chronology of the geoglyphs (Clarkson 1996; Clarkson, Dorn 1991). Originally she suggested that only the biomorphic figures were from Nasca times, whereas lineal geoglyphs dated to the Middle Horizon and the Late Intermediate Period (Clarkson 1990:170). This result did not coincide well with the results of other researchers and caused many debates. Based on subsequent fieldwork and chronometric datings Clarkson later changed her point of view (Clarkson 1996:437; Clarkson 1999:169; Clarkson, Dorn 1991: cuadro 1), now sustaining that in certain areas also lineal geoglyphs date to Nasca times. Concerning the function of the geoglyphs, Clarkson puts emphasis on them being walked upon, either in a ritual or profane way, which is suggested on the one hand by footpaths on the geoglyphs, on the other hand by the many artifacts found on or nearby them. Clarkson furthermore raises the question if not the making of the geoglyphs was an important aspect in itself (Clarkson 1990:170f). She interprets stone circles and utilitarian ceramic vessels as associated with people working on the construction of the geoglyphs, and suggests that pots of fineware ceramics were intentionally smashed in a ritual context (Clarkson 1990:140).

Clarkson was the first one after a long hiatus to draw attention to archaeological remains closely associated with the geoglyphs that had virtually been forgotten since Mejía and Horkheimer had mentioned them in their early reports (Mejía 2002; Horkheimer 1947). Her investigations help getting a clearer picture of the cultural context of the geoglyphs on a local level, although not all of the features presented by her are necessarily associated with the Nasca geoglyphs. She was also the first one to try to date the geoglyphs chronometrically.

Gary Urton

American anthropologist Gary Urton investigated social and ritual behavior in contemporary communities in both highland and coastal Peru. He furthermore studied historic sources and recorded oral traditions to trace the observed phenomena back in time. Urton participated in Aveni´s fieldwork on the Nasca *pampa* and contributed important insights from his ethnographic and ethnohistoric research to the reconstruction of the social background of the people who made and used the Nasca geoglyphs (Urton 1990). He put his focus on patterns of social organization revealed when social groups come together on certain occasions (prescribed by a religious calendar) to maintain public structures. Urton, working back in time from ethnographic reports on contemporary highland communities to ethnohistoric sources describing the situation in the

Nasca region in the 16th century and further on to archaeological evidence from Inkaic times, argues that pre-conquest Nasca society was structured in a three level hierarchy. According to Urton, local level *ayllus*, groups of people holding common land rights on strips of terrain, were grouped on the regional level into *suyus* or *parcialidades*, while several of these middle level units were in turn grouped into moieties, basic elements of the dual organization of pre-conquest Andean societies well documented in historic sources (Urton 1990: fig. IV.12). Concepts of social organization, like *ayllus*, were at the same time closely associated with concepts of spatial organization, like *chhiutas,* or strips of land. The persistence of these concepts from prehispanic well into modern times (although not unaltered) favors their projection back into Nasca times. Urton argues that the maintenance of the Nasca lines can be understood in terms of communal labor organized along *ayllu* lines, *e.g.* to maintain an alleged trans *pampa* road. This work could also comprise ritual activities, like the cleaning of sacred spaces as prelude to ritual processions or gatherings.

Although Urton's work has little to offer in terms of archaeological evidence from the geoglyphs, it presents a coherent model of the possible social organization at the time when the geoglyphs were made. Furthermore, it favors, much like the contributions of other researchers described in this chapter, an at least in part ritually motivated use of the Nasca lines.

Helaine Silverman

American archaeologist Helaine Silverman conducted extensive fieldwork in the Nasca region in the 1980s and has since published an outstanding series of articles and books on a wide range of topics concerning the prehistory of that region. Her main projects comprised on the one hand excavations in Cahuachi (Silverman 1990a, Silverman 1993a) and on the other hand a regional settlement survey of the Ingenio valley (Silverman 1990b, Silverman 1993b, Silverman 2002b). In spite of the considerable number of excavation and survey projects in recent years, Silverman's publications are still the only final reports available on any of this research. Silverman's work was never especially focused on the geoglyphs. She does not treat the geoglyphs as an isolated phenomenon like many of her predecessors, but rather as an integrated part of a culture, to be studied and understood only within their cultural-historic context. In the vicinity of Cahuachi and then also in the Ingenio valley, Silverman noticed that geoglyphs are often found in close proximity to settlements, or point towards them, or even interconnect them. Thus, a cultural context on the regional level could be reconstructed, which the geoglyphs on the *pampa* seemed to be devoid of at first sight. Drawing upon her interpretation of Cahuachi as the spiritual, ritual, and social (albeit not political) center of early Nasca times, Silverman interprets the geoglyphs as part of a ritual complex closely related to that site. Thus, she interprets lines through the *pampa* as pathways used by pilgrims on their way to Cahuachi, as culturally domesticated space in the desert, and as locus of gatherings and ritual activities of cognatic descent groups (Silverman 1994b, Silverman 2000). Like Urton (see above), Silverman believes that Nasca sociopolitical organization can be understood in terms of Andean dualism. In this model, the Nasca drainage would have been divided into two moieties north and south of the Nasca *pampa*, respectively, with each valley in turn split in an upper and lower moiety. The *pampa*, and with it the geoglyphs, would have served as a place or stage where people from the two moieties met, interacted, and negotiated their status. While historic documents from early colonial times seem to support the idea of intra-valley moieties prior to the conquest (Urton 1990: appendix III), Silverman finds further support for her idea in the proposed functional division or complementation of Cahuachi, the empty ceremonial center in the Nasca valley, on the one hand and Ventilla/Site 165, the alleged urban and administrative center in the Ingenio valley, on the other hand. Silverman believes that both sites were connected by a trans-*pampa* geoglyph, which would again strengthen the idea of the *pampa* as connector and common ground for both moieties. However, there are many unknowns in Silverman's equation: the alleged geoglyph was built over by the *Camino de Leguía*, predecessor of the Panamerican Highway, in the 1920s, *i.e.* before the first aerial images of the *pampa* were taken, so it is difficult to assess today if such a geoglyph ever really existed. Furthermore, Ventilla/Site 165 has never been investigated in detail, and there are serious doubts concerning the role of Cahuachi as proposed by Silverman (Schreiber 1998:265). Hence, apart from historic sources mentioned by Urton and the claimed plausibility of tracing back the well documented Andean concept of dualism to Nasca times, there is still no clear archaeological evidence to back such a model.

More than other researchers, Silverman puts emphasis on the compatibility and complementarity of the hypotheses proposed by Aveni, Urton, Reinhard, and herself. In her view, a ritual complex involving also ritual movements along straight lines, prediction of water flow and agricultural fertility, observation of the skies and heavenly bodies, and mountain worship was the background of the creation of the geoglyphs. She furthermore understands the geoglyphs as mnemonic device, or text, seeing

> "... the proliferation of lines on the Pampa as the cumulative result of repetitive ritual activity, perhaps calendrically organized ... Through this ritual activity on the Pampa the lines were made and in so doing the lines recorded ecological, climatological, hydrological, social, and political information necessary for social life and its prediction and scheduling." (Silverman in Silverman, Proulx 2002:179)

The specific role of the different aspects of their manifestation remains vague, however. The strength of Silverman's reasoning lies in a cogent model that explains the geoglyphs in a larger cultural context, but specific data from the archaeological record is underrepresented in her model.

David Browne

British archaeologist David Browne was the first researcher to concentrate his investigations exclusively on the then poorly known Palpa area. His survey, conducted in the late 1980s, covered the alluvial plain around Palpa, the Río Grande downriver to its junction with Río Ingenio, as well as short stretches upriver the Río Grande, Río Palpa and Río Viscas (Browne 1992; Browne, Baraybar 1988; Silverman, Browne 1991; Browne et al. 1993). Although the geoglyphs were not the focus of his prospection (Browne 1992:77), he describes several of them which he found in close proximity to registered sites from the Early Intermediate Period. The term *campo barrido*, or cleared field, used by him (Browne, Baraybar 1988:301, 309) seems to refer in most cases to some kind of cleared *plaza* forming a part of a settlement, but in other cases it is clear that Browne describes trapezoidal geoglyphs. He proposes a ritual function for the *campos*, possibly related with funeral rites, but does not explain in detail what this assumption is based on other than some intentionally smashed pots that he mentions. Concerning geoglyph research in general, Browne gives his opinion

> "... that the clues to the answers to many problems concerning the so-called Nasca lines lie in the small valleys tributary to the main drainage and that the emphasis in study should shift from the pampa to them." (Browne, Baraybar 1988:318)

While he certainly makes an important point here, published data on the geoglyphs in his survey area remains scarce.

María Rostworowski

Peruvian historian María Rostworowski has searched a vast amount of historic sources for indications of pre-conquest history and religion in the Andes. Her publications constitute an outstanding source of information on these topics. According to Rostworowski, old legends reported in colonial sources indicate that a deity called Kón was venerated before the god Pachacamac rose to prominence (Rostworowski 1993). Kón converted the once fertile coastal strip into desert and sent rivers as substitute for rain. Thus, this deity is closely associated with the flow of water in the rivers upon which the coastal economy is based. Kón is described as a boneless, flying being, whose origin can be traced back to the south coast. Based on this evidence, Rostworowski (Rostworowski 1993:196, 199) hypothesizes that Kón may have been the principal deity in the Paracas and Nasca pantheon, that this deity might have appeared only at certain seasons of the year, probably when the water in the rivers began to flow, and that the geoglyphs were made as places where the believers awaited Kón's appearance or as signs for the god to come. Water and fertility would have been important aspects in this religious concept, as on the whole Peruvian coast. Rostworowski furthermore proposes to identify flying beings depicted on ceramics and textiles that are generally characterized as Anthropomorphic Mythical Being (AMB) as Kón. Apart from Silverman´s and Proulx´s objection that the AMB is not related to flying (Silverman, Proulx 2002:185), Rostworowski´s hypothesis has the disadvantage that there will probably never be a way to prove or even test it with archaeological means. However, it fits well into the various attempts described in this chapter to explain the Nasca lines in terms of Andean religious concepts and beliefs.

Aurelio Rodríguez

Peruvian archaeologist Aurelio Rodríguez studied geoglyph sites on the coast of Peru, in particular in the vicinity of Lima. In order to establish an interpretative framework for their analysis, he searched historic sources from early and middle colonial times for accounts of ritual practices of the precolonial era (Rodríguez 1999). Although the Nasca geoglyphs were not the principal focus of his study, he applied much of his results to them since they are the best known complex of geoglyphs. Rodríguez argues that the geoglyphs served as locations for what he calls *desplazamiento ritual* (Rodríguez 1999:10, 13), which he subdivides further into processions/pilgrimage, ritual races, and dances. For each of his three subcategories he presents detailed accounts from colonial sources describing how these rituals were performed on marked spaces. According to his hypothesis, long straight lines served for processions and pilgrimage, while ritual races were carried out on trapezoids and their adjoining lines. Ritual dances in turn would have been performed on figural geoglyphs, with chains of dancers moving along the lines that form the figure.

Rodríguez' compilation of historic accounts results in a coherent picture of Andean ritual practices and seems to fit neatly to the Nasca geoglyphs, which were presumably marked spaces where such rituals were preformed. Rodríguez is more specific than other researchers as to the actual activities on certain types of geoglyphs. Nevertheless, he, too, faces the basic problem of an 800 year time gap between the Nasca geoglyphs and the historic accounts he presents, and he offers no specific archaeological evidence to sustain his ideas.

David Johnson

Whereas Aveni and others of the above mentioned researchers propose a possible relationship between geoglyphs and rivers, American private scholar David Johnson recently brought forward a new hypothesis that links the geoglyphs to subterranean water sources (Johnson 1999; Johnson et al. 2002). According to him, geoglyphs mark the course of aquifers that run through geological faults and intersect the valleys where water from them is captured in wells and filtration galleries. Johnson postulates a recurrent pattern of faults, aquifers, settlements, filtration galleries, and geoglyphs occurring together (Johnson et al. 2002:309). He even proposes some kind of code for the geoglyphs: trapezoids mark the course of aquifers, zigzags show places without subterranean water, etc. (Johnson 1999:160). The fieldwork recently conducted by American hydrogeologist Stephen Mabee to test Johnson's hypothesis shows that there is indeed strong evidence for water sources in the valleys that are independent of the rivers and are apparently supplied by aquifers carrying water from the highlands through subterranean courses towards the coast (Johnson 1999:159; Johnson et al. 2002; cp. summary in Silverman, Proulx 2002:185-189). It is interesting to note, and an important contribution of the research conducted by Johnson and his colleagues, that at least some of the ancient filtration galleries were constructed so as to tap the water from these aquifers, thereby providing an additional water supply that was certainly of great importance for the inhabitants of the valleys. It also comes as no surprise that ancient settlements are clustered around areas where reliable water sources were available.

However, the proposed relation of subterranean water to geoglyphs is not evident in the data provided by Johnson. Although he presents photos and sketches showing that some trapezoids align with faults likely to carry water, it has to be kept in mind that the desert zone close to the valley is the area where most geoglyphs are found, so any relation may be no more than coincidental unless statistically proven to be relevant. To do this, however, a detailed register of all existing geoglyphs is needed, which Johnson fails to present. Furthermore, some aspects of his reasoning seem questionable, *e.g.* his consideration of stone circles which are most probably of modern origin. In summary, the core of Johnson's hypothesis lacks as yet support from field data. However, the work by his colleague Mabee is an important contribution to Nasca research since it helps understanding ancient water management.

3.2.2 Review and own approach

The above review of recent investigations shows that Nasca geoglyph research has advanced considerably since 1980. Andean traditions of cultural concepts, religious practices, and social organization are now used as a fundament for new hypotheses to explain the origin and the nature of the geoglyphs. These new approaches are quite distinct from that of Maria Reiche, who dominated the debate on the Nasca geoglyphs, as well as the geoglyphs themselves, for several decades. When Kosok and Reiche proposed their astronomical hypothesis, they largely abandoned the base of contemporary knowledge on Andean cultural history. Although their approach was not in itself unreasonable, their tendency to neglect the cultural context of the Nasca geoglyphs prepared the ground for many unscientific and even fantastic ideas that were proposed in the '60s and '70s to explain the Nasca geoglyphs.

THE ANDEAN MODEL

This tendency was clearly reversed since 1980, when Nasca geoglyph research was redirected back to its roots. That is to say that recent approaches as described above are interestingly quite similar to the earliest attempts to interpret the geoglyphs. For example, Mejía, one of the modern rediscoverers of the geoglyphs, explained them as sacred pathways and was the first to compare them to the Cusco *ceques* (Mejía 1942, Mejía 2002), while Horkheimer argued that the geoglyphs were manifestations of an ancestor cult that involved dances along the lines performed by kin groups (Horkheimer 1947). Clearly, both these early researchers and their modern colleagues have been striving for embedding the Nasca geoglyphs in a broader context and for explaining them on the basis of current knowledge on Andean cultural, religious, and social traditions. It also becomes clear that, although each researcher stresses certain aspects of his or her hypothesis that might differ from those emphasized by others, the different contributions can be amalgamated into a single model,[9] as already pointed out by Aveni and Silverman and Proulx

9 The term “model” is used in two different ways in the present study. Concerning archaeological reasoning, a “model” is a set of hypotheses aimed at explaining archaeological data in a wider context. In geomatics, on the

(Aveni 2000a:209; Silverman, Proulx 2002:192). Such a model will be termed "Andean model" for the purpose of the present study. Its main aspects may be summarized as follows:

> The Nasca geoglyphs were created by a population organized in social groups whose members shared common ancestors and/or land rights. These groups met in the desert, marking and creating space according to common concepts and beliefs deeply embedded in Andean traditions. This social interaction was important for the position of each group within a broader societal context. A cult revolving around mountain deities, water flow, and fertility, probably organized by a ritual calendar, was the background of geoglyph related activity. The geoglyphs were organized in a spatial system that reflected social order, since they were associated with social groups and determined their status. They furthermore connected sacred places and were in some way or another related to the course of water. The geoglyphs served for processions performed by the groups that made and maintained them. These movements might have been related to pilgrimage, sacred sites, or other traffic across the desert. Fineware ceramic vessels, supposedly filled with food and drinks, were ritually smashed and deposited on line centers and along geoglyphs. Trapezoids were places where larger groups gathered or races were held, while biomorphic figures, whose motifs evoked the concept of fertility, were walked upon in dances. The geoglyphs marked social, cultural, and sacred space out in the desert. They symbolically expressed cultural concepts that could be understood by members of Nasca society. Superposition of geoglyphs reflected evolution of the cultural and social reality. All in all, the geoglyphs were deeply embedded in the daily live of Nasca society, and the basic concepts that guided their realization were in concordance with Andean cultural, religious, and social traditions.

In a further simplification, the main aspects of the Andean model as well as its contributors are illustrated in Figure 3.1.

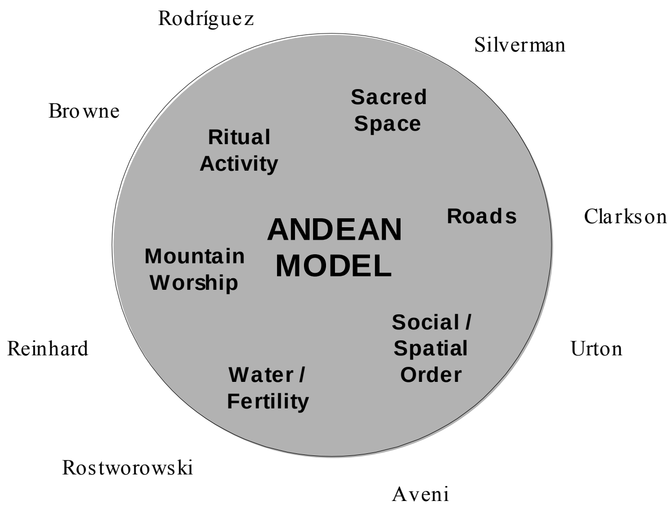

Figure 3.1: The Andean model to explain the Nasca geoglyphs

other hand, the term refers to the geometric representation of a real-world object.

The Andean model, though neither designated nor formulated as such by either of the above mentioned researchers, represents the state of the art in Nasca geoglyph research. Its basic assumption is that the Nasca culture was part of a long-term cultural tradition shared throughout the Andes that evolved slowly in time and proved persistent over the centuries. It is further assumed that this Andean tradition, which involves common concepts, beliefs, and behaviors, persisted, though not unaltered, even in the face of historic disruptions like the Spanish conquest and still persists today in traditional Andean communities. Following this reasoning, ethnographic and ethnohistoric studies not only allow to identify elements of this tradition, but also enable to establish a causal link between observed behavior on the one hand and material culture on the other hand. For example, Urton explains spatial division of the churchyard of Pacariqtambo, a contemporary village in the highlands, with social division of the community, while Aveni, on the basis of ethnohistoric sources, explains *huacas* and *ceques* in Inkaic Cusco in terms of Inkaic social organization and religious practices as described by early Spanish chroniclers. In the case of the Nasca geoglyphs, only the remains of material culture can be documented archaeologically, while the intangible cultural concepts behind them are not directly accessible through archaeological research. The above mentioned assumption that a long-lasting Andean tradition is the common framework for the Nasca geoglyphs, the Cusco *ceques*, and the Pacariqtambo churchyard strips, allows to establish an analogy on the basis of which conclusions can be drawn on the unknown concepts behind the geoglyphs (Bernbeck 1997: chap. 5). Accordingly, Urton and Aveni, as well as Rodríguez and Silverman, transfer concepts of social organization and religious practices from ethnographic and ethnohistoric cases to the Nasca culture in order to interpret the function and meaning of the geoglyphs. The result is the above described Andean model, a coherent set of hypotheses to explain the Nasca geoglyphs.

Critical comments on the Andean model

How can the validity of the Andean model be assessed? In archaeological research, an explanatory model cannot be proven to be true. Though it may be capable to explain certain archaeological contexts, other models might have the same capability as well. Thus, the model has to be assessed in terms of plausibility. This can be done in two ways. On the one hand, the analogies used to establish the model can be questioned, considering aspects like the time interval between compared phenomena and their degree of similarity. Such an approach may clarify the theoretical foundations of the model. On the other hand, archaeological fieldwork offers the opportunity to verify the material foundations of the model. As has been shown, the

Nasca geoglyphs are poorly known in terms of well documented contexts. Any new geoglyph study can be expected to reveal either contexts that are in accordance with the underlying assumptions of the Andean model, thus strengthening its plausibility, or context that are different, with the model failing to explain them. In this case, the model would either have to be adapted or replaced.

Concerning the plausibility of the analogies established between the Nasca geoglyphs and later contexts like *e.g.* the Cusco *ceques*, it has to be kept in mind that, starting from the general consensus that the geoglyphs were mainly made and used at the time of the Nasca culture, there is a time gap of almost a millennium between the latest geoglyphs and the earliest situations and contexts described in colonial written sources. In this considerable time span, the Nasca region faced several historic disruptions. Therefore, Proulx cautions that

> "... Nasca culture had disappeared almost eight hundred years prior to the emergence of the Inca Empire and was separated from it by the Tiwanaku/Wari religious tradition which was quite different from earlier Nasca religion, not to mention the different political context." (in Silverman, Proulx 2002:195)

These disruptions are clearly manifest in the archaeological record: changing ceramic traditions, notedly different settlement patterns, and the end of the geoglyph tradition are only the most obvious indications. The Spanish conquest was another major historic break. Thus, there is no smooth continuity between the Nasca geoglyphs and the situation described in the earliest chronicles.

That is not meant to say, however, that there is no persistent tradition. The fact that certain religious practices and principles of social organization in the 20th century seem easily comparable to contexts and situations described in the 16th century indicates that, in spite of major historic breaks and disruptions, there is still a stable cultural foundation upon which Andean societies are based. Thus, the projection of identified elements of such a tradition back into Nasca times seems reasonable, although it has to be kept in mind that even such a stable tradition is subject to a constant, if slow, change. This may be negligible over a short time span, but if at least 800 years and several major historic changes are to be bridged, then it is to assume that a change in certain aspects occurred. Thus, the task remains to find out which aspects may have changed, and to which degree.

The plausibility of the analogies used to establish the Andean model can furthermore be assessed by considering the degree of similarity between compared phenomena. In the case of the Nasca geoglyphs, it has become clear in chapter 3.1 that any comparison is rendered difficult due to a void in the database. In the literature on the topic, references to the actual archaeological record are sparse. Apart from some notable exceptions there is no detailed description of specific geoglyphs. Even recent projects largely failed to produce, or at least to publish, a comprehensive database that would allow other researchers to get a precise idea of the properties, or even the location, of specific geoglyphs. Instead, common characteristics supposedly shared by the majority of the Nasca lines are often summarily described, *e.g.* the straightness and radiality of lines, the subtractive construction technique of most geoglyphs, sherds of smashed pots scattered around geoglyphs, etc. These general traits are repeatedly mentioned and thus perpetuated in the literature. The fact that a serious attempt to document the Nasca geoglyphs has yet to be undertaken renders their generalization doubtful since many different geoglyphs contexts have so far not been considered. The analogy may therefore have a week point concerning compared traits.

These plausibility considerations lead over to archaeological fieldwork, which is the main topic of the present study. The more geoglyphs are documented, the better we will know if certain characteristics of the geoglyphs on which analogies are based are really typical or representative and may thus be useful for comparisons.

If archaeological fieldwork is aimed at assessing the Andean model, three basic issues have to be taken into account:

- the model mainly explains the geoglyphs on the Nasca *pampa* without consideration of the wide variety of existing geoglyphs;
- the model does not take into account the vast time span during which the geoglyphs were made;
- several aspects of the model are not testable with archaeological means.

Concerning the first issue, the Nasca *pampa* is not only the principal destination of the tourists' flights, but has also attracted most scientists who worked in the Nasca region. While early researchers were quite aware that geoglyphs are a phenomenon not restricted to the Nasca *pampa*, later research was focused almost exclusively on that vast plateau and, more specifically, on its northern edge. Silverman and Browne made notable exceptions by calling attention to the fact that geoglyphs are also located in other areas, often in contexts that are very different from that on the *pampa*. Many geoglyphs along the tributaries of Río Grande can be found in close proximity to settlements, are part of less complex sites or even isolated from one another, and occur in different topographical settings. The Andean model, however, is largely tailored to explain the situation on the vast, uninhabited, flat *pampa* that is covered by a maze of geoglyphs. Different manifestations of the geoglyph phenomenon in other regions of the Nasca drainage may thus not be explainable by the Andean model.

Concerning the chronology issue, geoglyphs are generally thought of having been made over approx. 1 000 years. Over such a large time span, cultural change cannot be expected to leave the construction, use, perception, and physical manifestation of geoglyphs unaffected. Thus, it is already clear from the outset that the Andean model has to be enhanced by giving it the time depth it currently lacks. Geoglyph chronology is still fraught with uncertainties. It relies mainly on dating of associated ceramics, whose chronology in turn has yet to be verified stratigraphically. Besides, such an indirect dating presents a constant methodological problem, since in most cases the actual temporal relation between a geoglyph and sherds found on it cannot be established unambiguously. The potential of relative chronology, reconstructed on the basis of stratigraphic relations of the geoglyphs to each other or to other cultural remains, has not been fully tapped due to the lack of a detailed record of the geoglyphs. The same applies for a direct chronometric dating of the geoglyphs. Thus, it is not clear if different shapes or sizes of geoglyphs, or different contexts or combinations can be explained chronologically rather then functionally or regionally. Furthermore, the maze of geoglyphs that we see today makes it difficult to keep in mind that most probably only a small part of it functioned together at any given time. Therefore it is clear that any interpretation of the geoglyphs can only make sense if it takes chronological variation into consideration.

Finally, it has to be kept in mind that the Andean model comprises several aspects that cannot be tested with archaeological means. Some will always remain elusive for archaeological verification, like for example Rostworowski's idea that the god Kón was venerated on the Nasca *pampa*. Other aspects have not been operationalized for archaeological fieldwork. The basic question here is: how is the archaeological record expected to look like if various aspects of the model actually apply? How do kin groups, ritual dances, or mountain worship become manifest in the archaeological record, if at all? What material traces of pilgrimage or a ritual calendar may have survived, considering the formation process and preservation conditions of the archaeological record? The literature reviewed above provides little clues to answer these questions. The archaeological record is composed of material remains, in this case the geoglyphs as well as other artifacts and structures associated with them. Their study may reveal geoglyph related activity and people involved in it. Intangible concepts, traditions, or systems that motivated or induced geoglyph-related activity can be assessed only indirectly. Thus, only certain aspects of the Andean model, namely those related to material culture and activities that lead to the formation of the archaeological record, can directly be tested. The main explanatory aspects of the model, *i.e.* those dealing with Andean concepts and cultural traditions, are elusive for direct archaeological testing. However, once archaeological data becomes available, they can be assessed in a better substantiated way.

With these issues in mind, it was decided to analyze the Palpa geoglyph data in various steps. The elaboration of a geoglyph typology of the Palpa sample helped getting a systematic overview of the formal variation of the geoglyph repertoire. Using stratigraphic and contextual evidence, a general chronological framework for the geoglyphs was then established. This step furthermore allowed to determine if the typological variety within the Palpa geoglyph sample can be explained chronologically. Thus, variety and chronology of the Palpa geoglyphs were addressed first. In a next step, activity related to the Palpa geoglyphs as manifest in the archaeological record was identified. This allowed getting a clear picture of what actually happened on geoglyph sites, a question of central concern to the Andean model, which was accordingly compared with the results. Other aspects of the model that postulate a link between the geoglyphs and their environment were then addressed by a GIS-based spatial analysis of the Palpa geoglyphs that revealed ordering principles for geoglyph placement, shape etc.

3.3 Summary: geoglyph research in the Nasca region

From the above review follows that previous research on the Nasca geoglyphs has resulted in a comprehensive hypothetical model to explain the geoglyphs. To confront it with archaeological data seems a promising way to learn more about the geoglyphs. However, as the review equally shows, any new attempt to study the geoglyphs only makes sense if it includes the acquisition of a fresh and comprehensive body of field data. The Nasca-Palpa project was intended to address some of these research problems, namely by elaborating a comprehensive documentation of the Palpa geoglyphs and by comparing archaeologically testable aspects of the Andean model with the obtained data.

4. The Nasca-Palpa project

SLSA's Nasca-Palpa project encompassed not just an investigation of the Palpa geoglyphs. Rather, its general purpose was a broad study of the Nasca culture in the Palpa area, one of the most fertile zones of the Nasca drainage (Figure 4.1, Map 1).

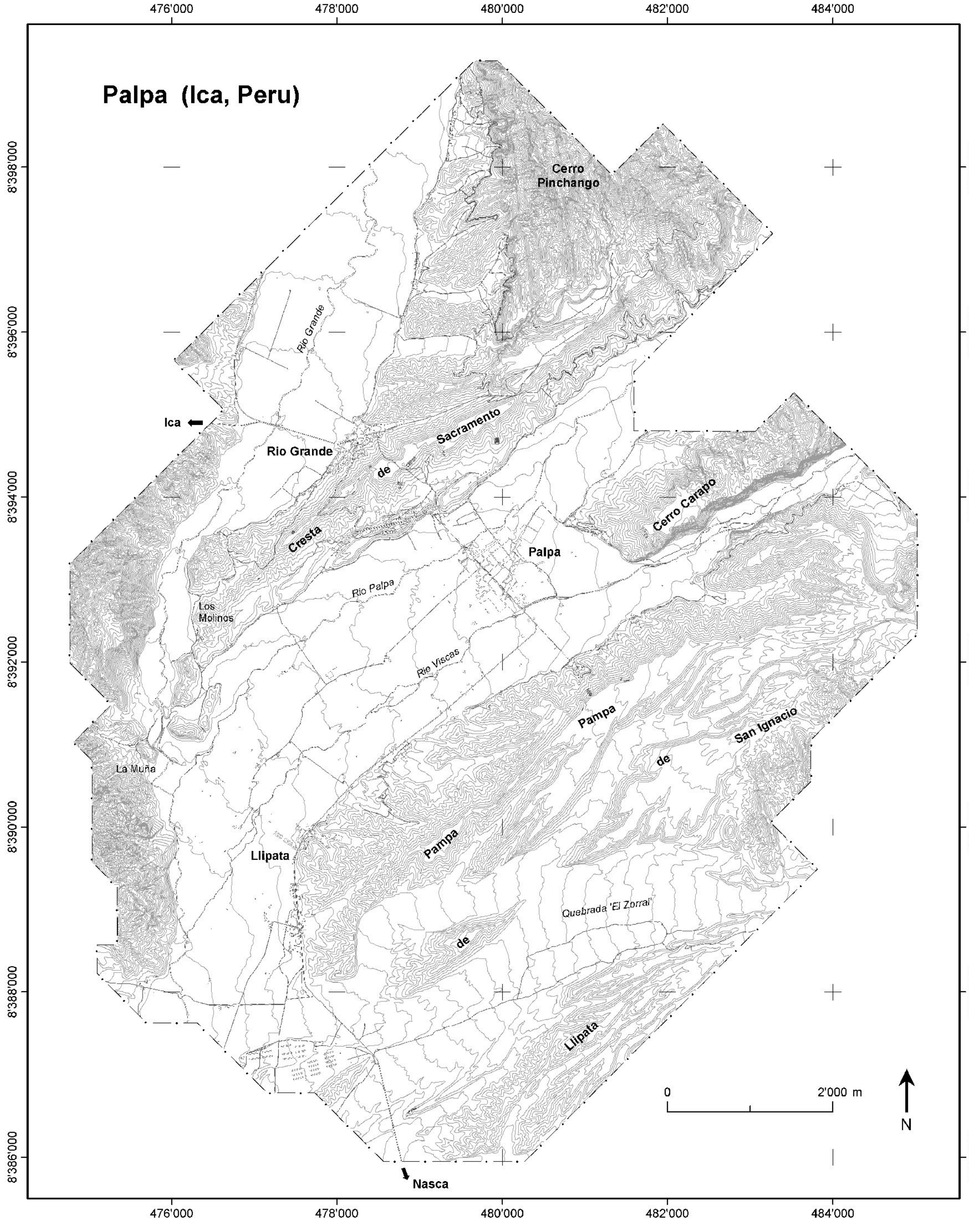

Figure 4.1: The study area around Palpa (Depto. Ica)

The first phase of the project (1997 - 2002) comprised three main activities:

- a regional settlement pattern survey, in the course of which more than 700 prehispanic sites were located, recorded, and classified (Reindel et al. 1999, Reindel et al. 2003a);
- extensive excavations at Los Molinos and La Muña, two large sites along Río Grande with public architecture from Early and Middle Nasca times, resp. (Reindel, Isla 2001; Reindel et al. 2002);
- a complete recording and analysis of the geoglyphs that cover the slopes, ridges and plateaus of the Palpa region (Reindel et al. 2003b; Grün, Lambers 2003; Sauerbier, Lambers 2003).

The Palpa area was in many respects a good place for the intended study. The geoglyphs on the slopes and hills along the valley margins (Figure 4.2, Figure 4.3, Map 6) are easily comparable to the geoglyphs on the Nasca *pampa*, but have so far received very little attention.

Figure 4.2: Aerial view of Cresta de Sacramento (left: Rio Viscas and Rio Palpa, right: Rio Grande)

This is somewhat surprising, since in the early years of Nasca geoglyph research the Palpa area played a prominent role. As mentioned above, Paul Kosok was struck by the idea that the geoglyphs constitute "... the largest astronomy book in the world" (Kosok 1965:49) while standing on a hill near Llipata, to the south of Palpa (Kosok, Reiche 1947:202; Kosok in Reiche 1993:137). In the following years, Maria Reiche also worked in the Palpa area, as various pictures, sketch maps, and other references in her publications indicate (Reiche 1976; Reiche 1993). However, she left no detailed account on her activities in Palpa. At about the same time, Hans Horkheimer studied the Palpa geoglyphs and took photos and sketches of several of them, among them the nowadays famous *reloj solar* (sundial) north of Palpa (Horkheimer 1947: figs. 7-9) and the combination of lines on which Kosok had had his inspiration some years before, near Llipata (Horkheimer 1947: figs. 5, 11). Thereafter, however, the focus of Nasca geoglyph research shifted almost completely to the Nasca *pampa* for a long time. Strong passed through the Palpa area and Mejía conducted excavations there, but neither of them worked on geoglyph sites (Strong 1957; Mejía 1972; Mejía 1976). The Palpa geoglyphs were mentioned again by Rossel (Rossel 1977: chapter X) and Browne (Browne, Baraybar 1988; Browne 1992), but have never been studied in detail. It was only known that

> "... the valleys north of the *pampa* are also full of ground markings which were constructed in the same manner, and have forms identical to those on the *pampa.*" (Silverman, Browne 1991:208)

Figure 4.3: Aerial view of Cerro Carapo (right: Rio Viscas)

Thus, a systematic investigation seemed promising. Other factors favored a study of the Palpa geoglyphs as well. They are situated, and have been so also in prehispanic times, close to densely settled zones along the valley floors. There are various sites where geoglyphs occur together with contemporary public or habitational architecture as part of the same site, which is not the case on the Nasca *pampa*. Another decisive point for choosing the Palpa area was that in this area, the geoglyphs are not protected. Since they are located in openly accessible terrain close to modern settlements, many of them have already been damaged or destroyed without having been registered or studied. Hence, the work was also thought of as a first step towards an effective protection and preservation of the Palpa geoglyphs.

The study of the Palpa geoglyphs started along with the regional settlement pattern study in 1997, when a first flight was conducted in order to obtain aerial images suitable for photogrammetric analysis. A second flight was carried out in 1998. The processing and analysis of the resulting images allowed to start archaeological fieldwork on geoglyph sites in 2000. It was continued in three field campaigns until 2001. Analysis of obtained data was largely conducted from 2002 to 2004 and resulted in the present study. Following the structure of chapter 3 in which previous research is reviewed, the documentation of the Palpa geoglyphs on the one hand and the analysis and interpretation of the resulting data are described separately in the following chapters 5 and 6, respectively.

5. Documentation of the Palpa geoglyphs

In this chapter, the investigation of the Palpa geoglyphs in the framework of SLSA's Nasca-Palpa research project is described in detail. The different steps of data acquisition and processing are outlined, and the applied archaeological and photogrammetric methods are explained.

Before fieldwork in Palpa started, a review of potentially suitable aerial photographs was undertaken in order to determine if existing imagery could be used for the planned photogrammetric documentation of the geoglyphs. As for most other coastal valleys, vertical aerial photographs of the Palpa area had been taken in previous decades by Peruvian governmental agencies. Images available prior to the start of the project are listed in Table 3.

Year	*Agency*	*Nominal scale*	*Area covered*	*Remark*
1944	SAN	1 : 5 000	Sacramento, San Ignacio	only partial coverage
1944	SAN	1 : 12 000	Sacramento	scale probably 1 : 15 000
1955	IGN	1 . 60 000	whole Palpa area	
1970	SAN	1 : 10 000	whole Palpa area	
1986	IGN	1 : 70 000 1 : 80 000	whole Palpa area	
1992 - 2002	IGN	1 : 30 000 1 : 60 000 1 : 80 000	whole Palpa area	

Table 3: Aerial imagery of the Palpa area available from Peruvian governmental agencies (based on review of SAN archive, Lima, and IGN website: www.ignperu.gob.pe)

Of these images, only the series taken in 1944 (1 : 5 000) and in 1970 (1 : 10 000) were acquired from the SAN office in Lima since the scale of the other series would not have allowed to discern enough detail to map the geoglyphs. No information on the camera used in either of the two flights was available. The 1944 images, which covered only the central part of Cresta de Sacramento, could not be oriented satisfactorily, most probably for lack of camera calibration data (Fischer, Künstle 1999). They could therefore not be analyzed stereoscopically. The 1970 images could be oriented but were scratched and blotchy, and their scale did not allow to discern enough detail. Thus, it was decided to base the work in Palpa on a new series of images to be taken in the framework of the Nasca-Palpa project. These images were especially designed to meet the requirements of a 3D documentation of the geoglyphs.

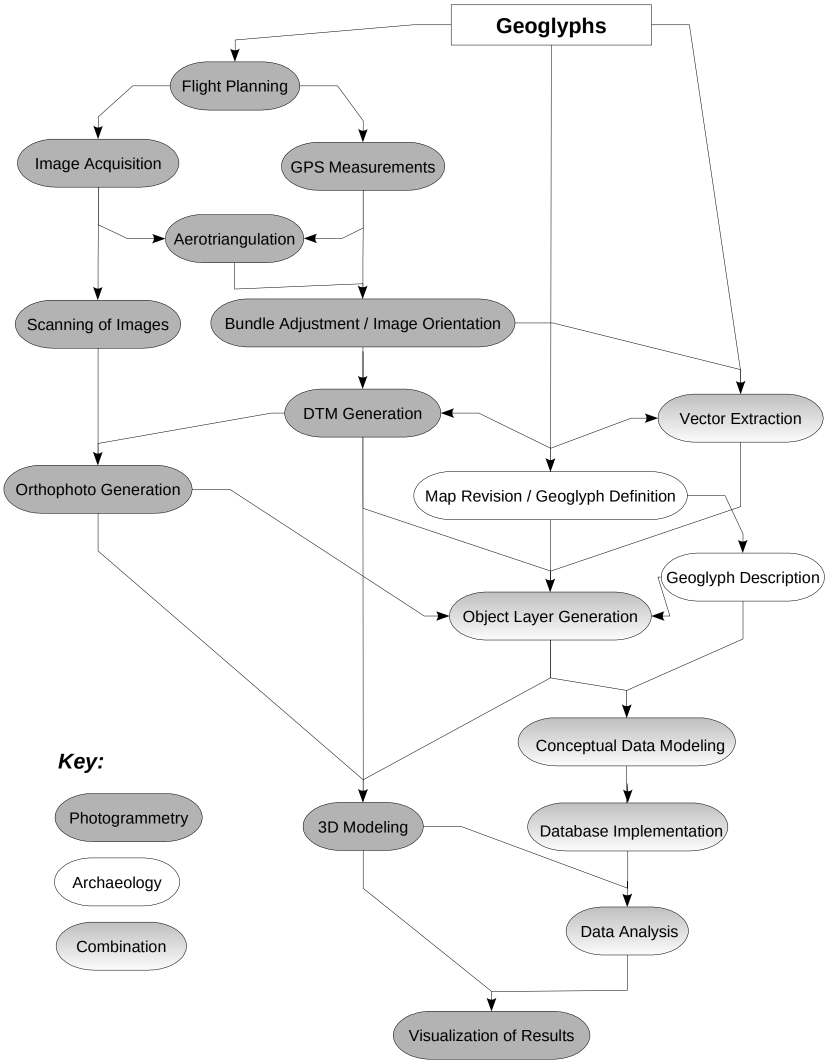

Figure 5.1: Workflow for geoglyph documentation, analysis, and visualization combining photogrammetric and archaeological techniques

In order to deliver the desired results, the application of photogrammetry to record the Palpa geoglyphs required a close cooperation between geomatic engineers and archaeologists. While the former provided the technological expertise and carried out the technical aspects of the work, the latter contributed the archaeological expertise and conducted the actual recording of the geoglyphs. A combined workflow was devised that integrated both archaeological and photogrammetric procedures in order to get from the real-world geoglyphs to digital records of them. The steps of the workflow, shown in Figure 5.1, are described in detail below. As the flowchart clearly shows, the different steps of the workflow were highly interwoven, so that the sequential description given in the following can characterize it only inadequately.[10]

10 The following description does not coincide in all technical details with previous, preliminary reports. Where differences occur, information given in the present study should be regarded as definite.

5.1 Flight planning

In the course of the project, two blocks were defined over the Palpa area where aerial images were to be taken (Figure 5.2).

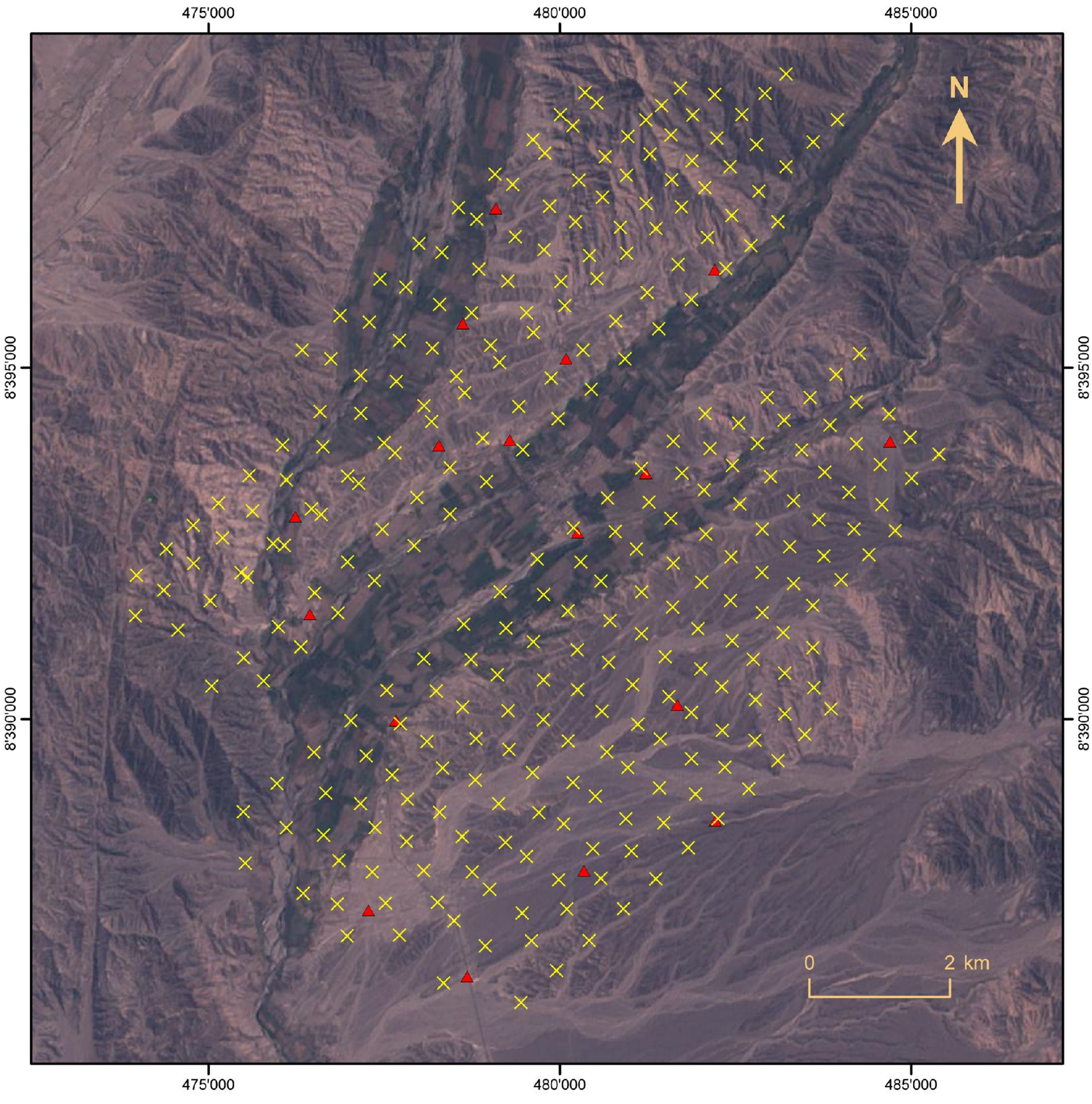

Figure 5.2: Landsat 5 TM image of the Palpa area with projective centers of 1998 black and white images (yellow crosses) and ground control points (red triangles)

Both were designed so as to cover the areas with geoglyphs on the ridges and plateaus along the valleys. The smaller block covered Cresta de Sacramento, a low ridge northwest of Palpa between Río Grande and Río Palpa that was the main focus of the archaeological investigations in the first field campaign in 1997 (Grün, Brossard 1998; Grün 1999; Reindel et al. 1999). The flight was planned so as to yield vertical aerial images at a scale of 1 : 5 000, organized in parallel strips with a 60% overlap in both directions in order to allow full stereoprocessing. The original plan was to take color photographs. When the 1997 flight over Sacramento did not deliver results good enough for our purposes (see below), it was decided to commission a second flight one year later in order to take black and white photographs of the same area, with the rest of the flight characteristics remaining the same. By the time the second flight was to be carried out, it had become clear that the *pampas* of San Ignacio and Llipata, to the southeast of Palpa, were also to be included in the archaeological project. Thus, a second image block was defined over that area that was to be flown at the same time. For each flight, the flying height was defined according to the desired image scale, and the positions of the intended projective centers were marked on a topographic map. This data was then passed on to Horizons Inc., Rapid City, SD, U.S. (www.horizonsinc.com), a private company that carried out the actual flights.

5.2 Image acquisition

On May 1, 1997, the first photogrammetric flight was performed over Cresta de Sacramento. The flying height was approx. 750 m above ground. Using a calibrated Zeiss RMK A15/23 aerial camera with a focal length of 152.994 mm, 212 color photos were taken along 8 parallel strips. After the flight the images turned out to be partially scratched and blotchy. Furthermore, their color was not ideal to discern the geoglyphs, and an intensity falloff was visible towards the image edges. Therefore, a second photo flight was undertaken the following year by the same company. On May 23, 1998, 169 images along 8 strips were taken over Cresta de Sacramento, this time in black and white (Figure 5.3). During the same flight, the second block over the *pampas* of San Ignacio and Llipata was covered, too. It comprised the area southeast of Palpa approx. 4.5 km into the desert from Río Viscas. 215 images along 11 strips were taken over the second block, with the same characteristics as the images of the first block.[11] Since Cerro Carapo, to the northeast of Palpa between Río Palpa and Río Viscas, had also to be included in the photographed area, the first strips of the second block covered a good part of the floodplain

11 Along with the acquisition of the Palpa images, another series of aerial images was taken over the Nasca *pampa*. These images have a nominal scale of 1 : 10 000 due to the larger area covered and were taken in 1997 (439 color images) and 1998 (401 black and white images), respectively. The Nasca images have not been analyzed during the first phase of the Nasca-Palpa project, in which all efforts were focused on the Palpa region. Only some images of the northern edge of the Nasca *pampa* have been used by the Nazca project of HTW Dresden (Teichert, Richter 2001, Teichert, Richter 2003). In the framework of the second phase of the Nasca-Palpa project, the Nasca image series is now being analyzed at IGP in order to map the Nasca geoglyphs as well. That work will be reported on in a later study, but see Sauerbier 2004 for some preliminary results.

and the town of Palpa, too (Figure 5.2). Thus, although not intended from the start, the photos of both blocks actually overlap slightly in the central part of the flown area (approx. 20% decreasing in northeasterly direction), which was very advantageous during analysis since it allowed to merge the two blocks into one (Sauerbier, Lambers 2003). All in all, the black and white aerial images taken in 1998 cover a roughly rectangular, SW-NO oriented area of approx. 89 km^2 around the town of Palpa (Map 1). The average image scale, intended to be 1 : 5 000, turned out to be approximately 1 : 7 000, which was still good enough for our purposes. Unlike the color photographs, the contrast of the black and white images allowed to discern even narrow lines, and the image quality was generally good. Thus, it was decided to use the 1998 images for analysis.

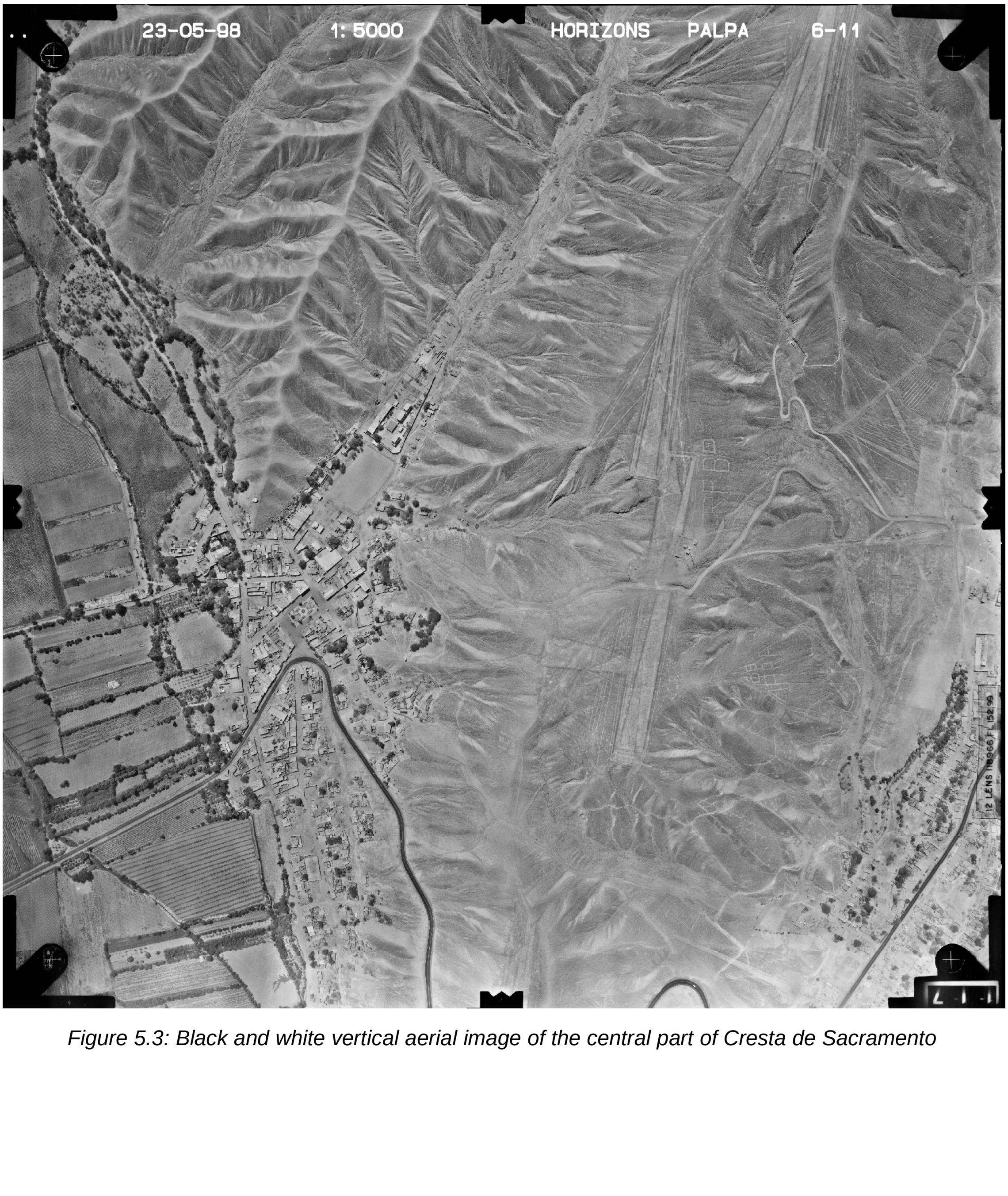

Figure 5.3: Black and white vertical aerial image of the central part of Cresta de Sacramento

5.3 GPS Measurements

In order to obtain control data to orient the images spatially, GPS was used in two different modes. In 1997, when the block over Cresta de Sacramento was flown for the first time, nine signalized ground control points were evenly distributed over the terrain whose position had been determined with differential GPS (Grün, Brossard 1998; Grün et al. 2000a; Grün, Lambers 2003). Furthermore, kinematic GPS measurements were performed onboard the plane that could serve as approximations for the positioning of the projective centers (Figure 5.2). In 1998, when both blocks were flown, kinematic GPS could not be used, and the signalized points in the Sacramento block were no longer available. The latter problem could be solved by performing a joint bundle adjustment of both the 1997 color images and the 1998 black and white images of the first block (see below). In the second block over San Ignacio and Llipata, however, no ground control points had been prepared. Therefore, in 1999 nine natural points – *i.e.*, points clearly discernible in the aerial images without having been marked on the ground – were measured in the San Ignacio block, again using differential GPS (Grün et al. 2000a; Grün, Beutner 2001). That way, solid GPS control data for both blocks was available for image orientation.

All GPS coordinates were transformed to UTM zone 18 S projection, which is the basis for the topographical maps of the area elaborated by IGN. It should be noted here that during fieldwork, a horizontal shift of several hundred meters was detected between the UTM coordinates obtained by GPS measurements and those taken from available maps. This was due to the fact that the topographic maps used in the first field campaigns (scale: 1 : 50 000 and 1 : 100 000, respectively) referred to the PSD 56 (Provisional South American Datum 1956, based on International Ellipsoid 1924), while in the GPS measurements, WGS 84 (World Geodetic System 1984) provided both ellipsoid and datum. A later comparison showed that current versions of the same IGN maps refer to WGS 84, too, so that the shift between GPS coordinates and map coordinates is now eliminated.

5.4 Aerotriangulation

The first step in image processing was the orientation of images relative to each other. For this purpose, five to ten tie points clearly identifiable in the overlapping area of two adjoining images had to be measured. Image matching is nowadays usually performed in an automated mode. However, the Palpa aerial images show largely the desert surface, which is very homogeneous in texture and provides little contrast. As several tests showed, matching algorithms implemented on different commercial systems failed to produce acceptable results due to this lack of texture (Grün et al. 2000b; cp. Sauerbier 2004 for up-to-date results). Thus, the measurement of tie points had to be done manually on the analytical plotters Wild AC3 and S9 available at IGP (Figure 5.4). In the Sacramento block, not only tie points to link images within the black and white series had to be measured, but also tie points to link the black and white images to the color images in which the signalized ground control points, whose position had been determined by GPS, were visible. 211 images (134 black and white and 77 color images) were triangulated in the Sacramento block. In the San Ignacio block, tie points and natural ground control points were measured within the black and white image series. Here, 168 out of 215 images were triangulated. The lower number of images used for triangulation as compared to the existing images is due to the fact that on the block margins, mountainous areas without geoglyphs were omitted for the sake of efficiency.

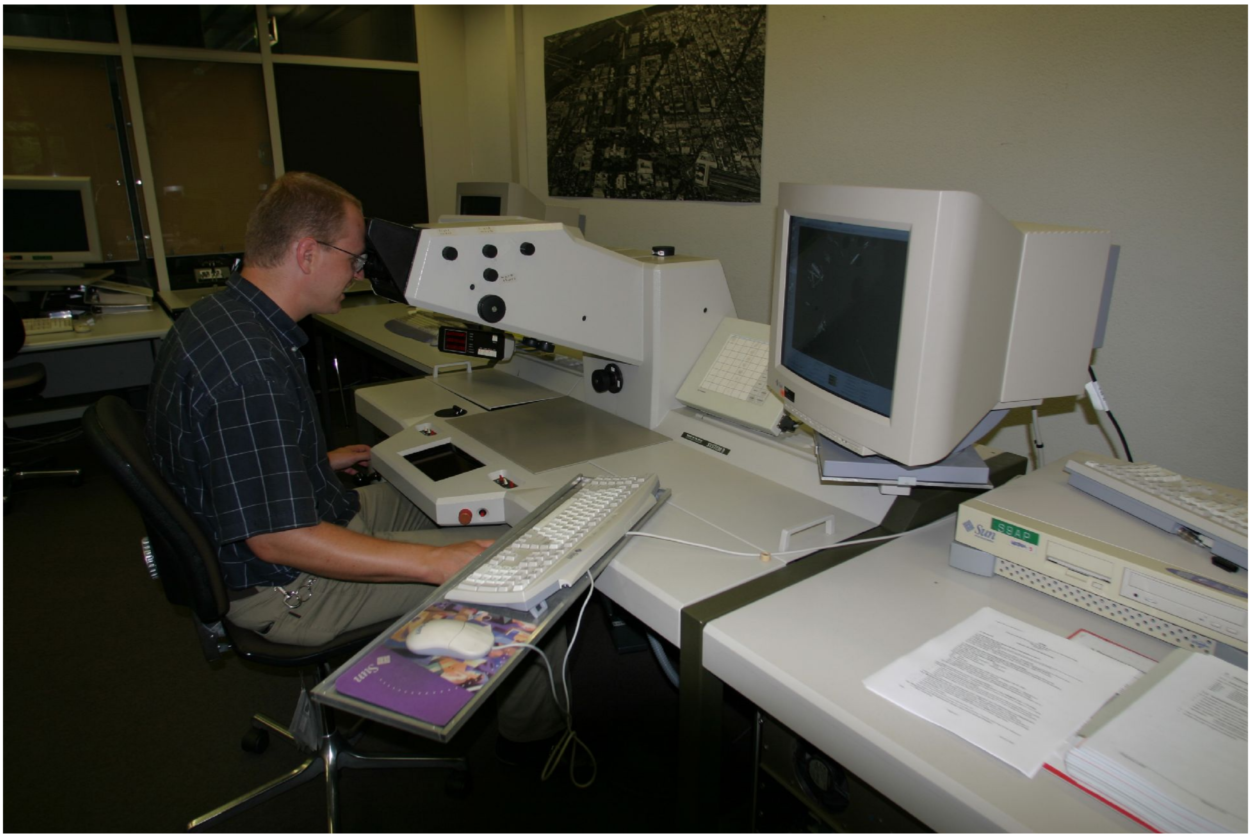

Figure 5.4: Photogrammetric measurements in stereopairs of Palpa aerial images at the analytical plotter Wild S9 at IGP

5.5 Bundle adjustment and image orientation

Once all images had been tied together via tie points and linked to the ground control points, a joint bundle adjustment for each block was performed using BUN, an inhouse software developed at IGP. The orientation of each image with respect to each other image and UTM coordinates for each image point were calculated. As a result, all images were provided with orientations relative to each other and absolute in the UTM zone 18 S coordinate system. Table 4 summarizes the triangulation characteristics of both blocks.

Block	*Images used*	*Control points*	*Kinematic GPS*	σ_0 (μm)	≅ *Ground accuracy (cm)*
Sacramento	134 b/w and 77 color	8 signalized	yes	13.3	9.3
San Ignacio	168 b/w	9 natural	no	9.5	6.7

Table 4: Triangulation characteristics of the two image blocks over the Palpa area

The achieved ground accuracy was good enough for the intended purpose. As a result of the bundle adjustment, oriented images were obtained that could then be used in pairs of two neighboring, overlapping images (so-called stereopairs or models) for 3D measurements.

5.6 DTM Generation

As a prerequisite for the intended geoglyph study, a highly accurate DTM (digital terrain model, *i.e.* a geometric model of the topography) was needed before the recording of archaeological objects could start. The matching problems described above meant that automatic DTM generation was not feasible. Therefore, the measurements were undertaken again on analytical plotters. The manual measurement offered the advantage that a very good DTM, describing the actual terrain, could be measured, while automated measurements would have led to a DSM (digital surface model), describing the surface including buildings, trees, etc. with lower accuracy. The terrain was measured in the stereopairs. 72 models from the Sacramento block and 94 models from the San Ignacio block were used for these measurements. Points were obtained along parallel profiles that had a distance of 20 m from each other. Along these profiles, the distances between measured points depended on terrain shape: in flat areas, less points were measured than in mountainous terrain. Special attention was paid to zones with geoglyphs. In addition to profiles, breaklines were measured along abrupt changes in the terrain. Unlike the profiles, the breaklines were measured as continuous vectors, whereas points measured along profiles were treated as isolated points not connected to each other. In the first iteration, only the actual terrain surface was measured. Later on, points measured during vector extraction (described below) were added in order to enhance point density especially in areas with geoglyphs. All in all, approximately 1.4 million points were measured in an area of roughly 89 km^2, corresponding to an average density of 1.6 points/100 m^2. Based on this data, a regular grid DTM was calculated with a grid spacing of 2 m. This was done in two iterations: firstly, a preliminary DTM was generated based on the corresponding measurements alone. After the revision of the resulting maps in the field (see below), the digital dataset was corrected, so that the final DTM could be produced (Figure 5.5).

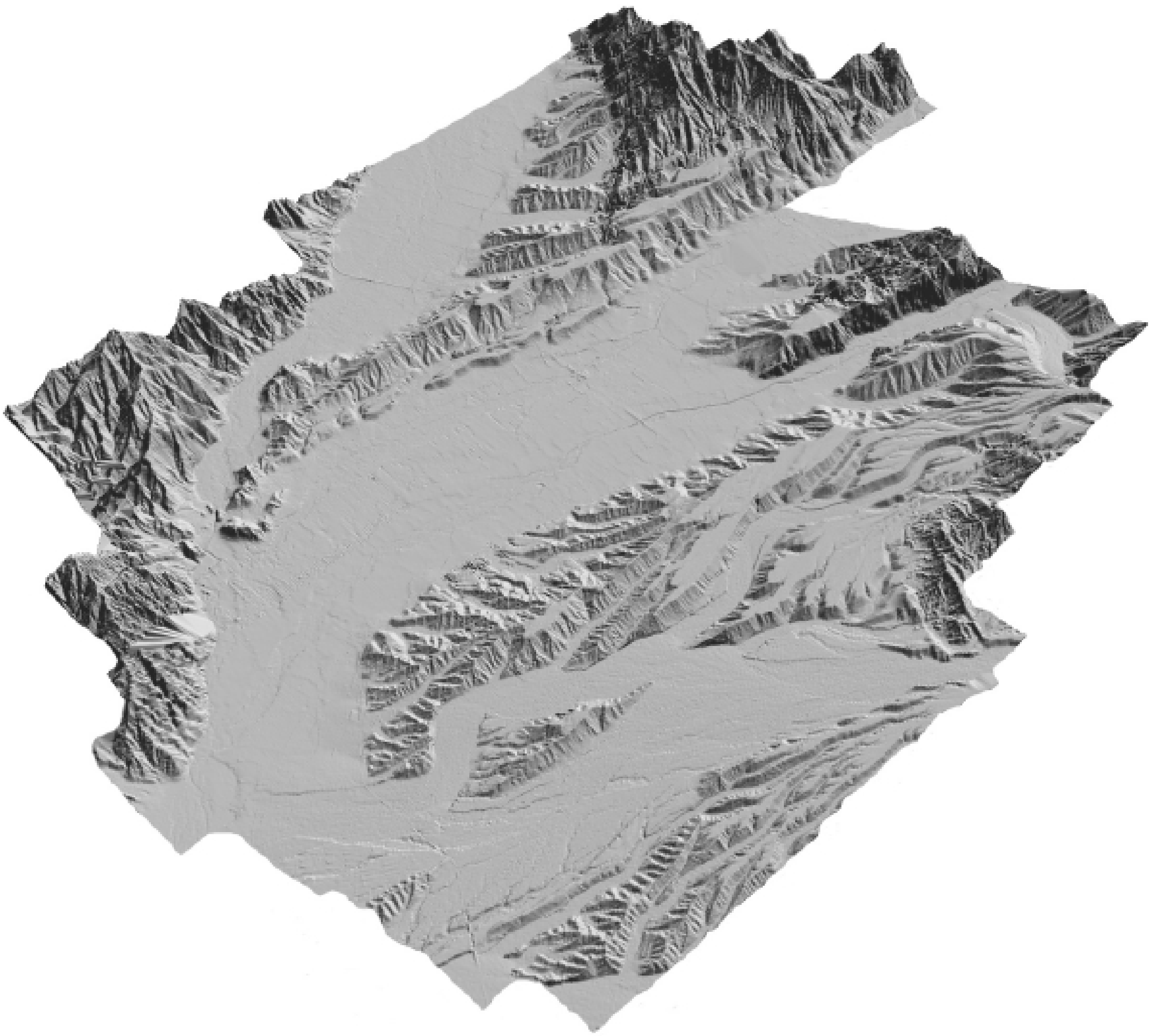

Figure 5.5: Digital terrain model (DTM) of the study area as shaded relief

The DTM was generated using DTMZ, another inhouse software that performs Delauney triangulation and bicubic finite element interpolation. Neighboring points were connected by edges of triangles, resulting in an approximation of the actual shape of the terrain surface. The breaklines were not bridged in the triangulation process to ensure that abrupt changes in the terrain were reproduced correctly in the DTM. Originally, two separate DTM blocks were generated that corresponded to the two original image blocks (Sacramento and San Ignacio, resp.). Since the blocks overlapped slightly, they could later on be merged into a single, continuous DTM. The file size is approx. 480 MB in ASCII xyz-format. The wireframe model can be used as a base for 3D modeling. Various byproducts, like shaded reliefs or contour maps, can be derived from the wireframe model.

5.7 Scanning of images

Parallel to the analysis of the stereopairs, the analog images acquired during the photo flight were scanned at high resolution in order to create an easily accessible photographic record of all geoglyphs and to produce an orthoimage as texture for the DTM. To enable the latter, the scanning had to be done on calibrated photogrammetric scanners that allowed high resolution scans with high geometric fidelity. The images of the Sacramento block were scanned at a resolution of 21 μm pixelsize on the Agfa Horizon image scanner at IGP (Figure 5.3). The images of the San Ignacio block were scanned at the same resolution on the Zeiss SKAI scanner at the Swiss Federal Office of Topography (Swisstopo, Wabern). The resolution corresponds to a footprint of 15 cm on the ground, which ensured that even the most narrow lines were still visible. Like in the DTM measurements, marginal images showing only mountainous areas were omitted for the sake of efficiency. The images were stored in TIFF format, the overall file size being about 2.15 Gbyte.

5.8 Orthophoto generation

The scanned images could be oriented based on the bundle adjustment. With the DTM as geometric reference, they were combined into an orthomosaic using Socet Set on the Leica/Helawa DPW (digital photogrammetric workstation) 770. The mosaic contains the rectified scanned images, *i.e.* images corrected so as to omit relief displacements caused by the central perspective of the original images, with smooth transitions between adjacent images. The result is a complete picture of the whole area covered by aerial images, with each pixel provided with coordinates (Map 2). Like the DTM, the orthophoto was initially generated in two parts corresponding to the two original image blocks. Later, when all necessary data had become available, a complete orthophoto was generated that covered the whole area of investigation. According to different requirements, several orthomosaics with a resolution ranging from 25 cm to 2 m pixelsize were generated.

5.9 Vector extraction

Once the DTM had been generated, the actual feature extraction, *i.e.* the 3D mapping of the geoglyphs, could begin. This was done once again on analytical plotters using the XMAP software by Aviosoft. In each oriented stereopair, outlines of visible geoglyphs were marked with 3D vectors that could be digitally stored. Only actually preserved, or securely deducible, borders of geoglyphs were mapped. Like the DTM, after a first iteration the vector data was revised in the field (see below) and then corrected and complemented in a second iteration. That way, 33 243 3D vectors, corresponding to roughly 1 500 geoglyphs, were produced. As these numbers show, a peculiarity of this dataset is that in virtually no instance a given vector represents the entire outline of a single geoglyph; rather, it usually shows only a small part of its border (Sauerbier, Lambers 2004). This is due to the state of preservation of the geoglyphs: many borders are interrupted where erosion had washed them away or where geoglyphs had been partially covered by other geoglyphs or footpaths. Furthermore, many geoglyphs do not have clearly defined borders on all their sides even if they are well preserved. For example, many trapezoids have an open narrow end without a clear margin. Thus, the result of the vector extraction was a huge number of unconnected 3D vectors. Based on this data, a vector layer was generated that could be exported into DXF format for further processing. The file size of the vector layer is about 20 MB.

In a separate step, all modern elements visible in the stereopairs were mapped, too, in order to allow easier orientation. This was done in a generalizing way, since the focus of the project was on the geoglyphs. The outlines of modern buildings, roads, etc. were marked and stored in a separate dataset. This dataset needed not to be revised in the field, since all modern elements were clearly visible in the stereopairs and did not constitute the focus of our investigation. The DXF file containing the modern elements has a size of about 9 MB.

5.10 Map revision and geoglyph definition

As indicated above, maps resulting from image analysis were revised in the field in order to improve their quality. The digital datasets were then revised accordingly. Map revision was accomplished during the field campaigns. Due to the photogrammetric mapping, prior to archaeological fieldwork it was already roughly clear what to expect in the field. Reliable, if preliminary maps were available, and no surveying work had to be undertaken. Rather, in contrast to previous projects, the limited available time during field campaigns could be dedicated to the actual archaeological recording of the geoglyphs.

Archaeological fieldwork started in 2000 and lasted eight months distributed over three field campaigns. Out of the approx. 1 500 geoglyphs that had been mapped with photogrammetric means, all 639 geoglyphs located on Cresta de Sacramento, Cerro Carapo, and the area around La Muña on the right bank of Río Grande were recorded.[12] These are the geoglyphs considered in the present study. Due to time constraints, only a small fraction of the San Ignacio and Llipata geoglyphs (226 geoglyphs on five sites) could furthermore be recorded, which is why their overall number cannot be given here. On some additional sites of that zone, among them the densest concentration of geoglyphs on the first plateau above the Viscas valley, at least the map could be corrected. The remaining majority of geoglyphs of San Ignacio and Llipata, however, was mapped by photogrammetric means alone. Although this procedure was not as reliable as the combined one employed on Cresta de Sacramento and Cerro Carapo, the San Ignacio and Llipata geoglyph maps can still be considered comparatively reliable since the geoglyphs are better preserved in that area, and their mapping was undertaken after considerable experience concerning geoglyph shape and preservation had been gained during the first field campaigns.

Fieldwork required the elaboration of paper maps based on digital data. In order to produce them, different datasets were combined. Contour lines with an equidistance of 10 m were derived from the DTM and shown as background of the geoglyph outlines. Furthermore, modern elements were added to allow easier orientation in the field. The datasets were combined in ArcView 3.2 and complemented with a coordinate frame. Using the layout tool, paper maps in A3 format could easily be layouted and printed in any desired scale.

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12 Geoglyphs 1 – 646, out of which numbers 246, 285, 362, 374, 420, 461 and 511 were not assigned to geoglyphs due to technical reasons. Different geoglyph numbers given in preliminary reports are due to geoglyph renumbering in the course of analysis, during which several geoglyphs originally recorded separately in the field were combined and others omitted.

The fieldwork allowed to detect some minor errors in the DTM, but the main focus was on the revision of the vector dataset. Maps at scales ranging from 1 : 1 000 to 1 : 100 were taken into the field. Each geoglyph was located with the aid of these maps. Since the maps showed only disconnected sections of borders, vectors belonging together as part of a single geoglyph had first to be determined. Once the context was established, each geoglyph was assigned a consecutive ID that allowed its unambiguous identification. This number was marked in pencil on the paper maps. Each geoglyph was then walked over in order to determine if the mapping was correct. Although many details had been visible in the stereopairs during the mapping process, there was still more to be seen on the ground. Badly preserved parts of geoglyphs, like eroded edges, sections covered by other geoglyphs or modern features, or geoglyphs on sandy terrain were usually better discernible on the ground. Furthermore, footpaths or erosion gullies erroneously identified as geoglyphs in the photos could be distinguished from actual geoglyphs in the field. Thus, additional information was obtained that could be used to improve the quality and reliability of the maps. The maps were revised accordingly, and corrections and completions were marked on them in pencil (Figure 5.6).

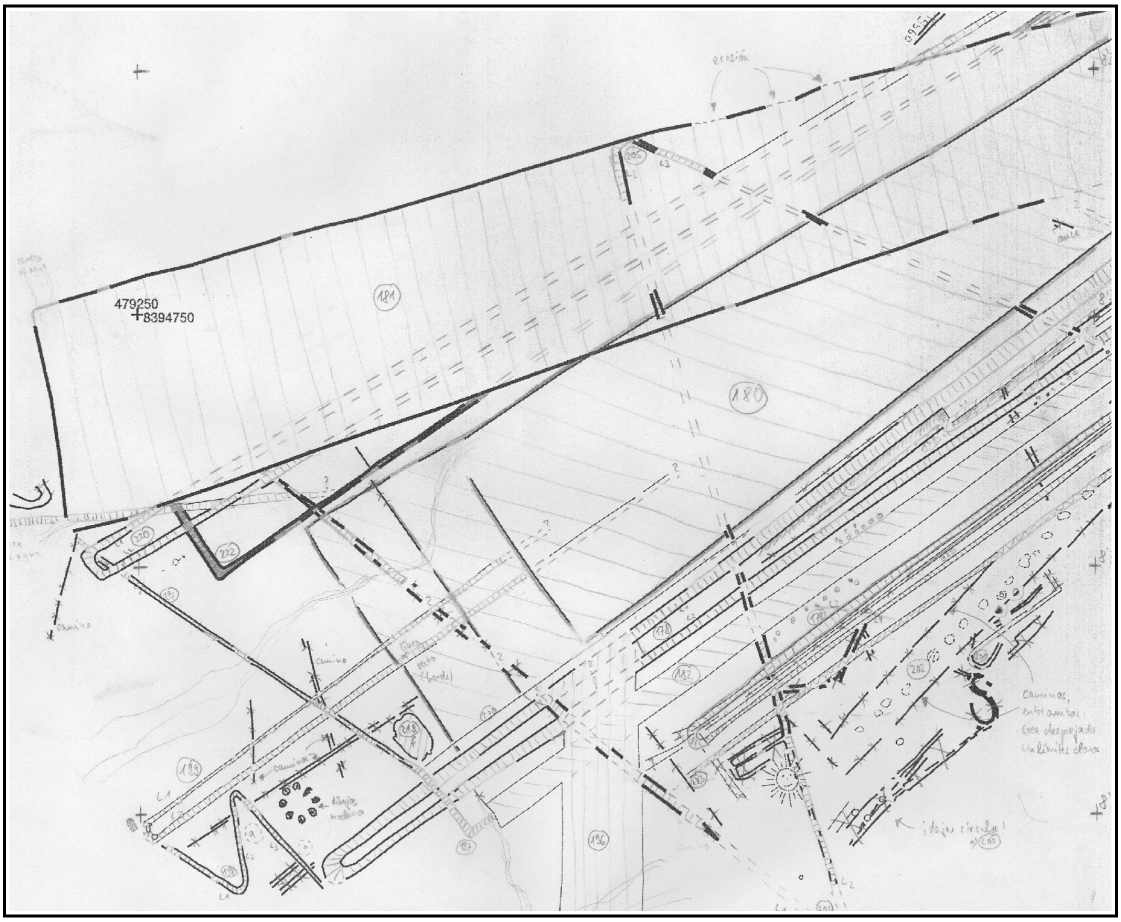

Figure 5.6: Preliminary map of the southwestern portion of site PV67A-47 corrected during fieldwork

Once the paper maps had been revised, they were taken back to the analytical plotter. Reviewing the stereopairs a second time, incorrect 3D vectors were deleted and missing 3D vectors added. Although the corrected parts had not been detected during the first analysis of the stereopairs, missing or incorrectly interpreted sections of geoglyphs could in most cases easily be discerned in the images once it was clear from observations made in the field what was to be looked for, and where. The quality of the 3D recording could that way be enhanced considerably. The revision of maps provided a good starting point for the following geoglyph description. On the *pampas* of San Ignacio and Llipata, the revision of the preliminary maps constituted the main activity, since only a small part of the geoglyphs was registered archaeologically due to time constraints.

5.11 Geoglyph description

The description of each mapped and defined geoglyph absorbed most of the time during fieldwork. The geoglyph ID was marked on a feature sheet. Each geoglyph was described in detail on such a sheet whose standardized categories helped registering all geoglyphs in a comparable way. Categories that had to be filled out included description of the geoglyph itself, its surroundings, orientation, size, shape, stratigraphy, associated cultural remains, state of preservation, etc. Of course, not all categories applied in all cases. If necessary, textual descriptions were complemented by sketches. The feature sheet was designed so as to structure the data as far as possible in order to allow its import into a database and its analysis using queries. However, the category “general description” also allowed a comprehensive textual description of the geoglyph in cases where the structured categories could not cover all aspects. Once the geoglyphs had been recorded in the field, the descriptive data was fed into a preliminary MS Access 2000 database which allowed easy data management during the field campaigns.[13] Each record followed the structure of the feature sheets. For some categories, predefined pop-down menus allowed only a limited selection of values. Thus, the data format was as standardized as possible.

13 Since a good part of the data was obtained and processed by Spanish speaking team members, and Spanish was the working language during field campaigns, all records were kept in that language. José Palomino (Los Molinos) and Alejandra Figueroa (Lima) entered most of the data. The whole database was then revised by Alejandra Figueroa to correct language errors, and by the author, to correct content errors. After fieldwork, the corrected datasets were integrated into the definitive Oracle database along with additional data (see chapters 5.14 and 5.15). An extract of this data complemented by additional information obtained during data analysis is available as MDB file on the DVD that accompanies this study.

During recording, finds on or close to geoglyphs were surveyed and classified. A typical find inventory mainly consisted of potsherds, while lithics, textiles, and bones constituted considerably smaller parts of the whole repertoire. General remarks on the nature, composition, cultural affiliation, and location of the finds on each geoglyph were noted on the feature sheet. Unfortunately it was not possible to sample finds systematically. On the one hand, the available time and manpower was too limited to pursue such an approach. On the other hand, the permits issued by INC differed for each field campaign, so that fieldwork had to be carried out under different legal conditions. For example, in the first field campaign in 2000 it was not permitted to collect finds, so that they could only be registered and described recapitulatorily. Fortunately, even for geoglyphs recorded in that campaign limited samples were available, since they had been recorded before on the site level in the course of the 1997 prospection, when the INC permit had included the right to collect finds (Reindel et al. 1999). However, since in the site survey the focus had been on datable materials, fineware ceramics are overrepresented in that sample. In the second and third field campaign we were permitted to collect finds, but did so only to a limited degree due to time constraints. However, we tried to collect samples from the most important geoglyphs that were representative not only with respect to the fineware ceramics, but also to undecorated pots.

The extensive fieldwork to register the Palpa geoglyphs could be dedicated exclusively to describe the geoglyphs in detail. No measurements had to be undertaken. The same is true for photos: since the aerial images already constitute a complete photographic record of all geoglyphs, only a few photos were taken in the field in order to show ground views of typical geoglyphs of different types.

5.12 Object layer generation

After the revision of geoglyph vectors, these still represented only the preserved or securely deducible borders of geoglyphs, yet not the geoglyphs themselves. Thus, the next step was to digitally combine vectors marking the outline of each of the geoglyphs defined during fieldwork into a closed polygon that represented the most likely original shape of that geoglyph, as far as it could be reconstructed on the basis of photos and field data. The goal was to create digital 3D objects that represented the geoglyphs and could therefore be linked with the corresponding description. In a first step it was tried to convert the vectors into polygons in ArcView 3.2 (Sauerbier, Lambers 2004). However, this procedure did not yield satisfactory results. The task could better be accomplished in ArcMap, a module of ArcGIS 8.3. Here, the revised vector layer was displayed with a high resolution orthoimage in the background. Based on what was visible in the orthoimage and what was known about the geoglyphs from fieldwork, existing vectors were connected and complemented in such a way that the most likely original outline of the geoglyph was marked by a continuous line. Using the topology tools available in ArcMap, polygons could then be automatically generated from these polylines. The resulting polygons, however, still did not represent specific geoglyphs for various reasons:

- during automatic calculation, all possible polygons were calculated, *i.e.* not only those pertaining to actual geoglyphs, but also unaltered areas completely surrounded by geoglyphs;
- in all cases where geoglyphs overlapped, each polygon represented only a part of a given geoglyph or, in other words, each geoglyph consisted of several (often many) polygons;
- for the same reason, some polygons pertained to several geoglyphs at the same time. Where one geoglyph crossed another one, the overlapping area corresponded to both geoglyphs.

In order to define which polygon pertained to which geoglyph, each polygon was assigned the corresponding geoglyph IDs adopted from the feature sheets. This part of the work had to be done manually. Where geoglyphs overlapped, the corresponding polygons were assigned two (or even more) geoglyph numbers. Finally, all redundant polygons, *i.e.* polygons not belonging to any geoglyph, could be automatically deleted. The result was a data layer with polygons clearly identifiable as pertaining to specific geoglyphs (Figure 5.7).

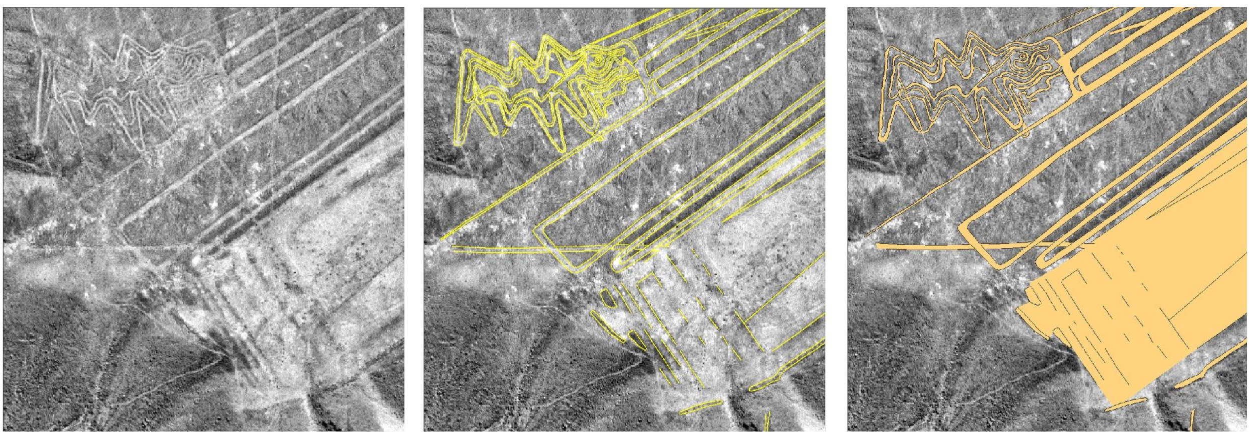

Figure 5.7: Photogrammetric geoglyph mapping: geoglyphs as visible in aerial images (left), vectors marking geoglyph outlines (center), polygons representing geoglyphs as defined from vectors (right)

The process of object definition was accomplished in ArcMap. The 3D vector layer in DXF format was converted into a 2D shapefile. The newly generated polygons were stored in a separate 2D shapefile (file size: 2 MB). By intersecting them with the DTM, the height dimension was added to the polygons. Since vectors and polygons are stored in different layers, the geoglyphs can be visualized (on maps or on-screen) in such a way that the provenience of the data is always transparent. The areal polygons, depicted for example as shaded in gray, represent the most likely original shape of the geoglyphs as far as it could be reconstructed based on available information from aerial images and field data. The lineal vectors, on the other hand, displayed for example as black lines on the shaded polygons, represent the preserved or securely deducible border sections of the geoglyphs, *i.e.* the actual information on which the reconstructed geoglyphs are based.

5.13 3D Modeling

One aim of the documentation of the Palpa geoglyphs was to produce a highly accurate and detailed virtual 3D model of the geoglyphs and their environment that would allow to navigate through it in real-time and in which each geoglyph would be shown as 3D object. Four different elements were used to generate the 3D model:

- the DTM showing the topography of the area around Palpa,
- the orthomosaic as photorealistic texture showing the environment,
- the vector layer showing the preserved outlines of the geoglyphs, and/or
- the polygon layer showing the most likely original shape of the geoglyphs.

The actual modeling process was accomplished using different commercial systems (*e.g.*, ERDAS Imagine Virtual GIS 8.4, Skylinesoft Terra Explorer 3.0, cp. chapter 5.17). The 3D model integrating the different layers (Figure 5.8) constitutes a complete, digital documentation not only of the geoglyphs, but also of their environment as of 1998, when the aerial images were taken.

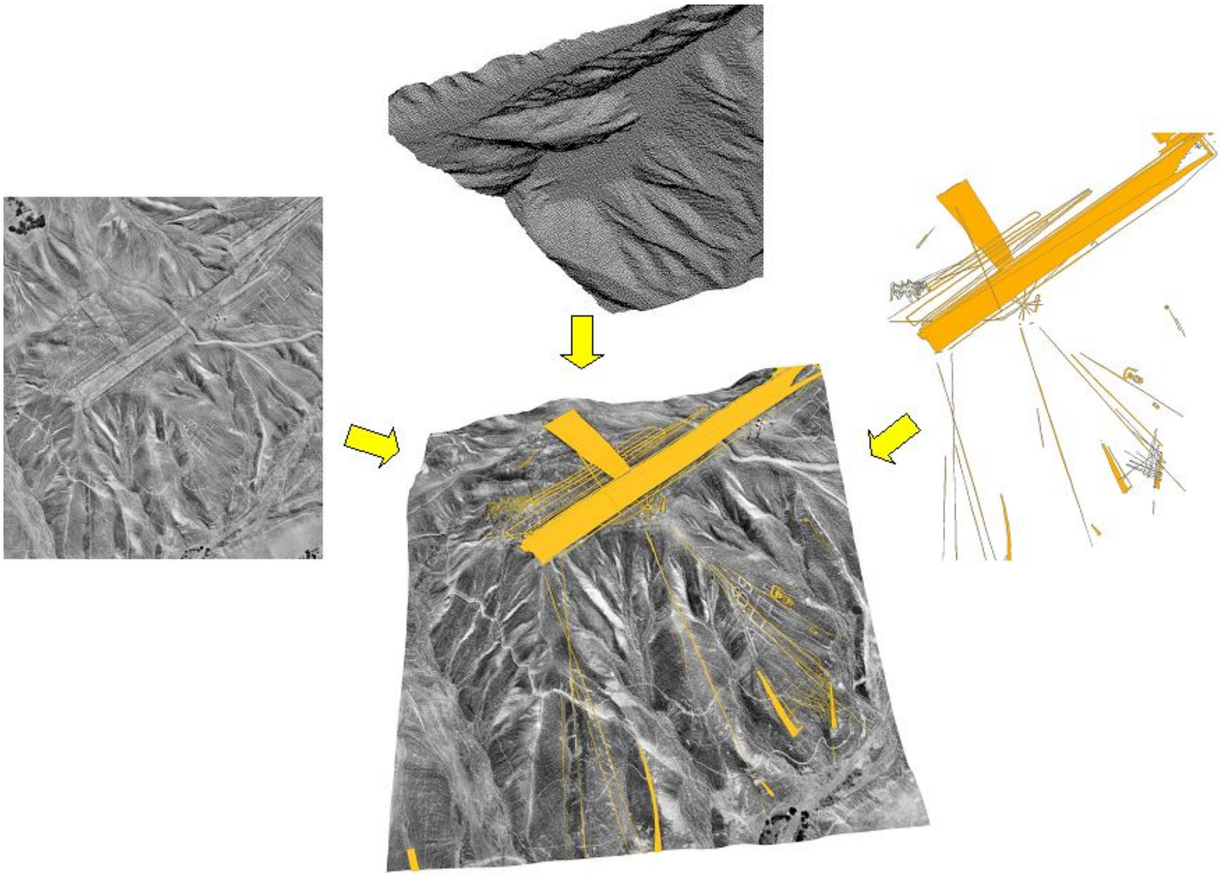

Figure 5.8: 3D model composed of DTM (upper center), orthoimage (left) and polygon layer (right)

5.14 Conceptual data modeling

Once the revised geoglyph descriptions and the object data layer representing the most likely original shape of the geoglyphs had become available, the first analytical step was the elaboration of a descriptive typology based on all recorded geoglyphs of Cresta de Sacramento, Cerro Carapo, and the area around La Muña. Formal criteria, described in detail in chapter 6.1.1, were used to sort geoglyphs sharing common attributes into hierarchical categories. In the process, it became clear that several geoglyphs originally defined separately in the field pertained to single geoglyphs. Therefore, while assigning each geoglyph to a type, they were renumbered at the same time with a super ID (as opposed to the original geoglyph ID).

Descriptive data resulting from archaeological recording of geoglyphs in the field had initially been stored in a preliminary, relational MS Access 2000 database. The final objective, however, was a more complex, object-relational database in which all data available for a given geoglyph – *i.e.* not only its textual description, but also its 3D geometry, images etc. – should be accessible via its super ID. This hybrid database was thought of as central data storage and management facility for all later work. It should allow data editing and retrieval from different platforms using standard procedures like SQL (structured query language), and its structure had to be flexible enough so as to allow the incorporation of additional data resulting from analyses of the original data. The database was furthermore to serve as core of the intended GIS. Due to its versatile capabilities, it was decided to implement an Oracle 9i database management system (DBMS).

In order to ensure a careful structuring of the database beforehand, a conceptual data model was developed using the object-oriented UML (unified modeling language[14]) (Lambers, Sauerbier 2003). The object-oriented approach allowed to structure all available data such that the real-world situation was reproduced in a simplified way, but as accurate as possible in the data model. Different types of data, *e.g.* spatial, textual, or image data, could be integrated into the model. Rational Rose 2002 was used for conceptual data modeling since it allows to graphically structure the data on-screen. Furthermore, the resulting class diagram could then be directly converted into the logical Oracle database. In the following, the principle elements of the class diagram of the Palpa geoglyphs as shown on Map 3 are briefly described.

The core of the class diagram is the supertype A_GEOGLYPHS around which all information is structured. The central part of the class box features a series of attributes potentially shared by all geoglyphs. All subtypes inherit these attributes yet may have additional ones. The lower part of the box usually contains methods associated with an object that could likewise be inherited. In our case, this option was not used. Each geoglyph is represented by a series of polygons stored as Oracle spatial data objects (SDO), here represented by the class G_SACRA_CARAPO_POLY1_2. The link between geoglyphs and polygons is established by the class G_GEOGL_CONNECT_GEOM2 that connects both classes via the attributes GEOGL_ID, identifying a geoglyph as primary key, and FID, identifying a polygon as primary key, respectively. The cardinalities “1” and “0..n” describe the fact that one polygon may pertain to more than one geoglyph. Each geoglyph may furthermore have a stratigraphic relationship with other geoglyphs, which is described by the class A_STRATIGRAPHY, the options being above, below, equal1 (equal) and equal2 (contemporary). The cardinalities are “0..1” on the A_GEOGLYPHS side, since not all geoglyphs are stratigraphically related to others, and “0..n” on the A_STRATIGRAPHY side, since a geoglyph may be superimposed by 0 up to n others.

The actual manifestations of the geoglyphs are represented by subtypes corresponding to the types defined in the descriptive typology (see chapter 6.1). Since the geoglyph typology is

14 UML™ by the Object Management Group, see UML resource page at www.uml.org (accessed July 9, 2004).

hierarchical in nature, it could easily be modeled in UML. Each geoglyph can be assigned to a subclass within this typological structure, so that the integrity constraints “disjoint; complete” were established.

Each geoglyph may have finds associated with it, here represented by the class A_OBJECTS. While this class contains attributes applicable for all kinds of finds, the different find categories are again modeled as subtypes with own attributes. The chronological classification of the geoglyphs is modeled as related to the find subtype A_CERAMICS since in fact only objects from this find category can be stylistically assigned to a time period. The subtypes representing chronological phases are hierarchically structured similar to the geoglyph typology. However, since datable ceramics were not found on all geoglyphs, whereas on others ceramics from different time periods were registered, the integrity constraints are less strict (“overlapping; incomplete”).

Further data not directly related to single geoglyphs but nevertheless stored in the database and used for analysis are here shown as unconnected classes. A_SITES contains data on all prehispanic settlements, cemeteries, and other sites obtained during the regional settlement pattern survey. R_DTMALL2_BR represents the DTM with a mesh size of 2 m, whereas the class R_IMAGEDATA stands for orthoimages, which are stored in Oracle raster format in the database. While metadata for the DTM is automatically generated during the import process, for photogrammetrically processed image data metadata like the attributes listed in R_IMAGE_METADATA have to be acquired separately.

Thus, the conceptual data model developed using UML proved to be an efficient way to ensure a useful data structure as well as data integrity. It is furthermore a helpful tool to visualize relationships and interdependencies between different kinds of data.

5.15 Database implementation

The conceptual data model was converted into a logical database using an object-relational Oracle 9i DBMS that should also serve as basis of the intended GIS. Since ArcGIS 8.3 was chosen as GIS tool, the link to the database could be established using ArcSDE, ESRI’s server application that allows to connect ArcGIS to different DBMS. The object-oriented data structure based on the conceptual data model was implemented in an object-relational tablespace using SQL data definition language (DDL). The archaeological data was then stored into the defined tables by first importing the MS Access tables into Oracle 9i and then distributing the attribute data into the table structure accordingly. Similarly, tables containing additional data, like super ID, type etc. were integrated into the database. For the import of geometric data, the ArcGIS toolbox was used to generate Oracle spatial data objects from the 2D polygon shapefile as well as DTM (2.5D) and images in Oracle raster format. To establish the predefined relations between geometric and archaeological data, as well as for visual error checking, scripts were developed in Visual Basic for Applications (VBA) that allowed convenient data editing via the graphical user interface of ArcGIS.

5.16 Data analysis

The first analytical step, the elaboration of a descriptive typology that allowed an initial sorting and easy handling of the geoglyphs and served as basis for their definitive numbering, had already been accomplished in the process of data modeling. Once the structured data was accessible in the Oracle DBMS, it could then be analyzed in different ways:

- Using scripts developed in Visual Basic, additional information on the geoglyphs was generated from their geometry, *e.g.* by calculating their surface area and orientation. The results were stored in the database.
- Using SQL, the database was queried for specific information. That way, quantitative data on the distribution of geoglyph types and datable ceramics on geoglyphs became available and could be graphically displayed in charts.
- Using tools for spatial analysis available in ArcGIS 8.3, geoglyph data and terrain data were related and analyzed. Distribution maps of geoglyphs and contemporary sites were produced for different time periods in order to study the development of geoglyph sites on a regional scale through time. Analyzing the topography of the terrain in which the geoglyphs are located, their accessibility, visibility, and orientation were investigated and displayed on maps.

The specific analyses as well as their archaeological results are described in detail in chapter 6.

5.17 Visualization of results

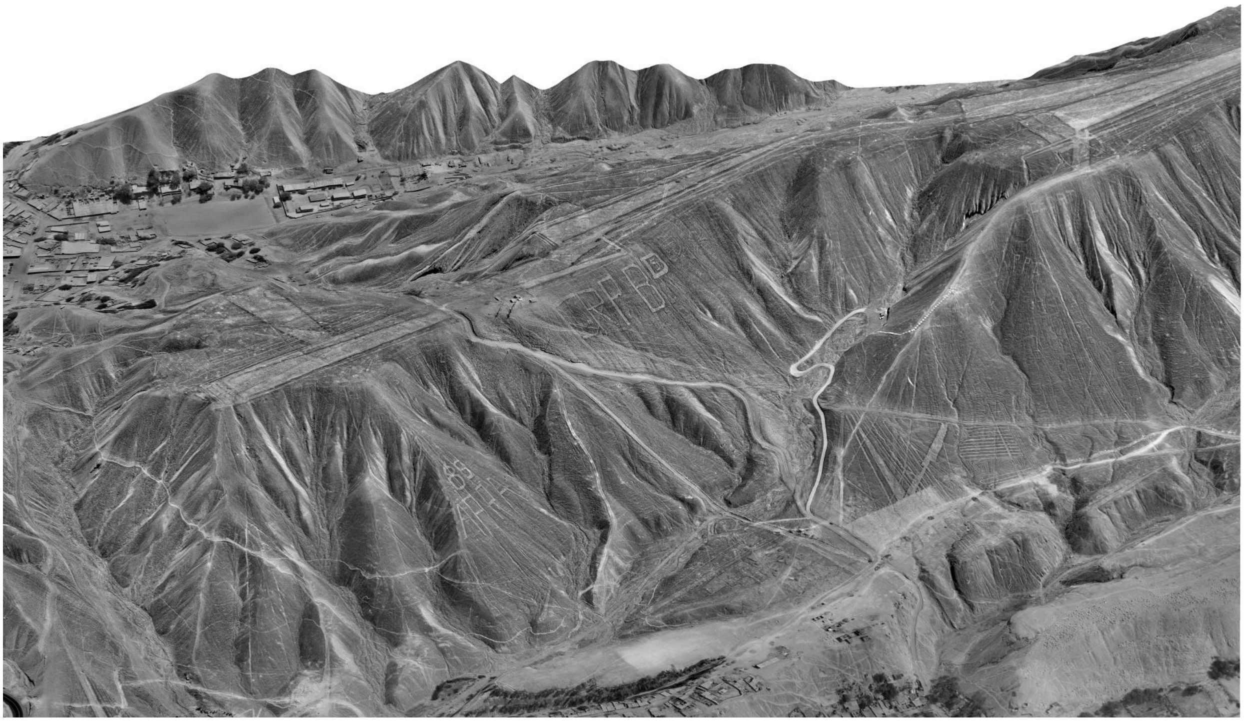

Figure 5.9: Virtual view of the central part of Cresta de Sacramento generated using ERDAS Imagine Virtual GIS 8.4

This step in the workflow comprised on the one hand the visualization of the 3D model composed of the layers mentioned above, and on the other hand the illustration of results of analyses.

The virtual 3D model of the Palpa region has been visualized, either completely or in parts, in different ways: virtual 3D views (either static or dynamic), 2D paper maps, and finally a physical 3D model. 3D views and paper maps were furthermore used to show results of data queries and other analyses.

The most advantageous way of visualizing a 3D model is the generation of virtual, on-screen views of it. A virtual 3D model allows to review the situation in every given part of the study region on-screen, *i.e.* in the office during analysis. A major constraint is the amount of data to be processed. In the case of the Palpa model, due to the large amount of phototexture about 2.7 GB of data had to be visualized. The aim was to achieve this on a common PC platform.

To generate synthetic still views of subsets of the 3D model in high resolution, mainly ERDAS Imagine Virtual GIS 8.4 by Leica Geosystems was employed (Figure 5.9, Figure 5.10). This software yields good results concerning the quality of the phototexture. The integration of vector and polygon layers is possible, but problematic. If they are integrated as 3D data, they do not coincide exactly with the interpolated DTM surface, which is why some sections of lines or areas might disappear. On the other hand, if they are integrated as 2D data and mapped onto the DTM surface, they are dissolved into the pixel structure of the texture surface. While polygons are displayed in acceptable quality this way, thin lines are usually blurred. Therefore, most synthetic views produced for the Palpa area contain the DTM and phototexture only. Furthermore, the capabilities of ERDAS Imagine Virtual GIS 8.4 are rather limited concerning the size of the dataset to be processed. On the other hand, it allows the generation of short fly-throughs and offers some basic GIS functionalities like viewshed analysis.

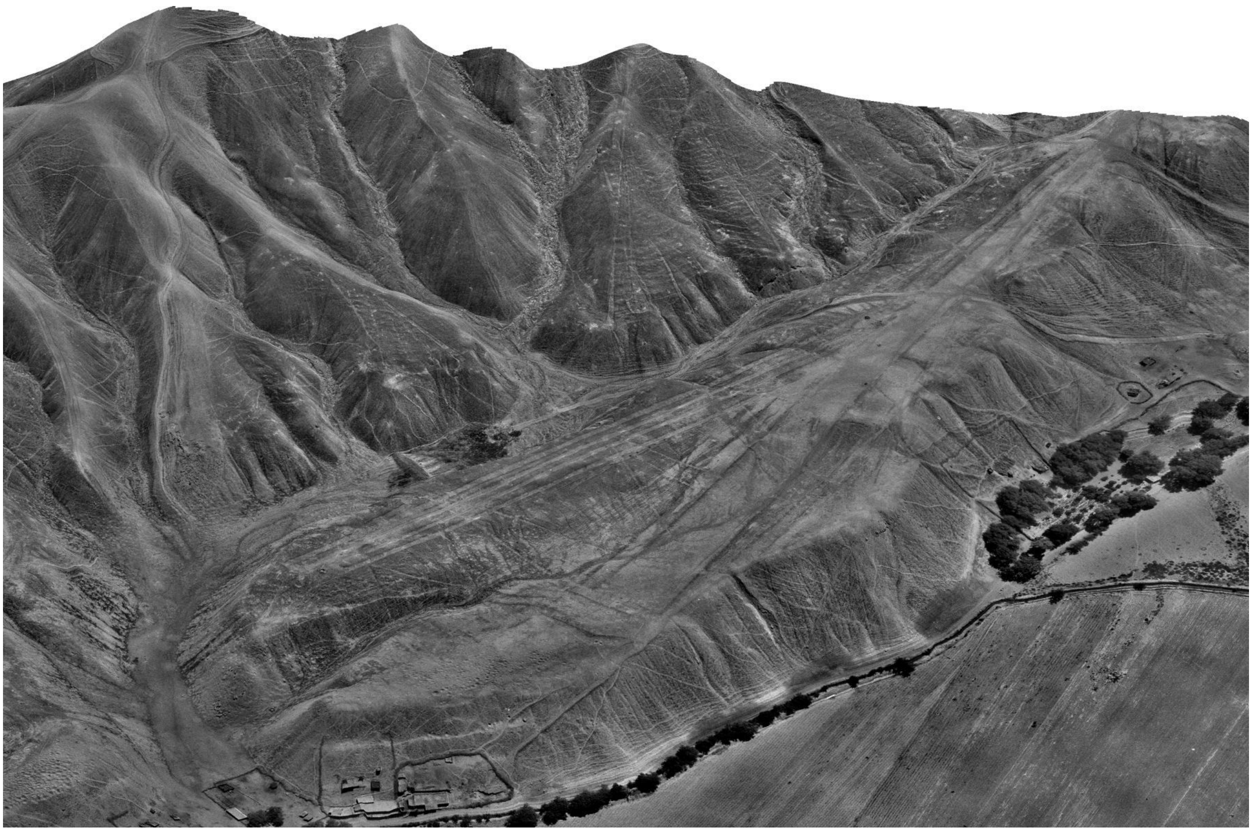

Figure 5.10: Virtual view of site PV67A-22 generated using ERDAS Imagine Virtual GIS 8.4

In order to visualize the Palpa 3D model in its entirety in real-time, *i.e.* allowing interactive navigation through the model, high-end visualization software with Level-of-Detail capability (LoD) was needed. LoD means that in every frame of an image sequence only the foreground portion (*i.e.*, close to the viewpoint) is shown at highest resolution, while the background is displayed at lower resolution. That way, the amount of computations necessary to render each frame is reduced considerably. A prerequisite for such an approach is the generation of data pyramids (vector and raster data) based on the input data. For the Palpa model, commercial software with LoD capability was used for real-time visualization.

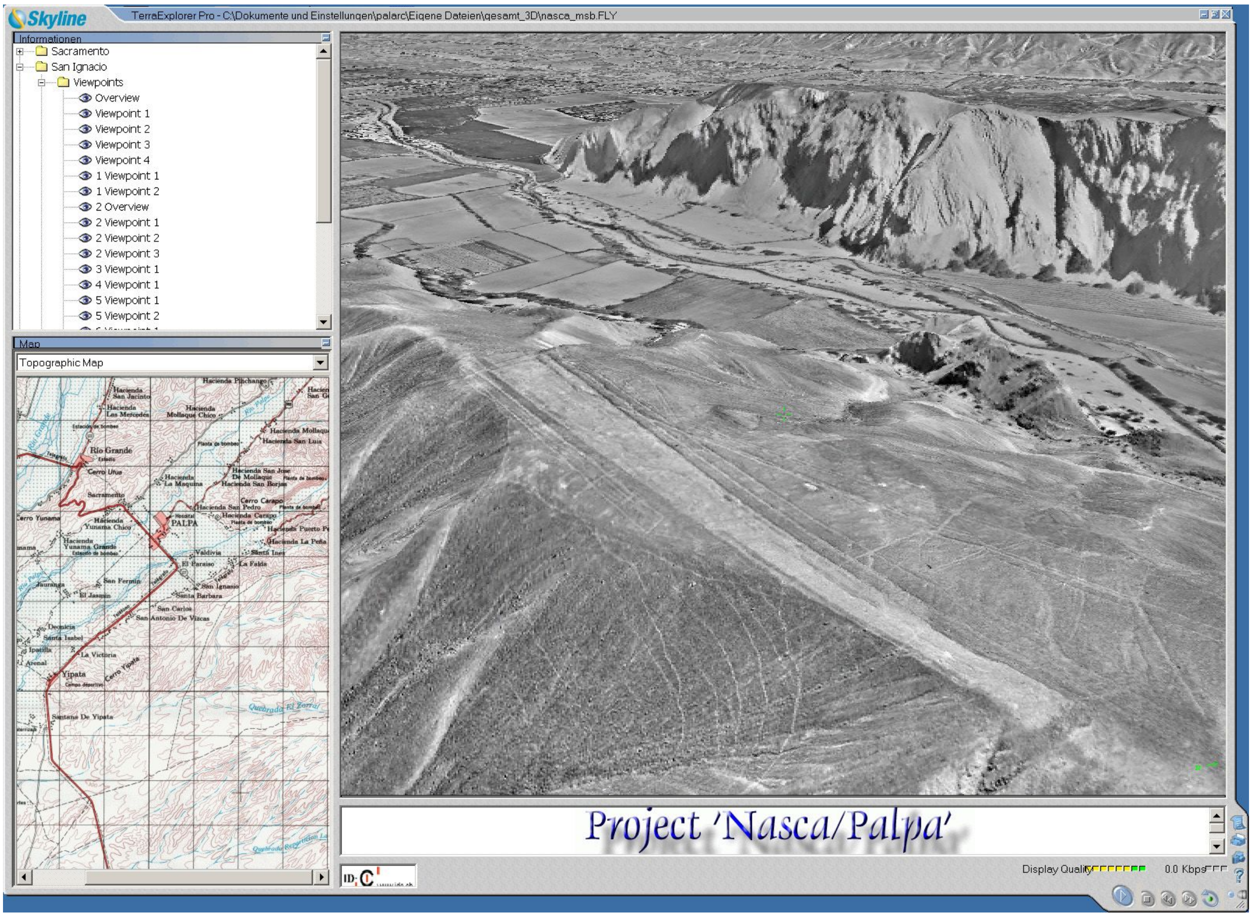

Figure 5.11: Terra Explorer user interface with a virtual view of Cerro Carapo as seen from east (upper right), predefined viewpoints (upper left), topographic map indicating location of viewer (lower left), and project website (lower right)

In Terra Explorer 3.0 by Skylinesoft (Figure 5.11) the hybrid input data (2.15 GB of phototexture plus DTM, vector, and polygon data) was compressed to a single file of roughly 600 MB. The model can be edited by the user, and additional data (predefined 3D objects, tabular data etc.) may be integrated. The user interface allows the lateral incorporation of further elements, like overview maps or the project website. Free navigation through the 3D model is possible via keyboard or joystick control. Fixed viewpoints can be defined and automatically approached, *e.g.* over certain geoglyphs. Flights through the model can be interactively defined and recorded to an export file, *e.g.* in AVI format. An example of a video produced this way is given on the DVD that accompanies this study. It features a virtual flight over the entire area around Palpa covered by the 3D model.

A problem concerning the Palpa model was that image resolution was not as good as input data would allow, and in recorded flights the limits of the area shown in highest resolution were clearly visible against areas displayed in lower resolution. Another major disadvantage was that objects from the vector layer were either blurred or not correctly mapped onto the surface due to the same issue described above for the ERDAS software. On the other hand, a pro of the Terra Explorer is that it allows to integrate self-defined objects into the model, *e.g.* in the Palpa case virtual posts like those found in excavations (see appendix 9.2.2). All in all, the Skyline software is a comfortable tool for interactively exploring the photorealistic 3D model, but with certain limitations. A viewer without editing functionality is freely available for download from the provider website (www.skylinesoft.com), so that the model can easily be distributed to potentially interested parties. The pros and cons of the Skyline software have been discussed in more detail elsewhere (Sauerbier, Lambers 2003).

Another way to visualize the 3D model is the generation of 2D paper maps derived from 3D data (see various examples throughout this study). Although maps clearly do not tap the full potential of the available data, the fact that reliable maps of the Palpa geoglyphs can be easily generated is a major step forward in Nasca archaeology. The Palpa data is available in digital form and organized in layers with different content. According to the required purpose, this allowed on the one hand free data scaling, and on the other hand the combination of different layers. While geoglyph layers (polygons and vectors) and the layer containing modern elements (roads, buildings etc.) can be shown largely unaltered on a map, the DTM may be replaced by a contour line layer derived from it (Map 1). The orthophoto layer may also be integrated into the map design (Map 2). Both ArcView 3.2 and ArcMap 8.3 offer user-friendly tools for easy map production. The combined layers were layouted and complemented with coordinate frames, legends, scale bars etc. Not only entire datasets, but also selections based on queries were generated using predefined map templates in order to ensure comparable results. That way, *e.g.* only geoglyphs of a certain type or time period could be automatically selected to be shown on the map. Labels, charts, symbols etc. were then added to explain the illustration. For printout, files were exported to standard raster or vector file formats, like EPS, TIFF etc. While maps used during fieldwork were produced in ArcView 3.2, all maps in the present study have been generated in ArcMap 8.3.

A less common way of visualizing the 3D model was the production of a physical model. For the newly established local archaeological museum in Palpa, a 3D model of Cresta de Sacramento was made using the modern casting facilities of the General Command of Mapping, Ankara, Turkey.[15] First, a mold was produced using an ASCII file containing the DTM data. In this mold, a plastic model (scale 1 : 4 000, vertical exaggeration 1.5) was then casted. The phototexture, derived from a Geo-TIFF file, was automatically applied to the model surface during the casting process. Due to the lengthy shape of Cresta de Sacramento, two separate blocks had to be casted, which could then be joined to form the complete model. Once the molds had been created, further casts could easily be produced. The Sacramento model now on display in a showcase in the entrance hall is hoped to become a major attraction of the Palpa museum.

All in all, different ways of visualizing the 3D model proved fruitful for different purposes. The production of 2D maps was important for fieldwork, but also for illustration of results and in the new Palpa museum, where the physical model is a further attraction. On-screen visualizations of the virtual model were not only used as tool for presentation, but also for research, since a detailed reconstruction of the study region was constantly available during analysis.

5.18 Summary: documentation of the Palpa geoglyphs

The combination of proven methods of archaeological fieldwork and analysis with photogrammetric and GIS techniques of data capture, processing, modeling, and visualization allowed for the first time the establishment of a comprehensive, digital database containing hybrid data on a large sample of geoglyphs. Products generated during the process include:

- DTMs of the Palpa area with up to 2 m mesh size,
- orthomosaics of the same area with a highest resolution of 25 cm on the ground,
- a hybrid database linking geometric representations of the geoglyphs with descriptive, structured attributes,
- a virtual, interactive 3D model of the Palpa region and the geoglyphs,
- geoglyph maps at different scales and with different content.

Figure 5.12 summarizes the project design including input data, data processing and analysis, and output results. It shows the integration and interdependence of archaeological and geomatic methods and the central role of the database and GIS for the joint management and analysis of both kinds of resulting data.

15 Prof. Orhan Altan, head of the Division of Photogrammetry of the Faculty of Civil Engineering at Istanbul Technical University, is warmly thanked for his help in this matter.

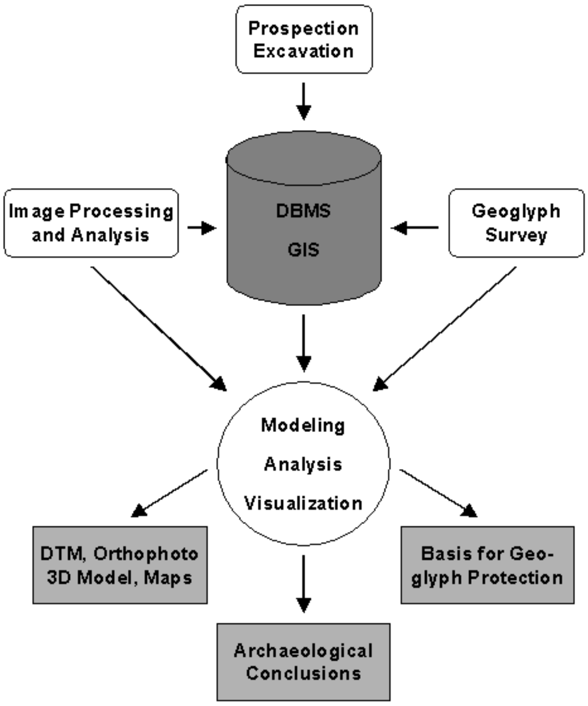

Figure 5.12: Project design

The available data on the Palpa geoglyphs resulting from this integrated approach is of unprecedented scope and detail in the context of Nasca archaeology. Its analysis, described in the following chapter, thus is an important qualitative step forward in geoglyph research. Furthermore, the digital archive of the Palpa geoglyphs can now serve as starting point for their protection and long-term preservation.[16]

16 After the conclusion of the present study, the Palpa geoglyph map was put at the disposal of INC Lima. It is planned to use the map to define in close cooperation with UNESCO an extension of the existing protected geoglyph zone on the Nasca *pampa* in order to include the Palpa geoglyphs.

6. Archaeological analysis of the Palpa geoglyphs

For reasons explained in chapter 5.10, all 639 geoglyphs of Cresta de Sacramento, Cerro Carapo, and the area around La Muña were considered for analysis, yet not the only partially documented geoglyphs on the *pampas* of San Ignacio and Llipata. Archaeological analysis was undertaken in four steps. Firstly, a descriptive typology was established in order to sort the geoglyphs into manageable categories that served as basic units during subsequent steps of analysis. Secondly, information on the chronology of the geoglyphs was compiled, since their dating was a prerequisite for any interpretation. Thirdly, activity on geoglyph sites as manifest in the archaeological record was identified. Fourthly, the spatial and contextual setting of the geoglyphs was investigated and tested for recurrent patterns. The implications of the results of this analysis for the Andean model and the cultural history of the Palpa region are then discussed in chapter 7.

6.1 Geoglyph typology

In order to enable an efficient management and analysis of the 639 geoglyphs that are considered in the present study, they had to be revised and sorted. The first step in data analysis was therefore the elaboration of a geoglyph typology.[17] Archaeological typology is here defined as the sorting of artifacts into abstract categories based on shared attributes that are chosen and weighted according to a previously defined purpose. Hence, such a typology is composed of etic artifact categories that may just by chance coincide with emic categories. The geoglyph typology as established here is accordingly to be understood as tool for archaeological research, rather than revelation of original cultural concepts (Eggert 2001:142f). Its purpose is to enable efficient data management. Whether the established descriptive types bear any chronological, functional, or other significance will be tested during subsequent steps of the analysis.

Like all archaeological artifacts, each geoglyph features certain properties. Some of them may be alike on all artifacts of a given assemblage (invariants), while others vary and can therefore be used for differentiation (variables). The different values the variables can assume are here termed attributes.[18] A typology is established by choosing certain variables and grouping all artifacts that

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17 If not noted otherwise, the following remarks and definitions are largely based on the rather practical approach to artifact typology by Adams, Adams 1991. The typology outlined here replaces preliminary typologies presented in earlier reports (Reindel et al. 2003b:193ff, 216ff; Lambers, Sauerbier 2003: fig. 3).

18 The term “variable” as used here corresponds to the term “attribute” in the context of conceptual data modeling (see chapter 5.14). There, the potential range of “attributes” in the sense of archaeological typology is termed “domain”.

share the corresponding attributes together into one category: a type. This can be accomplished on different levels. For example, if only one variable is considered, the number of artifacts sharing identical attributes and therefore being grouped together is relatively high. Further subdivisions can be achieved by considering additional variables. Since fewer artifacts are likely to share corresponding combinations of attributes, the number of artifacts in each category decreases or, in other words, the typology gets more fine-grained. The number of levels is determined, among other things, by heuristic considerations. A too fine-grained typology, in which each individual artifact ends up in its own category, is of no practical value; rather, each category should represent a certain minimum number of artifacts. On the other hand, the consideration of too little variables necessarily leads to artifact categories with considerable inherent variation. Usually, a hierarchical typology is useful, with each level having a different significance and use. Although each category on each level is actually a type as defined above, they are usually not termed so for practical reasons. For example, a three-level typology may consist of groups on the upper level, which are subdivided in types on the middle level, with the types being further subdivided in varieties on the lower level.

The choosing and weighting of variables is determined on the one hand by foreknowledge of the artifacts, on the other hand by the intended purpose of the typology. A certain familiarity with the artifacts to be analyzed is necessary to tell invariants from useful variables, and to understand which variables are significant for which problem. The purpose of the intended typology then determines which variables are chosen and combined to define types. For example, for a chronological typology, variables that are likely to bear chronological significance will be considered more important than other variables. Since in the case of the Palpa geoglyphs a descriptive typology is aimed at, formal variables are considered primarily.

6.1.1 Definition of geoglyph types

In the course of the archaeological as well as photogrammetric recording of the Palpa geoglyphs, a wide range of variables were registered. However, the only variables whose attributes are unambiguously known for all geoglyphs are construction technique and shape. Other variables registered in the field on standardized feature sheets are orientation (towards landscape features), topographical setting, stratigraphic relationships, associated structures, associated finds, indirect dating obtained through chronological classification of associated finds, and state of preservation. Information on further variables was derived from photogrammetrically obtained

3D data. This includes size, orientation (azimuth), and slope degree of the terrain covered by a certain geoglyph. However, all these additional variables except construction technique and shape are either not available or not applicable for all geoglyphs (orientations, stratigraphy, associated structures, associated finds, indirect dating), or are often not clearly definable (topographical setting, stratigraphy, associated structures, associated finds, slope degree), or yield information that should ideally be further structured to make sense (size, which should be subdivided into length and width), or are irrelevant for an archaeologically meaningful classification (state of preservation). Nevertheless, some were used in later stages of analysis.

Hence, due to the defined purpose and the availability of information, for the Palpa geoglyphs construction technique and shape were the basic variables to be considered in an initial sorting. The resulting typology as shown in Figure 6.1 is described in detail below.

The construction technique of the Palpa geoglyphs is largely determined by the environment in which they are situated. It shows only limited variability and is therefore used here for the first step in the sorting process. The geoglyphs are located in a rocky desert. Each of them is the visible result of an alteration procedure of the desert surface. To create a geoglyph, the more or less regular original desert pavement was disturbed, removing stones from their original place into a new one. Thus, the procedure always included a subtractive as well as an additive activity. Sometimes, unaltered parts of the original surface were incorporated into the geoglyph design, too. The difference in construction technique is determined by which element of a given geoglyph is made up of cleared, heaped, or unaltered parts.

The most common technique is here termed the positive one, matching its visual appearance. Geoglyphs that consist of cleared inner spaces framed by heaped borders outnumber other geoglyphs by far.[19] This is probably due to the fact that the visible difference between geoglyph and original surface is clearest that way. Certain variations of this technique are observable. The borders were not always continuously heaped. Where not enough stones were available, unaltered parts of the desert surface were incorporated as sections into the otherwise heaped border. The visual appearance of the positive technique was only marginally affected by this change. The same is true for a variation concerning the cleared interior spaces. While only stones of the desert pavement were usually removed, in some cases a part of the sediment beneath was also excavated. However, these sections were never very deep (and may have been deepened by erosion since their original construction), and they often made up only a part of a cleared area.

19 Quantitative data on the Palpa sample is presented in the following subchapter.

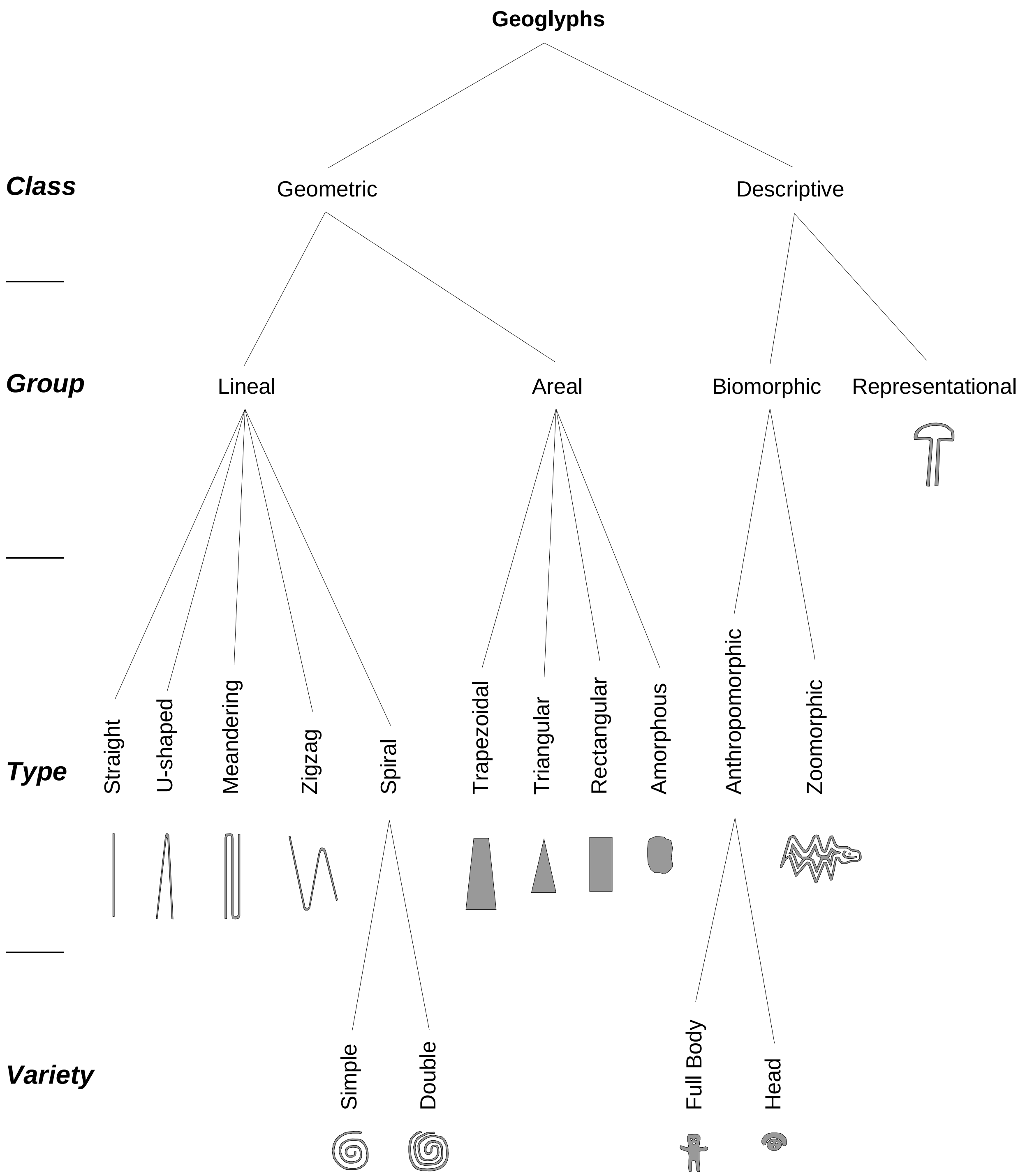

Figure 6.1: Palpa geoglyph typology based on variables construction technique and shape

The second construction technique is more varied and is here termed the combined one. The combined technique is easily distinguishable from the positive technique. The main difference concerns the interior part of a geoglyph, which is not just a cleared area, but incorporates other elements as well. Geoglyphs rendered in the combined technique feature some unaltered or heaped elements enclosed in the cleared area, along with heaped or unaltered borders and cleared interior parts which they share with geoglyphs made in the positive technique. In rare cases, the unaltered or heaped areas of geoglyphs made in the combined technique even form the central element of the geoglyph, being surrounded by cleared areas defining the geoglyph outline. Geoglyphs rendered in the combined technique are very multi-faceted, although they make up a smaller part of the overall Palpa sample.

Thus, the variable construction technique with its two attributes defines two basic categories of geoglyphs: those made in the positive technique and those made in the combined technique. These categories can be differentiated further by considering an additional variable, which is shape. This variable shows a much greater variety, or in other words, more attributes associated with it on different levels. Shape is understood here in a rather descriptive or approximative sense. Though some of the terms used for type labeling were borrowed from geometry, no geoglyph actually matches exactly any geometric form. This is prevented by the intrinsic irregularities of the construction process. Furthermore, each and every geoglyph is unique with regard to its specific shape. However, all these manifestations can be easily traced back to a relatively small repertoire of basic shapes.

A basic distinction of different geoglyph categories based on the variable shape coincides neatly with the distinction based on construction technique: all geoglyphs made in the positive technique feature geometric shapes in the widest sense (straight lines, rectangles etc.), whereas all geoglyphs made in the combined mode depict real-world objects recognizable to the modern observer, like human or animal figures. These modern, or etic, categories are not meant to say that geoglyphs of the first group do not symbolically represent any objects or phenomena, which may indeed be the case. This question, however, is not an issue in this initial sorting. Hence, two basic classes of geoglyphs can be defined on the uppermost level of the typology: geometric geoglyphs rendered in the positive technique, and descriptive geoglyphs rendered in the combined technique.

The diversity of the variable shape allows a further distinction of the geoglyphs into groups, types, and varieties. In the geometric class, there are two groups: lineal geoglyphs on the one hand and areal geoglyphs on the other hand. Geoglyphs of the lineal group are made up of lineal cleared elements that are much longer than wide. Geoglyphs of the areal group, on the other hand, have a wide cleared interior and are usually much more spacious than the lineal geoglyphs. Though theoretically desirable, it is practically not feasible to define a certain length-to-width ratio to distinguish areal from lineal geoglyphs, since the parameters length and width are in most cases difficult to determine. Empirically, however, it is relatively easy to decide whether a geoglyph pertains to the lineal or the areal group.

In the descriptive class, geoglyph shape is largely determined by depicted motifs. These shapes can be classified into two groups. Biomorphic geoglyphs depict animate beings, including humans and animals. Representational geoglyphs, on the other hand, depict inanimate objects, *e.g.* tools or other objects or phenomena.

Thus, on the second level of the typology we have four groups of geoglyphs: lineal and areal geoglyphs in the geometric class, and biomorphic and figurative geoglyphs in the descriptive class. Most of these groups can be subdivided further into types, and some into varieties, according to their specific shape.

Figure 6.2: Lineal geoglyphs on the southern hillside of Cresta de Sacramento: straight line 248 on site PV67A-39 (left) and turning point of U-shaped line 249 on the same site (right)

Geoglyphs from the lineal group are basically formed by a single line. According to the shape of this line, they can be classified into five types that occur frequently in the Palpa sample: straight lines, U-shaped lines, meandering lines, zig-zag lines, and spirals. Purely or basically straight lines are a common type, while many others bend and turn once or several times (Figure 6.2).

Lines turning once and featuring two straight sections are classified here as pertaining to the U-shaped line type. Lines turning twice or more often are classified depending on the relation of their three or more straight sections to each other: if they are parallel, they are of the meandering line type, if they are not, their type is termed zigzag line. A type of lineal geoglyphs with no straight section at all is that of spiral shape. There are two varieties of spirals. In the more common, double one, the spiral is formed by a line that runs to the center of the spiral, turns, and leads back out of the spiral (Figure 6.3). The less common, simple variety is formed by a line ending in the center of the spiral.

Figure 6.3: Spiral 336 (double variety) on site PV67A-49

Areal geoglyphs can be classified into four types: trapezoids, triangles, rectangles, and amorphous areas. The most common type of areal geoglyphs is usually called trapezoid (Figure 6.4). Trapezoidal geoglyphs have two non-parallel borders that are usually longer than the two parallel borders. It has to be stressed, though, that the parallel borders of trapezoidal geoglyphs are often hardly defined, which makes the term trapezoid somewhat inappropriate. However, since it is widely used, and alternative denominations (like *e.g.* truncated isosceles triangle) are rather cumbersome, it will be maintained here. Trapezoids make up by far the biggest portion of areal geoglyphs. Triangles are a rarer type, similar to the trapezoids but with a well defined, pointed end. Likewise, geoglyphs of the rectangular type are similar to trapezoids, the only difference being roughly parallel longer borders. Finally, another common type of areal geoglyph is an irregularly shaped, or amorphous, but clearly anthropogenic cleared area.

Figure 6.4: Trapezoid and flanking lines (geoglyph 16) on site PV66-72 in a dry valley northeast of Los Molinos

Figure 6.5: Anthropomorphic geoglyph 228 (head variety) on site PV67A-39

Geoglyphs of the biomorphic group can be classified into two types: anthropomorphic and zoomorphic figures. The anthropomorphic type features images of human-like bodies or parts of them, often with additional features like headdresses or objects held in their hands. Geoglyphs of the anthropomorphic type can be further classified into two varieties: full bodies and heads. The body of the full body variety is usually shown in front view, whereas side-face views are less common. Heads are always shown in front view in either variety (Figure 6.5). Another category in the biomorphic group is the zoomorphic type. The depicted animals are basically made up of lines that define the outlines and sometimes additional features of the figures (Figure 9.7).

Geoglyphs pertaining to the representational group are rare and are not further classified into types or varieties here. In the wider Palpa area, there are several geoglyphs showing *tumis* (one of them located on Cresta de Sacramento), tools well known from archaeological contexts throughout the Andes that are usually interpreted as ceremonial knives, or other geoglyphs that seem to represent the sun (Figure 6.6).

Figure 6.6: Geoglyph 31 (tumi) on site PV66-73 on a hillside in a dry valley northeast of Los Molinos (also note unfinished trapezoid 33, lower left)

However, representational geoglyphs are generally rare. In this typology, new categories on the type level are only defined if there is a certain number of actual geoglyphs that represent the type, whereas single geoglyphs are not used to define additional types. This may be done later once similar geoglyphs have additionally been recorded. Until then, the hierarchical structure of the typology presented here allows to simply place single geoglyphs on a higher, more general level, *e.g.* into a group. That way, all geoglyphs are covered by the typology, though not all of them can be placed on the same level. This is especially evident on the lowest level, since varieties are only defined for a few types.

It has to be stressed that this typology was elaborated for the Sacramento/Carapo sample from Palpa. It is not necessarily applicable to geoglyphs from other areas. For example, no phytomorphic type has been defined to accommodate the well known plant-like figures from the Nasca *pampa* since no such geoglyph has been recorded in the area covered by the present study. However, such a type could easily be integrated into the typology described here.

6.1.2 Distribution of geoglyph types

In the present study, all 639 geoglyphs located on Cresta de Sacramento, Cerro Carapo, and the right bank of Río Grande around La Muña have been assigned to one of the categories of the typology defined above. Their typological distribution, established by querying the database and illustrated in Figure 6.7, clearly shows a preference for certain geoglyph construction techniques and shapes.

On the class level, 597 geoglyphs (93.4 %) pertain to the geometric class, compared to only 42 (6.6 %) of the descriptive class. Thus, the vast majority of geoglyphs in the Palpa sample were made in the positive technique, including cleared areas and heaped borders, but without interior heaped or undisturbed areas.

Within the geometric class, 404 geoglyphs (63.2 % of the overall sample) pertain to the lineal group, out of which 298, or 46.6 %, are straight lines. That means that nearly half of all registered geoglyphs in the Palpa sample are straight lines.[20] In descending order, the next frequent types are U-shaped lines (48, or 7.5 %), meandering lines (19, or 3.0 %), and zigzag lines (nine, or 1.4 %). Of the ten spirals (1.6 %), two are of the simple variety, five are double spirals, and three could not be classified further. Likewise, 20 lineal geoglyphs (3.1 %) could not be assigned to specific types.

Within the group of 192 areal geoglyphs, there is again a predominant type outnumbering all others. 133 of them, or 20.8 % of the overall sample, pertain to the trapezoidal type. Only two geoglyphs have been classified as triangles (0.3 %), while there are 21 rectangles (3.3 %) and 16

20 The actual number of straight lines is even higher since in several instances parallel lines that apparenty were created at the same time as part of a single design have been registered as one geoglyph for the sake of efficiency.

amorphous geoglyphs (2.5 %).[21] 20 areal geoglyphs, or 2.5 %, could not be classified further into types. All in all, in the geometric group, and thus also in the entire Palpa sample, straight lines are predominant, followed by trapezoids. All other geometric types or varieties are present in much lower numbers.

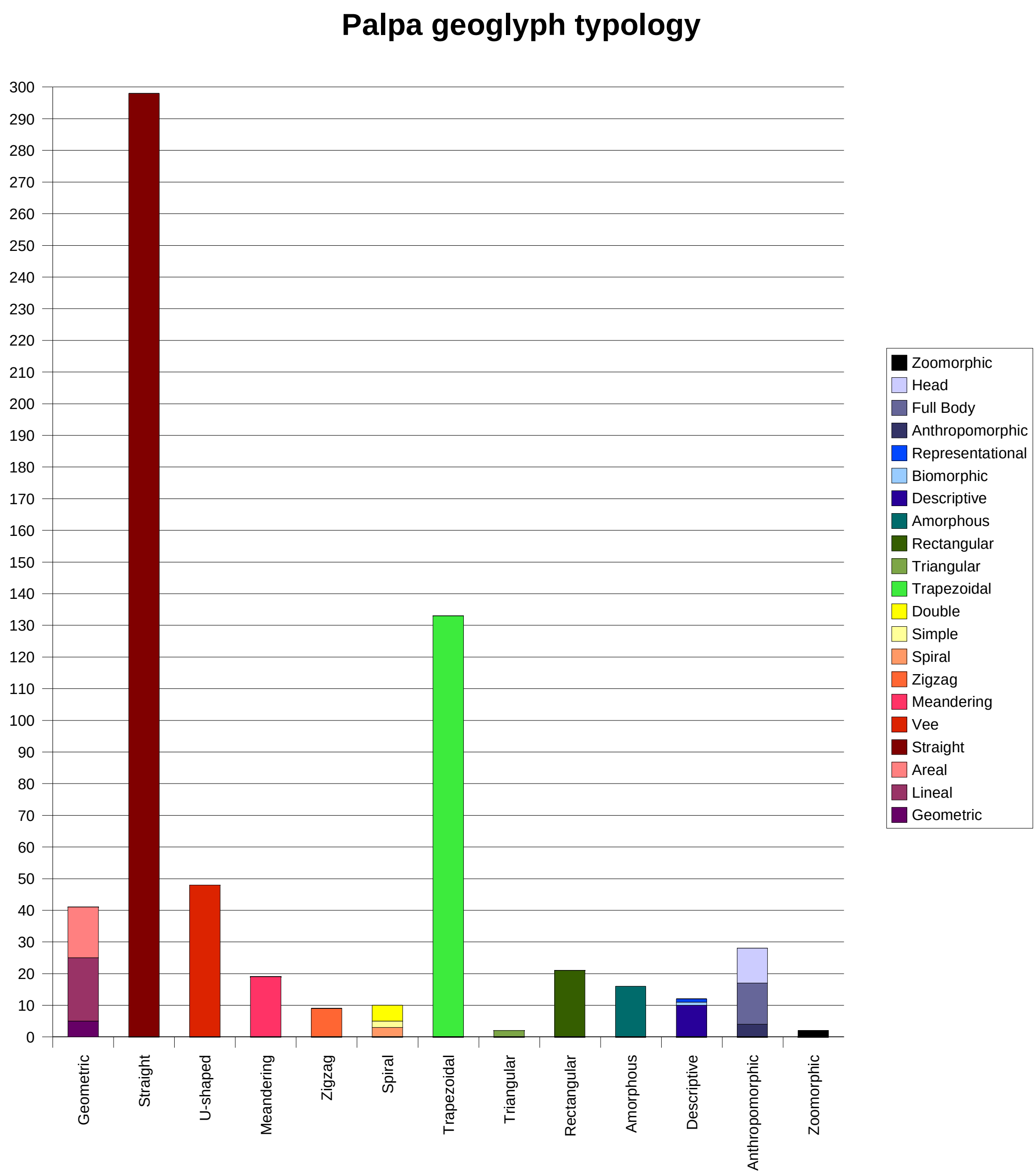

Figure 6.7: Number of geoglyphs per type

In the descriptive class, 31 out of 42 geoglyphs, or 4.9 % of the overall sample, have been classified as pertaining to the biomorphic group. The majority of them (28, or 4.4 %) show anthropomorphic figures. These figures can more or less evenly be divided into the full body

21 Here again, in some cases several amorphous geoglyphs close to each other were registered under a single ID.

(13) and head variety (11), resp., while four anthropomorphic geoglyphs (0.6 %) could not be identified further. Only two zoomorphic geoglyphs, a whale figure and a possible, largely destroyed bird figure, both of them on Cresta de Sacramento, have been identified in the Palpa sample. Ten descriptive geoglyphs (1.6 %) could not be classified further. There is only one representational geoglyph in the Palpa sample, which is, as mentioned above, the elaborated figure of a *tumi* (a tool with handle and semicircular, adorned blade) in a dry valley close to Los Molinos. All in all, among the relatively few descriptive geoglyphs, anthropomorphic figures occur most often, while most others are not easily classifiable into types.

6.1.3 Summary: geoglyph typology

The Palpa geoglyph repertoire shows on the one hand a considerable formal variety. A head of an anthropomorphic figure only few meters in diameter on a slope of Cresta de Sacramento seems to have little in common with a 600 m long trapezoid on the plateau directly above the figure. Each and every geoglyph is unique with regard to its specific shape. Yet the variety can be traced back to a relatively simple system of basic shapes. Within this scheme, there is a clear preference for straight lines and trapezoids, both of which are predominant features on the hillsides and plateaus around Palpa. This is worth mentioning, because in public perception, biomorphic geoglyphs are the most famous ones, and many hypotheses concerning geoglyph function and meaning build heavily on them. For the Palpa area, this would clearly mean an overestimation of the importance of biomorphic geoglyphs, since they constitute only a small fraction of the whole geoglyph sample (4.9 %). Thus, the attention clearly should shift to lineal and areal geoglyphs.

6.2 Geoglyph chronology and cultural affiliation

In general, there are four potential sources of information on the chronological placement of geoglyphs, considering both relative and absolute chronology (cp. Clarkson 1996:430ff):

- direct datings obtained using scientific methods,
- stratigraphic relations to other geoglyphs and cultural remains,
- chronological classifications of associated finds,
- iconographic parallels with dated materials from other artifact categories.

For the Palpa sample, chronological data is available only from stratigraphy, dated finds, and iconography, whereas direct chronometric datings have so far been obtained only on a limited scale, though more are planned for the near future.

The only previous attempts to date geoglyphs in the Nasca basin directly with scientific methods made use of the fact that on formerly unexposed faces of stones that were removed from their original position during the construction process of a geoglyph, a patina, or desert varnish, begins to form over time. Microscopic organic material enclosed between stone surface and desert varnish can be dated by AMS (accelerator mass spectrometry) radiocarbon dating (Clarkson, Dorn 1995:59). Several geoglyphs on the Nasca *pampa* and other parts of the Nasca region were dated this way during the 1980s and '90s by Ronald Dorn and Persis Clarkson, choosing stones from heaped borders of lines and trapezoids that had likely remained undisturbed since their removal and subsequent exposure during the construction of the geoglyph (Clarkson, Dorn 1991; Clarkson 1996). The AMS datings confirmed a Middle to Late Nasca date for the chosen geoglyphs. However, these results were later questioned due to indications that some of the used samples may have been contaminated. This controversy (Beck et al. 1998 *vs.* Dorn 1998), whether substantiated or not, led to the abandonment of desert varnish dating in Nasca archaeology.

In the framework of the second phase of the Nasca-Palpa project, a new method of direct geoglyph dating is currently being developed and tested. In granitic rocks, feldspar and quartz crystals directly underneath the stone surface emit measurable optically stimulated luminescence (OSL; Wagner 1998:262ff). During exposure to daylight, this latent signal is stopped. Once the bleaching is stopped, *e.g.* when a stone is covered or buried in a heaped border during the construction of a geoglyph, the OSL signal starts to build up again. Given that the increase rate is known, the intensity of the measured OSL signal can be used to date the event of last light exposure. Thus, whereas desert varnish dating requires stone surfaces exposed during geoglyph construction, OSL dating is based on stone surfaces covered in the process. At the time of writing (2004), this novel method is still being tested, and no confirmed datings are so far available for the geoglyphs considered in the present study (but see Greilich et al. 2005 for some preliminary results). However, OSL datings are likely to become available for several Palpa geoglyphs in the near future, offering the chance to check some of the chronological results obtained from other sources.

The same is true for radiocarbon datings of organic materials recovered during excavations of stone structures associated with geoglyphs. On several sites on Cresta de Sacramento and Cerro Carapo, such structures have been excavated in the course of the Nasca-Palpa project (see appendix 9.2). Datable organic materials from deposits on these stone platforms as well as wooden posts could be recovered. However, the temporal relation of posts and organic materials to the respective geoglyph was not always easy to establish, so that the expected datings can only serve as approximations for geoglyph dating. Radiocarbon datings of wooden posts on geoglyphs have occasionally been mentioned (Strong 1957:46; Morrison 1987:56; Aveni 1990a:21), but the exact context was never clearly stated so that the resulting dates cannot be associated with specific geoglyphs. As for the Palpa geoglyphs, up to the time of writing (2004) only one of the recovered samples could be dated. A wooden post pertaining to a stone structure on trapezoid 52 (site PV67A-15) yielded a corrected date of AD 603-644 (see detailed description in appendix 9.2.2). After this date, the structure was remodeled and continued in use for some time. Associated ceramics cover the time span from Early Nasca to the Early Middle Horizon.

Apart from this sample, radiocarbon datings cannot yet be considered in this study but will become available in the near future. Thus, the other sources mentioned above – stratigraphy, datable finds, and iconography – here provide the starting point for a chronological placement of the Palpa geoglyphs. The available evidence is discussed in two steps. Firstly, a general chronological framework is established in order to determine the beginning, duration, and end of the geoglyph phenomenon. This framework will mainly be based on an overview of datable fineware ceramics, as well as stratigraphic relations of geoglyphs to other cultural remains. In a second step, it will then be checked if the established types bear any chronological relevance, *i.e.* if they occur only during a certain time span within the general chronological framework. This investigation will largely draw on the distribution of dated fineware ceramics per type, as well as on stratigraphy and iconography.

6.2.1 General chronological framework

ASSOCIATED FINDS

Of the many categories of finds registered on or nearby the Palpa geoglyphs (ceramics, lithics, textiles, bones, shells), only decorated fineware ceramics can so far be assigned to stylistic phases tied to a chronological sequence (Table 1). These fineware sherds have been the most important vehicle for previous attempts of geoglyph dating (*e.g.* Hawkins 1974; Clarkson 1990; Silverman, Browne 1991). A methodological issue here is that datable surface finds can only provide a *terminus ante quem* for the creation of the geoglyph, and the time span elapsed between the creation of the geoglyph and the deposition of the find upon it is unknown. A long lasting construction process (discussed in chapter 6.3) and the possibility that the geoglyphs may have been kept clean during their time of use (Urton 1990) further add to the inherent uncertainty of this approach. However, recurrent patterns in large samples can partially compensate for these shortcomings, and this is how the method has usually been used. For the Palpa sample, stylistic dating of associated finds is only one, though the most important, avenue of obtaining information on the chronological placement of the geoglyphs.

Figure 6.8: Broken Nasca ceramic vessel close to geoglyph 143 on site PV67A-34

During fieldwork in Palpa, ceramic fragments were classified according to the established sequence of Early Horizon to Late Intermediate Period pottery (see chapter 2.2). Due to certain constraints explained above (see chapter 5.10), ceramic finds could not be sampled systematically, so that most finds were classified in the field and left on the spot. The accuracy and reliability of the classification was on the one hand determined by the state of preservation of the sherds. For instance, some sherds with eroded surface could be classified based only on vessel shape, which is why some were registered *e.g.* as Early Nasca without further distinction between Nasca 2 and Nasca 3. On the other hand, a certain bias was introduced by the field staff (including the author) being generally more familiar with earlier than with later ceramics, which is why no distinction was made between different phases of the Late Intermediate Period. In spite of these shortcomings, a review of the chronological distribution of finds reveals interesting insights into the history and development of the Palpa geoglyphs.

On 398 of the 639 geoglyphs considered here (corresponding to 63.3 % of the overall sample), ceramic finds were registered during fieldwork. Painted fineware ceramic fragments (Figure 6.8) constitute the majority of these materials. Plainware fragments are slightly less common, but nevertheless present in significant numbers. Since they cannot yet be classified chronologically, the following discussion will focus on datable fineware ceramics. These were found on 264 geoglyphs (41.3 %), meaning that this kind of chronological information is available for less then half of the Sacramento/Carapo geoglyph sample. In the following, the numbers of finds per phase are listed, considering first all registered finds, and then only earliest finds on their respective geoglyphs, since the latter ones are indicators of first-time use of the geoglyphs. Both distributional patterns were elaborated by querying the database using SQL, and the results are illustrated in Figure 6.9. Designation of time periods is given as registered in the field.

On five geoglyphs, or 0.8 % of the overall sample, diagnostic sherds dating to the Early Horizon were observed. On three of them, these were classified as Tajo,[22] on one as Late Paracas, and for another one no further detail was given. All of them were the earliest finds on their respective geoglyphs.

Ceramics dating to the Paracas-Nasca transitional period, here termed Initial Nasca, were found on 20 geoglyphs, corresponding to 3.1 % of the total sample. All except one of them were the earliest registered finds in their context.

The great majority of ceramics found on Palpa geoglyphs date to Early Nasca times. On 179 geoglyphs, or 28 %, Early Nasca ceramics were observed, out of which 51 finds were classified as Nasca 2, 111 as Nasca 3, and the remaining 17 simply as Early Nasca. Theses numbers are lower, however, when considering only the sherds that were the earliest datable finds on their respective geoglyphs. This was the case on 136 geoglyphs, or 21.3 %, with 44 fragments classified as Nasca 2, 80 as Nasca 3, and 12 as Early Nasca.

22 For a definition of Tajo see Silverman 1994b. This designation was only used in an early stage of our fieldwork and later abandoned in favor of the Ocucaje sequence (see Isla et al. 2003 on Paracas ceramics in Palpa).

The second highest number of ceramic sherds on the Palpa geoglyphs dates to Middle Nasca times. On 119 geoglyphs (18.6 %), Middle Nasca ceramics were found, 36 finds dating to Nasca 4, 69 to Nasca 5, while 14 were classified as Middle Nasca. Considering only earliest finds, the numbers are again significantly lower: all in all 65 geoglyphs (10.2 %) had Middle Nasca ceramics, out of which 22 were identified as Nasca 4, 32 as Nasca 5, and the remaining eleven as Middle Nasca.

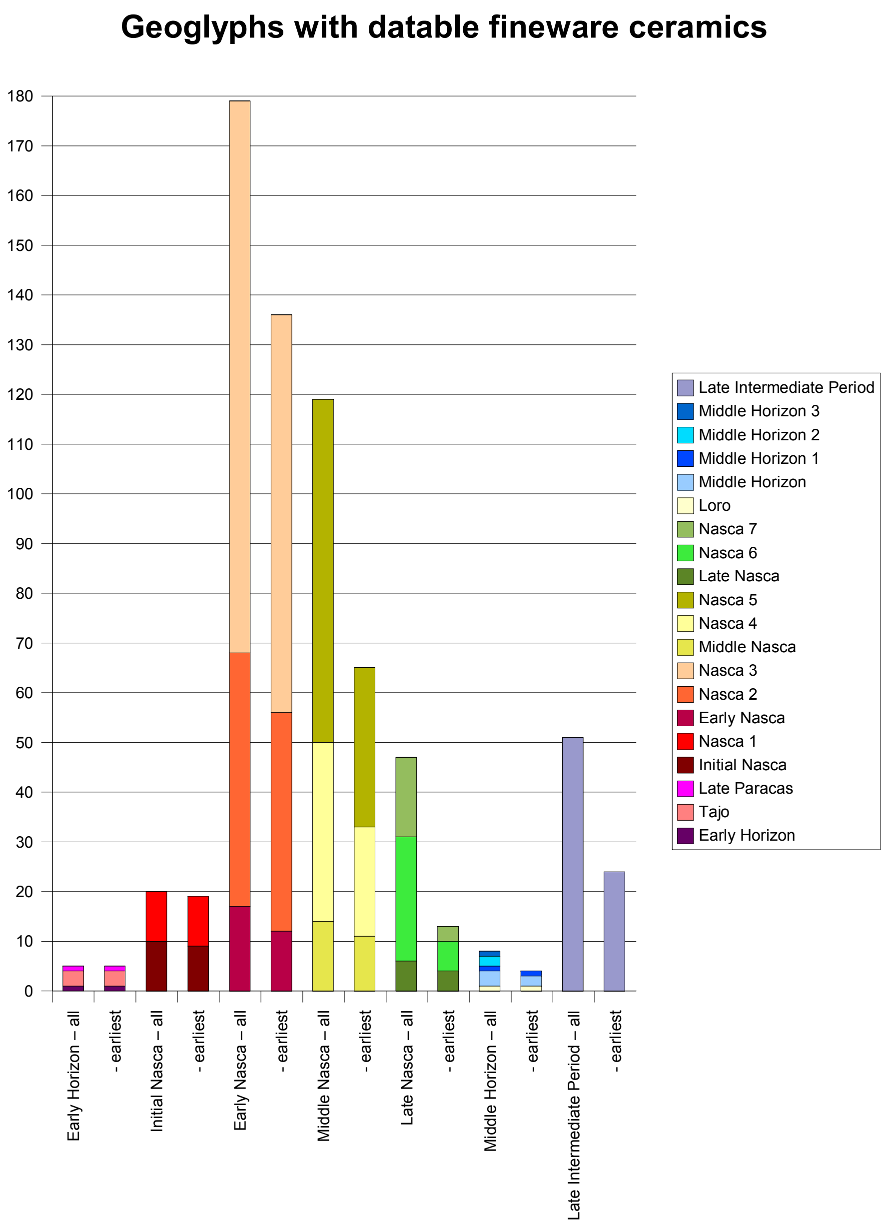

Figure 6.9: Number of geoglyphs with associated fineware ceramics per chronological phase (left column: all finds, right column: earliest finds)

The numbers decrease further in Late Nasca times. On 47 geoglyphs, corresponding to 7.4 % of the overall sample, Late Nasca ceramics were found. 25 of them were classified as Nasca 6, 16 as Nasca 7, and six as Late Nasca. However, on only 13 geoglyphs (2 %) Late Nasca ceramics were the earliest registered finds, out of which six were Nasca 6, four Nasca 7, and three Late Nasca in general.

For the Middle Horizon, numbers drop to very low levels. On eight geoglyphs, or only 1.3 % of the whole sample, ceramics dating to that epoch could be found. One of these finds was registered as Middle Horizon 1, one as Loro, two as Middle Horizon 2, one as Middle Horizon 3, and three generally as Middle Horizon. Out of these, four finds were the earliest on their respective geoglyphs (0.6 %): one was Middle Horizon 1, one Loro, and two Middle Horizon without further differentiation.

Ceramics from the Late Intermediate Period were found on 51 geoglyphs, or 8 % of the Palpa sample. However, less than half of them (24, or 3.8 %) were found on geoglyphs without earlier finds.[23]

All in all, as Figure 6.9 clearly shows, there is a peak in the chronological distribution of datable finds in Early Nasca times, especially Nasca 3. The beginning of geoglyph making and use during the Early Horizon is difficult to define on the basis of associated finds alone, since many apparently early geoglyphs have no pottery upon them, while others have likely been disturbed or obliterated in Nasca times when geoglyph related activity reached its peak in the Palpa area. Geoglyph numbers increase constantly from the late Early Horizon to Nasca 3, with a sharp rise especially from Nasca 2 to Nasca 3. In Nasca 4, geoglyph number decrease to considerable lower levels but resurge in Nasca 5, to which still more geoglyphs can be assigned than before the Nasca 3 peak, though not in terms of earliest finds. Late Nasca sees again a considerable decrease of finds on geoglyphs, but among them are still earliest finds on their respective geoglyphs. The same is true for the Middle Horizon, although overall numbers drop to very low levels during that time. Another peak is reached during the Late Intermediate Period, yet lower in numbers than during Nasca times, and less than half of these finds are the earliest ones on the geoglyphs. This second peak, which runs contrary to the overall tendency of chronological geoglyph distribution, can be explained under consideration of stratigraphic evidence of LIP buildings and geoglyphs.

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23 The quantitative information on chronological geoglyph distribution as given above was used again for the elaboration of distribution maps illustrating the spatial development of geoglyph sites on the regional level through time (Maps 7-16). That aspect is discussed in chapter 6.4, whereas here a general chronological framework is established.

STRATIGRAPHY: GEOGLYPHS AND BUILDINGS

Apart from stone structures clearly associated with geoglyph construction, such as *e.g.* stone platforms on trapezoids or at the end of straight lines (see appendix 9.2), stratigraphic relations between geoglyphs and stone buildings can only be established in relatively few instances in the Palpa region. Most common are stone buildings built upon geoglyphs, as occurring mainly on flat plateaus (sites PV67A-84, PV67A-47), but also at the foot of the southern flank of Cresta de Sacramento (site PV67A-45). A good example is site PV67A-89, one of the easternmost sites of the flat plateau on Cresta de Sacramento (Figure 9.18). It consists mainly of two large trapezoids successively constructed along the southern edge of the plateau (geoglyphs 350/351). On the western end of the later trapezoid 350, two large rectangular stone enclosures pertaining to Los Batanes (PV67A-84), a large site located further to the SW, are built upon the geoglyph, destroying its heaped borders, obliterating its outlines, and rendering the western end almost unrecognizable. Similar examples occur on sites and PV67A-47, PV67A-80 (Figure 9.21) and PV67B-55 (Figure 4.3). Wherever such a situation is present – stone buildings built on, and thus later than, geoglyphs – associated ceramics date the buildings (walled enclosures and houses on plateaus, platforms on slopes) to the Late Intermediate Period (LIP). LIP sites are easily recognizable in the archaeological record of the Palpa region due to some characteristic features:

- they are usually located far from the irrigated valley floor, *e.g.* on slopes, in nowadays dry valleys, on plateaus or even close to hilltops;
- they are quite large and often densely clustered, with well preserved stone architecture;
- great amounts of broken pottery are usually scattered among the ruins.

Their distinct distribution pattern, architecture, and pottery clearly sets LIP sites apart from earlier settlements. Important sites are located on top of flat plateaus or on rock outcrops on their margins, like sites PV67A-47 and PV67A-84 on Cresta de Sacramento and site PV67B-54 on Cerro Carapo (Map 16). The amazing amount of broken pottery on these sites has its counterpart in apparently contemporaneous footpaths crossing the plateaus, along which comparatively many LIP ceramic sherds can be found. The association of LIP architecture, LIP pottery, and geoglyphs on flat plateaus seems to indicate contemporaneity at first glance (cp. Clarkson 1990:167f; Silverman, Proulx 2002:175). However, in the Palpa area LIP stone buildings were clearly constructed without consideration of the geoglyphs, which were largely destroyed in the process. Furthermore, footpaths with LIP ceramics on the plateaus cross the geoglyphs just like modern paths, making use of cleared surfaces wherever possible, but without following their spatial order. Thus, rather than indicating contemporaneity, all available evidence of LIP dwelling and other activities on geoglyphs in the Palpa area indicates that the geoglyphs were no longer important or cared for in LIP times (cp. Horkheimer 1947:53, 56).

Figure 6.10: La Muña (site PV66-49) overlooking the Palpa valley (left: geoglyphs cut by terraces, right: central part of the site with enclosed shaft graves and habitational zone on the lowest terrace)

Another case where constructions superimpose geoglyphs has been documented in La Muña (PV66-49), the great site from Middle Nasca times on the right bank of Río Grande close to its confluence with Río Palpa (Reindel, Isla 2001). The site, comprising a settlement zone, public architecture, and a cemetery, is located in a short, but wide dry valley (Figure 6.10). To the southeast this *quebrada* opens towards the valley floor. On the northeast and southwest the site is framed by rocky hills. The terraces on which the main part of the site is located rise from the valley floor in northwesterly direction, ending in a short spur above the settlement zone on which a trapezoid flanked by several straight lines is located (geoglyphs 634-639). The lower, northeastern end of this spur was converted into a series of semiartificial platforms, apparently during the main occupational phase of the site, which was Nasca 5. The four terraces were not built at the same time. Although the stratigraphic sequence is not altogether clear, it seems that the lowest terrace was the earliest one to be constructed, whereas at least the upper terrace was never finished. Prior to the construction of the terraces, the surface of the sloping ridge had to be leveled. During this process, the wide ends of the trapezoid and its flanking lines were cut off. The dating of this event is difficult. On the trapezoid, very few diagnostic ceramic fragments were found, among them Nasca 3 fragments, corresponding to ceramics encountered in the earliest layers of the settlement zone. On the platforms, slightly more sherds were present, dating to Nasca 3 to Nasca 5. Thus, it seems that already in Nasca times geoglyphs were built over, too. The interpretation is difficult. At first glance, the partial destruction of the geoglyphs in order to build the terraces clearly seems to have put an end to their use. On the other hand, the resulting terraces were structurally similar to the earlier trapezoid: wide spaces with clearly defined boundaries above the central part of the site. Thus, we may simply face a remodeling event easily comparable to other alterations so frequently occurring on geoglyph sites (see chapter 6.3), albeit in La Muña assuming a somewhat different shape.

While buildings on geoglyphs do occur, though not often, in the Palpa area, the reverse situation is extremely sparse. The only clear example of geoglyphs superimposed upon earlier structures can be observed on site PV66-122 (Figure 6.11). Here, a series of terraces facing the valley was built on a low hill on the northern flank of Cresta de Sacramento. Associated ceramics date these structures to Initial Nasca times. Towards the ridge, the hill and the terraces were enclosed by a defensive wall made of large boulders, gravel, and vegetational layers. Later, this construction fell out of use, and a trapezoid flanked by a series of parallel lines (geoglyphs 523, 526-530) was created on the slope, with its wide base located on the hill and its upper part crossing the partly collapsed wall. Early Nasca ceramics were found on the geoglyphs. It is not clear whether the terraces were still in use by the time the geoglyphs were created.

All in all, geoglyphs and buildings or other structures rarely have well defined stratigraphic relations to each other. Of the few cases described above, only the first one – LIP buildings on geoglyphs – seems to allow general remarks on the temporal relationship between both kinds of features (in this case, that geoglyphs had already lost their importance in LIP times). The other situations described above rather seem to be special cases from which no general conclusions should be drawn until similar situation are registered elsewhere.

Figure 6.11: Trapezoid 523 superimposed on rampart on site PV66-122

SUMMARY: GENERAL CHRONOLOGICAL FRAMEWORK

Available chronological evidence from Palpa suggests that the earliest geoglyphs date to the Early Horizon, although the precise starting date remains unclear (this topic will be discussed in the following subchapter). Geoglyph related activity is in any case present in Late Paracas times and increases in Initial Nasca, reaching its peak in Early Nasca times. Afterwards, it decreases continuously through Middle and Late Nasca times and finally ceases during the Middle Horizon, for which the numbers of finds drop to very low levels, comparable to the Early Horizon. Again, the precise ending remains elusive. The considerable amount of ceramics from the Late Intermediate Period on geoglyphs is most probably due to the use of plateaus as dwelling places during that period.

Thus, in the Palpa area geoglyphs were created and used at least from the late Early Horizon through to some point in the Middle Horizon, which in absolute terms would roughly correspond to 400 BC - 800 AD, a time span of approx. 1 200 years. The chronological distribution of different categories of geoglyphs within this time span is discussed in the following.

6.2.2 Typochronology

ASSOCIATED FINDS

In order to test if the formal types based on the variables construction technique and shape bear any chronological significance, the distribution of datable finds (Figure 6.12) per type can serve as indicator (Figure 6.13). In the following overview, only earliest finds, presumably providing the *terminus ante quem* for the construction of the corresponding geoglyphs, are considered. This data was once again obtained by running SQL queries against the database.

Figure 6.12: Sample of Nasca pottery sherds found on the surface of geoglyph site PV67B-55

Starting with the predominant type, out of the 298 straight lines only 82 had datable ceramics on them. Summarizing the earliest finds per cultural phase, finds from two lines date to the Early Horizon, four to Initial Nasca, 48 to Early Nasca, 25 to Middle Nasca, four to Late Nasca, and twelve to the Late Intermediate Period. This indicates that straight lines were created from Paracas to Late Nasca times. The peaks in Early and Middle Nasca times correspond to the general frequency of geoglyphs. Thus, the straight line type does not seem to be a chronological indicator.

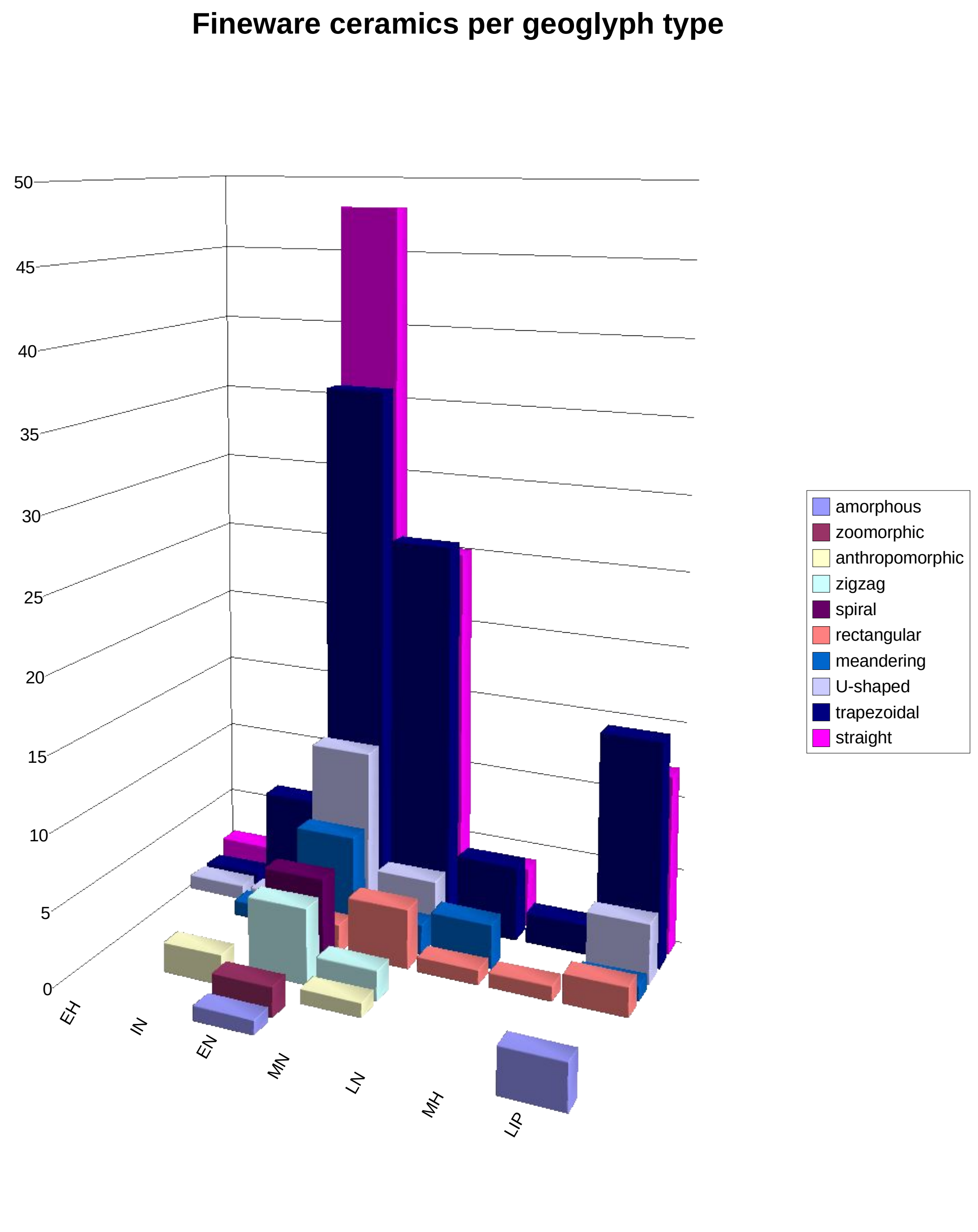

Figure 6.13: Distribution of datable fineware ceramics per geoglyph type (earliest finds only)

The next frequent geoglyph type in the Palpa sample is represented by 133 trapezoids, out of which 85 had datable ceramics on their surface. On one geoglyph, Early Horizon sherds were the earliest finds, while seven had Initial Nasca on them. The majority of earliest finds, found on 36 geoglyphs, date to Early Nasca. Almost as many earliest finds, on 26 geoglyphs, date to Middle

Nasca times, while on five geoglyphs, Late Nasca ceramics were the earliest. Two trapezoids had Middle Horizon ceramics on them and 15 LIP ceramics. Thus, here again the distribution of earliest finds corresponds more or less to the general chronological distribution, which is why trapezoids seem to have been created during the whole period of time of the geoglyph phenomenon, similar to the straight lines, but maybe with a slightly later component as indicated by the Middle Horizon finds.

48 U-shaped lines represent the next frequent type. 21 of them had datable ceramics on them. Summarizing the distribution of earliest find of these geoglyphs, one dates to the Early Horizon, another one to Initial Nasca, twelve to Early Nasca, four to Middle Nasca, and four to the Late Intermediate Period.

Concerning the 28 anthropomorphic figures, datable ceramics were associated to only three of them. Two of these sherds date to Initial Nasca and one to Middle Nasca.

Of the 21 rectangles, ten had datable ceramics. Two of these finds date to Early Nasca times, four to Middle Nasca, one to Late Nasca, one to the Middle Horizon, and two to the Late Intermediate Period.

On 13 out of 19 meandering lines, datable ceramics were found. On one of these geoglyphs, the earliest find pertained to Initial Nasca, on seven to Early Nasca, on two to Middle Nasca, on three to Late Nasca, and on one to the Late Intermediate Period.

Four out of 16 amorphous areal geoglyphs had datable ceramics upon them. One of these sherds dates to Early Nasca and three to the Late Intermediate Period.

Of the ten spirals, six had datable ceramics, all of them dating to Early Nasca.

The ceramics registered on seven (out of nine) zigzag lines date predominantly to Early Nasca times (five), while two finds are Middle Nasca.

Both zoomorphic figures registered on Cresta de Sacramento were associated with Early Nasca ceramics.

Reviewing this data, certain results draw special attention:

- Since the chronological distribution of ceramics on straight lines coincides largely with the overall distribution on all geoglyphs, this type seems to have been created during the whole time span of the geoglyph phenomenon and cannot serve as chronological indicator. This is corroborated by stratigraphic evidence from different sites (cp. appendix 9.1).

- The situation is similar with trapezoids, though two finds of Middle Horizon ceramics on them seem to indicate a slightly later component. This is also true for the formally similar rectangles, although the numbers of geoglyphs with Middle Horizon ceramics are generally very low.
- Meandering lines have slightly more Late Nasca than Middle Nasca ceramics, although the peak is again in Early Nasca times. Nevertheless, they may, together with some areal geoglyphs, have been more important in late phases of the geoglyph complex.
- Both zoomorphic figures and spirals date consistently to Early Nasca times, although the sample may be too small to be representative, especially in the case of spirals.
- There is no indication of neither U-shaped nor zigzag lines having been created later than Middle Nasca times. Thus, these line types seem to be another rather early component of the geoglyph complex.

ICONOGRAPHY

Iconography is here discussed only with regard to possible cross-dating of geoglyphs via dated objects from other artifact categories. A direct comparison of iconographic styles requires common motifs on different media. Geoglyphs can be compared mainly to depictions on fineware ceramics and fancy textiles. However, this is true only for a small subset of geoglyphs. Neither trapezoids nor common line types are depicted on Paracas, Nasca, or Wari ceramics or textiles, or at least not in an easily comprehensible way. It is basically the biomorphic figures that have their counterparts on textiles and ceramics.

Head and body of anthropomorphic geoglyphs (Figure 6.14, Figure 9.1, Figure 9.2) are always shown in front view, whereas legs may in some cases be depicted in profile, though this if often difficult to decide due to erosion. The full body variety usually consists of a head with eyes and mouth, a body, and legs. Arms and feet are not always present. Optional features are headdresses (Figure 6.5) and objects held in hands. Headdresses are composed either as concentric rays, or crest shaped headpieces, or combinations of both. The execution is always simple, head and body formed by cleared areas with stone heaps indicating eyes and mouth, while legs and raylike headdresses are shown by lines. The motif, its attributes, and the way it is depicted closely resemble anthropomorphic figures on Paracas Necrópolis textiles (*e.g.*, Paul 1999: figs. 56, 58; Schindler 2000:39, 43, 45). These depictions show considerable more detail than the geoglyphs and help understanding some of their features. Crescent shaped headpieces seem to represent long caps, while raylike features may have been feathered headdresses. Elongated objects held by the figures may represent serpents or some kind of staff. Other figures hold trophy heads in their hand or wear them attached to their belts. The head geoglyph 235 next to the body of geoglyph 234 on site PV67A-40 (Figure 6.14) seems therefore part of the same design. Thus, anthropomorphic geoglyphs closely resemble anthropomorphic depictions on Paracas Necrópolis textiles in motif and style and are therefore likely from that period, which makes them the earliest geoglyphs in the Palpa region.

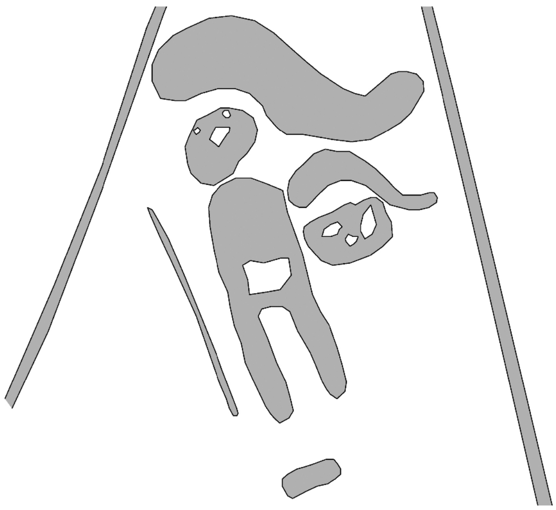

Figure 6.14: Anthropomorphic geoglyphs 239 and 240 on site PV67A-40

Of the two zoomorphic figures on Cresta de Sacramento, a possible bird figure (geoglyph 389 on site PV67A-90, see Figure 9.18) is too heavily destroyed to judge its style. Geoglyph 151 on site PV67A-35, however, is well preserved and only on one end disturbed by later lines (Figure 6.15, Figure 9.7). This figure has usually been identified as a whale. Kosok is the only one to call it "cat-demon" (Kosok 1965: fig. 13). Aveni has argued that better known whale figures on the Nasca *pampa* likely depict sharks rather than whales due to certain anatomic details (Aveni 2000a:199; cp. Schindler 2000:69). This may be true for the Sacramento figure as well since its tail fin is vertical, not horizontal.

Stylistically, the figure is composed of several lines forming a profile view of body, head, and fins. Not only the outline and the eye are formed by lines (the eye center being marked by a small stone heap) like some Nasca *pampa* figures, but the body is also adorned with lines roughly following the body outline. The presence of different lines is at least partially due to a remodeling of the original figure, though the geoglyph never consisted of a single line only. The area below the eye shows several lines that due to later disturbances are not clearly recognizable. Most probably, an open mouth was depicted here. Iconographically, the motif is known as Mythical Killer Whale frequently depicted on, or even plastically modeled in, Nasca ceramics (Eisleb 1977: plate 72; Aveni 2000a: fig. 50b; Wieczorek, Tellenbach eds. 2002:122). The Sacramento figure does not have a protruding arm carrying a trophy head or other objects like many whale figures on Middle Nasca pottery. It rather resembles earlier, more naturalistic depictions. This is confirmed by ceramics found upon it, the earliest of which date to Nasca 2.

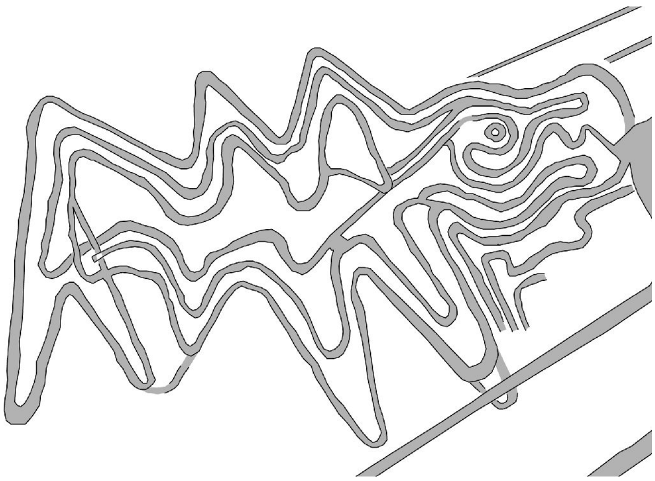

Figure 6.15: Zoomorphic geoglyph 151 on site PV67A-35

STRATIGRAPHY: GEOGLYPHS AND GEOGLYPHS

Geoglyphs affected by later alterations are common in the Palpa area, most of all in complex sites comprising many geoglyphs. Most of this remodeling occurred when a geoglyph was enlarged or built over by another, new geoglyph (Figure 6.16). These processes are discussed in more detail in chapter 6.2.1. Nevertheless, stratigraphic relations between older and younger geoglyphs are usually not easy to define for several reasons:

- the construction technique of geoglyphs often does not allow to discern clearly which stones were moved in the context of which construction activity;
- new geoglyphs were frequently added to existing ones in such a way that older geoglyphs were not, or not completely, built over, but rather incorporated into the ensemble;
- geoglyphs as registered today are often the result of several working steps: lateral enlargements, repeated surface clearing, redrawing on the same spot, etc.

Due to these constraints, stratigraphic relations between different geoglyphs in the Palpa sample could not often be determined unambiguously. Nevertheless, on some of the most complex geoglyph sites on Cresta de Sacramento and Cerro Carapo, the study of stratigraphic relationships resulted in a relatively clear picture of the construction sequence of the geoglyphs. Detailed sequences are presented in appendix 9.1. On many other sites, overlap between two or more geoglyphs could be registered. This information is available in the geoglyph database that accompanies this study on DVD. A review of stratigraphic relations among the Palpa geoglyphs reveals some trends showing that some of the established geoglyph types are chronologically relevant, whereas others are not.

Figure 6.16: Border of trapezoid 188 crossing border of trapezoid 189 on site PV67A-47

On hillsides, straight lines and anthropomorphic figures often occur in close proximity. In the few instances where stratigraphic relations between the two types of geoglyphs can be established (geoglyphs 95/96, 509/514, 574/576), lines always cut through figures. Thus, lines on slopes are tendentially younger than anthropomorphic geoglyphs in similar settings.

Another clear case is the relationship between trapezoids and zigzag lines on plateaus. Both frequently occur together, and wherever this is the case, trapezoids cover lines (*e.g.* geoglyphs 81/78, 189/183, 591/616). At first glance, the true sequence often does not reveal itself easily, though, since in most cases the heaped borders of trapezoids do not cross lines but have gaps, so that the line seems to cut through the border. However, upon careful examination it becomes clear that the border of the trapezoid was intentionally left discontinuous when covering parts of the zigzag in order to allow access to the line during the building process (see chapter 6.3), while remnants of the largely removed original borders of the line within the trapezoid clearly indicate posteriority of the latter.

Meandering lines flanking geoglyphs are another case where a recurrent stratigraphic relation can be observed. Wherever a geoglyph flanked by a parallel meandering line was enlarged laterally, the meandering line was partially covered (*e.g.* geoglyphs 109/110, 480/481). The reverse case has nowhere been registered. However, unlike zigzag lines, meandering lines are frequently oriented parallel to trapezoids, and both seem to have been constructed as part of a larger complex. Also, the subsequent partial covering by the trapezoid often left large parts of the meandering line intact. Thus, though stratigraphically earlier, meandering lines seem frequently to have functioned together with trapezoids.

Straight lines, though usually among the earliest geoglyphs on their respective sites, tend to occur during all phases of the construction sequence of geoglyph complexes, which is also indicated by associated finds. A similar stratigraphic tendency is evident in the case of trapezoids, though again, as already indicated by ceramics, with a slightly later component: they usually are not the first geoglyph in a given complex, but on several occasions the last one.

All in all, recurrent stratigraphic relations between geoglyphs pertaining to different types in the Palpa sample seem to indicate that anthropomorphic figures are earlier than straight lines and zigzag lines earlier than trapezoids, whereas meandering lines, though often partially covered by trapezoids, rather seem to be contemporaneous with those. Stratigraphy further corroborates that straight lines and trapezoids were made during all phases. No other general trend can be deduced from stratigraphic relationships observed in the Palpa sample.

Summary: Typochronology

Unfortunately, the most frequent geoglyph type, the straight line, bears no chronological relevance since it covers the whole time span of the geoglyph phenomenon. A similar case is the second frequent type, the trapezoid, although some trapezoids are among the latest registered geoglyphs. In general, geoglyph variety was greatest in Early Nasca times, when all kinds of geoglyphs were made and used. Anthropomorphic figures, probably the earliest geoglyphs, were common apparently up to Early Nasca, when spirals, biomorphic figures, and different line types coexisted with trapezoids and rectangles. Later, in Middle Nasca times diversity was reduced to certain line types (straight, U-shaped, meandering) alongside trapezoids and rectangles. By Late Nasca times, only straight lines and large areal geoglyphs had survived. Thus, straight lines and trapezoids were not only the most common types throughout all phases of the geoglyph phenomenon, but represented also the quasi standard to which the geoglyph repertoire was finally reduced towards the end of the geoglyph phenomenon.

6.2.3 Summary: geoglyph chronology and cultural affiliation

The earliest geoglyphs in the Palpa sample are anthropomorphic figures, both in terms of relative and absolute chronology. Their style and motifs clearly indicate an Early Horizon origin, probably dating to Late Paracas. It is interesting to note that all these early geoglyphs are located on hillsides. This is also where petroglyphs can be found. Contrary to Clarkson's statement that in the Nasca region there are no adequate sites for rock art close to geoglyphs (Clarkson 1996:435), in the valleys of Palpa there are many single large boulders on slopes and in *quebradas* covered with engravings (circles, anthropomorphic and zoomorphic figures) presumably from Paracas times. Hence, petroglyphs and earliest geoglyphs are not only similar with regard to their motifs and iconography, but also share the same settings in the landscape. Thus, it seems likely that geoglyphs developed out of petroglyphs by transferring common motifs from one medium to another one close-by.

The first geometric geoglyphs (straight lines and trapezoids) were also created in Late Paracas times. It is to assume that this new, formally distinct development also originated on slopes, *i.e.* in the setting where the first geoglyphs were created. Maybe the possibilities of the new medium fostered the experimentation with new forms and motifs.

The first geoglyphs on plateaus date to Initial Nasca times. Geoglyphs on plateaus are thus slightly later than those on slopes, though geoglyphs in both settings occur together during most stages. On the plateaus with their new possibilities regarding accessibility and available space, the geoglyph phenomenon reached its peak in Early Nasca times. A wide variety of geoglyphs was created during this phase, out of which biomorphic figures, spirals, and zigzag lines seem more frequent than in earlier or later phases. Straight lines, trapezoids, and meandering lines were also created in Early Nasca times. These latter types, however, became more prominent in Middle and Late Nasca times. By then, apparently no more biomorphic figures and spirals were created. All in all, formal variety decreased towards the end of the geoglyph tradition, with only some types out of the geometric class surviving till the end. The latest evidence of geoglyph related activity was registered on large trapezoids during the early stages of the Middle Horizon. However, there is no clear indication of new geoglyphs still being added by then.

Concerning geoglyph dating in general, although many detailed information on the chronological placement of geoglyphs could be given in this subchapter, it is still not possible to date a geoglyph unambiguously only on the basis of what is visible in the field. Generally, only tendential statements seem possible. Clearly, there is need for reliable methods of scientific datings of geoglyphs, the results of which may then become transferable to similar geoglyphs once a representative number of datings becomes available. It is hoped that the attempts to date Palpa geoglyphs using OSL will help advancing geoglyph chronology.

6.3 Activity related to geoglyphs

As discussed in chapter 3, the material nature of the archaeological record allows to a certain degree the reconstruction of recurrent activities that led to its formation. Such activities on geoglyphs are one of the few aspects where the Andean model can be directly confronted with archaeological data. Therefore, a careful review of data on activity related to Palpa geoglyphs will be undertaken in this subchapter.

6.3.1 Geoglyph creation, remodeling, and maintenance

The first activity related to geoglyphs that can be identified unambiguously in the archaeological record is their creation. At least 639 geoglyphs have been created on Cresta de Sacramento, Cerro Carapo, and around La Muña in the course of time, implying a considerable amount of labor investment. Out of the whole sample, 15 geoglyphs seem to have remained unfinished,[24] while the evidence is less clear in several additional cases. All apparently incomplete geoglyphs pertain to the areal group. These geoglyphs in various stages of completion allow a detailed reconstruction of their construction process. This, in turn, allows conclusions on the way the work was organized, and the different social groups involved.

24 Geoglyphs 6, 33, 77, 89, 103, 126, 160, 168, 198, 214, 297, 366, 492, 605 and 632.

Figure 6.17: Unfinished trapezoid 33 on site PV66-73 (cp. Figure 6.6)

Common features of presumably unfinished areal geoglyphs (most of them trapezoids) are: precisely marked yet unfinished outlines, partly uncleared interior spaces, and small stone heaps dotting areas where the clearing process was abandoned before completion. Geoglyph 33 on site PV66-73 is a typical specimen of a presumably unfinished trapezoid and will therefore be described in detail here. It was laid out at the end of the dry valley leading in northeastern direction from Los Molinos. Close to the *tumi* figure (31), trapezoid 33 occupies a depression between two low hills (Figure 6.6, Figure 6.17). Only its wide base is clearly defined, comprising borders, marked by heaped stones and a cleared interior. The borders are not very high, however, and only the interior area close to them is clear of stones, while further towards the center, many small stone piles dot the partially cleared interior. Towards the upper, narrow end, the heaped borders end after approx. one third of the originally planned trapezoid length. The rest of the outline is marked merely by middle-sized stones driven into the ground at varying distances in an upright position. The interior is cleared only along the heaped stretches of the borders, whereas the upper two thirds of the geoglyph interior consist of the original, unaltered desert pavement.

The evidence suggests the following construction process:

- Once a place for the future geoglyph had been chosen and its shape determined, its entire outline was marked with upright stones several meters apart from each other.

- Starting on the wide base, this outline was then marked by a continuous row of small stones picked up for that purpose along the interior side of the future border, from a narrow strip less than a meter in width. This initial border was evenly straight.
- While border marking was still in progress, clearing of the interior area started again near the wide end of the future trapezoid. Stones of the desert pavement were accumulated on small piles at a distance of less than 1 m from each other. Apparently, stones in easy reach from a crouched position were gathered before starting the next pile.
- Once a certain amount of stone piles had been accumulated, they were then removed and transported to the geoglyph border. There, the stones were piled up onto the already marked border, making it higher, wider, and more irregular. The latter fact suggests that the stones were simply dumped onto the border from some kind of container.

Of these four steps, the first one – geoglyph outlining – had to be accomplished prior to the other three steps, which were at least partially conducted simultaneously. The first step was furthermore distinct from the other steps by different requirements. Before a future geoglyph could be traced on the ground, it had to be decided where to place it and what shape to give it. This required not only knowledge of the concepts underlying the geoglyph phenomenon, but also the authority to make such a decision. Furthermore, groups of people had then to be motivated in some way to carry out the actual construction of the geoglyph. These requirements point towards specialists with special knowledge and authority who conducted the initial step in geoglyph creation.

The remaining working steps required mainly coordinated group labor in order to convert the blueprint defined in the first step into a real geoglyph. While some people would make their way along the geoglyph borders marking them with straight lines of stones, the majority of people involved would pile up stones in the interior and remove them in order to accumulate them on the already marked borders. This work did not require special skills and involved on the technical side basically the use of some some kind of container to transport stones to geoglyph borders. It is to assume that this work was accomplished by non-specialists, possibly guided or organized by the specialists responsible for the first step in the working process.

This reconstruction of the construction process of geoglyph 33 is in concordance with what can be observed at other presumably unfinished areal geoglyphs and seems typical for the construction of areal geoglyphs in general. Concerning other types of geoglyphs, no evidence of unfinished lineal or descriptive geoglyphs has been observed, or recognized as such, in Palpa. This might be due to the fact that many endpoints of lines, especially on slopes, are totally eroded, and hardly any original line endpoint could clearly be identified as such in the Palpa sample. Thus, due to their state of preservation and the fact that the construction of lineal geoglyphs did not involve easy recognizable stone piles, evidence of unfinished lines may be present, but unrecognizable. The same is true for anthropomorphic figures, of which no apparently unfinished specimens were recorded in Palpa. It seems clear, however, that the head variety is not just an unfinished version of the full body variety, because else one would expect to find headless torsi as well. All in all, for other geoglyph types than the areal one there is no clear evidence as for their construction process.

Returning to areal geoglyphs, there are other observations that allow further insights into their construction process. This work apparently did not end once an area with heaped borders had been cleared. Instead, many geoglyphs were enlarged, remodeled, or otherwise altered after their initial creation, sometimes more than once. For example, trapezoids 81, 109, and 411, as well as several other geoglyphs, were laterally enlarged, as indicated by old, only partially removed former lateral borders in their interior. In some instances, *e.g.* geoglyphs 109 and 480, straight sections of lateral meandering lines were covered in this process. The meandering lines 55 and 56, together forming one of the longest line complexes accompanying a trapezoid (in this case geoglyph 52), were converted into a huge rectangle (57) by clearing the surface between the lines. The whale figure (151) was altered on several occasions and included in its final stage many different line elements (Figure 6.15). A special case is the S-shaped double spiral (206/207) on site PV67A-47 (Figure 9.8, Figure 9.10) whose shape was not suitable for enlargement. Instead, the spiral was redrawn on the same spot, obliterating the original design without taking into consideration that the discernibility on the ground was that way greatly affected. Hence, apparently completed geoglyphs could be remodeled, so that the terms “finished” or “unfinished” may be inappropriate. Rather, there seems to have been a kind of constant construction process on geoglyph sites.

This result is consistent with other observations from geoglyph sites in the Palpa region indicating that the creation of a geoglyph was a rather slow process. Calculations based on empirical data to assess the labor investment required to create a geoglyph (*e.g.* Hawkins 1974:120; Aveni 1990a:25) suggest that less time and manpower was necessary than an uninitiated observer would expect. Yet these calculations, though not wrong, may be misleading. The implicit assumption seems to be that a geoglyph was created in an efficient, continuous process without major breaks. Evidence from the Palpa geoglyphs, however, suggests that the creation of a new geoglyph lasted longer than technically necessary. On several sites (*e.g.* PV66-99 and PV67A-22) new areal geoglyphs were created covering older, lineal ones. In these cases, the original lines were thoroughly kept free of stone piles. Furthermore, heaped borders of new geoglyphs did not simply cross the older line, but were rather accumulated such that the original line was meticulously kept open and thus accessible. Had the line be replaced by the areal geoglyph in an uninterrupted, fast working process, there would have been no need to keep it accessible during the working process. This indicates that the process of constructing the new geoglyph lasted a certain lapse of time during which the use of the original line, which presumably involved walking along its course (see below), continued. Thus, there was no continuous, fast construction process, at least in the case of areal geoglyphs. Rather, construction as well as other geoglyphs related activity occurred together or alternately.

This is true on the site level as well. Geoglyphs usually occur in complexes, not isolated from each other, and once a geoglyph had been created on a certain spot, new geoglyphs were frequently added, either next to the original one or crossing or even partially covering it (see appendix 9.1). Some geoglyph sites grew considerably over time, with the original geoglyphs often largely obliterated at the end of this long construction process. This observation further strengthens the impression of a long lasting, nearly constant construction activity on geoglyph sites. Within this process, the geoglyph site always incorporated what seem to be completed, remodeled, and incomplete geoglyphs in various combinations. It is interesting to note in this context that apparently unfinished trapezoids are not necessarily the latest geoglyphs on their respective sites. For instance, geoglyph 214 on site PV67A-47, an unfinished areal geoglyph, is partially covered by the later (completed) trapezoid 188 (Figure 9.10, see appendix 9.1.2). Furthermore, some geoglyphs, though not entirely cleared (*i.e.* with some remaining, unremoved stone piles on the on the otherwise cleared surface), show clear signs of having been walked over just like finished geoglyphs. Thus, incomplete trapezoids do not seem to mark the abrupt end of the geoglyph tradition as previously assumed (Silverman, Browne 1991:218; Silverman, Proulx 2002:282). Rather, it seems that no geoglyph could ever be considered finished: it could be used in some way or another even before it was entirely outlined, and vice versa it could be remodeled after its initial use. The long duration of geoglyph construction implies implies that different people were involved on different occasions over time.

During the construction process, other activities occurred on the geoglyphs as well. Hence, the distinction between construction and use of geoglyphs may be misleading. Rather, it seems that both were part of a single activity complex, which may also have included geoglyph maintenance. It has been suggested that geoglyphs were kept clean by sweeping them in regular intervals (Urton 1990). According to Urton, this would have allowed social groups to interact and negotiate their status. Whatever the social function, the traceable result of such an activity would be a higher find density outside the geoglyphs than in their interior. On the Palpa geoglyphs, find density indeed tends to be higher on, or close to, geoglyph borders. This evidence, however, is not necessarily the result of sweeping the geoglyph interior. Another possible explanation would be that fragments removed from the original surface during geoglyph construction may have been heaped along the borders, just like removed stones. Furthermore, heaped borders seem to have been favored places for depositing whole vessels, since many finds on borders pertain to partially reconstructible vessels. Thus, there is no clear hint that geoglyphs were swept on a regular base. A further argument against such a procedure is a practical one: the exposed sandy layer that formed the cleared interior surface of a trapezoid was not suitable for sweeping, since it was not hard enough (which does not exclude other means of geoglyph cleaning, like picking waste materials from the surface). The case is different on lines, though. Lineal geoglyphs on plateaus generally show clear signs of compaction of the exposed sandy layer. This leads to the next identifiable activity on the geoglyphs, which is walking on them.

6.3.2 Walking on geoglyphs

In the Palpa sample, most lineal geoglyphs on flat terrain show clear indications of having been walked on regularly. The exposed sandy layer, on the trapezoids often composed of rather loose material, is heavily compacted on many lines, forming shallow depressions. This can be observed on all types of lines on flat terrain that are rather narrow and therefore predefine the walker's path. Lines in straight, U-shaped, zigzag, meandering, and spiral shape were likewise walked on. The evidence is less clear in the case of wide lines and even less on areal geoglyphs. Both do not offer predefined pathways, so movements over them may have been rather evenly distributed, leaving less traces. The uncompacted, exposed sandy layer of a trapezoid or a wide line remains stable in spite of prevailing winds due to air humidity, which causes the formation of a thin crust on the surface. Such a process, however, requires a long time period without disturbance. Human activity on trapezoids and similar geoglyphs obviously was not intense enough to compact the whole surface regularly, yet has taken place without doubt, as the presence of finds clearly indicates. Activities on geoglyphs that involved the movement of a large number of people over the surface of areal geoglyphs are likely to have taken place in a cloud of dust. The only clear evidence of compaction on trapezoids is found near stone platforms (see appendix 9.2.2). All in all, there is evidence of people walking regularly over cleared spaces on lines and on certain parts of trapezoids on flat terrain.

The situation is different on hillsides. Geoglyphs on sloped terrain, though often sharing common shapes with their plateau counterparts, are often not suitable for walking on or nearby them due to steep, stone covered, or sandy terrain. Lines on slopes are often furrowed and do not lend themselves for walking on them. The fact that most of them are heavily eroded indicates that their interior surface was not compacted. Trapezoids on slopes are often easier to walk on, but are equally difficult to access over sloping, stone covered terrain. The same is true for anthropomorphic figures. Both of them seem not suitable for walking on or nearby them. As mentioned earlier, this is corroborated by the fact that geoglyphs on slopes, especially anthropomorphic figures, have much less ceramics on them than geoglyphs on plateaus (see following subchapter). Thus, there is a functional difference between geoglyphs on slopes and those on flat terrain (plateaus or *quebrada* floors), with walking mainly occurring on the latter ones, even though their shapes are similar.

6.3.3 Vessel deposition

As mentioned in chapter 6.2.1, finds registered on geoglyph sites are not necessarily related to geoglyphs. Rather, *a priori* it is unknown how much time elapsed between the creation of a geoglyph and the deposition, whether intentional or not, of a find upon it. However, apart from some inter-valley footpaths and LIP settlements restricted to well defined areas, geoglyphs are the only clear indicators of human presence out in the desert. It is therefore plausible to assume that finds found on or nearby them are in some way related to them, and all the more so if there is a recurrent pattern of geoglyphs and certain artifact categories occurring together.

This is the case with ceramic fragments, which make up the vast majority of surface finds registered on the Palpa geoglyphs (Figure 6.8, Figure 6.12, Figure 6.18). Other artifact categories occurring in very low numbers (< 10 each on 639 geoglyphs) include stone tools (chert and obsidian blades), weights of spindle whorls, and textile fragments. Their association with geoglyphs is less clear. Further categories of materials not registered on open geoglyph surfaces have been recovered from excavated stones structures built upon geoglyphs. These are mentioned in appendix 9.2. The following discussion will focus on ceramics, by far the most important find category.

Figure 6.18: Broken Nasca vessel found on site PV67B-55

On the geoglyphs of Sacramento, Carapo, and La Muña, pottery has been found only in fragments, never as whole vessels. There are, however, dense clusters of sherds pertaining to single vessels that could largely be reconstructed in several instances. These vessels seem to have been intentionally broken, or smashed, on the spot where they are found. Others may simply have been deposited unbroken and were damaged later. Findspots of fragmented vessels have been registered in different settings, but the majority is located close to, or on, heaped borders of lineal geoglyphs (*e.g.* geoglyphs 101, 157, 603), at bending points of zigzag or meandering lines (*e.g.* 319), as well as along heaped borders of trapezoids, usually closer to the wide base than to the narrow end (*e.g.* 88, 284, 480). Further findspots, often several close to each other, have been registered in between lines of larger geoglyph complexes (*e.g.* close to lines 144, 164, 643). Thus, intentionally deposited vessels tend to occur in the same setting where there are also the clearest indications of walking on geoglyphs: on lines and near wide ends of trapezoids. Both kinds of activity seem thus closely related.

The remainder of fragments registered during fieldwork are isolated sherds scattered over the surface. Although find density varies, and no order is easily recognizable, these isolated sherds tend to occur more frequently along heaped borders of geoglyphs or around stone structures upon them (*e.g.* geoglyphs 1, 43, 113, 468, 540). While the origin of these finds is difficult to explain, they are unlikely to have been deposited intentionally.

Due to technical constraints explained earlier, no quantitative information is available on the composition of the ceramic sample on the Palpa geoglyphs concerning vessel decoration and shape. The overall impression from fieldwork is that painted fineware ceramics are present in only slightly higher percentages than plainware ceramics. Fineware ceramics comprise plates, bowls, goblets, vases, as well as – in lesser frequency – head jars and double-spout-and-bridge bottles. No ceramic musical instruments were found or recognized as such. The percentage of open fineware vessels is much higher than that of closed vessels. For plainware ceramics, however, this ratio is reversed, with large jars predominating.

No vessel recovered on the desert surface contained recognizable remains of its potential former content. This is either due to their fragmented state, or vessels did not contain anything when deposited. Considering potential vessel function based on shape, fineware ceramics found on geoglyphs were mainly suitable for serving and consuming food. Plainware ceramics, on the other hand, were suitable for preparing food and transporting it to the geoglyphs. Thus, there is indirect evidence hinting at food consumption and deposition on geoglyph sites.

All in all, as far as geoglyph related activity is concerned, artifacts found on geoglyphs evidence vessel deposition, apparently involving vessel smashing. Furthermore, they indicate food consumption and deposition. Further activity deduced from artifacts recovered during excavations of stone structures on geoglyphs is discussed in the following subchapter.

6.3.4 Construction and use of stone structures on geoglyphs

Construction activity on geoglyph sites comprised not only geoglyphs, but also stone structures associated with them. Several of them were excavated on Cresta de Sacramento and Cerro Carapo. While detailed descriptions of the structures excavated on sites PV67A-16, -35, -47, -62, -80, and -90 are presented in appendix 9.2, the main characteristics of these stone structures are summarized in the following. Two types can be distinguished.

Firstly, there are low, narrow, elongated, platform-like stone structures that are in most cases located along the wide end of a trapezoid or on the edge of a plateau marking the upper end of a line on the slope (Figure 6.19).

Figure 6.19: Stone platform on site PV67A-47 overlooking site PV67A-39

These low platforms are constructed in a simple way, without mortar, using stones of the desert pavement that were removed during the clearing of a new geoglyph. Larger stones were put in the ground in upright position, forming a retaining wall that was then refilled with smaller stones. Only rarely do these platforms have a second row of stones. Many show internal subdivisions, or chambers. Most platforms are 1 - 1.2 m wide and 0.3 - 0.4 m high, while the length varies from 1 m up to 42 m. Several of these platforms have lateral chambers. Some platforms bend or show other irregularities, mostly where chambers abut. This suggests that these platforms were often not constructed in one process, but in several steps. Thus, they are clearly related to geoglyph construction: the materials used to build these structures come from the geoglyphs, and like them their building process seems to have been discontinuous in some cases. Concerning finds, there is no clear evidence of objects deposited on this kind of platforms, though find density is tendentially higher around them than elsewhere.

Figure 6.20: Pair of rectangular stone structures on site PV67A-80

Secondly, there are stone structures inside cleared areas of trapezoids and rectangles, located in a central position between the lateral borders close to one end of the geoglyph. Typically, a pair of two structures is located close to the narrow end (Figure 6.20), while a single structure is placed on the wide end. Variations of this archetype occur frequently. These structures have been looted almost without exception and therefore at first glance give the impression of simple, round stone cairns with a depression in the center. However, all but one structures excavated on Cresta de Sacramento and Cerro Carapo consisted of carefully constructed stone buildings. While some of them formed walled, accessible enclosures in a first building phase, all of them assumed the shape of platforms at least in their latest building phase. The majority of platforms were rectangular in shape, with a retaining wall of large stones or slaps, mostly just one row high, containing a stone fill. Mud mortar or *adobe* bricks were rarely used in both the outer walls and the interior fill. Several of these structures showed different construction phases or later additions. In most cases, the upper surface was not well enough preserved to know how the interior fill was covered, but it was presumably sealed by a mud layer. Among the debris covering the platforms, a variety of materials were recovered that were likely deposited on the platform surface. These include ceramic vessels, *Spondylus* seashells (whole shells, fragments, and fragments worked into pendants, see Figure 6.21), maize cobs, some of them wrapped in cloths, crawfishes, and chrysocole fragments.

Figure 6.21: Objects found on stone structures on site PV67A-22

In some cases, the structures were associated with wooden posts, either groups of small ones, or thick, large ones that presumably stood alone. Below some of these posts, well preserved guinea pigs were found, apparently placed there as offering. Single, high wooden posts placed on trapezoids on flat terrain had the property of being visible from far away. It is not known which height these posts actually reached nor if anything was attached to them. In any case they must have been visible from far away. Power poles erected on Cresta de Sacramento in recent years, though probably higher than the ancient posts, are visible along the whole ridge and even across the valley from Pampa de San Ignacio. Thus, ancient wooden posts could have served people moving through, or into, the desert zone as orientation, indicating the location of geoglyphs and stone structures.

Concerning the context of the stone structures, although they are clearly associated with the trapezoids they are found on, evidence from datable finds suggests that some of them may have been constructed considerably later than the geoglyph they are standing on. Others are clearly located in such a position that they could have been built only after enlarging the original geoglyph. Thus, these stone structures indicate a long-term use of the geoglyph after its initial construction. There is some evidence that platforms may have been intentionally covered after their abandonment. All in all, evidence from stone platforms indicates that activity related to them covered a considerable time span, including initial construction, remodeling, repeated use as place for deposits, and maybe covering at the time of abandonment.

6.3.5 Summary: activity related to geoglyphs

For the following kinds of activity, direct evidence could be found on the geoglyphs of Sacramento, Carapo and La Muña:

- construction and remodeling of geoglyphs and stone structures,
- walking on lineal geoglyphs and around stone structures on areal geoglyphs,
- deposition (including smashing) of pots on or along borders of lines and trapezoids,
- deposition of vessels, field crops, *Spondylus* shells, and other objects on stone structures,
- erection of high wooden posts on areal geoglyphs close to stone structures, occasionally accompanied by placing of offerings in the excavated pit.

Indirect or ambiguous evidence was observed for:

- food consumption and deposition,
- cleaning and maintenance of geoglyphs,
- covering of stone structures at the end of their use.

The high degree of integration of various activities has already been emphasized. Construction and use of geoglyphs and associated structures were not neatly separated, but rather aspects of an integrated complex. Available evidence suggests that many groups of people were involved in geoglyph related activity over a long period of time. The construction, remodeling, and maintenance of geoglyphs, *i.e.* the part of the activity complex which required most labor investment, was probably carried out by non-specialists. Thus, large percentages of the ancient population of the Palpa region may have participated in some way or another in geoglyph related activity. The activity complex seems designed so as to involve as many people as possible, though not necessarily in large groups. Activity was clearly initiated by specialists sharing common concepts and specialized knowledge. This is indicated by the relative uniformity, or only gradual change, of geoglyph (and stone structure) shape and construction technique over time and space.

The many breaks in the construction of a geoglyph, and the number of people involved, may explain why some geoglyphs were left in an apparently unfinished state after some initial work had been carried out: differently composed groups of people working on the geoglyph in successive construction stages, or other kinds of changing circumstances, may have brought about a preference for starting a new geoglyph rather than continuing to work on an existing one. The successive working steps in the construction of a trapezoid may further become manifest in different chambers of associated elongated platforms. The construction of different chambers at different times by different people, each group setting some stones apart to be used for the platform, may account for the irregularities in some of theses structures.

The possible consumption of food and drinks may have been related to geoglyph construction (which would explain the many isolated sherds of plain- and fineware ceramics), but also to activity related to stone structures and vessel deposition. Walking along lineal geoglyphs involved the deposition of ceramic vessels along geoglyph borders, either intact or broken. These vessels may have contained food or beverages. Geoglyph walking was a repetitive activity, as clearly indicated by the heavy compaction of line surfaces. It must have included many people, though again not necessarily at the same time. Similar movements may have taken place on trapezoids, although there is no clear evidence for frequent gatherings of very large groups of people.

The above summarized evidence for geoglyph related activity refers mainly to geoglyphs on plateaus. On slopes, there is little evidence for any kind of activity after the initial construction of a geoglyph, though some deposited vessels have been found along lines on slopes, too. The degree to which this divergent picture is due to different conditions of preservation on plateaus and hillsides, respectively, is difficult to assess.

6.4 Geoglyph setting and order

On Cresta de Sacramento, Cerro Carapo, and around La Muña, geoglyphs are located in many different settings with regard to topography and settlement patterns. A study of the internal order of geoglyphs in complex sites, as well as the external order of geoglyph sites in their environment reveals certain criteria that were apparently important for geoglyph placement.

6.4.1 Order on the site level

Though geoglyph complexes often seem a mess at first glance, and each one is composed of different elements, there is an inherent order recognizable to a certain degree. On several sites, the same types of geoglyphs are found together in the same construction sequence.

On sites PV67A-47 (Figure 9.8, Figure 9.10) and PV67B-55 (Figure 9.11, Figure 9.12) a zig-zag-line is covered by a trapezoid (geoglyphs 183/188 and 616/591, respectively). On site PV67A-15 (Figure 9.24) a meandering line (55) is crossed on one end by the narrow end of an obliquely collocated trapezoid (52). Both situations coincide on site PV67A-22 (Figure 6.22). Here, a zig-zag-line (78) is partially covered by a meandering line (76), which in turn is crossed by an oblique trapezoid (81), the main body of which covers also a part of the zig-zag. Thus, three frequent types in the Palpa geoglyph repertoire occur together on several occasions in the same construction sequence: zigzag line, meandering line, and trapezoid.

Other combinations observed on more than one site are:

- a trapezoid flanked by parallel straight or meandering lines – probably the most frequent combination (observed *e.g.* on sites PV66-72, PV66-86, PV67A-40),
- a trapezoid accompanied by a spiral, which may or may not be framed by a wide-angled U-shaped line (observed *e.g.* on sites PV67A-47, PV67A-80, and PV67A-32, where the now destroyed spiral is still visible in old aerial images),
- straight lines crossing each other or branching off from another straight line (observed *e.g.* on sites PV67A-23, PV67A-32, PV67A-40).

On all mentioned sites, there are additional geoglyphs of varying number and kind, making each site a unique complex, but some patterning clearly does exist. The combination and sequence of geoglyphs may have been determined by a prescribed kind of activity carried out upon them that necessarily required certain geoglyph types. Changes in the composition of these complexes – *e.g.*, the addition of an areal geoglyph to lineal ones – may have been due to changes in the rules that guided these activities. As indicated by stratigraphic and other chronological evidence, zigzag and meandering lines are tendentially earlier than trapezoids. They served for walking and vessel deposition and initially apparently functioned alone. The later addition of a trapezoid to the complex (which did not put an end to walking on lines) may have been due to new, or additional, kinds of activity effectuated on the geoglyphs. Though these also included vessel deposition, it is not clear what other activities were carried out on trapezoids. In any case not all of them were related to stone structures, since many trapezoids did not have any, and even those on which stone structures were built later had initially functioned without.

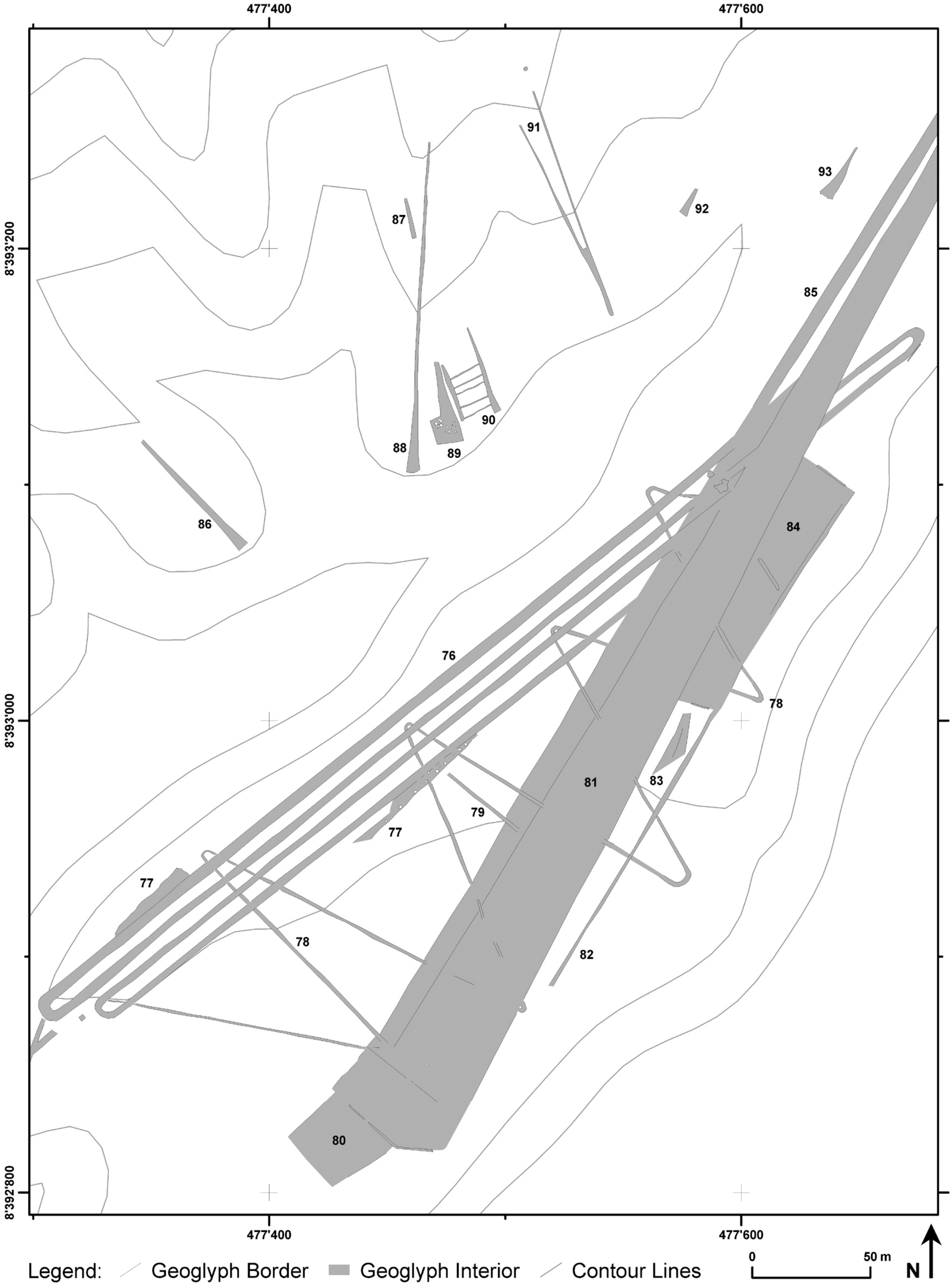

Figure 6.22: Geoglyph site PV67A-22 on Cresta de Sacramento

In any case, the composition of geoglyph complexes followed at least in part certain rules. These seem to have been stuck to even though the formation of geoglyph sites and complexes lasted a considerable time. This confirms the notion of stable, only gradually changing concepts and notions underlying the whole process, shared by specialists who preserved their knowledge over time.

Certain types of geoglyphs seem to follow certain rules with regard to local topography as well. It has already been mentioned that anthropomorphic geoglyphs have only been registered on sloped terrain, while all zoomorphic figures occupy flat terrain just like zigzag lines. Lines on hillsides are in most cases oriented along the slope direction (*e.g.* on minor ridges), although a minority of lines clearly crosscut these given directions (Figure 9.1, Figure 9.2). Concerning trapezoids, the vast majority of them, whether on slopes or on plateaus, has its wide base on a lower level than its narrow, open end. There are, however, exceptions from this rule, *e.g.* on site PV67A-89 where the original NE-SW oriented trapezoid 351 was later partially covered by the SW-NE oriented trapezoid 350 (Figure 9.18). The precise orientation of areal geoglyphs seems mainly determined by efforts to make the best possible use of the given terrain. This is especially evident where large geoglyphs were added to complexes that already comprised many geoglyphs, like trapezoid 188 on site PV67A-47 (Figure 9.10) and rectangle 591 on site PV67B-55 (Figure 9.11, Figure 9.12). Both were oriented such that the last remaining large portions of free surface were used for the new geoglyphs, although many old ones were at least partially covered in the process.

Summarizing the available evidence, it is obvious that when new geoglyphs were added to existing complexes, certain rules guided the choice of shape and place for the new ones. Existing geoglyphs were often incorporated into the new design and continued in use. This did not prevent them from being partially covered in many instances. Such changes, however, were anyway the common fate of most geoglyphs.

6.4.2 Order on the regional level

All major plateaus in the study area are nowadays densely covered by geoglyphs, so that a search for distribution patterns may seem futile at first glance. However, a chronological distinction reveals preferences for certain locations through time. This is especially evident when compared to contemporary site distribution patterns.

GEOGLYPH DISTRIBUTION PATTERNS AND ACCESSIBILITY THROUGH TIME

Geoglyphs were located in an environment that was used neither for habitation nor for agricultural or other production purposes. The question is how this territory was organized. In order to study geoglyph distribution through time and potential relationships between geoglyphs and contemporary settlements, distribution maps comprising also potential access routes were generated for each time period (Maps 7-16 in the supplement). Three datasets were combined on these maps:

- Sites: Data on site distribution and cultural affiliation is based on results of a regional settlement survey conducted from 1997 to 2003 by Johny Isla in the framework of the Nasca-Palpa project. Survey data is still under study and will be published elsewhere. For the present study, a preliminary site database was available. Time constraints only permitted to consider site location and cultural affiliation (based on dated artifacts), whereas type (settlements, cemeteries, geoglyph sites, etc.) and rank could not be considered here. All sites on which ceramics from a certain time period were found are symbolized by triangles on the respective maps. Thus, every triangle generally indicates some kind of human activity during a certain time period, yet not necessarily a settlement in the heyday of its development.[25]
- Geoglyphs: All geoglyphs on which ceramics of a certain phase were found are shown in black. The geoglyphs have been compiled by querying the database for finds on geoglyphs per phase. Since on only 41.3 % of the Palpa geoglyphs datable ceramics were found (see chapter 6.2.2), the selection of geoglyphs displayed on the maps is necessarily incomplete. It is to assume that during every given time period there where more geoglyphs in use than shown on the maps, among them additional geoglyphs constructed during that time as well as older ones still being used.
- Access routes: Potential access routes to geoglyph complexes are shown on the maps as dark lines leading from sites to contemporary geoglyphs. These routes were calculated as least cost pathways using the cost surface tool implemented in ArcMap 8.3. Since potential paths lead mainly through a desert environment without vegetation, slope degree was considered the main factor in determining direction of movement. It was

25 Discrepancies between site data as presented here and in a preliminary report (Reindel et al. 1999) are due to different stages of analysis. Furthermore, site numbering has since been changed from an internal system to the "Peru valley" system (PV66: Río Grande, PV67A: Río Palpa, PV67B: Río Viscas; with site numbers ascending from coast to highlands).

derived from the existing DTM of the Palpa area[26] and used to calculate a cost surface (van Leusen 1999; Wheatley, Gillings 2002:151ff). The effort necessary to cross a terrain cell was calculated using the formula $C = e^S$, with C being the cost and S the slope degree in radiant. The exponential function ensured that the steepest parts of the terrain would not be crossed by the derived pathway. Once the cost surface had been generated, a cost weighted surface was calculated as grid, depending on the predetermined starting point of a potential access route. Furthermore, a direction grid was generated showing for each cell the easiest direction to get to the starting point. A least cost pathway was then calculated from these grids, aiming at a minimization of the required effort to get from starting to end point. The resulting pathways are determined by economic considerations without taking into account cultural parameters. It is not known if any of these routes were ever actually chosen by people living during the corresponding time periods. Nevertheless, as potential access routes they serve the purpose of illustrating the spatial interdependency of geoglyphs and other sites.

The resulting maps have to be assessed with caution, since each dataset introduces certain biases. None the less, certain trends in geoglyph distribution are clearly evident when compared to the settlement history of the study region as summarized in an earlier report (Reindel et al. 1999). In the following discussion, dating and duration of time periods are given according to preliminary results obtained by the Nasca-Palpa project. They will probably be subject to readjustment once more chronometric datings become available.

All phases of the Early Horizon (Map 7) are here lumped together since at least for the geoglyphs there is not enough data available to distinguish individual phases. However, judging from registered finds, most sites and geoglyphs date to the late Early Horizon (approx. 400 - 200 BC). Sites from this time period agglomerate on the foothills of Cerro Pinchango on the right bank of Río Palpa. Few sites are located on Cresta de Sacramento proper, usually not directly along the margins of arable land but slightly further uphill. Geoglyphs from this time do not correlate with the site distribution pattern since they are located on the lower part of Cresta de Sacramento. Consequently, relatively large distances had to be covered to reach a geoglyph site from a contemporary settlement, at least when compared to later phases. No geoglyphs are located close

26 Slope degree was calculated for a DTM with 10 m mesh size. The best available DTM resolution (2 m meshsize) was not used since test showed that too small a cell size lead to unreasonable small-scale twists and turns of the resulting least-cost pathway in flat terrain, so that some degree of generalization seemed appropriate. Furthermore, the time required to calculate the cost surface could that way be reduced considerably.

to the densest concentration of sites. Thus, geoglyphs dating to the Early Horizon were located in rather remote locations from contemporary sites.

This picture changes only gradually during Initial Nasca times (approx. 200 - 1 BC; Map 8), although site density increases considerably. Sites now dot most part of the valley margins, except for some stretches of the lower left bank of Río Grande, and some initial activity is evident on more elevated parts of the ridge. During this time, geoglyphs continue to occupy mainly sites on the middle and lower parts of Cresta de Sacramento. For the first time geoglyphs are placed in remote locations on the foothills of Cerro Pinchango as well as on Cerro Carapo. However, apart from some small lines and trapezoids, the largest plateaus remain untouched. Though site density is now more regular over the study area, geoglyphs still seem to follow an independent distribution pattern save for a cluster of geoglyph and other sites towards the southwestern end of Cresta de Sacramento.

During Nasca 2 (approx. 1 - 100 AD; Map 9), site density is generally lower than before, notedly on Cerro Carapo and the opposite flank of Cresta de Sacramento. On the other hand, some stretches on the lower left bank of Río Grande are occupied for the first time. Geoglyph sites, however, are still sparse along Río Grande, and access to the Sacramento plateaus is generally easier from the Río Palpa side. During this time, some of the largest trapezoids in the study area are constructed, and the main plateau in the middle section of Cresta de Sacramento is converted into an impressive geoglyph complex. Other parts of Cresta de Sacramento closer to Cerro Pinchango are still largely free of geoglyphs. On the main plateau of Cerro Carapo, geoglyph density also increases. Due to higher site as well as geoglyph density, distribution patterns seem to converge for the first time in Nasca 2, with at least some geoglyph sites (though not necessarily the major complexes) in easy reach from close-by sites on the valley margins.

Nasca 3 (approx. 100 - 250 AD; Map 10) sees a clear increase in site density to a level slightly higher than in Initial Nasca times. During this time, the region most probably reaches a demographic peak. All valley margins are occupied, though in some cases (Cerro Carapo, some stretches along the Río Grande) not as dense as during other phases. Los Molinos (PV66-63) on the left bank of Río Grande is the largest site of this time. A notable increase can be observed concerning the number of geoglyphs constructed or used. For the first time, all major plateaus of the study region show some kind of geoglyph related activity, and the first major geoglyph complexes develop on the left bank of Río Grande. Likewise, the dense cluster of sites on the right bank of Río Palpa on the foothills of Cerro Pinchango, probably the most stably settled region of the study area during different phases of its prehispanic history, is for the first time accompanied by an important complex of large geoglyphs. On the southern slopes of Cresta de Sacramento, several straight lines connecting settlement zones and geoglyph complexes on plateaus are constructed. Geoglyph complexes are easily accessible from neighboring sites. However, the somewhat marginal position of Los Molinos with regard to geoglyph sites required considerable distances to be covered to reach major geoglyph complexes from this center, touching several smaller sites along the way. All in all, by Nasca 3 times at least some geoglyphs seem to have been established on all major geoglyph sites or, in other words, on none of the more complex geoglyph sites began geoglyph related activity later than in Nasca 3. Like in Nasca 2, site and geoglyph distribution seem to follow similar patterns, though this impression is largely due to the fact that the whole study area was densely occupied.

In Nasca 4 times (approx. 250 - 300 AD; Map 11), site numbers drop considerably, and large stretches along the middle part of Cresta de Sacramento seem to have been largely abandoned. Site clusters can be observed again on the upper right bank of Río Palpa and on the southern edge of Cresta de Sacramento. Existing geoglyph sites namely on plateaus continue to be used, and new geoglyphs are added, yet activity may have been restricted to fewer geoglyphs, and distances between sites and geoglyph complexes are generally larger than before. Thus, the distribution pattern of geoglyph sites seems to become once again independent of site distribution.

During Nasca 5 (approx. 300 - 450 AD; Map 12), site numbers rise again, yet not reaching Nasca 3 levels. This increase can be observed especially on Cerro Carapo, around the southwestern endpoint of Cresta de Sacramento, and in the area around La Muña (PV66-49, the largest Nasca 5 site) on the right bank of Río Grande. On the other hand, large stretches along the left bank of Río Grande are left unoccupied, and site density on both flanks of the middle part of Cresta de Sacramento is generally low. The picture is different concerning geoglyph sites, though. All major sites on the plateaus of Cresta de Sacramento and Cerro Carapo show significant signs of use, and (some) new geoglyphs continue to be added. Since geoglyph distribution during Nasca 5 is largely determined by sites established in previous phases, it does not correspond to site distribution. Thus, access routes at least to the main plateau were once again much longer than in Nasca 3 times.

In Nasca 6 (approx. 450 - 525 AD; Map 13), site density reaches Nasca 5 levels only around the southwestern endpoint of Cresta de Sacramento and along the right bank of Río Palpa facing

Cerro Carapo. Most other sections, namely both flanks of the middle part of Cresta de Sacramento, the whole left bank of Río Grande, and Cerro Carapo show very few sites. The large geoglyph complex on Cerro Carapo is abandoned by Nasca 6 times, just like several geoglyphs sites along Río Grande. Geoglyph related activity continues on several plateaus and on the southern slope of Cresta de Sacramento, including the construction of new geoglyphs. However, the lower site density is reflected in less activity on geoglyph sites, namely on the central part of Cresta de Sacramento.

In Nasca 7 (approx. 525 - 600 AD; Map 14), the most notable change in site distribution can be observed around the southwestern endpoint of Cresta de Sacramento where less sites are located than before, and none of them on either bank of Río Grande, along which site density drops almost to its lowest level. A slight increase of site numbers is observable on both banks of the upper Río Palpa. Geoglyph related activity seems now restricted to several major sites from previous phases on the middle and southern parts of Cresta de Sacramento. However, the largest trapezoid registered on Cresta de Sacramento was apparently constructed in Nasca 7. Important evidence of activity on geoglyph sites is found in areas where no contemporaneous sites are located close-by.

The Middle Horizon (approx. 600 - 1000 AD; Map 15) left little traces in the archaeological record of the study region, both in terms of sites and geoglyphs. The few registered sites are found mainly in the same areas as in Nasca 7, but in lesser density. Very few Middle Horizon ceramics have been found on Palpa geoglyphs, but in similar conditions as in Nasca times (*i.e.*, broken vessels on geoglyph borders), indicating a continuing use at least for a certain time after Nasca, although that does not seem to have included the construction of new geoglyphs. Most corresponding geoglyphs are located close to the few registered contemporaneous sites, so that access required little efforts.

In the Late Intermediate Period (approx. 1000 - 1400 AD; Map 16), site density once again increases sharply, most of all on Cerro Carapo, the opposing flank of Cresta de Sacramento, and along some sections of Río Grande, whereas the southwestern endpoint of Cresta de Sacramento is sparsely settled. LIP ceramics are frequently found on geoglyphs, but, as has been shown in chapter 6.2, this is due to the presence of large LIP sites on plateaus, not to a continued use of geoglyphs in that time. Least cost pathways for this time period are therefore shown connecting major settlement of this time period. These routes clearly touched some major geoglyph sites from previous epochs, explaining the presence of LIP pottery sherds on several geoglyphs.

Summarizing the available evidence, it has become clear that there is no parallel development of site and geoglyph distribution. Rather, both developed independently over time. Settlements and production sites along the valleys were dependent on the availability of natural resources, the most important one being water. Recent insights into the paleoclimate of the Palpa region (Eitel et al. 2005) show that climatic conditions fluctuated more than previously expected. Thus, sites along valley margins were short-lived in comparison with geoglyph sites and more easily abandoned. Geoglyph complexes, on the other hand, did not depend on the availability of such resources. Rather, the desert itself was the main resource, offering space for easy creation of geoglyphs at a large scale. The desert remained stable even if natural or political conditions in the valleys changed. Thus, once a new geoglyph site had been established, it was not easily abandoned.

VISIBILITY OF GEOGLYPHS

Visibility must have played an important role in the placement of geoglyphs. As mentioned in chapter 3.2, geoglyphs were seen and perceived from a ground perspective. No matter if their function was primarily symbolic (geoglyphs to be seen and understood) or stage-like (geoglyphs as places for certain kinds of activity), geoglyphs needed to be seen in some way or another. From close range, every geoglyph is visible, though its overall form may not be recognizable. The question is then to which degree geoglyphs were visible from far away. The situation in Palpa differs from that on the Nasca *pampa*, where some efforts are required to overlook a geoglyph from a ground perspective. In Palpa, at least geoglyphs on hillsides are easily visible from the valley and from sites along the valley margins. This is not the case with geoglyph complexes on plateaus, but the situation is still different from the Nasca *pampa*. On the one hand, the topography provides vantage points on the flanks of Cerro Pinchango from which every geoglyph complex on the plateaus of Cresta de Sacramento is visible. On the other hand, lines on slopes, posts on trapezoids, and stone platforms on plateau edges used to reveal the position of geoglyphs on the plateaus from a valley perspective even if the geoglyphs themselves were not visible. The topography not only of Cresta de Sacramento, but of the whole study area with its numerous potential cross- and along-valley sight lines furthermore allowed many views from one geoglyph site to another.

Due to time constraints, the visibility and intervisibility of geoglyph sites could not be investigated systematically in the framework of the present study. Using the viewshed tool implemented in ArcMap 8.3, however, some representative points in the terrain could at least be tested either for their visibility from other positions or for potential fields of visions that these points offered to observers standing upon them. An anthropomorphic geoglyph, a wooden post, a viewpoint on a geoglyph on a hillside, and a naturally elevated point overlooking a geoglyph field were chosen accordingly and their viewsheds calculated. This step required a precise DTM since inaccurate terrain data may render the results of sight line calculation useless (Wheatley, Gillings 2002:201ff). Other important parameters are height over ground of either the starting or the endpoint of a sight line, a minimum viewing angle, and a maximum radius:

- Height: A sight line should start at eye level of a potential observer. For the Palpa examples, a viewing height of 1.80 m above ground was adopted. Likewise, the endpoint of a sight line might be above ground if not only the geoglyphs themselves, but objects or people upon them are considered, too. For example, in the case of a post on the lower Cresta de Sacramento, a height of 5 m above ground was assumed.
- Viewing angle: A feature located flat on the ground like a geoglyph requires a minimum viewing angle to be recognized as such. For the anthropomorphic geoglyph, an angle of 30º was presumed in order to give a potential observer the chance to recognize the main features of the figure. For larger geoglyph sites, viewsheds were calculated without minimum viewing angle since not only the geoglyphs, but also people moving on them are potential endpoints of sight lines.
- Maximum radius: The larger a geoglyph, the better it is visible from far away. Small figures, on the other hand, are not visible any more beyond a certain distance. This maximum distance for the anthropomorphic figure was empirically determined to be 1.5 km. For larger geoglyphs, calculations were based on a radius of 4 km.

The resulting viewsheds are discussed in the following for each chosen point in turn.

- Anthropomorphic geoglyph 60 on site PV67A-16 (Figure 6.23, Figure 9.24). This figure is located close to an impressive complex of geometric geoglyphs. The question here was how the presumably early figural geoglyph was related to the generally later geoglyph complex close-by. As Figure 6.23 shows, the viewshed covers the main geoglyph complexes below the figure and in both directions up- and downriver along the slope as well as parts of the valley floor. Thus, the figure was potentially visible from most later geoglyphs that surrounded it. Whether this effect is coincidental or the result of a careful placement of later geoglyphs cannot be decided.

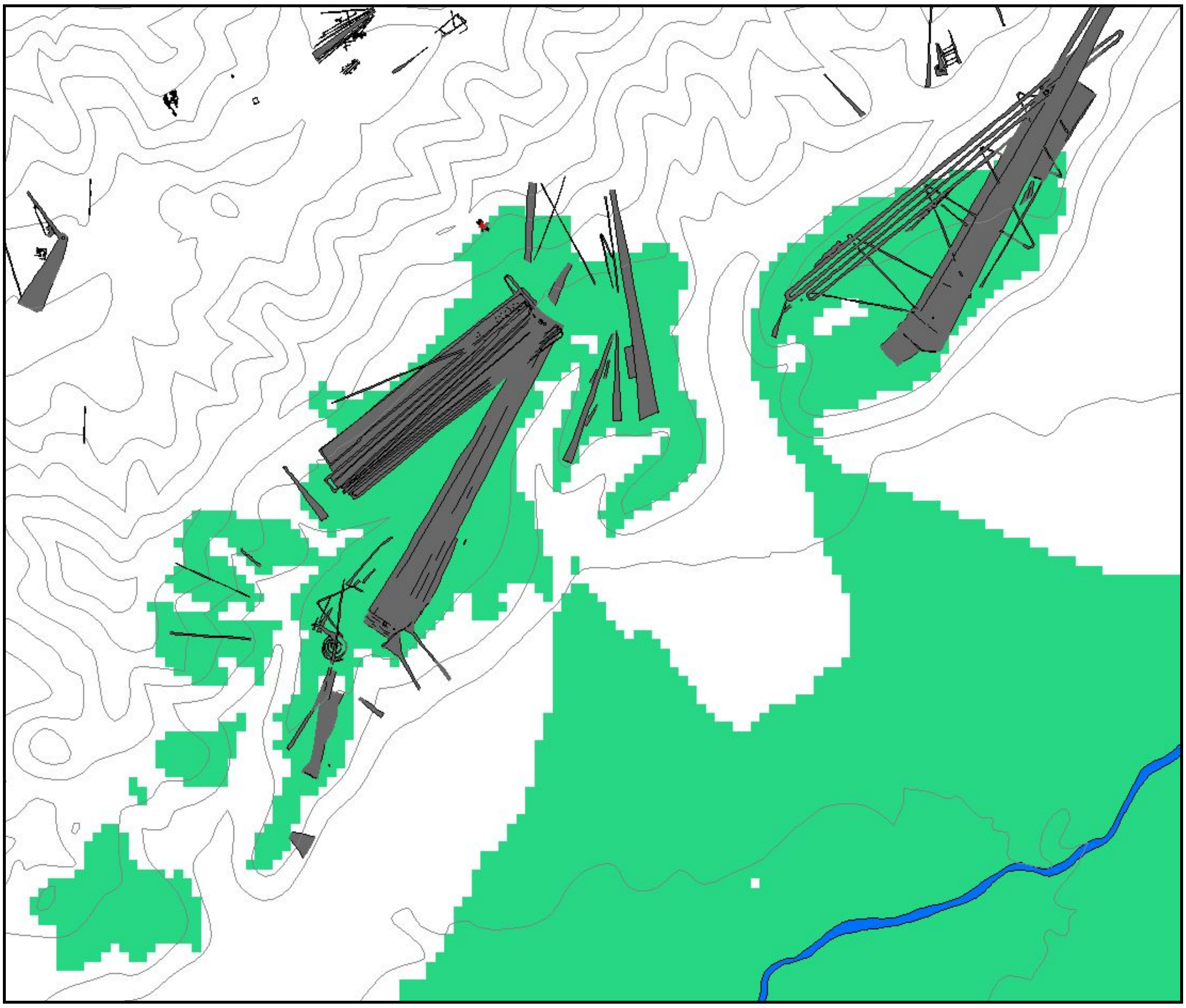

Figure 6.23: Anthropomorphic geoglyph 60 on site PV67A-16 (red triangle); areas from which the figure can be seen are marked in green

- Wooden post on trapezoid 52 on the same site (Figure 6.24, Figure 9.24). This site is located on a plateau on a middle level in between the valley floor and the main ridge. The large trapezoids are not visible from the valley, but the post may have served as indicator of their position. The question was from where the post was visible. As expected, the viewshed covers large parts of the valley floor, so that the post could have served as indicator of the geoglyphs not visible from the valley. Even more important, however, is that the viewshed along the southern flank of Cresta de Sacramento neatly coincides in most cases with the location of lines on slopes or geoglyph complexes on lower parts of the hillside, as well as plateau edges where elongated stone platforms are located. Thus, intervisibility between geoglyph sites on slopes seems to have been an important factor.

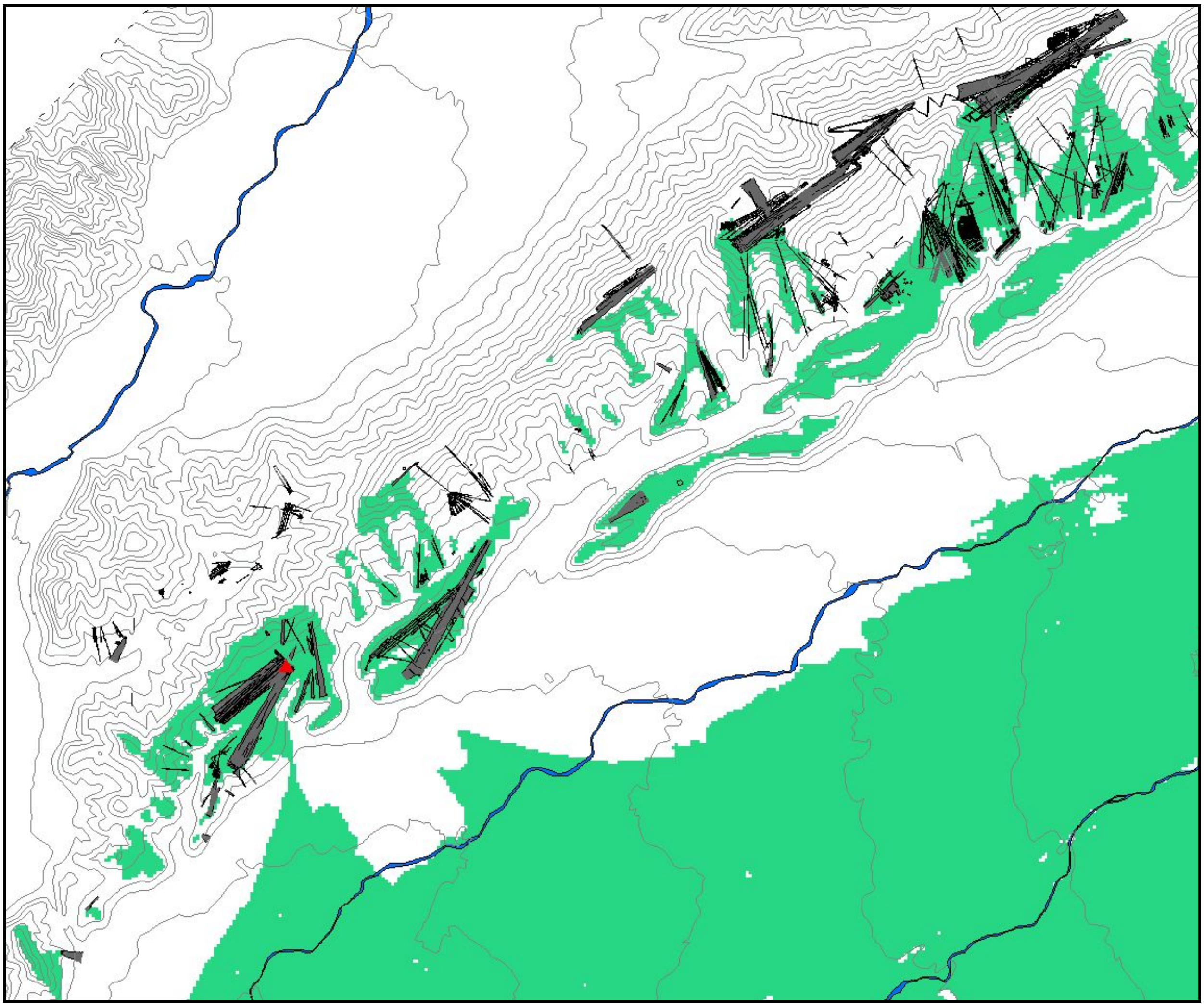

Figure 6.24: Wooden post on site PV67A-16 (red triangle); areas from which the post can be seen are marked in green

- This is confirmed by the viewshed of a viewpoint on trapezoid 109 on site PV67A-29 on the southern hillside of Cresta de Sacramento (Figure 6.25). This site is one in a row of sites dotting the slope of Cresta de Sacramento. The question here was if intervisibility between these sites may have been significant. Apparently it was. Much like the post, the viewshed covers the main geoglyph sites in both directions along the slope, as well as the complexes on flat terrain at the base of the slope. However, an important difference is that due to some branches of the middle plateau of Cresta de Sacramento, the visibility of the site was blocked towards the valley floor.

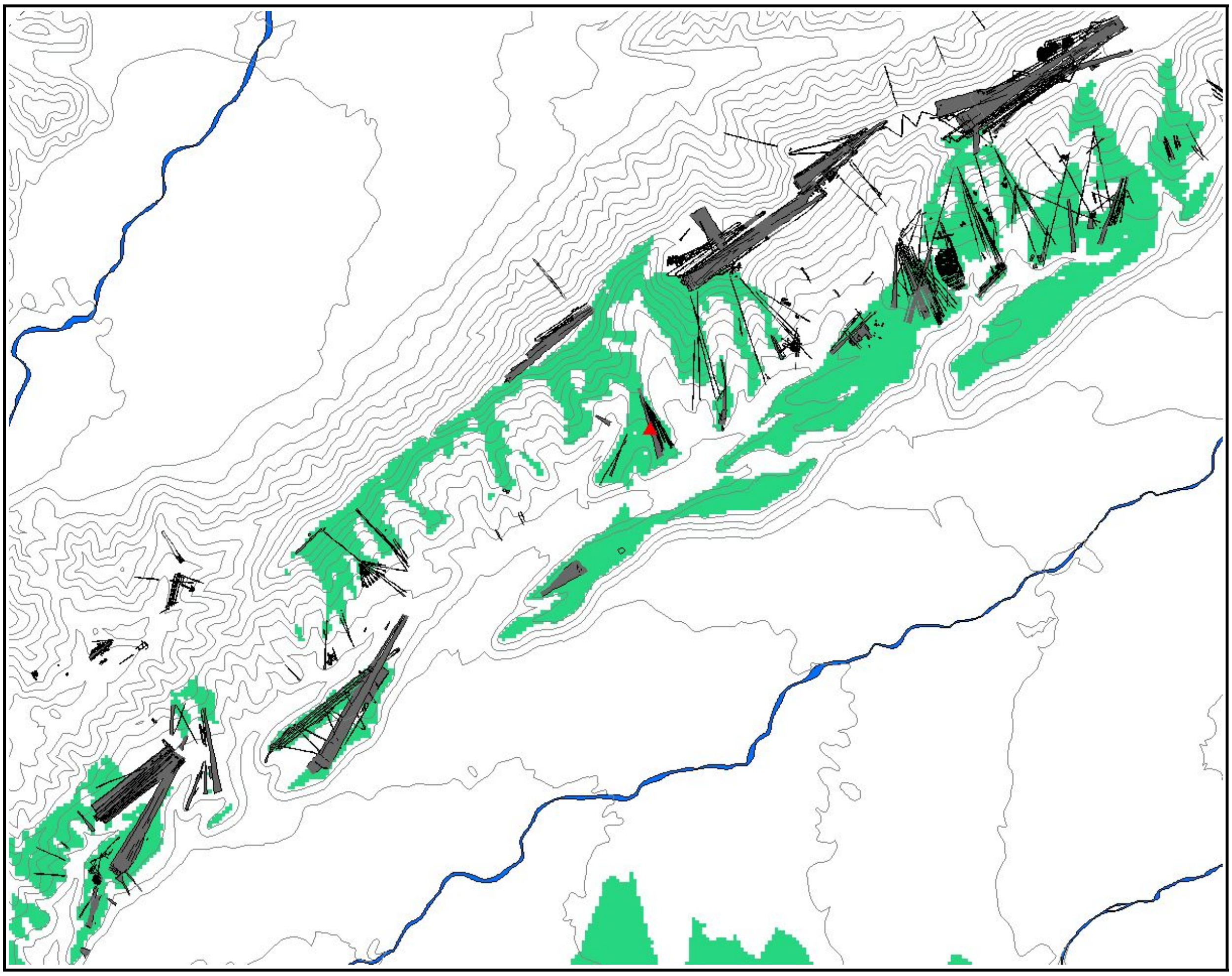

Figure 6.25: Viewpoint on trapezoid 109 on site PV 67A-29 (red triangle); areas visible from the viewpoint are marked in green

- Vantage point above site PV67A-90 close to Cerro Pinchango (Figure 6.26, Figure 9.18). Situated on elevated terrain above a major geoglyphs complex, this potential viewpoint is marked by two converging lines and a small stone structure. The question was whether this place had deliberately been marked for offering views over geoglyph sites. Again, there is evidence that this was indeed the case. Not only can neighboring sites be completely overlooked. The viewshed also covers geoglyph complexes in rather remote locations from the vantage point. Although geoglyphs may not have been discernible over that distance, people on geoglyph sites certainly were. The fact that the point is marked by lines and a stone structure further strengthens the impression that this place was related in some way to activity on geoglyphs.

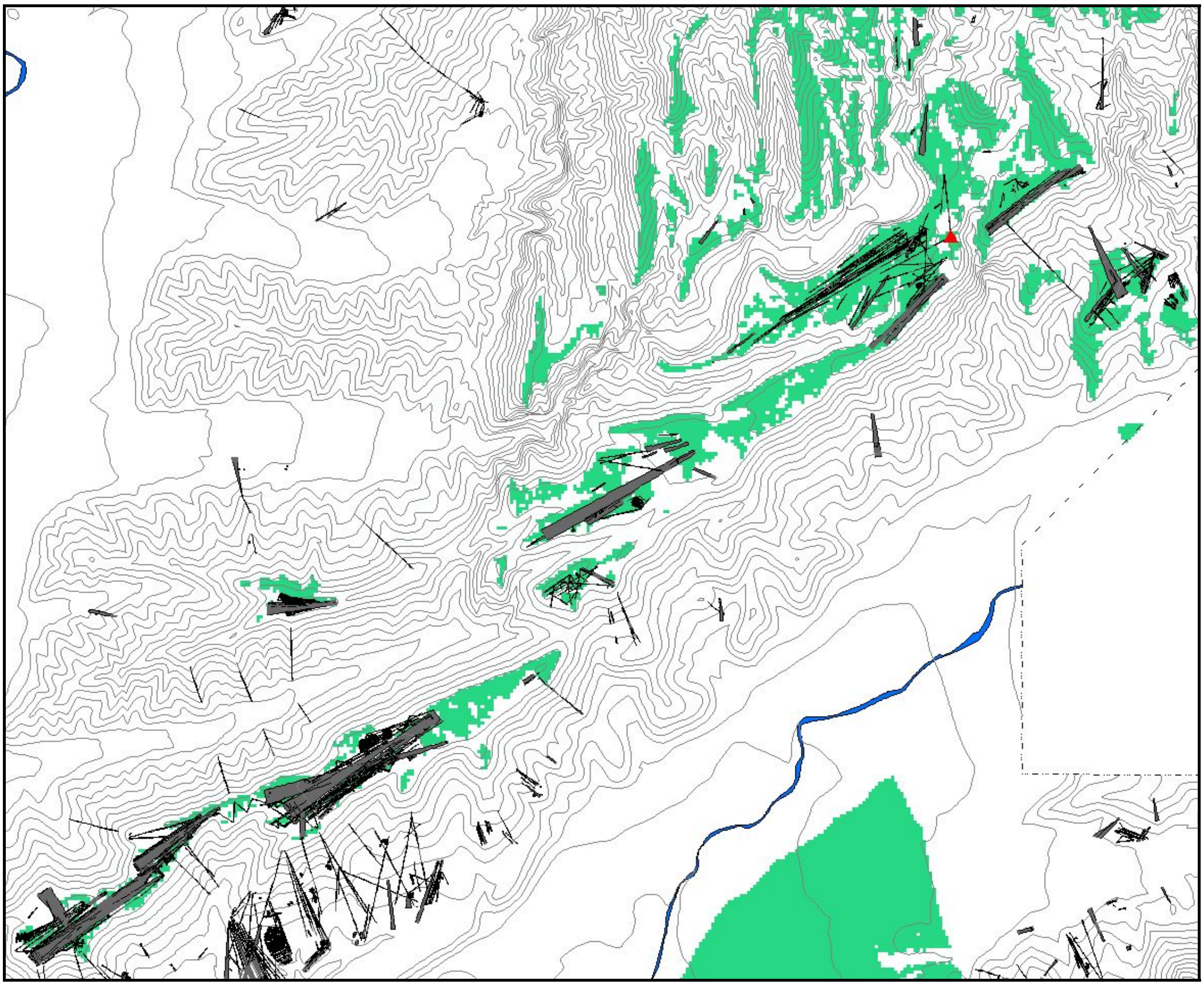

Figure 6.26: Viewpoint marked by a stone structure and two converging lines above geoglyph site PV-67A-90 (red triangle); areas visible from the viewpoint are marked in green

These results indicate that the general degree of visibility of geoglyphs was relatively high. Not only could certain geoglyphs be directly seen from other places, including other geoglyphs, but posts or people on geoglyph sites further enhanced their visibility. The latter aspect seems especially important since activity on geoglyph sites was most probably a near constant phenomenon, and the desert was much busier than today. This widens the perspective on geoglyph related activity, since potential observers on remote viewpoints may have been involved in some way or another. Intervisibility of geoglyph sites may thus have been an important criteria in determining places for new geoglyphs. However, this aspect has yet to be studied further.

Orientation of geoglyphs

The orientation of geoglyphs has for a long time been their single most discussed feature. While orientation towards celestial bodies was originally sought after, the Andean model later proposed orientation towards landscape features like mountain tops or rivers as criteria for the spatial context of a geoglyph.

In order to shed light on the latter hypothesis, the orientations of 337 out of 639 geoglyphs on Cresta de Sacramento, Cerro Carapo, and around La Muña were calculated. This number was determined by geoglyph shape on the one hand and the applied method on the other hand. The calculation of geoglyph orientation is only meaningful if a given geoglyph has a dominant straight section that can visibly provide orientation. This requirement excluded all biomorphic, amorphous, and spiral geoglyphs from the calculation. Another limitation was due to the method used to calculate orientation. The polygons of which each geoglyph is composed (see chapter 5.12) served as starting point. Using the nodes that define the outlines of each polygon, the principal axis through the point of gravity was calculated for each geoglyph that had at least one polygon whose orientation was representative for the overall orientation of the geoglyph. Since the method was based on single polygons, the orientation of geoglyphs composed of many different polygons oriented in varying directions, like some of the major trapezoids, could not be calculated. Nevertheless, the orientations of 337 geoglyphs, or 52.7 % of the overall sample, are available in the geoglyph database. Since every straight or near-straight geoglyph pointing in one direction points in the opposite direction as well, each calculated orientation provides its counterpart as further orientation. Thus, 674 orientations are available for the Palpa geoglyph sample.

The extrapolated principle axes of 337 geoglyphs are shown in Figure 6.27. Here, axes are georeferenced and therefore have different center points. Some general tendencies can be observed. Orientations cover virtually the full circle. No orientation seems to have been deliberately avoided. A majority of orientations, however, is clustered around two general directions: along the major course of Cresta de Sacramento and perpendicular to it, respectively, the variation of the latter direction being wider than the former. It is clear that these main directions represent geoglyphs on top of Cresta de Sacramento on the one hand and geoglyphs on its southern flank on the other hand.

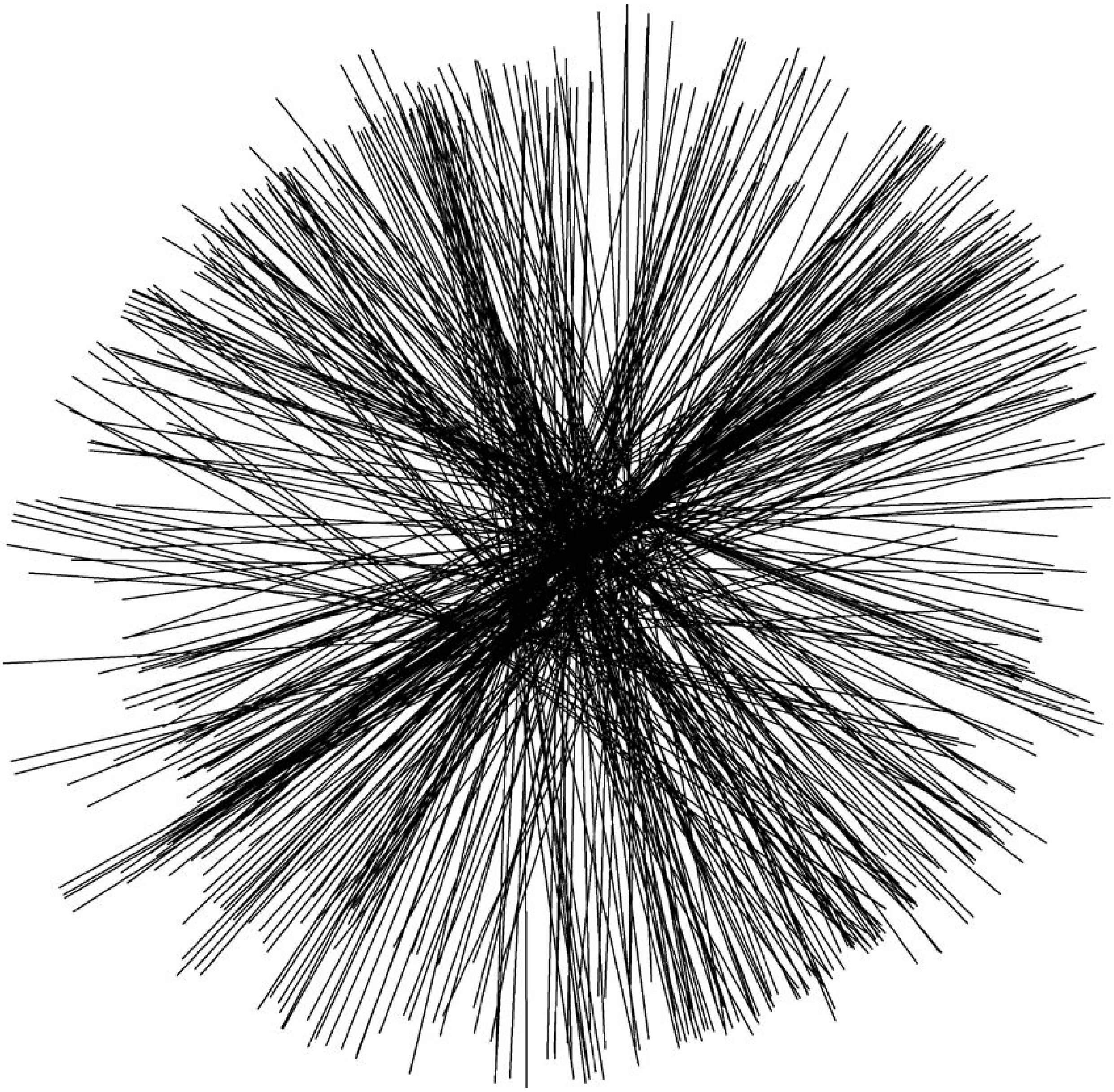

Figure 6.27: Orientations of 337 geoglyphs from the Palpa sample; lines are shown according to geoglyph location and therefore do not share a common center point (north is on top)

A thorough investigation of geoglyph orientation is expected to reveal more detailed results. A review of intersection points seems promising. Observations made in the field indicate that several geoglyphs are oriented towards Cerro Pinchango. The summit of this and other mountains was unfortunately outside the range of the DTM available for this study. Furthermore, the separate investigation of the orientations of subsets of geoglyphs, *e.g.* of a certain type or time period, seems necessary. Time constraints did not permit to pursue such an approach in the present study.

6.4.3 Summary: geoglyph setting and order

The above investigation into spatial ordering principles of geoglyphs and geoglyph sites, though not as complete as desirable, shows that certain rules existed that determined where new features were placed. On the site level, these rules included typical combinations of geoglyphs built in a predefined sequence. The composition of these combination was probably determined by activity conducted on geoglyphs. Topography further determined to a certain degree the orientation of a geoglyph. On the regional level, there are strong indications that intervisibility of geoglyph sites played an important role, which underlines the stage-like character of geoglyph sites. Accessibility, on the other hand, was apparently no decisive factor for the placement of geoglyph sites. Of course, overall distances were never as large as on the Nasca *pampa*, so that accessibility might have been a negligible parameter only in the Palpa area.

The most important result of the study of spatial order of geoglyphs seems to be that it did not correlate to settlement patterns. The first geoglyphs were constructed in rather remote locations with regard to contemporary sites along the valley margins. This changed in Early Nasca times, when bit by bit all potential locations for sites on valley margins as well as for geoglyphs on flat plateaus were occupied. Thus, geoglyphs sites were necessarily in easy reach from contemporary settlements. After that time, the study area was never again fully occupied, so that settlements and other sites once again were concentrated in certain areas. The occupation of geoglyph sites, however, was more persistent over time. Those established during Early Nasca times continued in use in Middle Nasca times, even though some of them were not any more easily accessible from sites along the valley margins. Only when in Late Nasca and later occupation density dropped to very low levels, proximity to inhabited sites seem to have determined which sites continued to be used.

There is no indication of important geoglyph complexes pertaining to certain settlements. Although small geoglyph complexes form part of both Los Molinos and La Muña, the biggest sites in the Palpa region during Nasca 3 and Nasca 5 times, respectively (Reindel, Isla 2001), these groups of geoglyphs are considerably less complex than the larger geoglyph sites on both Cresta de Sacramento and Cerro Carapo. These large complexes apparently cannot be associated with certain settlements on the valley margins. They continued in use much longer than average sites, even when settlements close-by were abandoned. Thus, whatever the settlement pattern or hierarchy in the valley at any given time period, the locations of geoglyphs in the desert were largely independent of it.

7. Discussion: the Andean model and the Palpa geoglyphs

In the previous chapter, the Palpa geoglyphs have been investigated concerning geoglyph variation (formal, temporal, and spatial) and human activity related to geoglyphs. This chapter is dedicated to the discussion and interpretation of the results. For that purpose, archaeological evidence as documented on geoglyph sites on Cresta de Sacramento and Cerro Carapo is confronted with the main aspects of the Andean model as defined in chapter 3.2.2 in order to assess the capabilities of that model to explain the geoglyphs. According to the model (Figure 3.1), geoglyphs expressed social and spatial order, provided places for ritual activity, were considered sacred space, were related to mountain worship and concepts of water and fertility, and some of them were used as roads.

7.1 Geoglyphs expressing social and spatial order

As shown in chapter 6.3.1, the construction of a geoglyph, or a complex of geoglyphs, involved the participation of groups of people. A place was claimed by a certain group and henceforth served as stage for collective activity including maintenance, remodeling, and use of a geoglyph or a group of geoglyphs in different ways. This string of geoglyph related activity often extended over a considerable time span, during which group members were involved in different acts, whether in larger numbers (*e.g.*, for construction activity), in smaller subgroups (*e.g.*, for activity related to stone structures) or maybe alone (*e.g.*, for line walking and vessel deposition).

Archaeological evidence from the geoglyphs alone does not reveal easily how these social groups were composed or identified themselves. Nevertheless, some conclusions can be drawn that position the geoglyphs and the social groups associated with them in a wider societal context. On the one hand the geoglyphs played an integrative role encompassing the whole society, on the other hand they were of special importance for subgroups within this society. Both aspects were closely related.

Geoglyphs show a noticeable uniformity through time and space. In spite of clearly observable formal and temporal variation described in previous chapters, the basic principle of marked space in the desert worth investing time and manpower and representing important aspects of ancient world view remained largely unaltered throughout more than 1 000 years. It furthermore seems that regional variation within the drainage was minimal, though this will have to be investigated more thoroughly once comparable data from other valleys become available. Geoglyph distribution did not correlate directly with contemporaneous settlement patterns but rather proved more stable through time. Important changes in sociopolitical organization, like the break observable between Early and Middle Nasca (Reindel et al. 1999:372; Silverman 2002a:167; Orefici, Drusini 2003:89f), are rather marginally reflected in geoglyph distribution and use. The concern with water and fertility mirrored in goods deposited on geoglyph sites was constantly important to the ancient inhabitants of the region and therefore transcended changing political circumstances, even though the protagonists of geoglyph related activity were of course in some way or another affected by those changes. The geoglyph phenomenon was one strong link (among others) between late Paracas and Nasca culture and society and had its roots even earlier in the Paracas petroglyph tradition. It was certainly influenced, yet not fundamentally altered, by major technological, political, and other changes along the time line of the Paracas-Nasca cultural continuum.[27] In this sense, geoglyphs can literally be understood as common ground (Clarkson 1999) for all members of Late Paracas and Nasca society.

Within this common conceptual framework subgroups of Nasca society acted and interacted. Guided by geoglyph specialists, members of these groups gathered on certain occasions out in the desert to create new geoglyphs, to remodel existing ones, or to walk along lines and trapezoids in a prescribed fashion, depositing ceramic vessels (possibly containing food or beverages), field crops, textiles, *Spondylus* shells or other goods on geoglyph borders or stone platforms. Apparently, an important aspect of this group activity was its visibility from other geoglyph sites, from vantage points on elevated terrain, and partially even from the inhabited and cultivated valley floor. Geoglyph sites can thus be understood as stages, with actors upon and spectators around them. In this sense, the importance of group activity transcended the individual group. Awareness of group identity (possibly defined by other parameters discussed below) was raised among members as well as outsiders. Group interaction across geoglyph sites may have assumed a competitive character concerning status within a larger societal context.

In order to better assess this aspect, it is necessary to discuss how these groups may have been defined. Economic considerations are an important aspect here. Group members constructing geoglyphs spent many working hours away from other activity and had to be provided with food and water. Goods to be deposited on geoglyph sites had to be produced and transported. These economic requirements, though difficult to quantify, show that geoglyph related groups must have had access to economic resources like water, arable land, clay deposits, or to goods

27 From this point of view, the fact that the geoglyph tradition came to an end early in the Middle Horizon is a strong indication that the Wari intrusion into the Nasca basin entailed greater change in culture and society than all disruptions suffered throughout the centuries before.

produced thereof. Geoglyph related units of social organization may thus have coincided to a certain degree with economic units. These economic considerations provide a link to spatial order as well. Economic resources, like arable land and water sources, as well as access to them are place-bound, and habitational patterns of group members utilizing them were placed in certain spatial relations to those resources. Thus, though there is no direct correlation between geoglyph and settlement distribution, spatial order may have become indirectly manifest in social groups related to geoglyph sites.

The unit of ancient Andean social and economic organization best known from ethnographic and ethnohistoric sources is the *ayllu* (Moseley 2001:53ff). This multifaceted concept from Inkaic times encompassed social, economic, and religious aspects like *e.g.* kinship, land and irrigation rights, group labor, and ancestor veneration. Was ancient Nasca society organized in *ayllus*, and if so, did these units coincide with the geoglyph related groups defined above?

In the framework of the Andean model, Urton, projecting social organization in early colonial times in the Nasca area back into prehispanic times, suggests that this was indeed the case. He argues that the maintenance of lineal geoglyphs was organized along *ayllu* lines (Urton 1990:205). In a similar vein, Silverman suggests that Cahuachi's temple mounds can be traced back to individual *ayllus* (Silverman 1993a:309f). She defines *ayllus* as cognatic descent groups (*i.e.* groups claiming descent from a common ancestor) with further characteristics such as residence or redistribution of goods.

On the other hand, according to a stricter definition used by William Isbell, *ayllus* were linked to a specific kind of mortuary monument called by him “open sepulcher” that allowed access to, and public display of, the ancestor's mummy (Isbell 1997:136ff). Following Isbell's line of reasoning, *ayllus* would not have been present in Nasca society since they made their first appearance in the southern Andean region centuries later (Isbell 1997:285).

Though open sepulchers were indeed unknown in Nasca times, there is clear evidence of other forms of an ancestor cult that may not have involved the actual mummy, but effigies replacing it (Silverman, Proulx 2002:214ff, fig. 8.6; DeLeonardis, Lau 2004 2004:104ff; cp. evidence of mortuary ritual in La Muña: Reindel, Isla 2001:306, figs. 27, 30.13-14). The posts in the Room of the Posts at Cahuachi have been interpreted in terms of ancestor worship (Silverman 1993a:174ff). These posts may furthermore have a parallel in those depicted on a Nasca 5 vessel on exhibition in the Museo de America, Madrid, Spain (Blasco, Ramos 1991:231; Rickenbach ed. 1999:325). Several posts are shown on that jar, each with a rectangular banner attached to its top and a lateral bar from which a trophy head is suspended.[28] Trophy heads, in turn, may also have been used in the context of ancestor veneration (Proulx 2001:130, fig. 6.13). Thus, evidence for an ancestor cult involving posts, trophy heads, grave precincts, and maybe even geoglyphs is present in the Nasca archaeological record. It seems reasonable to assume, then, that social groups not unlike the *ayllu*, claiming descent from a common ancestor (irrespective of their being formed by actual or imaginary kin) and being linked to economic resources, may well have been present in Nasca society, even though there is no evidence for open sepulchers.

Who led these groups? Silverman's description of *ayllu* structure suggests that leadership depended on individual capabilities and had to be negotiated and justified (Silverman 1993a:309). If geoglyphs were the stable cultural expression of worldview or social ideology described above, then the capability of leading a group to create or remodel a geoglyph may have been a means of legitimation for a potential leader:

> To the degree that ideologies are materialized, they become part of the physical world that is constructed by social labor. Thus the material nature of an ideology, essential for cultural sharing, offers opportunities for control identical to that over production of other objects. (Earle 1997:152)

By performing a socially acknowledged act of leadership a group member may legitimate his claim and become, or remain, group leader. Another observation seems to hint in this direction as well. The more Nasca society became politically fragmented from Early to Late Nasca, the more standardized became the formal geoglyph repertoire. If geoglyphs were the benchmark against which ephemeral group leadership was tested, then this self-restriction to the types that were most common through all phases – straight lines and trapezoids – may be explained by potential group leaders having to ensure their recognition by socially accepted acts. The creation of less common geoglyph types would have questioned their claims. Such an interpretation, however, is highly speculative, and there is clear evidence that leadership was organized in a more stable fashion during much of Nasca history (see, *e.g.*, the Middle Nasca elite graves at La Muña and Puente Gentil: Reindel, Isla 2001; Isla 2001a).

Summing up the available evidence, the existence in Late Paracas and Nasca society of *ayllu*-like social groups related to geoglyph complexes seems possible in the light of archaeological evidence from the Palpa geoglyphs. Thus, the Andean model provides a valid explanation for their social context. The presence or absence of such groups or of different social formations (or

28 It is tempting to view the posts erected on trapezoids in the same context. However, neither the posts shown on the Madrid vessel nor the ones of the Room of the Posts are directly linked to geoglyphs in any recognizable way.

on other levels of social organization) can, however, only be assessed to a limited degree based on evidence from the geoglyphs alone. Data on regional settlement patterns, internal structure of domestic sites, distribution of prestige goods, grave furniture, diet etc. may provide a broader basis to build conclusions on Nasca social organization upon. Corresponding data from the Palpa sites obtained in the framework of SLSA's Nasca-Palpa project are currently being studied. The results will certainly shed more light on the issue discussed here.

7.2 Geoglyphs as places for ritual activity

As an important element of the Andean model, activity on geoglyph sites has frequently been called “ritual” (*e.g.* Urton 1990; Silverman 1990a; Rostworowski 1993; Rodríguez 1999). This term is problematic since it is not clearly defined. In the context of the Nasca geoglyphs, the term carries with it widely differing connotations, the most important being religious (offerings, pilgrimage, processions, worship) and social (social groups claiming space, expressing their identity, and negotiating their status). This is a rather broad concept of “ritual”. Other definitions or uses of the term in anthropological as well as archaeological research are similarly multifaceted (*e.g.* Merrifield 1987:6; Bell 1992:69ff; Rappaport 1999:24ff; Sundqvist, Kaliff 2003; cp. historical review of theories on ritual in Bell 1997: part I). The scope of the term “ritual” is not clearly defined either. While it is often used to describe action as opposed to thought (see overview in Bell 1992:19ff), others define it as involving both action and the ideas and concepts by which the action is motivated (Insoll 2004:10ff).

Two basic problems arise when trying to identify ritual in archaeological research. The first one is a practical issue. The archaeological record is composed of material remains that are the results of human activity:[29]

> “What we have are the acts – or more precisely, the traces of artifacts used for the acts or the place where the acts occurred and also physical results of the acts (e.g., deposits).” (Bertemes, Biehl 2001:15)

These acts may be reconstructible based on archaeological evidence. The more a certain kind of activity is repetitive and place-bound in nature and repeatedly involves the same kind of objects, the clearer it becomes manifest in the archaeological record. Thus, activity is to a certain degree accessible with archaeological means. On the other hand, concepts or thoughts that motivated or induced activity are more difficult to reconstruct. Usually, additional information from other

29 The cultural and environmental formation processes of the archaeological record, though important for its interpretation, are of no concern for the topic at hand and are therefore not discussed here.

sources is needed, like written or oral history, analogies etc. Thus, if the question is whether or not ritual activity took place on geoglyphs sites, then the answer from archaeological research can in the first instance only refer to different kinds of activity as reconstructed from material remains (action), while conclusions concerning the underlying concepts (thought) require additional information.

The second issue when looking for ritual activity is a heuristic one. What is to be found out, or asserted, by pigeonholing a certain kind of activity as “ritual”? Brück, in her critical review of different uses of the term in archaeological research (Brück 1999), identifies its – usually implicit – equalization with non-functional action devoid of rationality as most important common trait. From a functionalistic viewpoint, ritual is conceived as being opposed to rational activity concerned with housing, subsistence, production, trade etc. Thus, by calling a certain activity “ritual”, a sphere of human activity is set apart that to the modern observer has a different role than other activity, a role that may not be as easily explainable as that of other spheres. “Ritual” is thus primarily an analytical concept.

It has to be kept in mind that this analytical category (just like other analytical categories, *e.g.* the geoglyph types as presented in chapter 6.1) did not necessarily have its counterpart in the cultural concepts of the ancient society under study. According to Brück, different world views may well assign causality and rationality to activity labeled “ritual” in the above described sense. In a similar vein, Insoll has recently proposed to view religion, which is often seen as origin of ritual activity, not as mere sphere of life alongside other spheres like subsistence, social organization etc., but rather as central characteristic of life that determines all spheres (Insoll 2004: fig. 2). In this sense, religion or, more neutral, social ideology or world view equally determines and imbues with meaning all spheres of human life and activity.

Following Brück's and Insoll's reasoning, it becomes clear why ritual and other activity are often not as neatly separable in the archaeological record as the archaeologist would wish (Marangou 2001).[30] If the same concepts determine ritual and non-ritual activity, and the same rationality is assigned to both, then both may be highly interwoven or take on similar expressions or

30 For example, it has been postulated that religious ritual be recognized as such in the archaeological record on the basis of positive traits (Renfrew, Bahn 2000:406; Bertemes, Biehl 2001; Müller 2002), not just in a questionable *in dubio pro deo* attitude (Colpe 1970:28) that interprets everything not otherwise explainable as religious. However, check-lists of such traits (*e.g.* Renfrew 1994:51f) draw heavily upon belief systems known from written sources and are mainly suitable in well preserved and well documented contexts. In less favorable circumstances, such trait lists are of little practical value.

manifestations. Indeed, certain traits often used to identify ritual (repetitiveness, place-boundedness, special objects) are equally typical for daily household activity.

Activity related to the Palpa geoglyphs included, among other things, gatherings of social groups, line walking, deposition of vessels and other objects along lines and on platforms, food consumption etc. (see chapter 6.3). Whether or not processions or races were held on geoglyphs cannot be decided. Geoglyph related activity required a considerable investment of time and labor. It involved large parts of the ancient population of the Palpa region, organized in different social groups. These groups interacted on and across geoglyph sites. As described in the previous subchapter, all these activities had an important social function since they determined group status and maybe group leadership.

All these acts may well be termed “ritual” in the above described sense. Thus, the Andean model provides once again a plausible framework for archaeological evidence from the Palpa geoglyph sites. It has to be stressed, however, that the term "ritual" in itself is not an explanation, nor does it alone provide an understanding of the meaning of the discussed acts. For the people involved, it seems clear that geoglyph related activity was functional and rational according to their world view and could not be seen separated from other kinds of daily activity.

7.3 Geoglyphs as sacred space

Much like the term “ritual”, “sacred” is equally problematic for similar reasons. As has become clear in the previous subchapter, archaeological evidence alone does not reveal if geoglyphs were considered sacred space. However, two aspects evident in the Palpa data suggest that geoglyph sites were considered places with a value of their own and of special importance in a wider context.

Firstly, geoglyphs were located in the desert. They were made and used in places that during large periods of time were situated rather remote from settlements. The different environment and elevation clearly set geoglyph sites apart from inhabited settlements and agricultural zones. Apart from inter-valley traffic, there was no other activity out in the desert whose extent and importance came close to geoglyph related activity. Through the geoglyphs, large portions of the desert were incorporated into the cultural domain of the valley-based society (Silverman 1990b:451). The cultural territory was that way considerably enlarged and enriched by new components. In no other time period, neither before the Spanish conquest nor afterwards, received the desert portion of the Nasca landscape such a special attention than when it was marked with geoglyphs at large scale and filled with human activity. Large amounts of labor were invested into this space over time. Thus, the culturally marked desert landscape was a valuable resource for society.

This value proved, secondly, persistent over time. Geoglyph sites, once established, were not easily abandoned. As discussed in chapter 6.4, geoglyph sites developed rather independently of settlement patterns and often continued in use even when settled zones closest to them were abandoned. They were constantly frequented over time, even if the place where people who gathered on the geoglyphs lived might have changed. Thus, geoglyph sites maintained their importance even in the face of major changes down in the valley. Their special role was not short-lived, but rather represented a stable facet in the cultural history of the Palpa region for more than 1 000 years.

It is a plausible explanation to assume a sacred connotation of this special value and persistant tradition. The archaeological evidence is thus once again in concordance with an important aspect of the Andean model. However, the critical comments on the term "ritual" apply to the term "sacred" as well.

7.4 Geoglyphs related to mountain worship

Reinhard and Rostworowski proposed that specific deities were venerated on geoglyphs, some of them related to mountains (Reinhard 1996; Rostworowski 1993). The results of the present study do not allow us to assess this proposition with any certainty since it is not clear how mountain worship would become manifest in the archaeological record. Probably the most obvious indicator would be orientation of geoglyphs towards mountain peaks (Reinhard 1996:22ff). A possible analogy hints in this direction: many line centers on the Nasca *pampa* are located on elevated terrain (Aveni 1990b:49). As for the Palpa geoglyphs, on the narrow plateaus of Cresta de Sacramento and Cerro Carapo no line center as described by Aveni was registered.[31]

A possible orientation of lines from the Palpa sample towards higher mountains has yet to be investigated. Though observations during fieldwork suggest that some geoglyphs (among them trapezoids, straight lines, and sections of meandering lines) were directed towards Cerro Pinchango, this could not be checked systematically in the GIS environment since this and other prominent mountains visible from Cresta de Sacramento and Cerro Carapo were situated beyond

31 However, lines on slopes, some emanating from a common platform on the plateau edge, others branching of from a central line (Figure 6.2, Figure 9.1, Figure 9.2), come structurally close to line centers and may be expressions of the same concept under different topographical conditions.

the borders of the DTM available for the present study. Any potential relation would furthermore have to be statistically proven to be relevant.

7.5 Geoglyphs related to water and fertility

The deities mentioned by Reinhard and Rostworowski were associated with concepts of fertility. This aspect can better be judged on the basis of the Palpa data. Biomorphic geoglyphs depicting water related animals and plants (Reinhard 1996: figs. 46-63) are less common in Palpa than on the Nasca *pampa*. However, objects deposited on stone platforms (Figure 6.21), the most prominent of them being *Spondylus* shells, strongly indicate that the concept of fertility played indeed an important role in geoglyph related activity. The presence of *Spondylus* shells along the Pacific coast is determined by warm currents. During El Niño years, these currents shift, and *Spondylus* shells are found in coastal regions where they do not occur in normal years (Marcos 1986; Marcos 2002). At the same time, rain is brought to regions where it usually does not rain. Apparently, the association of *Spondylus* shells and rain was well known throughout the regions affected by El Niño, so that the shell became a symbol of water and rain. Other objects found on stone structures carry with it a similar connotation. Crawfishes are only available when the rivers carry water. Field crops, on the other hand, depend on irrigation of arable land. Thus, a concern with the availability of water in the valleys and the fertility of the irrigated land is clearly reflected in objects deposited on stone structures.

Apart from this rather indirect association of geoglyphs with water and fertility, a more direct relationship has been proposed by Aveni, with trapezoids being oriented parallel to river courses and lines orthogonal to it (Aveni 1990b). Although many Palpa geoglyphs indeed match this pattern, it seems rather coincidental. Wherever there are two or more large trapezoids in a geoglyph complex, at least one of them is not oriented alongside the river. The main criteria for defining the place and orientation of large trapezoids seems to have been the topography of the available terrain. Lines, on the other hand, are necessarily roughly orthogonal to the river course if placed on the neighboring hillside. On plateaus, however, lines point in many other directions as well, so that no pattern can be discerned (Figure 6.27).

Although not considered part of the Andean model for the purpose of this study, a comment seems worthwhile on Johnson's hypothesis that directly links geoglyphs to water. The Palpa geoglyphs most likely do not map subterranean water sources in the way proposed by Johnson. This assertion could not be tested against hydrological data, yet Johnson's geoglyph code

(Johnson 1999:160) simply does not work in Palpa. Elements of his code include triangles ("pointers"), trapezoids, zigzag lines, and stone circles. In Palpa, only two true triangles were registered. Small trapezoids, though similar in shape, have on open narrow end and therefore do not point anywhere in the way proposed by Johnson. Zigzag lines are supposed to indicate absence of water, while trapezoids would map major water flows. It has been shown that both types of geoglyphs in Palpa usually occur together, with the trapezoid superimposed on the line – a contradiction in terms? Finally, the stone circles and rows mentioned by Johnson are present in Palpa, but they are of modern origin. Where old SAN aerial images are available, the circles are not visible. One stone out of a row of stones on Cresta de Sacramento was placed on car tracks. Beneath a stone of another circle in San Ignacio we found an electric cable. Thus, although the origin and function of the stone circles is unknown, they are clearly not related to prehispanic geoglyphs, which is why they have not been mapped by the Nasca-Palpa project.

All in all, the Palpa geoglyphs seem indeed to be related to water, but not necessarily in terms of spatial relations. Rather, objects evoking concepts of water and fertility were deposited along geoglyphs. Thus, this important aspect of the Andean model finds corroboration in the Palpa data.

7.6 Geoglyphs used as roads

Based on structural similarities between geoglyphs and Inka roads (Hyslop 1984), it has been suggested that some straight geoglyphs on the Nasca *pampa* were used as roads or paths for traffic of people and goods (Clarkson 1990; Silverman 1990a; Urton 1990). A review of available evidence for walking over the geoglyphs on Cresta de Sacramento, Cerro Carapo, and around La Muña indicates that in the Palpa region this activity was not related to traffic. Here, the geoglyphs did not form pathways leading from one settlement zone to another. Many of them were placed in terrain not suitable for walking. Although people traveling through the area might have used occasionally some stretches of geoglyphs as paths, this was clearly not their primary purpose. Rather, there seems to have existed a separate set of roads and paths for inter- and intra-valley traffic, although evidence is sparse due to long lasting reuse. In the area around Palpa, some paths apparently of prehispanic origin that are not being used any more have been registered during fieldwork in several locations. They usually lead up from the valley margins to prehispanic sites on plateaus, like geoglyph sites or LIP settlements. Prehispanic sherds, in most cases covering different epochs, are scattered along their course. Unlike modern trails through the desert that are formed simply by traveling frequently over them, most of these paths tend to be wider and seem to be the result of an actual construction process. These ancient pathways have been studied in the framework of the regional settlement survey and will be reported on elsewhere. Inter-valley traffic routes, on the other hand, did not necessarily ran through the desert. As old maps (*e.g.*, Mejía 2002:209) show, the main road between Palpa and Ingenio ran alongside the rivers before the Panamerican highway was built.

The absence of evidence for a use of geoglyphs as roads includes pilgrimage towards a ceremonial center. Silverman suggests such special kind of travel for the Nasca *pampa* (Silverman 1990a; Silverman 1994a) and hypothesizes if the group of people shown in a famous clay model in the Museo Nacional de Antropología, Arqueología e Historia, Lima (Silverman, Proulx 2002:xx), may have been pilgrims. The Palpa geoglyphs did not serve as traffic roads, and no musical instruments like the panpipes played by the people shown in the clay model were found on them. This does not mean that Silverman is wrong, though. The topographic situation between Río Ingenio and Río Nasca suggests that the easiest way to travel between both valleys was by crossing the Nasca *pampa*. Thus, traffic across the *pampa*, be it as part of a pilgrimage or for other purposes, must have existed, and it is to assume that there was a network of paths or roads serving this purpose that may have been formally similar to geoglyphs. Even though a distinction between both features seems difficult on the basis of available data, a thorough documentation of the *pampa* geoglyphs may still be revealing in this regard.

To sum up, the Palpa geoglyphs were not used as roads or paths through the desert. However, considering the different topography, it is plausible to assume that traffic routes (possibly used, among others, by pilgrims) ran through the Nasca *pampa*. This aspect of the Andean model is clearly tailored to explain the situation on the Nasca *pampa* and can be better assessed only once new field data become available from that area.

7.7 Summary: the Andean model and the Palpa geoglyphs

The above review shows that archaeological data from the Palpa region is generally in concordance with central assumptions of the Andean model, even though it corroborates only some of them. This was to be expected, however, since not all of its aspects can be assessed with archaeological means. The purpose of an explanatory model is just to explain the intangible aspects missing in the archaeological record. Generally, the Andean model fulfills the purpose of explaining the Palpa geoglyphs in a wider historical and cultural context quite well. Building on

Andean traditions documented by other means, for other time periods, and in other areas, a conceptual framework is established in which the archaeological evidence from Palpa can be explained in terms of function and meaning.

In spite of the Andean model´s general applicability to the Palpa data, there are also gaps and incongruities caused by the fact that the model was developed considering especially the *pampa* geoglyphs as opposed to the valley geoglyphs. As mentioned above, the existence of line centers and roads on the Nasca *pampa* is due to the specific topographical situation there with its exceptional vast plain that has no counterpart on the rather narrow ridges of Cresta de Sacramento and Cerro Carapo. On the other hand, there are peculiarities in the Palpa archaeological record, like *e.g.* many anthropomorphic figures, that are so far largely unknown from the Nasca *pampa*. The Andean model does not cover these early manifestations of the geoglyph complex. In the framework of SLSA's Paracas project, the Palpa figures are currently being investigated by Markus Reindel and Johny Isla in more detail than in the present study.

Finally, a more general comment on the way the Andean model has been developed and described by some of its main protagonists shall be made here. Important terms to denominate concepts of the Andean model are in Quechua (like *huaca, ceque, ayllu*) and have been borrowed from historical source describing Inkaic concepts. Though some of these terms have been used in the present study as well, their use in Nasca archaeology seems generally questionable as they imply, whether intended or not, too close a relationship between societies separated from each other by several centuries, different environmental conditions, and major historical breaks. It has rightly been cautioned that

> “... we run a risk of finding only Inka-analogous designs if we project Tawantinsuyu ... too vigorously into Andean antiquity.” (D'Altroy, Schreiber 2004:255)

A possible solution would be to stick to non-Quechua terms to denominate certain concepts. Even though the concepts originate in an Inkaic context, it should be possible to describe them using more neutral terms. Such a procedure may prove more cumbersome, but it might facilitate alternative views on the geoglyph phenomenon.

The Andean model is useful to explain most of the geoglyphs that we currently know in terms of function and significance. However, it is still an explanatory model that has to be questioned and tested once new data become available. The investigations conducted by the Nasca-Palpa project offered the first chance to test hypotheses elaborated after the last major wave of geoglyph research since the 1980s. Future geoglyph research in other regions, *e.g.* along the southern tributaries of Río Grande, is likely to reveal further facets of the geoglyph phenomenon that are not yet known today and cannot be explained by currently available hypotheses. Clearly, further work is needed. The more evidence becomes available, the better the Andean model can be assessed.

8. Results and conclusions

Summarizing the main topics treated in the previous chapters, the present study has allowed us

- to accurately document and analyze a large body of hitherto neglected geoglyphs using up-to-date geomatic technologies in combination with archaeological fieldwork,
- to clearify in detail which kinds of human activity related to the geoglyphs can be inferred from the archaeological record, and finally
- to assess the coherence and plausibility of a recent model to explain the geoglyphs in their cultural and historic context.

In this concluding chapter some important results of the present study are highlighted that complement the discussion and interpretation in the preceding chapter. This refers on the one hand to the cultural-historic development of the geoglyphs, on the other hand to our present perception of them. Furthermore, the methodology applied to study the geoglyphs, in many regards a new contribution to Nasca archaeology, is critically reviewed in order to identify starting points for future research both within the Nasca-Palpa project as well as in follow-up projects.

8.1 The Palpa geoglyphs in the prehistory of the Nasca basin

The Andean model as described in chapter 3.2 (see Figure 3.1) provides a solid framework to understand and explain the geoglyphs. According to this model, the Palpa geoglyphs were an important aspect of society and culture from the late Early Horizon to the early Middle Horizon. A marked landscape imbued with cultural meaning was created throughout this time period that integrated vast stretches of the desert into the cultural domain of the valley-based society and opened up stages for activity involving large parts of the population. Social groups acted and interacted on geoglyph sites, thereby defining, demonstrating, or claiming their status within a wider social context. The near constant presence of people along with construction and other activity meant that the geoglyph landscape was much more vibrant and dynamic than today. Construction and use of geoglyphs were highly interwoven and significant in itself. Activity on geoglyphs, which may be termed ritual, was concerned with water availability and fertility down in the valley. The scale and stability of the geoglyph phenomenon through time indicates that they were important manifestations of world view and basic cultural concepts. Change through time is observable, but was gradual in character and showed no major breaks unlike the settlement patterns in the valley. While the first geoglyphs were mainly thought to be seen, activity upon geoglyphs became more important through time and reached its peak in Early Nasca times. Later, it became less frequent and varied, until during the early Middle Horizon the last vessels were deposited on trapezoid borders.

Throughout their time of use, in spite of some variation the geoglyphs were a relatively stable element in Nasca culture that proved more long-lived than political organization. Geoglyphs may therefore best be understood literally as common ground for people making, using, and perceiving them, even in the face of changing socioeconomic, political, or even climatic conditions. Nevertheless, some variation occured, and a closer look on the origin, development, and end of the geoglyphs helps understanding their cultural significance through time.

The starting point of the Palpa geoglyph tradition is apparently to be found in the petroglyph tradition of the Paracas period. During the Early Horizon, rock faces as well as large boulders on hillsides were used to carve petroglyphs into their surface. The best known site is Chichictara, 11 km upstream from Palpa, with more than 200 petroglyphs (Hostnig 2003:169; Orefici, Drusini 2003:26ff). However, petroglyphs can be found in the lower parts of the valleys as well. Isolated large boulders on hillsides and plateaus were often adorned with petroglyphs. Among the motifs are biomorphic depictions (anthropomorphic and zoomorphic figures) with clear parallels in embroidered Paracas textiles and, less common, geometric motifs (*e.g.*, cirles) similar to certain decorations on Ocucaje pottery. Clearly, during the Early Horizon petroglyphs were part of an iconographic repertoire spanning different kinds of media.

A part of this repertoire, namely anthropomorphic figures, was at some point transfered from rocks on hillsides to a new medium: the surrounding desert surface. Just when this happened for the first time is as yet unknown due to a scarcity of associated finds that would allow cross-dating. A conservative estimate places the dating of this event around 400 B.C., *i.e.* during the late Early Horizon. A much earlier date cannot be ruled out, though. Current investigations into Paracas and earlier (Initial Period) remains in the Palpa region directed by Markus Reindel and Johny Isla, as well as the new OSL dating method are hoped to shed more light onto the beginning of the geoglyph phenomenon.

Whatever the exact dating, the first geoglyphs remained very similar to petroglyphs regarding their location, motif, and probably function. They were not suitable for walking on them, and deposition of ceramic vessels or other objects upon them or nearby was apparently not a part of their function. Rather, just like petroglyphs they were placed in locations such that they could be seen and perceived in their entirety from certain points in the terrain (not necessarily close-by). Contrary to later trapezoids there is no evidence that these early (mostly anthropomorphic) geoglyphs were ever left unfinished. Thus, their primary function was apparently to be seen, to convey a message to their observers.

In spite of this initial continuity, the geoglyphs soon developed out of a mere extension of an existing iconographic repertoire into an independent, versatile and powerful means of expressing cultural concepts. The possibilities offered by the new medium – large stretches of easily removable desert pavement – fostered this new development, although they were probably not the prime mover. New motifs and, even more important, different functions associated with the geoglyphs emerged and determined the geoglyph phenomenon throughout most of Nasca history.

Geometric geoglyphs like straight lines and small trapezoids were the first new motifs to be drawn on hillsides. The techniques necessary to draw these forms on the surface, namely slightly carved lines and cleared areas, had already been employed earlier to render anthropomorphic figures. However, it was only when these new motifs were transfered to flat terrain – *i.e.*, the plateaus above the valleys – that people began to walk upon them on a regular base, and a new set of activities associated with geoglyphs developed. This included the first-time construction of stone structures as well. It is this conglomerate of highly interwoven geoglyph related activities – geoglyph construction and remodeling, walking on geoglyphs, deposition of offerings, food consumption – that left clear traces in the archaeological record of the Nasca basin and which the Andean model is tailored to explain (see above).

Initial Nasca and then most notably Early Nasca were the times when the geoglyph phenomenon flourished and reached its apogee in terms of quantity and variety. This development coincides with a demographic peak at least in the Palpa region. It also coincides with the heyday of regional centers like Los Molinos (Reindel, Isla 2001) and, on a regional level, of Cahuachi (Silverman 1993a). By this time the geoglyphs had become an constitutive symbol of "Nascaness" (as described by Silverman 2002b:122), and large efforts went into their construction and use.

The emergence of activity taking place on geoglyphs included the placing of objects that mirror a concern with water and fertility, like ceramic vessels containing food, field crops, crawfishes, and *Spondylus* shells. These concepts remained an important aspect of geoglyph related activity throughout the remainder of the Palpa geoglyph history. Recent paleoclimatic studies in the Nasca-Palpa region (Eitel et al. 2005) indicate that during Nasca times, and especially in the 5th to 7th centuries AD, the climate became constantly dryer, and the eastern margin of the desert shifted slowly up-valley. These changing environmental conditions clearly influenced, and probably motivated, certain geoglyph related activities. Nevertheless, this is not to say that everything happening on geoglyph sites can be understood solely in the framework of a fertility cult. Such a monocausal explanation would certainly underrate the social dimension of the geoglyphs. Throughout most of their history, the geoglyphs provided a spatial framework for negotiating and symbolizing the status of certain social groups within a changing sociopolitical system. How this happened in detail and how the mentioned groups were defined cannot be assessed on the basis of evidence from the geoglyphs alone. In any case, geoglyphs were most probably no less important for social processes within Nasca and earlier societies than for responses of these societies to influences from outside like changing environmental conditions.

After its Early Nasca peak, Palpa geoglyph history entered into a slow and gradual decline. During Middle and Late Nasca times formal variety of newly constructed geoglyphs was reduced bit by bit. Apparently, there was a need for formal standartization, and no new type was added to the existing repertoire. For the first time, certain geoglyph fields on Cresta de Sacramento and Cerro Carapo were abandoned, and no new one was added. However, it has to be stressed that the principal characteristics of geoglyph construction, use, and social function remained intact until the Nasca/Wari transition. Important geoglyph sites from Early Nasca times continued in use, new geoglyphs were still being added and existing ones altered and enlarged, and especially trapezoids grew even larger than before. Unfortunately, geoglyph dating is so far not fine-grained enough to study this long process in detail. As for now, a constant but slow decline seems most likely.[32]

There is no easy explanation for the end of the geoglyph phenomenon. It is generally still poorly understood what happened when what we call the Nasca culture came to an end. The Wari intrusion, whatever its nature, is archaeologically marked by changing settlement and burial patterns, a lower population density, and new ceramic styles (Silverman, Proulx 2002:chapter 11; Isla 2001b), such that it has been suggested that these changes were induced by an exchange of population (Schreiber 2001). Environmental changes, namely an increasing desertification, seem to have contributed as well to the stress late Nasca society was exposed to (Eitel et al. 2005). In Palpa, there was a clear break in geoglyph related activity at some point at the beginning of the

32 The lower number of geoglyph assigned to Nasca 4 as compared to Nasca 5 (Figure 6.9) does not mean that the geoglyph phenomenon sharply declined from Nasca 3 and then regained importance by Nasca 5. Rather, this seems due to a much shorter duration of Nasca 4, a phase which is generally still poorly understood.

Middle Horizon, probably in the course of the 7th or 8th century AD. On the one hand, geoglyph use continued on a small scale into the Middle Horizon before it ceased altogether. Ceramic vessels (now in the new style) were still being deposited on trapezoid borders at least during the early Middle Horizon. On the other hand, however, there is no indication that any new geoglyphs were still being constructed by that time, and Middle Horizon ceramics on geoglyphs are much fewer in number than earlier ceramics. Apparently, some parts of the population stuck to ancient traditions for a certain time but could not perpetuate or revive them before they got lost. Settlements from the Late Intermediate Period placed on geoglyph fields, using the plateaus of Cresta de Sacramento and Cerro Carapo for totally different purposes and obliterating and destroying ancient geoglyphs, are a clear sign that already in pre-Inkaic times the geoglyphs were no longer valued or understood.

8.2 Geoglyph perception and understanding

Geoglyph making and use during more than 1 000 years has changed the landscape in the Nasca basin at large scale and forever. Large stretches of the desert were converted into cultural space. Yet this impressive, giant opus bears in itself the reasons why it is often misunderstood.

In order to understand the meaning of the geoglyphs in Nasca times a change of perspective is indispensable. Our current perception is shaped by an aerial perspective: tourists as well as scholars usually see the geoglyphs from above, and photos taken from an airplane are the dominant means of illustration in the literature on the Nasca geoglyphs. This modern perspective, however, is misleading since it disguises important aspects of the geoglyph phenomenon:

- Aerial photographs show even very large geoglyphs (*e.g.*, trapezoids on the Nasca *pampa*) in their entirety, allowing a complete overview of the geoglyphs and their context. Such a view was not possible in Nasca times. Most lines and trapezoids on flat terrain were only partially visible from a ground perspective. Though the limited repertoire of basic forms and distinguishing constructional features allowed to recognize the overall shape of a geoglyph even on the basis of certain elements (*e.g.*, parallel heaped borders etc.), the entire form was usually not visually perceivable.
- Furthermore, what we see today on the desert surface is the static final result of many centuries of geoglyph making and use. The geoglyph conglomerate as visible today is not, however, the outcome of a master plan that aimed at the resulting picture from the

beginning. Rather, it is the final stage of a long lasting construction process during which elements of the whole picture were constantly added, remodeled, obliterated, or changed by use.

- Aerial photographs furthermore show empty geoglyphs out in the desert far away from inhabited zones. In Nasca times, in contrast, there was a near constant activity going on upon and around the geoglyphs, as groups of people frequently moved over the geoglyphs, performing codified acts meaningful to them and others. People and activities were integral parts of the ancient geoglyph reality that have nowadays vanished. They were easily visible from other geoglyph sites or from the valley. In fact, people on geoglyphs, rather than geoglyphs themselves, may well have been the main focus of common perception at least in Nasca times. Without this dynamic element the geoglyphs cannot be understood.

These biases have to be kept in mind when trying to interpret the geoglyphs. Only a small part of the geoglyphs were meant mainly as symbols, or signs, to be viewed and understood from far away. This includes mainly the early anthropomorphic geoglyphs on hillsides that were visible from a certain distance, repeated motifs known from other media (textiles, ceramics), did not show signs of human activity around them, and remained largely unchanged once drawn. In contrast, many later geoglyphs in large complexes on plateaus were not visible in their entirety, their shapes were not repeated on other media, they were constantly remodeled and otherwise used and altered. These geoglyphs cannot be understood as mere visual signs. Geoglyphs alone most probably were not able to symbolize or convey certain cultural concepts at least in their later stages. Rather, they only made sense as integrated part of a dynamic complex involving also people and activities as indispensable, and maybe even more important, elements. Any serious study of the geoglyphs has to keep this bias in mind.

8.3 Geoglyph documentation: review of applied methods

The present study introduces several new approaches into Nasca archaeology. Modern aerial photogrammetry, 3D modeling, database and GIS technologies enabled for the first time the complete recording, visualization, and detailed analysis of a corpus of geoglyphs that had previously received little attention. The new dataset could be used to test how well a recent model to explain and understand the geoglyphs is founded on archaeological evidence. New insights into the formal, temporal, and spatial variety of geoglyphs were gained, and the documentation elaborated in the course of this study is hoped to be used in the future to facilitate the protection and long-term preservation of the Palpa geoglyphs.

In spite of, or maybe due to, the novel approach pursued in this study, the work was not without methodological problems. Some major issues shall briefly be mentioned in the following.

The geoglyphs of San Ignacio and Llipata, including the most complex geoglyph site in the Palpa area and the largest known trapezoid, could not be considered in the present study since time constraints did not permit to document them at the same level of detail as the geoglyphs north of Palpa. Although the photogrammetric mapping of the area south of Palpa was completed (Map 1), and some sites in that area were documented entirely and others partially in the field, it soon became clear that the available time and manpower to cover the whole area had initially been underestimated. Nevertheless, data already obtained from that area may serve as starting point for future research.

Geoglyph mapping based on vertical aerial images offered the opportunity to document all Palpa geoglyphs on a high level of detail and accuracy. However, this approach reached its limits when it came to figural geoglyphs on hillsides. Although most of them could be detected in the stereopairs, they were usually not well enough discernible to be mapped accurately. Verification on the spot often did not help to solve the problem either since further details recognized in the field could afterwards in many cases not be reproduced at the analytical plotter. The best way to document figural geoglyphs on slopes is with oblique aerial photographs in combination with field survey. This is currently being done in the framework of SLSA's Paracas project. Thus, new insights into this important subset of geoglyphs can be expected for the near future, which will certainly complement and reshape some of the ideas expressed in this study.

Concerning data registered in the field, a major shortcoming of the present study is the lack of a systematic registration or sampling of surface finds. This was at least partially inevitable due to legal constraints, but also due to limitations of time and manpower. In any case, the lack of quantitative information about ceramics impedes the investigation of several potentially interesting problems. These include the ratio of fineware to plainware ceramics, the percentage of certain vessel shapes, a comparison of find inventories from geoglyph and other sites, and the change of these parameters over time.

The potential of GIS functionality could not be fully tapped in this study. On the one hand, this was due to time constraints towards the end of the time period available for this thesis. On the other hand, other features to which the geoglyphs may be related have not yet been studied in enough detail to be considered in the present study. This refers to excavation and survey data from settlements and other sites in the Palpa region. The analysis of these datasets is underway, however, and they are hoped to be integrated into the GIS at a later date.

8.4 Summary and conclusions

Some methodological shortcomings notwithstanding, the results of this study are hoped to show that a serious investigation of the geoglyphs, laborious as it may seem, is worthwhile since it still allows to learn more about the geoglyphs in spite of all that has already been written about them. Rather than unsubstantiated speculations that have shaped the public impression of the "mysterious" Nasca geoglyphs for so long, a sound archaeological approach embracing techniques from neighboring fields has the potential to reveal detailed insights into these fascinating cultural features. Serious investigations by researchers cited in the present study have led the way in recent years. A coherent explanatory model, though not as simple and straightforward as many a geoglyph *aficionado* would wish, is now available that provides a good starting point to understand the geoglyphs. And there are still many geoglyphs around that have not yet received the attention they deserve.

9. Appendix

In this appendix, detailed descriptions of specific archaeological contexts (stratigraphy, excavations) in the Palpa area are compiled on which some of the results presented in chapter 6 are based. Furthermore, it contains a glossary of abbreviated terms, bibliographic references, and a list of the contents of the accompanying supplement.

9.1 Development of complex geoglyph sites

For some rather complex sites (> 20 geoglyphs) on Cresta de Sacramento and Cerro Carapo stratigraphic sequences could be reconstructed that allowed to study site development in some detail. While two sites (PV67A-39 and -40) on sloped terrain can only be described summarily here due to their state of preservation, three sites on plateaus (PV67A-35 and PV67A-47 on Cresta de Sacramento and site PV67B-55 on Cerro Carapo) offered detailed stratigraphies that were visualized in Harris matrices elaborated with ArchEd 1.4.1.[33] Stratigraphic relationships of geoglyphs on further sites are reported in the database on DVD.

9.1.1 Geoglyph sites on sloped terrain

Geoglyph sites on hillsides generally lack on the one hand the complexity of sites on plateaus, since geoglyphs are usually placed further apart from each other. On the other hand, they are more difficult to date both in terms of relative and absolute chronology. Wherever geoglyphs on slopes cross other geoglyphs, erosion has usually long since washed away any clear signs of stratigraphic sequence. Datable ceramics are associated to geoglyphs on slopes in lower numbers and less clearly than to geoglyphs on plateaus. On the most complex and most interesting site featuring the famous *reloj solar* geoglyph (240), site PV67A-39, all stratigraphic evidence was destroyed when the geoglyphs were cleansed and reconstructed in the 1980s by a local schoolteacher. However, the placement of different geoglyph types on slopes indicates site development over time. Two neighboring sites on the southern flank of Cresta de Sacramento can serve as example here.

33 Available for free download at www.ads.tuwien.ac.at/ArchEd/ (accessed August 18, 2004)

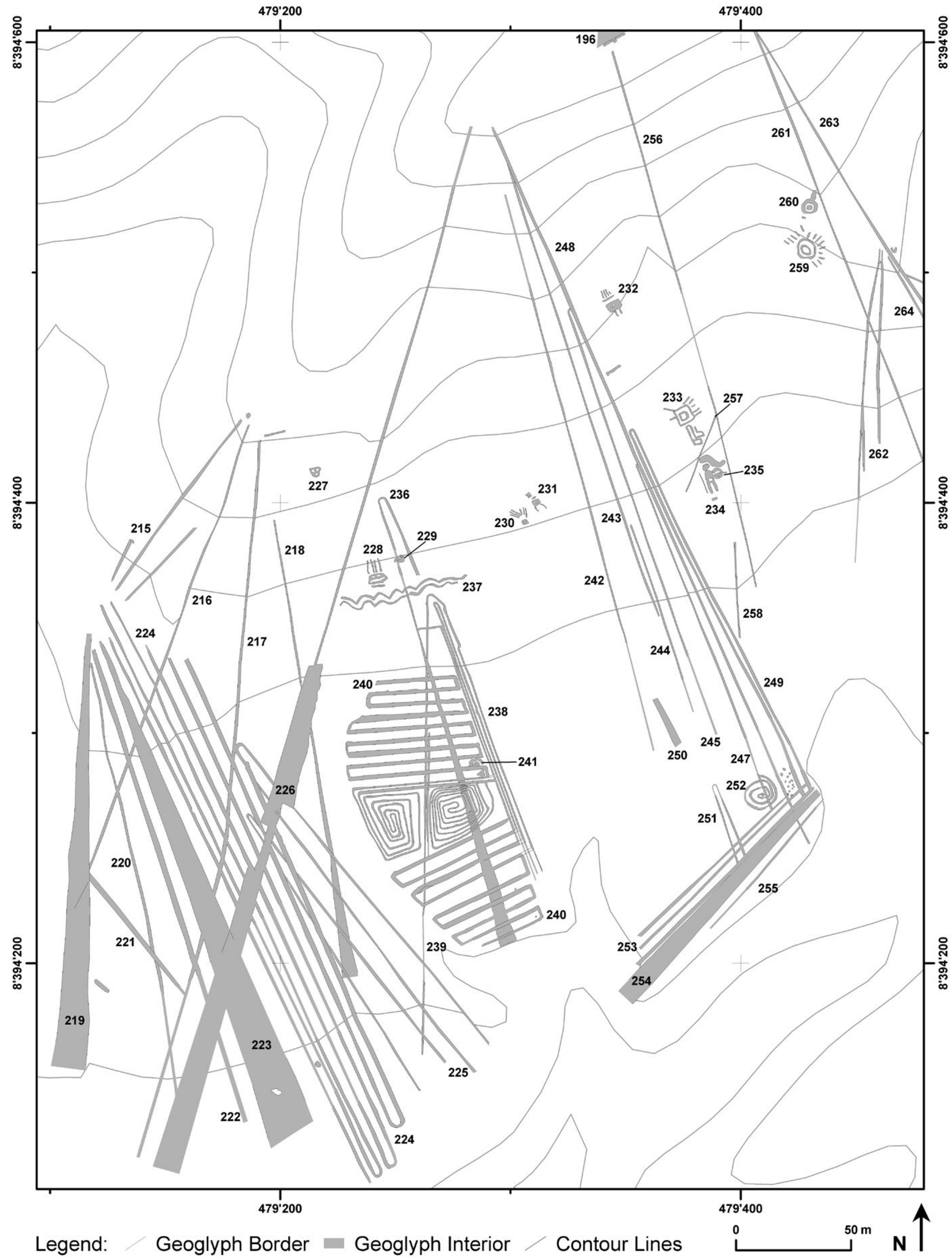

Figure 9.1: Geoglyph site PV67A-39 on Cresta de Sacramento

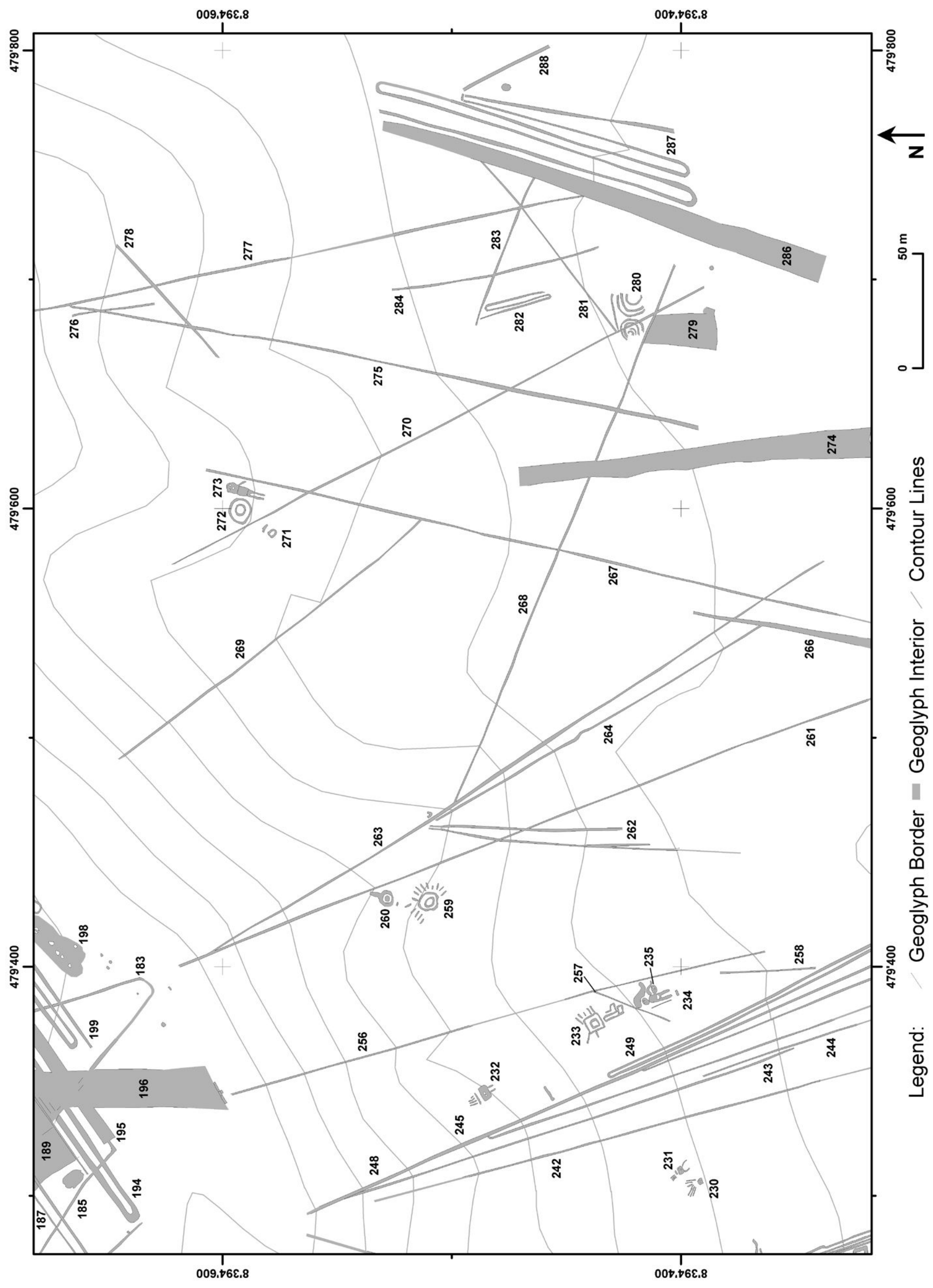

Figure 9.2: Geoglyph site PV67A-40 on Cresta de Sacramento

Sites PV67A-39 and -40 (Cresta de Sacramento)

On these two neighboring sites (Figure 9.1, Figure 9.2), anthropomorphic figures are usually placed on the steepest part of the slope, although at different levels. Sometimes, two figures are placed close to each other. Wherever they occur together with lineal geoglyphs, the latter cut the former (240/241, 236/229). Thus, anthropomorphic figures were the earliest geoglyphs on hillsides. Most other types of geoglyphs found on sloped terrain are known from all time periods of the geoglyph complex and are therefore not datable on the basis of shape alone. Most probably they were made over a long period of time, from Initial Nasca to Late Nasca.

Figure 9.3: View over geoglyphs on site PV67A-39 from the upper plateau of Cresta de Sacramento

Groups of lineal geoglyphs on slopes have common points of origin on the edge of the plateau (226/242/248, 261/263), or they branch off from a main line running downhill (248/243/245/247, 263/264/268, 277/275). This indicates that new lines were adapted to existing ones, adding one line after another over a long period of time. Trapezoids on hillsides, considerably smaller than their plateau counterparts, were placed on the lower parts of slopes where the degree of terrain inclination is lower (219, 223, 254, 274, 286). Just like on plateaus, they were flanked by meandering lines (224, 253, 287) and spirals (252). The *reloj solar* geoglyph (240) is a peculiar combination of both line types (Figure 9.3). Its construction date remains unknown, but evidence from other sites suggest that spirals were constructed no later than in Early Nasca times. Some of the lines on slopes seem to cut through trapezoids, but the evidence is usually not clear. The odd-shaped geoglyph 226, which seems to cut a series of lines and a trapezoid, was probably left unfinished. Its uncommon shape is in any case not due to the modern reconstruction of geoglyphs mentioned above, since it is already visible in that shape in an 1944 SAN aerial photograph.

9.1.2 Geoglyph sites on plateaus

Site PV67A-35 (Cresta de Sacramento)

This site occupies the southwesternmost part of the main plateau of Cresta de Sacramento. It is composed of three major trapezoids, a series of lines, and the figure of a whale or shark (Figure 9.5, Figure 9.6). The central part of the site is crossed by a road leading from Río Grande to Palpa. A radio transmitter has been built on the northern side of the road on the main plateau. Both modern features have destroyed parts of several geoglyphs. Furthermore, cars have left their tracks on many parts of the site, and modern litter has been deposited in several places. All in all, however, the geoglyphs are well enough preserved to study them in detail (Figure 9.4).

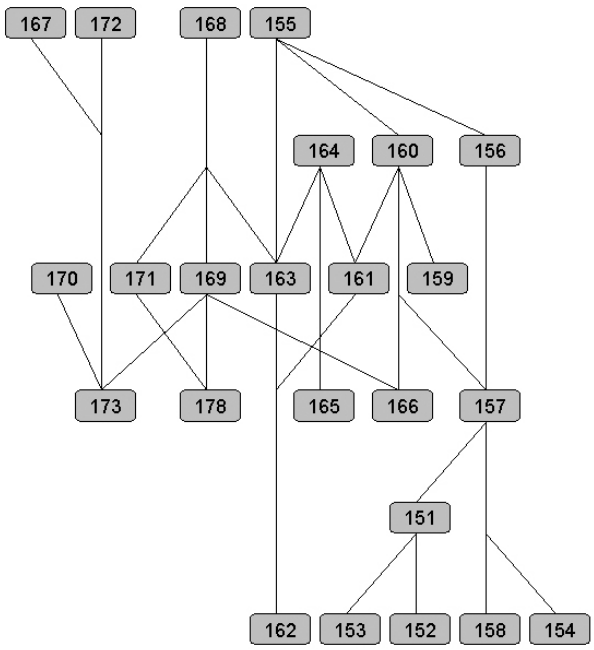

Figure 9.4: Geoglyph stratigraphy on site PV67A-35

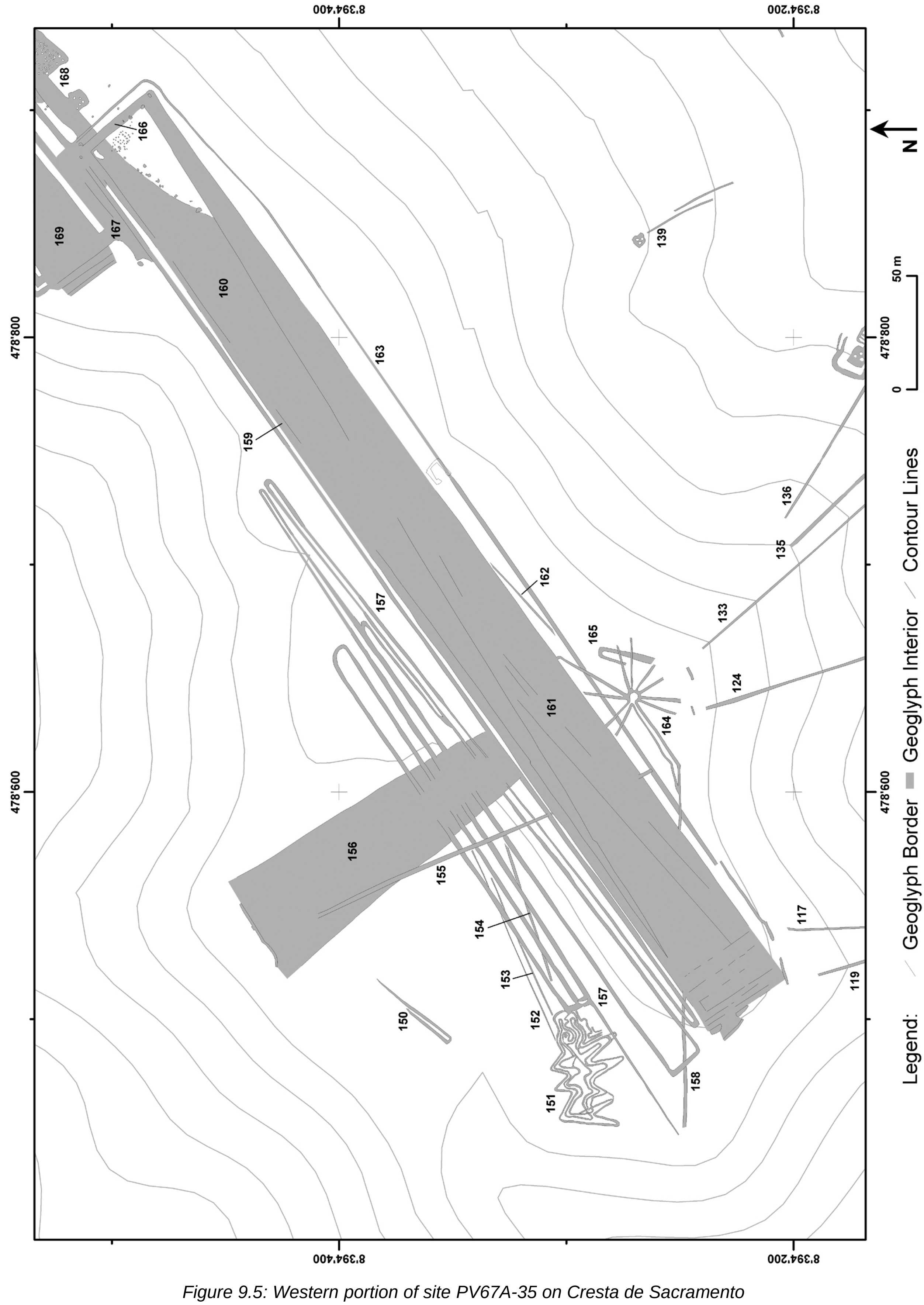

Figure 9.5: Western portion of site PV67A-35 on Cresta de Sacramento

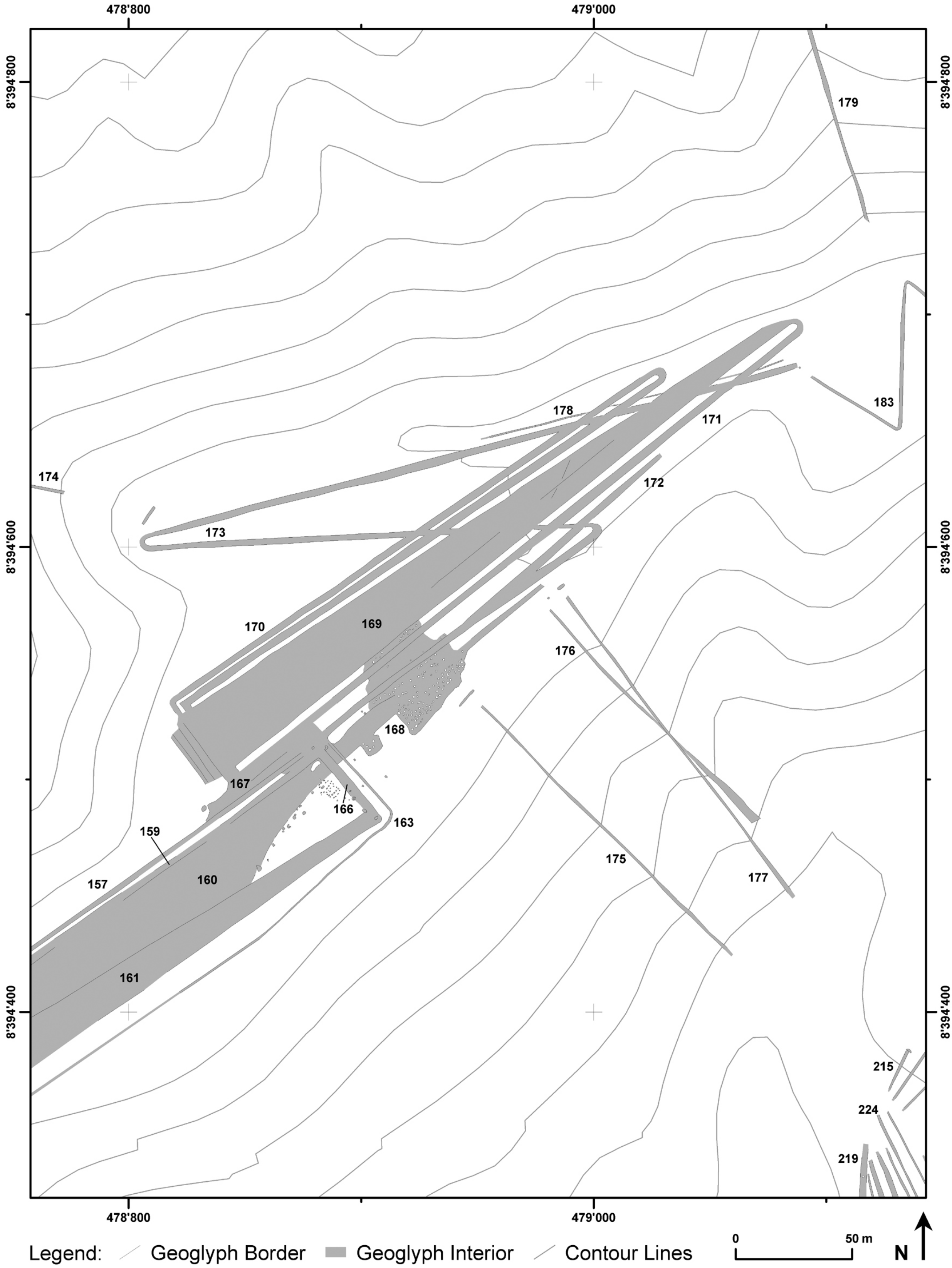

Figure 9.6: Eastern portion of site PV67A-35 on Cresta de Sacramento

The first geoglyphs to be constructed on the plateau were several narrow straight lines (152-154, 158, 162, 178), none of them very long, some parallel to each other. Since no datable ceramics were found on either of them, it is unclear when this first activity occurred, but certainly no later than Nasca 2 when the first datable geoglyphs were constructed, partially covering the mentioned lines. The whale or shark figure (151) as well as the largest trapezoid dominating the site (161) were constructed next (Figure 9.7). Both had ceramics dating to Nasca 2, 3, and 5 upon them, indicating a long period of use, which is confirmed by evidence that both geoglyphs were remodeled at least once. Thus, Nasca 2 marked the beginning of large-scale geoglyph related activity on the site. In the northeastern part of the site, the second major trapezoid (169) was also constructed during that time, partly covering an already existing zigzag line (173).

Figure 9.7: Aerial view of western portion of geoglyph site PV67A-35

Though no ceramic evidence is available, several lineal geoglyphs must have been constructed in Early Nasca times as well due to their stratigraphic position. This includes lines flanking the major trapezoids (159, 163, 171) and maybe the star-like geoglyph 164 (in fact composed of six U-shaped lines), though these geoglyphs may have been constructed as well during the second major activity phase on the site, which is marked by ceramics dating to Nasca 5. In this time, meandering lines flanking the major trapezoids were constructed (157, 170) and later partially covered by a series of areal geoglyphs, some of which were designed so as to connect existing cleared areas (167, 168) while others occupied hitherto unused parts of the plateau (156). Furthermore, the largest trapezoid (161) was converted into a rectangle (160), though this remodeling was never finished, just as geoglyph 168 dating from the same time nearby. Some straight lines cutting earlier geoglyphs (156, 172) complete the group of geoglyphs dating to Nasca 5. By the end of that phase, geoglyph construction seems to have ceased, though some kind of activity clearly went on.

For epochs later than Middle Nasca there is evidence solely from datable fineware ceramics. These are clustered around trapezoid 156, *i.e.* on the northern part of the western portion of the site. While the meandering line 157 had Late Nasca ceramics upon it, on the trapezoid Middle Horizon as well as LIP ceramics were found. However, there is no evidence of new geoglyphs being constructed later than Nasca 5.

SITE PV67A-47 (CRESTA DE SACRAMENTO)

Figure 9.8: Aerial view of site PV67A-47 on Cresta de Sacramento

This site occupies the central part of the main plateau of Cresta de Sacramento just above the famous *reloj solar* (sundial) geoglyphs on the southern slope of the ridge. Though situated far from trafficable roads, the site is equally marked by modern car tracks. Its proximity to the touristic viewpoint overlooking the *reloj solar* site has furthermore led to a frequent traffic of people over the main geoglyphs. The eastern end of the geoglyph complex has been destroyed by a LIP site already in prehispanic times. Again, however, the preserved evidence is suitable for a detailed study of the development of the geoglyph complex based on stratigraphic relationships and associated datable ceramics (Figure 9.9).

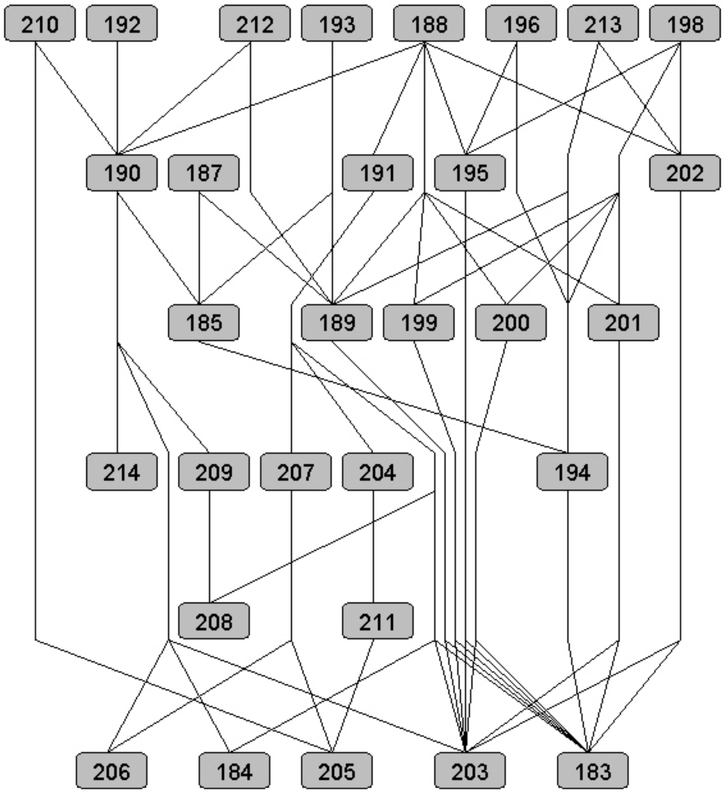

Figure 9.9: Geoglyph stratigraphy on site PV67A-47

Site PV67A-47 (Figure 9.8, Figure 9.10) is linked to site PV67A-35 by a long zigzag line (183) that crosses the free space between both sites, making use of its full width. This zigzag line was one of the earliest geoglyphs to be constructed on the site and dominated it in the beginning, which is marked by Nasca 2 ceramics. Just like site PV67A-35, several rather isolated straight lines (184, with Initial Nasca ceramics upon it, and 205) were furthermore among the earliest geoglyphs on site PV67A-47. The zigzag line 183 was accompanied by a second line of the same shape (203). Both were covered by a large trapezoid (189) on which the earliest ceramics date to Nasca 2.

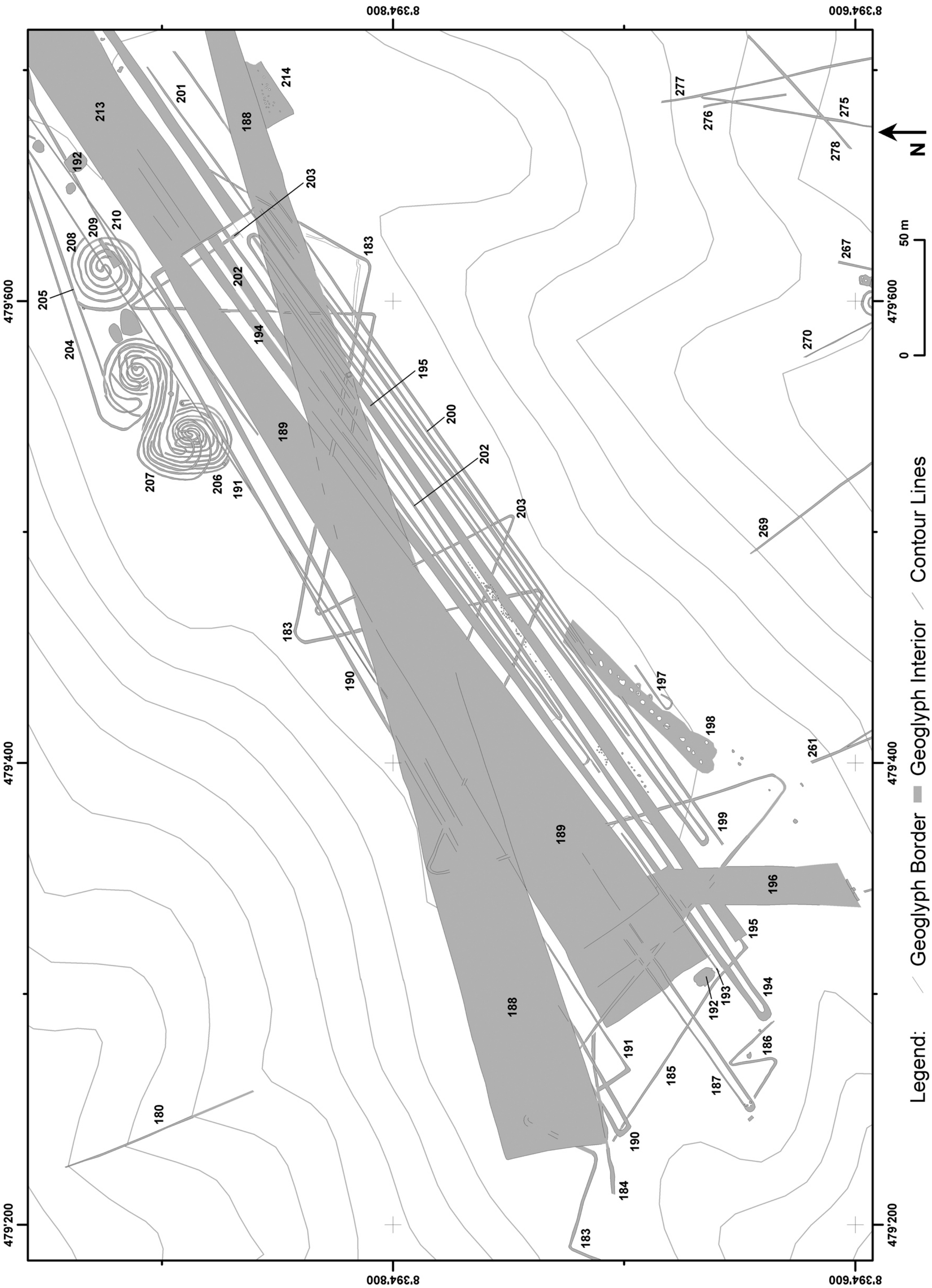

Figure 9.10: Site PV67A-47 on Cresta de Sacramento

Two spirals (206, 208) on the northern edge of the site were constructed at about the same time, just like several lineal geoglyphs (190, 193, 202) flanking the main trapezoid. The S-shaped spiral (206) was remodeled during Nasca 3 (207), when an areal geoglyph linking the main trapezoid with a viewpoint overlooking the valley (196) was constructed, too. All in all, construction activity was substantial and varied in Early Nasca times.

By Middle Nasca times, several lineal geoglyphs were added to the complex on the southern side of the main trapezoid (195, 199-201) and on its western end (187) as indicated by Nasca 4 and 5 ceramics. The spirals on its northern side were partially cut or covered by several lines (191, 210) as well as one of the smallest registered trapezoids (209). Close by, the eastern, narrow end of the central trapezoid (189), which continued in use, was converted into a large rectangle.

In Late Nasca times, a large trapezoid (188), the largest one registered on Cresta de Sacramento, was built that cut through most existing lines and the central trapezoid in an oblique direction. Nasca 7 sherds were found on this geoglyph. Its orientation was so that it made optimal use of the remaining free space on either side of the central complex of geoglyphs. Near its narrow end, the trapezoid partially covered an unfinished areal geoglyph with Nasca 6 sherds on it. Some Nasca 7 and Loro sherds were found on areal geoglyphs close to the eastern end of the site. The presence of LIP sherds also found on that part of the site is most probably due to the construction of LIP buildings there which obliterated some geoglyphs. All in all, the latest evidence of activity on site PV67A-47 dates to the Nasca 7/Loro transition. Contrary to site PV67A-35, this activity still included the construction of large geoglyphs.

Site PV67B-55 (Cerro Carapo)

This site occupies the westernmost foothills of the ridge between Río Palpa and Río Viscas (Figure 4.3, Figure 9.11, Figure 9.12). This is the only plateau on the Carapo ridge comparable to the larger plateaus on Cresta de Sacramento and Pampa de San Ignacio. Though closer to Río Viscas, the site is only accessible from Río Palpa via a slope also covered by geoglyphs, whereas a sharp escarpment separates it from the Viscas valley. Towering on small hills above this escarpment, a LIP site dominates the plateau. Constructions built during that time, among them walled enclosures, graves, and a ditch, have damaged the central trapezoid of the site. Other than that, the geoglyphs are well preserved since no modern path or road crosses the site.

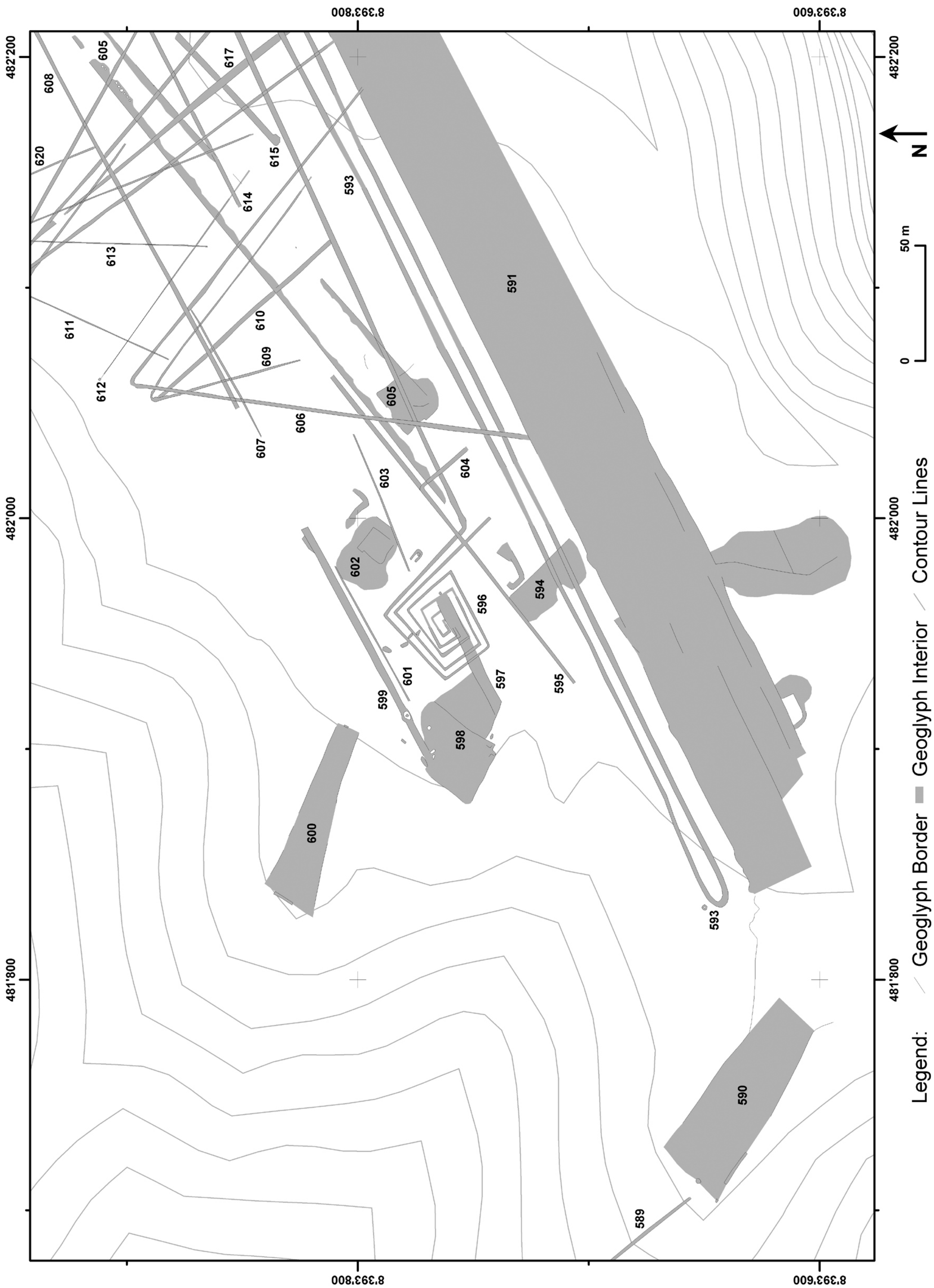

Figure 9.11: Western portion of site PV67B-55 on Cerro Carapo

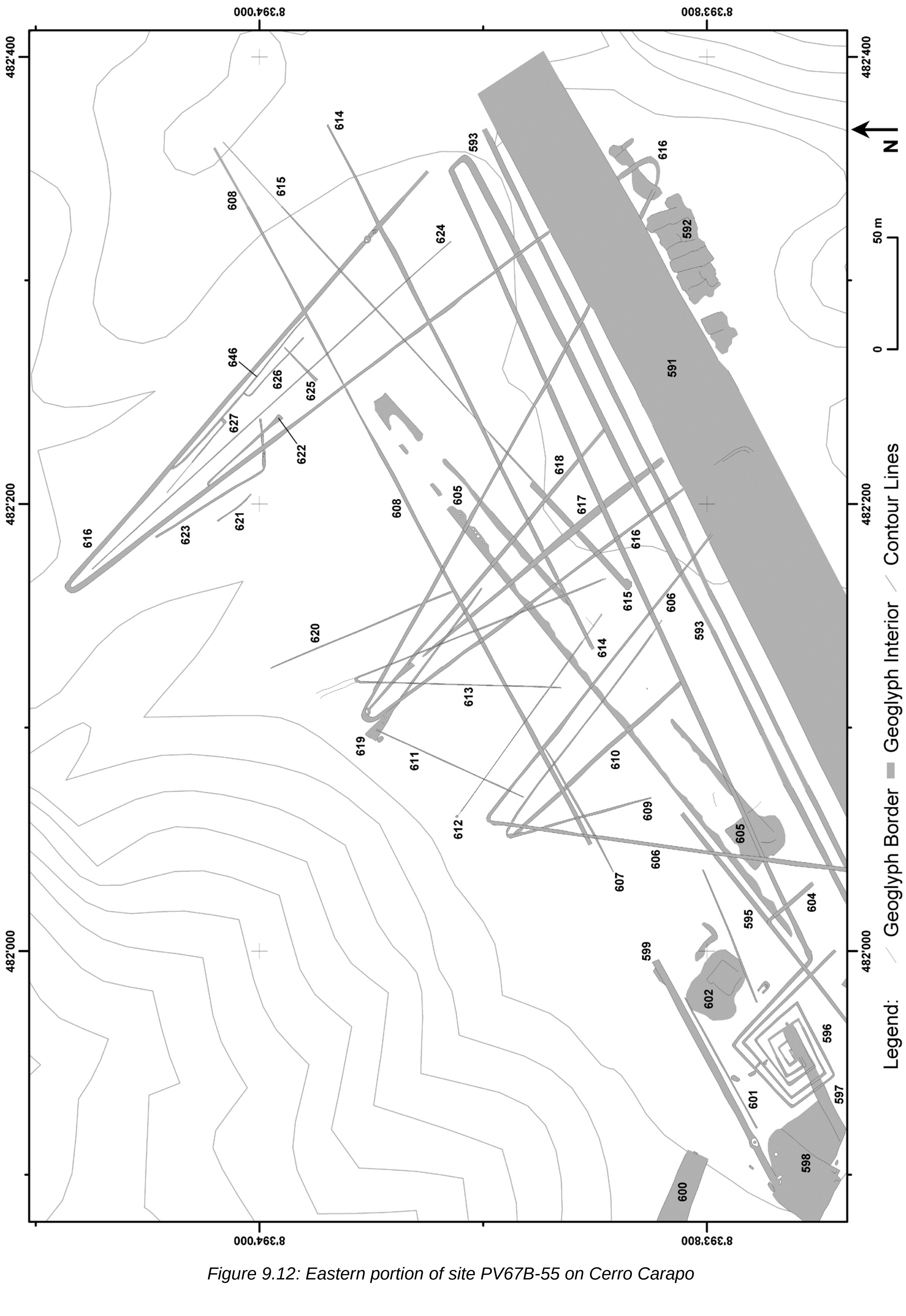

Figure 9.12: Eastern portion of site PV67B-55 on Cerro Carapo

Just as on the Sacramento sites, the first geoglyphs constructed on Cerro Carapo were several narrow straight lines distributed over different parts of the site (595, 599, 603, 612, 613, 615, 620, 624 and probably others more). Associated ceramics date the earliest of these lines to Nasca 2. Early Nasca furthermore saw the construction of an angular spiral (596) and a large meandering line (593). Probably at about the same time, the first large trapezoid of the site (605) was started but never finished. Though associated ceramics suggest a later date, the stratigraphic position of two large zigzag lines crossing the plateau shows that they also were constructed in Early Nasca times, cutting several earlier geoglyphs. Thus, a wide array of geoglyphs dates to that period. On many of these, Nasca 5 ceramics indicate a continued use in Middle Nasca times, when new geoglyphs were added to the complex. Among them were several amorphous geoglyphs (592, 597, 598, 602) and probably some of the lineal geoglyphs, although the latter are lacking datable finds. Most important of all, the large trapezoid 591 that dominates the southern half of the site was constructed during Middle Nasca times, probably covering a series of earlier geoglyphs and thus changing the layout of the site. By then, a good part of the available space of the plateau had been covered by geoglyphs.

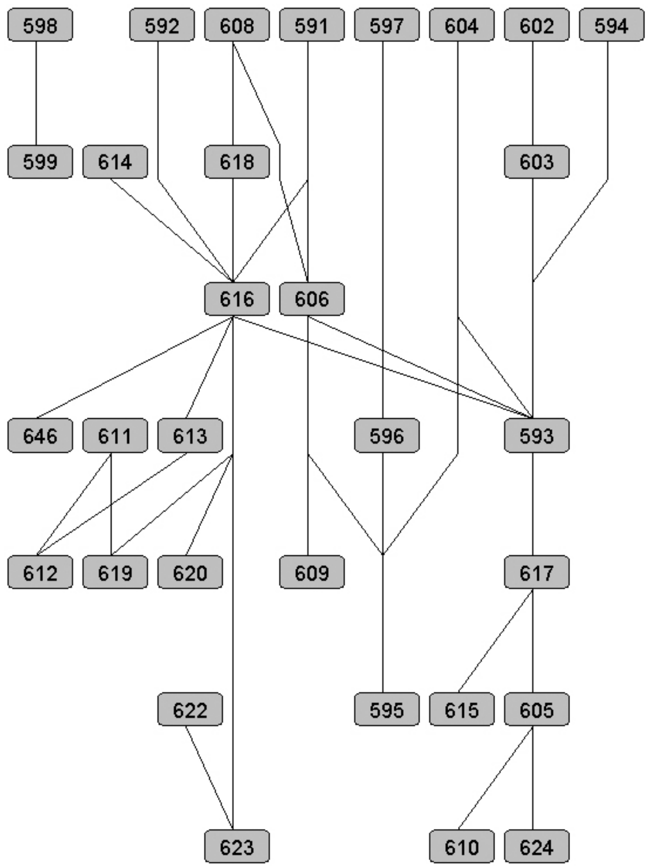

Figure 9.13: Geoglyph stratigraphy on site PV67B-55

The date of other trapezoids (590, 600) on the site is unknown. There is no evidence of Late Nasca activity. LIP sherds scattered on the surface are clearly associated with the stone structures of the LIP site situated south of the geoglyphs.

9.2 Excavation of stone structures on geoglyph sites

Several well preserved stone structures associated with geoglyphs were fully or partially excavated on Cresta de Sacramento and Cerro Carapo in order to determine their construction technique, age, function, and relationship with the geoglyphs. Two types of stone structures could be distinguished: elongated platforms on the edge of plateaus, and rectangular platforms on trapezoids.

9.2.1 Elongated platforms on terrain edges

Site PV67A-47 (Cresta de Sacramento)

Figure 9.14: Stone platform at the end of geoglyph 196 on site PV67A-47

On the southern margin of the vast plateau on which PV67A-47, the most complex geoglyph site on Cresta de Sacramento (Figure 9.8), is located, a low stone platform is situated on the edge of the flat terrain, overlooking the Palpa valley (Horkheimer 1947: figs. 21, 22; Reindel et al. 1999: fig. 16). Unlike the main part of the plateau, the surface is not covered by a continuous stone pavement around the platform.[34] To the north, a roughly rectangular cleared area (geoglyph 196) crossing a shallow *quebrada* connects the platform with the central trapezoid of the site (189) crosscutting several lines (183, 194, 195). To the south, the platform marks the starting (or ending) point of a straight line (256) running down (or up) the slope, ending (or starting) at a not clearly defined point at the foot of the slope.

Figure 9.15: Partially excavated stone platform on site PV67A-47

The stone structure (Figure 9.14, Figure 9.15) is oriented in SW-NE direction, *i.e.* following the general orientation of Cresta de Sacramento. It has an elongated, roughly rectangular shape. It is composed of six adjoining chambers of roughly equal size organized in a somewhat irregular row and one lateral chamber abutting the middle chambers on the southeastern side. The structure is approx. 11 m long and 1.00 – 1.20 m wide. The chambers are outlined by a single row of unworked boulders or slabs standing upright in the subsoil. There is no evidence of

34 Similar areas without dense stone cover have been repeatedly noticed on the *pampas* around Palpa, always along the margins of plateaus. They seem to lack a stone cover due to natural reasons, whereas an anthropogenic origin can be ruled out since the transition to the dense stone cover is gradual and without clear limits. It is not clear whether the term *campo barrido* as used by Silverman and Browne, describing cleared areas without well defined boundaries, refers to such areas (Silverman 1990b:444; Silverman, Browne 1991:211f).

mortar or additional stone layers. The chambers are filled up to an average height of approx. 0.20 m with gravel composed of stones of different sizes, apparently the same material that forms the desert pavement. No debris is visible around or upon the platform. Although some stones of the retaining wall are missing or seem to be out of their place, the overall state of preservation of the stone structure is good.

Two chambers were excavated in 1997: the northeastern and the lateral one. The situation encountered was the same in both pits. The main part of the fill consisted of gravel as described above. Below it was a thin layer of beige dirt, apparently the material excavated to post the stones of the retaining wall. Below this second layer of the construction fill, the natural desert surface appeared. Apart from one Nasca 3 sherd, the construction fill contained no other cultural remains. Contrary to Horkheimer's speculation (Horkheimer 1947: figs. 21, 22), there was no indication whatsoever that the structure may have contained a tomb.

SITE P67A-35 (CRESTA DE SACRAMENTO)

A similar elongated stone structure was partially excavated on the neighboring site PV67A-35. It is situated on the southwestern edge of the main plateau of Cresta de Sacramento, not far away from the whale figure (geoglyph 151), and is oriented in NW-SE direction following the edge of the plateau (Figure 9.7). Together with two gravel heaps, this structure marks the somewhat irregular wide base of the central trapezoid of the site (161). The stone structure is constructed in a similar fashion as its counterpart on site PV67A-47, with a row of stones retaining gravel fill. It consists of five chambers in a row and two lateral chambers attached to the central section on both sides (Figure 9.16). Unlike the structure on PV67A-47, however, the chambers vary greatly in size, the lateral chambers being the smallest ones, and the two easternmost chambers slightly bend towards the north. The overall length of the structure is 12 m, its average width 1 m. The structure is generally well preserved.

A small pit was excavated in 1997 in the central part of the stone structure, comprising the two lateral chambers and part of the chamber in between them (Figure 9.17). The situation was exactly the same as described for the structure at PV67A-47, except that no ceramics were found in the construction fill.

Figure 9.16: Stone platform at the end of geoglyph 161 on site PV67A-35

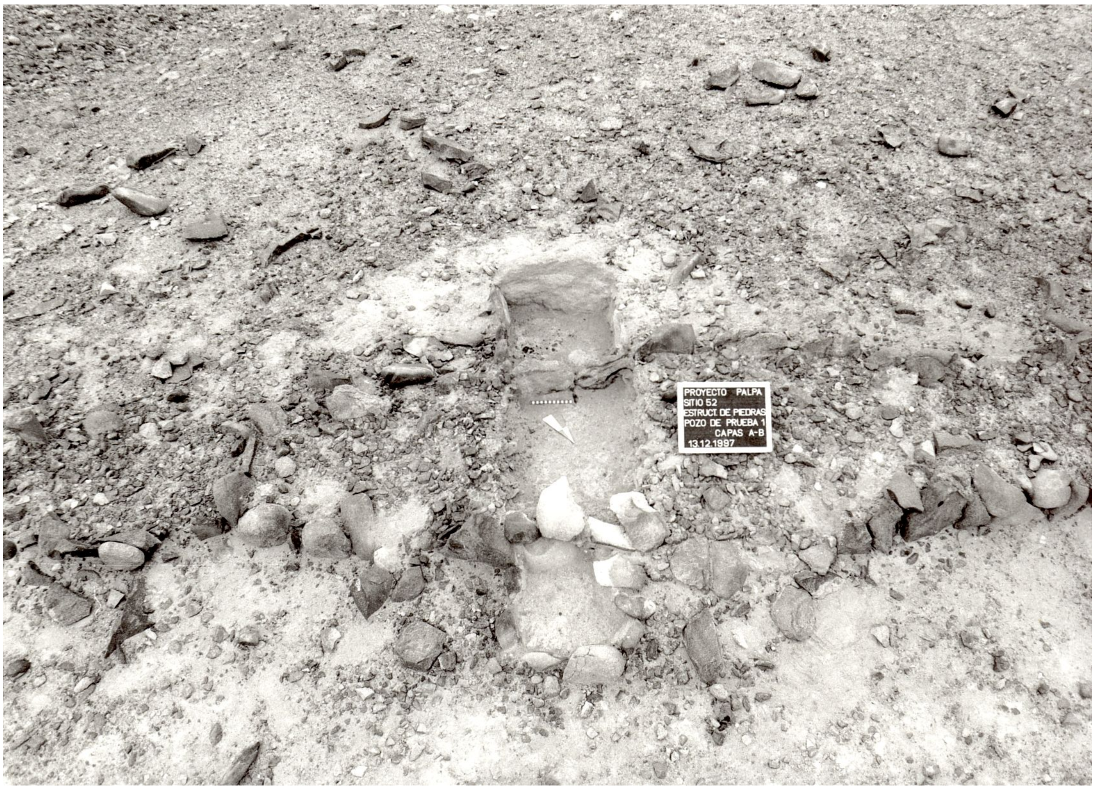

Figure 9.17: Partially excavated stone platform on site PV67A-35

Summary

Low, elongated platform- or bench-like stone structures like those excavated on sites PV67A-47 and PV67A-47, respectively, are a common feature on geoglyph sites in the Palpa region. They generally occur in two contexts: at the wide end of large trapezoids or on the edge of plateaus where one or several straight lines run up (or down) the hillside. Often, albeit not always, both conditions coincide. The structures were constructed in a simple manner, using only materials available on the spot. The presence of individual chambers suggest that the platforms were constructed in several steps, though no clear building stratigraphy is usually evident. An accentuation of the central section of the structure is observable in some cases, either by lateral chambers or by the incorporation of large boulders (*e.g.* on site PV67A-22). Stones used to construct the structure were probably picked up when creating a new geoglyph. It is clear, however, that only a small part of the removed stones ended up in the platforms, whereas the majority were used to form the heaped borders of the new geoglyph. The platforms do not feature any surface finish. It is not clear whether they were used to stand upon them. There is furthermore no clear evidence that objects were deposited on them, although broken vessels seem to occur in higher frequency around those platforms. What draws the attention most is the position of the structures in the landscape: they are usually found on edges of high plateaus marking the upper end of one or several straight lines on the slope. Both the valley and the geoglyph sites can often be overlooked from these vantage points. Often, lines on slopes and trapezoids on plateaus meet at such a structure, or they are connected by some kind of bridging geoglyph like the one on PV67A-47. Thus, the platforms together with the lines on the hill indicate, when seen from the valley floor, where the trapezoids on the plateaus are located, which are otherwise not visible.

9.2.2 Rectangular platforms on trapezoids

Site PV67A-90 (Cresta de Sacramento)

PV67A-90 is one of the biggest geoglyph sites on Cresta de Sacramento, situated on the eastern end of the main plateau close to the foothills of Cerro Pinchango (Figure 9.18).

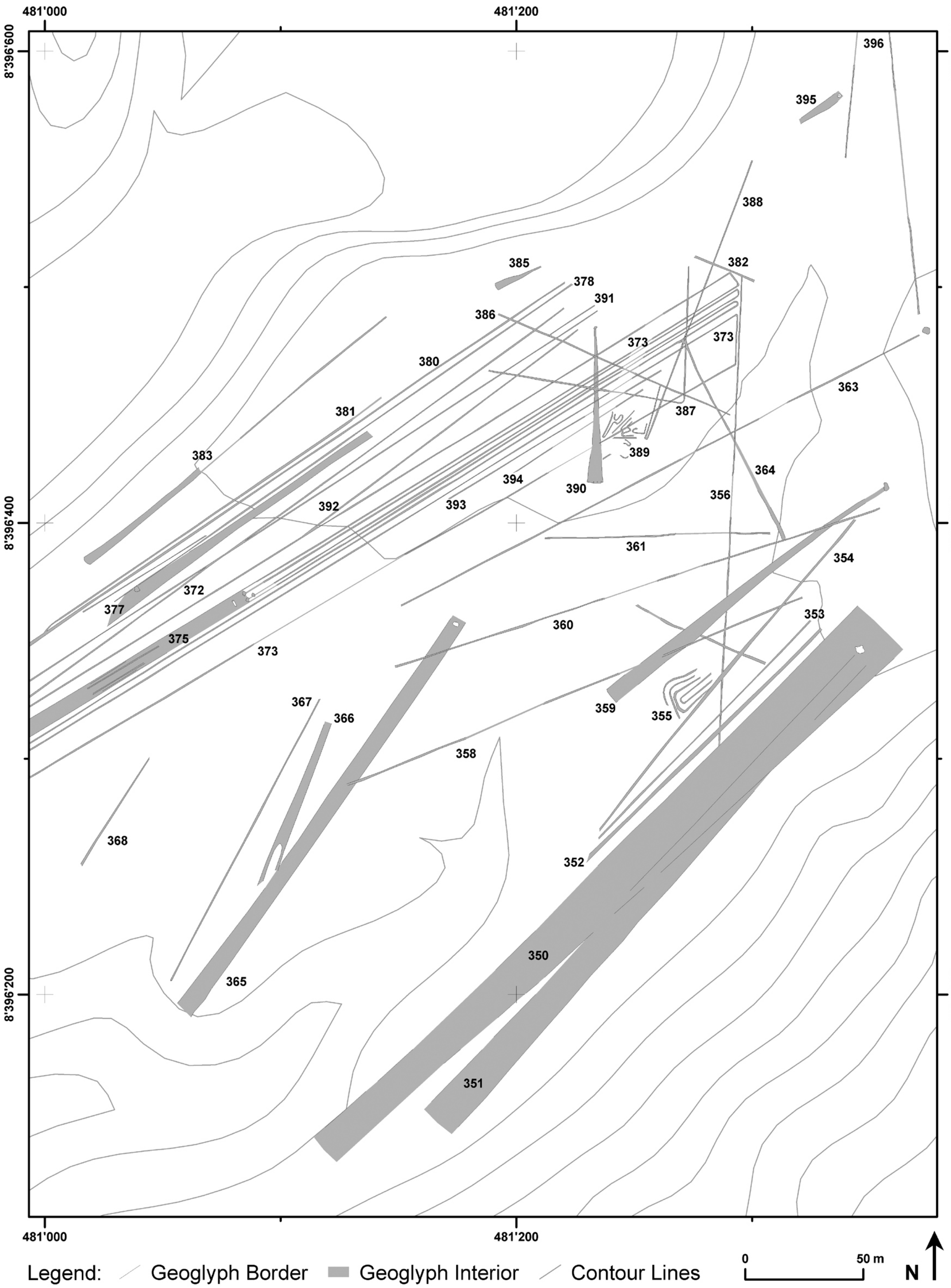

Figure 9.18: Geoglyph sites PV67A-89 (south) and -90 (north) on Cresta de Sacramento

The main part of the badly preserved site is composed of an impressive series of lineal geoglyphs, but there are also some small trapezoids and rectangles and a possible bird figure (geoglyph 389, now largely destroyed). On the northeastern end of the site, one of the smallest trapezoids registered in the Palpa area is located somewhat separated from the main geoglyph complex close to a shallow *quebrada*. This trapezoid (geoglyph 395) is only about 21 m long and up to 3.20 m wide (Figure 9.19). It is defined by two heaped borders framing a cleared interior. Between the stones of one of the borders, sherds of a Ocucaje 8 ceramic vessel were recovered. Close to the northeastern end (the wider one), a small stone cairn approx. 1.40 m in diameter is located in the cleared interior of the geoglyph. It has a sand-filled hole in its center, probably due to looting, which would also explain the presence of larger stones dispersed around the cairn. Sherds of a Nasca 7 painted vase were found on and between the small stones of which the cairn was apparently accumulated (Figure 9.20).

Figure 9.19: Geoglyph 395 with stone structure on site PV67A-90

This was confirmed by excavation. In 2001, a small trench was dug through the center of the cairn down to the original desert surface. The whole cairn consisted of stones or small boulders accumulated without any type of construction like *e.g.* a retaining wall. No worked stones were present, and no evidence of mortar was found. Between the stones, aeolian sand had accumulated over time. The cairn rested directly on the desert surface.

Figure 9.20: Stone structure on site PV67A-90 with broken pottery

The whole trapezoid, and especially the small cairn, seem to mimic the well known larger specimens of the same type. The chronological evidence is confusing. Two vessels were recovered that date to different times (Late Paracas and Late Nasca, respectively) and seem to indicate different construction dates for the geoglyph and the cairn. This would be in accordance with evidence from other trapezoids where stone buildings upon them seem to have been built long after the geoglyph itself. What seems clear is that the Nasca 7 vase was intentionally smashed when deposited on the cairn.

SITE PV67A-80 (CRESTA DE SACRAMENTO)

Crossing the flat plateau on top the Sacramento ridge in southwesterly direction from PV67A-90, the next big geoglyph site is PV67A-80, the northeastern end of which is heavily affected by a LIP site partially covering several geoglyphs (Figure 9.21; cp. Clarkson 1990: fig. III.6).

Figure 9.21: Stone structures on geoglyph 333 on site PV67A-80 (note LIP buildings covering geoglyphs)

PV67A-80 is dominated by a large trapezoid (geoglyph 333) about 535 m long, which is among the largest geoglyphs on Cresta de Sacramento. It is flanked by other areal geoglyphs, several lines, and a spiral (Figure 6.3). The northeastern, narrow end of the trapezoid is somewhat irregular, maybe because it was left incomplete: it gets narrower where two stone structures were placed in a central position between its lateral borders. The situation is unclear due to disturbances by LIP structures and modern dirt roads. The partially looted stone structures, both approximately 3 m wide, 0.60 m high and 1.20 m set apart from each other, were excavated in 2001 (Figure 9.22, Figure 9.23). They turned out to be low rectangular platforms consisting of a retaining wall of a single row of large stones set without mortar on the leveled ground, and a fill of gravel and some sand. The northern platform measured 1.45 x 2.0 m^2, whereas the southern one was slightly larger (1.55 x 2.40 m^2). No second row of stones and no surface finish were observed, although the platforms originally might have been higher judging from the amount of debris. On the debris, but not in the platform fill, two datable sherds could be recovered (Nasca 5 and Nasca 7, respectively). No other finds or constructional features were observed.

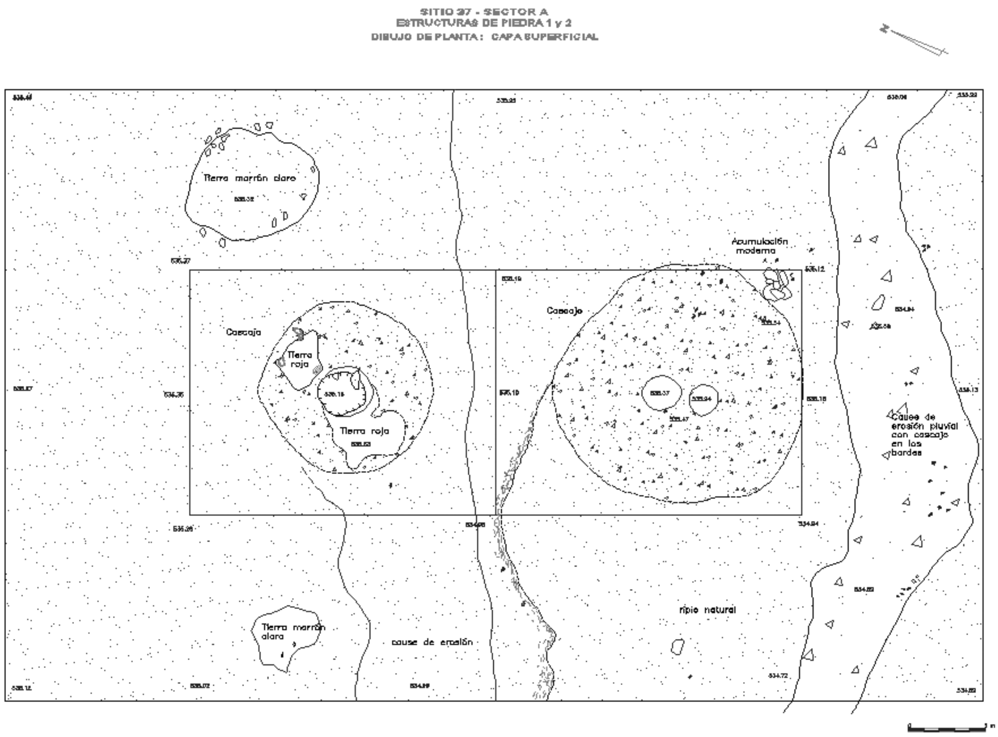

Figure 9.22: Stone structures on site PV67A-80 before excavation

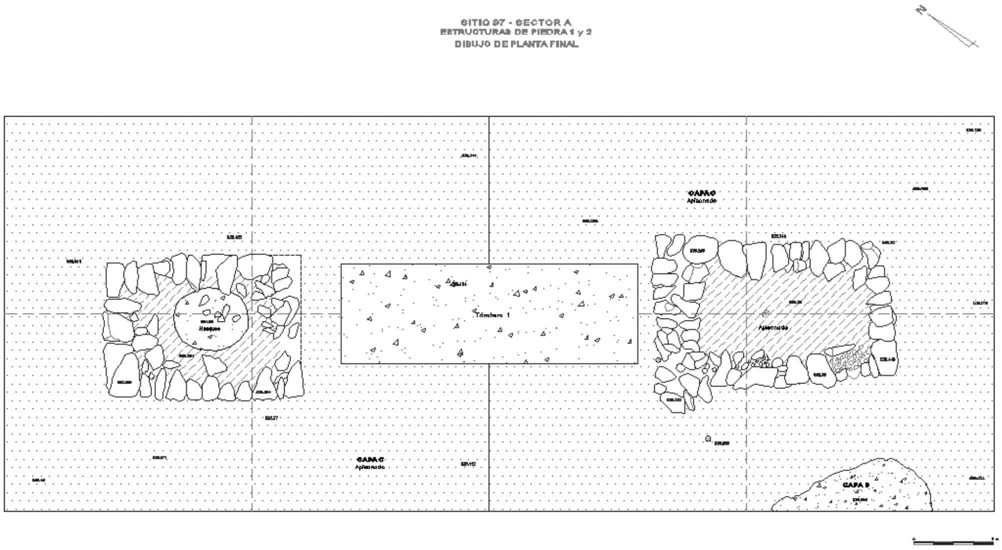

Figure 9.23: Stone structures on site PV67A-80 after excavation (cp. Figure 6.20)

Sites PV67A-15 and -16 (Cresta de Sacramento)

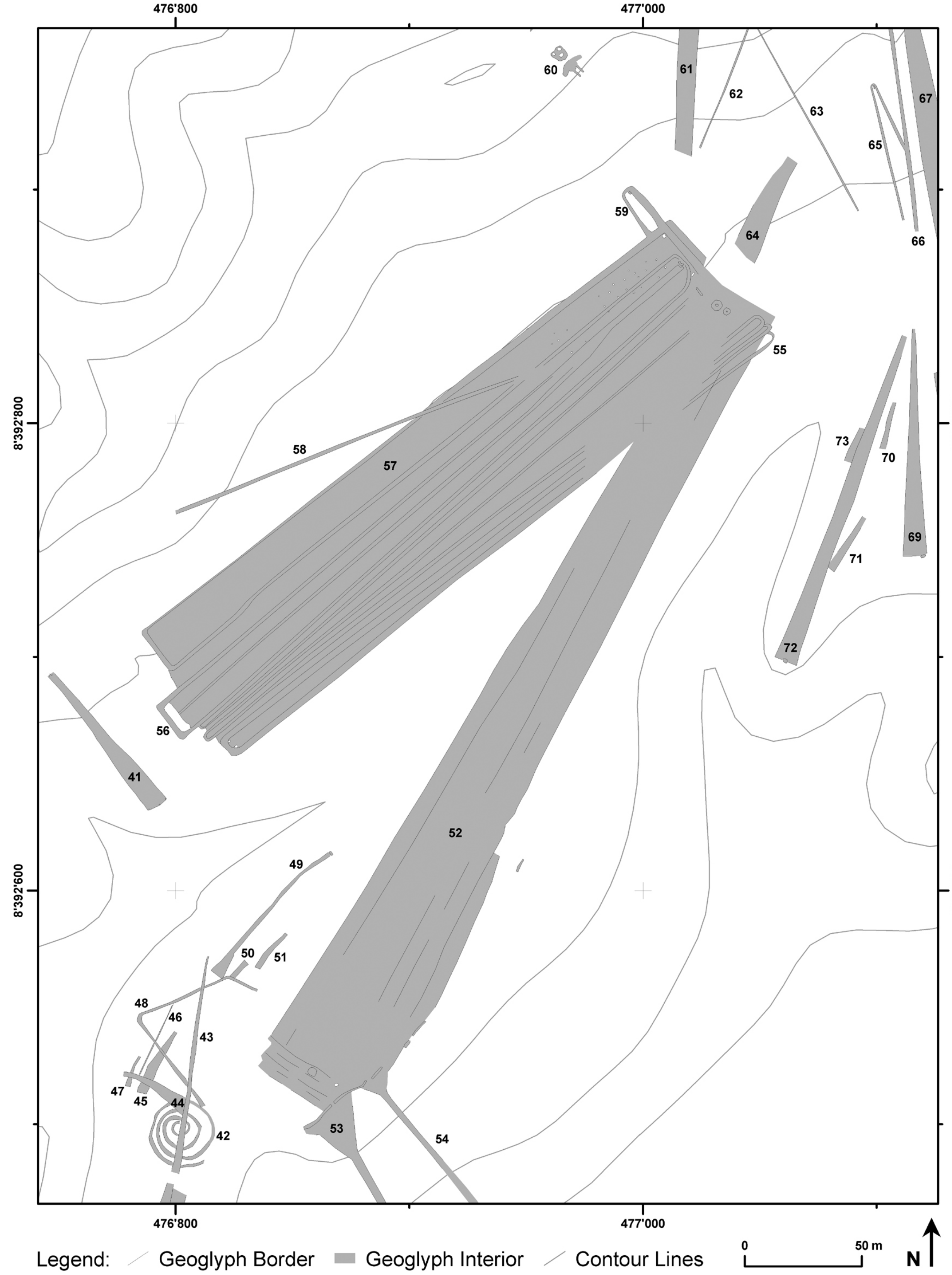

Figure 9.24: Geoglyph sites PV67A-15 (south) and -16 (north) on Cresta de Sacramento

The geoglyphs of site PV67A-15 and -16 are located on a flat terrace on a medium level between the floor of the Palpa valley and the top of Cresta de Sacramento (Figure 9.24). Apart from a series of smaller geoglyphs, the site is dominated by a large trapezoid (geoglyph 52) approximately 390 m long. Its narrow end crosses obliquely the end of meandering line 55. Along with a parallel meandering line (56), this lineal geoglyph was converted into a huge cleared rectangle (57) after its initial creation. Another later alteration of the ensemble was a lateral enlargement of trapezoid 52 on its northwestern side. On this trapezoid, two stone structures were placed on the narrow end and a larger one on the central axis close to the wide base of the geoglyph. The former were excavated in 2000, the latter one year later.

Figure 9.25: Excavated stone structures on the narrow end of trapezoid 52 on site PV67A-16

The two stone structures close to the narrow end of the trapezoid (Figure 9.25) are located in a place where several geoglyphs (52, 55/56, 57) converge and which is disturbed by modern footpaths and the frequent presence of goat herds in the neighboring *quebrada*. It is therefore difficult to determine the relationship between stone structures and geoglyphs. The two mentioned structures are not placed on the central axis of trapezoid 52, but shifted in northwestern direction, roughly in the prolongation of the border of the lateral enlargement of that trapezoid. It is therefore clear that the structures could not have been built on the original trapezoid. The stone structures are furthermore positioned such that part of the meandering line 55 seems to pass through them, but since that line is almost completely obliterated by the later rectangle 57 on which the stone structures also rest, this relation remains ambiguous. In any case, the combination of two structures on the narrow end and one bigger structure on the wide base of a trapezoid, known from other geoglyphs in the Palpa area, indicates that the stone structures were built as pertaining to trapezoid 52, but at a time when other geoglyphs of the ensemble had already been created.

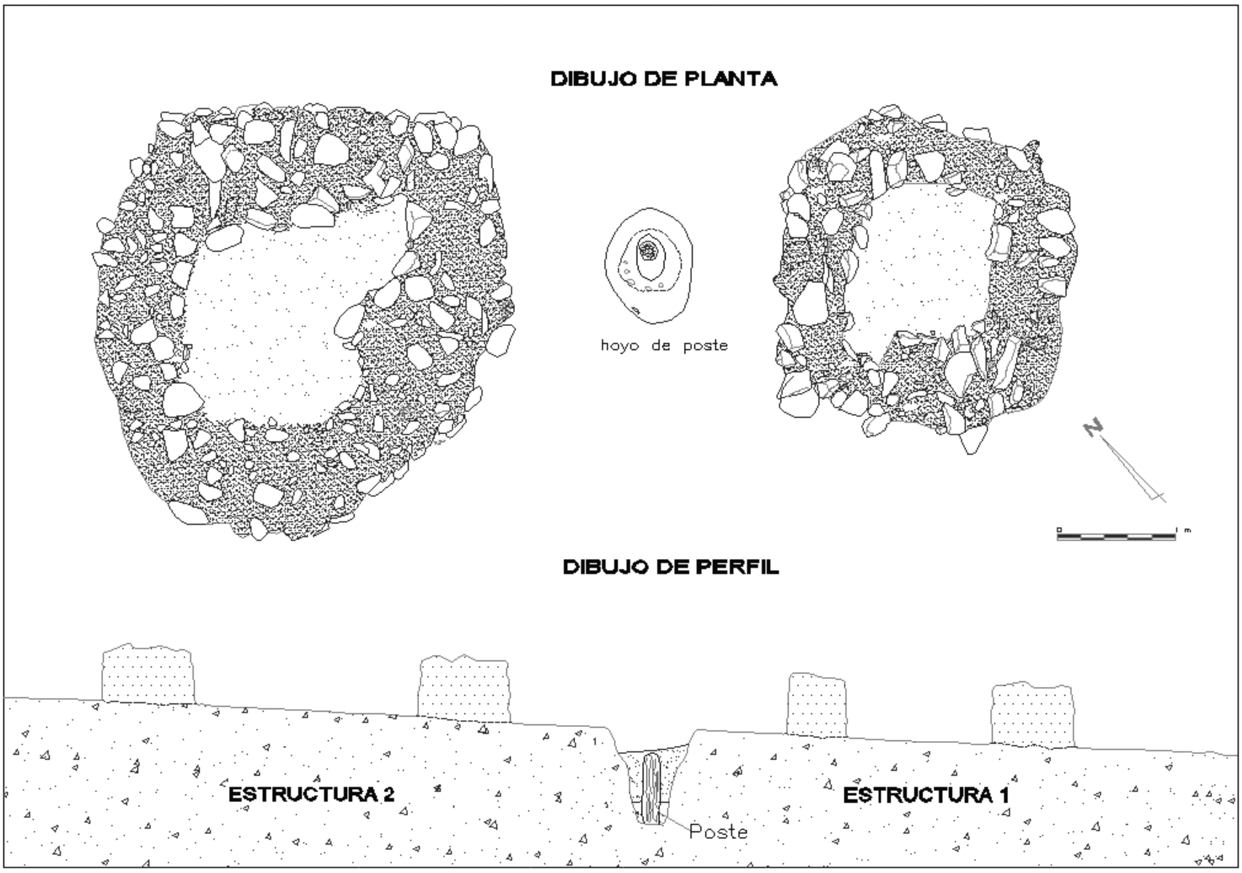

Figure 9.26: Excavated stone structures and wooden post on site PV67A-16

The stone structures appeared to be simple stone heaps before excavation, both roughly 4.50 m in diameter and 1 m high, with holes in their centers indicating looters' activities. The excavation revealed two irregular, roughly rectangular, low structures with double-faced walls made of large unworked stones set with mud mortar on the natural ground (Figure 9.26). The southern structure had interior subdivisions of upright stones retaining construction fill. In this first building phase, the interior of the structure had apparently been accessible. In its final state, however, it was covered by gravel and sand that served as fill retained by the outer walls. In the debris that covered the preserved remains as well as in the construction fill, field crops, sherds from Nasca ceramic vessels (Initial Nasca, Nasca 3 and 7), several fragments of *Spondylus* shells, one of them made into a pendant (Figure 6.21), and fragments of crawfish were found. Due to the looters' pits the original context could not exactly be determined, but some of the finds seemed to have been deposited as offerings, while others were part of the construction fill.

The northern structure was built in a similar way but turned out to be a little smaller. The overall shape, construction technique, interior subdivision, and recovered materials closely resembled the southern platform, but a maize cob wrapped in textiles was furthermore found in the fill.

Midway in between both platforms, the remains of a wooden post (*sauce*) were found in a hole in the ground. It had apparently been cut already in prehispanic times, and the hole filled up with stones. As on the stone structures, sherds dating to Initial Nasca and Nasca 7 were found in the pit.

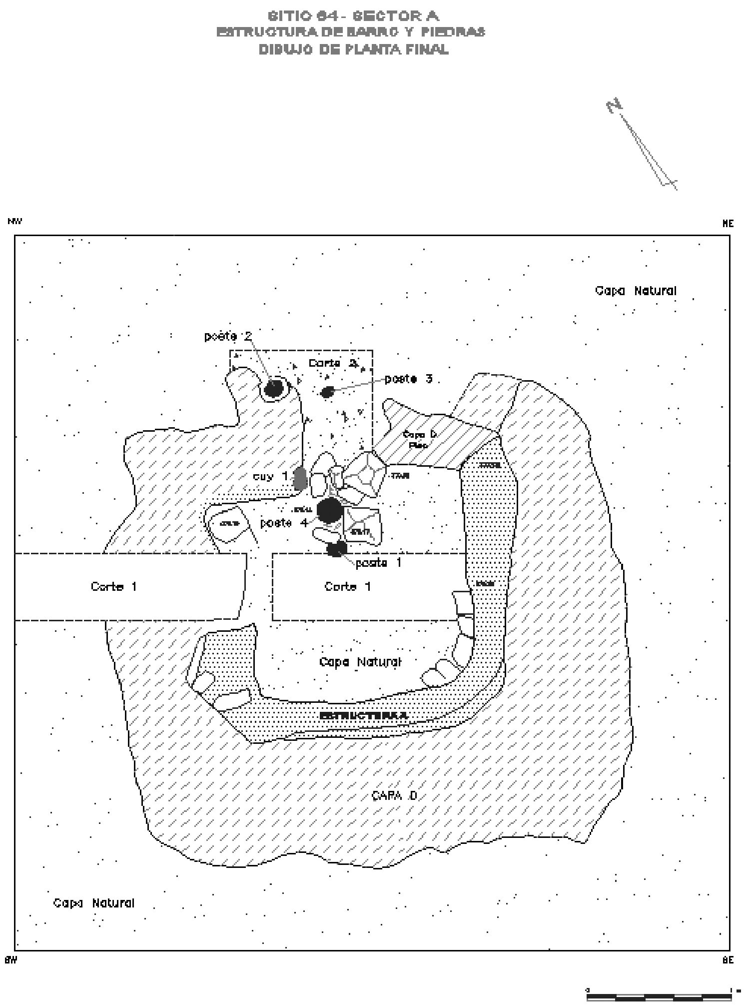

Figure 9.27: Excavated stone structure on the wide end of trapezoid 52 on site PV67A-15

Close to the wide base of the same trapezoid, placed on its central axis, another partially looted stone structure was excavated in 2001 (Figure 9.27, Figure 9.28). It had a roughly oval form and measured 3.60 x 4.50 m^2. The low height of only 0.60 m was mainly due to looting, which is why many large stones were scattered around the structure. The excavation revealed a badly preserved structure with two building phases corresponding to different uses. In the first phase, a rectangular wall entirely formed of mud was set on the leveled ground, measuring about 2.20 x 2.20 m^2, with a height of 0.40 m. A compacted floor inside the enclosure as well as around it indicates that the wall in that first phase enclosed an accessible room, with an entrance on its northern side. However, due to later remodeling and the subsequent destruction of the structure, no traces were left of the alleged access. Four wooden posts, three of them arranged in a row leading out of the room in northernly direction and a fourth one outside the structure, were part of the first building phase, although due to subsequent destructions it is not clear in which way the walls, the interior room and the posts functioned together. All of the posts were poplar (*sauce*) logs, their diameter ranging from 0.07 to 0.18 m, their preserved height from 0.20 to 0.91 m. Furthermore, all of them were deeply embedded in the ground and affixed by a framework of stones, indicating that they once reached a considerable height above ground. In three of the post holes, well preserved guinea pigs placed there as offering could be recovered.

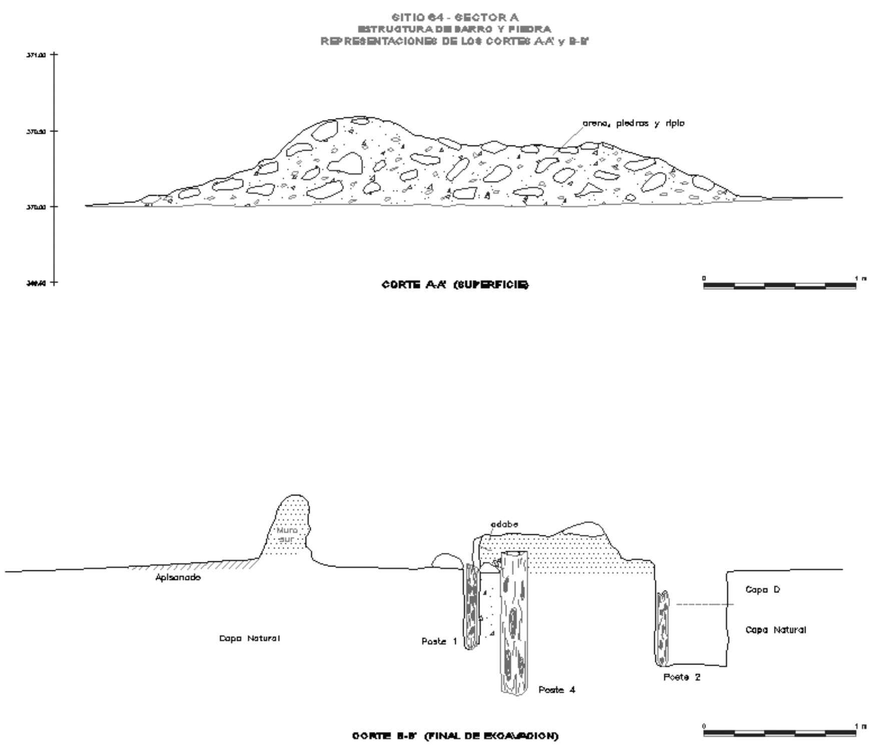

Figure 9.28: Cross section through stone structure on trapezoid 52 before and after excavation

In a second building phase, the posts were cut and covered by adobe bricks, the interior room was filled with gravel, adobe bricks, straw, and mud, and the original walls were heightened using stones and mud mortar. Apparently, the fill was sealed with a mud layer, providing a plain surface. In the construction fill, fineware ceramic sherds dating to Initial Nasca and Nasca 7 were found. In the debris caused by the decay of the structure further fineware sherds dating to Nasca 2, Nasca 3, Nasca 5, and Loro could be recovered. Further finds include maize cobs, rodent bones, chrysocole fragments, and *Spondylus* shells. The disturbance caused by looting made it difficult to determine which layers the finds pertained to, but in any case the recovered sherds indicate a long period of use of the structure. A radiocarbon sample of the single post outside the structure (*poste 2* in Figure 9.27, Figure 9.28) was dated to AD 603-644.[35] The date seems late since the post pertains to the first building phase before the structure was remodeled. Nevertheless, Nasca 7 and Loro sherds indicate that the structure was still in use during the transition from Late Nasca to the early Middle Horizon.

Site PV67A-62 (Cerro Carapo)

Site PV67A-62 is located on the base of the northern slope of Cerro Carapo, near the western end of the ridge. The slope is covered by several lines and figures. At the foot of the hill a rectangle (583) measuring approximately 50 x 13 m^2 is located on gently sloping terrain, partially destroyed by an irrigation channel and a field. In its cleared interior two relatively well preserved stone cairns were placed close to the narrow end of the geoglyph (Figure 9.29). Both had a diameter of approximately 3 m and a height of about 0.80 m, affected by looters' pits placed in their centers. Both stone structures were excavated in 2001.

The northern structure (the one closer to the valley floor) turned out to be a low, rectangular platform measuring approximately 2 x 2 m^2, with a preserved height of 0.70 m. It consisted of one row of large, unworked stones set upright on the leveled ground without mortar, serving as retaining wall for a fill composed of gravel and some sand. On its northern side a small annex built in the same way abutted the platform, serving either as constructional support or as step leading up to the platform. The upper surface of the platform was not preserved. Fineware ceramics recovered from the constructional fill of the main platform dated to Nasca 4 and 5, while sherds from the annex fill derived from Nasca 7 vessels. The platform was covered by debris resulting from the decay of the platform after its abandonment, although parts of it may

35 Sample HD-24683, age given as calibrated 1 sigma range. Date courtesy of Ingmar Unkel, Heidelberg.

also have been placed on it intentionally to cover the structure. Among the debris, maize cobs, obsidian and chrysocole fragments, seashells, rodent bones, and Nasca 4 sherds were found, materials once probably deposited upon the platform.

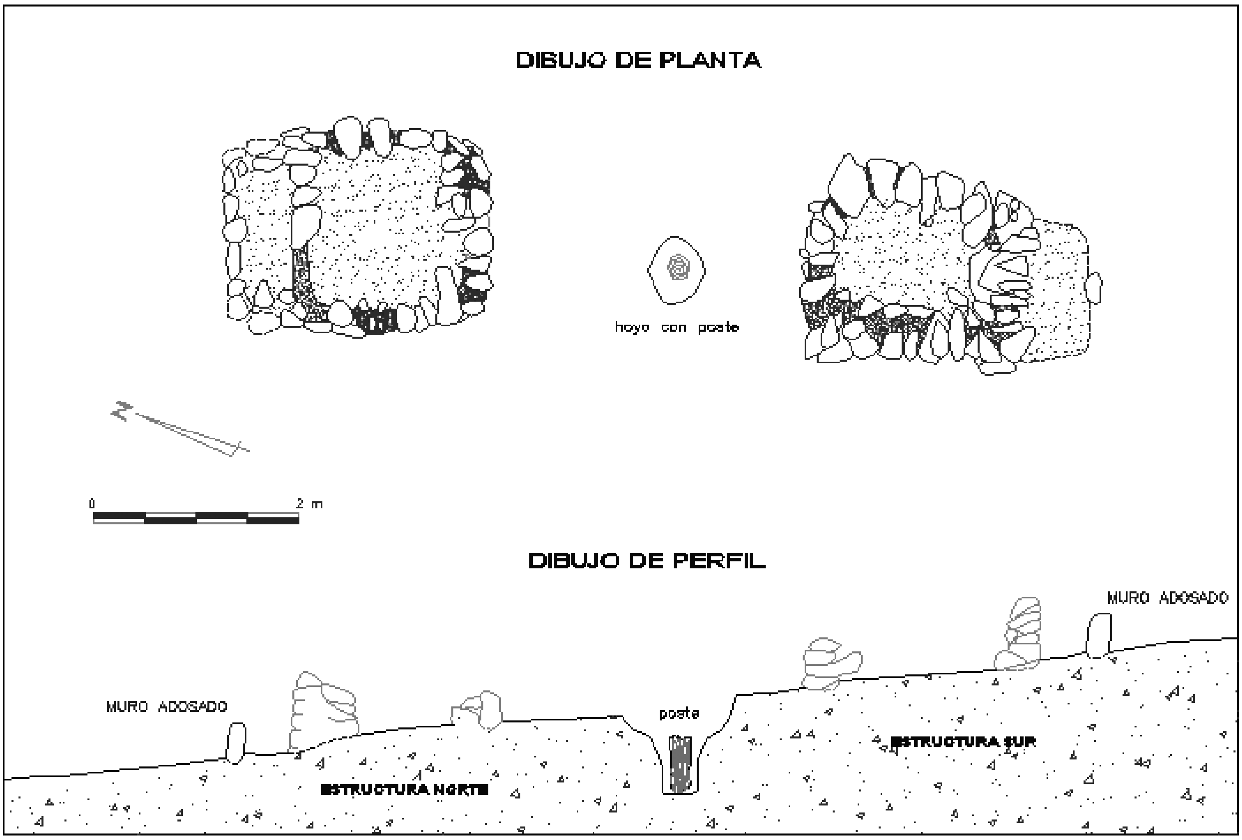

Figure 9.29: Excavated stone structures on rectangle 583 on site PV67A-62

The southern structure, built on slightly higher terrain, was constructed in much the same way, including the presence of a later annex. The platform measured 1.75 x 2.25 m^2, again with a preserved height of 0.70 m. Due to a looters' pit it was less well preserved than the northern platform.

Midway between the two structures the remains of a wooden post were found set in a hole in the ground approximately 1.10 m deep. The post, a poplar (*sauce*) log with a diameter of 0.10 m, was preserved to a height of 0.47 m. The fact that the post hole was more than 1 m deep and the post had been affixed with large stones indicate that it once had reached a considerable height above ground. Under the post, chrysocole fragments and a guinea pig were found, the latter well preserved due to arid subsoil conditions. It had apparently been placed there as offering before the post was collocated, just as on PV67A-15.

Summary

While low, elongated platforms like those excavated on PV67A-35 and PV67A-47 apparently were built at the beginning or during the construction process of adjoining geoglyphs, only a few, if any, of the pairs of stone structures excavated on PV67A-15/16, PV67A-80, PV67A-90, and PV67A-62 were built along with the geoglyphs they were placed upon. Furthermore, several of them show clear indications of later alteration. Along with the considerable time period covered by associated finds, this indicates a large time span during which the structures were used in some way or another, although it is often unclear which phase the datable finds pertain to due to the bad state of preservation of most structures. All in all, the structures seem to have been part of the long-term construction, use, and alteration process typical of complex geoglyph sites of which also the creation and alteration of geoglyphs as well as other activities formed a part.

The stone structures were constructed in a simple manner, with most of the used material apparently having been picked up on the site. Mud mortar was used only in some cases, while other structures feature dry walls or, as is the case with the smallest excavated structure on PV67A-90, no walls at all.

The best identifiable activity related to the structures was the placing of field crops, ceramic vessels, seashells (among them *Spondylus*), fragments of chrysocole, and other materials on the platform tops. The platforms may also have been used to stand upon them. although the evidence is unclear in this regard. Only on PV67A-15/16 are there indications of the structures having served as rooms or enclosures, but both were later converted into platforms, too. On PV67A-15/16 and PV67A-62, their are some indications that the debris covering the platforms does not result from the decay of the structures alone, but that part of it may have been placed intentionally on them after their abandonment.

The role of the wooden posts associated with the stone structures is not entirely clear. In two cases (PV67A-15 and PV67A-62), a single post was placed in the middle of two stone structures near the narrow end of the trapezoid, a position where no post was found on PV67A-80. On PV67A-15 wooden posts were furthermore associated with the single structure placed in the center of the wide base of the trapezoid, whereas on PV67A-90 no such posts were found. All posts must have reached a considerable height above ground, as judged by the deep holes they were placed into, and must therefore have been visible from far away. Their general association with the central axis of the trapezoids may indicate that they were needed during the construction process of the trapezoids. The leveled and compacted ground around the structures indicate the frequent presence of people close to them. Compared to lineal geoglyphs, many of which are compacted along their whole course, on the trapezoids the zones around the platforms are often the only parts with unambiguous evidence of compaction indicating human activity.

9.3 Glossary of abbreviated terms

Abbreviation	***Meaning***	***Translation***
AMB	Anthropomorphic Mythical Being	
AMS	Accelerator Mass Spectrometry	
BMBF	*Bundesministerium für Bildung und Forschung*	Federal Ministry for Education and Research (Bonn, Germany)
DAAD	*Deutscher Akademischer Austauschdienst*	German Academic Exchange Service (Bonn, Germany)
DAI	*Deutsches Archäologisches Institut*	German Institute of Archaeology (Berlin, Germany)
DBMS	Database Management System	
DDL	Data Definition Language	
DFG	*Deutsche Forschungsgemeinschaft*	German Research Foundation (Bonn, Germany)
DPW	Digital Photogrammetric Workstation	
DSM	Digital Surface Model	
DTM	Digital Terrain Model	
EH	Early Horizon	
EIP	Early Intermediate Period	
ETH	*Eidgenössische Technische Hochschule*	Swiss Federal Institute of Technology (Zurich, Switzerland)
GIS	Geographic Information System	
GPS	Global Positioning System	
IGN	*Instituto Geográfico Nacional*	National Geographic Institute (Lima, Peru)
IGP	*Institut für Geodäsie und Photogrammetrie*	Institute of Geodesy and Photogrammetry (Zurich, Switzerland)
INC	*Instituto Nacional de Cultura*	National Institute for Culture (Lima, Peru)
INDEA	*Instituto Andino de Estudios Arqueológicos*	Andean Institute of Archaeological Studies (Lima, Peru)
KAVA	*Kommission für Allgemeine und Vergleichende Archäologie*	Commission for General and Comparative Archaeology (Bonn, Germany)
LH	Late Horizon	
LIP	Late Intermediate Period	
LoD	Level of Detail	
MH	Middle Horizon	
MPI	*Max-Planck-Institut*	Max Planck Institute (Heidelberg, Germany)
OSL	Optically Stimulated Luminescence	
PSD 56	Provisional South American Datum 1956	
RMS error	Root Mean Square Error	
SAR	Synthetic Aperture Radar	
SDO	Spatial Data Object	
SLSA	*Schweizerisch-Liechtensteinische Stiftung für Archäologische Forschungen im Ausland*	Swiss-Liechtenstein Foundation for Archaeological Research Abroad (Zurich, Switzerland)
SQL	Structured Query Language	
UML	Unified Modeling Language	
UTM	Universal Transverse Mercator	
WGS 84	World Geodetic System 1984	

Table 5: Glossary of abbreviated terms

9.4 References

Adams, Adams 1991: Adams, William Y., Ernest W. Adams: *Archaeological typology and practical reality: a dialectical approach to artifact classification and sorting.* Cambridge University Press, Cambridge 1991.

Anschuetz et al. 2001: Anschuetz, Kurt F., Richard H. Wilshusen, Cherie L. Scheick: An archaeology of landscapes: perspectives and directions. *Journal of Archaeological Research* 9(2), 157-211. 2001.

Aveni 1990a: Aveni, Anthony F.: An assessment of previous studies of the Nazca geoglyphs. In: Aveni, Anthony F. (ed.), *The lines of Nazca* (Memoirs of the American Philosophical Society 183), 1-40. American Philosophical Society, Philadelphia 1990.

Aveni 1990b: Aveni, Anthony F.: Order in the Nazca lines. In: Aveni, Anthony F. (ed.), *The lines of Nazca* (Memoirs of the American Philosophical Society 183), 41-113. American Philosophical Society, Philadelphia 1990.

Aveni 1999: Aveni, Anthony F.: Theorien zu den Nasca-Linien. In: Rickenbach, Judith (ed.), *Nasca: geheimnissvolle Zeichen im alten Peru*, 109-142. Museum Rietberg, Zurich 1999.

Aveni 2000a: Aveni, Anthony F.: *Between the lines: the mystery of the giant ground drawings of ancient Nasca, Peru.* University of Texas Press, Austin 2000.

Aveni 2000b: Aveni, Anthony F.: Solving the mystery of the Nasca lines. *Archaeology* 53(3), 26-35. 2000.

Aveni 2003: Aveni, Anthony F.: Archaeoastronomy in the ancient Americas. *Journal of Archaeological Research* 11 (2), 149-191. 2003.

Aveni ed. 1990: Aveni, Anthony F. (ed.): *The lines of Nazca* (Memoirs of the American Philosophical Society 183). American Philosophical Society, Philadelphia 1990.

Baena et al. 1997: Baena, Javier, Concepción Blasco, Fernando Quesada: *Los S.I.G. y el análisis espacial en arqueología* (Colleción de Estudios). Universidad Autónoma de Madrid, Madrid 1997.

Bauer 2000: Bauer, Brian S.: *El espacio sagrado de los Incas: el sistema de ceques del Cuzco* (Archivos de Historia Andina 33). Centro de Estudios Regionales "Bartolomé de las Casas", Cusco 2000.

Beck et al. 1998: Beck, W., D. J. Donahue, A. J. T. Jull, G. Burr, W. S. Broecker, G. Bonani, I. Hajdas, E. Malotki: Ambiguities in direct dating of rock surfaces using radiocarbon measurements. *Science* 280, 2132-2135. 1998.

Bell 1992: Bell, Catherine M.: *Ritual theory, ritual practice.* Oxford University Press, New York 1992.

Bell 1997: Bell, Catherine M.: *Ritual: perspectives and dimensions*. Oxford University Press, New York 1992.

Bernbeck 1997: Bernbeck, Reinhard: *Theorien in der Archäologie* (UTB 1964). Francke, Tübingen, Basel, 1997.

Bertemes, Biehl 2001: Bertemes, François, Peter F. Biehl: The archaeology of cult and religion: an introduction. In: Biehl, Peter F., François Bertemes, Harald Meller (eds.), *The archaeology of cult and religion* (Archaeolingua Main Series 13), 11-24. Archaeolingua, Budapest 2001.

Biermann 2001: Biermann, Daniela: Tejidos de la cultura Nasca - informe intermedio de los objetos textiles de las excavaciones de Palpa. In: Solanilla, Victòria (ed.), *II Jornadas internacionales sobre textiles precolombinos*, 347-358. Department d'Art de la Universitat Autònoma de Barcelona, Barcelona 2001.

Blasco, Ramos 1991: Blasco, M. Concepción, Luis J. Ramos: *Catálogo de la cerámica Nazca del Museo de América II.* Ministerio de Cultura, Madrid 1991.

Browne 1992: Browne, David: Further archaeological reconnaissance in the province of Palpa, Department of Ica, Peru. In: Saunders, Nicholas J. (ed.), *Ancient America: contributions to New World archaeology* (Oxbow Monograph 24), 77-116. Oxbow, Oxford 1992.

Browne, Baraybar 1988: Browne, David, José P. Baraybar: An archaeological reconnaissance in the province of Palpa, Department of Ica, Peru. In: Saunders, Nicholas J., Olivier de Montmollin (eds.), *Recent studies in pre-columbian archaeology* (BAR International Series 421), 299-325. BAR, Oxford 1988.

Browne et al. 1993: Browne, David, Helaine Silverman, Rubén García: A cache of 48 trophy heads from Cerro Carapo, Peru. *Latin American Antiquity* 4(3), 274-294. 1993.

Brück 1999: Brück, Joanna: Ritual and rationality: some problems of interpretation in European archaeology. *European Journal of Archaeology* 2(3), 313-344. 1999.

Capra et al. 2002: Capra, Alessandro, Stefano Gandolfi, Laura Laurencich, Francesco Mancini, Alberto Minelli, Carolina Orsini, Aurelio Rodriguez: Multidisciplinary approach for archeological survey: exploring GPS method in landscape archeology studies. *Journal of Cultural Heritage* 3(2), 93-99. 2002.

Carmichael 1994: Carmichael, Patrick H.: Cerámica Nasca: producción y contexto social. In: Shimada, Izumi (ed.), *Tecnología y organización de la producción cerámica prehispánica en los Andes*, 229-247. Pontificia Universidad Católica del Perú, Fondo Editorial, Lima 1994.

Clarkson 1990: Clarkson, Persis B.: The archaeology of the Nazca pampa: environmental and cultural parameters. In: Aveni, Anthony F. (ed.), *The lines of Nazca* (Memoirs of the American Philosophical Society 183), 115-172. American Philosophical Society, Philadelphia 1990.

Clarkson 1996: Clarkson, Persis B.: Técnicas en la determinación de las edades cronológicas de geoglifos. *Chungará* 28(1-2), 419-460. 1996.

Clarkson 1998: Clarkson, Persis B.: Archaeological imaginings: contextualization of images. In: Whitley, David (ed.), *Reader in archaeological theory: post-processual and cognitive approaches* (Routledge Readers in Archaeology), 119-130. Routledge, London 1998.

Clarkson 1999: Clarkson, Persis B.: Geoglyphen als Artefakte, Geoglyphen als Erfahrung - Bodenzeichnungen auf dem amerikanischen Kontinent. In: Rickenbach, Judith (ed.), *Nasca: geheimnisvolle Zeichen im alten Peru*, 165-175. Museum Rietberg, Zurich 1999.

Clarkson, Dorn 1991: Clarkson, Persis B., Ronald I. Dorn: Nuevos datos relativos a la antigüedad de los geoglifos y pukios de Nazca, Peru. *Boletín de Lima* 78, 33-47. 1991.

Clarkson, Dorn 1995: Clarkson, Persis B., Ronald I. Dorn: New chronometric dates for the puquios of Nasca, Peru. *Latin American Antiquity* 6(1), 56-69. 1995.

Colpe 1970: Colpe, Carsten: Theoretische Möglichkeiten zur Identifizierung von Heiligtümern und Interpretation von Opfern in ur- und parahistorischen Epochen. In: Jahnkuhn, Herbert (ed.), *Vorgeschichtliche Heiligtümer und Opferplätze in Mittel- und Nordeuropa*, 18-39. Vandenhoek & Ruprecht, Göttingen 1970.

Cook 1999: Cook, Anita G.: Asentamientos Paracas en el valle bajo de Ica, Perú. *Gaceta Arqueológica Andina* 25, 61-90. 1999.

D'Altroy, Schreiber 2004: D'Altroy, Terence N., Katharina Schreiber: Andean empires. In: Silverman, Helaine (ed.), *Andean archaeology* (Blackwell Studies in Global Archaeology 2), 255-279. Blackwell, Malden, Oxford 2004.

DeLeonardis, Lau 2004: DeLeonardis, Lisa, George F. Lau: Life, death, and ancestors. In: Silverman, Helaine (ed.), *Andean archaeology* (Blackwell Studies in Global Archaology 2), 77-115. Blackwell, Malden, Oxford 2004.

Desmond, Bryan 2003: Desmond, Lawrence G., Paul G. Bryan: Recording architecture at the archaeological site of Uxmal, Mexico: a historical and contemporary view. *The Photogrammetric Record* 18/102, 105-130. 2003.

Dorn 1998: Dorn, Ronald I.: Response. *Science* 280, 2136-2139. 1998.

Doyle 1985: Doyle, Frederick J.: The large format camera on shuttle mission 41-G. *Photogrammetric Engineering & Remote Sensing* LI(2), 200-203. 1985.

Earle 1997: Earle, Timothy: *How chiefs came to power: the political economy in prehistory*. University of Stanford Press, Stanford 1997.

Eggert 2001: Eggert, Manfred K. H.: *Prähistorische Archäololgie: Konzepte und Methoden* (UTB 2092). Francke, Tübingen, Basel 2001.

Eisleb 1977: Eisleb, Dieter: *Altperuanische Kulturen II: Nazca* (Veröffentlichungen des Museums für Völkerkunde, N. F. 34). Museum für Völkerkunde, Berlin 1977.

Eitel et al. 2005: Eitel, Bernhard, Stefan Hecht, Bertil Mächtle, Gerd Schukraft, Annette Kadereit, Günther Wagner, Bernd Kromer, Ingmar Unkel, Markus Reindel: Geoarchaeological evidence from desert loess in the Nazca-Palpa region, southern Peru: paleoenvironmental changes and their impact on pre-Columbian cultures. *Archaeometry* 47(1), 137-158. 2005.

Fischer, Künstle 1999: Fischer, Susanne, Silvia Künstle: *Zeitlicher Vergleich der Geoglyphen von Palpa.* Diploma thesis, Institute of Photogrammetry and Remote Sensing, University of Karlsruhe, 1999.

Fritz 1999: Fritz, Lawrence W.: High resolution commercial remote sensing satellites and spatial information systems. *ISPRS Highlights* 4(2), 19-30. 1999.

Gillings et al. eds. 1999: Gillings, Mark, David Mattingly, Jan van Dalen (eds.), *Geographical Information Systems and landscape archaeology* (The Archaeology of Mediterranean Landscapes 3). Oxbow, Oxford 1999.

Gourad 1999: Gourad, Khalid: *Geographic Information Systems in archaeology: a survey*. Master of Arts thesis. http://khalid.gourad.com/thesis. 1999.

Gramsch 1996: Gramsch, Alexander: Landscape archaeology: of making and seeing. *Journal of European Archaeology* 4, 19-38. 1996.

Gray, Boardman 2002: Gray, Christopher, Clive Boardman: An examination of heritage survey in the international area: the survey of the hieroglyphic stairway in Copán, Honduras. *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* XXXIV-5/C7, 397-401. 2002.

Greilich et al. 2005: Greilich, Steffen, Ulrich Glasmacher, Günther Wagner: Optical dating of granitic stone surfaces. *Archaeometry* 47, in press. 2005.

Grün 1999: Grün, Armin: *Photogrammetrische Aufnahmen der Geoglyphen von Nasca, Palpa und San Ignacio*. Museum Rietberg, Zurich 1999.

Grün, Beutner 2001: Grün, Armin, Sabine Beutner: The geoglyphs of San Ignacio - new results from the Nasca project. *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* XXXIV-5/W1, 18-23. 2001.

Grün, Brossard 1998: Grün, Armin, Jean-Claude Brossard: Photogrammetrische Kampagne Nasca/Palpa 1997. *SLSA-Jahresbericht* 1997, 163-168. 1998.

Grün, Lambers 2003: Grün, Armin, Karsten Lambers: The geoglyphs of Nasca: 3-D recording with modern digital technologies. In: *Acts of the XIVth UISPP Congress, University of Liège, Belgium, 2-8 September 2001, section 1: theory and methods - general sessions and posters* (BAR International Series 1145), 95-103. Archaeopress, Oxford 2003.

Grün et al. 2000a: Grün, Armin, Simon Bär, Sabine Beutner: Signals in the sand: 3-D recording and visualization of the Nasca geoglyphs. *PFG Photogrammetrie - Fernerkundung - Geoinformation* 6/2000, 385-398. 2000.

Grün et al. 2000b: Grün, Armin, Simon Bär, Thomas Bührer: DTMs derived automatically from DIPS - where do we stand? *Geoinformatics* 3(5), 36-39. 2000.

Hawkins 1974: Hawkins, Gerald S.: Prehistoric desert markings in Peru. *National Geographic Research Reports* 1967, 117-144. 1974.

Horkheimer 1947: Horkheimer, Hans: Las plazoletas, rayas y figuras prehispánicas en las pampas y crestas de la Hoya del Río Grande. *Revista de la Universidad Nacional de Trujillo* II(1), 45-63. 1947.

Hostnig 2003: Hostnig, Rainer: *Arte rupestre del Perú: inventario nacional*. CONCYTEC, Lima 2003.

Hyslop 1984: Hyslop, John: *The Inka road system* (Studies in Archaeology). Academic Press, Orlando 1984.

IGN 1993: Instituto Geográfico Nacional: *Líneas y geoglifos de Nasca.* Plano topográfico, método estereofotogramétrico, escala 1:10,000. 1993.

Insoll 2004: Insoll, Timothy: *Archaeology, ritual, religion* (Themes in Archaeology). Routledge, London 2004.

Isbell 1997: Isbell, William H.: *Mummies and mortuary monuments: a postprocessual prehistory of central Andean social organization.* University of Texas Press, Austin 1997.

Isla 2001a: Isla, Johny: Una tumba Nasca en Puente Gentil, valle de Santa Cruz, Perú. *Beiträge zur Allgemeinen und Vergleichenden Archäologie* 21, 207-239. 2001.

Isla 2001b: Isla, Johny: Wari en Palpa y Nasca: perspectivas desde el punto de vista funerario. *Boletín de Arqueología PUCP* 5, 555-584. 2001.

Isla et al. 1984: Isla, Johny, Mario Ruales, Andres Mendiola: Excavaciones en Nasca (Pueblo Viejo, sector X). *Gaceta Arqueológica Andina* III/12, 8-11. 1984.

Isla et al. 2003: Isla, Johny, Markus Reindel, Juan Carlos De La Torre: Jauranga: un sitio Paracas en el valle de Palpa. *Beiträge zur Allgemeinen und Vergleichenden Archäologie* 23, 227-275. 2003.

Johnson 1999: Johnson, David W.: Die Nasca-Linien als Markierungen für unterirdische Wasservorkommen. In: Rickenbach, Judith (ed.), *Nasca: geheimnisvolle Zeichen im alten Peru*, 157-165. Museum Rietberg, Zurich 1999.

Johnson et al. 2002: Johnson, David W., Donald A. Proulx, Stephen B. Mabee: The correlation between geoglyphs and subterranean water resources in the Río Grande de Nazca drainage. In: Silverman, Helaine, William H. Isbell (eds.), *Andean archaeology II: art, landscape, and society*, 307-332. Kluwer Academic / Plenum, New York 2002.

Johnson et al. 1990: Johnson, Gerald W., Douglas E. Meisner, William L. Johnson: Aerial photography of the Nazca lines. In: Aveni, Anthony F. (ed.), *The lines of Nazca* (Memoirs of the American Philosophical Society 183), 271-283. American Philosophical Society, Philadelphia1990.

Kern, Reiche 1974: Kern, Hermann, Maria Reiche: *Peruanische Erdzeichen / Peruvian ground drawings*. Kunstraum München e.V., Munich 1974.

Kosok 1965: Kosok, Paul: *Life, land and water in ancient Peru*. Long Island University, Brooklyn 1965.

Kosok, Reiche 1947: Kosok, Paul, Maria Reiche: The mysterious markings of Nazca. *Natural History* LVI(5), 200-207, 237-238. 1947.

Kosok, Reiche 1949: Kosok, Paul, Maria Reiche: Ancient drawings on the desert of Peru. *Archaeology* 2(4), 206-215. 1949.

Kraus 2004: Kraus, Karl: *Photogrammetrie I: Geometrische Informationen aus Photographien und Laserscanneraufnahmen.* 7th ed. De Gruyter, Berlin 2004.

Kroeber 1956: Kroeber, Alfred L.: *Toward definition of the Nazca style* (University of California Publications in American Archaeology and Ethnology). University of California, Berkeley, Los Angeles 1956.

Kroeber, Collier 1998: Kroeber, Alfred L., Donald Collier: *The archaeology and pottery of Nazca, Peru: Alfred L. Kroeber's 1926 expedition*. Patrick H. Carmichael (ed.). AltaMira, Walnut Creek 1998.

Kvamme 1999: Kvamme, Kenneth: Recent directions and developments in Geographical Information Systems. *Journal of Archaeological Researc*h 7(2), 153-201. 1999.

Lambers, Sauerbier 2003: Lambers, Karsten, Martin Sauerbier: A data model for a GIS-based analysis of the Nasca lines at Palpa (Peru). *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* XXXIV-5/C15, 713-718. 2003.

Lefort et al. 2003: Lefort, Alexandra, Manuela Grippa, Nicholas Walker, Laura J. Stuart, Iain H. Woodhouse: Interferometric coherence for change detection in the Nasca region of Peru. In: *Proceedings of the IGARSS Conference, 21-25 July 2003, Toulouse, France*, on CD-ROM. 2003.

Lefort et al. 2004: Lefort, Alexandra, Manuela Grippa, Nicholas Walker, Laura J. Stuart, Iain H. Woodhouse: Change detection accross the Nasca pampa using spaceborne SAR interferometry. *International Journal of Remote Sensing* 25(10), 1799-1803. 2004.

Lerma 2002: Lerma, José Luis: *Fotogrametría moderna: analítica y digital*. Universidad Politécnica de Valencia, Valencia 2002.

Liddell, Scott 1996: Liddel, Henry G., Robert Scott: *A Greek-English lexicon*. 9th ed. with revised supplement. Clarendon, Oxford 1996.

Lillesand et al. 2004: Lillesand, Thomas M., Ralph W. Kiefer, Jonathan W. Chipman: *Remote sensing and image interpretation*. 5th ed. Wiley, New York 2004.

Luhmann 2002: Luhmann, Thomas: *Nahbereichsphotogrammetrie in der Praxis: Beispiele und Problemlösungen*. Wichmann, Heidelberg 2002.

Luhmann 2003: Luhmann, Thomas: *Nahbereichsphotogrammetrie: Grundlagen, Methoden und Anwendungen*. 2nd ed. Wichmann, Heidelberg 2003.

Lumbreras 2000: Lumbreras, Luis G.: *Plan de manejo de las líneas de Nasca I: contexto arqueológico*. INC, UNESCO, Lima 2000.

Makowski 2000: Makowski, Krzysztof: Los seres naturales en la iconografía Paracas y Nasca. In: *Los dioses del antiguo Perú* (Colección Arte y Tesoros del Perú), 277-307. Banco de Crédito, Lima 2000.

Makowski 2001: Makowski, Krzysztof: Las civilizaciones prehispánicas en la costa central y sur. In: *Historia de la cultura peruana* I, 163-244. Fondo Editorial del Congreso del Perú, Lima 2001.

Marangou 2001: Marangou, Christina: Sacred or secular places and the ambiguous evidence of prehistoric rituals. In: Biehl, Peter F., François Bertemes, Harald Meller (eds.), *The archaeology of cult and religion* (Archaeolingua Main Series 13), 139-160. Archaeolingua, Budapest 2001.

Marcos 1986: Marcos, Jorge: Intercambio a larga distancia en América: el caso del Spondylus. In: Marcos, Jorge (ed.), *Arqueología de la costa ecuatoriana: nuevos enfoques* (Biblioteca Ecuatoriana de Arqueología 1), 197-206. Corporación Editoria Nacional, Quito 1986.

Marcos 2002: Marcos, Jorge: Mullo y Pututo para el Gran Caimán: un modelo para el intercambio entre Mesoamérica y Andinoamérica. *Gaceta Arqueológica Andina* 26, 13-36. 2002.

Massey 1992: Massey, Sarah A.: Investigaciones arqueológicas en el valle alto de Ica: Período Intermedio Temprano 1 y 2. In: Bonavia, Duccio (ed.), *Estudios de arqueología peruana*, 215-235. Fomciencieas, Lima 1992.

Mejía 1942: Mejía, Toribio: Acueductos y caminos antiguos de la hoya del Río Grande de Nasca. In: *Actas y* *trabajos científicos del XXVII Congreso Internacional de Americanistas (Lima, 1939)* I, 559-569. Librería e Imprenta Gil, Lima 1942.

Mejía 1972: Mejía, Toribio: Algunos restos arqueológicos del período Pre-Paracas en el valle de Palpa. *Arqueología y Sociedad* 7-8, 77-86. 1972.

Mejía 1976: Mejía, Toribio: Sitios arqueológicos del valle de Palpa, Ica. *San Marcos* n. s. 17, 23-47. 1976.

Mejía 2002: Mejía, Toribio: *Arqueología de la cuenca del Río Grande de Nasca* (Cuadernos de Investigación del Archivo Tello 3). Universidad Nacional Mayor de San Marcos, Museo de Arqueología y Antropología, Lima 2002.

Menzel et al. 1964: Menzel, Dorothy, John H. Rowe, Lawrence H. Dawson: *The Paracas pottery of Ica: a study in style and time* (University of California Publications in American Archaeology and History 50). University of California, Berkeley, Los Angeles 1964.

Merrifield 1987: Merrifield, Ralph: *The archaeology of ritual and magic*. B. T. Batsford, London 1987.

Mikhail et al. 2001: Mikhail, Edward M., James S. Bethel, J. Chris McGlone: *Introduction to modern photogrammetr*y. Wiley, New York 2001.

Morrison 1987: Morrison, Tony: *The mystery of the Nasca lines*. Nonesuch, Woodbridge 1987.

Moseley 2001: Moseley, Michael: *The Incas and their ancestors – the archaeology of Peru*. 2nd ed. Thames & Hudson, London 2001.

Müller 2002: Müller, Felix: *Götter, Gaben, Rituale: Religion in der Frühgeschichte Europas* (Kulturgeschichte der Alten Welt 92). Philipp von Zabern, Mainz 2002.

Neubauer 2004: Neubauer, Wolfgang: GIS in archaeology - the interface between prospection and excavation. *Journal of Archaeological Prospection* 11(3), 159-166. 2004.

Nikitzki 1993: Nikitzki, Viktoria: *Líneas y figuras en la pampa de Nasca, Perú*. Plano topográfico, escala 1:8,333. Asociación Pro-Museo y Conservación Arqueológica, Lima 1993.

Orefici 1999: Orefici, Giuseppe: Zeremonial- und Wohnarchitektur im Nasca-Tal. In: Rickenbach, Judith (ed.), *Nasca: geheimnisvolle Zeichen im alten Peru*, 97-108. Museum Rietberg, Zurich 1999.

Orefici, Drusini 2003: Orefici, Giuseppe, Andrea Drusini: *Nasca: hipótesis y evidencias de su desarollo cultural* (Documentos e Investigaciones 2). CISRAP, Brescia 2003.

Paul 1999: Paul, Anne: Ein Mumienbündel aus Paracas Necropolis. In: Rickenbach, Judith (ed.), *Nasca: geheimnisvolle Zeichen im alten Peru*, 49-58. Museum Rietberg, Zurich 1999.

Paul ed. 1991: Paul, Anne (ed.): *Paracas art and architecture: object and context in south coastal Peru*. University of Iowa Press, Iowa City 1991.

Rappaport 1999: Rappaport, Roy A.: *Ritual and religion in the making of humanity* (Cambridge Studies in Social and Cultural Anthropology 110). University of Cambridge Press, Cambridge 1999.

Ravines et al. 1995: Ravines, Juana, Rogger Ravines, Mercedes Cárdenas, Andrés Lancho: Algunas apreciaciones sobre las "marcas" de Nasca. *Boletín de Lima* 97, 11-23. 1995.

Reiche 1976: Reiche, Maria: *Geheimnis der Wüste / Mystery on the desert / Secreto de la pampa*. 6th ed. Stuttgart 1976.

Reiche 1993: Reiche, Maria: *Contribuciones a la geometría y astronomía en el antiguo Perú*. Asociación María Reiche para las líneas de Nasca, Lima 1993.

Reindel 1993: Reindel, Markus: *Monumentale Lehmarchitektur an der Nordküste Perus* (Bonner Amerikanistische Studien 22). Holos, Bonn 1993.

Reindel, Isla 2001: Reindel, Markus, Johny Isla: Los Molinos und La Muña. Zwei Siedlungszentren der Nasca-Kultur in Palpa, Südperu / Los Molinos y La Muña. Dos centros administrativos de la cultura Nasca en Palpa, costa sur del Perú. *Beiträge zur Allgemeinen und Vergleichenden Archäologie* 21, 241-319. 2001.

Reindel, Wagner eds. 2004: Reindel, Markus, Günther Wagner (eds.): *Neue naturwissenschaftliche Methoden und Technologien für die archäologische Forschung in Palpa, Peru / Nuevos métodos y tecnologías para la investigación arqueológica en Palpa, Perú*. Companion volume, Nasca-Palpa project field conference, Palpa, Peru, 17-22 September 2004. Goethe Institut, Lima 2004.

Reindel et al. 1999: Reindel, Markus, Johny Isla, Klaus Koschmieder: Vorspanische Siedlungen und Bodenzeichnungen in Palpa, Südperu / Asentamientos prehispánicos y geoglifos en Palpa, costa sur del Perú. *Beiträge zur Allgemeinen und Vergleichenden Archäologie* 19, 313-381. 1999.

Reindel et al. 2002: Reindel, Markus, Johny Isla, Karsten Lambers: Abschliessende Untersuchungen zu Geoglyphen und Siedlungen in Palpa, Südperu: Ergebnisse der Feldkampagne 2001 des Archäologischen Projektes Nasca-Palpa. *SLSA-Jahresbericht* 2001, 37-54. 2002.

Reindel et al. 2003a: Reindel, Markus, Johny Isla, Karsten Lambers: Die Arbeiten des Archäologischen Projektes Nasca-Palpa, Peru, im Jahr 2002. *SLSA-Jahresbericht* 2002, 119-132. 2003.

Reindel et al. 2003b: Reindel, Markus, Karsten Lambers, Armin Grün: Photogrammetrische Dokumentation und archäologische Analyse der vorspanischen Bodenzeichnungen von Palpa, Südperu / Documentación fotogramétrica y análisis arqueológico de los geoglifos prehispánicos de Palpa, costa sur del Perú. *Beiträge zur Allgemeinen und Vergleichenden Archäologie* 23, 183-226. 2003.

Reinhard 1988: Reinhard, Johan: The Nazca lines, water and mountains: an ethnoarchaeological study. In: Saunders, Nicholas J., Olivier de Montmollin (eds.), *Recent studies in pre-columbian archaeology* (BAR International Series 421), 363-414. BAR, Oxford 1988.

Reinhard 1996: Reinhard, Johan: *The Nazca lines: a new perspective on their origin and meaning*. 6th ed. Editorial Los Pinos, Lima 1996.

Renfrew 1994: Renfrew, Colin: The archaeology of religion. In: Renfrew, Colin, Esra Zubrow (ed.), *The ancient mind: elements of cognitive archaeology* (New Directions in Archaeology), 47-54. Cambridge University Press, Cambridge 1994.

Renfrew, Bahn 2000: Renfrew, Colin, Paul Bahn: *Archaeology: theories, methods, and practice*. 3rd ed. Thames & Hudson, London 2000.

Rickenbach ed. 1999: Rickenbach, Judith (ed.): *Nasca: geheimnisvolle Zeichen im alten Peru*. Museum Rietberg, Zurich 1999.

Rodríguez 1999: Rodríguez, Aurelio: *Los campos de geoglifos en la costa central del Perú* (Cuadernos de Investigación 2/1997). Instituto Riva Agüero, Lima 1999.

Rossel 1977: Rossel, Alberto: *Arqueología sur del Perú*. Editorial Universo, Lima 1977.

Rostworowski 1993: Rostworowski, María: Origen religioso de los dibujos y rayas de Nasca. *Journal de la Société des Américanistes* LXXIX, 189-202. 1993.

Rowe 1960: Rowe, John H.: Nuevos datos relativos a la cronología del estilo Nasca. In: Matos, Ramiro (ed.), *Antiguo Peru, espacio y tiempo*, 29-45. Editorial Juan Mejía Baca, Lima 1960.

Ruggles 1990: Ruggles, Clive L. N.: Statistical examination of the radial line azimuths at Nazca. In: Aveni, Anthony F. (ed.), *The lines of Nazca* (Memoirs of the American Philosophical Society 183), 245-269. American Philosophical Society, Philadelphia 1990.

Ryan 2004: Ryan, Nick: Databases. *Internet Archaeology* 15. http://intarch.york.arc.uk/journal/issue15/ryan_toc.html, 2004.

Sauerbier 2004: Sauerbier, Martin: Accuracy of automated aerotriangulation and DTM generation for low textured imagery. *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* XXXV-B2, 521-526. 2004.

Sauerbier, Lambers 2003: Sauerbier, Martin, Karsten Lambers: A 3D model of the Nasca lines at Palpa (Peru). *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* XXXIV-5/W10, on CD-ROM. 2003.

Sauerbier, Lambers 2004: Sauerbier, Martin, Karsten Lambers: From vectors to objects: modeling the Nasca lines at Palpa (Peru). In: Fischer Ausserer, Karin, Wolfgang Börner, Maximilian Goriany, Lisa Karlhuber-Vöckl (eds.), *Enter the past: the E-way into the four dimensions of cultural heritage* (BAR International Series 1227), 396-399 and on CD-ROM. Archaeopress, Oxford, 2004.

Sauerbier et al. 2004: Sauerbier, Martin, Melanie Kunz, Matthias Flühler, Fabio Remondino: Photogrammetric reconstruction of adobe architecture at Túcume, Peru. *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* XXXVI-5/W1, on CD-ROM. 2004.

Sawyer 1997: Sawyer, Alan R.: *Early Nasca needlework*. Laurence King Publishing, London 1997.

Schindler 2000: Schindler, Helmut: *Die Kunstsammlung Norbert Mayrock aus Alt-Peru*. Staatliches Museum für Völkerkunde, Munich 2000.

Schreiber 1992: Schreiber, Katharina J.: *Wari imperialism in Middle Horizon Peru* (Anthropological Papers 87). Museum of Anthropology, University of Michigan, Ann Arbor 1992.

Schreiber 1998: Schreiber, Katharina J.: Nasca research since 1926. In: Kroeber, Alfred L., Donald Collier, *The archaeology and pottery of Nazca, Peru: Alfred L. Kroeber's 1926 expedition* (Patrick H. Carmichael ed.), 261-270. AltaMira, Walnut Creek 1998.

Schreiber 1999: Schreiber, Katharina J.: Regional approaches to the study of prehistoric empires: examples from Ayacucho and Nasca, Peru. In: Billmann, Brian R., Gary M. Feinman (eds.), *Settlement pattern studies in the Americas - fifty years since Virú*, 160-171. Smithsonian Institution Press, Washington, D. C. 1999.

Schreiber, Lancho 2003: Schreiber, Katharina J., Josué Lancho: *Irrigation and society in the Peruvian desert*. Lexington Books, Lanham 2003.

Silverman 1990a: Silverman, Helaine: The early Nasca pilgrimage center of Cahuachi and the Nasca lines: anthropological and archaeological perspectives. In: Aveni, Anthony F. (ed.), *The lines of Nazca* (Memoirs of the American Philosophical Society 183), 207-244. American Philosophical Society, Philadelphia 1990.

Silverman 1990b: Silverman, Helaine: Beyond the pampa: the geoglyphs in the valleys of Nazca. *National Geographic Research* 6(4), 435-456. 1990.

Silverman 1993a: Silverman, Helaine: *Cahuachi in the ancient Nasca world*. University of Iowa Press, Iowa City 1993.

Silverman 1993b: Silverman, Helaine: Patrones de asentamiento en el valle de Ingenio, cuenca del Río Grande de Nasca: una propuesta preliminar. *Gaceta Arqueológica Andina* VII23, 103-124. 1993.

Silverman 1994a: Silverman, Helaine: The archaeological identification of an ancient Peruvian pilgrimage center. *World Archaeology* 26(1), 1-18. 1994.

Silverman 1994b: Silverman, Helaine: Paracas in Nazca: new data on the Early Horizon occupation of the Rio Grande de Nasca drainage, Peru. *Latin American Antiquity* 5(4), 359-382. 2004.

Silverman 2000: Silverman, Helaine: Nasca: geografía sagrada, ancestros y agua. In: *Los dioses del antiguo Perú* (Colección Arte y Tesoros del Perú), 239-276. Banco de Crédito, Lima 2000.

Silverman 2002a: Silverman, Helaine: *Ancient Nasca settlement and society*. University of Iowa Press, Iowa City 2002.

Silverman 2002b: Silverman, Helaine: Nasca settlement and society on the hundredth anniversary of Uhle´s discovery of the Nasca style. In: Isbell, William H., Helaine Silverman (eds.), *Andean archaeology I: variations in sociopolitical organization*, 121-158. Kluwer Academic / Plenum, New York 2002.

Silverman, Browne 1991: Silverman, Helaine, David Browne: New evidence for the date of the Nazca lines. *Antiquity* 65, 208-220. 1991.

Silverman, Proulx 2002: Silverman, Helaine, Donald Proulx: *The Nasca* (The Peoples of America). Blackwell, Malden, Oxford 2002.

Strong 1957: Strong, William D.: Paracas, Nazca, and tiahuanacoid cultural relationships in south coastal Peru (Memoirs of the Society for American Archaeology 13). University of Utah Press, Salt Lake City 1957.

Sundqvist, Kaliff 2003: Sundqvist, O., A. Kaliff: Rituale. In: Beck, Heinrich, Dieter Geuenich, Heiko Steuer (eds.), *Reallexikon der Germanischen Altertumskunde* 25, 28-52. De Gruyter, Berlin 2003.

Teichert, Richter 2001: Teichert, Bernd, Christiane Richter: The Nasca lines and geoglyphs - on the way to a multimedia GIS. *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* XXXIV-5/W1, 24-29. 2001.

Teichert, Richter 2003: Teicher, Bernd, Christiane Richter: The Nasca mysteries – a multimedia GIS application. *Geoinformatics* 6(1), 12-15. 2003.

Teichert et al. 2002: Teichert, Bernd, Christiane Richter, Michael Schiebold: Nasca - mit Topobase dem Mythos auf der Spur. *Der Vermessungsingenieur* 5/2002, 356-361. 2002.

Tello 1959: Tello, Julio C.: *Paracas - primera parte*. Scheuch, Lima 1959.

Tello, Mejía 1979: Tello, Julio C., Toribio Mejía: *Paracas, segunda parte: Cavernas y Necrópolis*. Universidad Nacional Mayor de San Marcos, Lima 1979.

Uhle 1913: Uhle, Max: Zur Chronologie der alten Kulturen von Ica. *Journal de la Société des Américanistes* X, 341-367. 1913.

Urton 1990: Urton, Gary: Andean social organization and the maintenance of the Nazca lines. In: Aveni, Anthony F. (ed.), *The lines of Nazca* (Memoirs of the American Philosophical Society 183), 173-206. American Philosophical Society, Philadelphia 1990.

Valdez 2000: Valdez, Lidio M.: La tradición cultural de Huarato de Acarí y sus relaciones con Nasca. *Arqueología y Sociedad* 13, 159-171. 2000.

van Leusen 1999: van Leusen, Martijn: Viewshed and cost surface analysis using GIS (cartographic modelling in a cell-based GIS II). In: Barceló, Juan A., Ivan Briz, Assumpció Vila (eds.), *New techniques for old times - Proceedings of the 26th CAA conference, Barcelona, March 1999* (BAR International Series 757), 215-223. Archaeopress, Oxford 1999.

Vaughn 2004: Vaughn, Kevin J.: Households, crafts, and feasting in the ancient Andes: the village context of Early Nasca craft consumption. *Latin American Antiquity* 15(1), 61-88. 2004.

Vaughn, Neff 2000: Vaughn, Kevin J., Hector Neff: Moving beyond iconography: neutron activation analysis of ceramics from Marcaya, Peru, an Early Nasca domestic site. *Journal of Field Archaeology* 27(1), 75-90. 2000.

Velarde 1999: Velarde, Leonid: La transición Paracas-Nasca en el Valle de Chincha. In: Chevalier, Alexandre, Leonid Velarde, Isabelle Chenal-Velarde (eds.), *L'Amerique du sud: des chasseurs-ceuilleurs à l'empire Inca* (BAR International Series 746), 63-77. Archaeopress, Oxford 1999.

Wagner 1998: Wagner, Günther: *Age determination of young rocks and artifacts*. Springer, Berlin 1998.

Wheatley, Gillings 2002: Wheatley, David, Mark Gillings: *Spatial technology and archaeology: the archaeological applications of GIS*. Taylor & Francis, London, New York 2002.

Wieczorek, Tellenbach eds. 2002: Wieczorek, Alfried, Michael Tellenbach (eds.): *An die Mächte der Natur: Mythen der altperuanischen Nasca-Indianer* (Publikationen der Reiss-Engelhorn-Museen 5). Philipp von Zabern, Mainz 2002.

Zuidema 1964: Zuidema, R. Tom: *The ceque system of Cuzco: the social organization of the capital of the Inca*. E. J. Brill, Leiden 1964.

9.5 Supplement contents

DVD	*readme.txt:* Instructions concerning the DVD content
	palpa_geoglyphs.mdb: MS Access 2000 database containing data of 639 Palpa geoglyphs
	virtual_palpa.avi: Video of a virtual flight through the 3D model of Palpa
	lambers_palpa_thesis.pdf: Text containing the main volume of the present study
Map 1	Prehispanic geoglyphs of Palpa (Ica, Peru)
Map 2	Orthophoto of Palpa (Ica, Peru)
Map 3	Conceptual data model describing the structure of the geoglyph database
Map 4	Arrangement of partial views on A3 maps
Map 5	Prehispanic sites registered by the Nasca-Palpa project
Map 6	Geoglyphs on Cresta de Sacramento, Cerro Carapo, and around La Muña
Map 7	Sites, geoglyphs, and potential access routes dating to the Early Horizon
Map 8	Sites, geoglyphs, and potential access routes dating to Initial Nasca
Map 9	Sites, geoglyphs, and potential access routes dating to Nasca 2
Map 10	Sites, geoglyphs, and potential access routes dating to Nasca 3
Map 11	Sites, geoglyphs, and potential access routes dating to Nasca 4
Map 12	Sites, geoglyphs, and potential access routes dating to Nasca 5
Map 13	Sites, geoglyphs, and potential access routes dating to Nasca 6
Map 14	Sites, geoglyphs, and potential access routes dating to Nasca 7
Map 15	Sites, geoglyphs, and potential access routes dating to the Middle Horizon
Map 16	Sites, geoglyphs, and potential access routes dating to the Late Intermediate Period

Table 6: Supplement contents (DVD and maps)

9.6 Curriculum Vitae

Academic Formation

2003 - 2004

University of Zurich, Switzerland: Doctoral studies in Pre- and Protohistory, Ph. D. thesis on "The geoglyphs of Palpa: documentation, analysis, and interpretation" (*summa cum laude*)

1992 - 1998

University of Bonn, Germany: Master of Arts studies in American Anthropology, Pre- and Protohistory, and Spanish; M. A. thesis on "Späte Besiedlung in Xkipché, Yucatán, Mexiko"

Professional Experience

2005 - present

German Institute of Archaeology (DAI), Commission for General and Comparative Archaeology (KAVA), Bonn, Germany: Researcher, archaeological fieldwork in Peru

1999 - 2004

Institute of Geodesy and Photogrammetry (IGP), Swiss Federal Institute of Technology (ETH), Zurich, Switzerland: Researcher, archaeological fieldwork in Peru

1999

Fa. Angewandte Baugrundarchäologie GmbH, Bonn, Germany: Site technician, archaeological fieldwork in Germany

1992 - 1998

Archaeological fieldwork internships in Germany, Bolivia and Mexico

Grants and Awards

2005 *Jahrespreis* 2004, University of Zurich, Faculty of Arts

2004 Research grant, University of Zurich, Research Commission

2000 Doctoral scholarship, German Academic Exchange Service (DAAD, Bonn)