1. Introduction

Fig. 1. The study area on the south coast of Peru.

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 has conducted major 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)

The present study is the result of extensive fieldwork to investigate the geoglyphs of the Palpa region which is located in the northern part of the Nasca drainage (frontispiece, fig. 1). The number of geoglyphs in the vicinity of Palpa is second only to the Nasca *pampa*. They are located on the slopes and plateaus along Río Grande, Río Palpa, and Río Viscas. This investigation of the Palpa geoglyphs is intended to fill some of the many large gaps in our scientific knowledge of the geoglyphs in the Nasca region.

Since the 1940s researchers and others have used astronomical hypotheses to interpret the geoglyphs. German-born mathematician 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 this recent model with archaeological data.

In order to test this recent hypothesis a large amount of data about the geoglyphs had to be systematically collected. 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 current 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 problem of documentation methodology thus constituted a significant part of the research described in this study.

The Palpa area of the Nasca basin has 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) in Zurich started a long-term archaeological research project at Palpa that provided the framework for the research described in the present study (see section 4). 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 in the vicinity of 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 for Archaeology of Non-European Cultures (KAAK, Bonn) of the German Archaeological Institute (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 (frontispiece). It was defined by the limits of a series of aerial images taken especially for the intended geoglyph research (supplements 1–4). This zone comprises in its center the wide floodplain formed by Río

[1] The second phase of the Nasca-Palpa Project started in 2002 and is now co-sponsored by SLSA, ETH Zurich, and the German Federal Ministry of Education and Research (BMBF, Bonn). The project currently comprises four major fields of activities: (1) Excavations at Paracas sites in the Palpa area, (2) Investigations of the paleoclimate and ecology of the Nasca region, (3) The application and improvement of new methods of archaeological prospection and chronometric dating of archaeological remains, and finally (4) 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, and Bernhard Eitel, of the Institute of Geography of the University of Heidelberg. The second phase of the Nasca-Palpa Project will not be concluded before 2007. The present study therefore refers mainly to results of the first phase.

Palpa and Río Viscas shortly before they join Río Grande. This is also where the modern town of Palpa is situated. The alluvial plain is bounded 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 been joined by both Río Palpa and Río Viscas. The aerial images covered all of the above mentioned ridges, plateaus, dry valleys and areas between the valleys where geoglyphs are located.

The geoglyphs of Palpa were the actual object of investigation of the present study (maps 1–13). They are 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 there is 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 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 Palpa an easier place to study the relationships between the two classes of cultural remains than Nasca, 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. Later, most of the geoglyphs 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 into a geographic information system (GIS). That accomplished, the actual archaeological analysis was undertaken, combining standard archaeological methods with database and GIS computer analysis. Spatial analyses were performed to understand the role of the geoglyphs in the Nasca cultural landscape, and recent hypotheses on geoglyph function were confronted with the archaeological record of Palpa. The result of this investigation is a cultural historical interpretation of the geoglyphs of Palpa solidly based on archaeological evidence.

When compared to other recent investigations of the Nasca geoglyphs, the research presented here has several new methodological contributions. Apart from studying the Palpa geoglyphs for the first time, three new 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 tries to explain the Nasca geoglyphs in terms of Andean traditions of social organization and religious practices
- The first-time use of GIS technology that integrates all available information on a multi-data platform in order to investigate the ordering principles that guided the making and use of geoglyphs.

The structure of this study is as follows. In section 2 the Nasca area and the geoglyphs are described, and a brief overview of their cultural background is given. In section 3, basic issues are identified that have to be addressed when investigating the Palpa geoglyphs. This is accomplished by reviewing recent contributions to Nasca geoglyph research. The approach pursued in the present study is then detailed. In section 4 the aims and scope of the Nasca-Palpa Project are summarized. This is followed in section 5 by a description of the documentation of the geoglyphs. Section 6 is dedicated to the archaeological analysis of the Palpa geoglyphs and the corresponding results. In section 7 the results are then discussed and interpreted in the light of current knowledge on the Nasca geoglyphs. In section 8 results as well as applied methods are summarized and reviewed. Detailed descriptions of archaeological contexts are grouped in a final appendix (section 9). This is followed by a Spanish summary.

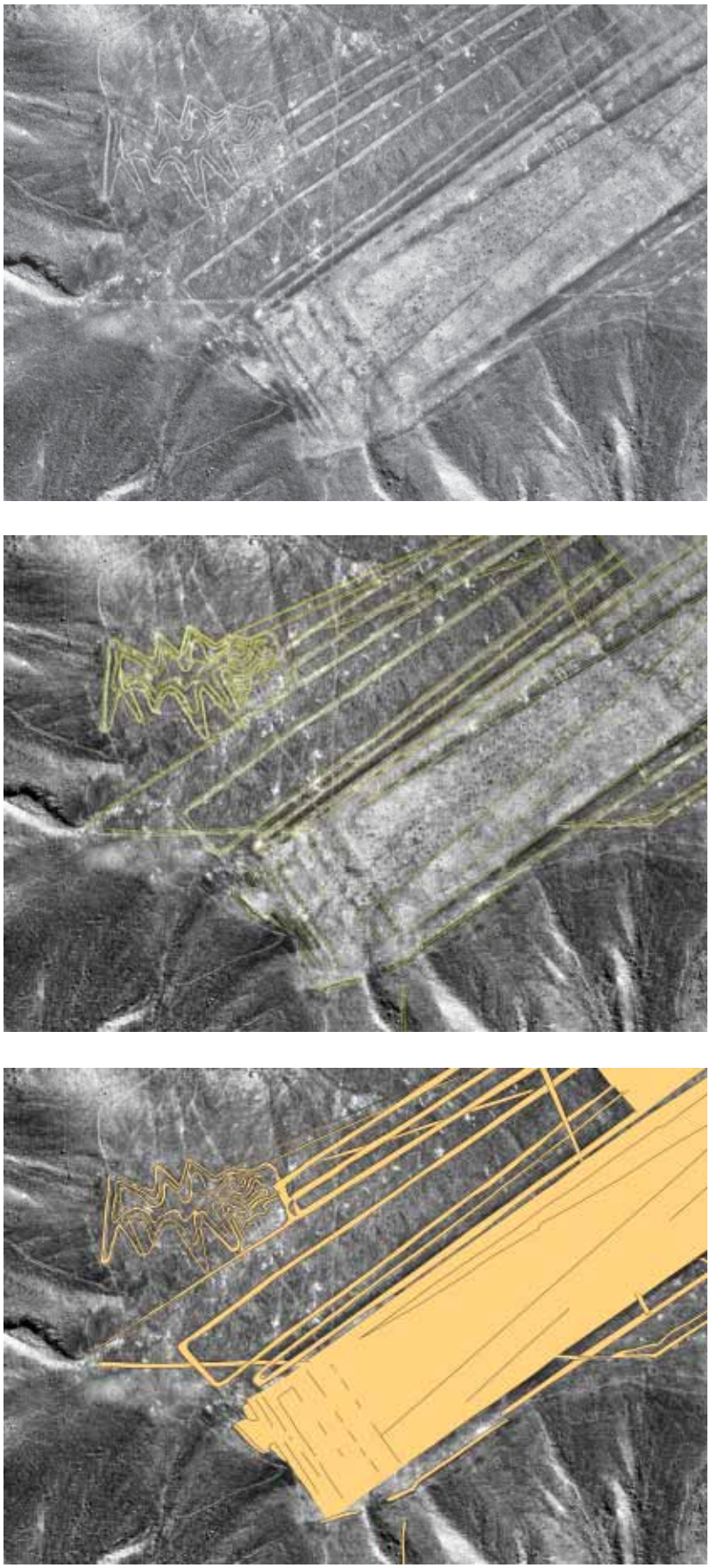


Fig. 13. Photogrammetric geoglyph mapping: Geoglyphs as visible in aerial images (top), vectors marking geoglyph outlines (center), polygons representing geoglyphs as defined from vectors (bottom).

Fig. 14. 3D model composed of DTM (upper center), orthoimage (left) and polygon layer (right).

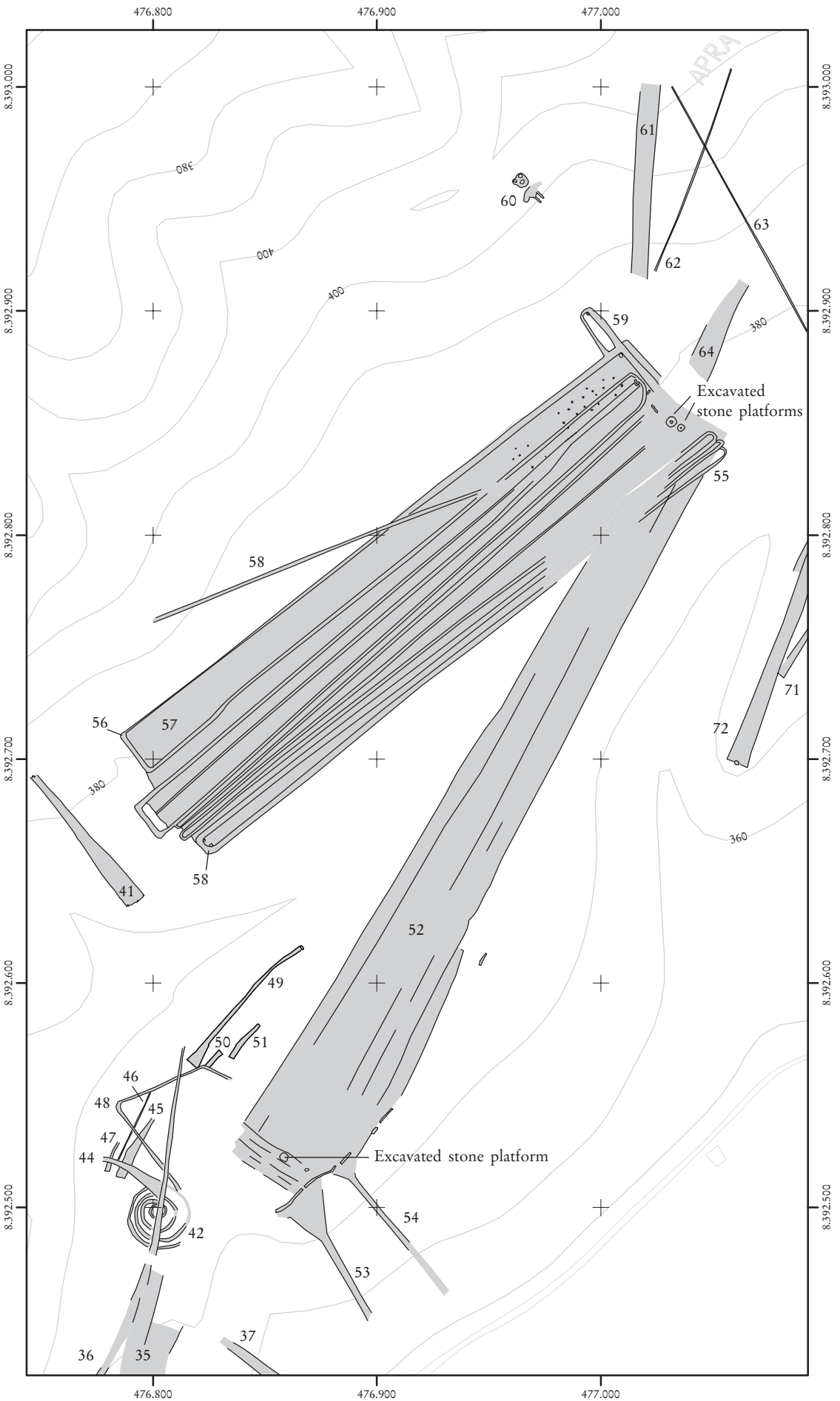
and field data. The goal was to generate digital 3D objects that represented the geoglyphs and could therefore be linked with the corresponding description.

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 the following 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 (fig. 13).

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



Map 9. Geoglyph sites PV67A-15 (bottom) and -16 (top) on Cresta de Sacramento.