Chapter 21
Perspectives and Contrasts: Documentation and Interpretation of the Petroglyphs of Chichictara, Using Terrestrial Laser Scanning and Image-Based 3D Modeling

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Abstract In this chapter we present our research activities at the petroglyph site of Chichictara near Palpa. Along with the discussion about the documentation methodology including terrestrial laser scanning and photogrammetry we here present the Geographic Information System (GIS) that we intend to use as a tool for archaeological interpretation of the site and its components. Furthermore, we focus on the question of the added value of the adoption of new documentation technologies concerning archaeological interpretation. We are confident that through such adoption new perspectives regarding both the interpretation of the original social meaning of the petroglyph site and the iconography of its pictures are revealed. The adoption of new technologies sheds new light on the archaeological interpretation of the petroglyphs of Chichictara.

21.1 The Project's Perspective

If not in theory, then certainly in the practice of archaeology one traditionally likes to separate documentation and interpretation of findings, a principle which seems especially true in the case of recent rock-art research. In terms of adoption of new technologies, the focus is usually set on accuracy of the documentation, whereas discussion about the possible added value of the adoption with regard to interpretation—notably inquiries into the once social meaning of the specific place and especially iconography—is often missed. Cognizant that rock-art in general represents a class of cultural heritage especially exposed to destruction, in particular because of its fixed position in the landscape, the goal of realistic documentation is certainly justified. The evaluation of an accurate documentation method is therefore one aim of the

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Fig. 21.1 Zoomorphic petroglyphs on rock 20, sector 2

Chichictara project presented here. Furthermore, the project aims to exemplify in which regard the adoption of new technologies leads to insights into the original social meaning of the petroglyph site of Chichictara and even affords new perspectives for iconographic studies.

Although in the Nasca–Palpa region many petroglyph sites have been well known to archaeologists for a long time (the site of Chichictara, e.g., was mentioned by several authors (Orefici 1983, Núñez 1986, Hostnig 2003)), none have been archaeologically analyzed in further detail. Indeed, Matos Avalos (1987) did an excellent job, taking into account his limited resources, in recording the entire site of Chichictara, and Nieves (2007) is to be lauded for her comprehensive documentation of rock-art sites in the Nasca–Palpa region. However, a satisfying interpretation of the social meaning of a specific site and its figures has not yet been conducted. Thus, this is the aim of our Chichictara project.

Along the eastern slope of the lower valley of the Palpa River there are several concentrations of petroglyphs within a range of about 2.5 km Fig. 21.1. The largest of them is Chichictara, situated 11 km to the northeast of Palpa at an altitude of around 550 meters above sea level (see Figs. 21.2 and 21.9). It is the largest petroglyph site in the Nasca–Palpa region. Approximately 150 sculptured rocks are covered with anthropomorphic, zoomorphic, and geometric figures or with depictions of activities such as hunting (Fig. 21.5). On the basis of iconographic similarities with datable archaeological findings, for example, textiles or ceramics, most of these petroglyphs can be dated to the Paracas

Fig. 21.2 A panoramic view of the lower Palpa valley. The Chichictara side valley at the eastern slope is framed in red

period (800–200 BC; see Fux et al. in press). The rocks are mostly located on the bottom of the Chichictara valley and on its rocky slopes.

Because we strongly advance the view that rock-art in general has to be regarded as "an intentional and meaning afflicted human assertion," which corresponds to Geertz's (1973) appreciation of the term *symbol*, we opt for a consideration of rock-art as symbols. Whereas the term *symbol* has to be understood in an open and general sense—it comprises letters, words, texts, images, diagrams, maps, models, and more (see, e.g., Goodman 1976)—the discussion concerning the comprehension of symbols is a delicate issue. However, in general it seems to be clear that for an appropriate understanding of any assertion, be it within the range of language or even art, the consideration of further contextual information, for example, gestures, attitudes, and attendant circumstances, is indispensable (e.g., Langer 1942).

At this point, skepticism regarding the ability to understand symbols from ancient societies and cultures is common (see, e.g., Layton 2001: 316). The most skeptical view conceivable is presumably the one of the relativists: they argue that there are different ways of organizing experience and systems of categories that give form to the data of sensation. There are different points of view from which individuals, cultures, or periods survey the passing scene. Such ways of organizing experience are called *conceptual schemes* (Davidson 1974), and potentially we may not be able to understand assertions belonging to a foreign conceptual scheme (see, e.g., Whorf's (1956) comments on the impossibility to "calibrate" the language of the Hopi with English) because reality itself was relative to a scheme. Note at this point that understanding of an assertion means the ability to translate it into our own language, or, in other words, to find an explanation within our own conceptual scheme. The relativist's demur seems especially appropriate to symbols from ancient societies and cultures.

However, Davidson (1974) pointed out that even the postulation of disjunctive conceptual schemes in which assertions are made is only valid by the assumption of a common coordinate system in which these different conceptual schemes could be plotted, whereas, at the same time, the existence of such a common coordinate system falsifies the claim of dramatic incomparability. Obviously, we face a dualism of scheme and content, of organizing system and something waiting to be organized. Inquiries into this dubious something waiting to be organized are commonly seen as the business of (empirical) science per se, inasmuch as universal explanations for any human assertion can be expected. Science, we are told, differs from softer discourse in having contact with the real as a touchstone of truth. As true believers in science, one expects to detect the coordinate system in which different conceptual schemes can be plotted by means of empirical disciplines. In other words, there is widespread confidence that scientific inquiries into this underlying coordinate system will allow rational explanation of any cultural behavior, which itself may be, and is occasionally expected to be, thoroughly irrational (see, e.g., Langer 1942).

Hence, in rock-art research too, the request for universal, and therefore "scientific," explanations is well established: Approaches such as neuroscientific studies that Whitley regards as providing "a key to unlocking the mind and emotions of prehistoric shamans and other creators of rock art" (Whitley 1998: 32), or unified explanations of how the human being responds to his environment (see, e.g., Swartz's "Unified Space Model" in Swartz and Hurlbutt 1994) may be cited as examples.

By contrast, mainly due to dissatisfaction with dogmatically generalized explications, we follow Davidson's comment that the postulation of an underlying coordinate system is nothing but dogmatism (see Davidson's so-called "Third Dogma of Empiricism" in Davidson 1974), by giving up the aim to discover a general empirical content of rock-art. Dropping the image of science as a touchstone of truth means to dispose of both the hope for unified explanations of meaning or function of rock-art and the fear of potential incomprehensibility.

What we propose is to search for latent structures of a frame of action related to a given rock-art site. As in the case of any assertion—be it a spoken word or sentence, a scientific symbol, literature, or a piece of art—understanding of rock-art is only possible by taking into account contextual information of many kinds. This point was impressively pointed out by Wallace (1986) and furthermore illustrated with the example of the decipherment of Minoan scripts, called Linear B: many latent structures of action and life form, which certainly cannot be reduced to pure evidence, were considered. To give an example, assuming that one would have found the Linear B plates not within palace structures but in a temple or in any kind of sacral context, the translation of Linear B would be completely different from the current state of knowledge. In such a context the plates would have been understood as notes or texts of ritual chants rather than accounting records. Only by means of the conception of the social structure, life form, frame of action, and specific needs of the society that produced these Linear B plates, did a translation and comprehension become possible. Because there are no grave inconsistencies apparent within the dense mesh of argumentation, we seem to be comfortable with our understanding of Linear B. Hence, the understanding of intentional and meaning-afflicted human assertions, and therefore of rock-art as well, is always possible. Our satisfaction with an offered translation or explanation of any assertion depends much more on our empathy with its producer than on scientific provability and dogmatism (see, e.g., Geertz 1995). And that is as objective as can be.

In order to obtain as much contextual information about the petroglyph site of Chichictara as possible, we opted for the following methodology. To capture the natural environment the petroglyph site of Chichictara was recorded in 3D using terrestrial laser scanning (Fig. 21.3). Then, each rock with petroglyphs was documented and modeled in 3D by means of photogrammetric image processing. From these models 3D vector graphics for iconographic studies can be extracted (see Fig. 21.13). The goal of the project was the integration of each particular rock-model with its petroglyphs in high resolution into the Digital Terrain Model (DTM) of Chichictara (Fig. 21.4). Additionally, the integration of the whole Chichictara model into a second Digital Surface Model (DSM) derived from ASTER satellite imagery, which covers the Palpa region with its river valleys, is planned. Finally, the aim is to integrate the entire combined terrain model into a GIS database containing spatial and archaeological information, collected during ten years of multidisciplinary research activities (see Reindel, this volume). The presented approach allows a comprehensive analysis of the petroglyph site Chichictara as a whole and its single components.

In the following the field work conducted in 2006 and the ongoing work are summarized and the first results of the archaeological interpretation are presented.

21.2 Putting the Landscape in Perspective: Terrestrial Laser Scanning

The planned digital terrain model for the Chichictara valley needed to suit the integration of photogrammetric 3D models of the rocks. Because investigations on generation of DTMs by means of terrestrial laser scanning were conducted successfully in 2004 with the capture of a Saxon ring embankment (Hönniger and Kersten 2005), we decided on terrestrial laser scanning in order to model the Chichictara valley. The dimensions of the valley are approximately 250 m in length, 130 m in width, and 70 m in height. A terrestrial laser scanner MENSI GS 200 from Trimble with a wavelength of 532 nm and an optimum range of 200 m, but with somewhat longer range capacity in reality, was used due to its long measurement range. The instrument works according to the time-of-flight principle and measures between 1000 and 2000 points per second. In order to guarantee power supply for the computer and scanner during the fieldwork, we used a gasoline-driven generator with a power of 1 kW.

The data acquisition in Chichictara was completed during six days of fieldwork by using 13 scan positions. We distributed 14 spherical tie points in the terrain for the registration of the individual point clouds derived from each scan position. The coordinates of the spheres were determined using a Leica TCA 700 total station in a local coordinate system. We achieved a mean standard deviation of 6 mm after network adjustment for the 3D coordinates. By means

Fig. 21.3 Fieldwork with the laser scanner: The laptop is protected against dust and sunlight by a cardboard box

of the GPS measurements we transformed the resulting local network to the Universal Transverse Mercator (UTM) system, in which the spatial data of the Nasca–Palpa project are available. The absolute accuracy of the transformation of the DTM to the UTM system can be regarded as 0.3 m.

For the terrain scans we chose a resolution of 15 cm at a distance of 100 m, so that for each scan position, even at distances greater than 100 m, a point density of at least 50 cm could be obtained. In addition, for certain petroglyphs we collected scans at a high resolution of 3 mm at a distance of 10 m, aiming for

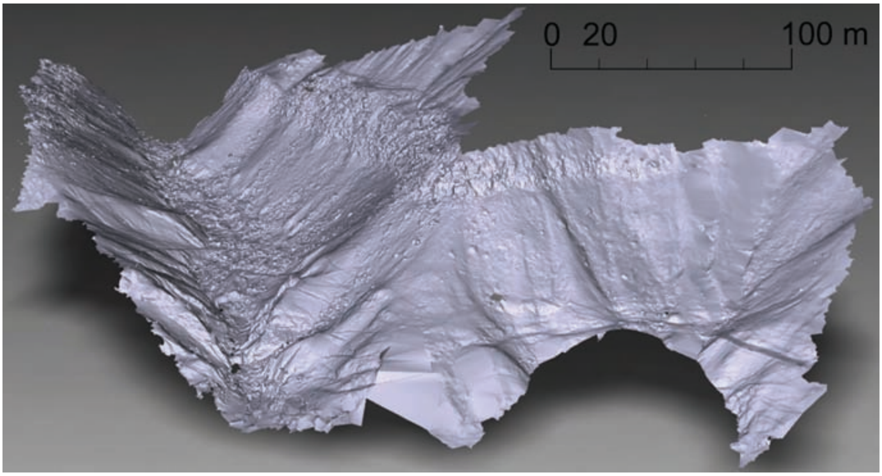


Fig. 21.4 The digital terrain model of the Chichictara valley derived from terrestrial laser scanning

exemplary comparison with the photogrammetrically derived 3D models. In total, 27 million points were measured, resulting in 512 MB of data.

21.3 Utilizing Contrasts: Photogrammetric 3D Modeling of the Rocks

Documentation of petroglyphs and other types of rock-art was conducted in the past by various means, from hand-drawn sketches to photos to images rectified using control points or surface models, mostly in 2D. In recent years, with the emergence of terrestrial laser scanners and their wide application, and with developments in digital photogrammetry, these two techniques have also been applied to record rock-art, extending the documentation to three dimensions (see, e.g., Barnett et al. 2005; Chandler et al. 2007; Díaz-Andreu et al. 2006; Jones 2007). Currently, even structured light systems, providing very high accuracy under controlled conditions, have been successfully applied to rock-art digitization (Landon and Brent Seales 2006). Nevertheless, the results obtained in an on-site experiment compare to the accuracy achievable by means of multi-image photogrammetric processing.

Especially for petroglyphs, 3D documentation can provide added value. Depth information, if acquired at sufficient accuracy, can contribute to investigations into the construction technique of the petroglyphs (see Fig. 21.7). In addition, in some cases worn or damaged structures might become visible in the modeled geometry. As already mentioned, a further important aspect of 3D petroglyph documentation is the issue of preservation. Environmental and human impact threatens most of the unique rock-art sites. The consequences can be observed in Chichictara as well. Therefore, a 3D recording at least allows for a digital preservation of the objects and research on them even after possible destruction. Due to the advantage of digital cameras compared to other mentioned documentation instruments in terms of manageability (this point is of particular interest in a rocky, sandy, and steep environment such as Chichictara) we decided to apply photogrammetry in order to document the rocks with petroglyphs.

21.3.1 Image Acquisition

The photogrammetric image acquisition was conducted during a field campaign from the end of August to the middle of October 2006 (Sauerbier et al. 2007, Fux 2007, Fux et al. in press). The goal was to obtain a 3D documentation, textured photorealistically, as a basis for 3D vectorization of the petroglyph drawings using image-based and geometric information. For this purpose we used a Canon EOS 10D digital still-video camera with single lens reflection optics and with an image format of 3072 by 2048 pixels. All 66 rocks covered with petroglyphs were documented. These were situated either on single rocks on the valley floor or on vertical rock facades in the upper part of the valley. Because some of the petroglyphs are located in groups, on rocks as well as on the facade, image blocks contain one or more rocks with petroglyphs and typically consist of 20–80 images. For the image acquisition we used two types of configurations: whereas the single rocks were photographed with a radial network of acquisition points, the rock facade parts were acquired using approximately horizontal and parallel viewing directions.

During image acquisition, we affixed carton targets on the rocks to ensure the availability of well-defined tie points for image orientation. Furthermore, in each image block at least three points were measured using differential GPS with Trimble GeoExplorer XT instruments, which allow for rough positioning of the rock in the superior UTM coordinate system. The positioning accuracy of the GPS measurements was limited to 0.3 m in differential mode. However, due to partial occlusions of the horizon caused by the topography even this accuracy could not be achieved. Additional scale bars placed in the images ensured that the generated 3D models could later be transformed to the correct scaled size. This was necessary due to the lack of control points. Considering the chosen configuration for image acquisition in terms of image scale, base length, and object distance as well as the camera parameters, an accuracy of the measured points of approximately $s_{X,Y} = 0.8$ mm in X and Y (planimetric with respect to the sensor chip) and $s_Z = 2$ mm in Z (optical axis) can be expected for most of the rocks. In some cases, it was not possible to achieve an optimal configuration due to the neighboring topography, therefore the expected accuracies were not achieved for all rock models.

21.3.2 Image Orientation

For both the orientation of the image blocks in an arbitrary 3D coordinate system and for the manual tie point measurement and bundle adjustment including the scaling we used the photogrammetric close-range software PhotoModeler, versions 5 and 6. In addition to the well-defined target points mentioned above, natural points on the rock were also measured and used for orientation. By means of a bundle adjustment with self-calibration, the following parameters were determined, resulting in oriented images, which serve as a prerequisite for the subsequent modeling procedure.

- Coordinates of the perspective centers X, Y, Z for each image
- Three angles ω, φ, κ representing the spatial rotation of each image
- Corrections for the camera constant c and the principal point coordinates x_H, y_H
- Correction parameters for the lens distortion

For the completed image blocks, standard deviations of the image coordinates of $\sigma_{xy} = 0.9 - 3.2$ pixels were achieved as precisions for the image measurements for 60 of the 66 image blocks.

21.3.3 3D Modeling of Rocks and Petroglyphs

Image-based 3D models of objects such as the petroglyphs and basic rocks can be generated using two approaches. One can manually measure the required features—points, lines, and surfaces—in the oriented images. On the other hand, automatic surface extraction can be performed. The first approach is a straightforward standard method. Error sources mainly result from orientation precision and the human operator's measurement skills. With the software PhotoModeler 3D points, lines, and surfaces can be measured quite comfortably in the relevant images. The generated 3D models including the texture information were exported to different 3D data formats to enable visualization using different software on various platforms. We mainly used the formats VRML 1.0, OFF, and OBJ (Wavefront Technologies) and the programs Vrmlview (Systems in Motion) and MeshLab (CNR) for visualization and editing purposes (Fig. 21.5). The advantage of both programs is the multiplatform design, which allows us to run them on PCs as well as on Apple computers, which was an important issue in this project.

In order to investigate the applicability of automated surface generation, we applied the ETH Zürich in-house software SAT-PP (SATellite Precision Processing), which was enhanced by a sensor model for close-range applications. SAT-PP is capable of generating, in comparison to manual measurements, highly dense 3D point clouds using a complex image-matching technique (Zhang 2005). Basically, the matching routine goes from coarse to fine through the generated image pyramids. It tries to match three different types of features in two or more images: interest points, grid points, and edges (see Zhang 2005). Matching of these features overcomes some of the weaknesses of matching algorithms implemented thus far in existing commercial photogrammetric software packages:

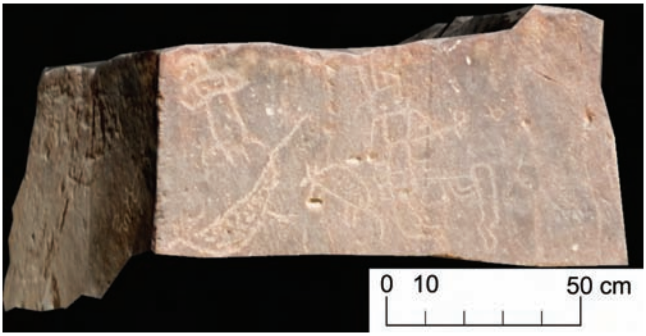
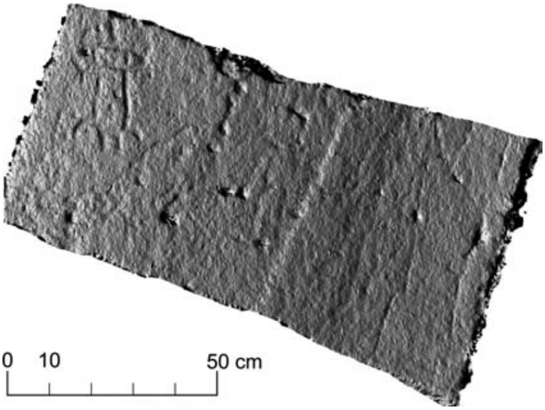


Fig. 21.5 Photogrammetrically derived 3D model of rock 33, sector 2. Depicted is a hunting scene: the person on the lower right holds a blowtube and aims at an animal, probably an armadillo. On the upper left, a bird is depicted

Fig. 21.6 3D Surface model of rock 33, sector 2 (see Fig. 21.5), derived using image matching with SAT-PP



- Grid point matching improves the results in areas with low texture information.
- Interest point matching measures well-defined points and ensures high accuracy at least in areas where significant points can be detected.
- Edge matching improves the modeling of edges that define the shape of an object. Smoothing effects therefore can be minimized in order to preserve edges.

The result obtained with SAT-PP clearly shows that it was even possible to model the geometry of the petroglyph carvings based on images (Fig. 21.6). Due to the fact that automatic processing was not considered in image acquisition planning, image matching did not yield results for all rocks. Nevertheless, on the basis of the results from the surface modeling of some selected petroglyphs we are convinced that the method bears huge potential regarding analysis of worn and damaged structures, because in some cases they might become visible in the model geometry or in radiometry (compare Fig. 21.5 with Figs. 21.6 and 21.7). SAT-PP is also suitable for orthoimage generation in order to texture the surface model.

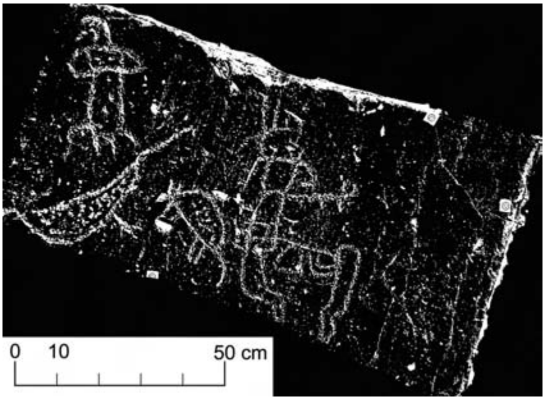


Fig. 21.7 The binary image of rock 33 clearly makes the petroglyphs and their construction technique (pecking) visible

Finally, based on the oriented images, we digitized the petroglyphs manually in 3D using PhotoModeler. PhotoModeler provides various geometric primitives for 3D modeling, such as points, lines, triangles, and the like. In our case, we used lines and curves to digitize the petroglyphs. The resulting 3D vectors were exported to the VRML format as an integrated model with the textured rock and as standalone 3D vectors (see Fig. 21.13).

21.3.4 Transformation of the 3D Models to the UTM System

A common analysis in a GIS environment can only be accomplished if all spatial data are available in a common coordinate system. For this reason, we aimed for a transformation of the rock models as well as of the laser scan DTM into the UTM Zone 18 S system, with WGS-84 as horizontal and vertical data (Fig. 21.8). Although the laser scan DTM could be transformed based on the GPS coordinates of registration control points, which additionally were measured using a tachymeter and refined by network adjustment, the rock models had to be transformed by means of the 3D modeling software Geomagic 9 (Raindrop Geomagic Inc.). For this purpose, based on the rock coordinates obtained from the network adjustment, a rectangular part from the laser scan point cloud with 3 × 3 m extent was segmented using a C program. This

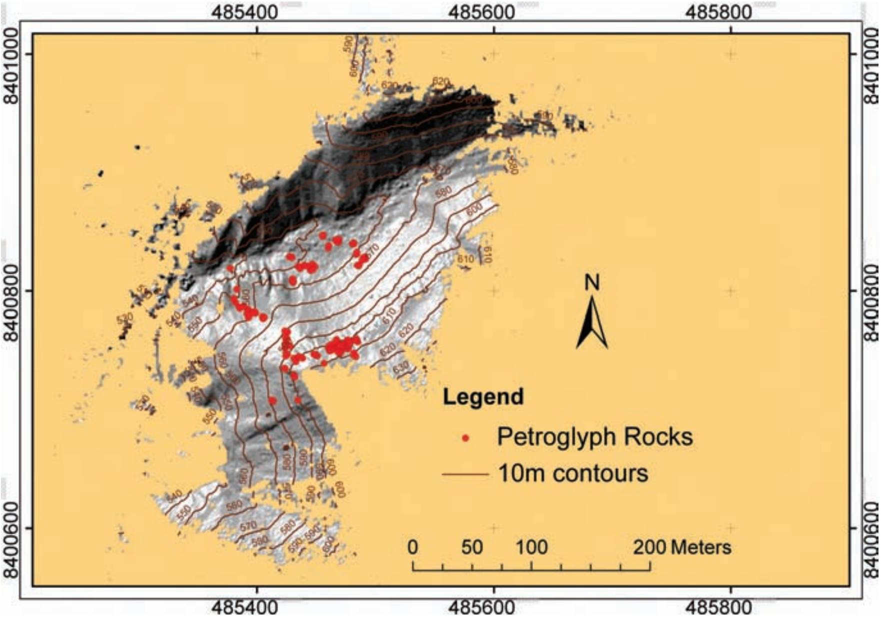


Fig. 21.8 The digital terrain model of the Chichictara valley in the UTM coordinate system. The rocks with petroglyphs are marked as red points

preserved the original resolution and was loaded in Geomagic together with the photogrammetrically derived rock model.

Using the manual registration functionality, the laser scan subset was set as a reference, which means that the coordinates were fixed during the registration procedure, and common points were manually measured in both datasets. Based on three or more common, manually measured points, the coordinates of the rock model were transformed into UTM coordinates using the implemented ICP algorithm. In case of the rock models, not only the geometry, but also the texture coordinates which connect each triangle that describes parts of the rock surface by a triangular patch from the source image, had to be transformed into UTM in order not to lose the texture. This requirement was ensured by the VRML data structure. The triangles are connected to the point coordinates via their point ID, such that a transformation does not affect the relation of the patches to the texture sources.

Because the DTM derived from terrestrial laser scanning and the 3D rock models were available in the UTM system, they could in turn be integrated in a DSM generated from ASTER images, which has a mesh size of 30 m. The ASTER DSM covers a large region from the modern city of Ica in the northwest to Laramate in the northeast and the Pacific coastline at Monte Grande and therefore serves as a basis for large area investigations. The accuracy of the ASTER DSM can be assumed to be approximately 20 m in the plain areas, according to a comparison with a DTM derived from aerial images. The accuracy is 2–5 times worse in the mountainous areas according to our experiences with other satellite sensors.

21.4 Capturing Contextual Information: 3D GIS Database

In addition to spatial data, further information was acquired describing the characteristics of the petroglyphs. In order to be able to store these data in a structured way and to make them accessible for attribute queries and spatial analyses, a conceptual data model using the Unified Modeling Language (UML) was defined and implemented in an Oracle 10 g database management system. Unique identifiers enable the exact connection of a petroglyph object to the relevant 3D model and its position in UTM coordinates. Furthermore, concepts realized in 3D data formats such as VRML or X3D, were also modeled and implemented in the database. This procedure has two main advantages. The 3D data can be stored inside the database and allow for queries on parts of the geometry, and the storage is independent of data formats; an export to arbitrary 3D formats can be accomplished via conversion programs. For current ASCII-based 3D formats such as VRML, X3D, KML, or COLLADA, converters can be developed in PL/SQL with comparably low effort. The simultaneous high-resolution real-time visualization of the combined datasets including texture is still an unresolved issue at present.

21.4.1 GIS-Based Analysis

The integrated multiresolution 3D data served as a basis for a first analysis conducted in order to investigate a possible relation of petroglyph sites with routes connecting the coastal region in the vicinity of Nasca and Palpa with the highlands (compare Jensen 2003). The modern settlement Laramate, located upwards of the Palpa valley with respect to Chichictara, served as a target point for a first analysis. The goal was to determine routes towards the Andes that pedestrians would most likely choose for traveling from the coast to the highlands and vice versa. For this purpose, a cost surface was generated based on the ASTER DSM representing the walking speed for crossing each cell of the DSM. An empirically determined function of slope degree was implemented to calculate the cost surface according to the following formula (Tobler 1993),

$$v = 6^{*} \exp(-3.5^{*} abs(S + 0.05)),$$

where v means the walking speed in kilometers per hour and S the slope in radians.

In Fig. 21.9, the light grey and white values display cells that can be crossed comparatively quickly, whereas dark cells require more effort and can only be

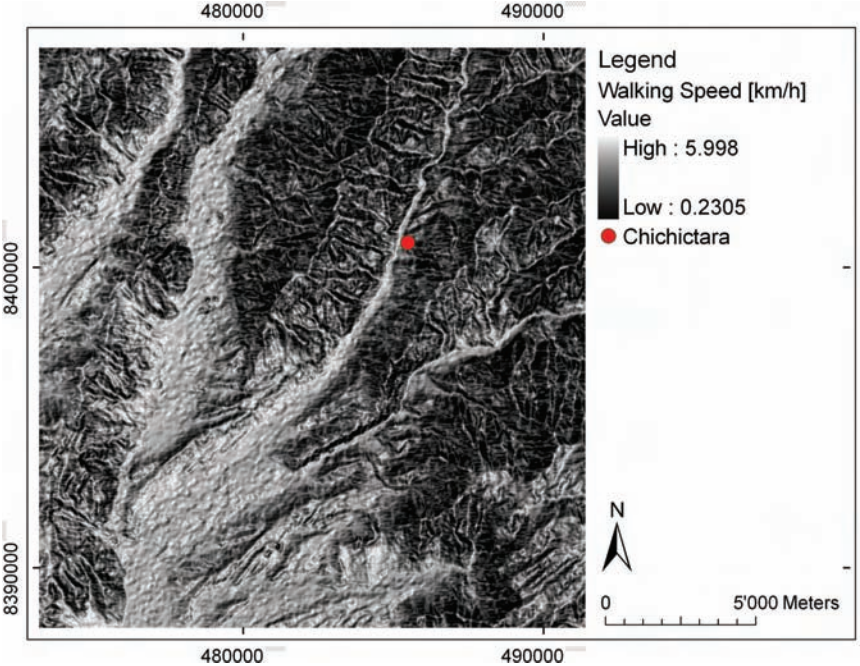


Fig. 21.9 The walking speed raster derived from the ASTER DSM. Chichictara is marked by the red point. Note the comparably high walking speeds on the mountain ridges in the northern part

crossed more slowly. Even from visual inspection, one can deduce that two types of topographic features are suitable for walking. One option is to travel along the river valleys, and the other option is to follow the mountain ridges. Taking into account the vegetation on the fertile valley ground, the second possibility was more likely to be chosen. Taken as a cost surface, cost analyses for travel routes and least cost path calculations can be performed to investigate possible connections between different regions. Nevertheless, for this purpose the area of investigation has to be enhanced significantly (see below).

21.5 New Perspectives for Archaeological Interpretation

As mentioned initially, two issues are matters of particular interest to the Chichictara project. First, due to the exposure of the petroglyphs to destruction, mainly by uncontrolled visitors, the goal of accurate documentation is certainly a target. For this reason, sector 2 (according to the division of the site into four sectors by Matos Avalos (1987)), which is the most frequently visited part, was chosen for detailed documentation in 3D. The digital terrain model of the Chichictara valley with the integrated rock models in high resolution, in combination with the GIS database containing among other information vector graphics describing each petroglyph, represents the optimum documentation in terms of modeling (Fig. 21.13). Furthermore, our successful application of the software SAT-PP to model carved rock surfaces in 3D demonstrates the capability of extracting barely visible petroglyphs by simply using a handy and inconspicuous calibrated digital camera in the field.

Secondly, the added value of the adoption of new technologies regarding interpretation—notably inquiries into the original social meaning of the specific place and iconography—should be discussed on the basis of our investigations at Chichictara:

We are convinced that mainly the decision to model the Chichictara valley in digital 3D put the landscape into the center of our attention as an integral part of the petroglyph studies. Indeed, Chippindale and Nash (2004), for example, already pointed out the high importance of the landscape for rock-art studies. However, in the case of Chichictara it was the change of perspective, obtained by the application of new documentation technologies, that evoked further contextual insights. As in the case of the decipherment of Linear B, information about a frame of action and life form, mainly derived from latent structures, is a key for understanding.

First of all, our discovery of an ancient footpath originating from the nearby ridge and entering the slope of the Palpa valley exactly at Chichictara is illuminative (Fig. 21.10). Furthermore, in the highlands at an altitude of 3200 m a.s.l. another petroglyph site with similar iconography, Letrayoc, was found by T. Stöllner (Ruhr-Universität Bochum, Germany). This site is located where the footpath leaves the ridge in the vicinity of a water source (see Fig. 21.10). The distance between Chichictara and Letrayoc is around 30 km, which is, in consideration of the altitude difference of around 2600 m, within a day's walking

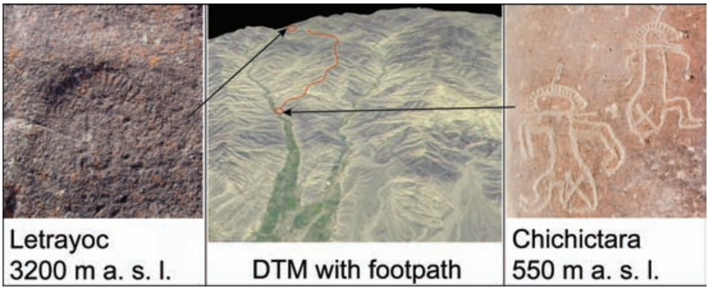


Fig. 21.10 The center image shows the footpath between Chichictara and Letrayoc, mapped in the textured 3D model derived from ASTER satellite imagery. The left and right images show petroglyphs of similar type found at the two sites Letrayoc and Chichictara

distance. It is reasonable to contemplate Chichictara in the context of this footpath and the availability of water, because Chichictara is just by the Rio Palpa.

This thesis is supported by the discovery of further petroglyphs of a similar type at the rock shelter of Coyungo, a few kilometers from the estuary mouth of the Rio Grande and after its confluence with the Rio Palpa (see furthermore Fux 2007). Numerous shell artifacts occurred within archaeological contexts near Chichictara that dated to the Paracas period (e.g., Jauranga, Mollake Chico; Reindel and Isla 2004) thus a connection between the adjacent plain of Palpa and the coast is clearly documented. Therefore, one could postulate the continuation of the above-mentioned footpath between Letrayoc and Chichictara to the Pacific coast (near Monte Grande?), passing the site of Coyungo.

In addition, there is an apparent pattern of Andean people moving up and down the mountains, crossing multiple ecological zones (Murra 1972; Moseley 1992: 25–51). The exploitation of many different ecological zones, in combination with cultural interactions and material exchange, can be seen, among other reasons, as an adaptation to extreme topographic and climatic situations and as a reduction of a substantial risk. This circumstance is in line with many archaeological findings: obsidian artifacts, found, for example, in the graveyard of Jauranga (Reindel and Isla 2004), near Palpa (350 m a.s.l.), dated to the Paracas period (800–200 BC) are evidence of interaction between people from the highlands and the coastal lowlands, because obsidian exclusively occurs in the highlands, predominantly near Huanca Sancos (Fux 2007; Silverman and Proulx 2002: 65–66). Vice versa, Paracas-style ceramic findings in the highlands are further evidence for interaction (Hohmann 2006: 44).

On the basis of this contextual information we propose to regard the petroglyph site of Chichictara within the frame of interecozonal interaction. Most probably, Chichictara, just as the other mentioned petroglyph sites Letrayoc and Coyungo, served as a resting place for caravans (with camelids as pack animals? Note camelid depictions, e.g., Rock 44, Fig. 21.12) on the way between different ecological (and cultural) zones, or as their handover place. Regarding the section between Chichictara and Letrayoc this thesis is furthermore supported by the cost surface analysis described above (Fig. 21.9).

At this point it is worth mentioning that there is a good reason to ascend or descend the easily walkable ridge exactly at Chichictara. Here, the steep run-of-hill scree is covered with loess, and therefore exceptionally walkable. Nieves' (2007: 162–169) conclusion that the petroglyphs within the Nasca–Palpa area differ from valley to valley in style seems to support our interpretation. Interaction (mainly regarding goods and material exchange) makes much sense between different ecological and climatic zones, but little between parallel and ecologically similar river valleys. Thus, latent structures of interaction (e.g., similarity in the style of petroglyphs) are expected in the west–east direction along the river valleys. Additionally, it seems plausible that the above-mentioned petroglyph sites had the following social function in common with geoglyphs dated to the Paracas period, for example, El Mirador near Llipata (see Fux 2007: 190). The figured landscape, whose original absence of especially striking structures is characteristic, allows a conversation about areas, places, and stretches of way. Analogous social functions are stated for geoglyphs of the Atacama Desert in Northern Chile (Briones 2006).

We now show in which regard the proposed frame of action will enable new perspectives for iconographic studies. Against the background of the footpath and its use by caravans carrying goods and materials between different ecological zones, one presumably is inclined to expect (with reference to the cultural affiliation) well-established symbols as petroglyphs at sites such as Chichictara. Indeed, the petroglyphs of Chichictara's sector 2 contain figures that are said to be typical for the coastal Paracas culture (800–200 BC; see, e.g., Silverman and Proulx 2002: 142; Proulx 2006: 88/89 and 94), such as the so-called two-headed Serpentine Creature (rock number 47, according to the numbering of Matos Avalos (1987), Fig. 21.13) or feline depictions (e.g., rock 44, Fig. 21.12). Furthermore, there are figures that make long-distance cultural connections apparent, such as the Chavin Head (rock 6), pointing to northern Peru, or depictions of monkeys (e.g., rock 12, Fig. 21.11), pointing to the rainforest on

Fig. 21.11 The petroglyph on rock 12 shows a monkey

Fig. 21.12 View of the 3D model of rock 44, which shows among others a feline and a camelid on the upper left

the eastern slope of the Andes. Depictions of camelids (e.g., rock 44, Fig. 21.12) illustrate the connection with the highlands (see Horn et al., this volume).

Because a connection between the plain of Palpa and the coast is clearly documented, the proposal of Wickler and Seibt (1998: 15–25) to regard the so-called two-headed Serpentine Creature (Fig. 21.13), as depicted on rock 47, as a derivation of a marine bristle worm is strengthened. Presumably the bristle worm's periodic appearance near the water surface attracts fish and indicates favorable conditions for fishing. Alleged Serpentine Creatures regularly occur on textiles and ceramics in close relation with representations of human beings

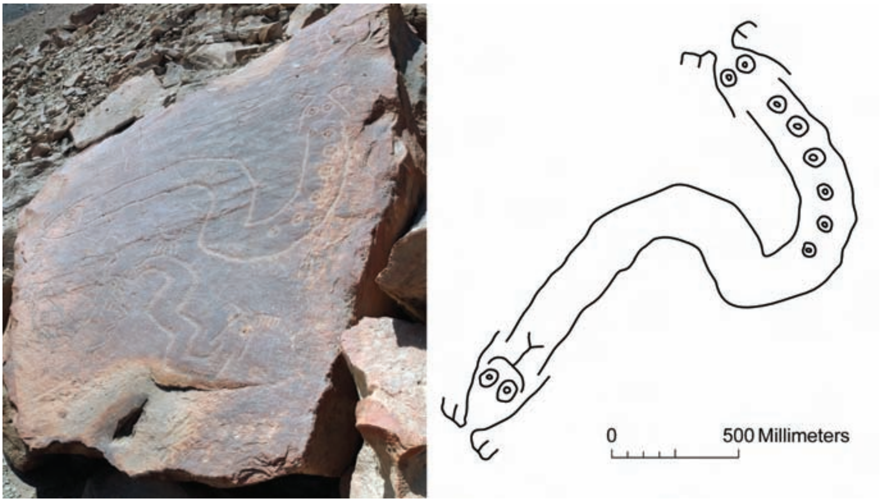


Fig. 21.13 Left: Rock 47 with several "Serpentine Creatures." Right: Result of the 3D digitalization of a "two-headed Serpentine Creature" depiction on rock 47

during the Paracas (800–200 BC) and Nasca periods (200 BC–650 AD), and could therefore be interpreted as a symbol of the dependency of humans on these animals, which bring them food, or, because of the bristle worm's periodic appearance, as an indicator of time.

Second, monkey depictions (e.g., rock 12, Fig. 21.11) should be regarded as indicating cultural contact with the rainforest. Moseley's above-mentioned argument for the high importance of interecozonal interaction for Andean people (see Reindel, this volume) even becomes apparent in the petroglyph figures themselves. A good deal of further archaeological indications, such as parrot feather findings in Paracas and Nasca contexts and monkey depictions on ceramics and in the form of geoglyphs, clearly support this claim (see, e.g., Proulx 2006). At Chichictara we seem to face the footsteps from the coast area to the highlands and even towards the rainforest and vice versa. Against the background of this circumstance one should put into perspective long-distance cultural connections across multiple ecological zones while analyzing the iconography of both the coastal Paracas and Nasca cultures.

Indeed, the figure on rock 44 (Fig. 21.12), as with feline depictions on ceramics and textiles from the Paracas culture in general, looks similar to a small feline (with ruffled fur?) known as the pampas cat (*Felis colocolo*; see, e.g., Proulx 2006: 88/89), which is an identification further strengthened by climatological evidence, inasmuch as a clearly less arid climate and a pampas vegetation are postulated for the Paracas period (see Eitel, this volume). However, there is another question of whether the figure named the *Mythical Spotted Cat*, which we know from ceramics and textiles dated to the subsequent Nasca culture, is a direct development from the feline depictions of the preceding Paracas culture (see Proulx 2006: 88/89).

It is remarkable that this figure is—as pointed out by Wolfe (1981)—mainly represented in close relation to crops and fruits, frequently holding them in its forepaws, which is generally seen as supporting Seler's (1923: 174) widely accepted interpretation of this creature as standing for a "bringer of food" within the Nasca culture. Mainly by reason of the difficulty of relating felines meaningfully to crops and fruits (not to mention the action of bringing) and the above-argued cultural contact with the rainforest in the Paracas period (a pattern that certainly was still effective during the Nasca period), the question about the relation of this figure to a raccoon (see Wickler and Seibt 1998: 34/35), instead of a feline, seems not to be digressive, inasmuch as raccoons are still present in the Amazon Basin (see Pearson and Beletsky 2002: 441) and furthermore well known for holding crops and fruits in their hands. However, the *Mythical Spotted Cat* was rather identified as a "remover of food" within the Nasca culture.

Based on all of the evidence, we are convinced that, taking into account a multitude of multifaceted contextual information, the petroglyph site of Chichictara should be regarded within the herein-exposed frame of action of cultural interaction by means of caravans, carrying goods and materials between different ecological zones. It is this postulated frame of action, which opens up the understanding of the petroglyphs of Chichictara, just as the form of life and the needs within a Minoan palace structure enabled the decipherment of Linear B. Because of the contemplation of Chichictara and Letrayoc in the context of the footpath on the ridge, in addition to further described indicative archaeological findings (see Reindel, this volume), the postulated interaction between the highlands and the plain of Palpa, and even the coast, is conclusively documented. As illustrated, the cultural contacts between these zones are reflected in the petroglyph figures themselves. Furthermore, we postulate that mainly on the basis of the petroglyph's iconography, and supported by a good deal of other indications, these interecozonal cultural contacts should be regarded as expanding as far as the rainforest. The investigation of this issue certainly is a desideratum.

We are confident that our explanation has shown that by means of the adoption of new technologies for the documentation of the petroglyph site Chichictara new perspectives regarding both the interpretation of the prior social meaning of the petroglyph site and iconography of its pictures are opened up. The adoption of new technologies brings a new edge to the archaeological interpretation of the petroglyphs of Chichictara.

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