

NAZCA LINES AS AN INDICATOR OF ANCIENT IRRIGATION SYSTEM ELEMENTS

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ABSTRACT

Nazca lines in Peru are well known for their geometric precision and ancient images. It is assumed that these lines were created by ancient Nazca civilization almost 2,000 years ago, mainly motivated by religious considerations. Satellite images and publicly available images from airplanes and air balloons were studied, as well as on-site observations performed. The orientation, interconnectedness and quality of geoglyphs were evaluated. The results suggest that only a small portion of geoglyphs may indeed be very ancient, while most have been created just over the last centuries. The oldest lines and trapezoidal bands are connected with the attraction of water resources and their accumulation along with the groundwater for further use for agricultural purposes. Only a small number of lines and shapes can really be associated with ancient religious practices, but it is also likely to be associated with water attraction that has been in ancient times, and is still, a life-critical resource in this region. In this sense, the attempts of ancient Nazca civilization to find unusual solutions for water supply can be regarded as a prominent example with a high cultural and historical significance.

Keywords: geoglyphs, water supply, groundwater resources, ancient civilization

INTRODUCTION

The Nazca Lines are well known as a series of large scale ancient geoglyphs in the Nazca Desert (14°43'S 75°08'W) in southern Peru. Nazca Lines are negative geoglyphs created by removing the uppermost surface and exposing the underlying pale pink sand ground. Most of the lines are depicted as just simple lines and geometric shapes, yet about 70 figures are designed as animals, birds, trees, flowers and humans. Dimensions of lines vary from several meters and up to 370 meters. In 1994 these lines, which are located on the area of 75.36 thousand ha, were included in the World Heritage list of UNESCO. Nazca Lines have puzzled the world since Peruvian archeologist Toribio Mejia Xesspe discovered them in the 1920s, but most of the ground studies were carried out by Maria Reiche (1903-1998), followed by hundreds of particular studies and research.

Most of the Nazca figures in limited scale can be recognized on site, but in full scale – from surrounding high places, foothills and, in modern days, from airplane or air balloon. As it is known today, the lines and figures were designed by Nazca culture between 500 BC and 800 AD and most of interpretations of these figures are ascribing religious significance to them [1]. However, most studies demonstrate very

limited reflections on how Central Andean igneous people regarded nature and environment [2] in relation to Nazca lines and figures. Besides several researchers proposed, that at least part of these lines can be related to water, the source of life for sedentary communities [3].

The variety of opinions and fragmentary research has led us to the task of our study – an attempt to find a general explanation for the Nazca Line complex, refraining from wider cartographic constructions of all this territory, focusing on details that would provide rational explanation and directions for future research.

STUDY

The number of studies available on the Nazca Lines reaches in thousands. There are even more images of different quality in the public information space available. However, there are not many facts for material analysis and evaluation, and they already contain a certain point of directions. A number of compilation studies provide a modern insight into research problems, the context of the conditions and the methods used [4].

It should be noted that this whole territory is a protected cultural and historical monument and is not directly accessible to visitors, and not available for studies with destructive methods. The area can be explored applying remote methods only, and the data obtained can be verified on site only moving along the edges of the road until the specified area of restriction. Therefore, the study is mainly based on visual observations made on site and analysis of satellite maps publicly available.

Basic studies were carried out using Landsat 5 Thematic Mapper data, Google Maps, as well as Bing Maps aerial imagery web mapping service (including ArcGIS services). Data processing was performed in traditional manner for archaeological studies [5], taking into account the successful experience of several previous studies e.g. Lasaponara, R., Masini, N. (2011) [6].

RESULTS

A general assessment of the obtained satellite imagery did not allow us to identify any significant structures or figures and their compositions not yet described in the literature; however, it should be noted that some lines, fragments of figures are occurring approximately on twice as large territory as the Nazca Line territory is thought to be now. At the same time, in this expanded area these marks and lines are very small and quite fragmented. These lines as individual objects are known to be located far to the north and stretch until the Ica City.

The assessment of dominant trends in the geographic orientation of lines recognized in satellite imagery, also by grouping them in accordance with their width and length, did not give statistically reliable results when the territory of the study is regarded as one study area. In turn, its division would require additional justification, which would probably allow us to obtain acceptable results.

In order to get additional information, in the next phase of research, parts of individual bands and shapes were analysed. Unfortunately, satellite imagery is not a suitable source of information for such studies because their resolution is not sufficient. Therefore, additionally self-acquired and publicly available images were analysed, without predefined selection of images according to their quality, object displayed, time

of the year, image quality, etc. Further a simple photographic database was created in MS Excel format including over 2,000 images. Their assessment indicates that the detailed analysis of the layout and shape of lines and figures was not performed before. This would allow us to evaluate critically the creation of geoglyphs and well-known figures.

Over 100 images clearly indicate that the actual layout of lines and shapes differs from well-known and commonly acknowledged perception. For example, the "Flower" geoglyph (alternative name "Windmill") (Figure 1A) shows an articulated flower image deviated to the right from the original visible on the left, and another "flower" that is not highlighted but still visible on the right. Other non-distinguished structures and their drawings are also visible, as well as all the significant deviations from the idealized geometric forms. Similarly, the same can be observed in the case of the "Spirals" (alternative name "Fish Hooks") (Figure 1B) which contains a free interpretation combining several shapes (and also excludes several shapes).

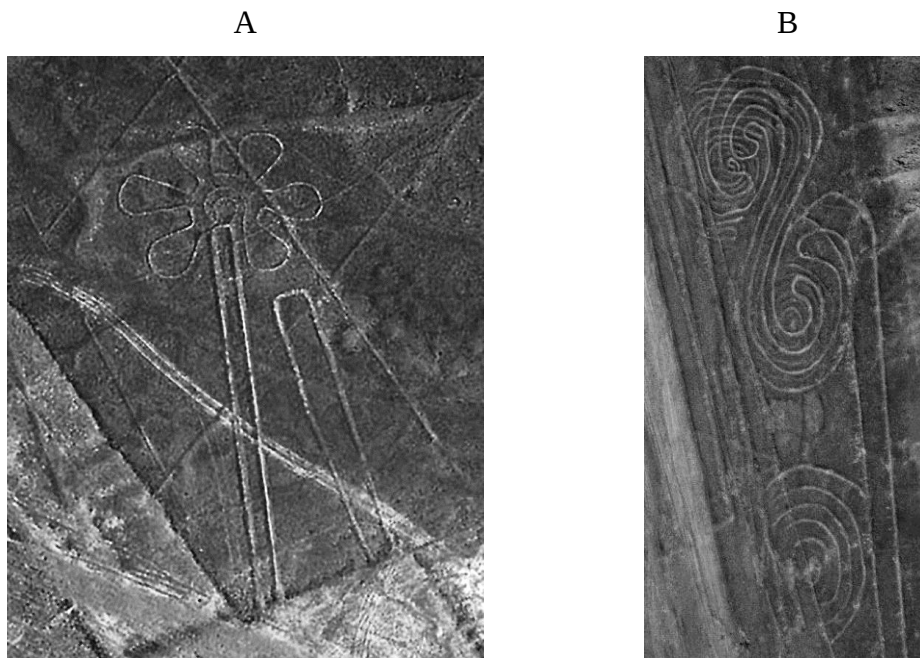


Figure 1. Ancient geoglyph „Flower” (A) and the “Spirals” (B) [7].

At the same time, it is quite clear that at some places lines form a certain system. However, in most of these cases, there are several separate systems overlaying each other. They differ in their orientation on site, in details, line width, accuracy and interconnections. It is easy to see that many geometrically precise and clearly recognizable bands (broad lines, stretched trapezium, etc.) are artificially highlighted in some places and their contours were restored. Figure 2 most likely demonstrates the distribution of agricultural land plot for the cultivation of agricultural crops. This arrangement obviously was not completed and the abandoned structures now form

rather regular network of lines. It can be seen that these lines cover and cross other lines with different orientation.



Fig. 2. Possible land plot design and abandoned structures [8]

The technical design of many lines and geometric shapes (thickness and depth of the lines, sharpness of corners and joints, crossing and partial overlap) clearly indicate that these lines and shapes are formed in several stages in a relatively long period of time and may not have the same purpose. Intercrossing of the lines does not indicate that the latest lines and shapes were created more professionally; on the contrary, the latest ones are much more superficial and technically less accurate.

However, the structures located in the northern area of the Nazca Line territory are directly linked to the streams and rivers that periodically renew their activity. These structures can be reliably related to the seasonal water accumulation in the stratum and its further direction to agricultural areas (Figure 3). This is implicitly confirmed by modern archaeological research [9]. The artificial terraces and drainage system of the excess water located at the end of the trapezoidal band marked as geoglyph, indicates that these structures were created for irrigation purposes to provide water to the adjacent agricultural lands [10] (Figure 4).

This indicates that, at least, most of the structures are linked to the accumulation and redirection of water resources for agricultural purposes in separately formed fields of land. The number of lines and their rather complicated configurations demonstrate that these attempts in many cases have not been successful and that this technique has not been sufficiently sustainable for a longer period of time.

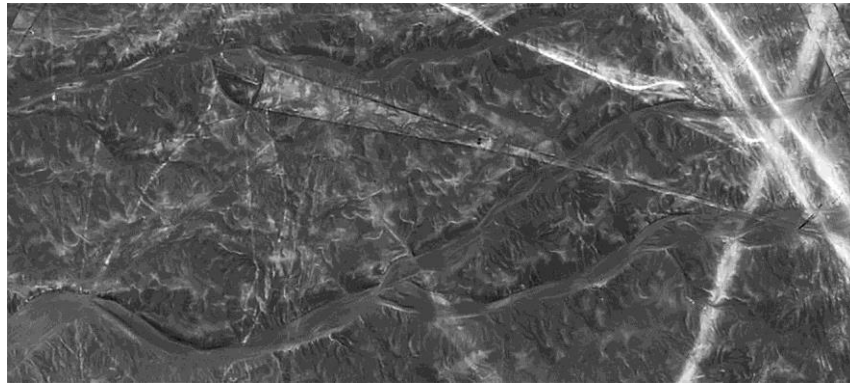


Fig. 3. Trapezoidal structure created to redirect water stream waters [10]



Fig. 4. Agricultural terraces remaining at the end of the trapezoidal structure [10]

Such configurations and link to mountain streams at the points where they reach the plain, are recognizable, but remain only fragmentary. However, here it is seen that the boundaries of many ancient linear polygons are poorly indicated, rather concave, but not straight, yet the overall directions are maintained. Similar weakly indicated older boundaries are also visible in the vicinity of clearly contoured polygons, indicating that geometrically accurate and clearly defined boundaries are obtained by correcting older ones. The exact expression of these new borders and good degree of their preservation demonstrate that these lines have been restored more recently, most likely just in the last century. Thus, there is no reason to raise any new hypotheses about the high precision of these lines and their significance today, without first identifying those polygons that have remained "unmodified" to this day.

DISCUSSION

The study indicates that the distribution of Nazca Lines is much wider than currently assumed. Poorly preserved fragments of lines, structures and figures are recognizable on images taken from space on a territory approximately two times larger, yet it is almost impossible to recognize these fragments on site. The lines and linear structures were not formed at the same time - in many places they overlap in several layers. Work technique and accuracy also differ. In general, all that points to the different times of creation of these features, the experience and qualification of the personnel involved. At the same time, it should be noted that it is not possible to identify a significantly large construction project here - these are separate activities carried out in different time periods. During the creation of the oldest lines and figures, the ancient Nazca's inhabitants could not mobilize enough human and material resources necessary for the realization of such grand projects. It is also impossible to identify the benefits of the implementation of such projects to the ancient society. The material culture of this society refers to skilled craftsmen, but not to the excellent knowledge of mathematics and geometry in the European sense.

Although some very long, precisely drawn lines that cross different terrain forms can be recognized and could potentially be used as a local "meridian" for future planning and organization of space, yet this has not been done. Unrelated local reference systems were used here to arrange lines, polygons and bands, which prevents the recognition of any old maps and drawings here. Thus, the main three points or base stations in the north, that form a radial line network, most likely indicates a poorly performed work in the first half of the last century, which in a difficult survey environment was realized by a graphometer, but in the case if it was not available, simply by adjusting the protractor. The directions of the identified lines and the position of these points indicate most likely the application of very simplified instruments to such land survey works. However, this work was done certainly not before the end of the 19th century and has no relation to the ancient Nazca civilization.

However, according to geo-referencing and technical realization, the polygons and wide bands as structures that were consciously planned and created here undoubtedly relate to the accumulation and distribution of water, where the ancient Nazca inhabitants have achieved high craftsmanship. Thus, rather modest runoff water from the northern mountains and water of periodically rejuvenating streams and rivers could be collected, which allowed the water to be added to the groundwater in designated areas.

There is a separate discussion about highlighting of individual lines, bands, polygons and figures, border correction and retouching, giving them visually high-quality properties. All that is in contrast with the corrections and adjustments of older lines, and cannot be attributed to the ancient Nazca cultures. Most likely they were formed only in the last century. The same can be applied to all attractive and some even artistically valuable animal and plant images.

CONCLUSION

The Nazca Lines are undoubtedly a cultural heritage monument, which is reasonably included in the World Heritage list of UNESCO; however its protection status is insufficient for its preservation and exploration. Even if most of the well-known

depictions were created only in the last century, partly by reconstructing the images that were created already in antiquity and reflect the vision and understanding of Maria Reiche, this is a piece of art and a monument dedicated to a researcher who has devoted all her life to the exploration of this site.

Unfortunately, the territory has become too familiar, too visited and too influenced before it has been explored in details. This results in hundreds of different theories and hypotheses, but does not provide a sufficiently substantiated explanation and direction for future research. Our accomplishments call for mapping of this territory with a high resolution LIDAR or similar technology that would allow to obtain sound micro relief data and enable more precise separation of individual structures and link them to the ancient hydrological network. Perhaps, it would be possible to search for untraditional methods of attracting and using water in those conditions and in areas of increased drought risk, where there will never be a universal solution.

Water resources in this region have always been critical to the survival and prosperity of the population. Geographical referencing of lines and figures to watercourses and mountain slopes is associated with the use of existing modest water resources for rural irrigation and groundwater recharge for their further use.

A layout of detailed temporary and rarely reconstructive hydrological network clearly indicates that water from these transitional watercourses was directed to linear structures. However, the infrastructure for attracting and redirecting water has not been sufficient in ever-changing natural environments, and structures have been transformed several times substantially. Probably this transformation was also not successful, and the use of the structures has not been sufficiently effective as well, which has resulted in the failure of unfinished infrastructure and the migration of citizens to more environmentally-friendly areas.

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