

## **Aqueducts and geoglyphs : the response of Ancient Nasca to water shortages in the desert of Atacama (Peru)**

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The desert of Atacama is a plateau in South America, covering a 1,000-kilometre strip of land on the Pacific coast, west of the Andes mountains, between Chile and Peru. Due to the confluence of a cold ocean current (the Humboldt Current) along with other climatic factors, connected to the particular topography and geomorphology of the region, Atacama desert is one of the most arid areas of the world.

In particular, in Nasca region (Southern Peru) the lack of water was (and still is) due to the following causes: (i) the scarce pluvial precipitations and the (ii) high infiltration capacity, and the consequent yearly significant reduction of the surface water (Schreiber & Lancho Rojas 2009).

Over the millennia long periods of drought occurred and frequently the lack of water was persistent for several decades.

Despite the arid and extreme nature of the environment, this region was populated by important civilizations, such as Paracas and Nasca, which flourished in the Early Intermediate period (200 BCE-500 AD) (Silvermann & Proulx 2002).

In particular the Nasca civilization is well-known for its refined and colourful pottery, characterized by a rich iconographic repertory, and, above all, by the huge and mysterious geoglyphs drawn on the arid plateaus of the Rio Grande de Nasca Basin.

In order to practice agriculture, the Nasca developed adequate strategies to cope with hostile environmental factors and water scarcity, building a very efficient aqueduct system. They were aided by the fact that underground water was likely enough close to the surface and accessible by constructing wells and underground aqueducts, known with quechua name of puquios (Schreiber & Lancho Rojas 2009; Lasaponara & Masini 2012a; 2012b)

The effectiveness of the techniques of hydraulic engineering depended on the climate and the weather events that sometimes underwent drastic changes, as results of the cyclical phenomenon of El Niño Southern Oscillation (commonly called ENSO).

Hence the origin of Nasca religious belief based on the worship of the mountain gods, in charge of the rain, and, therefore, related to the worship of water and fertility, including rituals which took place inside and outside Cahuachi pyramids (Orefici 2012; Masini et al. 2008; 2009) and over the famous geoglyphs (Orefici 2009; Reinhard 1988)

Therefore, the response of Nasca to make liveable the desert was twofold, aimed at addressing the problem in its causes (climate), by religion, ritual and ceremonial activities, and in its effects, through the construction of aqueducts.

The paper deals with the results from 3-year scientific and interdisciplinary investigations conducted by ITACA Mission (Masini et al. 2012) in Peru of CNR-IBAM and IMAA, in the Rio Nasca drainage basin. The main purpose of the investigations was the study of lost and functioning aqueducts using active and passive satellite data along with spatial analysis and geophysics (Cigna et al. 2013; Tapete et al. 2013).

In particular, multitemporal analyses of satellite data were carried out in order to identify the different moisture content from upper to lower valley and the seasonal changes from one to another year. Geoelectrical prospecting along with geological investigations enabled us to characterize the table water and to study the hydrogeology of the investigated area.

Finally, GIS and spatial analyses provided new information on the relationship between the puquios, settlement patterns and geoglyphs.

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