Nasca Puquios and Aqueducts

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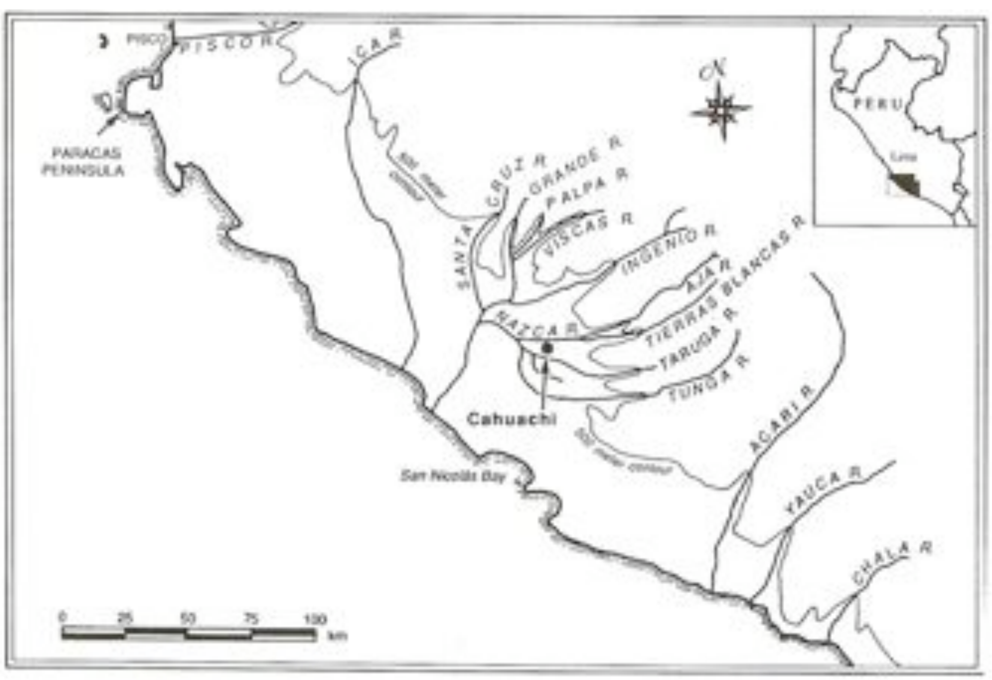
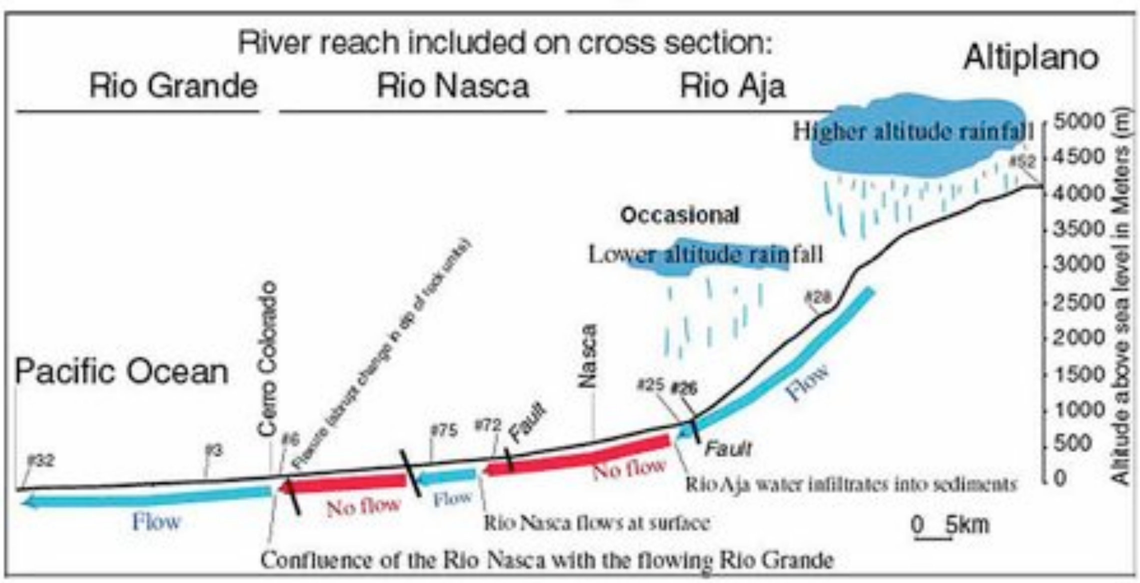
A unique system for tapping underground water sources was developed in the drainage of the Rio Grande de Nasca in Pre-Columbian times. This technique involved the excavation of horizontal trenches and tunnels to reach subterranean aquifers that hold water deep beneath the ground. Still in use today by the inhabitants of the valley, these tunnels, wells and trenches are known collectively as <u>puquios</u>. The need for a supplementary source of water can clearly be seen in the statistics regarding the available water resources today. Modern observations indicate that in the middle portions of the tributaries of the Rio Grande de Nasca, the rivers carry surface water only two years out of seven (Schreiber and Lancho 1995:231) When water does flow, the volume is far below that of other valley systems further to the north. Within the Nasca drainage, the southern tributaries of Aja, Tierras Blancas, Nasca, Taruga and Las Trancas have the least amount of water. "The Aja River....has an average annual flow of only 30.27 million m^3 of water, compared to 198.05 million m^3 of water that flow down the Rio Grande (Onern 1971). The amount of water is simply not sufficient for the inhabitants, past and present, especially during times of drought.



The more traditional way of obtaining water for irrigation is to divert the flow from the rivers into acequias or canals and either store the water or disperse it over the fields. This can only take place during the rainy season in the highlands, January through April, when the water flows from the mountains down into the desert river systems. Unless sufficient water can be stored, the populations have meager supplies during the remainder of the year, and during the years when no surface water is present, disaster can occur. The puquios were constructed as an alternative source of water in those times of need.

Before describing the form and use of the Puquios, it is necessary to describe the geological conditions that produced the underground aquifers. Previous scholars have failed to understand the structural geology of the valley and therefore provide misleading information on the source of the water in the puquios. The most recent work on the puquio system is an article by Schreiber and Lancho (1995) in which they state that the water coming down the rivers "drops below the surface" due to the porosity of the deep alluvium in the valley, becoming underground or "influent" streams" which eventually re-emerge further down the valleys (Schreiber and Lancho 1995:231). According to their argument, the puquios tap into these underground streams that basically parallel the existing river system.



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On-going investigations by David Johnson, who has considerable experience in geology and hydrology, argue that a series of geological faults cut across the tributaries of the Nasca drainage, trapping water flowing down from higher elevations and conducting it great distances into other parts of the drainage (Johnson 1997). These faults and rock formation changes are generally perpendicular to the rivers, not parallel to them. Thus, the water that "re-emerges" down river at places like Usaca or at Cahauchi often flows from fault systems that have carried the water from other parts of the drainage. This can be demonstrated at the Aja puquio where Johnson and geologist Paul Salchert found wells with water levels approximately 20 meters higher than that of the Aja River. Obviously, since water cannot flow uphill, the aquifer supplying the Aja puquio derived its water from fault systems, not from water below the present river (ibid.:2)

A major fault crosses from north to south between the Nasca and Taruga Valleys and is intersected by other faults crossing from east to west beneath the mountain known as Cerro Blanco. This fault is identifiable on the geological survey map and is visible on the satellite photo of the region. The fault redirects water from the east into the two valleys. Where it enters the Nasca Valley, one finds the Cantalloq puquio and two wells with high rates of flow; where it continues into the Taruga Valley, there are three puquios and a modern well with a high rate of flow. We also find that in places where a valley is higher than the water table of the fault crossing beneath it, water does not enter the valley, it crosses beneath it. For example, the Socos Valley is one of the driest valleys within the drainage. "However the lower valley is exceptionally dry and without wells. The reason for this is a large fault which crosses the valley about six kilometers east of the Pan American Highway. This fault is deep enough to capture the water passing along the valley from east to west and redirect it southward towards the Nasca Valley (Johnson 1997:4).

A typical puquio consists of several parts. A horizontal tunnel or "gallery" is excavated laterally until it intersects with the underground aquifer. The walls of the tunnels are lined with river cobbles without the use of mortar, and at the uppermost end, the water filters between the stones into the gallery (Schreiber and Lancho 1995:234). The roof of the gallery is constructed from either dressed stone slabs or from wooden logs, the

latter having to be replaced at regular intervals (ibid.) Most of these excavated tunnels are relatively narrow, generally less than one meter square, with barely enough room for a crouching person to move through them. Other galleries appear to have been constructed by digging an open trench and then filling it in after building the walls and ceiling of the conduit (tunnel) at the bottom. These tunnels are generally of greater height (about 2 meters) than those made by tunneling through deeper levels to reach the water source. The length of these galleries is quite variable, ranging from a few meters to as long as 372 meters.

Spaced above the galleries at varying intervals are funnel-shaped holes, or ojos, which had several functions. They provided access to the water in the tunnels and thus could be used as wells by the local inhabitants. They also served as entrances to the tunnels for annual cleaning of the galleries--a task which continues up to the present day. Finally, they provided air and light to the chambers for these workers. The opening of the conical ojos can be as wide as 15 meters on the surface of the ground,

narrowing down to a meter or two at the bottom. Care had to be taken to insure that debris did not wash down the sides of the pit and fill or contaminate the water in the tunnel. It seems likely, therefore, that some type of enclosure or cap may have been placed over the opening when not in use. Several of these ojos have been reconstructed in recent years to include spiral, cobble-stone ramps leading to the bottom, such as those now visited by tourists at Cantalloq in the Nasca Valley. It is not certain that the ancient Nasca people had such elaborate construction in each of the ojos which were spaced between 10 and 30 meters apart and could number in the dozens for each major puquio. According to Schreiber and Lancho, the record number of ojos for a single system is the Totoral puquio in the

Las Trancas tributary (Schreiber and Lancho 1995:244).

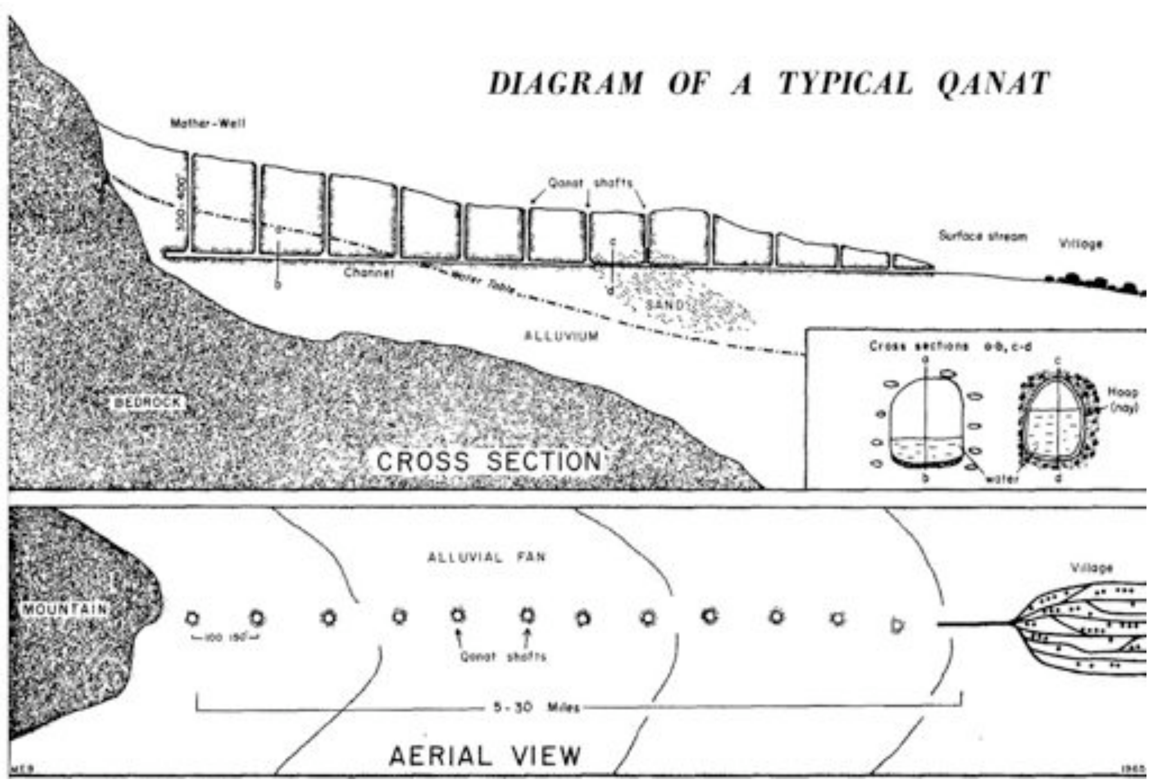
The lower end of the puquio system consists of open trenches which emerge from the tunnels allowing public access to the water for drinking, bathing, and washing clothes as well as a means to channel it for agricultural purposes. These trenches or aqueducts are V-shaped, often with terraced sides lined with river cobbles that form retaining walls. The bases of these trenches can be as narrow as a meter and the tops as wide as 10 meters (Schreiber and Lancho 1995:234). In the Nasca Valley, ten of the puquios are open trenches for their entire lengths, indicating that the water table is relatively close to the surface in these locations (ibid.:236). Some of these open trenches can be quite long; one at Achako in the Nasca Valley is over one kilometer in length, while many others are at least a half kilometer long.

Many of the open trenches empty into small reservoirs, or kochas, which serve as wells and as distribution points for directing the water into irrigation canals (acequias) According to Schreiber and Lancho, modern kochas are constantly being renovated sometimes being lined with concrete or having concrete slabs and wooden sluice gates added to them (ibid.:236).

There are 36 puquios still functioning in the Nasca drainage today, 29 in the Nasca Valley, 2 in the Taruga Valley, and 5 in the Las Trancas Valley (Schreiber and Lancho 1995:234). There appear to have been more in the past, perhaps as many as 50, but these have been altered or destroyed. The Puquios are named after the land that they water, e.g. Achako, Aja Alto, Pangavari, etc. They were first mentioned by the anthropologist Alfred Kroeber who worked in the valley in 1926 (Kroeber and Collier 1998) and a few of them were later described by Mejia Xesspe (1939), Regal (1943) and Rossel Castro (1942). The most complete description of the existing puquios was made by Schreiber and Lancho who provide measurements of the galleries and trenches along with other valuable information on their construction and use Schreiber and Lancho 1995). More recently, David Johnson has been conducting his own investigations of the puquios and has argued that where aquifers enter major tributaries, a puquio perpendicular to the aquifer, captures and redirects the water to other puquios in arid regions of the valley. For example, the Aja puquio intersects an aquifer and distributes water to the Curve, Achako and Anklia puquios. Several systems like this exist in the Nasca Valley.

The dating of the puquios has been a matter of much controversy in recent years. It has always been assumed by most Andeanists that they had been first constructed in Pre-Columbian times, if not by the Incas, then by earlier cultures such as the Huari or the

Nasca. In 1991, Monica Barnes and David Fleming proposed another view in which they argue that the filtration systems were built by the Spanish during the Colonial period. They point to the use of similar galleries in Iran (where they are known as qanats) from which the Arabs disseminated the technology to northern Africa and eventually to Spain, among other areas. In the New World, filtration galleries are found in Mexico, California and Bermuda in addition to Peru (Barnes and Flemming 1991: 50-51). The authors claim that the galleries in Mexico were constructed by the Spanish in 1526, before they had ever arrived in Peru, using their knowledge of the Islamic qanats present in their homeland. They further argue that the earliest Colonial documents from Peru fail to mention the presence of puquios prior to the seventeenth century, and therefore the puquios in Peru must have been constructed by the Spanish.



Schreiber and Lancho provide a thorough and convincing rebuttal of this view, suggesting that there is ample evidence to demonstrate that the earliest puquios were constructed by the Nasca people in the middle (Phase 5) of their sequence, perhaps as a reaction to a documented drought that occurred at that time (Schreiber and Lancho 1995: 246ff). I will attempt to summarize their rebuttal below and to add some new data which confirms the Nasca dating of the construction.

Schreiber and Lancho point out that of the five Colonial period authors cited by Barnes and Fleming as failing to mention puquios in their chronicles, four of them had never visited the Nasca Valley including Cieza de León (Ibid.) The fifth chronicler, Reginaldo Lizárraga, writing in 1605, was the first to provide a description of the puquios of Nasca, however he attributes them neither to the Incas nor to the Spanish (ibid.) It is significant that, if indeed these galleries had been constructed by his fellow countrymen, why did he not mention this fact?

Because of the ambiguity of the historical documents, we should examine the archaeological evidence as the best means of answering the question of the date of the puquios. There is nothing unique about the architecture of the galleries that could be used to date them to a specific culture, however Dorn has studied the formation of desert varnish on the lintels of the Orcona and Cantalloq puquios, and the dates obtained on this material range between A.D. 552 and 658 (Dorn et al 1992). Since the varnish begins to form on fresh surfaces once the stone is cut, these are minimum ages and fall squarely in the time frame of the Nasca Culture.

The location of archaeological sites in direct association with the puquios also provides evidence for the early construction of these works. Although early populations avoided living on the fertile valley floor, the excavation of the trenches for the outflow from the galleries created elevated ridges or berms on which limited habitation could take place (Schreiber and Lancho 1995:248). One would expect to find evidence post dating the construction of the puquios on these ridges, and Schreiber has located pottery and other artifacts ranging in date from Nasca Phase 5 through the Middle Horizon and Late Intermediate Period (ibid.) If the debris from these trenches had been deposited by the Spanish, then it would be impossible for these earlier artifacts to be present in this context.

Schreiber and her students have spent a number of years conducting an archaeological survey of the Nasca, Taruga and Las Trancas tributaries--the areas containing the puquio system. She hypothesized that there would be few Nasca habitation sites in the middle parts of the tributaries prior to the construction of puquios, since there is little to no surface water on a predictable basis in that region. The results of her yet unpublished survey confirm that in the Early Nasca period, habitation sites were distributed in the lower valley and in the zone of filtration and the upper valley; not a single habitation site was found in the dry middle portions of these tributaries (ibid.: 249). Following the construction of the first puquios, which Schreiber dates to the middle Nasca period (Phase 5), new sites appear in the middle valley adjacent to lands watered by the puquios, attesting to their initial construction at that time. The construction coincides with a period of prolonged drought on the south coast which occurred between A.D. 540 and 560 and again between 570 and 610 (Thompson et al 1985).

One of the most interesting new discoveries in the Nasca drainage provides a link between the puquios, their water sources and the Nasca Lines. While David Johnson was studying the puquios and their sources of water in the subterranean aquifers in 1996, he noticed a relationship between the lines of Nasca and the water sources. As he identified the source and width of the aquifers and the geological faults which conduct them into the valley from the mountains, he discovered that many of the geoglyphs, particularly triangular-shaped designs, pointed exactly to the faults which conducted water into the valley or to the course of the underground aquifers leading to the puquios. Conversely, he found another form of geoglyph, a zig zag or wavy line, that marked the boundaries of the aquifers and denoted the lack of water on either side (Johnson 1997) At this point, he decided to test his hypothesis. Instead of following the aquifers to determine if they were identified by the geoglyphs, he followed the geoglyphs to the water sources. Each time they clearly identified the aquifers. It would appear that the ancient peoples of the valley had sufficient geological and hydrological knowledge to identify and mark the underground water courses within the valley system.

When one thinks of the Nasca Lines, it is the large cluster of geoglyphs, both geometric and representational, on the Pampa de San José that comes to mind. This is the area where the tourists come to fly over the pampa and view the lines. Most people do not realize that the entire valley is covered with geoglyphs, many of which have not been adequately recorded. During 1996 and 1997, David Johnson, accompanied by archaeologist Donald Proulx, geologist Paul Salchert, volunteer Richard Schmidt, and a crew of Peruvian assistants, visited large sections of the lower Rio Grande, Nasca, Las Trancas and Taruga valleys. Often, in the most remote areas, huge geoglyphs were spotted, and in virtually every case, they pointed to faults which conducted water into or across the region. Johnson is in the process of mapping the location of the aquifers discovered to date, however much additional work needs to be accomplished. A team of geologists, hydrologists and archaeologists will continue this study over the next few years to gather even more convincing data to definitively solve the age old question of the function of the Nasca lines.

In the meantime, Johnson and his team hope that this new found knowledge will be of benefit to the people of the valley who are currently suffering from the lack of adequate water resources. Once the most productive aquifers can be identified, wells with pumps can be installed which should revolutionize agricultural productivity in the area.

Epilogue

Since this paper was written almost 10 years ago (1998), several clarifications must be made. Johnson's theory about the role of geological faults and groundwater veins in conducting water into the valley's hydrological system has been modified to include the role of alluvial gravels in this process. He now accepts the idea that geoglyphs have a number of different functions, and that not all of them are associated with water. See my discussion of the Nasca Lines Project elsewhere on this web site:
http://www-unix.oit.umass.edu/~proulx/Nasca_Lines_Project.html

Dorn's tecnique of using the desert varnish to date the stone construction of the puquios has been discredited. The method may be applicable in other situations, but has flaws when used in this case. In addition, many of the stones used in the constriction of the puquios have been replaced over the years, further compromising the dating.

In 2003, Katharina Schreiber and Josué Lancho Rojas published a more comprehensive book on the puquios. It contains a wealth of information not available in their 1995 journal article which I used when this paper was written (see the bibliography below).

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