

Society for American Archaeology

New Chronometric Dates for the Puquios of Nasca, Peru

Author(s): Persis B. Clarkson and Ronald I. Dorn

Source: *Latin American Antiquity*, Vol. 6, No. 1 (Mar., 1995), pp. 56-69

Published by: [Society for American Archaeology](#)

Stable URL: <http://www.jstor.org/stable/971600>

Accessed: 15/12/2010 12:49

Your use of the JSTOR archive indicates your acceptance of JSTOR's Terms and Conditions of Use, available at <http://www.jstor.org/page/info/about/policies/terms.jsp>. JSTOR's Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Please contact the publisher regarding any further use of this work. Publisher contact information may be obtained at <http://www.jstor.org/action/showPublisher?publisherCode=sam>.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.



Society for American Archaeology is collaborating with JSTOR to digitize, preserve and extend access to *Latin American Antiquity*.

<http://www.jstor.org>

NEW CHRONOMETRIC DATES FOR THE PUQUIOS OF NASCA, PERU

Persis B. Clarkson and Ronald I. Dorn

Numeric age assessments of organic material encapsulated by rock varnish present on stone lintels of two "puquios" in the Nasca region of the south coast of Peru indicate a Precolumbian age. Accelerator mass spectrometry radiocarbon analyses at the Isotracer Laboratory revealed ages of cal A.D. 560(620)650 and cal A.D. 600(640)660 (1 sigma). These calibrated measurements are considered to be appropriate in the context of the archaeological settlement pattern data for the region. As well, the written documents of the colonial period neither confirm nor deny the presence of the puquios. Three assumptions are inherent in the acceptance of these dates: (1) AMS ¹⁴C dating and its application to rock varnish yield reliable results, (2) sample contamination can be recognized, and (3) determination of the age of the puquios rests upon testable available information; ex silentio arguments about the presence or absence of the puquios in the Nasca region before the Spanish conquest are inadequate for the resolution of the question.

Se ha determinado la edad cronológica en los dinteles de dos puquios de la región de Nasca, costa sur del Perú, en base a material orgánico encapsulado en barniz de roca; los fechados indican que los puquios son prehispánicos. Los estudios radiocarbónicos de espectrometría por aceleración de masa (¹⁴C ACM) realizados en los laboratorios Isotracer han proporcionado dos fechas radiocarbónicas calibradas 560(620)650 D.C. y 600(640)660 D.C. (1 sigma) respectivamente. Estas fechas calibradas se consideran apropiadas dentro del contexto de los patrones de asentamiento prehistórico de la región de Nasca, entendiéndose además que los documentos coloniales no confirman ni niegan la existencia de puquios en la zona. Tres premisas son inherentes a la aceptación de estos fechados: (1) el fechamiento de ¹⁴C mediante ACM proporciona resultados fiables e aceptables para el estudio del barniz de roca, (2) cualquier contaminación de las muestras puede ser detectada, y (3) la determinación de la edad de los puquios se basa en técnicas reproducibles y datos verificables. El uso de argumentos ex silentio no es adecuado para demostrar si los acueductos existieron o no en tiempos prehispánicos.

Researchers working in the Nasca region of southern Peru are no doubt familiar with an intriguing cultural feature known as *puquios*. Puquios, also referred to as aqueducts or filtration galleries, are artificial channels constructed as tunnels or trenches to gain access to the water table. Between approximately January and April each year, during the rainy season in the Andes, the rivers flow and the water table rises, thereby providing sufficient water for the fields surrounding the puquios. The necessary cleaning of the subterranean channels is timed to coincide with the lowest water level at the warmest time of the year, usually between October and December, when people crawl through the subterra-

nean channels and clear out the debris accumulated over the last year (Urton 1981:4).

While a variety of hydraulic systems were used and adapted throughout the New World before and after the Spanish arrival in the sixteenth century, the puquios discussed here include the three drainages of the Rio Grande de Nasca: the Nasca (Aja and Tierras Blancas), Taruga, and Las Trancas (Figure 1).

Precipitation in the Nasca region itself is insufficient to support current human and agricultural needs: the average rainfall recorded between 1957 and 1965 at the Majoro station, situated about 3 km from the town of Nasca, was 5.03 mm, with a range between 23 mm (in 1963) and 0 mm (in 1958, 1960,

Persis B. Clarkson ■ Department of Anthropology, University of Winnipeg, 515 Portage Avenue, Winnipeg, Manitoba R3B 2E9, Canada

Ronald I. Dorn ■ Department of Geography, Arizona State University, Tempe, AZ 85287-0104

Latin American Antiquity, 6(1), 1995, pp. 56-69.
Copyright © 1995 by the Society for American Archaeology

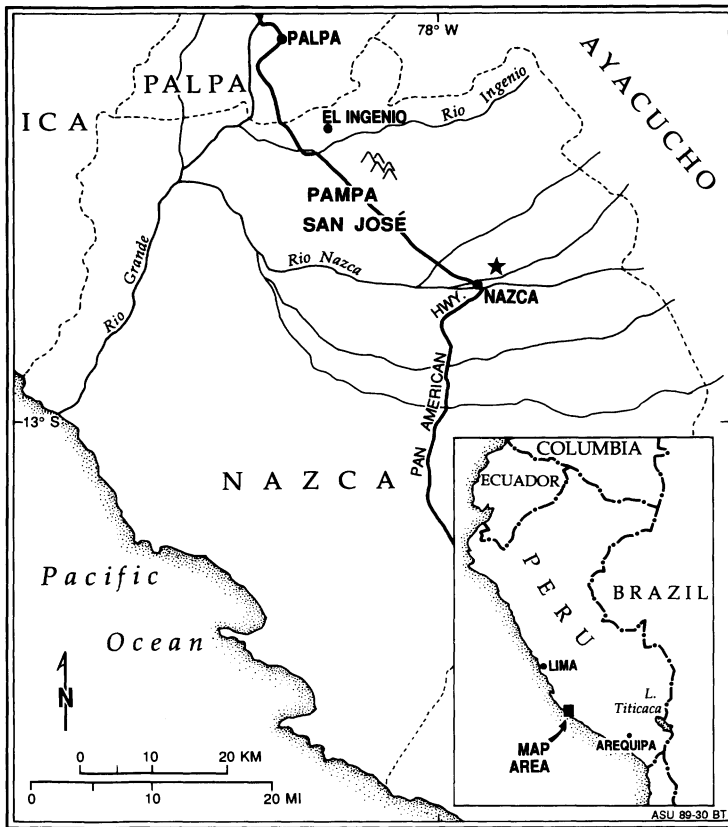


Figure 1. Map of the Nasca region.

and 1965 with January through September only recorded for the latter year; ONERN 1971 II:15). The puquios help to offset the insignificant amount of precipitation in the Nasca region by acting as a buffer against drought. Although the waters in some of the puquios may fail to rise during times of drought in the Andes, placing some stress upon the system, many never dry up. A drought during 1990 and 1991 ended in March 1991 when heavy rains arrived in the Andes, causing severe flooding in the rivers and damage to the retarded crops in the surrounding fields that were not watered by puquios; in fields where puquio water was available, many of the crops had grown sufficiently that they were able to withstand the effects of the flooding.

The Age of the Nasca Puquios

Evidence for the age of the Nasca puquio system has been brought forth by archaeol-

ogists and ethnohistorians. In a preliminary archaeological study of the prehistoric settlements of the Nasca region, Schreiber and Lancho (1988) note that there was an increase of settlements in previously uninhabited areas in the Nasca Valley during Nasca 5, or approximately A.D. 500. These areas are sufficiently dry that the kind of settlement expansion witnessed during Nasca 5 would have been impossible without a permanent water system. Schreiber and Lancho posit that the sudden expansion of Nasca 5 settlements into these zones was due to the construction of the puquios. The settlement pattern study of the Nasca Valley is still ongoing, and the final results have not yet been published (Schreiber and Lancho 1995). Silverman (1986:20) has also suggested that the location of Nasca Valley sites, such as the Middle Horizon Pacheco (Menzel 1964; Paulsen 1983) and the Late Horizon Paredones, might have been

chosen to take advantage of the already existing water system.

The origin of the puquios has been studied by a variety of researchers. An Inka origin was posited by the historian Clements Markham based on his examination of the puquios in 1853 (in Joyce 1912:119–120), as well as by other researchers (see Auza A. 1948, Conkling 1939, González G. 1934). The Peruvian priest and amateur archaeologist A. Rossel Castro stated that the Inka had never built subterranean irrigation systems anywhere in their domain, other than Nasca, and suggested that they were pre-Inka in age (Rossel Castro 1942). Rossel described “Classic Naska” remains recovered from the puquios (Rossel Castro 1977:175–176). There are no illustrations of the artifacts recovered in the puquios by Rossel, nor is there any information about the puquios in question nor the specifics of the location of the artifacts; Rossel’s conclusions are considered unsubstantiated here. Based upon Rossel’s 1977 publication, Petersen (1980) stated that the puquios were built between middle and late Nasca times, or approximately A.D. 400–800. The evidence of the presence of highland Huarpa peoples from Ayacucho, where complex underground water systems had been used extensively in the Nasca region during late Nasca times (Paulsen 1983:104), might also suggest a precedent for the Nasca puquios. Rossel also linked the subterranean puquios with the geometric geoglyphs (see Rossel Castro 1959:355), which he stated contained tombs with Nasca artifacts. We suspect that Rossel was referring to Nasca cemeteries, which abound on the valley margins in the vicinity of the geoglyphs in the Las Trancas, Taruga, and Nasca valleys. There is no direct archaeological or spatial link between the geoglyphs and either the Nasca cemeteries or the puquios.

Some of the better-known early colonial Spanish accounts of the Nasca region, such as those of the sixteenth-century chroniclers Cieza de Leon and Guaman Poma de Ayala, or the seventeenth-century Vazquez de Espinosa, lack specific mention of the presence

of puquios. Barnes and Fleming (1991) suggest that the lack of an eyewitness account regarding the puquios dating back to early colonial times indicates that the puquios were a post-Conquest construction by the Spanish. Barnes and Fleming believe that the puquios share much in common with Moorish *qanats*, which were built throughout the Iberian peninsula, and that the techniques of constructing these hydraulic systems came to the New World with the Spaniards. However, as Kosok points out, there are few references to ancient irrigation works by the early Spanish chroniclers, perhaps because “(m)ost of the writers . . . record the luxury, wealth and abundance of fruits and vegetables in the coastal valleys without inquiring into the method of their production. . . . They were therefore not primarily interested in the economic life of the coast insofar as the people there could be used as human pack animals and mine laborers” (Kosok 1940:172–173).

Trimborn had two wooden lintels from the Cantalloq and Majoro puquios in the Nasca Valley radiocarbon dated (see Scharpenseel and Pietig 1974). These yielded ages of 110 ± 100 B.P. (Bonn-1971) and 140 ± 100 B.P. (Bonn-1972). Radiocarbon ages within this range fall outside the range of reliability of radiocarbon dating because they are too recent. However, it should be noted that such measurements are consistent with the periodic replacement of wooden lintels, and with the fact that maintenance of the puquios has been continuous over many centuries. Thus, radiocarbon ages of perishable materials associated with the regular maintenance of the puquios probably cannot provide evidence for the original construction date of these features. Rather, we must seek more reliable materials for dating that are indicative of, or associated with, the construction of the puquios.

Methods of Numeric Age Assessment of Nasca Puquios

With the exception of Trimborn’s ages, all previous studies of the age of the Nasca puquios have relied upon inferential evidence

of the association of the puquios with demographic, archaeological, ethnohistoric, or comparative data. Recent studies of rock varnish reveal techniques by which the age of construction or the formation of natural and cultural stone features can be discerned by criteria independent of associated cultural material or assigned cultural meaning. These absolute, or numeric, techniques include cation-ratio dating (Dorn 1989), which can provide relative ages, and AMS radiocarbon dating (Dorn et al. 1989; Dorn et al. 1992b).

Rock varnish is a ubiquitous coating of manganese oxides, iron oxides, and clay minerals fixed by bacteria found on exposed rock surfaces. The varnish accretes over time, forming layers that can be discerned under a microscope (Dorn and Oberlander 1982). In stable environmental situations created by arid environments, the chemical composition of uninterrupted layers of varnish can be used to indicate the relative ages of varnished features. The presence of datable organic materials contained on and within rock varnish layers and between the basal layer of varnish and the stone means that the age of varnished cultural features such as the pyramids of Egypt (Blackwelder 1948) and stone artifacts (Hayden 1976; Dorn et al. 1986) can be ascertained independent of typological and iconographic criteria; furthermore, these ages can be corroborated by historical data where available, such as for the Egyptian monuments.

We (Clarkson and Dorn 1991; Dorn et al. 1992a; see also Bray 1992) have undertaken studies of the rock varnishes associated with cultural features in the Nasca region. The nine reported AMS ^{14}C ages from the geoglyphs range between 92 B.C. and A.D. 658, which effectively span the Early Intermediate Phase of Nasca culture. Aside from an internal consistency of the dates (which nevertheless must be carefully considered; see Andrews and Hammond 1990), the ages derived from the rock varnish associated with the Nasca geoglyphs are consistent with independently derived iconographic and archaeological correlations (Clarkson 1990, 1992).

Inspection and analysis of the rock varnish formation on Nasca puquio stones indicated a very different varnish from that of the geoglyphs; this varnish did not fulfill the constraints for cation-ratio dating (Dorn 1989). The type of varnish on these faced stones is characteristic of varnish from wet environments, and is totally dissimilar to the type of varnish found in the nearby desert surfaces (Figure 2). Viable cation-ratio dating is dependent upon varnish formed in stable arid environments. The chemistry of the puquio varnish is also dissimilar to subaerial varnish in the nearby desert (Table 1). This evidence of wet-environment formation is consistent with the situation of the stones used to construct the puquios, which is a damp micro-environment relative to the surrounding desert region.

The stones used in the construction of the puquios are from the surrounding region. Open trench-style puquios may be faced with stone retaining walls, while tunnels have masonry or cobble side walls. Some of these are riverine cobbles similar to those found in the nearby riverbeds, and would have been a likely source of this building material. The lintels are also made from a stone consisting of quartzite with iron; this type of stone is locally available, although stones of the size used for the puquio lintels may have been imported. However, in dressing these stones to create the desired rectilinear shape for the lintels, preexisting varnish was removed. If these stones were to have been reused from any of the numerous architectural features scattered throughout the valley, desert-type varnish would have been clearly discernable beneath the damp-climate varnish under microscopic examination.

Microscopic examination of varnished stones shows organic material at the interface between the varnish and the stone that formed on the surface of newly exposed stone surfaces before the onset of varnish formation; very rarely is organic material trapped within varnish layers. Organic material such as cyanobacteria, fungi, and lichens from this interface can be collected and dated using ac-

Table 1. Microchemical Variability in Rock Varnishes Collected from Different Waterflow Environments, Compared with Subaerial Rock Varnish.

| Sample | MgO | Al ₂ O ₃ | SiO ₂ | P ₂ O ₅ |
|---|------------|--------------------------------|------------------|-------------------------------|
| Wailua River, Kauai, Hawaii (Figure 2C) | | | | |
| Lighter texture | <.04 | 19.71 | .22 | na |
| | <.04 | 18.97 | .21 | na |
| | <.04 | 15.96 | .34 | na |
| | <.04 | 19.06 | .22 | na |
| Average ± 1 sigma | <.04 | 18.43 ± 1.68 | .25 ± .06 | na |
| Darker texture | <.04 | .29 | 85.23 | na |
| | <.04 | .69 | 91.90 | na |
| | <.04 | .82 | 87.21 | na |
| | <.04 | .45 | 93.61 | na |
| Average ± 1 sigma | <.04 | .56 ± .24 | 89.49 ± 3.92 | na |
| Kin Kin District stream, Queensland, Australia (Figure 2B) | | | | |
| Lighter texture | .09 | 19.67 | .64 | na |
| | <.04 | 24.55 | .18 | na |
| | .05 | 20.73 | .72 | na |
| | <.04 | 20.57 | .21 | na |
| Average ± 1 sigma | ≤.07 ± .03 | 21.38 ± 2.16 | .44 ± .28 | na |
| Darker texture | <.04 | 22.88 | 15.83 | na |
| | <.04 | 28.09 | 12.33 | na |
| | <.04 | 22.48 | 11.68 | na |
| | <.04 | 24.48 ± 3.13 | 13.28 ± 2.23 | na |
| Orcona Puquio (Figure 2A) | | | | |
| Lighter texture | <.04 | 24.36 | .46 | na |
| | <.04 | 19.93 | .38 | na |
| | <.04 | 17.47 | 1.49 | na |
| | <.04 | 13.81 | .75 | na |
| | <.04 | 24.36 | 1.76 | na |
| | <.04 | 19.99 ± 4.55 | .97 ± .62 | na |
| Darker texture | <.04 | 34.57 | 17.65 | na |
| | <.04 | 27.69 | 16.84 | na |
| | <.04 | 33.74 | 15.34 | na |
| | .04 | 23.32 | 15.00 | na |
| | <.04 | 29.83 ± 5.31 | 16.21 ± 1.25 | na |
| Subaerial Rock Varnish (Figure 2D) | | | | |
| Desert pavement, Terrace of Rio Ingenio, north of Nasca, Peru | 1.89 | 19.93 | 26.85 | .92 |
| | 2.02 | 18.71 | 28.65 | 1.26 |
| | 1.58 | 19.14 | 24.20 | 1.08 |
| From surface of varnish to base of varnish | 1.67 | 15.78 | 19.70 | 1.08 |
| | 1.49 | 16.23 | 18.76 | 1.67 |
| | 1.76 | 16.55 | 21.67 | 1.40 |
| | 2.16 | 16.33 | 20.90 | 1.24 |
| | 1.24 | 14.40 | 16.41 | .89 |
| | 1.64 | 16.55 | 20.24 | 1.17 |
| | 1.49 | 15.49 | 17.97 | 1.33 |
| Average ± 1 sigma | 1.69 ± .27 | 16.91 ± 1.76 | 21.54 ± 3.92 | 1.20 ± .23 |

Notes: Analysis by wavelength dispersive microprobe, using ZAF correction and 10 micrometer spot size. Transects identified on micrographs in Figure 2. Na = not analyzed; bld = below limit of detection.

celerator mass spectrometry (AMS) radio-carbon dating. The varnish formation on stones from Nasca puquios was examined in cross-section by backscatter electron microscopy, revealing suitable formation for collection of organic material for AMS ¹⁴C dating (Figure 2a).

Rock varnish samples were collected from the lintels of the Orcona and Cantalloq puquios in the Nasca region. The lintels were chosen because their durability, and the effort that went into shaping them, would have made them unlikely to have been replaced. In addition, the shape of the two-faced lintel

Table 1. Extended.

| K ² O | CaO | TiO ² | MnO | FeO | BaO |
|------------------|------------|------------------|--------------|--------------|------------|
| <.04 | <.04 | <.03 | 45.69 | .06 | 3.39 |
| <.04 | <.04 | <.03 | 55.52 | .08 | 4.22 |
| <.04 | <.04 | <.03 | 50.34 | .18 | 3.77 |
| <.04 | <.04 | <.03 | 50.03 | .45 | 3.64 |
| <.04 | <.04 | <.03 | 50.40 ± 4.02 | .19 ± .18 | 3.76 ± .35 |
| bid | <.04 | <.03 | .57 | bid | bid |
| .18 | <.04 | <.03 | .28 | .05 | .04 |
| .17 | <.04 | <.03 | .12 | .02 | .08 |
| .02 | <.04 | <.03 | .38 | .04 | bid |
| .12 ± .09 | <.04 | <.03 | .34 ± .19 | .04 ± .02 | .06 ± .03 |
| .04 | .04 | <.03 | 50.98 | .08 | 3.46 |
| .80 | <.04 | <.03 | 44.93 | .13 | 3.10 |
| .10 | <.04 | <.03 | 41.66 | .62 | 2.89 |
| <.04 | <.04 | <.03 | 50.01 | .08 | 3.34 |
| ≤.31 ± .42 | ≤.04 | <.03 | 46.90 ± 4.38 | .23 ± .26 | 3.20 ± .25 |
| <.04 | .07 | .06 | 26.17 | 7.70 | 1.15 |
| <.04 | <.04 | .04 | 19.04 | 4.36 | .87 |
| <.04 | <.04 | .05 | 17.77 | 9.56 | .91 |
| <.04 | ≤.07 | .05 ± .01 | 20.99 ± 4.53 | 7.21 ± 2.63 | .98 ± .15 |
| <.04 | <.04 | <.03 | 45.68 | .33 | 2.65 |
| <.04 | <.04 | <.03 | 47.48 | .57 | 2.51 |
| <.04 | <.04 | <.03 | 45.87 | .89 | 2.30 |
| .04 | <.04 | .04 | 49.48 | .97 | 2.57 |
| .07 | .04 | <.03 | 46.32 | .34 | 2.41 |
| ≤.06 ± .02 | ≤.04 | ≤.04 | 46.97 ± 1.57 | .62 ± .30 | 2.49 ± .14 |
| <.04 | .03 | .05 | 18.42 | 4.77 | 1.04 |
| <.04 | .03 | <.03 | 16.05 | 3.19 | 1.19 |
| .04 | .07 | .05 | 21.30 | 3.70 | 1.26 |
| .04 | .05 | <.03 | 24.55 | 3.75 | 1.40 |
| ≤.04 | .05 ± .02 | ≤.05 | 20.08 ± 3.67 | 3.85 ± .66 | 1.22 ± .15 |
| 1.12 | 1.12 | .37 | 12.74 | 14.68 | .21 |
| 2.22 | 0.88 | .63 | 9.25 | 14.58 | 1.21 |
| 1.48 | 1.19 | .43 | 10.50 | 19.14 | 1.50 |
| 1.59 | 1.41 | .70 | 9.53 | 24.24 | 2.17 |
| 1.41 | 1.33 | .55 | 12.12 | 24.82 | 1.82 |
| 1.78 | 1.23 | .58 | 10.67 | 24.59 | 1.84 |
| 1.71 | 1.26 | .47 | 8.34 | 24.26 | 2.21 |
| 1.64 | 1.12 | .58 | 9.17 | 22.77 | 1.98 |
| 1.51 | 1.16 | .58 | 10.48 | 26.93 | 1.84 |
| 1.48 | 1.09 | .63 | 12.47 | 22.69 | 2.05 |
| 1.59 ± .29 | 1.18 ± .15 | .55 ± .10 | 10.53 ± 1.51 | 21.87 ± 4.31 | 1.68 ± .60 |

stones is unusual, carved from unusually large stones uncommon in the region; we have not seen such dressed stone slabs in structures present in archaeological sites in the region. The ages of each of the samples, 1460±50 B.P. (TO-1622; organic matter from rock varnish; $\delta^{13}\text{C} = -25\text{‰}$), cal A.D. 560(620)650 (calibrated at 1 sigma) (Stuiver and Reimer

1993) from the Orcona puquio lintel, and 1430±60 B.P. (TO-1623; organic matter from rock varnish; $\delta^{13}\text{C} = -25\text{‰}$), cal A.D. 600(640)660 (calibrated at 1 sigma) (Stuiver and Reimer 1993), from the Cantalloq puquio lintel, are internally consistent with each other, as well as with a suite of nine other radiocarbon dates from geoglyphs from the

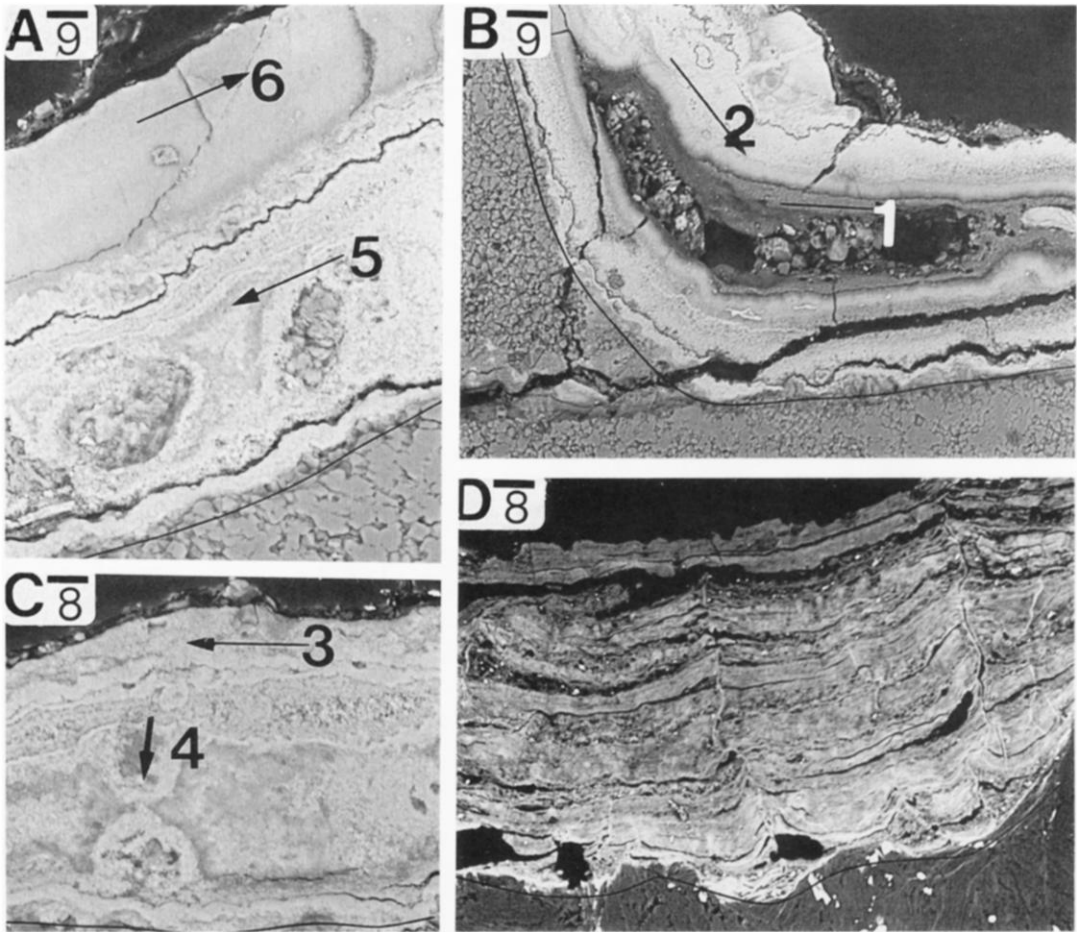


Figure 2. Backscatter electron micrographs of rock varnishes discussed in text. Numbers under scale bars are in microns. A thin black line in each micrograph marks the varnish-rock boundary. Arrows reflect locations of microprobe transects matched with transect numbers in Table 1. (A) Orcona Puquio varnish, Peru. (B) Stream varnish, Kin Kin District, Queensland, Australia. (C) Stream varnish, Wailua River, Kauai, Hawaii. (D) Subaerial rock varnish, natural desert pavement, Pampa San José, Nasca, Peru. Scale bars in micrometers.

Nasca region (Clarkson and Dorn 1991; Dorn and Clarkson 1992; Dorn et al. 1992a). While internal consistency is not necessarily an indication of overall reliability (see, for example, Andrews and Hammond 1990), these dates also fall within the age ranges suggested by other dependent means mentioned earlier. While it is theoretically possible that non-contemporaneous older organic matter had been incorporated into the sampled varnish (Dorn et al. 1989), no examples of this possibility have been encountered in analyzing scores of samples worldwide (Dorn et al. 1992a).

Implications of Radiocarbon Dates for Nasca Puquios

Two assumptions are implicit in the analysis presented here: (1) AMS ^{14}C dating of rock varnish provides reliable minimum-limiting ages, and (2) sample contamination can be recognized. These assumptions are explored in this section.

Rock Varnish Dating

AMS ^{14}C is a reliable dating technique in archaeology when used within the limitations of the method (Goh 1991; Taylor 1987).

Statements to the effect that radiocarbon dating is an unreliable or "experimental" method (Barnes and Fleming 1991:61) ignore a body of literature that indicates otherwise. While our approach to extracting organics is indeed experimental, independent assessments of the validity and reliability of AMS ^{14}C dating of rock varnish demonstrate that the method is reliable (Dorn et al. 1989; Loendorf 1991). Radiocarbon ages for organic material on the surface of rock varnish must be younger than organic material at the interface of the rock varnish and the underlying surface. This has been shown in all prior tests (Dorn et al. 1989, 1992b; see also Dorn et al. 1986, 1987, 1989, 1991, 1992a, 1992b).

The AMS ^{14}C dates derived from organic material at the interface of the rock varnish and the dressed stone lintels of the two puquios are consistent with the ages derived for the puquios, based upon the shifts in settlement locations documented by Schreiber (Schreiber and Lancho 1988) in Nasca 5.

Sample Contamination

All samples to be considered for AMS ^{14}C dating are first subjected to microscopic examination for evidence of poorly formed or interrupted varnish development. These disturbances can be caused by the growth of lichens that destroy varnish, or by stone surfaces that have been alternately exposed to and hidden from varnish development through natural or cultural intervention. In these situations, the context of any organic material trapped between the stone and the initial layer of varnish is too disturbed to be considered. These analyses can indicate when a sample is inappropriate for AMS ^{14}C dating. Moreover, the differential nature of the formation of rock varnish in arid vs. wet conditions has been noted by Dorn, and these differences are easily detected under a microscope.

Barnes and Fleming (1991:61; see also Barnes 1992) reject the ages of the samples we collected from the Nasca puquios (Clarkson and Dorn 1991). Barnes and Fleming

suggest that the stones we sampled from the puquios were derived from earlier Prehispanic structures that were mined by the Spaniards for suitable stones for building puquios, and thus our radiocarbon dates provide an age for the stones, and not the construction of the puquios in question. We agree that this is, in theory, a possibility that should be considered, but the chemical, micrographic, and physical evidence indicate otherwise. These types of evidence are discussed below.

Rock varnishes can be found in a variety of environments, including springs, streams, caves, soil peds, regoliths, and the more commonly studied subaerial "desert" varnishes (Dorn and Oberlander 1982). Varnishes formed in different environments, such as the damp puquio and the adjacent "desert" varnishes of Nasca, have different chemistries and textures.

Figure 2a illustrates a backscatter electron micrograph of rock varnish formed in the Orcona puquio lintel, one of our sample sites. In backscatter images, the brightness of the texture reflects the chemistry (brighter = higher atomic number). The varnish of the puquio is brighter in color than the underlying rock because of the great abundance of manganese in the former (Table 1). However, the texture and chemistry of the adjacent subaerial varnish are totally dissimilar (Figure 3d; Table 1). The $\text{Al}_2\text{O}_3:\text{SiO}_2$ ratios in Table 1 are extremely high in the puquio varnish, yet are typical for subaerial varnishes in the adjacent desert. MgO , K_2O , CaO , and TiO_2 are virtually lacking in the puquio varnish, but are at typical minor element concentrations in the desert varnish. FeO is at very low or minor element concentrations in the puquio varnish, but in much greater abundance in varnishes in the nearby desert.

The texture and chemistry of the puquio varnish, in fact, are most similar to water flow varnishes found in tropical settings. Tropical stream varnishes are among the first types of rock varnish studied (see Boussingault 1882; Darwin 1897; Francis 1921; Hume 1925; von Humboldt 1812). Figure 2c shows varnish formed on boulders in the splash zone of

Wailua River, Kauai. Figure 2b illustrates varnish collected from the same region where Francis (1921) conducted a classic study of the formation of rock varnish on boulders of tropical streams in Queensland, Australia. The range of textures and chemistry in these stream varnishes is quite similar to the textures and chemical variation found in the puquio varnish (Table 1).

Finally, the situation and characteristics of the puquio lintels were examined in the field. The unusual size and shape of the lintel stones have already been noted here. Wooden lintels are known from puquios under current use. While wooden lintels would have been likely to deteriorate in the damp climate of the puquios, the stone lintels are unlikely to have suffered any damage or deterioration over the centuries, and thus were unlikely to have been replaced.

The implication of these findings is that the puquio varnishes we sampled were not "reused," as suggested by Barnes and Fleming. The puquio varnishes were formed in the damp environment of the puquio chamber, not in the adjacent desert. In our studies of the puquio varnish, there is no evidence of an "overprint" of water flow varnish superimposed over a previous subaerial varnish. If the varnishes on which we placed minimum ages were indeed reused, as Barnes and Fleming (1991:61) believe, the following *very unlikely* series of events would have had to transpire. First, the lintel stones would have to have been faced sometime before ca. 1560 B.P. (the 2-sigma variation of the ^{14}C age of 1450 ± 55). Second, *both* faced stones (from the Cantalloq and Orkona puquio lintels) would have to have been transported to a perennial stream where a water flow varnish would have formed. Third, after the water flow varnish formed on the *faced* surfaces (a process taking an unknown period of time), these faced stones were transported to two separate puquios and set in the roof. While this scenario is possible, it is not very plausible. Barnes's (1992) suggestion that the lintel stones may have come from the Early In-

termediate site of Tambo Viejo in the Acari Valley, where she says there is flowing water, presupposes that the unusually sized and shaped Nasca puquio lintel stones were sitting in flowing water at Tambo Viejo before transport to Nasca in 1954. Josue Lancho, a life-long resident of Nasca and former representative for the Instituto Nacional de Cultura in Nasca, has taken a special interest in studying the puquios (see Schreiber and Lancho 1988); he showed us puquios for which he had no knowledge or information of any reconstruction activity. He is certainly aware of the puquio reconstructions that have been undertaken in the region, having participated and advised in some of these reconstruction efforts.

We know of no water-flow varnish forming at present in the region, other than in the puquios (Figure 3a). Varnish is fairly delicate (Mohs hardness is $\leq 4\frac{1}{2}$). The transport from the hypothetical source of water and the subsequent puquio construction would have to have been accomplished in a fashion that would not have eroded the delicate varnish. Lastly, the similarity of the two radiocarbon ages derived from the puquios requires that the faced stones were placed in the water-flow environment at about the same time for the "reuse" hypothesis to be correct. In addition, all of the lintel stones that we viewed were securely in place, rendering it further unlikely that they would be easily dislodged.

Although there is ample building stone available in the Nasca region, it is possible that stones subjected to the conditions necessary for the formation of water-flow varnish were brought in from elsewhere to complete the construction of the Nasca puquios. The most likely source is the archaeological site of Tambo Viejo in the Acari Valley, where Menzel and Riddell noted trucks carrying off large quantities of cobbles from the walls throughout the site in 1954 "for the irrigation project on the pampa and elsewhere" (Menzel and Riddell 1986:3). It is unlikely, however, that stones removed from Tambo Viejo could be the same stones as those encoun-

tered in the Nasca puquios for three reasons. First, the majority of the stones used in building at Tambo Viejo were cobbles from the nearby Río Acari; Menzel and Riddell note that cobbles were used for Nasca structures and possibly reused by the Inka in later constructions (Menzel and Riddell 1986:7). While the interior walls visible from the entranceway of the Nasca puquios examined were made of river cobbles, there is an ample supply of river cobbles available in nearby streams at Nasca. Second, the only shaped stones mentioned at Tambo Viejo were grinding slabs (Menzel and Riddell 1986:13) and sandstone blocks in the Inka architecture at the site (Menzel and Riddell 1986:17). Neither of these conform to the shape or material of the puquio lintel stones tested in the Nasca region. Third, the situation of Tambo Viejo is on a bluff above the flood plain (Menzel and Riddell 1986:2–3), and the likelihood of flowing water through the site, except for that caused by occasional rainfall, is remote.

Viability of Nasca Puquio Varnish Ages

The Prehispanic radiocarbon ages obtained from the Orcona and Cantalloq puquios contrast with the eyewitness accounts of the Spanish colonial documents, in which there is a lack of any known mention of the puquios in the Nasca region before 1692 (Barnes and Fleming 1991:52). We have addressed the methodology of varnish dating and the sampling procedures used on two Nasca puquios; here we address the significance of the historical documents regarding the age of the Nasca puquios. A review of major documents on filtration-gallery irrigation systems in the New World and in the Iberian peninsula has been presented by Barnes and Fleming (1991). Perhaps the most significant information revealed in the Spanish colonial documents regarding the Nasca puquios is what is *not* recorded in the documents. There are three monumental features of the Nasca region—the puquios, the geoglyphs, and the site of Cahuachi—and none of them is mentioned in the colonial period documents known to

us. It is curious that the Spanish chroniclers recorded nothing about the geoglyphs in the Nasca region, nor those found elsewhere throughout the arid coastal desert of Peru. The linear geoglyphs in the Nasca region—trapezoids and straight lines measuring up to many kilometers long—are densely situated, visually impressive, and easily seen from the ground or from isolated low hills. Many geoglyphs exist in the vicinity of known colonial period haciendas. On the basis of iconographic, stylistic, and contextual grounds (Aveni 1990; Browne and Baraybar 1988; Clarkson 1985, 1990; Isbell 1978; Silverman 1990), there is little question that the geometric and biomorphic figures of the Nasca region are Precolumbian in age. Recent radiocarbon analyses of the varnish on the geoglyphs confirm a Precolumbian age (Clarkson and Dorn 1991; Dorn et al. 1992a).

A lack of commentary by the Spanish about the puquios must also be considered in the context of a similar lack of commentary about major archaeological complexes in the region with standing monumental architecture. No known colonial documents mention the huge Prehispanic archaeological complexes of Cahuachi and Estaqueria, downstream of the modern town of Nasca. There is no question that Cahuachi is a Precolumbian site (Strong 1957; Silverman 1985). Thus, an *ex silentio* argument by Barnes and Fleming (1991) regarding the lack of known written Spanish commentary on the puquios, until after the Spanish had settled the Nasca region, should logically be applied to the geoglyphs and Cahuachi, too.

Barnes and Fleming (1991:59) suggest that the Spanish tradition of constructing the puquios continues to this day, noting as evidence that a “recently remodeled” water system in the Azapa valley of northern Chile bears a “striking” similarity to the Nasca puquios. They point out that both systems use “small water-rounded stones to line the canals” and both “incorporate open channels.” The materials used in the Azapa and Nasca water systems were both readily available and

satisfied the needs of the builders. In fact, the radiocarbon ages obtained for the Cantallico and Orcona puquios in the Nasca region indicate that these puquios are of Prehispanic origin. Schreiber and Lancho's (1988) study of Prehispanic settlement patterns in the Nasca region indicates a correlation between puquios in three Nasca drainages and an expansion of Nasca 5 settlements. Neither Schreiber and Lancho's nor our studies address or indicate that other hydraulic systems of coastal Peru and Chile are of similar age. Indeed, until numeric age assessments of stones associated with hydraulic systems can be obtained, and archaeological explorations of these hydraulic features can be undertaken, a Prehispanic age of at least some of the Nasca puquios must be considered, based upon the evidence that *does* exist.

Implications of Puquios for Prehispanic Nasca Residents

What might have motivated the Precolumbian residents of the Nasca region to construct the puquios? Repeated failures of the water to appear in the upper reaches of the rivers may have been a factor motivating them to seek out alternative sources of water. Increasing aridity along coastal Peru around A.D. 500 is suggested by glacial cores from Quelccaya glacier (Thompson et al. 1985) and the environmental data from the north coast of Peru (Nials et al. 1979a, 1979b; Shimada et al. 1991).

The construction of such a major hydraulic system during Nasca times suggests social, political, ideological, and economic ramifications for the residents of the region. Any communities upstream of the newly constructed puquios would no longer have had any control over the water sources of downstream populations in the Nasca Valley, which may have led to a shift in power away from the upstream communities. Communities using the puquios would have likely participated in their maintenance, thereby indicating a level of coercion and cooperation typical of nonegalitarian societies. Regular maintenance of the puquios is essential, as

failure to clean debris out of the subterranean channels would leave them blocked and ineffective for delivering water to the communities relying upon them. The annual rise of subterranean water beginning around December–January in the Nasca Valley, coinciding with the rainy season in the Andes, would have been obvious to the inhabitants of the Nasca region. Cerro Blanco (White Mountain) stands out in sharp contrast against the dark-colored pampas and Andes mountains, and can be seen from virtually all parts of the Nasca region. It is likely that the Nasca residents noted other correlations with the rise of the subterranean waters. Cerro Blanco is connected with the origin of the puquios in a legend recorded in the Nasca region in 1982.

In ancient times, before there were aqueducts in the valley, a great drought occurred and the people had no water for years. The people began crying out to their god, Viracocha or Con. They cried and screamed the word *nanay* (Quechua for "pain"); they were Quechua-speakers. The word *nanay* was the origin of the name of the city: *nanay* → *nanascca* → *Nazca*. The people went en-mass to the foot of Cerro Blanco, which was their principal *templo* or *adoratorio*; this was the place where they spoke to the gods. At that moment, Viracocha/Con descended from the sky to the summit of the mountain and heard the weeping of his people. He was so moved by their cries that he began weeping, and tears flowed from his eyes. The tears ran down Cerro Blanco, penetrated the earth, and these tears were the origin of the aqueducts [Urton 1982:10–11].

It should also be noted that the December solstice sun rises behind Cerro Blanco as viewed from the region of the puquios. This "announcement" might have been to prompt the necessary preparations for the upcoming agricultural cycle.

Conclusions

The dilemma between "history" and "folk tradition" is by no means unique to the post-Conquest New World. In the Andean region, as well as elsewhere, people trained in the Western tradition tend to rely upon "historical" accounts of the Spanish chroniclers as fully reliable and to consider the "histories" of indigenous people as quaint and fabricat-

ed. As Urton (1990:11) notes with regard to Inka accounts recorded by the Spanish, "the traditions preserved in the Spanish chronicles are the product of variously motivated, hierarchical interpretations (i.e., teller → translator → recorder). The possibility of ambiguities, misunderstandings, and individually motivated interpretations entering the accounts throughout this process is enormous." In a similar vein, Ohnuki-Tierney (1987:3) has noted "that both ethnographic and historical representations are incomplete, partial, and overdetermined by forces . . . that are beyond the control of consciousness of the individuals who are involved in the complex process of representing and interpreting the 'other,' be it historical or ethnographic."

Chroniclers, like archaeologists, are only human, and cultural bias and errors are replete throughout the accounts of the Spanish chroniclers. As informative as the colonial accounts are of colonial Peru, it would be erroneous to assume that the total reality of early colonial Peru is accounted for in the chronicles. We feel that the hypothesis best shared by Occam is that at least the Orcona and Cantalloq puquios were constructed before ca. 1450 B.P., as corroborated by demographic, contextual, and absolute chronological analyses.

Acknowledgments. Funding for this research was provided by a Social Sciences and Humanities Research Council of Canada Grant #410-90-1097 to Clarkson, an Athabasca University Learning Services Professional Development Fund Grant to Clarkson, and a National Science Foundation Presidential Young Investigator Award to Dorn. The Instituto Nacional de Cultura in Peru provided permission to collect geological samples in Peru. We are particularly grateful to Josue Lancho R. for his assistance in Nasca, and to Katharina Schreiber (University of California at Santa Barbara), Gary Urton (Colgate University), and Warwick Bray (Institute of Archaeology, University College, University of London) for critique and commentary on this manuscript.

References Cited

- Andrews, E. W., V. and N. Hammond
1990 Redefinition of the Swasey phase at Cuello, Belize. *American Antiquity* 55(3):570-584.
- Auza Arce, C.
1948 El rol de nasca, Jaqui y Acari en el imperio de los incas. *Revista del Museo Nacional* 17:86-95.
- Aveni, A. A. (editor)
1990 *The Lines of Nazca*. Memoirs of the American Philosophical Society Vol. 183, Philadelphia.
- Barnes, M.
1992 Dating of Nazca Aqueducts. *Nature* 359:111.
- Barnes, M., and D. Fleming
1991 Filtration-Gallery Irrigation in the Spanish New World. *Latin American Antiquity* 2(1):48-68.
- Blackwelder, E.
1948 Historical Significance of Desert Lacquer. *Geological Society of America Bulletin* 59:1367.
- Boussingault, M.
1882 Sur l'apparition du manganese à la surface des roches. *Annales de Chemie et de Physique* 27 (Series 5):289-311.
- Bray, W.
1992 Under the Skin of Nazca. *Nature* 358:19.
- Browne, D. M., and J. P. Baraybar
1988 An Archaeological Reconnaissance in the Province of Palpa, Department of Ica, Peru. In *Recent Studies in Pre-Columbian Archaeology*, edited by N. J. Saunders and O. de Montmollin, pp. 299-325. BAR International Series No. 421. British Archaeological Reports, Oxford.
- Clarkson, P. B.
1985 *The Archaeology and Geoglyphs of Nazca, Peru*. Unpublished Ph.D dissertation, Department of Archaeology, University of Calgary, Alberta.
1990 The Archaeology of the Nazca Pampa: Environmental and Cultural Parameters. In *The Lines of Nazca*, edited by A. F. Aveni, pp. 117-172. Memoirs of the American Philosophical Society Vol. 183, Philadelphia.
1992 *Absolute Chronometric Dates of the Nazca Geoglyphs: Applications of Radiocarbon Dating in the Nazca Region, Department of Ica, Peru, 1991*. Report on file, Instituto Nacional de Cultura, Lima.
- Clarkson, P. B., and R. I. Dorn
1991 Nuevos datos relativos a la antigüedad de los geoglifos y pukios de Nazca, Perú. *Boletín de Lima* 13/78:33-45.
- Colman, S. M., K. L. Pierce, and P. W. Birkeland
1987 Suggested Terminology for Quaternary Dating Methods. *Quaternary Research* 28:314-319.
- Conkling, H.
1939 Explotación de aguas subterráneas en la costa del Perú. Sociedad Nacional Agraria, Lima.
- Darwin, C.
1897 *Journal of Researches into the Natural History and Geology of the Countries Visited During the Voyage of the H.M.S. Beagle Round the World, under the command of Capt. Fitz Roy, R.N.D.* Appelton, New York.
- Dorn, R. I.
1989 Cation-ratio Dating of Rock Varnish: A Geographic Assessment. *Progress in Physical Geography* 13:559-596.
- Dorn, R. I., and R. M. Oberlander
1982 Rock Varnish. *Progress in Physical Geography* 6:317-367.
- Dorn, R. I., P. B. Clarkson, M. F. Nobbs, L. L. Loendorf, and D. S. Whitley

- 1992a New Approach to the Radiocarbon Dating of Rock Varnish, with Examples from Drylands. *Annals of the Association of American Geographers* 82(1):136-151.
- Dorn, R. I., A. J. T. Jull, D. J. Donahue, T. W. Linnick, and L. J. Toolin
1989 Accelerator Mass Spectrometry Radiocarbon Dating of Rock Varnish. *Geological Society of America Bulletin* 101:1363-1372.
1990 Latest Pleistocene Lake Shorelines and Glacial Chronology in the Western Basin and Range Province, USA: Insights from AMS Radiocarbon Dating of Rock Varnish and Paleoclimatic Implications. *Palaeogeography, Palaeoclimatology, Palaeoecology* 78:315-331.
- Dorn, R. I., B. D. Turrin, A. J. T. Jull, T. W. Linnick, and D. J. Donahue
1987 Radiocarbon and Cation-ratio Ages for Rock Varnish on Tioga and Tahoe Morainal Boulders of Pine Creek, Eastern Sierra Nevada in California, and Paleoclimatic Implications. *Quaternary Research* 28:38-49.
- Dorn, R. I., F. M. Phillips, M. G. Zreda, E. W. Wolfe, A. J. T. Jull, P. W. Kubik, and P. Sharma
1991 Glacial Chronology of Mauna Kea, Hawaii, as Constrained by Surface-Exposure Dating. *National Geographic Research and Exploration* 7:456-471.
- Dorn, R. I., A. J. T. Jull, D. J. Donahue, T. W. Linnick, L. J. Toolin, R. B. Moore, M. Rubin, T. E. Gill, and T. A. Cahill
1992b Rock Varnish on Hualalai and Mauna Kea Volcanoes, Hawaii. *Pacific Science* 46:11-34.
- Dorn, R. I., D. B. Bamforth, T. A. Cahill, J. C. Dohrenwend, B. D. Turrin, A. J. T. Jull, A. Long, M. E. Macko, E. B. Weil, D. S. Whitley, and T. H. Zabel
1986 Cation-ratio and Accelerator-radiocarbon Dating of Rock Varnish on Mojave Artifacts and Landforms. *Science* 231:830-833.
- Francis, W. D.
1921 The Origin of Black Coatings of Iron and Manganese Oxides on Rocks. *Proceedings of the Royal Society of Queensland* 32:110-116.
- Goh, K. M.
1991 Carbon Dating. In *Carbon Isotope Techniques*, edited by D.C. Coleman and B. Fry, pp. 125-145. Academic Press, San Diego.
- González García, M. F.
1934 Los acueductos incaicos de Nazca. *Aguas e irrigación*. Boletín de la Dirección de Aguas e Irrigación 2(2):207-222. Ministerio de Fomento, Lima. Reprinted 1978 in *Tecnología andina*, edited by R. Ravines, pp. 129-156. Instituto de Estudios Peruanos, Lima.
- Hayden, J.
1976 Pre-althothermal Archaeology in the Sierra Pinacate, Sonora, Mexico. *American Antiquity* 41:274-289.
- Hume, W. F.
1925 *Geology of Egypt*. Volume I. Government Press, Cairo.
- Isbell, W.
1978 The Prehistoric Ground Drawings of Peru. *Scientific American* 239(4): 140-153.
- Joyce, T. A.
1912 *South American Archaeology*. G. P. Putnam's Sons, London.
- Kosok, P.
1940 The Role of Irrigation in Ancient Peru. *Proceedings of the 8th American Scientific Congress*, vol. 2, pp. 169-178.
- Krinsley, D., R. I. Dorn, and S. Anderson
1990 Factors that May Interfere with the Dating of Rock Varnish. *Physical Geography* 11:97-119.
- Loendorf, L. L.
1991 Cation-ratio Varnish Dating and Petroglyph Chronology in Southeastern Colorado. *Antiquity* 65: 246-255.
- Mejia Xesspe, T.
1959 Figuras geométricas prehistóricas de la Hoya de Río Grande de Nasca. *Actas y Trabajos del II Congreso Nacional de Historia del Perú*, 1958, vol. 1, pp. 351-359.
- Menzel, D.
1964 Style and Time in the Middle Horizon. *Ñawpa Pacha* 2:1-106.
- Menzel, D., and F. A. Riddell
1986 *Archaeological Investigations at Tambo Viejo, Acari Valley, Peru, 1954*. California Institute for Peruvian Studies, Sacramento.
- Nials, F. L., E. E. Deeds, M. E. Moseley, S. Posorski, and T. Posorski
1979a El Niño: The Catastrophic Flooding of Coastal Flooding of Coastal Peru. Part 1. *Field Museum of Natural History Bulletin* 50(7):4-14.
1979b El Niño: The Catastrophic Flooding of Coastal Flooding of Coastal Peru. Part 2. *Field Museum of Natural History Bulletin* 50(8):4-10.
- ONERN (Oficina de Nacional de Evaluación de Recursos Naturales)
1971 *Inventario, evaluación y uso racional de los Recursos Naturales de la Costa: Cuenca del Río Grande (Nazca)*, vol. 1. Anexos y Mapas, Lima.
- Ohnuki-Tierney, E.
1987 *The Monkey as Mirror: Symbolic Transformations in Japanese History and Ritual*. Princeton University Press, Princeton.
- Paulsen, A.
1983 Huaca del Loro Revisited: The Nasca-Huarpa Connection. In *Investigations of the Andean Past*, edited by D. Sandweiss, pp. 98-121. Papers from the First Annual Conference on Andean Archaeology and Ethnohistory. Cornell University, Ithaca.
- Petersen, G. G.
1980 *Evolución y desaparición de las alta culturas Paracas-Cahuachi (Nasca)*. Universidad Nacional Federico Villarreal, Dirección Universitaria de Investigación, Lima.
- Rossel Castro, A.
1942 Sistema de irrigación antigua de Río Grande de Nasca. *Revista del Museo Nacional* 11(2):196-202.
1959 Figuras geométricas prehistóricas de la hoya de Río Grande de Nasca. *Actas y Trabajos del II Congreso Nacional de Historia del Perú* 1:351-359.
1977 *Arqueología del sur del Perú*. Editorial Universo, Lima.

- Scharpenseel, H. W., and F. Pietig
1974 University of Bonn Natural Radiocarbon Measurements VII. *Radiocarbon* 16(2):143-165.
- Schreiber, K., and J. Lancho Rojas
1988 Los puquios de Nasca: Un sistema de galerías filtrantes. *Boletín de Lima* 10/59:51-62.
1995 The Puquios of Nasca. *Latin American Antiquity*, in press.
- Shimada, I., C. B. Schaaf, L. G. Thompson, and E. Moseley-Thompson
1991 Cultural Impacts of Severe Droughts in the Prehistoric Andes: Application of a 1,500-Year Ice Core Precipitation Record. *World Archaeology* 22(3): 247-270.
- Silverman, H.
1986 *Cahuachi: An Andean Ceremonial Center*. Ph.D. dissertation, University of Texas, Austin. University Microfilms International, Ann Arbor.
1990 Beyond the Pampa: The Geoglyphs in the Valleys of Nazca. *National Geographic Research and Exploration* 6(4):435-456.
- Strong, W. D.
1957 *Paracas, Nazca, and Tiahuanacoid Cultural Relationships in South Coastal Peru*. SAA Memoirs No. 13. Society for American Archaeology, Washington, D.C.
- Stuiver, M., and P. J. Reimer
1993 Extended ¹⁴C database and revised Calib 3.0 ¹⁴C age calibration program. *Radiocarbon* 35:215-230.
- Taylor, R. E.
1987 *Radiocarbon Dating: An Archaeological Perspective*. Academic Press, Orlando, Florida.
- Thompson, L. G., E. Moseley-Thompson, J. F. Bolzan, and B. R. Koci
1985 A 1500-Year Record of Tropical Precipitation in Ice Cores from Quelccaya Ice Cap. *Science* 229: 971-973.
- Trimborn, H.
1967 Probleme der andinen Bewässerungswirtschaft. *Jahrbuch der Geschichte von Staate, Wirtschaft un Gesellschaft Lateinamerikas* 4:1-16.
- Urton, G.
1981 Nazca Report. Manuscript on file, Department of Anthropology, Colgate University.
1982 Report of Fieldwork in Nazca, Peru—January, 1982. Manuscript on file, Department of Anthropology, Colgate University.
1990 *The History of a Myth: Pacariqtambo and the Origin of the Inkas*. University of Texas Press, Austin.
- von Humboldt, A.
1907 [1812] *Personal Narrative of Travels to the Equinoctial Regions of America*, vol II. Translated and edited by T. Ross. George Bell & Sons, London.

Received July 23, 1993; accepted March 31, 1994.