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CULTURAL DYNAMICS, CLIMATE, AND LANDSCAPE IN THE SOUTH-CENTRAL ANDES DURING THE MID-LATE HOLOCENE: A CONSIDERATION OF TWO SOCIO-NATURAL PERSPECTIVES*

DINÁMICA CULTURAL, CLIMÁTICA Y PAISAJISTA EN LOS ANDES SUR-CENTRALES DURANTE EL HOLOCENO MEDIO Y TARDÍO: ANÁLISIS DE DOS PERSPECTIVAS SOCIO-NATURALES

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Through a case study focusing on the Rio Ilave, Lake Titicaca Basin, Peru, this paper examines the Mid-Late Holocene climatic transition and the Archaic-Formative cultural transition as a means to evaluate two seemingly competing socio-natural theories for accelerated cultural change: resource stress and abundance. Stress based approaches emphasize the principle that experimentation, that may lead to behavioral adaptations, arises out of attempts to solve specific problems. Alternatively, abundance based approaches assert that rates of cultural change accelerate when material constraints or limits are eased. Results from the present case study indicate that during the relatively resource stressed arid Mid-Holocene, several new cultural practices developed: reduced residential mobility, storage, domestication, and intensified plant processing. During the succeeding moist and relatively resource abundant Late-Holocene, these new cultural practices greatly intensified. These intensified economic activities resulted in deforestation, and this in turn created new forms of environmental stress. Thus, experimentation occurred during a period of stress. This was followed by a relaxation of material constraints that led to intensification of the new economic activities. This intensification in turn appears to have generated new kinds of stress. This case study shows that, rather than forming competing theories, stress and abundance approaches explain different kinds and contexts of accelerated cultural change.

Key words: Archaic, climate change.

Este estudio se centra en el río Ilave, cuenca del Lago Titicaca, Perú, y examina la transición climática del Holoceno Medio-Tardío y la transición cultural Arcaico-Formativo. Esto con el objeto de evaluar las teorías socio-naturales, aparentemente competitivas, del estrés y la abundancia de recursos, que tratan de explicar cambios culturales acelerados. Enfoques basados en el estrés de recursos hacen hincapié en el principio de que la experimentación puede llevar a desarrollar comportamientos adaptativos para resolver problemas específicos. Por otra parte, los enfoques basados en la disponibilidad de recursos abundantes afirman que las tasas de cambio cultural se aceleran cuando se reducen los límites y limitaciones materiales. Los resultados del estudio de caso indican que durante el Holoceno Medio, de condiciones relativamente estresantes, se desarrollaron nuevas prácticas culturales: reducción de movilidad residencial, almacenamiento, domesticación e intensificación del procesamiento de plantas. Durante el subsiguiente periodo, Holoceno Tardío, de condiciones más húmedas y relativamente con mayor abundancia de recursos, las nuevas prácticas culturales se intensificaron. La intensificación de estas actividades económicas provocó deforestación, lo que a su vez generó nuevas formas de estrés ambiental. En suma, se verificó experimentación durante el período de estrés, lo que fue seguido por una reducción de las restricciones materiales, que permitió la intensificación de las nuevas actividades económicas. Esta intensificación, a su vez parece haber generado nuevos tipos de estrés. Este estudio de caso muestra que, más que formular teorías competitivas, los modelos de estrés y abundancia explican que los cambios culturales acelerados se producen en distintos contextos.

Palabras claves*: Arcaico, cambios climáticos, teorías de estrés y abundancia.*

Because it is one of the only means to examine the causes and consequences of long sequences of cultural change (van der Leeuw and Redman 2002), archaeology is an important academic pursuit. It is one that can have relevance to the present, especially in the context of understanding cultural responses to climate change. Thus, case studies that inform on the relationships between cultural and climatic

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changes are of particular importance. The case study addressed in this paper examines the Late and Terminal Archaic period occupations of the Rio Ilave drainage (Figure 1) in relation to climate changes that occurred during the Mid-Late Holocene transition. Two general socio-natural theories of cultural change are examined in light of the archaeological and climatic record from this region.

In the Andean highlands, the Archaic and Early Formative Periods represent an extremely important cultural trajectory for several reasons. This is the only region in the Americas that involved domesticating megafauna and using their secondary products (Mengoni Goñalons and Yacobaccio 2006; Wheeler et al. 2006). The cultural trajectory of this region led to the domestication of several major New World crop plants including chenopods and potatoes (Bruno 2006, 2008; Spooner et al. 2005). Several states and empires eventually developed within the Andean highlands (Stanish 2001, 2003). The circum-Titicaca region, which comprises the specific emphasis of Archaic culture described in this paper, factors into each of these major cultural developments (domestication and cultural complexity).

Much of the prior research on the Archaic of the highlands focused on cave and rock shelter sites from the Central Andes (Cardich 2006; Lavallée et al. 1985; Lynch 1971; MacNeish et al. 1980; Rick 1980, 1988). These investigations form an important intellectual foundation. However, because activities at cave and rock shelter sites are confined and structured by the extent of the cave walls, these contexts provide a limited view of ancient residential spaces (Moore 1988:154). Excavations from the Rio Ilave that are described in this paper (Aldenderfer and Barreto 2002, 2003, 2004; Aldenderfer and de la Vega 1999; Craig 2005) focus on systematic subsurface investigation of Archaic open air sites in the Lake Titicaca Basin (3,810 masl) (Figure 1). These data provide an additional point of observation for understanding the Archaic period in an important part of the Andean highlands. Yet, it will be clear that much remains to be known about the Archaic Period of the Rio Ilave specifically and the Andean highlands in general. This knowledge can only be achieved by sustained systematic research on this critical early cultural period. It is hoped that this paper will shed light on some issues and help to provide focus to a new battery of questions.

A Comparative Background

Given the incomplete state of knowledge regarding the Titicaca Basin Archaic, it is productive to reflect on what approaches have been successful in advancing knowledge in well studied regions. The Archaic and Early Formative Periods are well studied in the Near East (Simmons 2007; Zeder 2009), the U.S. Southwest (Simmons 2006; Wills 1995, 2001), the U.S. Southeast (Gibson 2006; Smith 2007), and Mesoamerica (Joyce and Henderson 2001; Voorhies 2004). The accumulation of knowledge from these regions demonstrates that whether it be climate change, demographic stress, ideological factors, or social striving –no single prime mover is capable of fully explaining the shift from mobile hunting groups to more sedentary farming villages. Rather, the transition involves the localized mutually reinforcing convergence of social, economic, and environmental factors.

While a theoretical appeal to prime movers may be epistemologically simplistic, in each world area mentioned above, climate change has been identified as playing a role in creating differing conditions of both challenge and opportunity. Yet, syntheses of well studied regions also show that specific responses to climate change are highly conditional in ways that can only be detected through detailed comparisons of local trajectories (Zeder 2009). For example, in the Near East during the arid Younger Dryas there was increased residential mobility in the southern Levant while at the same time the first early villages formed in the northern Levant (Byrd 2005; Simmons 2007; Zeder 2009). Based on the present state of knowledge in well studied regions it seems that: given local conditions, the same global climate change has had two very different responses within different parts of a single world region.

With respect to both cultural and climatic perspectives in the Andean Highlands, the Archaic foragers and Early Formative food producers of the Mid-Late Holocene Period represent a truly fascinating mosaic of complex interacting components. My discussion focuses on the Rio Ilave drainage in the Lake Titicaca Basin (Figure 1). The climatic record is much more finely resolved than the cultural sequences. Yet, even the environmental record is not clear cut and some of the ambiguities entail complex human-environmental feedbacks that I will discuss further on.

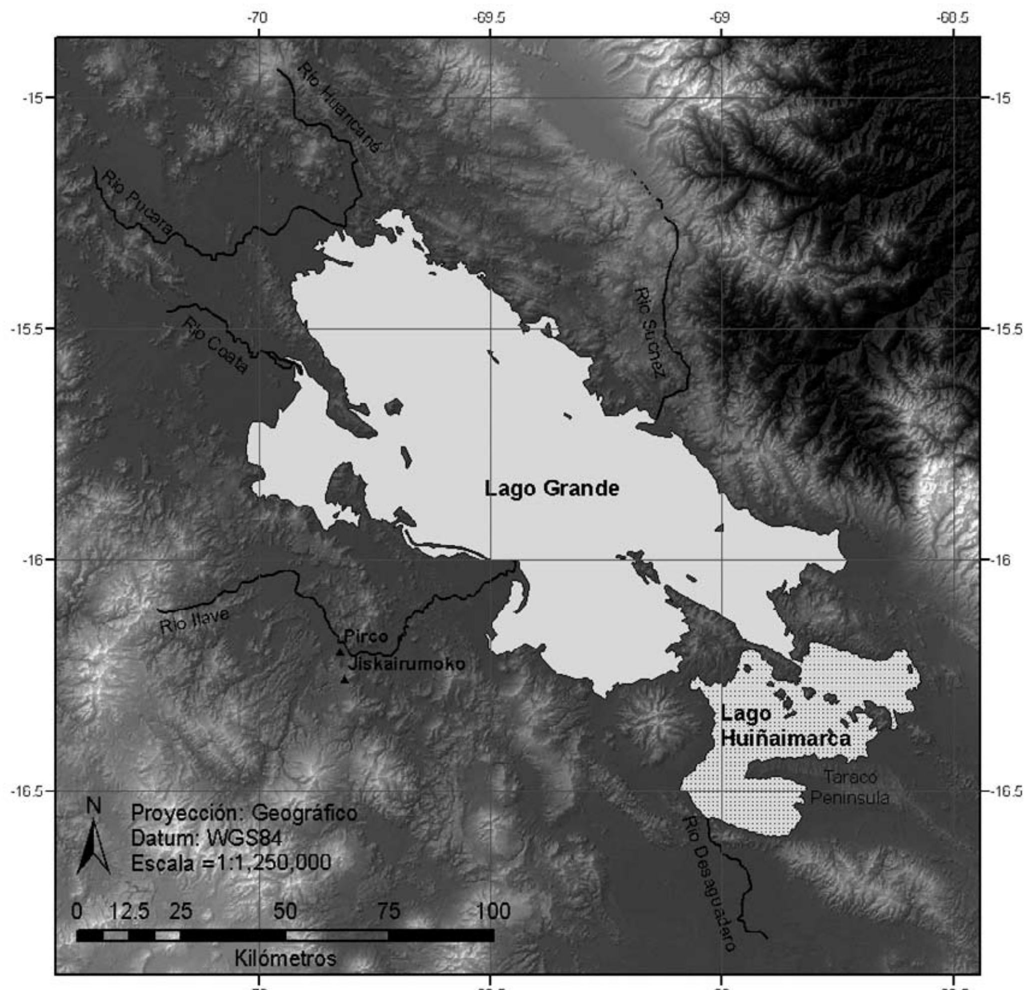

Figure 1. Regional map showing the two main basins of Lake Titicaca, the five major rivers that drain into the lake, the effluent Rio Desaguadero, the Taraco Peninsula, and the two main archaeological sites discussed in the text.
Mapa regional que muestra las dos cuencas principales del Lago Titicaca, los cinco ríos principales que desembocan en el lago, el río afluente Desaguadero, la Península de Taraco, y los dos sitios arqueológicos principales discutidos en el texto.

Two Socio-Natural Theoretical Perspectives on Cultural Change

In reviewing socio-natural theories for culture change, one can identify what appear to be two competing expectations regarding either physical or environmental stress. I dub these (1) stress and (2) abundance induced perspectives on accelerated cultural change. Adopting the perspective of "multiple working hypotheses" (Chamberlin 1890), I hope to present a discussion that illustrates that both conditions played a role in the processes of change in the Rio Ilave during the Archaic period. First, I begin with a discussion of each of the two general theoretical perspectives.

(1) Stress induced accelerated change theory proceeds from the expectation that culture is a behavioral adaptation and that specific socio-cultural complexes arise to solve adaptive problems (Binford 1983; Browman 1974:469; Jones et al. 1999; Keeley 1988:376; Rosenberg 1998). A fundamental assumption is that culture does not change *sui generis* (White 1959). Cultures change to address challenges. If there are no or few challenges, there

is no catalyst to alter behavior. Periods and contexts characterized by high levels of stress likely correspond to contexts of cultural experimentation and change. Cases where these innovative changes are successful could be called "adaptive". This general perspective is widely shared across circumscription theory (Carneiro 1970, 1986, 1987, 1988, 1992), is canonical for classic Binfordian processualisim (Binford 1965, 1983, 2001; White 1959), and is also evident in optimal foraging theory (Bettinger 1999; Bettinger and Baumhoff 1982, 1983; Foley 1985; Winterhalder 1983; Winterhalder and Goland 1997; Winterhalder and Smith 2000). For example, in optimal foraging theory –individuals are expected to eat the highest ranked prey first. These are food sources that come in large packages and do not incur high post encounter processing costs. As search costs increase, individuals begin to forage on lower ranked resources that have higher processing costs. What stimulates the shift from one foraging pattern to another? It is an increase search cost-scarcity stimulates change.

(2) Abundance induced accelerated change theories proceed from a very different basic assumption. I believe that, as applied in archaeology, multifarious though they may be, abundance induced perspectives on accelerated cultural change descend largely from possibilist thinking. The theory of environmental possibilism developed in light of critiques leveled against environmental determinism. Possibilism has its origins in cultural geography, but its influences are clearly felt within anthropology and archaeology (albeit in different ways by different investigators) (Hardesty 1977:4; Harris 1968:266; Higgs and Jarman 1969, 1972; Jarman 1976; Kroeber 1963; Meggers 1954; Steward 1955; Wedel 1941).

In his famous essay "Constraint and Freedom: Breaking and Entering the Ecosystem" the late Bruce Trigger (1991) discussed human-environmental interaction from an explicitly possibilist perspective. Trigger suggested that during periods of stress, there was greater constraint on experimentation, aggrandizing, politicization, and other dimensions of cultural change. Conversely, during periods of abundance, physical constraints on experimentation, aggrandizing, and politicization are relaxed. Flux between the two states is expected. Still, slow rates of change with little population growth are expected for resource poor contexts of constraint. Rapid rates of change and high population growth are expected during periods of freedom when constraints are loosened. For example, practitioners of the Cambridge paleoeconomy school interpreted the shift from Palaeolithic hunters to Neolithic farmers through the lens of possibilism concluding that early Neolithic villages were correlated with the distribution of high quality soils (Jarman et al. 1982). Productivity essentially made the transition possible. The more recent floodplain expansion model for the development of agriculture also exhibits possibilist logic (Davis et al. 2000:783; Freeman 2000:582; Huckell 1990, 1996; Smith et al. 1992). According to this model, widespread reliance on domesticated chenopods in the Southeastern US or maize in the Southwest was only possible after climate amelioration led to greater productivity of the riparian zone. This increased environmental productivity set in motion other changes like storage, population growth, and the development of complexity.

The Mid-Late Holocene Palaeoenvironmental Record of the Lake Titicaca Basin

So what does all this mean for the highland Archaic? Quite a lot I believe. As the discussion will show, the Andean highland Middle Archaic is firmly in the Mid-Holocene, but the Terminal Archaic and Early Formative are squarely in the Late-Holocene. These climatic and cultural transitions were both major in scope. During this climatically dynamic period, how did stress and abundance play roles in stimulating or constraining rates of cultural change? In this section, from the perspective of the Lake Titicaca Basin, I will discuss the paleoclimatic and paleoenvironmental contexts. In the following section, from the perspective of the Rio Ilave, I will discuss the cultural changes.

Multi-proxy data from Lake Titicaca (3810 masl) (Baker, Rigsby et al. 2001; Baker, Seltzer et al. 2001), and oxygen isotopic data from Lake Junín (4,300 masl) (Seltzer et al. 2000) show that the central and southern Peruvian highlands were significantly more arid during the Early and Middle Holocene than the region is today. Analysis of cored sediments from both Lakes Junín and Titicaca indicate peak aridity at the onset of the Holocene followed by gradual amelioration throughout the Holocene. This general trend was punctuated by multi-centennial periods of significantly higher- or lower-than-average precipitation (Baker et al. 2005; Baker et al. 2009; Ekdahl et al. 2008; Seltzer et al. 2000).

Some palaeoclimate records indicate slightly greater effective moisture during the Mid-Holocene. These proxies include shoreline deposits from Lake Aricota (Placzek et al. 2001) along with rodent middens from near Arequipa (Holmgren et al. 2001) and from Atacama (Betancourt et al. 2000). The cause or causes for these apparent discrepancies remains unclear. However, these records indicate only "moderately wetter than modern climate" (Placzek et al. 2001:189); this variation may be attributable to the punctuated multi-centennial periods of higher or lower than average precipitation mentioned above. Overall, multiproxy data indicate that the Mid-Holocene was significantly more arid than today. Still, variations like those revealed by the Lake Aricota shoreline sequence (Placzek et al. 2001) highlights the need for local proxies. Having considered both broad patterns and the potential for local variation, the following discussion of the palaeoclimatic record focuses specifically on Lake Titicaca basin and emphasizes the Rio Ilave.

Between 6050-2050 cal BC the water level in Lake Titicaca was 50-100m lower than today (Figure 2)[1]. Sediment cores and seismic-reflection data indicate the Early-Middle Holocene maximum lowstand occurred about ca. 3350 cal BC, and lake levels were between 85-100m lower than present (Cross et al. 2000; Cross et al. 2001; Grove et al. 2003). During the Mid-Holocene, Lago Huiñaimarca completely desiccated (see Figure 1). A significant decrease in effective moisture occurred during the Mid-Holocene (Cross et al. 2001; Talbi et al. 1999:198), and predicted mean rain fall during the maximum lowstand would have been between 20% (Talbi et al. 1999) to 40% (Cross et al. 2001) less than the modern amount.

After ca. 3050 cal BC generally wetter conditions prevailed in the Titicaca Basin (Baker et al.

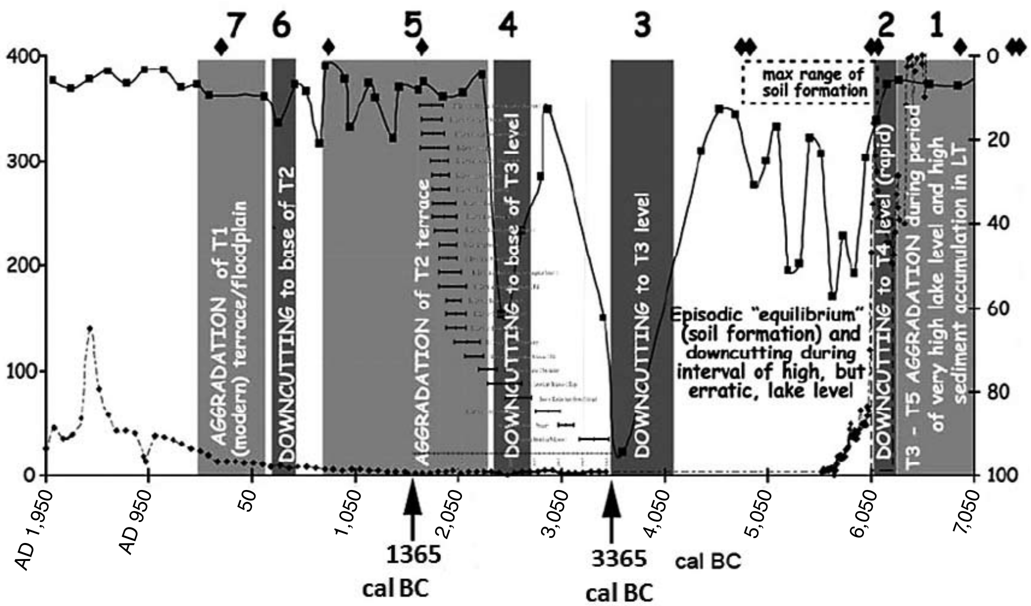

Figure 2. Lake Titicaca Level, Rio Ilave Terraces, and Jiskairumoko radiocarbon dates. Changes in lake level over time are shown by the solid black line at the top of the figure; these data derive from Baker, Seltzer et al. (2001). The episodes of aggradation and downcutting that produced the terrace sequence of the Ilave River are shown as numbered grey blocks; these data are derived from Rigsby et al. (2003). The radiocarbon dates from Jiskairumoko are shown as a series of horizontal bars (see also Table 3). The beginning and ending dates for the occupation of Jiskairumoko are annotated with arrows. Data for the occupation of Jiskairumoko are derived from Craig (2005) and Aldenderfer et al. (2008). Figure adapted from Rigsby et al. (2003: Figure 12).

Nivel del Lago Titicaca, terrazas del río Ilave y fechas radiocarbónicas de Jiskairumoko. Los cambios en el nivel del lago a través del tiempo se muestran con la línea negra continua en la parte superior de la figura; estos datos se derivan de Baker, Seltzer et al. (2001). Los episodios de agradación y erosión fluvial que produjo la secuencia de la terraza del río Ilave se muestran con barras grises numeradas; estos datos se derivan de Rigsby et al. (2003). Las fechas de radiocarbono de Jiskairumoko se muestran con una serie de barras horizontales (ver también Tabla 3). Las fechas de inicio y fin de la ocupación de Jiskairumoko están anotadas con flechas. Los datos de la ocupación de Jiskairumoko se derivan de Craig (2005) y Aldenderfer et al. (2008). Figura adaptada de Rigsby et al. (2003: Figura 12).

2005; Baker, Seltzer et al. 2001), and modern climate conditions were established after ca. 2050 cal B.C (Figure 2). Sediment facies analysis of strata from the northern section of the Rio Desaguadero valley indicate a moist period about 2050 cal BC (Baucom and Rigsby 1999). From 1600-1350 cal BC water levels in both Lago Grande and Lago Huiñaimarca rose (Abbott, Binford et al. 1997; Abbott, Seltzer et al. 1997; Cross et al. 2000; Mourguiart et al. 1992; Schwalb et al. 1999; Seltzer et al. 1998).

Five major river systems feed into Lake Titicaca (Roche et al. 1992:64) (see Figure 1). These are: Ramis, Coata, Ilave, Huancané, and Suchez (Grove et al. 2003:293). The Rio Ilave has the lowest relative flow of these. Fluvial geomorphological research in the Rio Ilave sheds light on the relationships between paleoprecipitation and landscape change (Baker, Seltzer et al. 2001; Rigsby et al. 2003).

Downcutting occurred from ca. 6,300 cal BC to ca. 4,830 cal BC producing a T4 structure. By ca. 4,830 cal BC, a T4 equilibrium phase developed (see Figure 2). This phase probably corresponds to the wetter period occurring sometime between ca. 5,050 cal BC and ca. 4,050 cal BC that was identified in the diatom record from sediment cores from Lago Grande (Baker, Seltzer et al. 2001). Downcutting occurred again at ca. 4,050 cal BC to ca. 2,050 cal BC (Rigsby et al. 2003:179). These episodes probably correlate with decreasing rainfall and lowering lake levels, perhaps correlating with the major lowstand that occurred about ca. 3,350 cal BC.

T2 and T1 aggradation occurred from ca. 1,950 cal BC up to ca. 550 cal BC and then again from ca. 250 cal BC to AD 350. These events correlate with periods of rising water levels in Lake Titicaca as well as with sedimentation in the Desaguadero valley and in the Rio Ilave delta. These latter two episodes are separated by brief equilibrium periods and brief downcutting events (Rigsby et al. 2003:180).

Analysis of pollen and charcoal from sediment cored from Lake Titicaca provides information on landcover changes. Pollen spectra are consistent with a Mid-Holocene arid period lasting from roughly 6,010-1,950 cal BC. During this time, Poaceae and *Polylepis* pollen replaced Cyperaceae (which includes *totora*) as the dominant taxa in the pollen assemblage (Paduano et al. 2003). Though this period is characterized as unusually spiky, the transition from Cyperaceae to *Polylepis* is likely associated with these trees invading the muds exposed by falling lake levels (Paduano et al. 2003:274). At this time, the Altiplano appears to have been covered with trees.

Between 1,950-1,150 cal BC the climate becomes moister and this is reflected also by an increase in pollen associated with moist conditions (Apiaceae, *Alnus, Acalypha*) (Paduano et al. 2003:273). After 1,750 cal BC there is an increase in Cyperaceae signaling the infilling of the lake and a flooding of the marshes on the western littoral (Paduano et al. 2003). About 1,150 cal BC there is a drop in arboreal pollen species, which likely indicates a decline in forested landcover. Fine particulate charcoal increases between 2,050-650 cal BC. It then declines in frequency and eventually disappears after about 50 cal BC.

The Archaic Occupation of the Rio Ilave

During the mid-Holocene, a *silencio arqueológico* has been detected for some parts of the southern Andean highlands, specifically portions of the Salar de Atacama south of Lake Titicaca (Núñez et al. 2002:822; Núñez and Santoro 2011, in this issue). This *silencio* is typified by an absence of sites during the Mid-Holocene and is interpreted as a regional abandonment. The *silencio arqueológico* model could serve as an appropriate characterization of some portions of the Lake Titicaca Basin, specifically the area surrounding the small and shallow Lago Huiñaimarca sub-basin. For example, full coverage survey of the Taraco Peninsula (Figure 1), a landform that extends into Lago Huiñaimarca, failed to identify a single Archaic Period site (Bandy 2001:87, 2005:215). Thus it seems that during the Mid-Holocene, some portions of the Lake Titicaca Basin were either abandoned or not occupied. However, survey and excavation data from the Rio Ilave drainage that are discussed below show a steady rise in settlement during the Mid-Holocene. This indicates that a *silencio* model of abandonment does not characterize the Mid-Holocene settlement patterns for some areas around the main basin of Lake Titicaca.

Survey

Though the Rio Ilave is the smallest and driest of the rivers that drain into Lake Titicaca (Grove et al. 2003:293), survey and excavation reveal that this

Table 1. Component counts are based on the Klink and Aldenderfer (2005) projectile point typology. Point types diagnostic to a given temporal period that are used to derive count data are reported as is the component count total for each temporal period. Counts are temporally calibrated by dividing the raw component count by the number of years represented by the temporal period; this product is then multiplied by 100 to produce a site deposition probability. Table adapted from Craig (2005, Table 8.1).
El número de componentes se basa en la tipología de puntas de proyectil de Klink y Aldenderfer (2005). Los tipos de puntas diagnósticas de un período determinado se utiliza para obtener datos de frecuencia que se registran como recuento total del componente para cada período. La cantidad es calibrada temporalmente dividiendo el número bruto de componentes por el número de años que representa el periodo, este producto se multiplica por 100 para producir una probabilidad de deposición del sitio. Tabla adaptada de Craig (2005, Tabla 8.1).

Temporal Period	Early Archaic 10,000-7,000 BC	Early-Middle Archaic 10,000-5,000 BC	Middle Archaic 7,000-5,000 BC	Late Archaic 5,000-3,100 BC	Terminal Archaic 3,100-2,300 BC
Temporal Span	2600	4800	2000	1800	800
Diagnostic Point Types	1A, 1B, 4A	2A, 3A	2C, 3B	3F, 4D	4F, 5A
Number of Sites at which point types are found	23	13	49	55	19
Temporally calibrated count/deposition probability	0.88	0.27	2.45	3.1	2.37

Table 2. Summary of projectile points collected from the surface during the pedestrian survey of the Rio Ilave drainage (Aldenderfer and de la Vega 1997). Point types are based on the Klink and Aldenderfer (2005) typology. EA = Early Archaic, EA-MA = Early-Middle Archaic, MA = Middle Archaic, LA = Late Archaic, LA-TA = Late-Terminal Archaic, TA-F = Terminal Archaic-Formative. Table adapted from Craig (2005:473, Table 8.2).
Resumen de las puntas de proyectil recogidas de la superficie durante el estudio de prospección de la cuenca del río Ilave (Aldenderfer y De la Vega 1997). Los tipos de puntas se basan en la tipología de Klink y Aldenderfer (2005). EA = Arcaico Temprano, EA-MA = Arcaico Temprano - Medio, MA = Arcaico Medio, LA = Arcaico Tardío, LA-TA = Arcaico Tardío - Terminal, TA-F = Arcaico Terminal - Formativo. Tabla adaptada de Craig (2005:473, Tabla 8.2).

Type	Temporal Span (BC)	Period	Number Points	Number of Sites where type is found	Mean number of points per site	Number of points per site scaled by time period
1A	1,000-7,000 BC	EA	7	7	2	0.35
1B	1,000-7,000 BC	EA	18	16	1.13	0.9
4A	1,000-7,000 BC	EA	3	3	1	0.15
3A	9,700-4,900 BC	EA-MA	13	10	1.3	0.33
2A	8,100-5,900 BC	Ea-MA	5	4	1.25	0.25
2C	6,900-4,900 BC	MA	16	12	1.33	0.8
3B	4,600-4,900 BC	MA	83	42	1.98	4.15
4D	4,900-3,100 BC	LA	78	37	2.11	4.88
3F	4,900-3,100 BC	LA	69	28	2.46	4.31
4F	3,800-1,900 BC	LA-TA	20	12	1.66	1.43
5A	3,100-1,900 BC	TA	8	7	1.14	1
5C	3,100 BC- AD 500	TA-F	29	16	1.45	0.3
5D	??		16	11	2.54	2.5

drainage was occupied throughout the Mid-Holocene (Aldenderfer and de la Vega 1996; Craig 2005, 2009; Craig et al. 2010; Klink 1998, 2005; Klink and Aldenderfer 1996; Tripcevich 2002). Population expansion occurred from the Early to the Late Archaic (Tables 1 and 2). This was followed by settlement aggregation during the Terminal Archaic and then “filling in” during the Early Formative.

In the Rio Ilave, field work recovered few Early Archaic points (Figure 3, Tables 1 and 2). This suggests light occupation, high residential mobility, and little occupational redundancy (Craig 2005). The Middle Archaic is characterized by an increase in the number of sites, the number of points, and a slight rise in the number of points per site (Tables 1 and 2). The increase in the number of sites is interpreted as

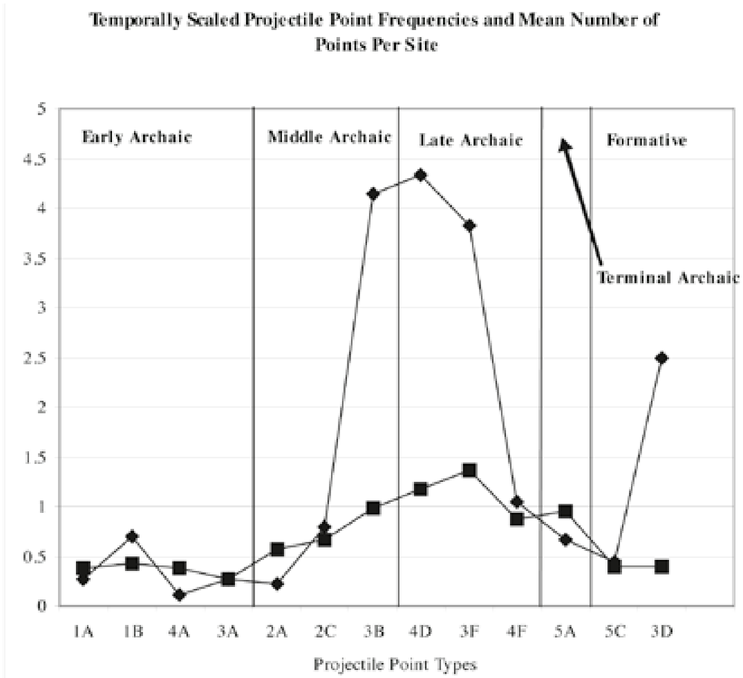

Figure 3. Temporally scaled projectile point frequencies and mean number of points per site. Diamonds represent projectile point count divided by the duration of the temporally diagnostic period of time. Squares represent average number of points per site divided by the duration of the temporally diagnostic period of time. Figure adapted from Craig (2005:474).
Escala temporal de la frecuencia de puntas de proyectil promedio por sitio. Los diamantes representan el recuento de puntas de proyectil dividido por la duración temporal del periodo diagnóstico. Los cuadrados representan el número promedio de puntas por sitio dividido por la duración del período diagnóstico. Figura adaptada de Craig (2005:474).

an indication of population growth and fissioning. The increase in the number of points per site is interpreted as an indication of longer residential stays or greater occupational redundancy (Craig 2005:470). The Middle Archaic corresponds temporally with an overall period of Mid-Holocene aridity, the time that some other parts of the Altiplano experience a *silencio arqueológico.*

The Late Archaic exhibits an increase in the number of sites and the number of points produced during the time period (Tables 1 and 2). Based on the Rio Ilave survey, the Late Archaic also boasts the highest number of points per site of any time period. The very end of the Late Archaic corresponds with a period of lake level resurgence (Baker, Seltzer et al. 2001) and fluvial aggradation (Rigsby et al. 2003).

In the Rio Ilave, the number of sites declines during the Terminal Archaic (2,300-1,650 BC) (Tables 1 and 2), and this is interpreted as settlement aggregation (Aldenderfer and de la Vega 1996; Klink and Aldenderfer 1996). There are a low number of points overall, and there is a slight decline in the number of points per site since the Late Archaic (Craig 2005). Based on what is known from neighboring regions, camelids were probably domesticated by this time (Aldenderfer 1998:131, 266, 2002:394; Rick 1980; Wheeler 1999:304). Near the Lake Titicaca Basin, the earliest direct evidence for camelid penning comes from a corral encountered in Level IV from the Awati Phase at Asana; this corral dated to ca. 3,000 cal BC (Aldenderfer 1998:131, 266). A decline in the importance of hunting likely occurred after the onset of pastoralism. This may explain why in the Rio Ilave fewer projectile points were produced during the Terminal Archaic (Table 2).

During this period, there is a marked increase in the use of obsidian (Craig 2005:475). Sourcing studies demonstrate that nearly all of the obsidian found in the Rio Ilave comes from the Chivay source (Burger et al. 2000; Craig 2005:683;

Craig et al. 2007; Shackley et al. 2004; Tripcevich 2007). Survey and excavation show that in the Rio Ilave, obsidian was largely used to produce projectile points (Craig 2005:684-685, 2009). Comparing tools made out of obsidian vs. tools not made out of obsidian, the difference is significant $\chi^2(4, N= 875) = 45.4\ p < 0.001$; obsidian is about twice as often made into projectile points as other materials. Thus, a non-local tool stone (Chivay obsidian) was used to create a form of technology that, due to the onset of pastoralism, was probably being used less-projectile points. Further, Chi-square shows that obsidian points exhibit serrated and denticulated edge embellishments at significantly higher rates than do non-obsidian points $\chi^2(1, N= 293) = 33.1\ p < 0.001$. Thus, obsidian points were often decorated in ways that non-obsidian points were not. Together, these patterns suggest that there were some very important social relations underlying the use of obsidian and the exchange networks through which it was transported (Craig 2005). It seems very likely that camelids facilitated the transport of larger quantities of goods. The Terminal Archaic is within the period of lake level resurgence and fluvial aggradation (Baker, Seltzer et al. 2001; Rigsby et al. 2003) (Figure 2).

Excavation

Pirco and Jiskairumoko (4,115 masl) are two sites in the Rio Ilave that were variously excavated by myself, Mark Aldenderfer, Mary Barreto, Cindy Klink, Jake Fox, Nico Tripcevich, Edmundo de la Vega, and William Yepez (Aldenderfer and Barreto 2002, 2003, 2004; Aldenderfer and Yepez 2001; Craig 2005) (Figure 1). Pirco is a small Late Archaic site (Craig 2005:410-451). The occupation of Pirco is not directly dated but projectile point styles (Klink and Aldenderfer 2005) indicate that the occupation is earlier than Jiskairumoko and is in the earlier part of the Late Archaic (Craig 2005:395-398). Jiskairumoko straddles the Late Archaic-Early Formative transition (Aldenderfer et al. 2008; Craig 2005:439). As described above, survey data indicates that this was a period of population growth (Aldenderfer and de la Vega 1996; Klink 1998; Klink and Aldenderfer 1996). During the Late Archaic, Jiskairumoko was first detectably occupied by people who resided in pithouses (Figure 4). By the end of the occupation, during the Early Formative, inhabitants of the site resided in above ground rectangular structures (Figure 5). This is a classic architectural change (Byrd 1994; Flannery 1972, 2002) that has been observed in many parts of the world including the Near East (Byrd 2005) and the US Southwest (McGuire and Schiffer 1983; Schiffer and McGuire 1992; Wills 2001) to name but a couple. Radiocarbon dates from Jiskairumoko range in time from ca. 3,300-1,400 cal BC (Craig 2005:430-431, Table 7.5) (Table 3). Therefore, occupation of the site also straddles the Mid-Late Holocene climatic transition that was described above. At the outset of the occupation, environmental conditions were more arid than today (Baker, Seltzer et al. 2001) –an environmental context of stress. By the time Jiskairumoko was abandoned there was more precipitation than today (Baker, Seltzer et al. 2001)– in other words greater abundance. Cultural changes at Jiskairumoko were rapid. How did the alternate perspectives of stress and abundance induced cultural change play out at Pirco and Jiskairumoko?

Pirco is a small lithic scatter located on a slight rise on the southern margin of the upper Rio Ilave (Craig 2005:410-412, 516-539) (Figure 6). Organic standing, arrangements of fire altered rock, and debitage scatters indicated an ephemeral base camp (Craig 2005:528-535, 539-540). Soil stains indicated the likely presence of shelters, but there appears to have been little investment in durable infrastructure. Excavations recovered only a few pieces of groundstone. One very badly eroded grave was encountered (Craig 2005:533). No grave goods were encountered. Organic preservation at the site was very poor. From what remains, the site looks to be a temporary or short term camp. The presence of the groundstone and the burial suggest that families were present and that people probably returned to this location.

Despite numerous GPR surveys at Pirco (Craig 2005:516-521), no storage pits were encountered. In the lithic assemblage, there is very little obsidian. This suggests that long distance trade goods were circulating, but they were not yet regularly transported in large quantities.

Compared to Pirco, Jiskairumoko contains much more material culture (Craig 2005:541-678) (Figure 7). All of the houses are much more durable. Hearths were built to be reused. Storage is present. There is much more groundstone. Domesticated chenopods were recovered. Throughout the occupation of Jiskairumoko, there is much more obsidian than was present at Pirco.

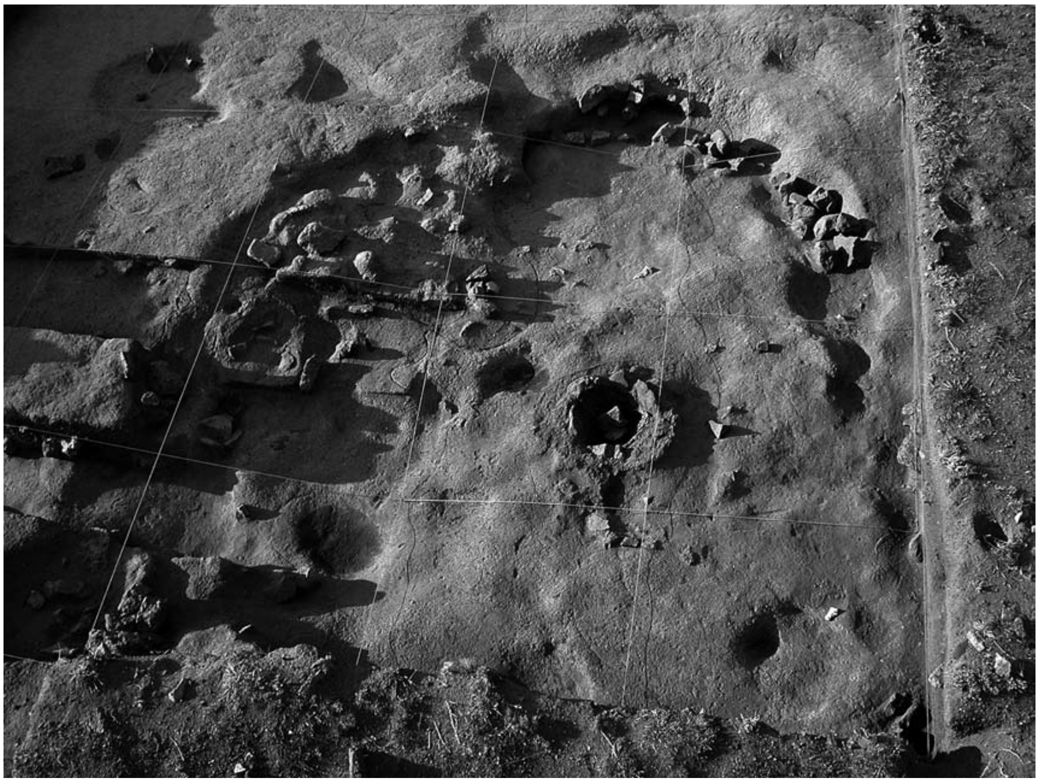

Figure 4. Late Archaic pithouse, block 9 looking northward, Jiskairumoko. Note the stone lined central hearth and several small internal storage pits. In this photograph the pits have not yet been completely excavated. Photograph by Nathan Craig.
Casa subterránea 1 del Arcaico Tardío, bloque 9, mirando Jiskairumoko hacia el norte. Note el fogón central delineado por piedras y varios pequeños pozos de almacenamiento interno. En esta fotografía, los pozos aún no han sido totalmente excavados. Fotografía de Nathan Craig.

Three radiocarbon dates from Jiskairumoko have calibrated ranges that extend into the Mid-Holocene arid period that persisted up until 3,050 cal BC (Table 3). One of the dates is from the hearth of Late Archaic Pithouse 1 (Craig 2005:566; Craig et al. 2006) and one of the other dates is from Burial 1. This burial is adjacent to terminal Archaic Phase 1 Pithouse 2 (Craig 2005:586). The close spatial association between Late Archaic Burial 1 and terminal Archaic Phase 1 Pithouse 2 suggests continuity between the Late and Terminal Archaic occupations of the site.

Compared to the ephemeral architecture from Pirco, the pithouses at Jiskairumoko indicate reduced residential mobility (Craig 2005). Thus at present, the dates from Pithouse 1 and Burial 2 indicate the earliest evidence for reduced residential mobility in the Lake Titicaca Basin. They also demonstrate that in the Rio Ilave, the transition to reduced residential mobility occurred during the arid Mid-Holocene sometime slightly after the lowstand at 3,350 cal BC during which the Rio Ilave was downcutting (Rigsby et al. 2003). This corresponds temporally with the tail end of the *silencio arqueológico* that is recorded in the Salar de Atacama.

Of the pithouses encountered at Jiskairumoko, Pithouse 1 is the largest and most deeply dug (Craig 2005:577) (Figure 4). This structure contained several internal storage pits, a well formed hearth, a clearly defined kitchen area (Craig et al. 2006), intensively used groundstone tools (Rumold 2010), obsidian from the Chivay source (Craig et al. 2007), abundant evidence for the use of ochre (Popelka-Filcoff et al. 2007), and numerous plant rasps (Haas et al. 2009).

At Jiskairumoko, GPR surveys performed in concert with excavations revealed that Pithouse 1 was not alone (Craig 2005:541-549) (Figure 7).

Figure 5. Early Formative rectangular structure 1, block 4 looking northward, Jiskairumoko. Note the lack of either an interior stone lined hearth or storage pits. Note also the presence of a kitchen rock located in the lower corner of the structure. Dark and heavy midden staining is visible outside the structure. Photograph by Nathan Craig.
Estructura rectangular 1 del Formativo Temprano, bloque 4, mirando Jiskairumoko hacia el norte. Note la ausencia de fogón central y de pozos de almacenamiento interior. Note, también, la presencia de una roca de cocina ubicada en la esquina inferior de la estructura. Una mancha oscura de basural es visible fuera de la estructura. Fotografía de Nathan Craig.

In an organized manner, at least two and probably three (see below) Terminal Archaic Phase 1 pithouses were built around Pithouse 1, and Pithouse 1 remained in use well into the succeeding Terminal Archaic Phase 1.

The Late Archaic Burial 1 is in close spatial association with Terminal Archaic Phase 1 Pithouse 2 and Terminal Archaic Phase 1 Secondary Burial 2 (Craig 2005:576, Figure 11.20) (Figure 7). The Late Archaic Burial 1 is a primary interment of an elderly female (Craig 2005:570, Figures 11.17-11.19). Her crania exhibits bi-lobate deformation. She was found with four turquoise beads, a fragment of groundstone, an obsidian cutting tool, and several chert scrapers. A small camelid effigy was placed just above the grave. Portable XRF shows that the obsidian was from the Chivay source (Craig 2005; Craig et al. 2007; Shackley et al. 2004).

Though there is evidence for generally wetter conditions after about 3,050 cal BC (Baker, Seltzer et al. 2001), downcutting in the Rio Ilave persisted as late as 2,050 cal BC and aggradation did not begin until about 1950 cal BC (Rigsby et al. 2003). There are three dates that fall within the span of time from 3,050-1,950 cal BC. Two of these are from the edges of Terminal Archaic Pithouse 2 (Craig 2005: Figure 11.20) and the third comes from a Terminal Archaic secondary interment called Burial 2 (Aldenderfer et al. 2008; Craig 2005:Figures 11.20 and 11.27). The additional dates from the Terminal Archaic pithouses show that these structures were used into the Late-Holocene.

The Terminal Archaic Burial 2 secondary interment dates to ca. 2,100 cal BC (Craig 2005:586). The burial was composed of at least two individuals. One is an older adult the other is a juvenile. Neither

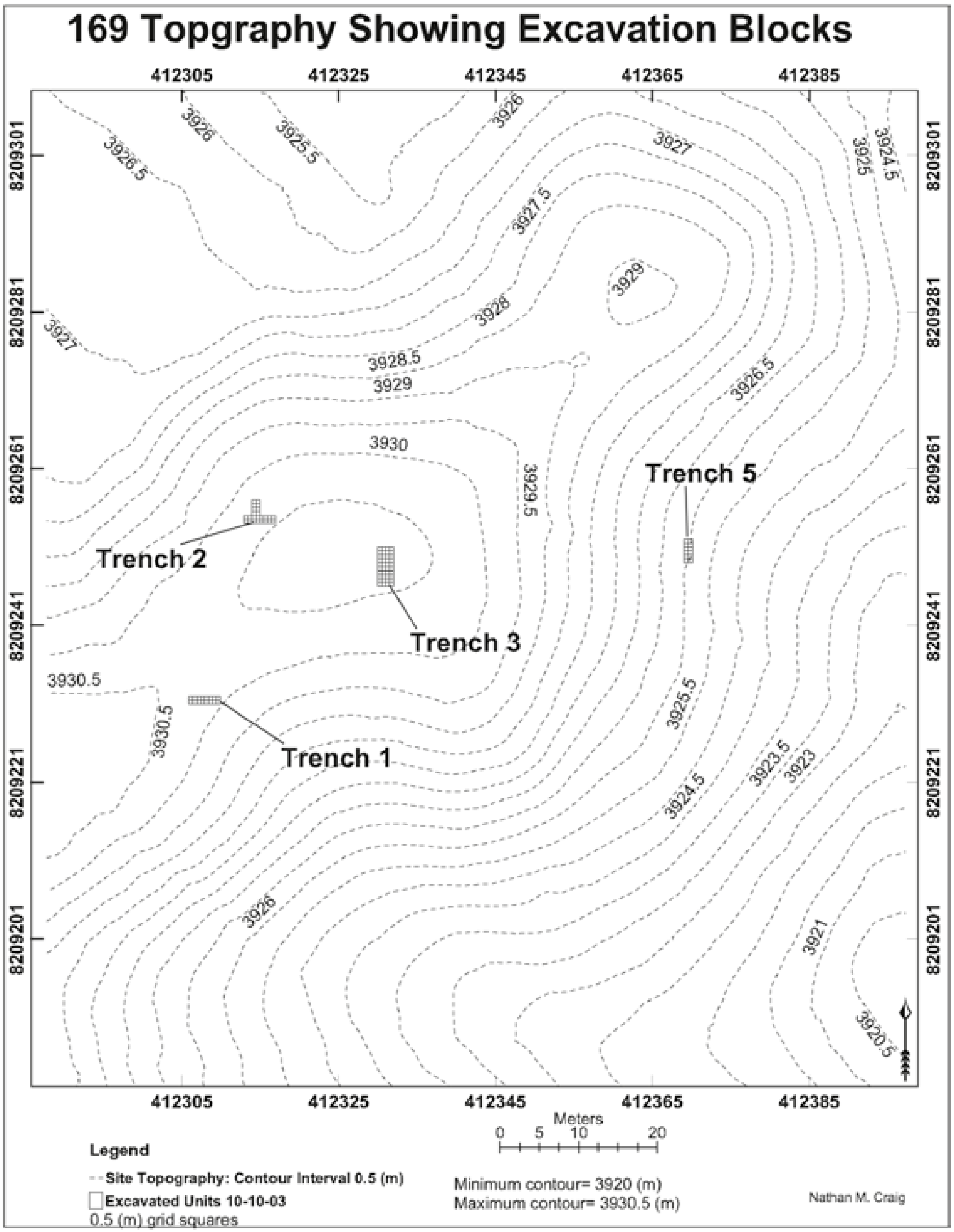

Figure 6. Map shows both the topographic setting and excavation blocks of Pirco (site 169). Figure adapted from Craig (2005:398).

Mapa muestra la configuración topográfica y la excavación de bloques de Pirco (sitio 169). Figura adaptada de Craig (2005:398).

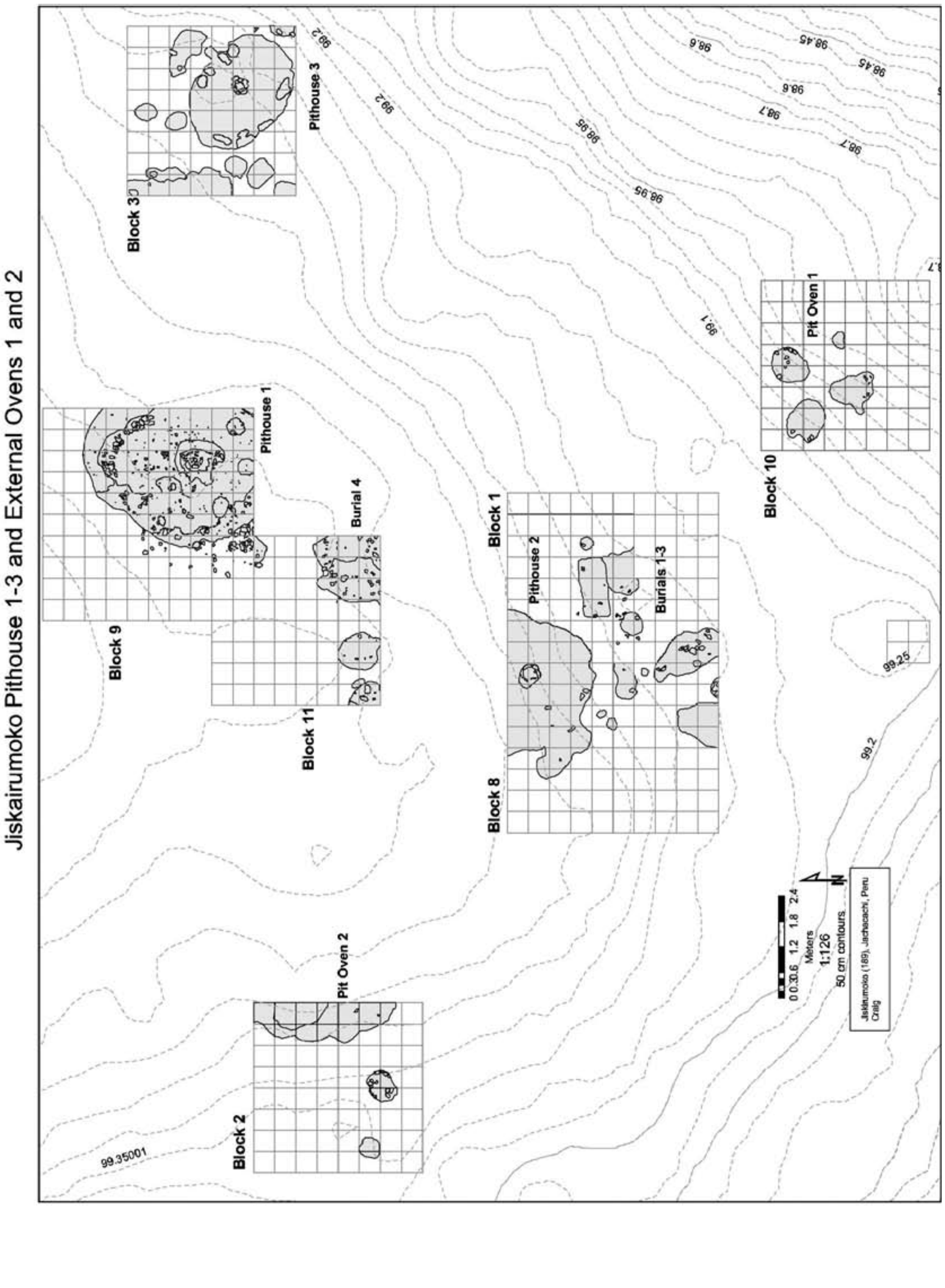

Figure 7. Pithouses 1-3 and External Pit Ovens 1 and 2. Figure adapted from Craig (2005:618).
Casas Subterráneas 1-3 y Hornos de Pozo Externos 1 y 2. Figura adaptada de Craig (2005:618).

Table 3. Radiocarbon samples from Jiskairumoko. Samples are organized by excavation block. All of the samples consisted of fine fragments of charcoal. The Prov. Code corresponds to the provenience code used in the field. All dates were calibrated using Calib v. 4.3 and the IntCal98 calibration curve (Stuvier and Braziunas 1993; Stuvier et al. 1998a 1998b). Low and Up correspond to the lower and upper limits of the 2 sigma probability curve after calibration. Prob. Refers to the probability value associated with the calibration curve intercept that is reported. Table adapted from Craig (2005:430-431).
Muestras de radiocarbono de Jiskairumoko. Las muestras están organizadas por bloques de excavación. Todas las muestras consisten de finos fragmentos de carbón. El Prov. Code corresponde al código de procedencia utilizado en el campo. Todas las fechas fueron calibradas utilizando Calib v. 4.3 y la curva de calibración IntCal98 (Stuvier y Braziunas 1993; Stuvier et al. 1998a; 1998b). Low y Up *corresponden a los límites inferiores y superiores de la curva de probabilidad de 2 sigmas después de la calibración. Prob. Refers es el valor de la probabilidad asociado a curva de calibración interceptada que se reporta. Tabla adaptada de Craig (2005:430-431).*

Sample ID	Prov. Code	^{14}C Years	S ±	13C	Cal BC	S Cal ±	Low	Up	Prob.	Provenience
AA36819	q25aF8iiia-2	3,411	51	–25	1,693	46	1,784	1,601	0.792	B1 Level IIIa-2 Pithouse 2 Edge
AA36814	q23bF5iiib	3,838	75	–20.4	2,296	89	2,473	2,119	0.951	B1 Level IIIb Pithouse 2 Edge
AA36818	2 q 3bF2iiic	3,620	48	–25	1,975	49	2,072	1,878	0.844	B1 Level IIIc Secondary Pithouse 2 Fill
AA36815	2 o 3cB1iv-1	3,733	43	–24.6	2,118	48	2,213	2,022	0.888	B1 Level IV-1 Burial 2 Secondary
AA36817	2 o 4aB2iv-1	4,275	46	–23.2	2,939	40	3,019	2,859	0.799	B1 Level IV-1 Burial 1 Primary
AA36816	1 u 4cF2iii	3,390	54	–24	1,650	63	1,776	1,524	0.934	B2 Level III Secondary Pit Fill
AA36813	u146F9iv	4,148	43	–25	2,749	64	2,877	2,620	0.965	B2 Level IV Midden Stained Matrix
AA36820	u13aF6v	3,448	47	–24.6	1,781	51	1,883	1,679	0.944	B2 Level V External Pit Oven 2
AA43380	w34c2iv	3,214	50	–21.9	1,507	54	1,615	1,399	1	B3 Level IV Secondary Pithouse 3 Fill
AA43381	x36b2iv	3,299	42	–23.2	1,590	48	1,686	1,494	0.982	B3 Level IV Secondary Pithouse 3 Fill
AA43373	z34c4ix	3,378	46	–23.6	1,550	58	1,754	1,524	0.982	B3 Level IX Midden Outside of Pithouse 3
AA43382	6x3 dix	3,382	48	–23.6	1,647	62	1,770	1,524	0.981	B3 Level IX Hearth in Pithouse 3
AA43383	x36dix2	3,448	44	–24.4	1,757	39	1,834	1,680	0.749	B3 Level IX Hearth in Pithouse 3
AA43376	jj22b6viii	3,330	45	–23.8	1,605	44	1,693	1,517	0.953	B4 Level VIII Ashy Midden
AA43375	2ii 2c9viii	3,401	45	–22.6	1,689	45	1,778	1,600	0.858	B4 Level VIII Hearth
Beta-97320	gg 19aiii-2	3,410	60	–24.3	1,715	58	1,830	1,599	0.81	B4 Level III-2 Midden Outside Rectangular Structure 1
Beta-97321	hh 19b1viii	3,240	70	–25.3	1,538	74	1,685	1,391	0.99	B4 Level VIII Midden
AA43379	rr26d3ii	4,547	95	–26.7	3,264	128	3,519	3,008	0.956	B7 Level II Semi-subterranean Structure 1
AA45952	qq25d2iv	3,235	58	–23	1,522	58	1,638	1,405	0.975	B7 Level IV Semisubterranean Structure 1
AA58475	rr25b23xii	3,208	58	–22.6	1,500	61	1,621	1,379	0.981	B7 Level XII Hearth Structure 1 in Semi-subterranean
AA36812	n2460aii	4,726	44	–25	3,593	22	3,636	3,549	0.4	Plowzone
AA43372	q21b2iiic	3,428	63	–23.2	1,742	71	1,884	1,600	0.95	B8 Level IIIc Secondary Pithouse 2 Fill
AA43377	o22c5iv	3,341	45	–21.9	1,607	44	1,694	1,520	0.929	B8 Level IV Burial 3 Secondary
AA43374	o22c5iv2	3,450	45	–24.5	1,782	51	1,883	1,680	0.96	B8 Level IV Burial 3 Secondary
AA58476	y27d11xii	4,562	73	–24	3,232	78	3,385	3,078	0.79	B9 Level XII Hearth in Pithouse 1
AA45951	u25b12x	3,573	50	–23.6	1,901	67	2,035	1,766	0.98	B 11 Level X Burial 4 Secondary

individual was sufficiently preserved to permit a determination of sex. The older adult individual was buried with nine hammered gold beads of a tubular shape (Aldenderfer et al. 2008; Craig 2005:586). A unifacial scraper was found with the burial, and a single piece of groundstone was found just above the burial. At Jiskairumoko, scraping tools and ground stone were recurrently found buried with females (Craig 2005:682; Rumold 2010). Therefore, though it cannot be definitively proven with the data presently at hand, the older adult buried with the gold beads is likely a female. No gold working artifacts were recovered from excavations at Jiskairumoko (Aldenderfer et al. 2008). The gold beads were probably trade items from somewhere else. The source of the gold remains unknown.

More than half of the dates from Jiskairumoko fall after 2,000 cal BC when aggradation and an expansion of the Rio Ilave floodplain began (Craig 2005:438, Figure 7.13) (Table 3). The contexts of these Terminal Archaic dates include houses, hearths, and burials. Occupants of the site seem to have continued living in pithouses up until about 1500 cal BC. However, the nature of the pithouses changed over time (Craig 2005:541-678; 2009). As I described above, the earliest residential architecture from Jiskairumoko is the Late Archaic Pithouse 1. The next oldest type of pithouse, attributed to Terminal Archaic Phase 1, tends to be slightly smaller and not as deeply excavated. There are two examples of this kind of structure, Pithouses 2 and 3 (Figure 8). A possible third structure was detected by GPR but it remains unexcavated (Craig 2005:546). Terminal Archaic Phase 1 pithouses contain internal storage alcoves. The storage features tend to be slightly less numerous than those encountered in the Late Archaic Pithouse 1. The central hearths of the Terminal Archaic Phase 1 pithouses continued to be constructed out of stone.

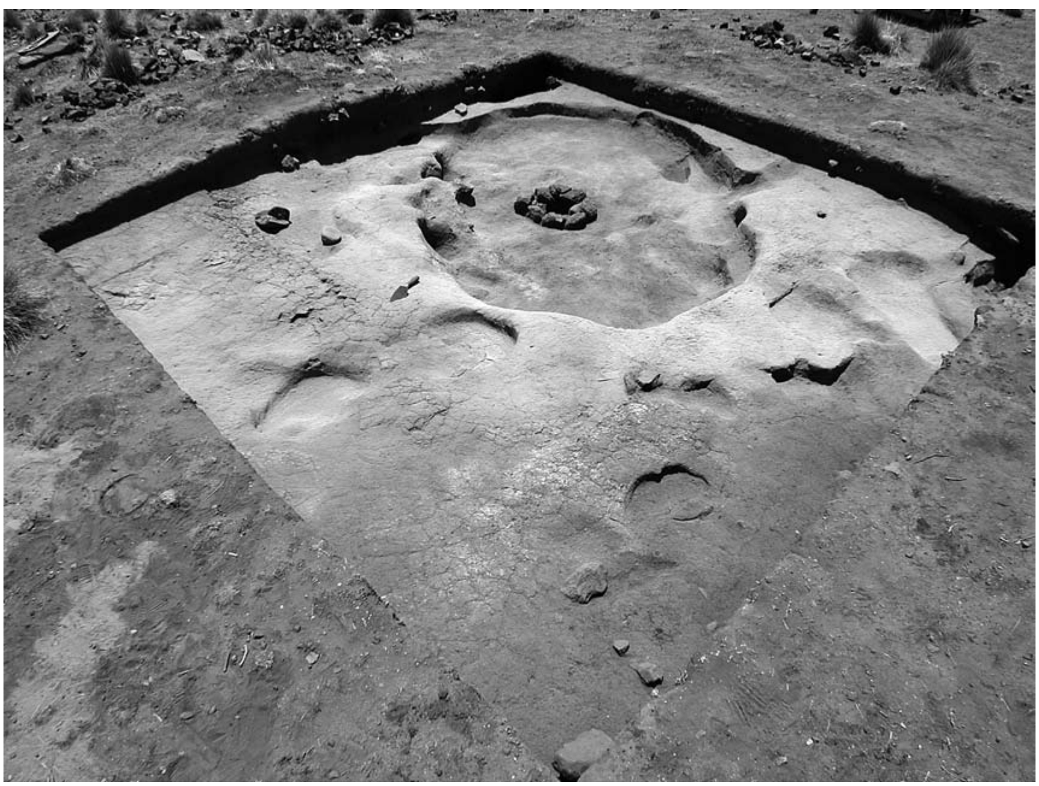

Figure 8. Terminal Archaic Phase 1 pithouse 3, block 3 looking south-east, Jiskairumoko. Note the stone lined central hearth, small internal storage alcoves, and exterior midden stained feature. Photograph by Nathan Craig.
Casa subterránea 3, Arcaico Terminal, Fase 1, bloque 3 mirando Jiskairumoko hacia el sureste. Note el fogón central definido por piedras, pequeños nichos de almacenamiento interno y manchas de basura afuera de la estructura. Fotografía de Nathan Craig.

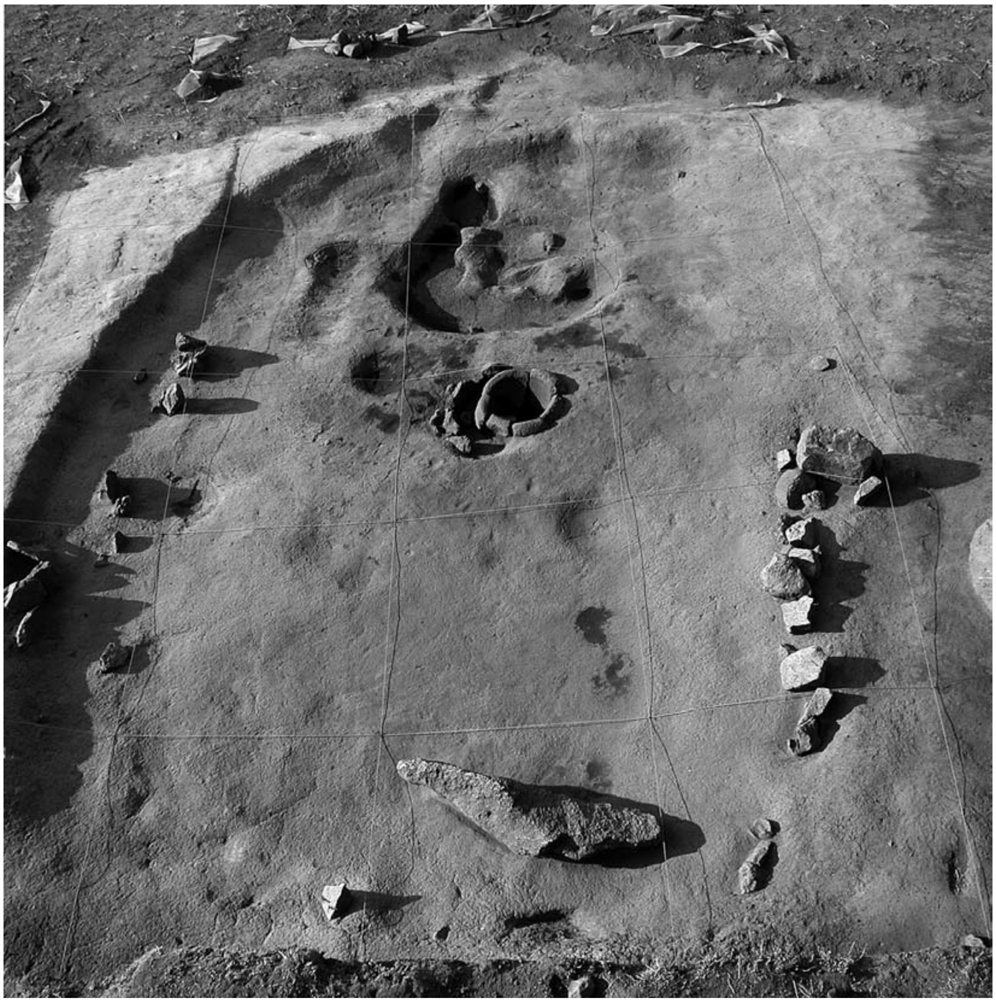

Figure 9. Terminal Archaic Phase 2 semi-subterranean structure 1, block 7 facing northward, Jiskairumoko. Note the stone lined central hearth, the single large internal storage pit, and the large kitchen rock. The kitchen rock has been pedistaled and is not sitting directly on the exposed floor surface. Photograph by Nathan Craig.
Casa semisubterránea 1, Arcaico Terminal, Fase 2, bloque 7, Jiskairumoko hacia el norte. Note el fogón central definido por piedras, el único gran pozo de almacenamiento interno y la gran roca de cocina. La roca de cocina ha sido pedestalada y no está asentada directamente sobre la superficie del suelo expuesto. Fotografía de Nathan Craig.

Outside of Terminal Archaic Phase 1 Pithouse 2 an earthen spindle whorl and two *wichuña* were encountered (Craig 2005:581, Figures 11.21-23). The spindle whorl bears evidence of fiber spinning. The two *wichuña* indicate that residents of the site wove textiles. The fact that all three of these objects were encountered together suggests that they were part of a weaver's kit.

Outside of the Terminal Archaic Phase 1 pithouses there are large organic stains that contain numerous chenopod seeds and pieces of groundstone (Craig 2005: Figure 11.20) (Figure 8). I believe that these stain features are chenopod processing areas. Scanning electron microscopy indicates that the seeds that come from these stains exhibit thin testa domesticated morphologies (Murray 2005a, 2005b). At the present time the earliest evidence for the use of domesticated chenopods at Jiskairumoko dates to about 2,000 cal BC, after climate amelioration and floodplain expansion.

By about 1500 cal BC there is another transition in residential architecture at Jiskairumoko. I attribute

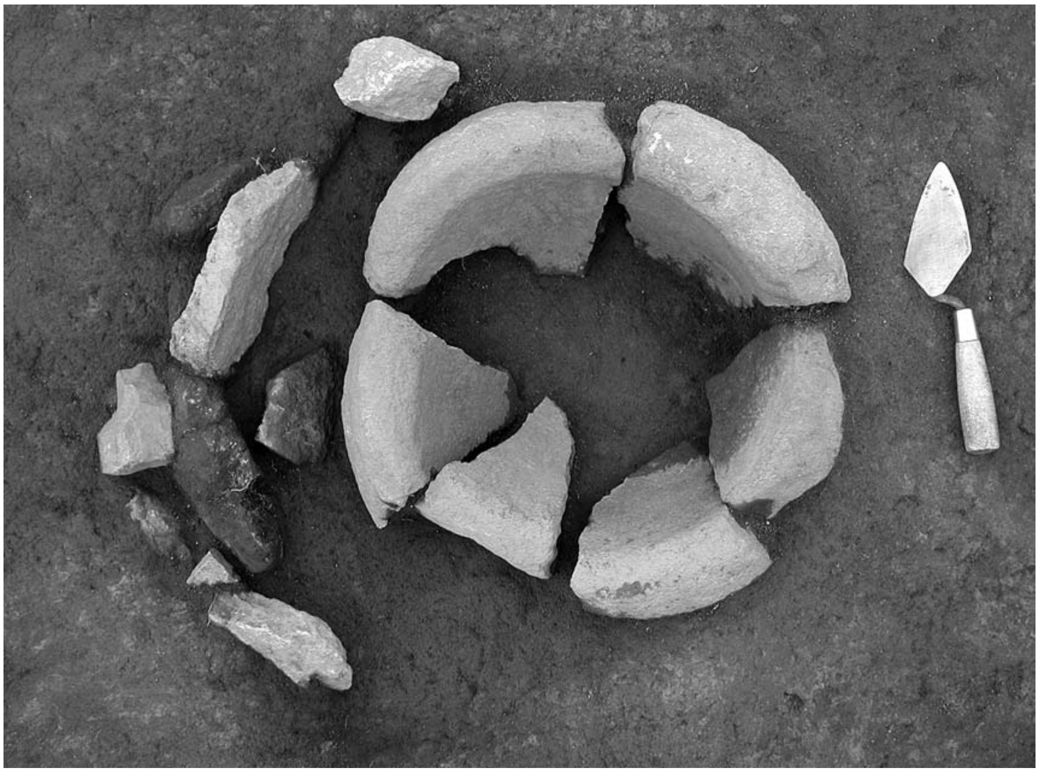

Figure 10. Central hearth of Terminal Archaic Phase 2 semi-subterranean structure 1, block 7, Jiskairumoko. Photograph by Nathan Craig.
Fogón central de la estructura semisubterránea 1, Arcaico Terminal, Fase 2, bloque 7, Jiskairumoko. Fotografía de Nathan Craig.

this new emergent form to the Terminal Archaic Phase 2 (Craig 2005:620). The phase is defined by the presence of a new type of pithouse called Semi-subterranean Structure 1 (Figure 9). It is slightly larger than the Terminal Archaic Phase 1 Pithouse 2 and 3 structures but it is smaller than the Late Archaic Pithouse 1. Unlike the preceding time periods, the central hearth of Terminal Archaic Phase 2 Semi-subterranean Structure 1 was constructed out of a broken stone bowl (Figure 10). Also a departure from the prior periods, Semi-Subterranean Structure 1 has a single large internal storage pit rather than numerous small internal pits. At some point during the occupation of the structure, this single large storage feature fell out of use. Another change that occurred during the occupation of the semi-subterranean structure was the introduction of a kitchen rock (sensu Aldenderfer 1998:92; Binford 1983:179). This rock did not sit on the basal occupation levels of the structure. The kitchen rock must have been introduced into Semi-subterranean Structure 1 sometime after the initial establishment of the structure (Figure 11).

Compared to the earlier occupations at Jiskairumoko, the abandonment of internal storage pits and the introduction of a kitchen rock during Terminal Archaic Phase 2 reflects a marked reorganization of interior space. A camelid effigy and a piece of copper gold alloy were also found within Semi-subterranean Structure 1. Thus, in terms of the importance of these material symbols of prestige and productivity, there is some consistency from the prior occupations.

In the Rio Ilave, sometime slightly after ca. 1,500 cal BC, begins what I now consider the Early Formative (Craig 2005:633)[2]. After ca. 1,500 cal BC, residents of Jiskairumoko began constructing and using above ground dwellings (Figure 5). Two were excavated, and these are designated Rectangular Structure 1 and 2 (Craig 2005:633-675). These structures lacked internal storage pits and had no central hearth features. Storage must have been

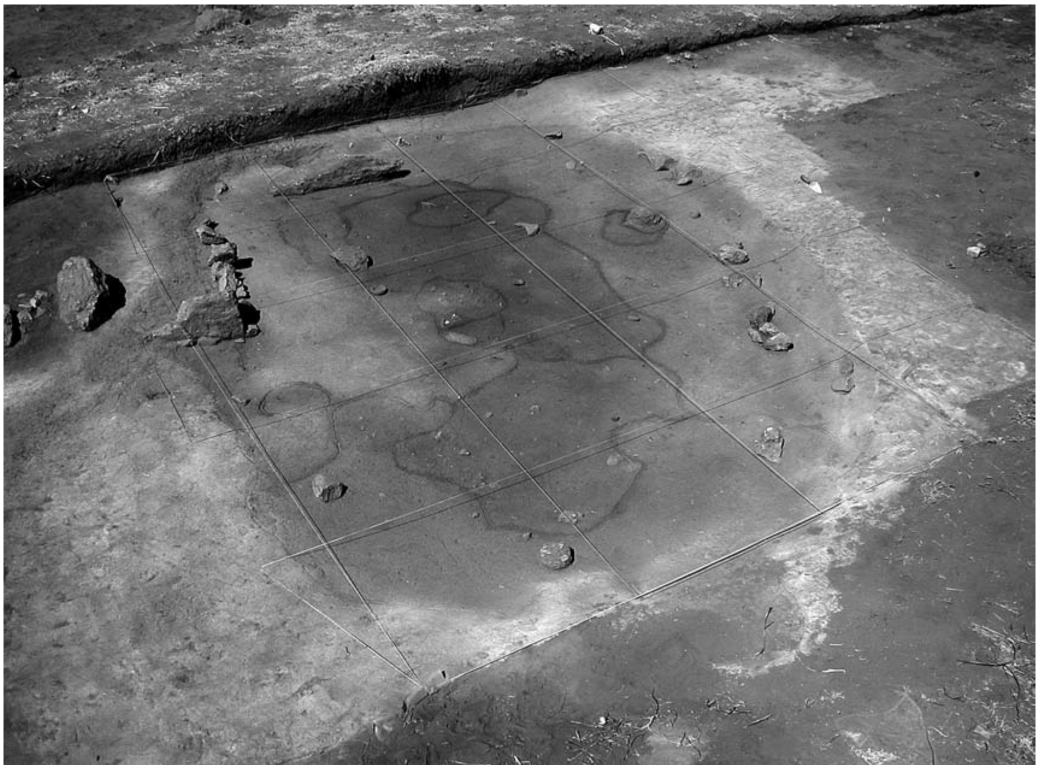

Figure 11. Terminal Archaic Phase 2 semi-subterranean structure 1, block 7 looking to the south west. Note that the kitchen rock is resting on this surface. Around the kitchen rock, there is dark organic stating and a scatter of small artifacts. Photograph by Nathan Craig. *Estructura semisubterránea 1, Arcaico Terminal, Fase 2, bloque 7 mirando hacia el suroeste. Note que la roca de cocina está asentada sobre la superficie. Alrededor de la roca de cocina hay manchas oscuras orgánicas y dispersión de artefactos pequeños. Fotografía de Nathan Craig.*

located elsewhere. Compared to the Late and Terminal Archaic, the Early Formative domestic hearths were far simpler and they were placed just outside of the dwellings. All of the rectangular structures contained a kitchen rock. Thus, the abandonment of internal storage pits and the introduction of a kitchen rock –which occurred first in the semi-subterranean structure– persisted into the occupation of the rectangular structure. Therefore, several changes in the internal organization of domestic space that occurred during Terminal Archaic Phase 2 are also manifest during the Early Formative.

At Jiskairumoko, the earliest good evidence for pottery was found in Rectangular Structure 2 (Craig 2005:655, Figure 11.53, 11.54)[3]. In Level III, two different fragments of pottery and a small pot-stand were encountered outside of the structure. Also associated with this structure was a gold disk, groundstone, an abundance of ochre, ochre covered camelid bones, obsidian, and what I believe is a lump of cal contained in some kind of a plant rind. Preliminary X-ray diffraction analysis indicates that the material contained in the rind is compositionally similar to cal (Jeff Speakman, personal communication 2008). Moreover, in comparing this substance to an ethograhpic reference collection of modern cal samples, the composition of the archaeological material contained in the rind most closely matched a cal that is produced today by Aymara people who live around the site of Jiskairumoko. Local residents of the region consume cal with chenopods (Baker and Mazess 1963). I suggest that, in the Rio Ilave, the material in the rind and the presence of domesticated chenopods indicates that this tradition may trace its roots back to the Early Formative.

Groundstone tools are found throughout the occupation of Jiskairumoko. At the site, groundstone is found inside and next to every structure and in direct association with every grave. Examination of the groundstone from Jiskairumoko in terms of the percent of wear management, the presence of multiple use facets, the degree of use, and the extent of facet area collectively indicate that during all represented time periods these tools were used intensively (Rumold 2010). The groundstone tools were either used frequently, for long durations, or some combination of both (Adams 2002:26). Moreover, during the occupation of the site, the intensity of groundstone use increased over time (Rumold 2010:224).

An analysis of starch grain residues from twenty of these grinding tools excavated from Jiskairumoko revealed the presence of *Solanum* (Rumold 2010:229-303). The presence of *Solanum* fossil starch grain residue on the groundstone indicates potato processing took place during the occupation of the site. The morphology of the starch grains is consistent with cultivated rather than wild-type *Solanum*. Although, at least one wild type *Solanum* starch grain was found on a groundstone tool recovered from one of the upper levels in Pithouse 1. This fact underscores the transitional nature of domesticated potato cultivation at Jiskairumoko. Chenopod starch grains are not easily identified by means of transmitted light microscopy (Rumold 2010:307). Thus, direct evidence of chenopod starch residues was not found on groundstone tools. However as mentioned above, outside of Terminal Archaic pithouses, groundstone tools were found in organic stains that contained chenopod seeds of domesticated morphologies.

Sometime after ca. 1,400 cal BC the site of Jiskairumoko was abandoned. Pottery and stone constructions suggest that the site was reoccupied sometime during the Middle Formative. However, these upper layers of the site were heavily impacted by modern plowing, and it is difficult to glean much information from them.

Discussion

So again, I'll raise the question– what does the Archaic occupation of the Rio Ilave mean for stress and abundance related socio-natural theories for cultural change? Results suggest that in the Rio Ilave, contexts of both stress and abundance stimulated periods of rapid cultural change. Although the *kinds and consequences* of the changes associated with each of these physical contexts seems quite different.

In the Rio Ilave, survey and excavation support the expectation that cultural innovations are stimulated by contexts of resource stress. Though, in the Lake Titicaca Basin, precipitation during the Mid-Holocene was between 20% (Talbi et al. 1999) to 40% (Cross et al. 2001) less than the modern amount, in the Rio Ilave the population was steadily growing. During this time, the Taraco Peninsula, like the Salar de Atacama, experienced a *silencio arqueológico*. Thus, this model is applicable to parts of the smaller Lago Huiñaimarca sub basin. However, in the Rio Ilave drainage, an increase in the number of sites during the Middle Archaic indicates that this area did not experience a *silencio arqueológico*; populations continued to grow in size throughout a prolonged period of resource stress. In the Rio Ilave, the discovery of Early and Middle Archaic points made out of Chivay obsidian suggests that long distance trade relationships were established well into the "stressed" Mid-Holocene.

At ca. 3,000 BC, towards the end of the Mid-Holocene, right at the cusp of climatic amelioration, several new cultural patterns developed: reduced residential mobility; the use of storage; camelid domestication; intensified seed processing, and intensification in long distance obsidian exchange. One also finds evidence for the adoption of adornments of personal prestige and the interment of the deceased next to residential architecture. Intensified seed processing, the use of storage, and a decrease in residential mobility together indicate a shift away from "foraging" towards what one typically thinks of as "low-level food production" (Aldenderfer et al. 2008; Craig 2005; Smith 2001). The Late Archaic burial of the elderly female with the groundstone, a scraping tool, and camelid effigy suggests the valorization of elders, female labor, and the tending of herd animals (Craig 2005, 2009). Just as the climate was ameliorating, the flow of obsidian from Chivay into the Rio Ilave greatly increased. Evidence from Asana indicates that camelids were corralled by ca. 3,000 cal BC (Aldenderfer 1998:131, 266). I suspect that the intensification of long distance obsidian trade may be related to the development of camelid caravans.

As the climate began to ameliorate from around 3,000-2,000 cal BC, the level of Lake Titicaca was rising but the Rio Ilave was still downcutting. At Jiskairumoko, during this span of time, occupational intensity increased as the suite of new cultural patterns were intensified and expanded upon. Pithouses become slightly smaller and more numerous. Internal storage persisted. The gold beads from Burial 2 bear evidence of adornments of personal prestige (Aldenderfer et al. 2008; Craig 2005). Through association in the grave, these objects are symbolically linked with groundstone and scraping tools. To me, this constellation of objects placed in the grave of a probable female implies a continued and perhaps intensified valorization of female labor. The presence of the weaver's kit next to a Terminal Archaic Phase 1 pithouse provides evidence for camelid fiber processing and textile production.

After about 2,000 cal BC, when floodplains in the Rio Ilave began to expand due to aggradation, and physical constraints were further eased- there was a major increase in the occupational intensity of Jiskairumoko. Though the site is occupied for 1,500 years, more than half of the dates derive from the last 500 years of its occupation (Table 3). All units were excavated to sterile, and there has been an effort to focus on dating early contexts. Therefore, the large number of dates that fall after 2,000 cal BC is not likely a function of sampling bias. I believe that the increase in the number of dates from 2,000-1,500 cal BC reflects a real increase in the use of the site. Based on the data from Jiskairumoko, it seems that a relaxing of the constraint of aridity to the point of floodplain expansion fostered a major increase in occupational intensity.

During this period of relative abundance: earlier forms of pithouses were abandoned; a new semi-subterranean form was occupied; and this was eventually abandoned in favor of above ground rectangular structures. Most of the major changes in the internal organization of dwellings occurred during the occupation of semi-subterranean architecture (Craig 2009). The adjustment of the location of storage features suggests changes in the level of economic risk sharing –perhaps from the scale of a single dwelling to the scale of several dwellings (Flannery 1972, 2002). By 1,400 cal BC, the site of Jiskairumoko was abandoned. It was not again reoccupied until much later. Thus occupational intensity increased up to a point, and then during an equally productive period– the site was abandoned. Perhaps the residents of Jiskairumoko moved to one of the large emergent Formative centers (Stanish 2003:111). However in the Rio Ilave, such a regional congregation site remains to be identified and studied.

The changes in the Archaic and Early Formative occupation at Jiskairumoko now need to be placed back into the broader context of landcover changes that occurred during the span of the site's early occupation. The founders of Jiskairumoko who arrived at the site around 3000 cal BC or so would have occupied a woody environment dominated by *Polylepis* forests (Paduano et al. 2003). By 1,500 cal BC, cores from Lake Titicaca indicate that *Polylepis* tree pollen had basically disappeared from the spectra. During this time there was a major increase in Chenopodiaceae pollen. This change in the pollen spectra corresponds well to the appearance of domesticated chenopods at Jiskairumoko by 2,000 cal BC (Murray 2005a, 2005b).

Starting around 2,050 cal BC, just as Lake Titicaca began to fill and as downcutting stopped in the Rio Ilave, the charcoal record indicates that the frequency of fires increased markedly (Paduano et al. 2003) –right when occupational intensity at Jiskairumoko greatly increased. Based on the 25,000 year long sediment core record from Lake Titicaca, for the first time in the Lake's history there is evidence for an increase in fire frequency during a moist period. Thus at the very outset of this period of abundance, it appears that residents of the basin began using fire as a landscape management strategy (Craig et al. 2010). Clearly more work on the issue remains to be done, but it appears that initial deforestation of the Titicaca Basin occurred in the context of intensifying reliance on domesticated plants and animals.

Greater abundance afforded by amelioration seems to have facilitated the process of subsistence intensification. However, the increased reliance on these new economic patterns in particular appears to have led to deforestation. Thus at least in the western Titicaca Basin, it seems that environmental degradation occurred during a period when material constraints were relaxed. These landscape changes undoubtedly presented new challenges to succeeding generations.

Conclusion

This case study has focused on a major macroevolutionary shift (sensu Zeder 2009), the Archaic-Formative transition, and considered these processes of cultural change in relation to contemporaneous Mid-Late Holocene climatic change. Doing so has revealed a trajectory in which innovation occurred during a period of stress, a context of abundance fostered intensification of these innovations, and intensification in the context of abundance significantly altered the environment by creating new, and probably unanticipated, forms of degradation-ones that may have presented challenges to future generations. I humbly submit that there may be a lesson in this for us today.

As society searches for answers to pressing questions regarding human responses to and impacts on climatic and environmental change, archaeology can and should have an important role to play. Archaeology, by virtue of being the only apparatus for reconstructing and studying long sequences of cultural change from empirical data, constitutes a primary means to evaluate and refine relevant socio-natural theories. For an important world region, in which early periods in the cultural sequence remain understudied, this paper has attempted to develop one such specific case study and relate those results to the climatic and palaeoenvironmental records with the aim of testing socio-natural theories. Clearly the archaeological database for the Lake Titicaca Basin remains small. However, I hope to have offered a starting point that will help contribute to future efforts.

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Notes

[1] All radiocarbon dates mentioned in this paper were calibrated using Calib v. 4.3 with the IntCal98 calibration curve (Stuvier and Braziunas 1993; Stuvier, Reimer, Bard et al. 1998; Stuvier, Reimer, Braziunas et al. 1998).

[2] Note that I previously referred to this as Terminal Archaic Phase 3 (Craig 2005). However, I now refer to this time period as the Early Formative.

[3] Note this fragment of pottery was initially described as a neckless olla (Craig 2005:655). This designation is erroneous. The fragment is a bowl.