Four-thousand-year-old gold artifacts from the Lake Titicaca basin, southern Peru

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Artifacts of cold-hammered native gold have been discovered in a secure and undisturbed Terminal Archaic burial context at Jiskairumoko, a multicomponent Late Archaic–Early Formative period site in the southwestern Lake Titicaca basin, Peru. The burial dates to 3776 to 3690 carbon-14 years before the present (2155 to 1936 calendar years B.C.), making this the earliest worked gold recovered to date not only from the Andes, but from the Americas as well. This discovery lends support to the hypothesis that the earliest metalworking in the Andes was experimentation with native gold. The presence of gold in a society of low-level food producers undergoing social and economic transformations coincident with the onset of sedentary life is an indicator of possible early social inequality and aggrandizing behavior and further shows that hereditary elites and a societal capacity to create significant agricultural surpluses are not requisite for the emergence of metalworking traditions.

Gold artifacts have often been discovered in copious quantities at the archaeological sites of cultures characterized by the presence of hereditary elites and complex economies with extensive trade networks. In these societies, gold was generally used to signal high status and was frequently incorporated into the dress and costumes of elite individuals. Based on this association, the tradition of gold working has often been associated exclusively with a high degree of social and political complexity, wherein elites supported craft specialists and provided them with access to necessary raw materials (1). This view assumes that, because gold metalworking can be technically complex and demanding, such traditions are feasible only when sufficient wealth, often in the form of agricultural surpluses, has been accumulated by these elites such that it can be used in the production of luxury objects (2).

The discovery of a gold necklace associated with a burial at Jiskairumoko, a small site occupied by a hunting and gathering people in the Lake Titicaca basin of southeastern Peru, however, calls these assumptions into question and suggests that status displays using gold artifacts in this region began long before the appearance of more complex societies capable of generating surpluses. The find also supports the hypothesis of an early advent of gold working in relatively simple societies.

The transition to sedentary life by hunters and gatherers can be associated with significant social and economic transformations. These include displays of valued objects that have been seen as the material manifestation of aggrandizing behaviors as individuals, families, or other social factions compete for status and new leadership positions (3–5) or may also signal differences in lineage, age, gender, or ethnicity. Objects composed of exotic, nonlocal, or difficult-to-obtain and difficult-to-process materials are frequently used in status display and competition. As such, they reflect the skill, ability, wealth, and range of social contacts of those individuals who possess them, thus enhancing their prestige. Their value in these competitive displays is further enhanced and imparted into social memory if they are disposed of in mortuary contexts or destroyed. Such status competitions are considered by anthropologists to be one pathway toward the establishment of persistent, multigenerational leadership in the transition to settled, sedentary life (6–8).

Gold artifacts were used as status markers among ancient Andean cultures. Many later, more complex societies, including Chavin, Moche, Chimú, and Inca, made great use of gold (9–11). The earliest published sites with gold artifacts or evidence of gold-working technology are Mina Perdida in the Lurin Valley (1410 to 1090 calendar years [cal yr] B.C.) (12) and Waywaka in the central Andean highlands in Andahuaylas (~1500 to 1000 cal yr B.C.) (13, 14). The 14C assay for Waywaka reported here is 3440 ± 100 14C yrs B.P. (UCLA-1808A) and has been recalibrated by us using Calib 5.0.2html with the Southern Hemisphere atmospheric calibration curve (15). Although the stratigraphic context of the gold at Waywaka appears to be secure, it has been dated only by association with a ceramic assemblage that has a wide chronological range. The gold may thus date significantly later in time, and recently the dating of the ceramic assemblage has been revised downward and may be no earlier than 1000 cal yr B.C. (16). We have chosen to be conservative in our assessment of the age of the gold.

Both sites were inhabited by settled village agriculturalists capable of generating surplus, and in the case of Mina Perdida the inhabitants constructed impressive corporate civic-ceremonial architecture. Until the discovery of gold at Jiskairumoko, none had been found in the sites of transhumant low-level food-producing peoples.

Research at Jiskairumoko

Excavations at Jiskairumoko, located in the Rio Ilave drainage of southern Peru, have revealed a transition to sedentary life beginning in the Late Archaic around 3400 cal yr B.C. and culminating by 2000 cal yr B.C. in the Terminal Archaic (17). Multiple lines of evidence attest to this transition. Geomorphic data from the Ilave river drainage (18) and limnological data from Lake Titicaca (19, 20) show that a key river terrace—Terrace 2—was created by ~2300 cal yr B.C. as the level of the lake rose from a much lower level in the mid-Holocene. Over the next 2,000 years increased precipitation led to terrace aggradation, creating a favorable environment for an increase in the density and abundance of plant species of dietary importance in the region, most notably Chenopodium spp. (17, **). Settlement

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data from the Ilave basin reflect population growth, settlement aggregation, and the movement of large sites toward the Terrace margins during the Terminal Archaic (17, 18). By 2300 cal yr B.C., a small hamlet was present at Jiskairumoko. Geophysical survey and extensive excavation revealed the presence of five pithouses arranged in a circular pattern. Storage alcoves within each of these structures had total capacities ranging from 130 to 150 liters. The primary components of the diet consisted of Chenopodium spp., tubers (Solanum and Ullucus/Oxalis spp. identified through starch grains extracted from grinding tools), and animal protein [taruca (Hippocamelus antitensis) and camelids] (17, 21, **). The presence of storage features and the plant species themselves indicate long-term residence at the site at least through the spring and well into the dry season. This interpretation is bolstered by evidence of extensive remodeling and repair of the pithouse structures, patterned secondary refuse disposal, periodic cleaning, and the structured, regular use of space (22). These patterns are commonly observed in the ethnographic record of the long-term residential sites of transhumant low-level food-producing peoples (23).

The site has multiple occupations extending from the Late Archaic into the Early Formative period as revealed by projectile point styles, ceramics, and 14C assays, which date the span of its use from ~3600 to 1500 cal yrs B.C. [supporting information (SI) Table S1]. Late Archaic point styles include the diagnostic 4D and 4F series; these are followed by the Terminal Archaic 5C type (24). The earliest ceramic materials at the site are consistent in surface treatment, paste, and vessel shape with published descriptions of the Pasiri tradition, which is currently the best-defined early ceramic assemblage in the Lake Titicaca basin and which dates from ~1500 to 1000 cal yrs B.C. (25).

At the time of excavation, the site had been plowed by draft animal traction for many decades. This created a plow zone of mixed soil that varies in depth from 10 to 25 cm and that averages at 15 cm (Fig. S1). The extreme northern boundary of the site was disk-plowed in 2000. However, this portion of the site is 25 m to the north of the location of the pit that contained the human burial and gold artifacts, and it was plowed the year after the excavation of the burial that contained the gold (Fig. S2).

The burial that contained the gold was recovered from a small pit, circular in plan view with straight walls, that was dug into the Level IIIC surface located ~1 m south of a contemporary Terminal Archaic pithouse structure (Fig. 1). In this area of the site, Level IIIB is below the disturbed soils of the plow zone, and the context shows no signs typical of churning by agricultural activity (Fig. 2 and Fig. S3). The burial pit originates on Level IIIC. A careful examination of the Level IIIB soil matrix that lies above the burial pit shows no evidence of the excavation of a pit into the soil matrix of Level IIIC from above (see Figs. S4 and S5). No features dating to the Formative period intrude into Level IIIC in this area of the site. The burial pit, then, is in primary archaeological context, originates in Level IIIC, and shows no signs of modification or disturbance after its initial excavation.

The human remains in the burial pit consisted of mixed adult and juvenile cranial fragments and cervical vertebrae (K. Prizer, personal communication). The adult fragments could not be
sexed, but tooth wear was very extensive, indicating that the individual was elderly. The juvenile was between 4 and 6 years of age based on fusion of the cervical neural arches. The adult cranium rested on its right side and faced the bottom of the burial pit. The bones were in extremely poor condition, highly eroded, and friable, making it impossible to use them to date the remains directly. The pit context at the time of discovery was damp, and the bone was in danger of being destroyed. A decision was made at the time to remove the pit contents as an entirety and to examine the burial in a secure laboratory context to preserve as much of the bone as possible and to avoid the theft of the gold because looting at the site had been a problem. The pit itself and the resting spot of the burial are well defined and, as noted above, do not show evidence of disturbance (Fig. 3).

Nine gold beads were discovered near the base of the adult cranium close to the mandible. They were found in a roughly circular pattern within the soil matrix that surrounded the cranium, and 11 circular beads of a coarse greenstone (possibly sodalite) were found interspersed between them. The location of the beads in relationship to the cranium and the pattern of the beads themselves are strongly suggestive of a necklace that must have been placed around the neck of the adult (Fig. 4). A small fragment of burned wood recovered directly below the mandible at the contact interface with the surrounding soil matrix was submitted for 14C assay and was dated to 3733 ± 43 14C yrs B.P. (AA-36815) or 2155 to 1936 cal yrs B.C. (AA-36818). We conclude that these beads were likely fabricated from quartz-vein native gold nuggets. Given the limitations of PXRF for sourcing gold, we cannot identify a specific source.

No obvious tools used to create the beads were found at the site, and, thus, the method of fabrication remains speculative. However, each of the beads shows distinctive hammer marks, suggesting that the raw native gold was first flattened with a stone hammer and then carefully bent and/or hammered around a hard cylindrical object to create the tubular shape. Despite the hammering, the metal maintained its ductility through this process. The edges of the beads are clearly folded over and do not appear to have been cut (Fig. 5 Lower). The beads do not

The elemental composition of the gold beads was characterized with a portable x-ray fluorescence (PXRF) spectrometer. They are chemically homogeneous, and the proportional values of gold, silver, and copper found in them are comparable to published samples of native gold from nearby regions of the Andes (Table 1). Extensive placer (or detrital) and quartz-vein gold is found to the north of Jiskairumoko on the eastern flanks of the Andes in the Río Sándia basin and the Department of Madre de Dios. Assays of the Sándia sources of native gold show elemental composition ranges of gold from 98.5% to 91.6% and ranges of silver from 1.85% to 5.6%. Cu values are not reported. Nuggets of native gold from the Sándia vein sources are often >1 cm in diameter (26, 27). We conclude that these beads were likely fabricated from quartz-vein native gold nuggets. Given the limitations of PXRF for sourcing gold, we cannot identify a specific source.

Table 1. Dimensions and composition of beads

<table>
<thead>
<tr>
<th>Bead</th>
<th>Length, mm</th>
<th>Diameter, mm</th>
<th>Thickness, mm</th>
<th>Weight, g</th>
<th>Au, %</th>
<th>Ag, %</th>
<th>Cu, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.5</td>
<td>7</td>
<td>1</td>
<td>4.2</td>
<td>95.4</td>
<td>4.3</td>
<td>0.27</td>
</tr>
<tr>
<td>2</td>
<td>18.5</td>
<td>6</td>
<td>1</td>
<td>3.3</td>
<td>95.9</td>
<td>3.8</td>
<td>0.31</td>
</tr>
<tr>
<td>3</td>
<td>14.0</td>
<td>6</td>
<td>0.5</td>
<td>1.5</td>
<td>95.1</td>
<td>4.6</td>
<td>0.29</td>
</tr>
<tr>
<td>4</td>
<td>12.0</td>
<td>6</td>
<td>0.7</td>
<td>2.0</td>
<td>95.1</td>
<td>4.6</td>
<td>0.29</td>
</tr>
<tr>
<td>5</td>
<td>29.0</td>
<td>7.5</td>
<td>0.5</td>
<td>5.2</td>
<td>95.5</td>
<td>4.2</td>
<td>0.30</td>
</tr>
<tr>
<td>6</td>
<td>11.5</td>
<td>7.0</td>
<td>1</td>
<td>1.8</td>
<td>96.1</td>
<td>3.6</td>
<td>0.29</td>
</tr>
<tr>
<td>7</td>
<td>15.0</td>
<td>6.5</td>
<td>0.5</td>
<td>1.7</td>
<td>95.3</td>
<td>4.5</td>
<td>0.21</td>
</tr>
<tr>
<td>8</td>
<td>19.0</td>
<td>7</td>
<td>0.6</td>
<td>3.8</td>
<td>95.6</td>
<td>4.1</td>
<td>0.27</td>
</tr>
<tr>
<td>9</td>
<td>21.0</td>
<td>6.6</td>
<td>0.9</td>
<td>4.3</td>
<td>95.1</td>
<td>4.6</td>
<td>0.32</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>95.5</td>
<td>4.3</td>
<td>0.28</td>
</tr>
</tbody>
</table>
The discovery of the gold beads at Jiskairumoko supports a hypothesis that the earliest metalworking in the Andes was the modification of native gold (28). Although both native gold and copper were cold-hammered at Mina Perdida, the materials from Jiskairumoko are at least 600 years earlier than these finds. There are striking differences in the objects produced among the sites. At both Mina Perdida and Waywaka, small, very thin foils of gold and copper were produced, and at Mina Perdida, there is evidence of gilding and annealing copper foils (12). However, these more complex metalworking technologies appear relatively late in the second millennium B.C. (16) and were preceded by experimentation with native metals in a variety of forms.

The gold from Jiskairumoko in a Terminal Archaic context provides new insight into the emergence of Andean metalworking and supports the concept of the early appearance of multiple, independent metalworking technologies focused on native materials, especially gold. From very early times, gold functioned in ceremonial, ritual, and mortuary contexts (12, 13, 29). The data from Jiskairumoko also allow us to document an emerging social role for gold beyond simple decoration. Used in a necklace, the gold signal the prestige of its wearer, while its interment with the deceased underscored the implied wealth and prestige of its owner through its disposal and removal from both display and recirculation. Over the next three millennia, gold would continue to highlight and emphasize prestige, but its use was ultimately restricted to the elite members of society (29). The gold from Jiskairumoko provides new insight into one pathway by which this process occurred. Furthermore, these data suggest that the cold hammering of native gold nuggets may be one of the earliest technologies used to fashion objects for status display in those areas of the world in which social and political complexity emerged.

Methods

Analyses were conducted by using an Amptek PXRF. The x-ray tube features a 300-μA power supply with an Ag target and Be end window. The detector is thermoelectrically cooled and has a resolution of 149 eV FWHM at the 5.9-kV peak of 57Fe. Because of the irregularity of sizes and shapes of archaeological materials, the tube and detector are mounted to a specially fabricated table so as to hold the components in a fixed geometry and at a consistent distance for each measurement. For each analysis, the flattest part of the sample was selected to minimize sample effects and scatter. The gold was analyzed at 20 kV and 5 μA in an air path for 200 seconds live-time. Thin film standards of single and multiple elements deposited on Nucleopore filters were used for the energy calibration of the instrument. Standards used in the analysis included RM-8079 (Royal Canadian Mint gold foil) and BCR-6091 (European Commission, Institute for Reference Materials and Measurements bronze standards). The XRF-FP software provided with the instrument calculates quantitative data for the elemental compositions of the samples using a fundamental parameters algorithm. Values for each analysis were constrained to 100%.

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