

LITHIC PROVENIENCE ANALYSIS AND EMERGING MATERIAL COMPLEXITY AT FORMATIVE PERIOD CHIRIPA, BOLIVIA

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Introduction

Technical analyses of lithic artifacts from the Formative Period component of Chiripa, on the south shore of Lake Titicaca, Bolivia, indicate a number of items of non-local provenience. Among the items originating from considerable distances, up to 300-500 km from the site, are copper ores from the arid Pacific coast, obsidian from the punas of Arequipa and Puno, sodalite from Cochabamba, and basalt from Lake Poopó. Construction stone employed in the facing and temple walls, weighing up to 4.5 tons, may have been extracted from quarries as far as 80 km distant by water. The identification of the systems by which the Chiripa inhabitants obtained these materials may serve to clarify the integration of the Chiripa polity with its neighbors, and its contributions to the development of the subsequent Tiwanaku federation.

The setting and chronology

Chiripa is an Upper Formative, or an Initial Period and Early Horizon phase occupation and temple site on the south end of Lake Titicaca in Bolivia, at 3835 m or 12,580 ft elevation (Figures 1, 2, and 3). During the later Tiwanaku federation period, the site was re-utilized. Initial test excavations were conducted by W. C. Bennett (1936); A. Kidder II (1956) carried out subsequent excavations; and the current report is based on a joint American-Bolivian project in 1974-75 directed by the author and Gregorio Cordero Miranda (Browman 1978a, 1989a, 1989b).

The first series of radiocarbon determinations for Chiripa was a suite of 14 dates submitted by Kidder from his excavation units in the upper levels of the mound (Ralph 1959:56-57). An additional 14 radiocarbon assays and 10 thermoluminescence determinations have been run on samples from the 1974-5 excava-

tions. The Formative Period occupation of the site may be defined by 28 dates from 5 radiocarbon labs and 1 TL lab, listed in Table 1. Christine Hastorf and her students have recently begun a new series of excavations at the site. Additional dates no doubt will be forthcoming.

The ceramics from Kidder's excavation were analyzed by K. L. Mohr for her Master's thesis. She proposed three phases: Pre-Mound or Sub-House level, 1400-900 b.c. (uncalibrated); Lower House level 900-600 b.c.; and Upper House level 600-100 b.c. (Layman and Mohr 1965:200; Mohr 1966:3). Recently, she has renamed these phases Early, Middle, and Late Chiripa (Mohr Chávez 1988:18).

Chiripa ceramics, when first reported, were unique in having fiber temper, mainly ichu grasses (*Stipa* sp. and *Festuca* sp.). Thus, for many years, fiber tempered wares in the south-central Andes were characterized as being derived from Chiripa, an interpretation now fortunately mainly abandoned. In our excavations, we identified a non-fiber tempered ware component pre-dating the fiber temper phases. New phase names taken from the local landowners of the site were employed to facilitate distinction between pre-fiber tempered and fiber tempered phases and to include other new archaeological elements in their definition.

The traits defining these phases are derived from ceramic (Browman 1980), archaeobotanical (Browman 1989b), zooarchaeological (Browman 1989a), and architectural (Browman 1978a) criteria. For example, the Condori phase (1350-850 b.c.) is defined in part by such ceramic traits as grit-tempered (sand and crushed sandstone with micaceous inclusions) ware, neckless ollas, rare decoration of red slips and occasional incised designs, and vessels with round bases and basal

lugs. The shift from Condori/I (1350-850 b.c.) to Llusco/II (850-650 b.c.) can be identified by new vessel and temper categories, but it is equally as evident in the archaeobotanical record (Browman 1989b:142), where a second chenopod species is added (provisionally identified as *caniwa* as well as *quinoa*), amaranth first appears, and some more minor weedy taxa first occur. It can also be identified zooarchaeologically as part of a pattern displaying a shift to greater dependence on lacustrine species. Fiber temper, which may first appear late in Condori/IB, becomes a significant ware in Llusco/II (850-650 b.c.), along with the addition of such traits as ring bases and flat-bottomed vessels. Classic Chiripa style decorations typify Mamani/IIIA (650-350 b.c.), the period of first temple construction and the appearance of the double wall bin-storage houses; and at the end of Mamani/IIIB (350-50 b.c.), Tiwanaku I-like ceramics are first identified.

Correlation between Mohr Chávez's phases and the Condori, Llusco and Mamani phases is aided by the fact that our project deliberately placed excavations (Unit II, Figure 2) below Kidder's House 2 and 3, and Lower and Sub-lower Houses 1 and 2, which are the basis of Mohr's three ceramic phases. Eight of the radiocarbon determinations for Condori and Llusco phases were derived from samples in Unit II under the Sub-lower houses. The assignment of the "pre-mound" Pennsylvania dates as Condori/IB is based on their approximate stratigraphic location in this same excavation unit. Inspection of the ceramics illustrated by Mohr (1966) suggests that her Early (or Pre-Mound), Middle (or Lower House), and Late (or Upper House) Chiripa ceramic phases are roughly equivalent to Condori/IB, Llusco/II-Mamani/IIIA, and Mamani/IIIA-IIIB.

Building stone and construction phases

Chiripa architecture is significant, in terms of our current knowledge of Titicaca basin Formative villages, in having a rectangular stone-faced mound on which first domestic dwellings, and later a subterranean temple were constructed. It is not unique: other

southern lake basin Formative Period sites such as Chissi and Titimani also have subterranean temples. The mound began as a rather typical sort of accretional habitation site, where centuries of refuse accumulation along with the disaggregation of adobe and/or tapia mud construction resulted in an accumulated deposition rising three to four meters above the surrounding fields. Evidence from our test cuts, supplemented by data from Bennett's and Kidder's work, indicate that the north side, and at least portions of the east and west sides of this mound (if not the entire mound), were later faced and enclosed with a stone wall, resulting in a roughly rectangular ground plan configuration (Figures 2 and 4). This event occurred near the beginning of Mamani/IIIA, based on evidence from one of our test units which cut the north wall (Unit I, Figure 2). Half a meter on the inside of the base of this wall is the oldest radiocarbon assay of 1530 b.c. $\pm$ 180, while the stratum on the exterior associated with the wall construction trench has a TL assay of 640 b.c. $\pm$ 390 and a ^{14}C assay of 350 b.c. $\pm$ 155.

My initial interpretation was that the visible subterranean temple (Figures 3 and 5) was constructed at this point as well. Much of the construction stone from Chiripa has been robbed and recycled in later sites in the area. Opportunistic samples were taken from the remaining stone, and submitted to Dr. Ernest Ehlers for x-ray diffraction (XRD) and thin-section microscopic analyses. Three different building stone materials were identified: andesite, limestone, and sandstone. No geologic origin voucher specimens were taken, as at that point we had no idea where quarries might be located.

Andesites were rare in our sample and were confined to only a few small-sized quarried stones. Three major areas of andesites are near the "Little Lake" or Lago Pequeño section of Lake Titicaca. There are also some minor outcroppings south of Tiwanaku (Figure 1). Based on the specific inclusions and characteristics of the specimens submitted for analysis, Dr. Ehlers indicated that they were most similar to the andesites described for a source near the town of Copacabana (Newell

1949; Mogrovejo Terrazas 1970). While visual inspection of the map suggests that, as the crow flies, it is only 30 km to this andesite source, because of local topographic features, the stone source is most readily reached by a lake voyage of about 80 km to a quarry on the north side of the peninsula. There is presently no evidence that andesite was transported by the more direct route over the intervening high hills.

Analyses of andesites associated with Ponce Sanginés's Tiwanaku III (a.d. 133-374) and IV (a.d. 375-724) phases at the site of Tiwanaku indicated that these construction stones also were quarried from the Copacabana peninsula, from the Yunguyo and Copacabana area sources illustrated in Figure 1 (Mogrovejo Terrazas 1970:251; Ponce Sanginés and Mogrovejo Terrazas 1970:274). Ponce Sanginés (1970a:75, 142, 146, 1971:90) reports blocks as heavy as 11 to 16 tons were first rafted by balsas (lake boats made from bundles of *totorá*, a cattail-like reed) from Copacabana, through the straits of Tiquina, to the prehistoric lake port of Iwawe some 95 km by water, and then dragged another 22 km overland from Iwawe to Tiwanaku. Movement of these massive blocks on and off the balsas, without capsizing, was difficult; several ash-lars, lost in off-loading, help define the quay and pier of the Iwawe port.

Limited observation of the shoreline directly in front of Chiripa failed to reveal any evidence of similar off-loading patterns. There is a linear levee or aqueduct which runs from the mound area north to the lake (Graf-fam 1990:138-150). This seems to be the logical route for transport of the stone from the lake to the temple. If dock facilities existed at Chiripa, they may have been somewhat removed from the immediate foreshore, or may have existed at a different lake level; we know that in the last 50 years, Lake Titicaca levels have varied more than 5 meters.

The most common building stones remaining at Chiripa were limestone and sandstone. Centuries of stone-robbing prevent accurate reconstruction of importance. The two largest sandstone ash-lars opportunistically

sampled were 4.5 and 3.3 tons, while the two largest limestone ash-lars sampled were 2.5 and 1.7 tons. These are the largest remaining stones in the temple floor plan map (Figure 3). Weights were determined by computing the volume of the whole ashlar, multiplied by the specific gravity determined from a sample of that ashlar.

There are three major sandstone formations around the "Little Lake" (Newell 1949), as illustrated in Figure 1: the Cabanillas (of which only a portion near Cumana Island is included on the map), the Táraco (along the Táraco peninsula just south of Chiripa), and the Puno (along the south side of the Little Lake). Because of the proximity of the Táraco Formation to Chiripa, I initially assumed that all the sandstones would prove to be derived from this source. Based on inclusions in the samples, however, Ehlers indicated that in addition to Táraco materials, sandstones from the Puno Formation were utilized as well, a source which for Chiripa would be most efficiently exploited via water transport. Significantly, much of the sandstone employed later at Tiwanaku (a.d. 500-1100) also came from the Puno Formation (Avila 1971:226; Castanos 1971:212; Urquidi 1971:234).

Limestone construction blocks from Chiripa were quarried at some distance, because there are no nearby sources on the peninsula. XRD and thin-section microscopy of the limestone samples submitted to Dr. Ehlers for analysis indicated that these limestones were all from the Copacabana Formation. This Formation crops out along a fault line which abuts the south side of the Straits of Tiquina on the Copacabana Peninsula and runs south through Cumana Island. Because Formative Chiripa ceramics had been reported by Bennett and others on sites on Cumana Island, my original interpretation was that limestone was quarried on the island, and transshipped by the balsas to the shores below Chiripa. But Chiripa wares also have been identified from a number of sites on the Copacabana peninsula by Gregorio Cordero Miranda, John Hyslop, Karen Mohr Chávez, Sergio Chávez, Charles Stanish, and others. Neither area of limestone outcropping can be specifically identified as

the source at this point, but access to either requires water transport of the construction stone. Ponce Sanginés (1970a:62) reports that limestone employed at the site of Tiwanaku comes from this same Formation, which also occurs at some isolated outcrops in the Pampa Koani and Tambillo area (two of which are shown in Figure 1). Thus the Tiwanaku masons seemed to have continued exploitation of the same sources of limestone as the Chiripa masons.

While some of the sandstone may have come from deposits directly behind Chiripa, other sandstone blocks came from Puno Formation deposits 20-30 km by water to the southwest. The limestone blocks came from Copacabana Formation sources 20-40 km by water to the northeast and the andesite appears to have derived from a quarry to the north which is most readily reached by a water route of 80 km in length. These data indicate that the masons of the semi-subterranean temple at Chiripa did not have a single preferred source, but rather secured building stone from a wide number of sites around the "Little Lake", no doubt in part based on ease of access to the shore. At this point in the analysis, it seemed that the pattern of quarrying andesite, sandstone, and limestone blocks of substantial size had first been initiated during the Mamani IIIA or Classic Chiripa phase, and continued unchanged on into Tiwanaku Period constructions.

As work continued, it became possible to differentiate some construction techniques of Chiripa masons from those of Tiwanaku masons.¹ The Mamani phase retaining wall on the north side of the mound, as exposed in our test cuts, as well as in Bennett's work, consisted of relatively small, partially coursed rectangular blocks (Figure 4). In unpublished photographs which Gregorio Cordero Miranda provided, as well as in the excavation cuts of

Bennett and Kidder, there was evidence of a later Tiwanaku Period retaining wall, with vertical ashlar set at intervals, with the smaller rectangular stone laid between them (Figure 5), very typical of "Classic" Tiwanaku architecture at the Tiwanaku type site. (By 1974, utilization of the site by the current village residents as an adobe fabrication "mine" had left the stones from this wall in a disturbed array.)

The extant, visible semi-subterranean temple in the center of the Chiripa mound, measuring 21.3 m by 22.6 m, employed vertical ashlar along with horizontally laid smaller stones. Most of the 1,450 cubic meters of fill removed from this temple was disturbed, but near the base of the walls we recovered some intact zones and floors of Tiwanaku III refuse, indicating a Tiwanaku III (a.d. 133-374) Period of construction for this version of the temple. During cleaning of the temple floor, we sank a test cut in the northeast corner to assess floor construction sequences. Much to our surprise, we found evidence of an earlier, deeper temple wall set back almost half a meter from the later Tiwanaku phase temple walls (Figure 6). Evidence of this earlier temple also appears in profiles of Bennett's test trench. Steel rod probes at half a dozen places around the perimeter of the Tiwanaku III phase temple suggest that this earlier structure was probably similar in outline to the Tiwanaku phase building, but slightly larger, roughly 23 m by 24.5 m. Ceramics recovered from the test cut in the northeast corner indicated the earlier structure was Classic Chiripa or Mamani phase. Alan Sawyer (1981), who worked as a member of Kidder's project, reported that portions of the walls of the upper Chiripa houses uncovered in their excavations had been leveled off, and the houses packed with backfill from temple construction. These data indicate that the second, Tiwanaku phase, temple was constructed after the abandonment of the mound, with the mound top leveled off and a new retaining wall constructed around the exterior.

The evidence of two distinct periods and styles of temple construction and mound facing raised the question whether the magnitude

¹Classic Tiwanaku style temple construction involves vertical ashlar with various types of coursed infilling. For examples, see Manzanilla's work (1992) at the Akapana, or Ponce's various publications on the Kala-sasaya.

of long-distance transport of massive building stone initially posited for Mamani phase in fact pertained to that period or to the later Tiwanaku rebuilding. Most of the large ashlar of limestone and sandstone that we had sampled were the vertical ashlar of the typical Tiwanaku style construction. On the other hand, a 0.6 ton, Pajano style sandstone monolith (Browman 1978b; Cordero Miranda 1977), characteristic of Mamani phase sites around the Little Lake, was found recycled as a vertical ashlar in the later Tiwanaku style temple, with its decorated side buried facing the wall fill and its undecorated backside showing. Thus we know that at least some large sandstone ashlar were quarried in Mamani III times. The only andesite pieces which can securely be placed as Mamani phase are small (under 20 kg); and unfortunately, none of the large limestone ashlar we sampled could be definitively associated with the earlier constructions. Nonetheless, the Mamani phase Chiripa residents were quarrying substantial quantities of stone. Although most of the wall stone subsequently has been robbed, the few remaining sections of the Tiwanaku Period temple indicate that approximately 200 tons of stone were required for that temple building. If the earlier temple is of the same magnitude, as our probes suggested, then it also required roughly the same quantity of quarried stone. The Mamani Period exterior facing walls of the mound may have required as much as 5 to 10 times more stone, depending on height and dimension estimates, and whether they enclosed all four sides or not. A similar quantity should be projected for the Tiwanaku Period facing walls.

A revised construction sequence model would suggest that the Mamani Chiripa builders at 600 b.c. were principally using sandstone, along with minor amounts of other building stone. The Tiwanaku III Period Chiripa area residents, who rebuilt the temple ca. a.d. 300-400, chose or found themselves forced to secure the large vertical ashlar from more diverse sources. Limestone blocks came from the Copacabana Formations 40 km to the east. Some sandstones were acquired as far as 30 km away from the Puno Formations at the southwest end of the Little Lake. In addition,

local sandstones from the hills behind the site were used, and andesites likely from the Copacabana quarry 80 km by water to the north were also employed. Because the style of construction of the second subterranean temple at Chiripa is similar to the Tiwanaku III phase Semisubterranean Temple at the prestigious center of Tiwanaku, it is not surprising that the materials utilized closely match those previously identified for the developing capital. The sandstone from the Puno Formation, which is closer to the Tiwanaku center, might have been brought to Chiripa by masons and their crews coming from Tiwanaku to supervise the temple's construction.

Metal and ores

A total of 31 gold, copper, and tin-copper bronze metal and copper-mineral items were recovered during our Chiripa excavations. Silver is known from Formative Period levels at Tiwanaku but was not recovered in our test units. Although gold has been reported from Formative Period sites elsewhere in the south central Andes as early as 2,000 b.c., the only gold from stratigraphic contexts found in our Chiripa work came from Tiwanaku III contexts; Bennett (1936) also reported finding gold in Tiwanaku Period burials at the site. Copper ore and copper artifacts, however, were recovered from the earlier Chiripa phases: two items from Condori IB contexts (1250-850 b.c.) and one from Mamani IIIB components. In addition, Bennett (*ibid*:433) excavated a Classic Chiripa phase burial which had copper, stone, and bone beads around each ankle. Thus, we have good evidence for copper metal use during the Formative Period.

Gold and copper metal artifacts, as well as a number of the turquoise and sodalite items, were recovered from the 1,450 cubic meters of disturbed temple fill excavated. While 95% of the artifacts from the temple fill were Mamani or Classic Chiripa, the other 5% included Tiwanaku III, IV and V, Inca, Colonial, and even 20th century artifacts. It is tempting to assume that because most diagnostic artifacts in the temple fill are Mamani phase-related, it is therefore likely that most of the metal arti-

facts could also be Mamani phase. However, the disturbed nature of the deposit makes this an uncertain proposition.

During recent historic periods, copper was extracted from several mines in the Titicaca Basin. Four mines are known in the immediate Chiripa/Tiwanaku vicinity (Ponce Sanginés and Mogrovejo Terrazas 1970:220-223), so the early occurrence of copper in the Chiripa site seems reasonable. The ores from the local mines are carbonates including azurite and various copper sulfides. However, by XRD and microscopy, Ernest Ehlers identified copper ore samples from the Condori IB and disturbed temple fill as being brochantite, and he also identified as brochantite a Formative specimen from Kidder's excavation provided by Alan Sawyer at my request (Ehlers, report of June 15, 1976). Brochantite is a form of copper mineral which only occurs in extremely arid areas. In reviews of the geological literature, both Ehlers (personal communication, June 15, 1976) and Heather Lechtman (personal communication, April 25, 1977) reported that the closest known sources for this mineral are along the Pacific Coast, from a series of mines in the north Chilean desert along the Tarapacá-to-San-Pedro-de-Atacama axis, as well as in some of the southern Peruvian mines in the Arequipa area, although it is not as typical of the Peruvian mineral beds.

There also is evidence of exploitation of local copper ores at Chiripa. A Tiwanaku Period ore sample from our excavations at Chiripa was identified as azurite by Ehlers. One specimen of azurite ore was identified among the Chiripa samples from Kidder's excavation, supplied to Ehlers at our request by Alan Sawyer. In an earlier XRD analysis on a sample from Tiwanaku, malachite was identified (Sawyer, personal communication, January 29, 1975). These findings suggest that local Titicaca basin ore sources were being exploited by the first centuries A.D., if not earlier. With copper ores readily available in the immediate area and exploited during Tiwanaku and later phases, the occurrence of apparent Pacific coast copper ores, such as brochantite and antlerite, seemed almost a "coals to Newcastle" situation. The associa-

tion of brochantite and antlerite with the Formative occupations, with local ores appearing only in the later phases, suggested a possible initial development of this technology in northern Chile, with a subsequent adaptation of the technology by the altiplano cultures. This interpretation seems to be reinforced by Ruppert's (1982, 1983) identification of the known turquoise sources as also North Chilean.

Analyses conducted on our other Bolivian samples replicated the pattern observed at Chiripa. We secured two copper ore samples from the Formative Period sites of Chullapata and Santa Lucia in Cochabamba while we were collecting comparative ceramics specimens from cuts made by William Kornfield, and two additional samples were acquired from the Putuni and Pumapunku structure areas at the Tiwanaku site. The ore sample from Chullapata included a mix of brochantite and antlerite, and the sample from Santa Lucia was brochantite. Antlerite, like brochantite, was only known from arid areas such as the north Chilean coast according to the sources available to Lechtman and Ehlers in 1975. Hence the two ore samples from the Cochabamba area appeared to reinforce a possible pattern of initial association of Chilean ores with Formative Period sites in Bolivia. The ore sample from the Putuni temple/palace area of Tiwanaku included antlerite, brochantite, and cuprite, while the second sample from the Pumapunku temple/palace area was brochantite. These data, taken in conjunction with the information from Chiripa, suggested that if antlerite and brochantite were in fact most typical of copper sources from the arid north Chilean coast, that as early as 1200-1000 b.c., Chile was a significant supplier of such ores to the Bolivian altiplano and valleys, and the coastal sources continued being important until a.d. 500 if not later. Locally available Titicaca basin ores, such as azurite and cuprite, at least in our extremely small sample, do not seem to have begun to be extensively exploited until perhaps as late as 100 b.c.-a.d. 100, a surprising situation, considering Ponce Sanginés's argument in several publications that an indigenous copper smelting industry

was well entrenched in this part of the altiplano by 1200 b.c.²

After presenting this model of Formative utilization in the Bolivian altiplano of copper ores from North Chile in several papers, I now have new evidence which will require modification of this hypothesis. While brochantite and antlerite are most typical of Chilean mines 300 to 500 km southwest of Chiripa, at least brochantite is found as a less common copper mineral at the Bolivian mine of Corocoro, only 100 air km south of Chiripa.³ Formative

²Much of Carlos Ponce Sanginés' model of extensive copper utilization by 1200 b.c. is based upon material which he identified as "escoria" or copper slag at the site of Wankarani, in a level dated between 1210 b.c. and 800 b.c. However, Marc Bermann (1995) reports that from his Wankarani culture site at La Joya, he submitted 34 samples of "scoria" apparently identical to Ponce's material, which Bermann thus assumed was copper slag. Test results indicate that none of these samples proved to have any copper. Rather they appear to be a type of natural pyroclastic tufa. Thus the basis for an extensive early copper smelting industry in the early formative period of the Bolivian altiplano seems now very much open to question.

³Richard H. Sillitoe, Consulting Economic Geologist of London, who has written extensively on the copper industry of the Andes, has offered some fine-tuning suggestions. He writes (Personal communication, February 22, 1992):

"Brochantite and antlerite only form by oxidation of chalcocite in the presence of pyrite. Chalcocite normally forms by supergene enrichment in arid to semi-arid climatic regions. The major chalcocite zones (blankets) in northern Chile (e.g. Chuquicamata) and Southern Peru (e.g. Cerro Verde in Arequipa) were generated in the Oligocene-mid Miocene (25-15 m.y.a.), and were then fossilized by intensifying aridity (hyperaridity). The brochantite and antlerite formed in oxidized zones above, and at the same time as, the chalcocite blankets.

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copper ores of brochantite could thus derive either from the coastal Chilean-Peruvian sources or the Corocoro area, although the Formative Period antlerite ores presumably indicate coastal origin. Thus Chiripa might be obtaining at least part of its copper minerals from the Corocoro source area, but it appears that the Formative Cochabamba sites might still be characterized as securing copper materials from Chile.

Beads and pendants: chrysocolla, sodalite and turquoise

Of the 24 beads and pendants recovered in our excavations, 16 were blue and green, mainly copper-mineral based stone. This blue-green mineral group was initially divided into three categories in the field: malachite, turquoise, and sodalite. These artifacts remain in the national museum in La Paz. However, some of the items were damaged by the workmen during excavation (the National Museum-trained crew insisted that Bolivian regulations required picks and shovels, rather than trowels), and the resulting small chips recovered were thus available for analysis.

True "chemical" turquoise is a specific crystalline compound of copper, but "cultural" turquoise may include a wide range of other copper-bearing blue and green stones, such as malachite, azurite, chrysocolla, and the like. Four turquoise artifacts were recovered in our Chiripa excavations; the three artifacts for which samples were available were identified as true chemical turquoise. No published identification or characterization of Andean turquoise sources was available for the geological consultants of the project when they

Cuprita), which is not linked to intrusive activity but generated in red clastic sediments by migration of cenate brines. Moreover, brochantite is reported as an oxidation production of chalcocite at Corocoro.

"So you have two options: brochantite from Corocoro or brochantite from Chile/Southern Peru. The former seems more likely, although pre-Colonial exploitation of oxide copper (including brochantite) was widespread at Chuquicamata. I'm not sure about Cerro Verde."

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Cuprita), which is not linked to intrusive activity but generated in red clastic sediments by migration of cenate brines. Moreover, brochantite is reported as an oxidation production of chalcocite at Corocoro.

"So you have two options: brochantite from Corocoro or brochantite from Chile/Southern Peru. The former seems more likely, although pre-Colonial exploitation of oxide copper (including brochantite) was widespread at Chuquicamata. I'm not sure about Cerro Verde."

conducted their studies in 1975; thus a place of origin could not be determined. However, since that time, Ruppert (1982:73, 1983:102) has conducted a series of trace element analyses and believes that the cultures of Northwest Argentina and Bolivia, including Tiwanaku, obtained the greater part of their turquoise from deposits in northern Chile: from the Chuquicamata area, including the mines of Chuquicamata, El Abra, and El Salvador; from a presumed mine east of Arica; and from still unknown other Chilean mines. The Chiripa materials no doubt were obtained from these same North Chilean turquoise mines.

The class of six items field-categorized as "malachite" proved to be a variety of copper-based minerals other than malachite, when appropriate thin-section and XRD analyses were performed on samples submitted. Two of these samples were identified as chrysocolla -- one from Mamani/IIIB strata deposits, and the other from the temple fill. The initial chemical analysis of the chrysocolla suggested that the mineral was in two phases, most typical of an artificial process, such as faience fabrication in Egypt. This tentatively was proposed by Ehlers as possible evidence for a previously unreported technology, but subsequent analyses by Zimmerman and Ehlers indicated that the samples had not been heated prehistorically, and that the two phases were due to natural processes. Another sample of the field category "malachite" was identified as chlorite and calcite, and a fourth as cuprite. Fragments were not available for the other two items, so the complete re-definition of the field category "malachite" may be even broader.

In order to assist in verifying the six sodalite artifacts collected for evaluation, I obtained a voucher piece of sodalite from the Cerro Sapo mine in Cochabamba, which was used for the type material against which Ehlers tested the sodalite category materials by XRD. The two sodalite fragments tested from our Chiripa excavations (one from a Mamani Period stratum and the other from temple fill) were from Cerro Sapo. A sodalite sample provided by Alan Sawyer from Kidder's Chiripa excavations also was determined

to be from Cerro Sapo. Bennett (1936:433) reported excavating a flexed burial from Classic Chiripa deposits, "around each ankle were beads of lapis-lazuli, bone and copper". As sodalite is locally mis-named lapis-lazuli, presumably these anklet beads also are sodalite.

Ehlers analyzed three additional sodalite samples that we had collected: one each from the Tiwanaku phase deposits of Tiwanaku, the Tiwanaku phase deposits at Lukurmata, and the Formative Period midden of Chullpapata, Cochabamba. XRD tests on these samples indicated Cerro Sapo origin. Sawyer (personal communication, January 29, 1975), has documented sodalite from in his collections from Tiwanaku through XRD, and Ponce Sanginés has reported in a number of publications on other samples of Cerro Sapo sodalite from Tiwanaku. At this point, all chemically identified samples of sodalite from the Bolivian altiplano have proved to be from the Cerro Sapo source. Ruppert (1982:74, 1983:103) reports that the sodalite from prehistoric sites near Andahuaylas and in the Asia Valley in Peru, as well as the Quiani complex of Arica, Chile, are also from Cerro Sapo; some of these samples are associated with deposits believed to date back almost four millennia, suggesting that the trade in sodalite from Cerro Sapo predates the origins of Chiripa by half a millennium or more.

Trade in Cerro Sapo sodalite items thus has a long duration in the Bolivian altiplano. Sodalite was exchanged on a continuing basis between the Cerro Sapo source in the Ayopaya area of Cochabamba 225 air km east of the Titicaca basin and other Andean centers for minimally 2,500 years (based on Chiripa data) and more than 4,000 years (based on external reports), and continued to be a significant jewelry item through Tiwanaku V occupations or later, or at least as late as a.d. 1100. Turquoise, chrysocolla, and other copper mineral-based artifacts may be part of the evidence relating to other exchange networks, such as with the Arica area in northern Chile 300 air km southwest, or the Chuquicamata area of Chile 500 air km south-southwest. Although the earliest stratified samples of turquoise, sodalite, and chrysocolla are only from

the Mamani component deposits (650-50 b.c.), the fact that copper ores were securely identified from the Condori/IB levels (1250-850 b.c.) indicates that the Titicaca shore inhabitants were participating in the trade in blue and green mineral beads and pendants by then, if not earlier as suggested by evidence from other localities.

Tools: obsidian and vitreous basalt

Chiripa Formative Period projectile points, knives, drills, scrapers, and other stone tools were manufactured from a variety of cryptocrystalline materials, including various cherts, quartzite, and obsidian. Stone hoes and an adze-like form were manufactured from vitreous basalt. Stone bowls, mortars, pestles, and other grinding stones were manufactured from several other stones, whose identification in the field was not secure; these items remain in Bolivia. Only the materials of volcanic origin, obsidian and basalt, can currently be identified as to source.

Samples of two of the 16 artifacts of vitreous basalt, a hoe from Condori/IB (1250-850 b.c.) and a hoe fragment from Mamani/IIIB (350-50 b.c.), were taken by Gregorio Cordero Miranda, Director of the Museo Nacional de Arqueología, and co-director of the project, and Luis Girault, of the Centro de Investigaciones Arqueológicas en Tiwanaku, for petrographic analysis in the national museum laboratory in La Paz for verification of field identification. Cordero and Girault reported (personal communications, June 1975) that these two artifacts were confirmed to be vitreous basalts from Cerro Querimita, in the Lake Poopó area, Oruro.⁴ Marquez *et al.* (1975) and Ponce Sanginés (1970b) report Cerro

Querimita vitreous basalts utilized as hoes from Wankarani through Imperial Tiwanaku (or later) Periods, or from as early as 1200 b.c. through at least a.d. 1100, from sites in La Paz and Oruro departments. In the Little Lake basin, these basalts previously had not been recovered in any dated contexts earlier than ca. 300 b.c. The Condori and Mamani samples suggest that the vitreous basalt industry of the Lake Poopó area was involved as a significant component of a long distance trade network with the Titicaca basin (and probably also with Cochabamba). Vitreous basalt hoes were observed during our surveys of the Formative mounds at Chullapata and Santa Lucia in association with materials dating from as early as 1200 b.c.

Obsidian materials from Chiripa were analyzed by Ehlers, Richard Burger, and Larry Haskin. Inopportunely, Ehlers's analysis of the first sample (C5) in 1976 using X-ray fluorescence (XRF) was before Burger and Asaro's seminal article on Peruvian and Bolivian obsidian was published (1977, 1979). The XRF-determined composition of this sample proved to be different than the XRF analyses published earlier by Avila (1975a, 1975b) for Bolivian obsidians. Hence Ehlers reported that sample C5 was from a different obsidian source than the Formative Sora Sora or later Tiwanaku obsidians that Avila had analyzed. But Burger and Asaro subsequently observed (1977:6) that "there are disturbing differences between our XRF results and those of Avila, although the samples analyzed from Tiwanaku and Sora Sora were taken from the same obsidian fragments used in the study of Avila." Thus the non-comparability of Ehlers' and Avila's XRF results may be methodological, rather than the documentation of a new obsidian type.

Burger and Asaro characterized 21 samples of obsidian from Bolivia by XRF and NAA (neutron activation analysis): 3 samples from Formative Sora Sora, 2 samples from Kallamarka (a Tiwanaku administrative site with Tiwanaku III, IV, and V materials) and 16 samples from Tiwanaku itself. These samples proved to be from a source they define as the Titicaca Basin Type. This obsidian type

⁴Petrographic laboratory procedures for identification of the basalts at the National Museum in 1974 are the same as those described by Marquez *et al.* (1975). Characterization was limited to a few elements. While this is less extensive than current NAA trace element analyses, recent NAA work reported for Oruro has shown these petrographic analyses, so far, to be quite adequate for the characterization of Cerro Querimita as contrasted to other possible vitreous basalt sources.

also is very common in sites from Arequipa and Puno Departments in Peru. Because this obsidian was particularly common along the Sicuani-Puno axis, and was utilized in Peru as early as 1200 b.c. at Pikicallepata, and as late as A.D. 1500 at Sillustani, Burger (Burger and Asaro 1977:37) posited a possible origin somewhere in Puno Department. Subsequently Burger (personal communication, April 21, 1980), suggested that "I now think that the actual mine may be in Arequipa". This prediction has been borne out as Sarah Brooks recently has located the Titicaca Basin Type source at a quarry in the Colca valley in Arequipa.⁵

Burger subsequently tested three additional samples (C1, C2, and C3) from the Chiripa project, using XRF. Two of the samples (C2 from a Mamani IIIB component, 350-50 b.c., and C3 from disturbed temple fill) proved to be of the Titicaca Basin Type; the third sample, C1, from a Condori IB component (1250-850 b.c.) was of the Tumuku Rare Type (Burger 1977). In his 1977 technical report, Burger observed that the Tumuku Rare Type is not infrequent in sites in the Chucuito area and other parts of the southern highlands, and should therefore be considered a major rather than a rare type. The source of the Tumuku Type was suggested to be near the Peru-Bolivia border on the west side of Lake Titicaca in the 1977 report; in his 1980 communication (Burger, April 21, 1980), he refined that hypothesis, suggesting that "the Tumuku Rare

Type is especially common in the Chucuito archaeological sites tested over the last few years and I suspect that its source should lie in that area."

The fifth obsidian analysis was conducted on a flake recovered from a Condori IB component (1250-850 b.c.) float sample. Haskin analyzed this sample, C4, using NAA. The results from this NAA work (Table 2) were unlike any of the NAA analyses by Burger and Asaro, suggesting a previously unknown source. Thus stratified Chiripa Formative Period obsidian artifacts come from at least three different sources.⁶

⁵ After the original draft of this paper was submitted, Sarah Osgood Brooks (personal communication, June 19, 1995) reported discovering two obsidian quarries in the Colca Valley in 1994, while conducting research for her Ph.D. dissertation (Brooks 1998) at the University of Wisconsin-Madison. NAA analyses of the obsidian samples conducted by Michael D. Glascock, Missouri University Research Reactor, indicated that the Cotalalli Quarry samples are "a perfect match" for the Titicaca Basin-type of obsidian (Glascock to Brooks, August 22, 1994). For further information, see Brooks *et al.* (1997:449). Richard Burger and colleagues have also identified the Colca Valley as the source of the "Titicaca Basin"-type obsidian. See Burger *et al.* (1998) in this volume.

⁶Michael D. Glascock of the Missouri University Research Reactor (MURR) has been conducting the analyses of obsidian from various Titicaca basin sites for Martin Giesso. Glascock recently reviewed my obsidian data from Chiripa as part of the background for that project. While he concurs that samples C2 and C3 are from the Titicaca Basin Type source, with respect to the identification of C1 being Tumuku Type, he notes the paucity of information in the literature on the characterization of this type, and thinks that we need more supporting data for a sure determination. Sample C4 does not match any of the types he had tested to that point (Glascock, personal communication, March 4, 1994). Sample C1 derives from the probable Tumuku Rare Type, from a source possibly in the Puno region; samples C2 and C3 derive from the Titicaca Basin Type from the Colca valley source in Arequipa; C4 comes from a previously unidentified source. Thus there are clearly 3 different obsidian sources. The XRF work by Ehlers on sample C5 did not match any of the XRF data published by Avila (1971, 1975a, 1975b), so he suggested that this sample was an unknown. As noted, other labs have had problems replicating the results of Avila. I do not have a copy of the XRF profile by Ehlers, so it is not possible to compare it with more recent studies. Thus, I cannot say whether it is yet another previously undefined source or not, and hence whether there are three or four different obsidian sources represented in our excavation work at Chiripa.

Glascock and Giesso (1994) have also recently conducted some additional analyses of Titicaca Basin obsidians. They identified 10 different obsidians: 5 fairly common, and 5 with one example only. One of the common types is Tiwanaku A, with no known source, which appears from visual inspection to most likely be from the same source as Burger's Tumuku Rare Type. Sora Sora obsidian, a common type in later

Burger (1977) observed that "the discovery of Tumuku Type obsidian in the early layers of Chiripa had not been anticipated. It suggests that early patterns of obsidian utilization near Lake Titicaca may have been very different than in later times." The subsequent definition of yet another new type of obsidian in the Condori layers supports this proposition. It appears that initially Chiripa may have been utilizing more local sources (the Tumuku source and the new type), and that later, exploitation of these sources was supplanted by the Titicaca Basin source, 325 air km west in the Colca valley of Arequipa Department, Peru. Chiripa may well have been one of the nodes on a network, which could have involved Tumuku and Titicaca Basin Type obsidians passing south to Lake Poopó in exchange for items such as Cerro Querimita vitreous basalt and Uyuni salar salt blocks moving north.⁷

Comestible earths

Two samples of comestible earth, one from a broken pot and one from a feature, were recovered from the Formative Period levels at Chiripa. With the aid of James Gundersen, several of the more than 25 comestible and medicinal earths utilized in ethnohistoric and modern Titicaca basin households have been chemically characterized (Browman and Gundersen 1993); additional work on samples collected in the local markets in Oruro and La

basin sites, is not present in our Chiripa sample. Giesse secured three additional samples from Chiripa (cultural associations unknown) which all were identified as the Titicaca Basin type. While these new samples do not change the number of obsidian sources known for Chiripa, they indicate that, as with other Titicaca Basin sites such as Lukurmata, Tiwanaku, and Khonko Wankani, the Titicaca Basin type seems to be the most commonly exploited source.

⁷Waldo Avila (personal communication, July 1975), believed he could identify Titicaca basin obsidian types from "Mound culture" (e.g., Wankarani) sites in Oruro. Work in progress by Martin Giesse will no doubt help in the evaluation of this model of obsidian trade.

Paz in April of 1995 are currently in progress.⁸ Ehlers tested one archaeological sample from a Condori/IB component (1250-850 b.c.) and Gundersen tested a second sample from a Mamani/IIIB component (350-50 b.c.). The first sample, examined by Ehlers in 1976 using XRF techniques, was tentatively identified as *katawi*, a calcium carbonate preparation frequently consumed with chenopod grains. The identification is listed as "tentative" because in 1976 I had no expectation of recovering such materials in prehistoric context, and thus had limited comparative materials. The second sample studied by Gundersen in 1987 using both XRD and XRF was more securely identified as *katawi* (see discussion in Browman and Gundersen 1993). While *katawi* may have been derived from local sources, many of the other comestible earths consumed in the Titicaca basin in historic and current times are not local, and may originate from areas up to 500 km distant. The *katawi* evidence appears to establish the antiquity of geophagy in the Andes at least two millennia earlier than previously documented.

Final comments

Locational patterns based on elemental analyses of various mineral artifacts suggest a substantial area for resource exploitation. Some of the temple building stone, up to 4.5 tons in weight, came from a quarry source more than 80 km north by water; some early copper ores appear to originate from mines of the Pacific Coast region of southern Peru or northern Chile, 300 to 400 air km west and southwest; turquoise is identified as coming from the Chuquicamata mines 500 air km south-southwest or from a hypothesized mine in the Arica area 300 air km southwest; sodalite artifacts came from Cerro Sapo mines 225 air km east in the Ayopaya area; obsidian came from at least 3 sources, one of which has

⁸A new series of earth samples was collected in the special pharmaceutical markets in La Paz and Oruro in April of 1995. Dan Kremser, Microprobe Specialist, Department of Earth and Planetary Sciences, Washington University, is conducting XRD, EDS, and other analyses of these samples.

been identified as a quarry 325 air km west in the Colca valley of Arequipa Department, Peru; basalt hoes originated from Cerro Querimita 325 air km south on the southwest shores of Lake Poopó, and so on.

A regional system in scarce resource acquisition appears to be functioning across the altiplano during the second and first millennia B.C. and was part of the basis for integrating the local level political elements.⁹ This exchange structure, which is argued to have involved movement of goods by balsa boats and llama caravans, must be included in any study examining the evolution of the complexity of Titicaca Basin societies.

Llama caravans are the local mechanism through which the lighter weight mineral items identified here most likely were mobilized, *e.g.*, the copper ores and metal; sodalite, turquoise, and chrysocolla jewelry; obsidian hunting, shearing, and butchering tools; basalt agricultural hoes; and at least some of the medicinal and comestible earths. Llamas were important in the Formative phases at the Chiripa site: a high frequency of llama bones were found in all levels (Browman 1989a; Kent 1982); llama dung was an major fuel source (Browman 1989b); several hundred bone weaving tools were recovered, suggesting a major wool textile industry; and bone

pack-harness toggles were retrieved, indicating llama pack usage.

The larger building stone of the temples and retaining walls at Chiripa appears to have been transported via a second mechanism, that of balsa totora-reed boats. Zooarchaeological analyses of the Chiripa assemblage reveal an increasing focus on lacustrine resources, including aquatic birds, various fishes, and harvesting of comestible algae and duckweeds, during the first millennium B.C., indicating intensified utilization of balsas for extraction of materials. Analyses by Horn (1984) have shown that the specific species of fish and aquatic birds recovered in the Chiripa zooarchaeological samples are the same as those taken by the contemporary Uru fishing cooperatives on Lakes Titicaca and Poopó that he studied.

The mineral goods discussed all appear to have been traded at least as early as 1200-1000 b.c. (the limit of project evidence available - see footnote 9), and to have maintained a significance in the economy of the altiplano outlasting any one particular regional political group. These mineral items continued to retain importance as culturally-defined status markers (such as the sodalite, turquoise, chrysocolla, and metals), or as necessary raw materials for the primary exploitation of the local resource base (such as the obsidian and basalt). They persist over long periods as important trade goods, and some of them may possibly even develop into mercantile commodities during Tiwanaku federation phases.

The acquisition of construction blocks of sandstone, limestone, and andesite seems to mirror these long-standing regional patterns, at a smaller scale. There was a long history of quarrying and transporting building stone from quarries around the Little Lake, as revealed by the origins of construction materials from Chiripa, as well as other sites. At Chiripa, the earliest evidence comes from a few samples in the Mamani phases. Such transport becomes a particularly notable component of the subsequent Tiwanaku phases both at Chiripa and other sites (Ponce 1970a, 1971, Ponce and Mogrovejo 1970), and con-

⁹Reconstruction of the magnitude, duration, and function of the regional resource procurement networks is deliberately limited to the evidence from the Chiripa excavations. Climatic evidence, discussed in a paper currently in preparation, suggests the potential for a rather dramatic reorganization of the Titicaca Basin about 4,000 years ago. In other areas of the Andes, preceramic resource procurement systems have greater time depth, and from studies on the Archaic Period in the southern sierra of Peru, might well be extended here. The evidence is not yet available to ascertain what impact the reorganization of the Titicaca basin economies four millennia ago might have had on the caravan systems. During the first millennium B.C., a number of local level polities developed at places like Sillumoqo, Chiripa, Chissi, Tiwanaku, and the like. The explication of the political interaction between these polities is beyond the scope of this paper.

tinued on through the Inca Period. In a sense, one could argue that the activity continued into the early Colonial and Republican Periods, because the built stone ruins of the pre-Columbian sites were employed as stone sources for the impressive Catholic cathedrals at places like Laja and La Paz, the cobble stones and foundation stones for residences in La Paz, and later even as construction stone for the late 19th century railroad bridges.

The current understanding of ceramic patterns of the Bolivian altiplano points to a sharing of specific ceramic vessel shape, decoration, and fabrication traits among discrete clusters of communities around the Lago Pequeño during the first millennium B.C., which appear to define a series of polities. One of the more general traits associated with Chiripa ware is fiber temper; because fiber temper was first identified in the archaeological record at Chiripa by Bennett, the occurrence of fiber temper wares from as far south as Northwest Argentina, east in Cochabamba, and west in northern Chile and far southern Peru, has often been linked with Chiripa -- but at this point fiber temper is such a general Titicaca basin Formative trait that simple observation of its occurrence is not sufficient to document an actual linkage with the Lago Pequeño polity. Rather, the accident of archaeological discovery which led to fiber tempered wares first being described at Chiripa has led to undemonstrated lists of associations. On the other hand, the trace elements analysis of the Chiripa mineral samples demonstrates early relations between Chiripa (Figure 7) and sites to the east in Cochabamba (sodalite), to the south at Corocoro (copper) and as far as Lake Poopó (basalt), to the southwest in northern Chile (copper minerals, turquoise), and to the west at Colca in southern Peru (obsidian). These associations allow us to verify and refine some of the linkages previously predicated on ceramic arguments, and to begin to outline the basis of the political economy resulting in the subsequent Tiwanaku hegemony.

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The integration and interpretation of the technical analyses has been done solely by Browman. While none of this paper would have been possible without the superb assistance and contributions of these colleagues, all syntheses and the responsibility for any errors resulting from them, are mine alone.

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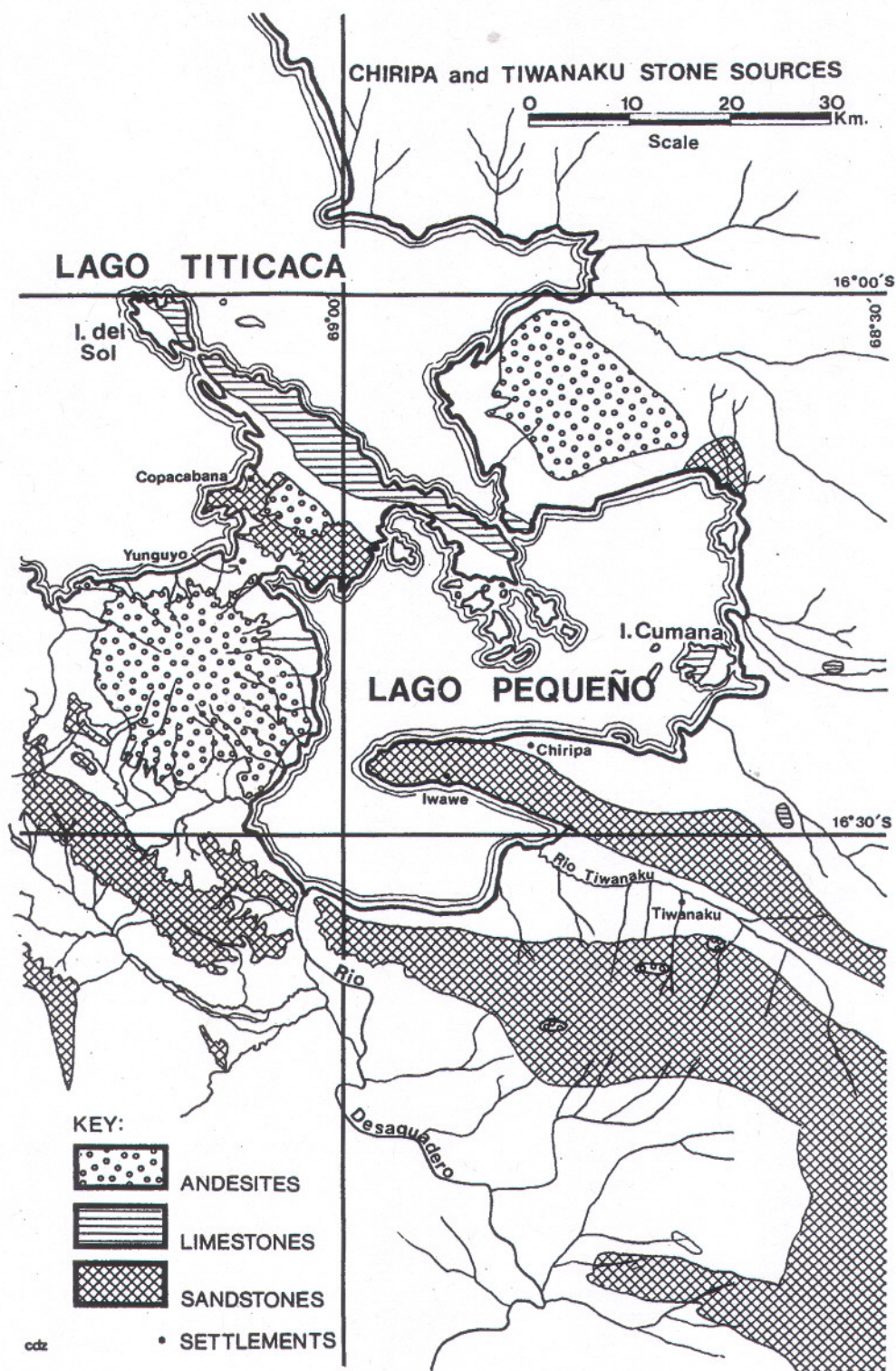
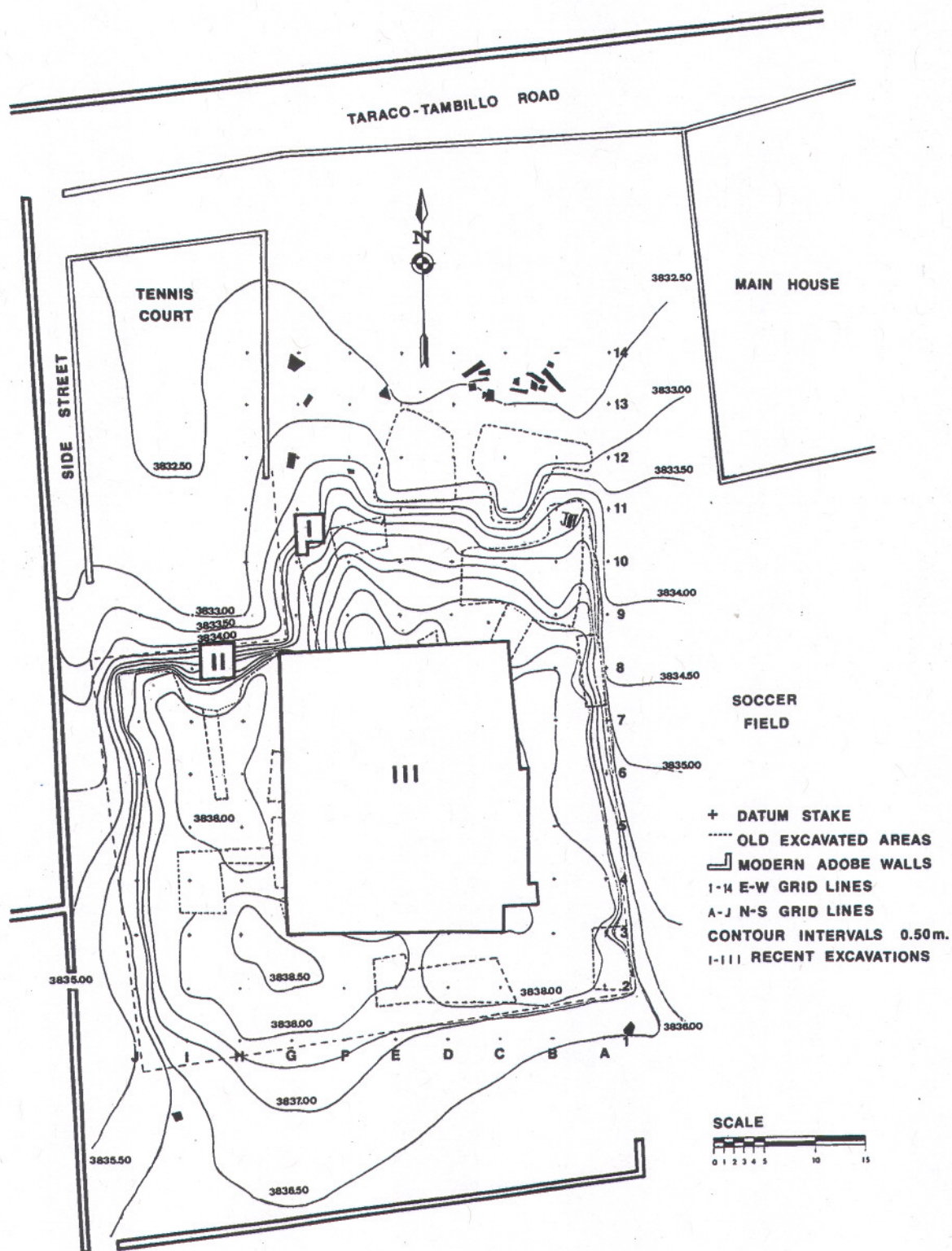
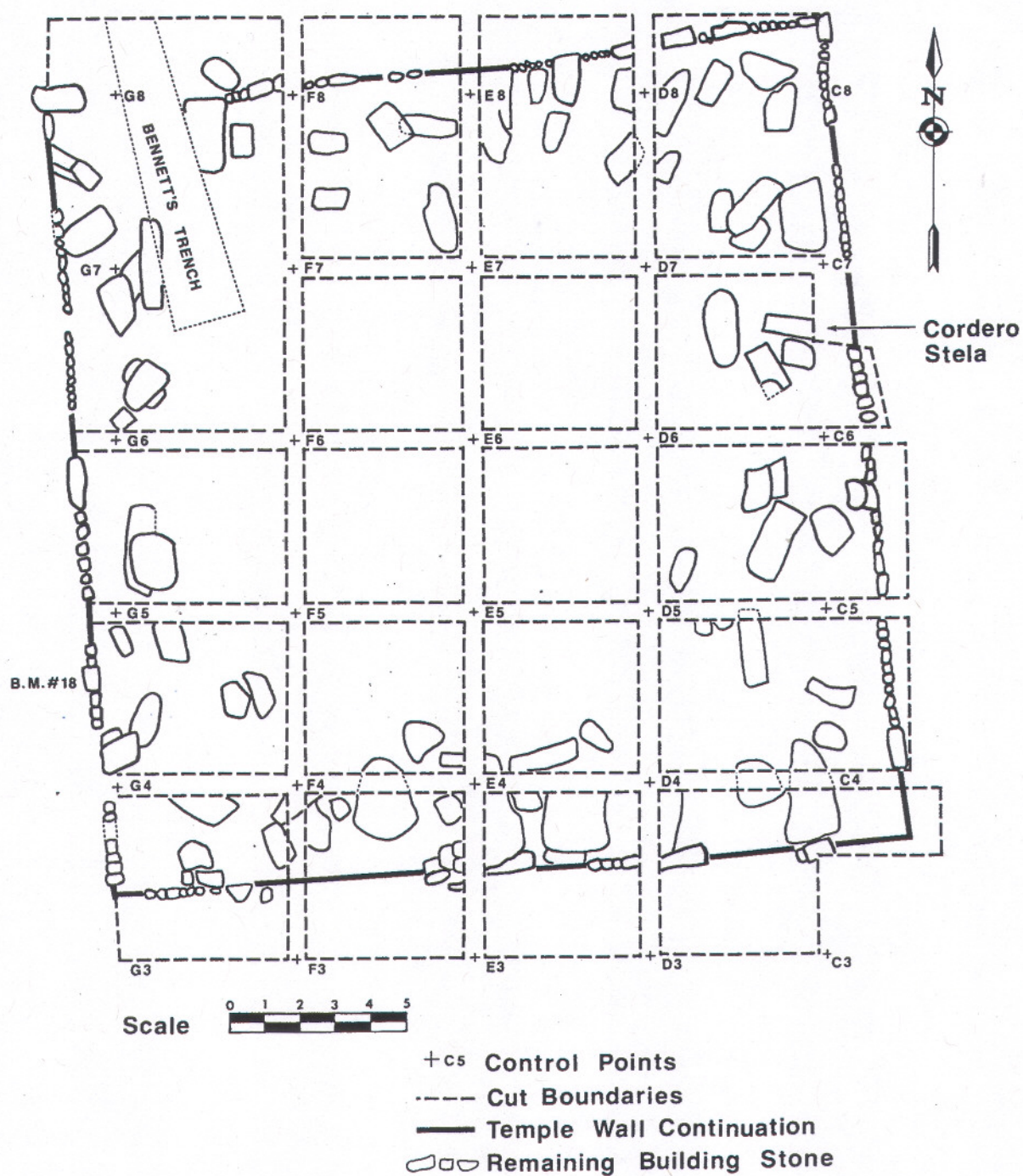


Figure 1. Location of Chiripa and the major stone sources near Chiripa, around the "Little Lake" portion of Lake Titicaca.



C.D.zG

Figure 2. Contour map of the Chiripa mound site, showing locations of the 1974-75 excavation units I, II, and III.



J.S.F. & C.Dz6.

Figure 3. Plat map of the excavation of the Tiwanaku phase temple, showing location of remaining wall and of abandoned robbed ashlar.

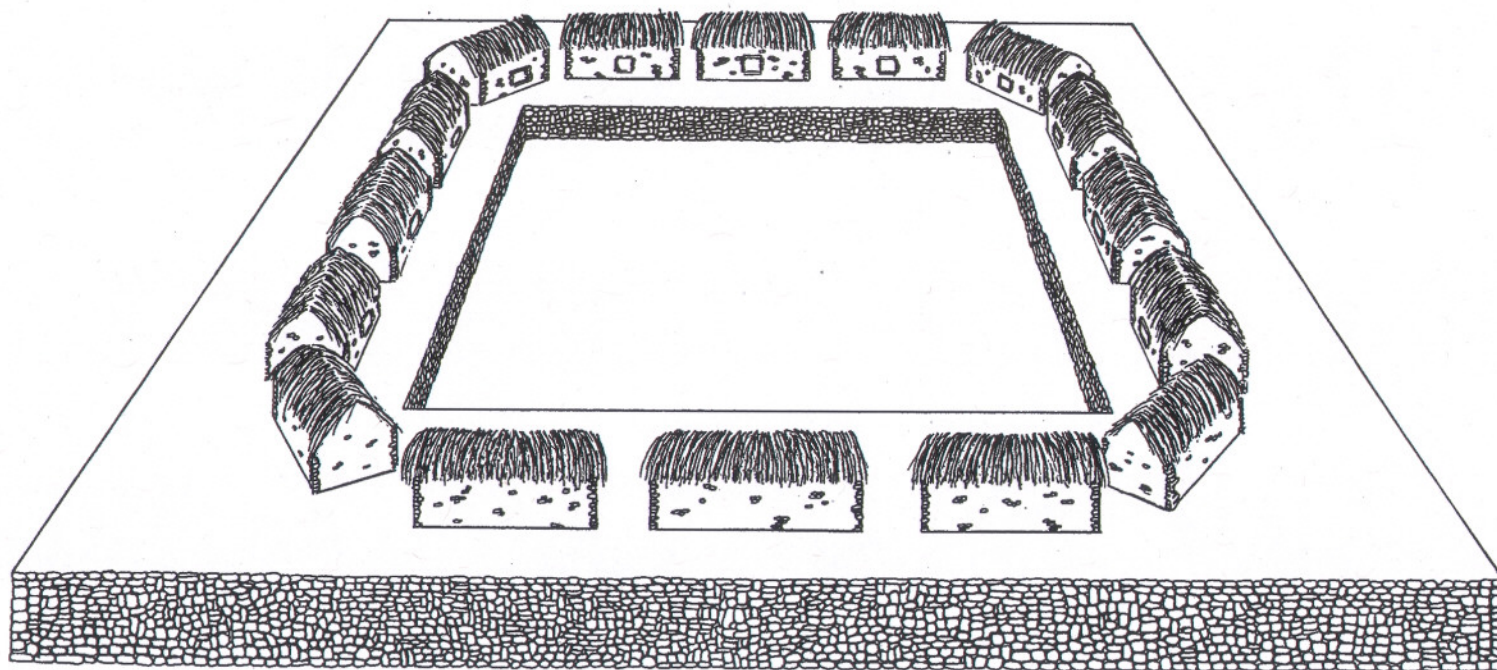


Figure 4. Idealized reconstruction of the Mamani phase houses, mound facing wall and temple at Chiripa. Based on a composite of information from Bennett, Kidder and our excavations. Some retaining walls omitted for clarity.

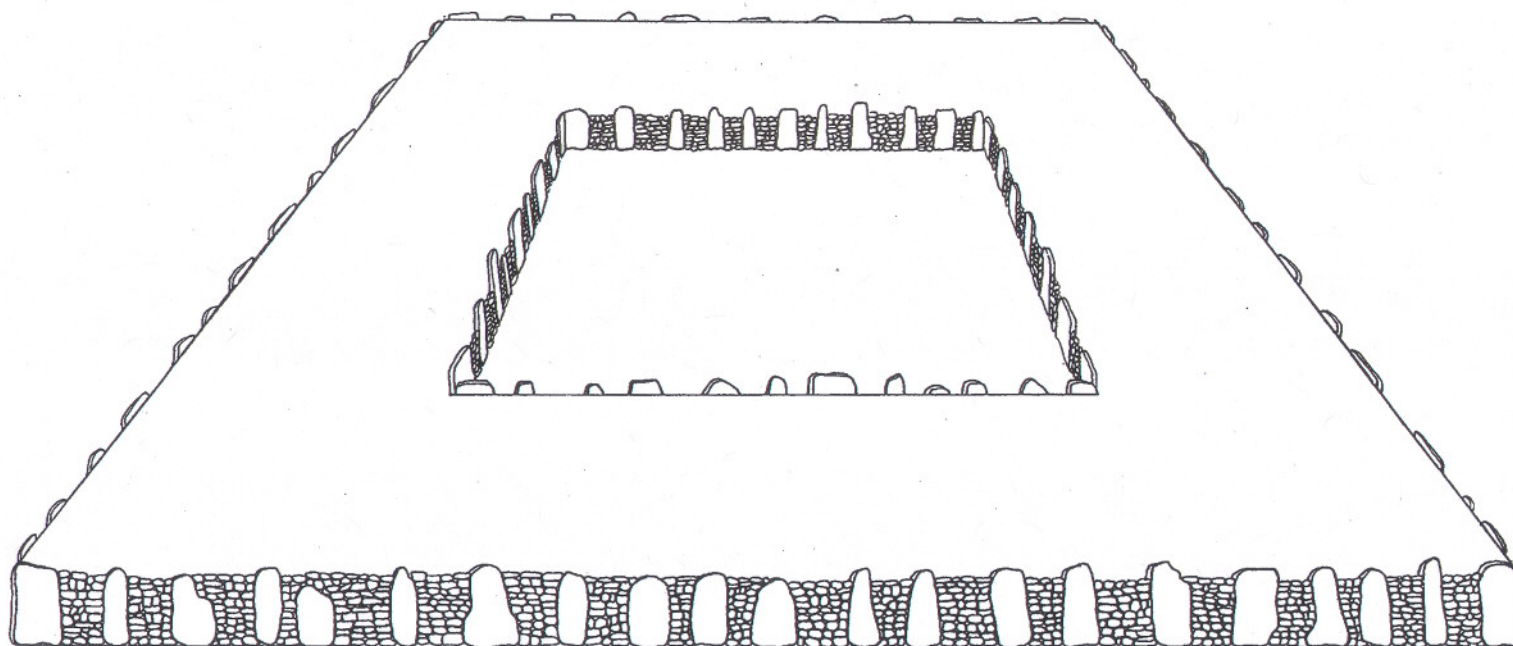


Figure 5. Idealized reconstruction of the Tiwanaku III phase temple at Chiripa, showing vertical ashlar construction technique.

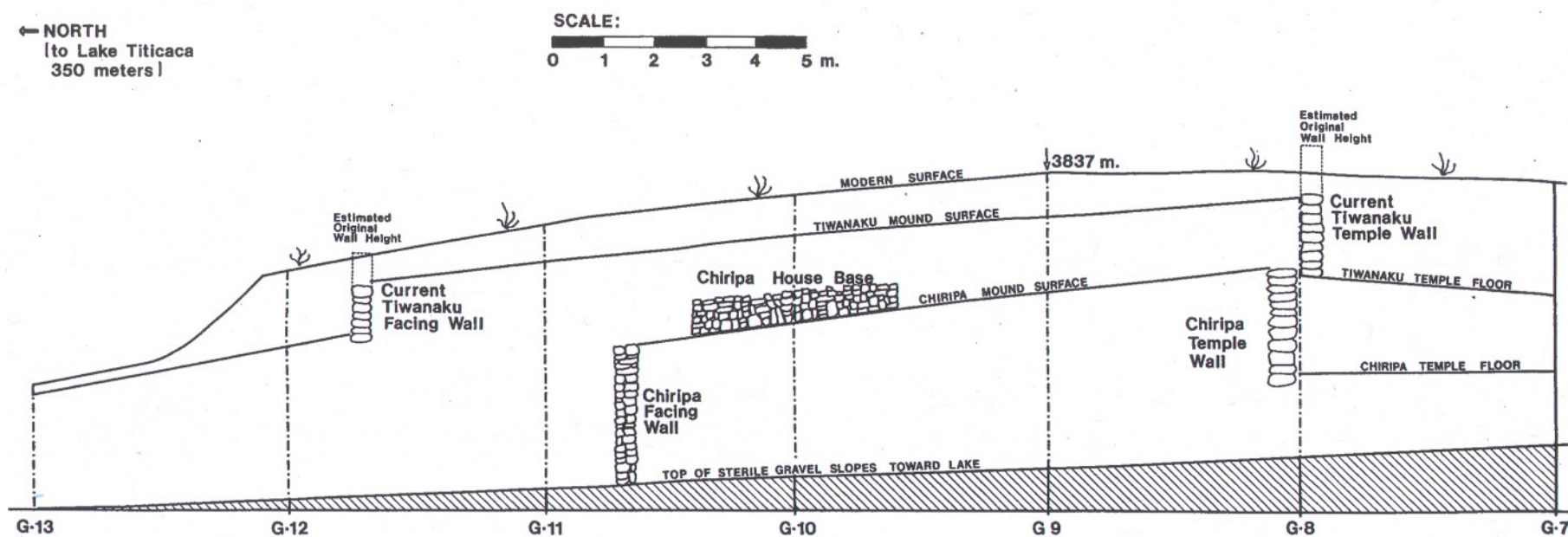


Figure 6. Composite 30 m. cross-section, showing relationship of the Mamani phase (Classic Chiripa) facing wall and temple wall to the subsequent Tiwanaku III phase constructions. Note relative position of the two temple walls and facing walls. Simplified section based on profiles from Bennett, Kidder, and our excavations.

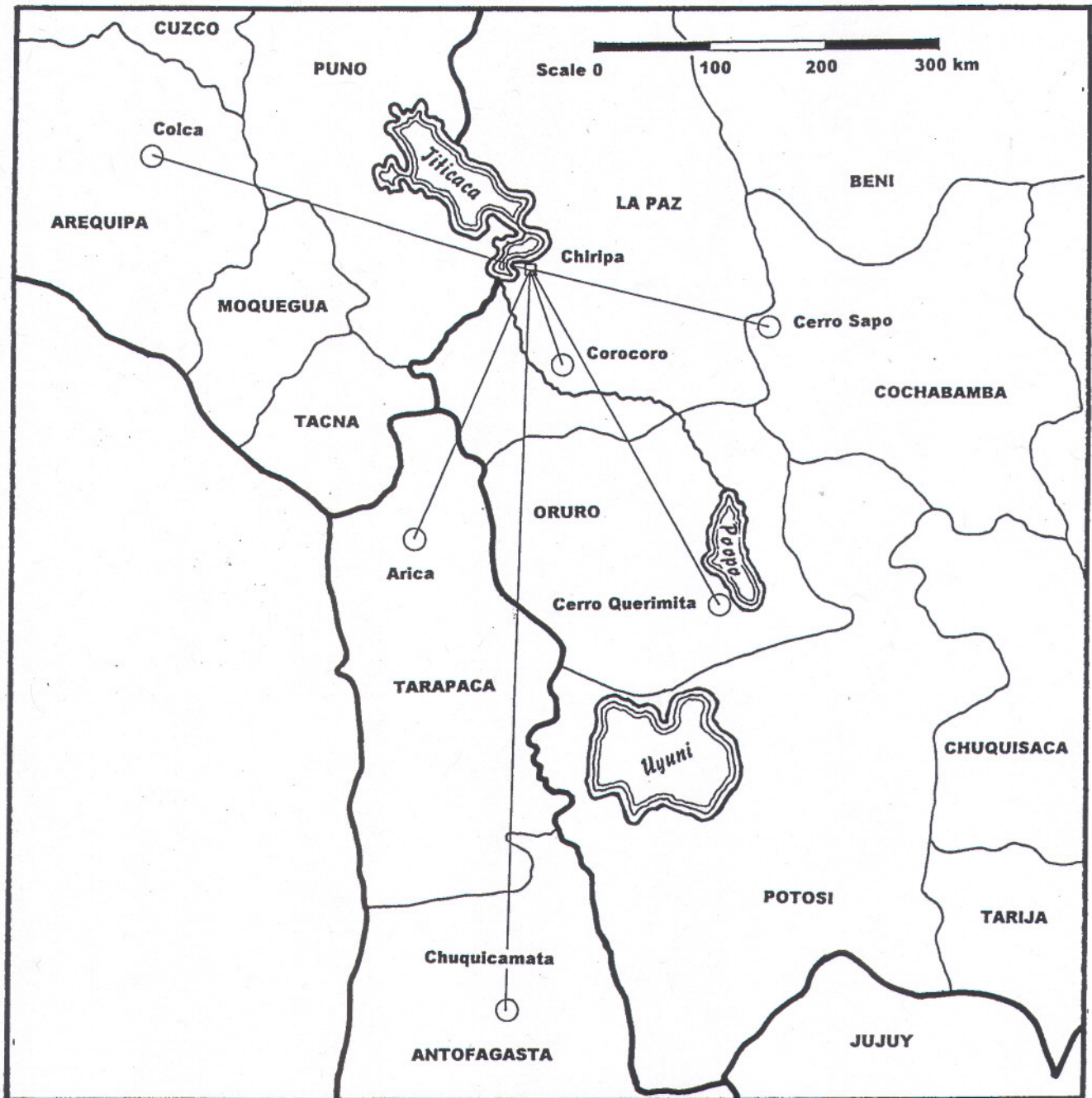


Figure 7. Approximate locations of the major sources for the long distance procurement at Chiripa.

Table 1. Chiripa radiocarbon and thermoluminescence determinations.

<i>Phase</i>	<i>Lab Number</i>	<i>Uncalibrated</i>	<i>Calibrated</i>
Condori/IA (1350-1250 bc)	Beta-31291	1530 b.c. $\pm$ 180	1820 B.C. $\pm$ 220
	GX-4057	1260 b.c. $\pm$ 170	1500 B.C. $\pm$ 200
	RL-496	1240 b.c. $\pm$ 120	1500 B.C. $\pm$ 130
	WU-TL49A	900 B.C. $\pm$ 430	900 B.C. $\pm$ 430
Condori/IB (1250-850 bc)	WU-TL49B	1380 B.C. $\pm$ 500	1380 B.C. $\pm$ 590
	P-129	1290 b.c. $\pm$ 130	1545 B.C. $\pm$ 145
	RL-495	1220 b.c. $\pm$ 120	1430 B.C. $\pm$ 120
	P-145	1020 b.c. $\pm$ 120	1180 B.C. $\pm$ 140
	RL-494	900 b.c. $\pm$ 110	1040 B.C. $\pm$ 130
	RL-493	870 b.c. $\pm$ 110	1010 B.C. $\pm$ 120
	WU-TL49C	510 B.C. $\pm$ 370	510 B.C. $\pm$ 370
Llusco/II (850-650 bc)	WU-TL49D	1050 B.C. $\pm$ 450	1050 B.C. $\pm$ 450
	RL-491	950 b.c. $\pm$ 140	1095 B.C. $\pm$ 175
	RL-492	860 b.c. $\pm$ 180	1015 B.C. $\pm$ 205
	GX-3596	435 b.c. $\pm$ 165	575 B.C. $\pm$ 215
	WU-TL49E	100 B.C. $\pm$ 310	100 B.C. $\pm$ 310
Mamani/IIIA (650-350 bc)	GX-3595	775 b.c. $\pm$ 100	900 B.C. $\pm$ 90
	WU-TL49F	640 B.C. $\pm$ 390	640 B.C. $\pm$ 390
	P-126	600 b.c. $\pm$ 116	670 B.C. $\pm$ 150
	P-115	518 b.c. $\pm$ 133	625 B.C. $\pm$ 145
	GX-4059	510 b.c. $\pm$ 165	590 B.C. $\pm$ 180
	WU-TL49I	470 B.C. $\pm$ 365	470 B.C. $\pm$ 365
	GX-4058	350 b.c. $\pm$ 155	360 B.C. $\pm$ 180
	P-125	346 b.c. $\pm$ 114	355 B.C. $\pm$ 165
	P-124	341 b.c. $\pm$ 115	355 B.C. $\pm$ 165
	P-142	331 b.c. $\pm$ 113	345 B.C. $\pm$ 165
	I-8314	285 b.c. $\pm$ 240	260 B.C. $\pm$ 280
Mamani/IIIB (350-50 bc)	P-116	427 b.c. $\pm$ 110	470 B.C. $\pm$ 90
	P-143B	368 b.c. $\pm$ 113	435 B.C. $\pm$ 95
	WU-TL49G	330 B.C. $\pm$ 340	330 B.C. $\pm$ 340
	P-141	325 b.c. $\pm$ 116	300 B.C. $\pm$ 130
	Beta-31290	290 b.c. $\pm$ 90	265 B.C. $\pm$ 65
	P-144	243 b.c. $\pm$ 111	275 B.C. $\pm$ 115
	P-143A	227 b.c. $\pm$ 112	265 B.C. $\pm$ 115
	WU-TL49H	40 B.C. $\pm$ 300	40 B.C. $\pm$ 300
	P-117	a.d. 13 $\pm$ 104	A.D. 35 $\pm$ 115
	P-118	a.d. 22 $\pm$ 105	A.D. 181 $\pm$ 31
	WU-TL49J	A.D. 160 $\pm$ 270	A.D. 160 $\pm$ 270

* All radiocarbon determinations (b.c., a.d.), except P-143A, on charcoal. Calibrated determinations (B.C., A.D.) based on Stuiver and Reimer 1986, 20 year average statistic, method B. TL determinations (WU-TLxxx) are calibrated in sidereal years. Assignment to phases based on stratigraphic and cultural associations.

Table 2. Trace element composition of the unknown obsidian, second millennium B.C. Chiripa. (Sample in direct association with assay RL-493, see Table 1. Data from analyses by Larry D. Haskin conducted in 1986. Sample irradiated at the Missouri University Research Reactor, Columbia.)

As	11.1 ± 0.4
Ba	440 ± 20
Br	1.8 ± 0.2
CaO (%)	<1.0
Ce	68.9 ± 1.0
Co	0.14 ± 0.03
Cs	15.0 ± 0.3
Eu	0.26 ± 0.02
FeO (%)	1.19 ± 0.03
Hf	7.7 ± 0.3
La	33.7
Lu	0.673 ± 0.015
Na ₂ O (%)	4.50 ± 0.05
Nd	29 ± 4
Rb	180 ± 8
Sb	1.23 ± 0.05
Sc	2.73 ± 0.05
Sm	6.41 ± 0.11
Ta	1.00 ± 0.05
Tb	1.13 ± 0.06
Th	17.5 ± 0.4
U	7.5 ± 0.3
W	3.0 ± 0.6
Yb	4.44 ± 0.07
Zr	270 ± 60