

## Epipaleolithic/early Neolithic settlements at Qinghai Lake, western China

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### Abstract

Transitions from terminal Pleistocene Upper Paleolithic foraging to Holocene Neolithic farming and pastoralist economic orientations in the northern Tibetan Plateau are examined from the perspective of Epipaleolithic sites located near Qinghai Lake, Qinghai Province, western China. Jiangxigou 2 is an artifact-rich, multicomponent midden site with the main period of occupation dating ca. 9000–5000 cal yr BP, containing abundant flaked stone artifacts including a substantial proportion of microlithic tools, abundant faunal remains including gazelle, deer, and sheep, and a small number of ceramics, including the oldest known on the Tibetan Plateau. Heimahe 3, on the other hand, is a brief hunter's camp dating ca. 8450 cal yr BP, with evident affinities to late Upper Paleolithic camps in the same region that date several thousand years older. The two distinctively different sites are probably nodes within a single Epipaleolithic foraging system that developed on the margins of the high Tibetan Plateau during the early Holocene, and that served as a basis for colonization of the high-altitude Plateau at that time. Jiangxigou 2 appears to be connected to early Neolithic agricultural settlements along the upper Yellow River (Huang He) drainage during the middle Holocene, and may provide insights into forager–agriculturalist interactions that lead to the development of pastoralist systems in the region.

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**Keywords:** Tibetan Plateau; Epipaleolithic; Neolithic; Western China; Forager–farmer interactions

### 1. Introduction

The Tibetan–Qinghai Plateau, the vast high-altitude core of central Asia, ranks among the most extreme environments on earth inhabited by early modern humans. By 15,000 years ago, Upper Paleolithic foragers had moved into the northeastern fringes of the Plateau in the Qinghai Lake and Qaidam basins (Fig. 1), surviving at altitudes of 3000–4000 m [47]. People

may have begun to occupy the high interior Plateau (at altitudes greater than 4000 m) by this time [1,2,14], but such an early date is unsubstantiated and it is likely that sustained occupation of the central Plateau probably occurred during the early Holocene by human populations with Epipaleolithic or Neolithic economic and social adaptations [15]. Whether the Upper Paleolithic behavior pattern represented by the small short-duration camps in the marginal Qinghai Lake and Qaidam Basins served as the basis for subsequent settlement of the high Plateau, and how such a behavior pattern may have evolved to enable more sustained occupation of high altitudes during the early Holocene, are still open questions.

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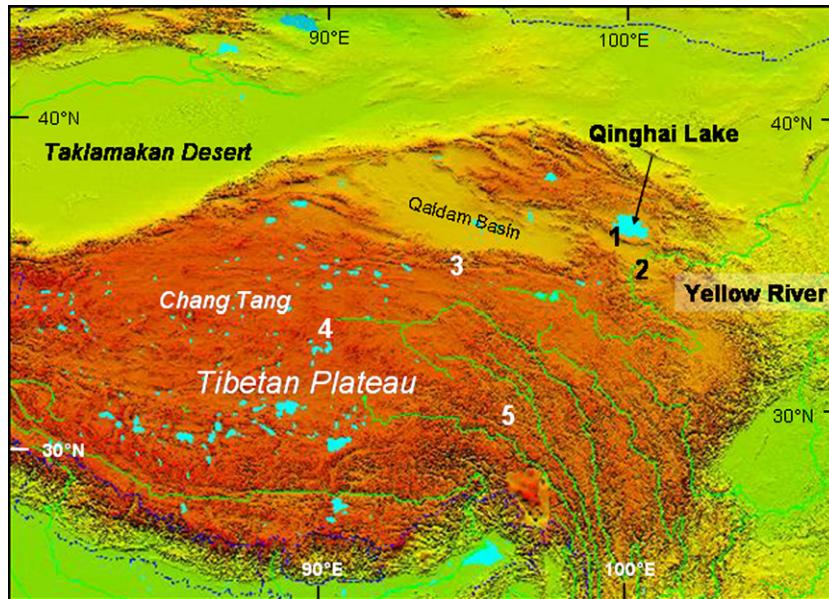


Fig. 1. The Tibetan Plateau in central Asia, showing locations of Qinghai Lake basin on the northeastern margin. Numbers refer to sites discussed in text: (1) Jiangxigou 2 and Heimahe 3, (2) Yellow River Sites (Layihai and Zongri complex in Gonghe Basin), (3) Xidatan, (4) Mirikgyadram Tso, (5) Karuo. Map source: Cornell University Digital Earth Geoscience Database.

Part of the answer to such questions must lie with the nature of Epipaleolithic and Neolithic populations in the Qinghai Lake region, the likely colonizers of the northern and central Tibetan Plateau [1,14,15]. Late Neolithic occupation of the Qinghai Lake region and northeastern margin of the Tibetan Plateau has long been known [1,2,8,17,20,22,37], but the earlier Epipaleolithic and Neolithic antecedents in this region — their age, economic orientation, and origins — are much less well understood.

In this paper, we present preliminary results from archaeological sites in the Qinghai Lake area that shed light on Epipaleolithic and early Neolithic occupation of the northeastern

Tibetan Plateau region (Fig. 2). One of these sites, Jiangxigou 2, is a stratified cultural midden containing abundant lithic implements, mammal remains, and some ceramics, with the main period of occupation dating possibly as early as 9300 cal yr BP and extending until sometime after ca. 5000 cal yr BP, with limited occupation thereafter until at least 2000 cal yr BP. The other site, Heimahe 3, is a small hunter's camp dating to ca. 8500 cal yr BP that is similar in many respects to Upper Paleolithic sites from the same region dating several thousand years older. (Calendar estimates of radiocarbon dates presented in this paper are based on the CALIB radiocarbon calibration program [60].)

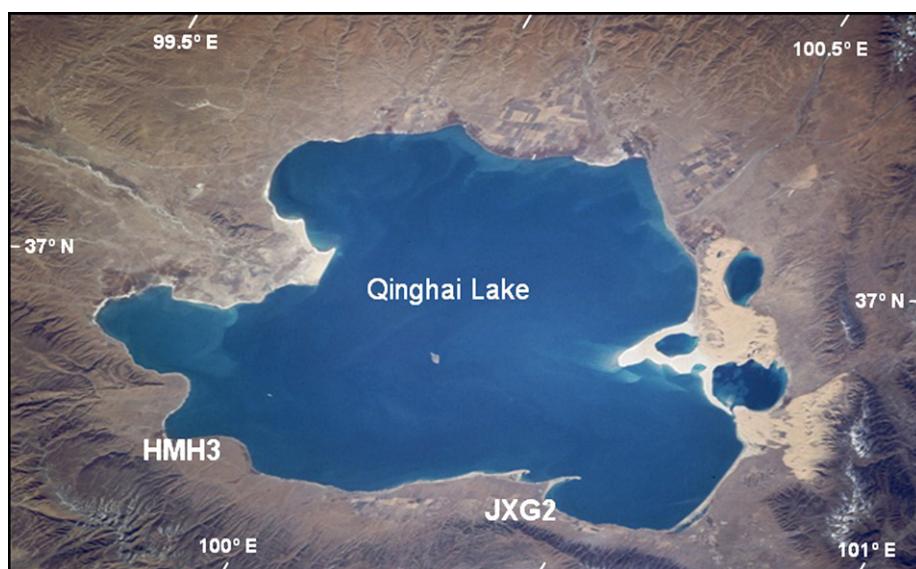


Fig. 2. Qinghai Lake, showing locations of Jiangxigou 2 (JXG2) and Heimahe 3 (HMH3).

Before describing the sites, it is worthwhile briefly considering our uses of the concepts “Epipaleolithic” and “Neolithic” in the context of western China and Tibet. Zhang [75] defined the Chinese “Epipaleolithic” as “artifact assemblages exhibiting the features of Paleolithic cultures but of Holocene date,” in keeping with the use of the term elsewhere in the world. We find that definition useful and follow it here, since it carries no particular behavioral connotations. Epipaleolithic artifact assemblages do retain certain features and artifact types commonly found in the sites of Upper Paleolithic foragers, consistent with a flexible and sophisticated hunting-based foraging economy [26]. In the northeastern Tibetan Plateau, these Epipaleolithic foraging groups interacted with emerging agricultural communities that initially developed in central China, and therefore likely differed substantially in terms of subsistence practices, mobility, and other features from their Upper Paleolithic counterparts. Likewise, we use the term “Neolithic” here in a limited sense, referring to the occurrence, in the Qinghai Lake basin and the Tibetan Plateau, of ceramics and other artifacts and features that are typical of those found in contemporaneous agricultural communities further east in central and western China [12,65]; the term does not here refer to the establishment of agricultural communities in the Qinghai Lake basin per se. We suspect that early Neolithic communities in far western China and on the Tibetan Plateau were profoundly influenced by interactions between local foragers and migrant farming groups, the incorporation of certain “Neolithic” subsistence practices and other useful technologies (such as ceramics) by local foragers, the persistence of long-standing foraging patterns, and the importance of newly evolving economic strategies such as pastoralism. In this respect, the Epipaleolithic–Neolithic ‘transition’ on the Tibetan Plateau (as elsewhere worldwide) might best be viewed as a dynamic set of interactions among people practicing various mixes of different economic strategies, rather than a unilateral shift of strategies or replacement of one population by another [1,15,40,59].

## 2. Environmental setting

Qinghai Lake (called Koko Nor in Mongol or Ngongpo Tso in Tibetan), on the northeastern margin of the Tibetan Plateau, is a vast ( $4278 \text{ km}^2$ ) but shallow (<27 m depth) closed saline lake, the terminus of the Buha River. The Buha drains a large ( $30,000 \text{ km}^2$ ) watershed on the southern slope of the Qilian Mountains, and contributes more than half of the water entering the lake [44,58,72]. Qinghai Lake itself has a present-day surface elevation of 3194 m asl; its broad shallow basin varies between 3200 and 3400 m altitude, and it is surrounded by subalpine to alpine mountains that reach altitudes exceeding 4500 m. The southern margin of Qinghai Lake is grassland meadow at present, changing to shrub meadow above ~3400 m in the South Qinghai Mountains (Qinghai Nan Shan) [32]. The northern and eastern lake margins are dominated by dry steppe vegetation.

The basin has a semi-arid climate characterized by long cold winters and short cool summers, with about 400 mm

average annual precipitation (at lake level) falling mainly in the summer [72]. It is positioned at the junction of three major climatic systems, lying within the regime of prevailing northwesterly continental dry winds from northern Eurasia, and at the outer fringes of southeast and southwest Asian summer monsoon influences. Fluctuations in the strength of these climatic regimes account for dramatic changes in the hydrologic balance in the Buha River watershed that are sensitively recorded in Qinghai Lake deposits [34,35]. Multiple shorelines attest to higher lake levels in the ancient past, reportedly up to ~140 m above the present lake [21,42,50]. In addition to these shorelines, the post-glacial record of environmental change in the basin is best recorded in sediment cores from the lake itself [21,42,58,68,69,70,72,73].

At the height of the very cold and dry last glacial maximum, Qinghai Lake was much reduced in size, possibly dry, and a sparse cover of desert steppe vegetation dominated the landscape. Beginning about 16,900 cal yr BP climate remained cold and arid and the lake remained nearly dry, but vegetation in the basin shifted slightly from desert steppe to a mosaic of desert steppe and conifer forest steppe, dominated by spruce and pine. From about 14,100–10,800 cal yr BP the summer monsoon system began to develop, bringing increases in temperature and humidity during century-to-millennia long periods that correspond with the Bølling and Allerød events in Europe, which alternated with cooler drier phases correlative with the Older and Younger Dryas [42,58]. During the warm wet events lake levels rose to a depth of up to 6 m, but declined to very shallow levels or even playa conditions in dry periods [42,72]. Significantly warmer and wetter conditions prevailed from about 10,800 to 8500 cal yr BP. Pollen data show expansion of birch, a warm-climate indicator, to become the dominant tree in the basin, an increase in marsh and meadow plants of the bulrush family (Cyperaceae), and a decrease in cold-desert indicators such as *Nitraria*. Yu and Kelts [72] consider the lake to have risen to a maximum of about 8 m depth during the early Holocene (compared to 27 m depth today). A brief cold episode is apparent in the pollen record ca. 8200 cal yr BP [58; cf. 4], with a decrease in birch and increase in dark conifers; but warmer and wetter conditions quickly returned by about 7800 cal yr BP, as the summer monsoon strengthened over the Tibetan Plateau [62]. During this Holocene climatic optimum a forest of deciduous hardwoods such as birch, elm, and poplar mixed with conifers (chiefly pine along with spruce and fir) probably covered the mountains and may have encroached on the meadows at the lake margin [58]. The lake itself apparently rose dramatically during this period. Lister et al. [42] suggest it reached a post-glacial highstand of ca. 12 m above the modern lake during this time, although our data from Heimahe 3 indicate it must have been less than that (see Section 3). The climatic optimum that resulted in Qinghai Lake’s rise persisted until about 6000 years ago, after which time the landscape changed to a more open forest steppe. Lake productivity also declined in response to decreasing warmth and precipitation after 6000 cal yr BP. Climate became significantly cooler and more arid after ca. 4500 cal yr BP, the level of the lake declined to

approximately modern levels, trees decreased in abundance and steppe vegetation came to dominate the landscape. Changes in the nature and distribution of mid-to-late Neolithic cultures in the Qinghai Lake region may be related to these later Holocene oscillations [5,6,43,46]. Climatic conditions have been fairly stable since about 3500 cal BP, with vegetation increasingly dominated by grassy meadow and steppe vegetation and diminishing woodland and shrublands. Diminishment of woody taxa over the last 2500 years may have resulted in large part from increased human activities in the vicinity [58], similar to the deforestation that apparently occurred as a result of human settlement in the southeastern Tibetan Plateau [38,53,54].

### 2.1. Jiangxigou 2

This multicomponent midden site is located at approximately 3312 m elevation in the mouth of a canyon on the north side of the South Qinghai Mountains, approximately 4.5 km south of Qinghai Lake (Fig. 2). The site occupies a fairly level open fluvial terrace on the east side of a small stream, within 100 m of an active spring (Fig. 3), and is protected east and

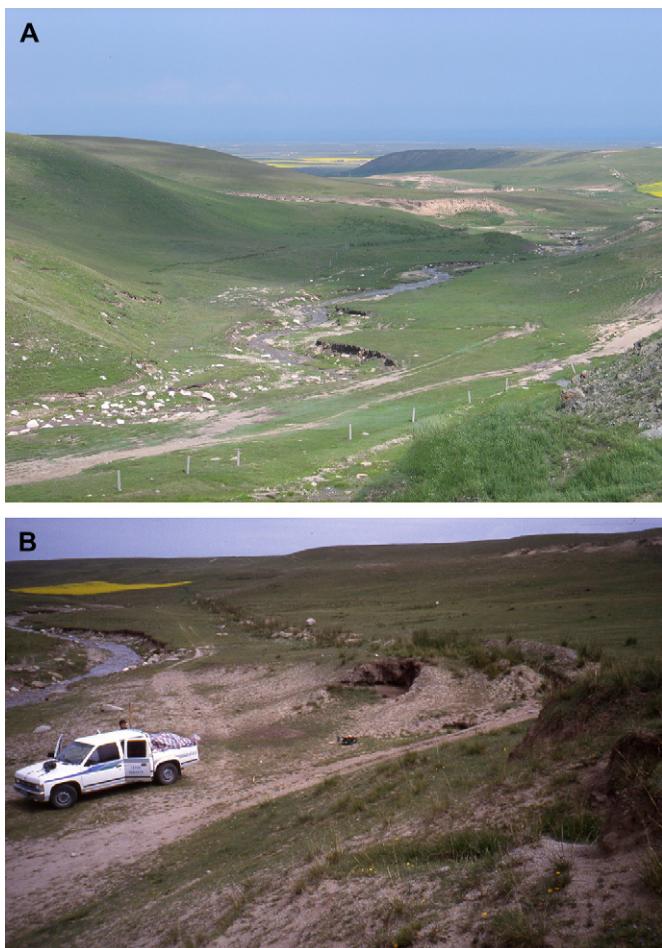


Fig. 3. Setting of Jiangxigou 2, looking north toward Qinghai Lake. (A) General overview of the Jiangxigou 2 site in the foothills of the South Qinghai Mountains. (B) The exposed cutbank and pipeline trench are visible in center of photo.



Fig. 4. Stratigraphic profile at Jiangxigou 2. Numbers refer to stratigraphic designations; see text for description.

west by low flanking ridges of alluvial, eolian, and possibly ancient deltaic sediments from the uppermost highstand of Qinghai Lake [69,74; but see 51]. The stream terrace is approximately 2–3 m higher than the present depth of the stream. The buried cultural deposit at Jiangxigou 2 is exposed in several small cutbanks on the margin of the terrace, as well as a pipeline trench from the spring.

Our investigations at this site have been limited to cleaning the face of one exposed cutbank (Fig. 4), mapping the profile of that face, collecting controlled samples of artifacts and datable materials that were removed in the process of cleaning the cutbank, and mapping the exposed pipeline trench profile. Sediments removed from the cutbank were screened through 3.2 mm hardware cloth to retrieve smaller-sized items. Although the amount of excavation and exposure at the site is extremely limited to this point, the results are potentially significant enough to warrant a preliminary report.

Fig. 4 depicts the stratigraphy revealed in the exposed cutbank. Five main stratigraphic units are identified from the site. The basal unit (Stratum 5) consists of fluvial cobbles and sands that form the core of the stream terrace; this unit is buried approximately 50 cm below the base of the profile shown in Fig. 4, but it was exposed in the pipeline trench and forms the level of a slightly lower terrace between the cutbank and stream. These stream deposits are capped by a layer of fine yellow brown carbonaceous loess dominated by silt with small fractions of sand and clay, very hard in structure but disturbed in places by mammal burrows, and containing scant artifacts (Table 1). It is shown as Stratum 4 in Fig. 4.

Above this lower, largely culturally sterile loess is a compact, light to medium gray-brown somewhat carbonaceous silty loam (Stratum 3, 80–110 cm depth in the profile in Fig. 4); it is the lowest stratum in the profile that contains significant quantities of artifacts (Table 1). The top of Stratum 3 (81 cm depth) is radiocarbon dated to  $7330 \pm 50$   $^{14}\text{C}$  yr BP (Beta-208336), or approximately 8170 cal yr BP (modal age estimate). The age of the base of this stratum is obtained

Table 1  
Jiangxigou 2 Strata, dates, and artifact counts

Depth (cm)	Stratum	Dates	Lithics	Bone	Ceramics	Fire-Broken Rock
0–10	1		4	9		
10–20	1		6	4		
20–30	1	1970 ± 90 cal yr BP; OSL, IRSL, TL weighted average; UW-1358	1	0	1	5
30–40	1	100 ± 40 $^{14}\text{C}$ yr BP = ~50, 120, or 230 cal yr BP multi-modal values (270 cal yr BP to present, $2\sigma$ ); Beta-208335	13	1		4
40–50	2a		50	37	1	11
50–60	2a	4973 ± 254 cal yr BP; OSL, FS05-95, UW-1360; 54 cm depth	58	47	2	12
60–70	2a	4850 ± 40 $^{14}\text{C}$ yr BP = ~5950 cal yr BP modal value (5657–5476 cal yr BP, $2\sigma$ ); Beta-209350	79	167	1	12
		6542 ± 472 cal yr BP; FS05-74, UW-1359				
70–80	2b		90	217		25
80–90	3	7330 ± 50 $^{14}\text{C}$ yr BP = ~8170 cal yr BP modal value (8303–8014 cal yr BP, $2\sigma$ ); Beta-208336; 81 cm depth	51	121		14
90–100	3	8170 ± 50 $^{14}\text{C}$ yr BP = ~9100 cal yr BP modal value (9268–9010 cal yr BP, $2\sigma$ ); Beta-194541; sample taken 60 cm east of profile, depth approximate	48	124		4
100–110	3		5	24		2
110–120	4		5	6		
120–130	4		2			
Total			412	757	5	89

from charcoal in an ash lens traced to the bottom half of this same stratum approximately 60 cm east of the profile, that gives a radiocarbon date of  $8170 \pm 50$   $^{14}\text{C}$  yr BP (Beta-194541), or about 9100 cal yr BP modal value. The dated charcoal is tentatively identified as willow or poplar.

Stratum 2, at a depth of 42–80 cm below surface, is a thick layer of dark gray-brown silty loam. This stratum may represent a buried middle Holocene paleosol, but it also contains the bulk of the artifacts at the site as well as charcoal flecks, ash, and scattered fire altered cobbles that probably represent cooking stones, so whether it is in fact a buried soil is not certain. Stratum 2 can be subdivided into upper and lower units, separable at an indistinct line of fire-affected cobbles at about 70 cm depth. The lower unit (2b) contains the greatest artifact density in the profile, including abundant lithics, highly fragmented faunal remains, and fire-affected rock fragments (Table 1). The lower unit 2b is not well dated, but based on the ages of bracketing strata it probably dates between 8000 and 6000 cal yr BP. The upper unit (2a) is slightly less densely laden but still contains abundant artifacts with a high proportion of microliths, faunal remains, and fire-affected rock, and a small number of ceramics (Table 1). The upper unit 2a is dated by radiocarbon to  $4850 \pm 40$   $^{14}\text{C}$  yr BP (60–70 cm depth, Beta-209350), or approximately 5950 cal yr BP. Two ceramic sherds also provide estimates of the age of this deposit. One sherd near the base of unit 2a (FS05-74; Fig. 5) yielded an optically stimulated luminescence (OSL) age estimate of  $6542 \pm 472$  cal yr BP (UW-1359). A second sherd from higher up in Stratum 2a (FS05-95) yielded an OSL age of  $4973 \pm 254$  cal yr BP (UW-1360).

Finally, at the top of the profile Stratum 1 consists of the modern soil developed into surficial silts and sands, extending to a depth of approximately 40 cm. Artifact density is much less than in Stratum 2 below, and may represent materials

displaced upward by rodent burrowing in the sediments (Table 1). A ceramic sherd from the 20–30 cm depth yielded a luminescence age of  $1970 \pm 90$  cal yr BP (UW-1358). (This age estimate is a weighted average of thermoluminescence, OSL, and infrared stimulated luminescence methods; J. Feathers, personal communication.) A radiocarbon date of charcoal from 30 to 40 cm depth yielded an age of  $100 \pm 40$   $^{14}\text{C}$  yr BP, indicating the extent of mixture in the upper 40 cm of sediments.

The main period of occupation at Jiangxigou 2 thus appears to date as early as 9300 cal yr BP, and extends until sometime after ca. 5000 cal yr BP. Sporadic occupation after 5000 cal yr



Fig. 5. Cord-marked potsherd (FS05-74) from base of Stratum 2a, Jiangxigou 2. This sherd returned an OSL date of  $6542 \pm 472$  cal yr BP (UW-1359).

BP is indicated by the single luminescence date on the sherd in Stratum 1, but the depleted number of artifacts in this stratum suggests that post-5000 cal yr BP occupation was very limited in intensity compared to the earlier habitation.

Lithic artifacts at the site are derived from microlithic, blade-bladelet, and flake-based industries (Fig. 6). Lithic raw materials include a wide variety of cherts, several visually differentiable types of quartz, quartz crystal, a few larger flakes formed from granite, and two flakes of obsidian (see Section 3). Microlithic industries are represented by abundant microblades and blade fragments, 10 microblade cores and core fragments, and four crested bladelets (*lame à crete*). Microlithic industries have their greatest representation in Stratum 2a, amounting to more than 40% of all lithic artifacts in this level, but they are nearly as frequent in lower strata as well. Within Stratum 3 and the base of Stratum 2a are a few larger specialized blade forms, flat and straight-sided with punctiform platforms, that appear to be end-hafted blade points that are very similar to those found at sites in the Chang Tang on the high central Tibetan Plateau [13,14]. Debitage from flake-based lithic industries are dominant throughout, though no flake cores have yet been found. Formal stone tools are rare in the cutbank profile, consisting of a single small thumbnail scraper (from Stratum 2b) and a few retouched microliths. Also noted at the site were a well-formed and well-used two-sided handstone presumably used for milling, a large bifacially retouched green chert knife or sickle, and microblades. These finds were not encountered in buried context, however, so their age is undetermined.

Several small ceramic sherds were located in the upper strata, including relatively thin (<7 mm) cord-marked (Fig. 5) and thicker (>7 mm) undecorated varieties. The sherds are light yellowish-brown to reddish-brown in color, often grading

to medium gray-brown on exterior surfaces. Inclusions typically include crushed angular quartz and other mineral fragments 0.5–1.5 mm in diameter; two of four sherds examined contain crushed pottery inclusions as well. Cracks and small vugs are frequent in most of the sherds; one sherd (FS05-61), the youngest, contains no cracks and only small well-distributed air pockets along with angular dark mineral temper. The sherds are all so small that little can be said about vessel shape or size. The cord-marked sherds (Fig. 5) resemble body sherds from painted “Zongri Culture” jars dating to ~5600–4000 cal yr BP found in a number of sites along upper Yellow River drainages in the Gonghe basin south of Jiangxigou 2 [20,55], although no painted sherds were recovered from the limited exposure. Luminescence ages of the ceramics at Jiangxigou 2 suggest they date as early as 6500 cal yr BP, the oldest known on the Tibetan Plateau (see Section 3).

Faunal remains are abundant at Jiangxigou 2, with more than 750 bone and teeth fragments recovered in the small area excavated. The remains are highly fragmented, suggesting that they may have been processed for grease or marrow extraction. A small proportion (<5%) are burned or calcined, suggesting that the bones themselves were not heavily utilized for fuel [63]. Based on size, the remains appear to represent primarily medium-sized mammals, though small mammal remains are present as well. The high degree of fragmentation makes taxonomic identification difficult. Skeletal parts represented include primarily limb (long bone) fragments, as well as ribs, vertebrae, scapula and pelvic fragments, and a few skull fragments including teeth. Several teeth and teeth fragments can be tentatively identified to sheep (most likely the bharal or Himalayan blue sheep, *Pseudois nayaur*, but possibly domestic sheep, *Ovis aries*), Tibetan gazelle (*Procapra picticaudata*), and a small deer. The teeth fragments tend to be

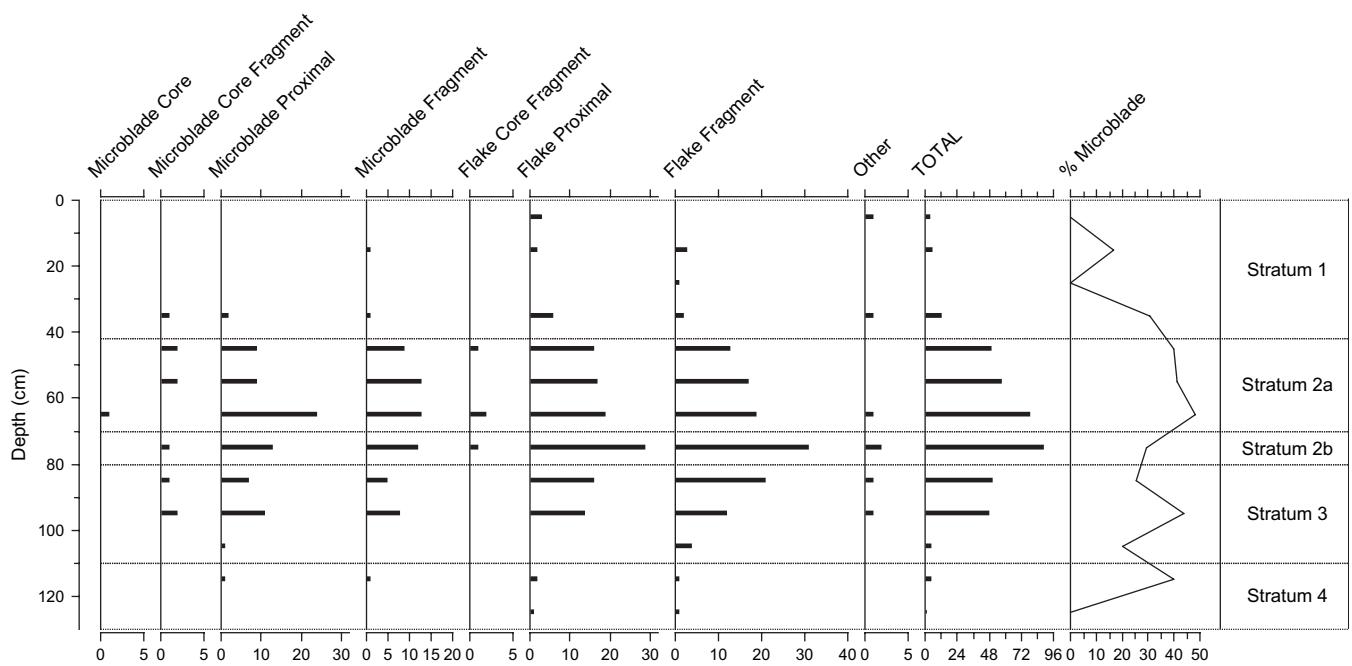


Fig. 6. Distribution of lithic artifacts across strata in exposed cutbank, Jiangxigou 2.

very well worn or small and deciduous, suggesting they came from either young or quite aged animals. These teeth are found in Stratum 2b and 3, the earlier component at the site. Additional identification and taphonomic study of larger faunal samples is clearly necessary before definitive answers can be given to the nature of the assemblage and changes in faunal representation through time, including the important question of whether the sheep remains represent wild hunted game or domestic herds (see Section 3).

## 2.2. Heimahe 3

This small site consists of the remnant of an isolated hearth exposed in the profile of an old meander scar of the Black Horse River (Heimahe) southwest of Qinghai Lake, at an altitude of ~3202 m about 6 m above the present level of the lake and 2 km southwest of its present shoreline (Fig. 2). The site rests within a 3.5 m exposure of stream channel alluvium, shoreline sands and gravels, and eolian silts and sands (Fig. 7). Charcoal from the hearth is concentrated in



Fig. 7. Heimahe 3. (A) Location of the cutbank in which Heimahe 3 is located (arrow) in relation to Black Horse River. Looking east toward town of Heimahe. (B) Position of Heimahe 3 in cutbank.



Fig. 8. Stratigraphic section of Heimahe 3 site. Note scatter of stones and reddened silt beneath hearth.

a 1–2 cm thick lens above an oxidized zone resulting from the heat of the central fire. This intermittent charcoal staining can be traced 2 m to the west and 1 m to the east of the hearth center and appears to mark the limits of the surrounding use surface. The meander extends in an L-shaped fashion around this use surface and no charcoal or other cultural material is evident elsewhere on the face of this meander scar.

The hearth remnant and associated use surface occurs 1.95 m below the modern surface and rests on the interface between an underlying set of fluvial sands and overlying loess-like depositions (Fig. 8). A mid-Holocene soil occurs 75 cm above the hearth surface. The underlying fluvial deposits consist of well-sorted gravel at the base, fining upwards to ripple-laminated sand and thin, flat-bedded silty sand. These fluvial deposits may represent the shoreline interface of the Black Horse River and Qinghai Lake. Charcoal from the hearth (identified as poplar) gives a radiocarbon date of ca. 8370–8540 cal yr BP ( $7630 \pm 50$   $^{14}\text{C}$  yr BP; Beta-208334), or approximately 8410 cal yr BP (modal value; 8540–8369 cal yr BP,  $2\sigma$ ). This age estimate suggests that the hearth is coeval with Stratum 3 of Jiangxigou 2.

The age estimate and the elevation of the site immediately above ripple-laminated sediments does not support the hypothesis [42] that a middle Holocene highstand of Qinghai Lake reached ca. 12 m above the modern lake level (ca. 4 m above the present elevation of the site), since such an event would have left a distinctive sedimentological signature at this site and also would have destroyed the hearth.

We exposed, mapped, and sampled a 2 m long by 50 cm wide semi-circular area of the remnant hearth and associated use surface (Fig. 9). This exposure revealed the remaining portion of a 50–60 cm diameter unprepared hearth laid directly on the underlying surface. Sixteen fire-cracked coarse- to fine-grained granite stream cobbles or cobble fragments to ~10 cm diameter occur in and around the hearth. The hearth contains both poplar wood charcoal and small, carbonized lumps of composite organic material tentatively identified as



Fig. 9. Plan map of Heimahe 3 occupation surface showing hearth feature and artifact scatter around it. Trowel points north.

herbivore dung. Bone fragments from a medium-sized mammal, possibly a gazelle, also occur across this surface, with the density thinning away from the central hearth. Lithic debris associated with limited tool production and rejuvenation is similarly distributed. Much of this material appears to have been raked from the hearth and sits on its unoxidized margins. The faunal remains consist of 22 highly fractured bone fragments possibly broken for marrow extraction. These are primarily long-bone splinters, but some possible skull or scapular fragments are also present. Five of the bone fragments are charred or calcined.

Lithic materials at Heimahe 3 consist of approximately 80 recovered items, mostly flaking debris from tool production and rejuvenation of black metamorphosed mudstone, fine-grained sandstone, and a small number of retouch flakes from chert tools. The limited tool inventory includes proximal and distal ends of a single green chert microblade and two retouched sandstone knives formed on cortical ‘salami slice’ flakes. Though most of the lithic debitage are black mudstone, no tools of this material were found. The overall impression is of limited expedient and informal tool production, with a significant proportion of flakes derived from rejuvenation of curated tools that were not recovered as part of this assemblage.

While only about half of Heimahe 3 remained intact at the time of excavation, it appears to represent a short-term, possibly overnight, camp occupied by a small foraging party. The single unprepared hearth is centered within a small, 3 m diameter use area. Charcoal, fire-cracked rock, bone fragments, microdebitage are scattered across this surface, thinning away from the central fire. There was no evidence of even a temporary structure within this use area. The artifact material is characterized by a limited diversity of tools and toolstone associated with core-reduction and microblade production. Bone scrap suggests preparation/consumption of a single gazelle-sized mammal. Extensive bone fragmentation and fire-cracked rock suggest marrow extraction and, possibly,

degreasing was part of this process. Charcoal from the hearth consists of a mixture of wood (branches of poplar trees, probably) and probable herbivore dung. Herbivore dung is commonly used for fuel in many places worldwide where wood or other fuels are rare or unavailable, and is known from archaeological contexts in the Near East, India, and elsewhere [49,52,64,71]. Yak dung in particular is a crucial fuel in the largely treeless Tibetan Plateau today [31,56,57]. The evidence from Heimahe 3 suggests that people used dried dung as fuel during much of the period of occupation of the Plateau and its margins, even during periods when woody fuel was more plentiful in the landscape.

### 3. Discussion

Although our investigations at Jiangxigou 2 and Heimahe 3 were limited in scope, several findings are broadly significant for our understanding of prehistoric occupation patterns on the northern and central Tibetan Plateau. As noted above, late Upper Paleolithic sites nearly identical to Heimahe 3 are known from both the Heimahe and Jiangxigou localities, dating roughly 15,000–10,000 cal yr BP [47]. Epipaleolithic sites are probably fairly common in the region but have not been well documented [2]: apart from the sites discussed here, the only dated Epipaleolithic site near the Qinghai Lake basin is Layihai [29,30], located approximately 80 km southeast of Jiangxigou 2 in the upper Yellow River (Huang He) valley, at an elevation of 2580 m (Fig. 10). Layihai is radiocarbon dated to approximately 7500–6500 cal yr BP [30,45], equivalent to Stratum 2b at Jiangxigou 2. Excavations yielded abundant cores, flakes, microblades and microblade cores, a variety of choppers, scrapers and burins, grinding tools, bone needles and awls, and a stone bead, but no pottery or polished stone tools. The broad tool assemblage at Layihai, compared with Jiangxigou 2, might reflect a broader range of activities at the lower-elevation site; but given the very limited

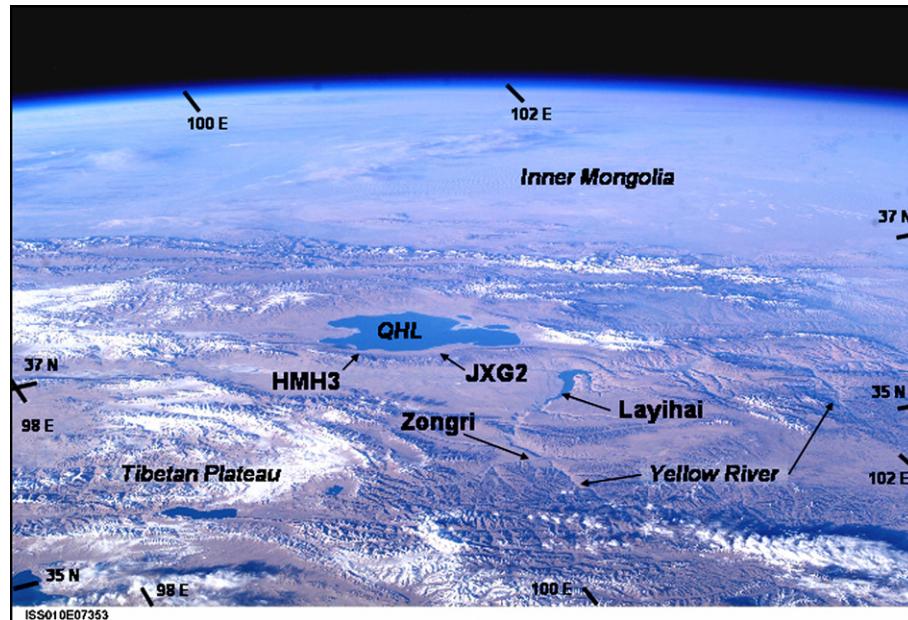


Fig. 10. Location of Epipaleolithic and Zongri Neolithic sites on upper Yellow River drainage in relation to Jiangxigou 2 (JXG2) and Heimahe 3 (HMH3) on the southern margin of Qinghai Lake (QHL). NASA photo, looking north-northeast.

sampling thus far conducted at Jiangxigou 2 the difference may be more apparent than real. Sites containing abundant microblades are common at lower elevations in north and central China, and are thought to have been associated with intensive hunting and gathering strategies during the latest Pleistocene and early Holocene [14,26,27]. In central China, microblades appear to have reached their greatest distribution during the early Holocene and then declined in importance in the middle Holocene with the development of Neolithic agricultural communities; but microblades persisted in north China well into the middle and late Holocene, often associated with ground or polished stone tools, bone tools, and pottery [23,29,45,46]. The abundance of microblades at Jiangxigou and at Layihai suggests that the upper Yellow River drainage and Qinghai Lake basin were similar to north China in the persistence of microblade technology through much of the Holocene.

Another Epipaleolithic site of significance is located at Xidatan, located approximately 550 km southwest of Qinghai Lake near Kunlun Pass, on a glacial terrace at an altitude of 4400 m, at the edge of the high Tibetan Plateau [15,16]. The site's artifact assemblage consists of a small scatter of flakes and microblades representing a brief hunting camp, buried in a shallow loess mantle on the glacial terrace. The site is dated to sometime between 8200 and 6300 cal yr BP using a combination of cosmogenic surface exposure dating of the glacial terrace, luminescence dating of loess and pond sediments, and radiocarbon dating of charcoal in overlying loess [16]. The connection between Xidatan and Jiangxigou 2 is made manifest by the occurrence of obsidian toolstone found at both sites. Obsidian artifacts are very rare on the Tibetan Plateau, but they occur at a few sites in the central Tibetan Plateau [13] and others we have investigated on the northern

Tibetan Plateau [15]. Their source has not heretofore been determined, but they likely derive from a source of high-quality dark green translucent obsidian probably located in the central Tibetan Plateau near the lakes of Mirikgyadram Tso and Tursudong Tso, west of the Tanggula Mountains (Ding Lin, personal communication). The region, at 5000 m elevation, is extremely barren and challenging to human occupation even today. The identity of the Jiangxigou 2 obsidian remains to be geochemically confirmed, but if this likely central Plateau obsidian source is verified, it represents transport of lithic raw material nearly 1000 km distant and indicates either a vast range of mobility of the inhabitants of the Qinghai Lake basin, or the establishment of a spatially extensive network of stone tool transport at a very early period of occupation of the Plateau. A likely scenario is that the obsidian was deposited at Jiangxigou 2 (and at Xidatan) by individuals employing a seasonally transhumant mobility system presumably based on hunting that encompassed both the northeastern margins of the Tibetan Plateau as well as its high central region. The presence of obsidian at Jiangxigou 2 demonstrates that the residents of this site made long-distance forays into the high Plateau during the early Holocene, or participated in an exchange network with people who at least occasionally occupied this extremely harsh landscape. The evidence from Jiangxigou 2 and Xidatan suggests that this pattern of occupation was in place by ca. 8000 cal yr BP [16] and possibly somewhat earlier [15].

Jiangxigou 2 yielded an additional finding of regional significance, namely the small array of ceramics found in Stratum 2. The presence of ceramics at this site might indicate a shift in resource procurement strategies, possibly involving more intensive processing of game (including boiling and marrow extraction in ceramic vessels), a broader diet including plant

foods, or more efficient use of fuels [11]. Apart from these speculations, and despite their small numbers, the ceramics at Jiangxigou 2 clearly indicate a connection with Neolithic developments in the upper Yellow River valley and elsewhere in the Tibetan Plateau. Those developments began ca. 8500–7000 cal yr BP with the Laoguantai (Dadiwan) Culture, a millet-based agricultural society along the middle Yellow River and its tributaries [12,28], and the subsequent Yangshao Culture in the same area and westward [65]. By 5400 cal yr BP the Majiayao, a well-developed, socially stratified society also based on millet agriculture, had become established on the Yellow River drainages of far eastern Qinghai and western Gansu [3,41,65]. The Zongri Culture (5600–4000 cal yr BP) probably represents the westernmost manifestation of these early Neolithic settlements found in the upper Yellow River drainage, at elevations as high as 3200 m [20,55]. With a direct OSL age of ca. 6500 cal yr BP, the oldest ceramics at Jiangxigou 2 are equivalent in age to the Yangshao Culture, are nearly 1000 years older than the Zongri Culture sites on the upper Yellow River, and are more than 500 years older than the Neolithic village site of Karuo, located on the southeastern Tibetan Plateau near Chamdo, which dates ca. 5900–4100 cal yr BP [2,23].

The Zongri sites so far examined appear to be small villages populated by “sedentists conducting agriculture with fishing and gathering” [20, p. 22]. These sites contain distinctive pottery in various vessel forms with complex painted, incised, and cord-marked designs [55]; a variety of worked bone tools, polished stone celts, axes, knives and possibly hoes, turquoise beads and other ornaments, and flaked stone tools including microblades and microcores (about 25% of the flaked stone assemblage [55]; numerous primary extended and disturbed secondary burials with grave goods suggesting some social stratification [19]; and faunal remains dominated by wild game including red deer, roe deer, musk deer, marmot, wild pig, Mongolian gazelle, and bharal. A small number of bones of domesticated dog and cattle were also identified from some of these sites [7; cited in 28], although the presence of domesticated cattle has been questioned [28]. The faunal evidence indicates that diet was heavily supplemented by hunting. The agricultural basis of these sites is not described in the literature available to us [20,55]. Chen [18] suggests that the Zongri Culture represents an initial migration of Majiayao agricultural communities into the upper Yellow River basin, the assimilation of agricultural and ceramic traditions by local Tibetan groups, followed by settled agricultural communities peopled by these local groups. It seems plausible that these villages represent settled foragers who practiced some horticulture, such as appeared in the Near East [10], the American Southwest [9,25,48,66], and elsewhere. Whether or not the Zongri represent fully settled farmers, farmers on foraging expeditions, settled foragers practicing low-investment horticulture, or full-time foragers interacting with Majiayao farmers may yet be an open question.

The Neolithic site at Karuo contains a full “Neolithic package” [1] of substantial residential architecture, domesticated millet, pigs, and cattle, a wide range of ground and polished

stone and bone tools, a few microliths, spindle whorls for textile production, and numerous ornaments, as well as abundant ceramics [2]. Ceramics at Karuo consist of incompletely fired basins, bowls, and jars with incised or graved geometric decoration, as well as appliquéd, cord-marking, basketry impressions, and rare instances of black and red painting. Aldenderfer [1] suggests that Karuo is distinctive enough from other known Neolithic complexes in north and central China to be considered an indigenous Tibetan archaeological culture, though with evident ties to Neolithic complexes in northwestern Sichuan Province [2,23], and presumably to complexes such as Zongri as well. As this fully developed Neolithic site likely had a less well-developed progenitor, it seems reasonable to assume that earlier pottery-bearing sites may exist on the Tibetan Plateau margins. Whether or not Jiangxigou 2 is such a site, remains to be confirmed.

The expansion of sedentary pottery-using communities westward into Tibet appears to have followed the natural route of travel up the Yellow River Valley. Such a route is consistent with models of occupation of the Tibetan Plateau [47,53,61,67], though there were almost certainly several avenues of expansion into the high Plateau from different lowland source areas such as Sichuan and Yunnan Provinces in China, the Sikkim, and the western Himalayas [1]. If Chinese Neolithic communities expanded up the Yellow River Valley, then geography of the region very likely guided such an expansion directly into the vicinity of Jiangxigou 2. The stream that gives the locality its name runs through a major canyon on the north side of the South Qinghai Mountains, providing ready access to the Yellow River immediately south (Fig. 10).

In any case, the presence of farming communities in the broader region would likely have substantially altered both the social and physical environments within which Epipaleolithic foragers on the mid-elevation step of the Tibetan Plateau margin operated. As a result of territorial restriction and resource depression around settled villages, foragers, whether operating independently or interacting with farming communities, might have been forced into more marginal environments or adopt more marginal resources. At the same time, farming communities would have brought additional resources into the foragers’ economic opportunity set, promoting a range of interactions ranging from economic symbiosis to raiding to fostering the development of new economic strategies such as pastoralism [24,33,40,48,59,76]. These interactions are likely to have shifted in time as resource availability changed and procurement/production strategies evolved.

The processes by which Neolithic societies developed along the Upper Yellow River, at relatively high altitudes of 2800–3200 m, are only now beginning to be clarified. The sites of Heimahe 3 and Jiangxigou 2 on the southern margin of Qinghai Lake, together with a small number of similar sites in the Gonghe basin on the upper Yellow River drainage, provide the beginnings of a possible reconstruction. They suggest that the transition from highly mobile Epipaleolithic foragers operating from the margins to the interior of the Tibetan Plateau to the farmer/foragers and pastoralists of the early Neolithic began between about 7500 and 6500 cal yr BP.

This is not substantially different from chronologies found elsewhere in central and western China, suggesting the rapid spread of millet agriculture [12] substantially altered the socio-economic conditions found in many disparate environmental settings. In the higher elevations of the Tibetan Plateau, however, the effects of these changes apparently differed because of the difficulty in producing domestic crops directly. This altitude is marginal for millet farming today, though perhaps not in the warmer wetter middle Holocene. On the other hand, it does provide good pasturage for wild game and for domestic animals such as sheep and goats (though these latter have not yet been reported at the Zongri sites). The presence of domestic cattle at the relatively high elevation Zongri sites, if confirmed, may be important in the domestication of the indigenous wild yak [28,57].

We have previously suggested that sustained occupation of the high Tibetan Plateau during the early and middle Holocene substantially increased with the development of sheep herding associated with a Neolithic agro-pastoral complex [15,36,47,57]. Sheep pastoralism in the high Plateau would have necessitated a transhumant pattern with summer camps in the high country and winter settlements at elevations below ca. 3500 m [31]. The Qinghai Lake region and Yellow River Valley nearby may have provided ideal locations for winter pastoralist settlements. Evidence from Jiangxigou 2 (obsidian and specialized blade forms) as well as sites on the high Plateau at Xidatan and Chang Tang [13,16] strongly suggests that a transhumant settlement pattern, based presumably on hunting, was in place by at least 8000 cal yr BP. The origin of sheep-based pastoralism in the region is not yet known, nor whether the development of such a system was related to earlier transhumant hunting systems. Further work at sites such as Jiangxigou 2 and Heimahe 3 will be useful to address how this transhumant pattern developed under Epipaleolithic hunting and was modified with the inception of pastoralism.

#### 4. Summary

Jiangxigou 2 and Heimahe 3 reflect substantially different settlement types in a large regional settlement organization. The small but rich artifact assemblage obtained at Jiangxigou 2 suggests that the site was a long-term base camp for Epipaleolithic and possibly Neolithic parties occupying the Qinghai Lake basin, with the majority of occupation dating between about 9000 and 5000 cal yr BP, essentially during the early and middle Holocene climatic optimum. Whether the occupants were principally hunters with a focus on wild sheep and other game, or alternatively were pastoralist sheepherders, is not yet known (though domestic sheep have not been identified in this or other sites dating to this time period in the region [28]). It is possible that the record at Jiangxigou 2 contains both economic orientations and the transition from Epipaleolithic hunting to Neolithic pastoralism.

Heimahe 3, on the other hand, is a small hunter's camp that may reflect a single night's stay by no more than a few individuals, dating approximately 8400 cal yr BP. Coeval with the early occupation at Jiangxigou 2, it is nearly identical to

small Late Upper Paleolithic hunters' camps we have previously described in the Qinghai Lake area that date several thousand years older [47]. Despite obvious differences in occupational duration and artifact abundance, the early component at Jiangxigou 2 and Heimahe 3 share similar artifact content, including microlithic tools, a lithic tool production technology resulting in a preponderance of generalized flakes, and procurement and processing of medium-sized ungulates involving heavy fragmentation of all skeletal parts suggesting intensive use of the carcass including marrow extraction and possibly degreasing. Together, these sites appear to represent a base camp – field camp dyad, a settlement system that may have developed during the early Holocene in the Qinghai Lake basin, and that served as a basis for more sustained occupation of the high Tibetan Plateau during this same period [15].

Both occupations date to a period when temperatures have been inferred to be higher and summer monsoons possibly stronger than today. Evidence from wood charcoal at the sites supports paleoenvironmental reconstructions [39,58] that the Qinghai Lake region supported woodlands, at least of water-loving trees along permanent streams. The sediment sequence and dating of the occupation at Heimahe 3 contradicts hypotheses of a supposed rise in the level of Qinghai Lake to levels above ~3202 m during the Middle Holocene climatic optimum [42]. Nevertheless, establishment of consistently occupied base camps such as Jiangxigou 2 appears to coincide with development of warmer wetter conditions in the Qinghai Lake Basin, and may represent an expansion of Epipaleolithic populations in the region as a result of improved environmental circumstances. Alternatively, it is during this period that Neolithic farming communities began to be established at lower elevations to the east of Qinghai and in the upper Yellow River drainage southeast of Qinghai Lake, and the establishment of these farming communities may have pushed foraging groups to higher elevations, more marginal environments, and possibly toward alternative adaptive strategies such as pastoralism [15].

The later component of Jiangxigou 2 was undoubtedly connected to early Neolithic occupations in the upper Yellow River watershed, but the nature of that connection is not yet clear. The most likely connection is with the Zongri Culture of the upper Yellow River drainage, but ceramics at Jiangxigou 2 predate Zongri and, indeed, are the oldest known in Tibet. The later component at Jiangxigou 2 continues the earlier lithic technology at the site but with a substantially greater emphasis on microlithic industries. In this respect it is more typical of Epipaleolithic forager sites, with a dominance of microblade tools, than of subsequent Neolithic sites [45,46], and may reflect the continued importance of Epipaleolithic-style hunting at higher elevations during the middle Holocene in this region. The later component also appears to represent a continuation of faunal processing strategies, although more work is needed to identify the taxa at this site, to determine whether procurement involved wild ungulates or domestic ones (sheep and goats). If domestic animals were not involved, then Jiangxigou 2 may represent a base camp of an essentially

late Upper Paleolithic subsistence organization that began in the Qinghai Lake basin ca. 15,000 cal yr BP [47]. If, on the other hand, domestic animals were present at Jiangxigou 2, the site may represent one of the earliest pastoralist occupations known on the Tibetan–Qinghai Plateau.

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