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TECHNOLOGICAL ANALYSIS OF A FORMATIVE LITHIC ASSEMBLAGE IN THE NORTHERN PERUVIAN AMAZON

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INTRODUCTION

The archaeological site of Ushpapangal, covers approximately twelve hectares, and is located on a low alluvial terrace on the south bank of the Huallaga River at an altitude of 216 masl, in the district and province of Picota, Department of San Martín (Figure 1). This area corresponds to a low Amazonian valley landscape composed of two well-defined ecological zones: a flat and low space near the river and other higher deforested areas.

During the Ushpapangal Archaeological Research Project, which took place between November and December 2011, eighty-four lithic artifacts were recovered from the site which was excavated in seven two by two meter units. The type of tool most commonly represented was axes.

Stratigraphic association of these tools with ceramic fragments from the Formative of the lower Amazon valleys was observed. Similar axes have been previously reported from the same period in other Andean and Amazonian regions. Thus, we conducted a detailed analysis of their reduction sequence and attempted to compare them with available data in order to explore potential implications for the construction of extensive regional exchange networks between the Andes and the Amazon.

Archaeology in the Lower Huallaga region is poorly known, and has mainly been explored through ceramic studies (DeBoer 1984; Ravines 1995), ethnohistorical research (Espinoza 2003), and preventive archaeology studies (*cf.* Echevarría 2008; Lozano 2002; Vecco and Vecco 2009).[1] With the aim of defining the characteristics of the archaeological occupations at the Ushpapangal site, Pieter van Dalen carried out

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[1] Preventive archaeology is the set of activities and interventions which include the detection, study, recovery, and protection of archaeological heritage within the framework of exceptional and specific situations in which said heritage is in danger of destruction, disappearance, or inaccessibility as a consequence of public or private works, deterioration of environmental conditions that endanger its conservation, or conflicts or social situations that raise fears of its loss or plunder.

excavations in 2011, identifying a natural mound that was subject to constant remodeling in different pre-Hispanic periods (van Dalen and Silva 2014). The mound exhibits uninterrupted flat surfaces along with levels resembling steps, reaching a maximum elevation of up to eight meters. Based on the artifacts observed on the surface (abundant ceramic fragments with black paste and dark red paste, both with linear incisions defining geometric motifs with curved corners), the site dates to the Formative. Other archaeological sites near Ushpapangal include the petroglyphs of Panguana, the petroglyphs of Polish, and Chazuta, among others, all of which were occupied from the Formative to the Inca horizon.

The general stratigraphy of the site is composed of five layers (Surface, A, B, C, and D).

The surface layer is a sediment of loose consistency, with a fine texture, abundant herbaceous vegetation, and a brown color. Layer A, a clayey soil, with a semi-compact consistency, a medium to coarse texture, grey to brown in coloration, and with inclusions of medium-sized roots and clasts, is uniformly present in all excavated units. The ceramic material present in this layer consists of two types, one with red paste and linear incised decoration and the other with red paste and a horizontal clay strip applied to the neck with small vertical incisions (*ibid.*). Layer B has similar characteristics, although it is a lighter color. Furthermore, this layer is a semi-compact, sandy-clay sediment, with a fine to medium texture. Layer C is a semi-compact, clayey soil with a medium texture, abundant small clastic inclusions, scarce medium-sized rocks, and some compact clods, with a leaden color. This layer contains polished black ceramic material corresponding to the Formative. Finally, Layer D is a compact, sandy-clay sediment, with a medium texture and a golden color. Occasionally, these layers present ceramic material, gourds (*Lagenaria siceraria*), bones (secondary human and animal burials), molluscs, and lithic materials, especially in Layers A and B (*ibid.*).The stone tools embody the unique perspectives and skills of the Amazonian communities; that is, they are tangible results of their labor and craftsmanship. These tools represent an extension of the human senses, which people use to satisfy their needs for subsistence, whether for food, protection from their environment, or for maintaining social cohesion through their world-view. In other words, they have a use value. Within the lithic tool kit, axes are a good indicator of a tool that satisfies needs. In this work, we have placed emphasis on axes using the analectic method (*sensu* Dussel 2012), applied to archaeology.[2]

MATERIALS AND METHODS

Lithic materials are differentially distributed throughout the four layers identified in Ushpapangal (Table 1). Axes (n=37; 44.05%) and manuports (unmodified lithic objets carried from their place of origin to another place by human activity) (n=35; 41.67%) predominate in the assemblage. Both types are present mainly in Layer B (n=36; 42.86%), but are also present in Layer A (n=16; 19.05%) and C (n=11; 13.10%). The remaining 24.99% were found on the surface and in Layer D. These artifacts are treated here as a singular assemblage.

This assemblage includes a radiolarite (siliceous sedimentary rock) core, made on a kidney-shaped blank, small in size (44.2 by 41.3 by 25.8 millimeters) and weighing 68.8 grams. It has an irregular morphology and a cortical percussion plane. The extractions were made through hard percussion. Ten negative removals

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[2] Dussel's analectics (1973, 2012), a synthesis of dialectics and analogy, offers a non-Eurocentric theoretical approach to lithic technology analysis. In the case of Ushpapangal, its methodological operationalization of artifacts, such as axes, is largely based on the techno-structural method developed by French experts in lithic technology who address the dynamic and dialectical dimensions of lithic artifacts.

can be observed on the debitage surface, organized according to a secant bifacial scheme (the extractions are spread across two knapping surfaces; one of which is secant, if the borders of one surface align with the edge of the other), without hierarchy between the percussion platform and the debitage surface.

A small primary flake of coarse-grained granodiorite (29.2 by 34.7 by 6.4 millimeters) and weighing 7.6 grams is also part of this assemblage. Its silhouette is irregular, with an irregular longitudinal section and a lenticular transversal section. The form of the potential active edge (with an angle of 15 degrees) is convex, and is located in the medial and distal sectors. It does not show any signs of use.

There is also a scraper on a primary flake of coarse-grained quartzite, of medium size (41.4 by 61 by 20 millimeters) and weighing 49.6 grams. The shape of the silhouette is ellipsoidal. Its longitudinal section is flat-convex, while its transversal section is lenticular. This instrument does not have patina or alteration of ribs or edges. The retouch is inverse (on the ventral surface of the flake), marginal and simple, located on the left edge of the flake. The angle of the potential active edge is sixty degrees.

A hammer-stone made of a small granite pebble (89.2 by 34.2 by 22.3 millimeters) and weighing 115 grams is also part of the assemblage. Its general shape is elongated ellipsoidal, while its transversal section is asymmetric ellipsoidal. It has two potentially active areas, at each end, one with a diameter of eleven millimeters and the other of six millimeters.

Finally, there are also miscellaneous items such as ceramic polishers and cassons (unshaped waste), among others (Figure 2).

The earliest axes are found in Layer C. The number of axes increases substantially in Layer B, and then decreases in Layer A, reaching its lowest presence in the surface layer. Manuports, on the other hand, are present from Layer D, increasing in frequency in Layer B, like axes, reaching their minimum expression in the surface layer. Axes are found in different stages of production, so a technological analysis of the reduction sequence was necessary to define their relationship to the manuports and the eventual function of the Ushpapangal site as related to lithic material.

A technological analysis was applied, based on the proposals of Boëda (2021), Boëda *et al.* (1990), Inizan *et al.* (1995), and Leroi-Gourhan (1964), and, in order to locate each axe in a precise technical context, we identified the processes used in its production, from the procurement of raw materials, to the manufacturing and use phases, and to its abandonment (Inizan *et al.* 1995). Previous work (van Dalen and Silva 2014) presented certain type-technological data, and in this report, we provide some corrections and new technological and metric data that will allow us, in future research, to address the particular characteristics of the interactions of human groups and the environment in the lower Huallaga Valley.

Lithic axes, made by percussion, chopping, and sleeking (a process accomplished before polishing, performed using a lithic smoother with a larger and harder grain than the material being worked, typically a plutonic rock), correspond to artifacts that were used in thrown percussion activities; that is, the axe is hurled or thrown towards a target. The cutting edge is therefore in a plane parallel to the axis of the handle (Fandos 1973). The analysis process began with the measurement of each piece, considering various morphometric attributes shown in Figure 3.

In addition, we have determined the place occupied by the axes in the operational chain of their manufacture. The symmetry of the pieces was determined by considering the presence or absence of notches on the edges of each piece. All the data collected will be used to determine a particular type of piece characteristic of the technological stage of the entire reduction sequence.

RESULTS

Raw material and possible procurement sources

Table 2 shows the frequency of raw materials used in different layers of Ushpapangal. The data shows that the most commonly used raw material across all layers is basalt (n=56; 58.29%). Andesite (n=7; 8.54%) is the second most commonly used material, and greywacke (n=5; 6.10%) is the third most commonly used. Certain raw materials, such as quartzite and granite, were not used in certain layers.

According to the Geological Map of the Utcurarca 14k Quadrangle (Sánchez *et al.* 1997), the Ushpapangal site is located on the Ipururo Formation, a sedimentary formation surrounded by other formations of the same nature. On top of this formation, there is an accumulation of rounded clasts, mostly of volcanic rocks. Given the lithology present in the formations surrounding Ushpapangal (Figure 4), there are only two possibilities for the origin of the clasts, both related to the presence of volcanic rocks.

According to the Geological Map of the Juanjuí 15j Quadrangle (Sánchez *et al.* 1998), the southern limit of the Juanjuí Formation is located in the stretch that begins near the town of Bellavista and extends up to five kilometers upstream, which is about thirty-eight kilometers southwest of Ushpapangal in a straight line. This coincides with a section of the Huallaga River, allowing for the transportation of the clasts downstream to Ushpapangal. The Juanjuí Formation consists of poorly selected, coarse heterolithic rounded clastic conglomerates of plutonic, volcanic, and sandstone rocks, with a slightly muddy matrix and sub-rounded clasts, mostly of lithic and quartz materials (*ibid.*:125).

The map of Juanjuí shows the presence of the Sacanche diapiric dome, a topographic depression on the left bank of the Sacanche River, where red mudstones and siltstones of the Sarayaquillo Formation crop out. There is also a small outcrop of Pucará Group limestones on the eastern edge of the dome, consisting of anhydrite, impure gypsum, and pink halite (*ibid.* 146–153). The blocks from the Sacanche dome would reach Ushpapangal in the form of rounded clasts, through the Sacanche, Saposoa, and finally the Huallaga River.

Previous research on a diapiric dome environment (Puffer and Laskowich 2012) has shown that diapiric structures consist of vesicular basalt intruded into the interior of an aerial basalt flow. The basalt flows towards a marsh with travertine encrustations saturated with alkali salts. Once the trapped alkali vapors under the lava are pressurized, a lower layer of vesicular and viscous flow is created. The coalescence of vesicles within this layer increases its buoyancy where it accumulates locally in diapirs and displaces the overlying lava. This means that finding basaltic rocks in the Sacanche dome is very likely, and it would also provide the salt required for the daily food of the communities in the region around Sacanche, including that of Ushpapangal.

The lithic axes: techno-morpho-metric data

Table 3 shows the primacy of aphanitic basalt (n=28; 75.67%) as raw material for the production of axes, followed by porphyritic basalt (n=9; 24.33%). Axes have been classified into four types according to Silva (n.d.a).

Type 1 is in the shape of a T, configured by a pronounced stem, with lateral notches at an angled bisector that forms a 45 degree angle with the heel, and with divergent straight edges. Type 1 axes are made on relatively thin cobbles and are of medium size. The techniques used are carving, chipping, incising, smoothing, and polishing. The retouch technique is bifacial. There is chipping on the base and edges.

Type 2: is a T-shaped piece, configured with a slightly pronounced stem and with very concave lateral notches whose axis forms a 45 degree angle with respect to its heel, and with divergent concave edges made on a relatively thin cobblestone. Its longitudinal section is ovoid and the transversal section is elongated ellipsoidal. The techniques used are carving, chipping, incising, sleeking, and polishing. The retouch technique is bifacial. It is chipped on the base and edges

Type 3: is a rectangular shape, with a small stem, with lateral notches at an angled bisector that forms a 45 degree angle with respect to the heel, and with divergent straight edges, made on a relatively thin cobble of medium size. The techniques used are carving, chipping, incising, sleeking, and polishing. The retouch technique is bifacial. It is chipped on the base and edges.

Type 4 is a thick piece with straight edges made on a thick cobble. Its longitudinal section is ovoid and its transversal section is short and elongated. The techniques used are carving, chipping, sleeking, and polishing. The retouch technique is bifacial.

Table 3 shows the total number of preforms (n=24), for which it was not possible to assign a particular type, due to their not being in an advanced stage of elaboration, as well as the number of axes of each of the four recognized types found at the Ushpapangal site (Figure 5). The table indicates that out of the total of thirty-seven axes found at the site, the most frequent were preforms, with a total of twenty-four pieces, representing 64.86 percent of the total. Type 2 was the most commonly found type, with six pieces, representing 16.21 percent of the total. Types 1 and 3 were the second most common types of axes, with three examples of each, representing 8.10 percent each. Type 4 was the least common, with only one representative.

If we analyze the main morphometric data obtained (Figure 5), we can observe that the maximum length and maximum width in the axes present practically the same range of values, with a greater frequency between 60 and 70 millimeters. Meanwhile, the maximum thickness is highly normalized around 20 millimeters. In terms of mass, the pieces have a range of values between 100 and 200 grams. If we observe the stem, the length and thickness present the same range of values between 5 and 20 millimeters, while the stem width has high values around 50–60 millimeters. As for the notch depth, the average is around 2 millimeters. Finally, all types present variable cutting edge lengths, but they range mainly between 30 and 40 millimeters (Figure 6).

The reduction sequence of lithic axes

The preforms are regrouped here in production phases and subphases (Figure 7).

Phase 0: cobble and pebble selection and acquisition

The supports for the axes are largely composed of granodiorite pebbles and cobbles. These supports were likely obtained from the nearby Huallaga River.

Phase 1: roughing out

This stage likely involved roughing out the basic shape of the axes. It can be divided into three technical subphases:

Subphase 1.1: roughing out by unifacial shaping on one edge.

This concerns the production of blanks or preforms which exhibit some very shallow notches and punctures.

Subphase 1.2: roughing out by unifacial shaping on both edges.

Subphase 1.3: roughing out by bifacial shaping mainly on lateral.

Phase 2: volume construction

The lithic axes were then crafted by bifacial shaping on both edges and picketing (a percussion task performed using a lithic pick of a harder grain than the material to be worked, with the goal of removing a portion of the artifact's mass) into their target volume construction using techniques such as sleeking and polishing. Artifacts during this phase display a bifacial reduction sequence, which likely involved the use of hammerstones or other tools to flake and notch the edges of the lithic axes.

Phase 3: finishing and abandonment

This phase is represented by preforms without final delineation, suggesting that some artifacts may have been abandoned before the finishing. Abandonment may have been due to damage, they may have been lost, or simply no longer needed.

Subphase 3.1. Finishing by bifacial shaping on one edge and picketing on another edge.

Subphase 3.2. Finishing by picketing on both edges.

DISCUSSION

The lithic axe reduction sequence at Ushpapangal is more complex than what might be assumed. Here we discuss each productive phase briefly in the context of the evidence reported in the Andean and Amazonian regions. The map in Figure 8 contextualizes the main sites mentioned in this section.

Raw material and functional technology

The raw material used in the manufacture of the Ushpapangal axes was generally volcanic rock, which had to be imported from distant sources, mostly sedimentary formations in the plains. In southern Peru, these volcanic rocks were obtained from the Central Volcanic Arc of Pliocene-Pleistocene age and the Cordillera del Divisor. In contrast, in central and northern Peru, they were obtained from the Andean Volcanic Arc of Jurassic-Cretaceous age. Therefore, the axes were very difficult to obtain and were used as long as possible through continuous resharpening. However, in the southern Peruvian Amazon, axes were also obtained from large flakes of sedimentary rocks such as greywackes (Silva 2002, 2003). But in the upper Madeira Basin, southwest of the Amazon, there is a long history of axe production on flakes dating back to the early Holocene (Meggers and Miller 2003).

According to geological work carried out (Sanchez *et al.* 1997; Sanchez *et al.* 1998; Zarate *et al.* 1997), we know that in the surroundings of Ushpapangal there are only sedimentary rocks of Jurassic, Cretaceous, and Cenozoic origin. None of these have produced basaltic rocks, except perhaps the Juanjui Formation, although it is unlikely, because basalt has not been identified among the volcanic rocks there.

Therefore, it is likely that the basalt from Ushpapangal was not imported, but, rather, its presence was due to fluvial transport, necessarily by rolling from upstream, through the Huallaga River. Given that the Sacanche dome is the only basalt-producing source upstream of the Huallaga, we believe that it may be the source of the basalt, which would arrive by rolling, through the Sacanche River, then the Saposoa River, and from there to the Huallaga River, until its deposition in Ushpapangal. This place precisely forms a meander whose external curvature is found on its right bank, where, due to the fluvial dynamics of the Amazonian rivers, the clasts are deposited. This coincides with the location of the site.

As for the proposed types in this research, it is necessary to emphasize that in the Upper Amazon, various types of axes of different sizes have been reported, with a typical one being in the form of a "T" (our Type 1), with some variants whose typology was established by Ibarra (1964). The laterally projected stem of certain types of axes served to tie the axe to the handle. Even once broken, the fragments themselves were used as sharpeners (Lathrap and Rivas 2010:96–97). The axes types found in Ushpapangal could be related to different functions representing the aesthetic, social, political and/or cultural options of the various towns where the axes would eventually arrive (*cf.* Bueno, 2007a, b).

A technical evolution?

We can note that the axes underwent technical evolution from knapped to sleeked and polished. On Sambaqui do Gomes, on the northern coast of Paraná, two distinct aceramic groups were identified. The older group was characterized by a poorly finished knapped lithic industry, with unifacial and bifacial shaped axes, where smoothing was a rare technique. It was later replaced by a second group associated with sleeked lithic artifacts (mainly axes) (Okumura 2008). An increase in the number of sleeked artifacts was also observed by Menezes (1976) at another site in Paraná.

An explanation for this might be found in the shifting ecosystem since the end of the Middle Holocene. Around 5000–4500 BP, there was an increase in vegetation cover in the Amazon. This change has been documented in pollen diagrams collected from various Amazonian environments: forests, including those that changed with the seasons, and, potentially, scrub-lands or wetlands,(Alizadeh *et al.* 2017; Fontes *et al.* 2017; Hermanowski *et al.* 2012). This possibly resulted in a phase of technical innovation occurring in the *sambaquis* (shell mounds), as in Sambaqui do Gomes where flaked axes were invented between 4,487±74 and 4,490±136 BP (Rauth 1968). After a phase of experimentation regarding their efficiency, polished axes were adopted, which, in the case of the Upper Amazon, would be represented by the Kotosh axe (Izumi and Terada 1963:123–124). Later, near the beginning of the Late Holocene (4200 BP), the amount of vegetation diminished significantly. This change caused Amazonian communities to experience different environments. Generally, there was a decrease in both types of forests: those that stay the same throughout the year, and those that change with the seasons. However, there were exceptions, such as the *Cecropia* genus,[3] which increased during this period (de Moraes *et al.* 2020). The new conditions imposed the need for new types of axes to take advantage of the new and varied environmental conditions. Finally, around 2100 BP, towards the end of the Formative, there was a new increase in vegetational cover, which would have been a catalyst for the emergence of types and the use of lithic axes.

The selection of hammer-stones for shaping the preform was based on the hardness of the raw material being used. It was important that the hammer-stones' mass was compatible with that of the preform (Souza 2008). Additionally, the process was influenced by the need to ensure that the hammer-stones were robust enough to withstand the respective effort required in the shaping process. Sleeking was produced by rubbing the tool against another support, which could be fixed or mobile, with the help of water, sand, or clay. Complete polishing was considered a technological characteristic of populations of farmers-potters (Costa 2009:136–137). Likewise, axes with polished edges have greater resistance than flaked ones, although they are less sharp (Souza 2008).

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[3] *Cecropia* is used by various Amazonian peoples, once incinerated, to produce a lime that they mix with coca leaves before chewing them.

The axe ergonomics: A key to understanding the technical system in Ushpapangal

The characteristics of the blade influence the shape of the handle and can indicate the type of grip of the axe. Thus, Ushpapangal Types 1–3 axes would need an additional concave and elongated cavity in the handle, so that once it is fitted, it is tied in a more stable way, which perhaps required some fixative vegetable resin.

The type of handle is related to the function of the lithic tool (Prous *et al.* 2002; Souza 2008). There are various shapes and different morphological characteristic adaptations in the mesial or proximal regions of the axes that may be related to different ways of fixing them to their handles. Thus, judging by the stem of the Type 1 ax (T-shaped), it would be handled with a fiber of medium width (1–2 centimeters) and Types 2 and 3, with rather narrow fibers (0.5–1 centimeters). These fibers could have been from plant tissue, especially from palm leaves, such as *chambira* (*Astrocaryum chambira*), *shapaja* (*Attalea phalerata*), *shikashika* (*Chamaedorea angustisecta*), *huasai* (*Euterpe precatoria*), *palmichi* (*Geonoma inter rupta*), *pona* (*Iriartea deltoidea*), *aguaje* (*Mauritia flexuosa*), *hungurawi* (*Oenocarpus bataua*), *sinamillo* (*Oenocarpus mapora*), *yarina* (*Phytelephas macrocarpa*), or *kashapona* (*Socratea exorrhiza*) (Sosnowska *et al.* 2010); or animal tissues, such as the intestines of a large herbivorous mammal, probably killed for consumption, such as capybara (*Hydrochoerus hydrochaeris*), huangana (*Tayassu pecari*), sajino (*Pecari tajacu*), majás or picuro (*Cuniculus paca*), among others.

The depressions excavated on the rock surfaces may have been used to ferment pulp mixed with water to obtain drinks, rather than having been formed, as is widely believed, when craftsmen sleeked lithic axes (Smith, 2014). For the Kotosh Mito Phase, Izumi and Terada (1972: plates 145-5 and 144-18) have reported a preform of an axe that could be the earliest predecessor in western Amazonia, linked to the Huallaga River through its tributary, the Higueras River. The presence of axes in the deposits of Early Tutishcainyo, near the Yarinacocha lagoon, a meander formed by the Ucayali River, could indicate the existence of agriculture, and the absence of other types of lithic tools may indicate that hunting equipment was manufactured with perishable materials, as currently done by tropical forest people (Lathrap and Rivas 2010:121).

The axe economics: The role of Ushpapangal in the distribution of resources

The circulation of axes throughout the Amazonian plain must have been a significant aspect of the economy for the various Amazonian peoples, from the Upper Amazon to the lower regions. In fact, in the eastern Amazon, small villages in southeastern Brazil (State of Pará), some of which were located on *terra preta* (see below), had similarities in their lithic and ceramic industries, probably due to the exchange of axes (da Silva 2012).

Udo Oberem (1980:51–52) points out that, according to Toribio de Ortiguera, a mayor of Quito (Ortiguera 1909 [1581–1586]), the late-period Quijos people of the Ecuadorian Amazon were equally interested in axes and the salt that the Incas could provide.[4] The Incas, in turn, desired the Quijos' resources, including gold, and were willing to form an alliance with them. The Quijos utilized lithic axes for planting crops like yucca and maize (Oberem 1980:329–330). This fact is interesting because if Amazonian populations required salt and axes, neither of which was common in the Amazon, to the point of making pacts and providing information about the loca-

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[4] To the west of the Orinoco Delta, Carib-speaking groups dominated the trade routes between the coast and the interior. Among the products derived from the coastal region was salt produced from seawater in the Araya Peninsula (Eriksen 2011:156).

tion of gold sources, which are found in rivers descending from the eastern Andes, it is because salt and axes were truly strategic and, therefore, very important.

Ushpapangal could have acquired a strategic role in the distribution of salt and axes in a significant radius of contemporary Amazonian settlements during the Formative, due to the proximity of the salt source in the Sacanche dome and the production of axes at the site itself.

Some of the axes appear to have been reused as pendants (Prümers 2020:267) or even directly made into small-sized pendants (Silva 2002, 2003). Another function of axes was as weapons, with their oldest representation in the monoliths of Cerro Sechín, in which six figures of warrior priests wielded axes (Samaniego 1995:28; Tello 1956:233). However, Cárdenas (1995:79) considers them to be more like staffs ("bastones de mando") or even just *macanas* (clubs) (Chamussy 2014). Nonetheless, their most common use was utilitarian.

It must be emphasized that lithic axes were primarily used for agricultural land cultivation, and the presence of a sufficiently high number of fragments of this type of axe at a site is good evidence that agriculture was economically significant there (Lathrap and Rivas 2010:96–97).

Amazonian Dark Earths (ADEs),[5] of the *terra preta* type, have been characterized as the unintentional by-product of long-term permanent settlement in the same place. The hundreds of years necessary to produce mature ADEs also suggest that the formation of ADEs was an unintentional process that spanned many generations. The formation of "terra mulata" type ADE involved the intentional, possibly laborious movement of organic matter from domestic contexts to fields, the felling and removal of trees with lithic axes, and systematic burning as part of semi-permanent agricultural activities (Andrade 1986 *et al.*; Denevan 2001; Kern *et al.* 2003; Mora 2003; Mora *et al.* 1991; Myers *et al.* 2003; Sombroek 1966; Woods and McCann 1999).

The presence of semi-sleeked axes documents some form of forest clearance and management, dating back as far as 8,000 years BP (Gnecco and Mora 1997; Oliver 2001). Forest clearance in the interior of Brazil occurred during this time (Magalhães 1994; Miller 1992).

The pre-Columbian forest clearance associated with migratory agriculture must have been an enormous task (Bush *et al.*, 2015; Denevan 1992; McMichael *et al.* 2012, 2015). By necessity, farmers would have explored all possibilities to avoid frequent felling of large trees in most tropical regions, and continuous cultivation of the same fields would have had important advantages in this regard (Neves *et al.* 2003). In central Amazonia, a high incidence of small bifacial axes on sandstone flakes suggests that only medium to small trees[6] were felled, as these artifacts would be ineffective for cutting large trees (Costa, personal communication in Neves *et al.* 2003). This evidence coincides with Denevan's (1992) expectation that pre-Columbian agriculture in the Amazon would have been characterized, among other things, by intensive itinerant cultivation in old or naturally altered fields, with young secondary forest.

On the other hand, experiments have shown that the time required to fell mature and leafy

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[5] Amazonian Dark Earths (ADEs) have been referred to as *terra preta de indio*, Indian black earth, black earth soils, black earth sites, anthropogenic dark earths, anthrosols, anthropic soils, *terra preta arqueológica*, and *tierra negra*.

[6] The axes found between the basins of the Urubamba and Apurímac Rivers were probably used by making a semicircular movement, possibly on a diagonal plane, as one of the pieces exhibited striations forming a 45 degree angle with respect to the active edge, and perhaps served as a means of procuring firewood (Silva 2002, 2003).

trees with a lithic axe is thirty times slower than with a metal axe, making migratory cultivation a very difficult task (*ibid.*). Additionally, Denevan (2001) and Carneiro (1974, 1979) have shown the inviability of slash-and-burn agriculture based on the use of lithic axes, demonstrating that the use of axes for forest clearance is very inefficient. As previously suggested (Denevan 1992), the inviability is probably due to the resistance of large trees, but also depends on the variables of the tree itself: species, age, relative humidity, presence of pathogenic agents such as fungi, parasitic plants, bacteria, nematodes, aquatic molds, viruses, and phytoplasmas; as well as the shape of the axe blade, the shape of the handle, and the handle material, as well as the user, their technique of use, the physical effort invested, and the time of use, among other factors. Inviability also depends on the variables of the axe: its geological origin and its physical properties under compressive stress, which, in turn, depend on its mineralogical composition, fabric, texture, type of cementation, degree of alteration, microfracturing, porosity, specific weight, density, degree of water saturation, permeability, durability, alterability, the speed of propagation of compression and shear waves, and deformation (González *et al.* 2002). Nevertheless, palynological evidence clearly shows that some type of forest clearance took place in Amazonia from around 7000 BP onwards (Eriksen 2011).

The axe symbolism

Regarding extra-functional dimensions, the symbolic aspect of axes was related to the cosmology of Amazonian peoples. For instance, in Huayurco, a possibly secondary collective burial included an adult who held a pink quartz axe (Clasby 2014). However, the greatest evidence is found in large, usually sedimentary rocks that occasionally emerge in the Amazon. For example, at Cucharayacu 4, located in the basin of the Paranapura River, which, in turn, is a tributary of the Huallaga River, there is a petroglyph with many representations, including the solitary figure of a T-shaped axe, made using a combination of percussion and abrasion techniques (Rivas 2014). Similarly, the Faical petroglyphs, located in a gorge that empties into the Chinchipe River, a tributary of the Marañon River, contain various panels covered with designs, including a group of human figures with ovoid or round heads and solid bodies performing various activities, with tools in their hands, including axes, all painted red (Gamonal and Olivera 2014). In another panel, there are figures marching in a line with their arms raised, holding a type of circular instrument or weapon in their right hand, and an axe in their left hand, facing a principal figure who may be the supreme *apu* or god of the mountain, whose triangular head retains human features with eyes, nose, and mouth, and who also holds an axe in his left hand and a circular weapon in his right hand. The figure's body is painted with double broken lines that descend from the top of the body to the feet, as if they were rivers or paths, and the lower part features a figure in the shape of a caiman attacking two foxes facing each other[7] (Gamonal and Olivera

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[7] Gamonal and Olivera (2014) refer to foxes as the predators and to a lizard, instead of a caiman. The only species of fox that inhabits the area around Faical is the short-eared fox, *atelocino*, *perro de monte*, or *nomensarixi* in the Chiquitano language and *uálaca* in Yucuna (*Atelocynus microtis*), but it could also be a bush dog (*Speothos venaticus*). The lizard is probably a caiman, because in Amazonian mythologies, the caiman has much more symbolic importance than the lizard. In this sense, it is worth commenting on the myth of the Kayuá of southern Mato Grosso recounted by Lévi-Strauss (1976), in which the caiman is the master of water and has the mission of preventing the earth from drying up: "the yacaré is the chief of the water so that the whole world does not dry up" (p. 190). The Tayronas of Colombia, for example, also worshiped the caiman, associating it with the sun, and attributing to it the ability to move at different levels of the cosmos, with the ceramics of this culture featuring representations of caimans, as well as other animals that were worshiped. The shamans of the Tayronas, by assuming the form of caimans and jaguars, acquired their qualities (Ramírez 2006).

2014). This may indicate that the axe was associated with ceremonies that would appease the evils represented by predators, as it became an important tool for agriculture that would generate a food source. Additionally, the caiman (*Caiman crocodilus*) has always played a role in Amazonian mythology as a generator of life.

The symbolism of the axe was still prevalent during late Inca and early colonial times, particularly around the birth of a new family member, when the father was forbidden to work with the axe to avoid harming the baby (Oberem 1980). Additionally, the *supai uchutican* (a character with a giant head and abundant hair) struck the aerial roots of large trees with his axe before it started raining (*ibid*. 1980).

The axe's contradictions: An instrument of technical and socio-economic evolution

Based on the analytic review of lithic axes, it is evident that a technological progression occurred, a transition from a flaking method to a polishing one. This suggests a likely dialectical shift. The flaked axe, prominent around 5,000–4,000 BP, seemingly contradicts its intended function in a new, more humid environment compared to its original, drier one. This conflict inherent in its use in changing environments was resolved through a technical advancement: the development of the polishing technique. However, the new polished axes are not unique, but rather distinct (*sensu* Dussel 2012), in the context of a great diversity, with low efficiency, which will be resolved through decreasing innovation and diversity, but increasing efficiency. In this sense, the T-type axe serves as a main critical analogue (*sensu* Dussel 2012). Its defining feature is its haft, and its overall internal structure bears the most similarity to other axe types. Not only does it echo other axe designs, but it also demonstrates ergonomic efficiency. The T-type axe, with its superior handle, reduces the physical exertion needed to wield it, thus optimizing its usability.

As can be seen, lithic axes hide a complex universe of functional and symbolic dimensions. Through the technological study of the Ushpapangal axes, we have attempted to open the door to new investigations into this type of materiality.

In conclusion, the archaeological site of Ushpapangal provides valuable insights into the technological aspects of the pre-Hispanic societies that inhabited the Bajo Huallaga region. The production of axes is one of the most striking features of the site, and our analysis has shed light on the different phases involved in their production, from the selection and acquisition of raw materials to the shaping and finishing stages. The use of volcanic rocks as the primary raw material for axes suggests a close relationship between the site's occupants and the local river environment.

Moreover, the distribution of axes and manuports across the different layers of the site indicates changes in the intensity of handaxe production over time. The high frequency of axes in the middle layers of the site (Layers B and C) suggests a peak in production during the Formative. Additionally, the technological analysis of lithic materials found at the site provides a better understanding of the techniques and tools used by pre-Hispanic populations to produce these artifacts.

The data presented in this article add to the growing body of research on the Bajo Huallaga region's pre-Hispanic societies, which are still relatively understudied in comparison to other areas of Peru. The results of our work will serve as a valuable reference for future research into the technological, social, and environmental aspects of these societies. Further studies of the site's lithic assemblages may also shed light on the social and economic organization of the site's inhabitants, and their relationship with other nearby settlements.

Overall, the technological analysis of the lithic materials found at Ushpapangal has allowed us to reconstruct the production sequence of axes and manuports, providing insights into the technological capabilities and resource use of pre-Hispanic populations in the region. This study contributes to a better understanding of the pre-Hispanic societies that inhabited the Bajo Huallaga region and the cultural and technological changes that occurred over time, using an analectic and techno-functional method.

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Artifactual category	**Layer**					**Total**	
	Surface	**A**	**B**	**C**	**D**	**n**	**%**
Core	1	-	-	-	-	1	1.19
Casson (unshaped waste)	-	1	-	-	-	1	1.19
Flake	-	-	1	-	-	1	1.19
Scraper	-	1	-	-	-	1	1.19
Axe	3	13	15	6	-	37	44.05
Ceramic polisher	-	-	2	-	-	2	2.38
Hammerstone	-	1	-	-	-	1	1.19
Miscellaneous	-	2	1	2	-	5	5.95
Manuport	2	3	21	5	4	35	41.67
Total	**6**	**21**	**40**	**13**	**4**	**84**	**100.00**

Table 1. Frequency of lihic material categories by layers at Ushpapangal.

Raw Material	**Surface**	**A**	**B**	**C**	**D**	**Frequency**	**Percentage %**
Radiolarite[1]	1	-	-	-	-	1	1.19
Basalt[2]	5	14	28	9	-	56	69.04
Andesite	-	2	4	-	1	7	8.33
Coarse-grained quartzite	-	1	2	-	1	4	4.76
Pink quartz	-	-	1	-	-	1	1.19
Orthquartzite	-	1	-	-	-	1	1.19
Greywacke	-	1	3	1	-	5	5.95
Orange Sandstone	-	-	-	1	-	1	1.19
Arkose	-	-	2	2	-	4	4.76
Granite	-	2	-	-	-	2	2.3/8
TOTAL	**6**	**21**	**40**	**13**	**2**	**82**	**100.00**

Table 2. Frequency of raw materials by layers in Ushpapangal.

(1) Initially, this material had been identified as silexite (van Dalen and Silva 2014), but this study has determined that it is in fact radiolarite.
(2) Initially, this material had been identified as diorite and granodiorite (van Dalen and Silva 2014), but this study has determined that they are instead basalts.

Raw material	**Preform**	**Type[1]**				**Frequency**	**Percentage %**
		1	**2**	**3**	**4**		
Anphanitic basalt	19	3	5	1	-	28	75.67
Porphiritic basalt	5	-	1	2	1	9	24.33
Total	**24**	**3**	**6**	**3**	**1**	**37**	**100.00**

Table 3. Frequency of lithic axe types by raw material.

(1) Initially, eight types had been identified at Ushpapangal, including preforms (type 0) (van Dalen and Silva 2014), but this study has determined that there are in fact only four types. As a result, some axes assigned to the previous types 2 and 17 have been reassigned into the new type 1, some axes from types 13, 17, 19, and 34 have been reassigned into type 2, some axes from type 34 have been reassigned into type 3, and some axes from type 17 have been reassigned into type 4. The type numbers refer to a system incorporating all of the types in Peru discovered up to date (Silva n.d.b).

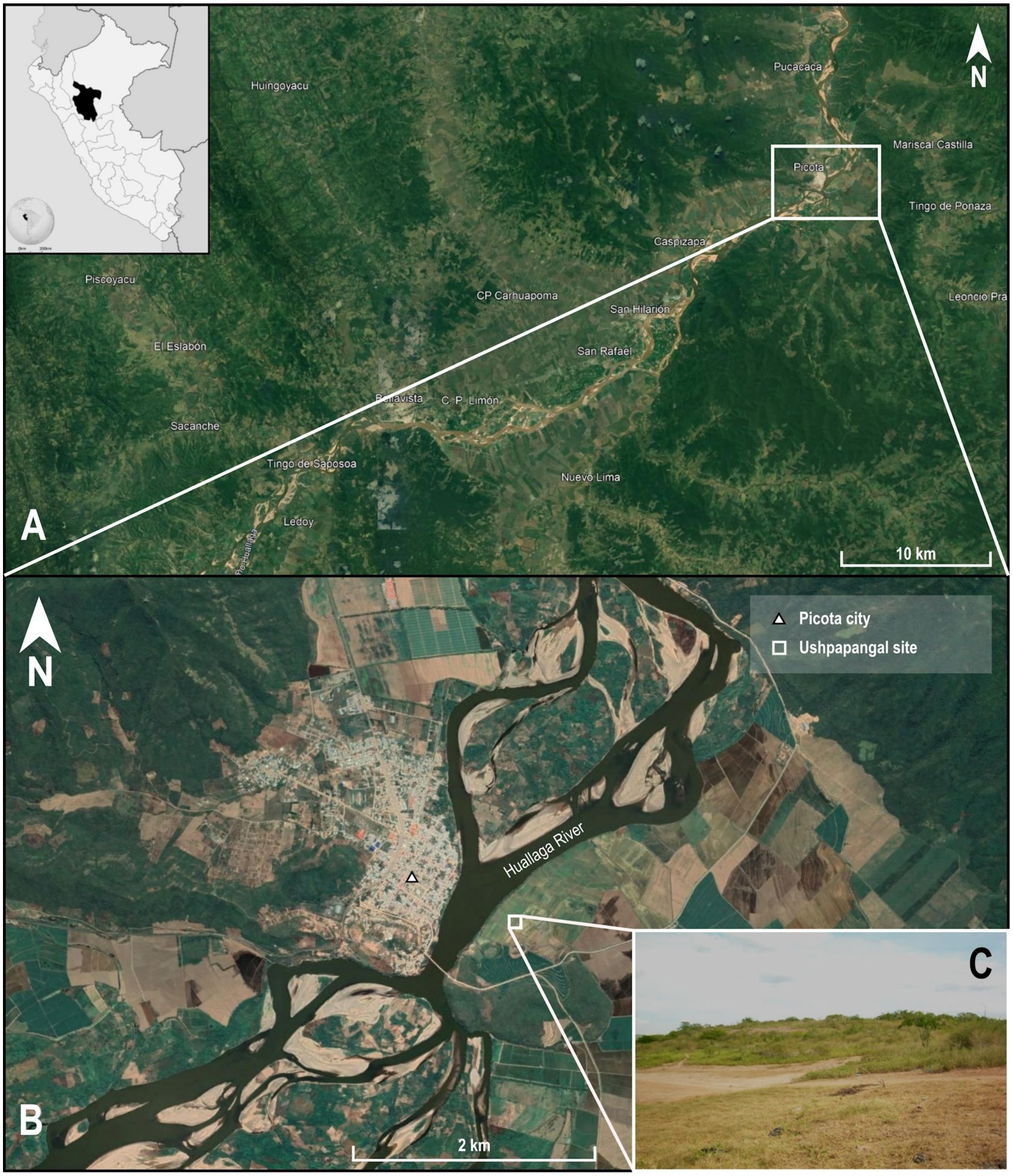

Figure 1. Archaeological site of Ushpapangal: (A) Geopolitical location of main sites and cities mentioned in the text; (B) immediate environment of the site (C); panoramic view from west to east of the mound (from van Dalen and Silva 2014).

Figure 2. Lithic materials from Ushpapangal: (a) Axe; (b) flake without retouching; (c) side-scraper on flake; (d) manuport, possibly a flake from the reconfiguring of an axe: (e) radiolarite core; (f, h) miscellaneous: sleeked cobblestone; (g) ceramic polisher; (h) miscellaneous: cylindric cobblestone (i) hammerstone.

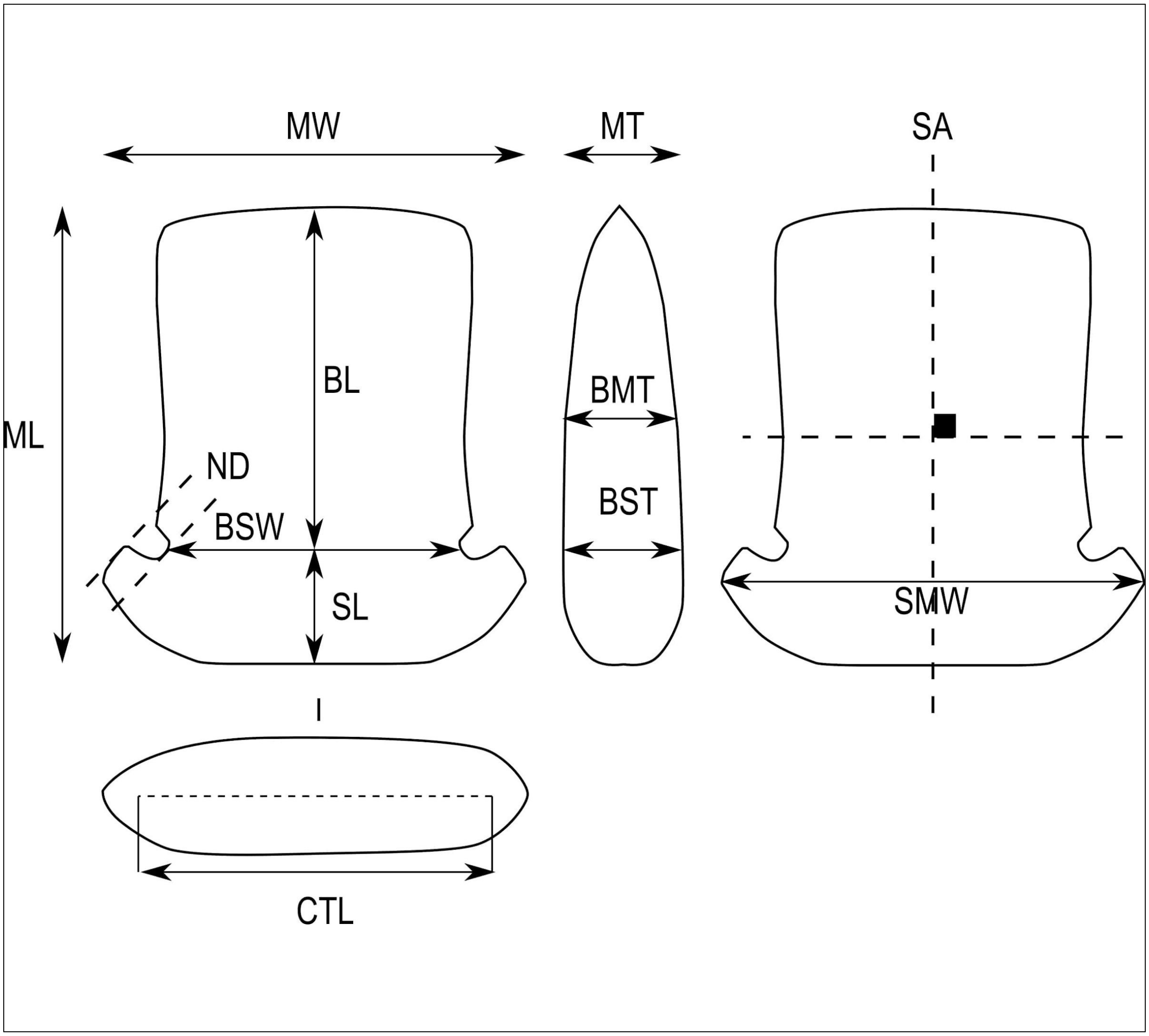

Figure 3. Measurements' positions: ML, maximum length; MW, maximum width; MT, maximum thickness; BL, blade length; SL, stem length; SA, symmetry axis; MW, maximum width; BSW, blade/ stem intersection width; SMW, stem maximum width; ND, notch concavity depth; BMT, blade maximum thickness; BST, blade/stem intersection thickness.

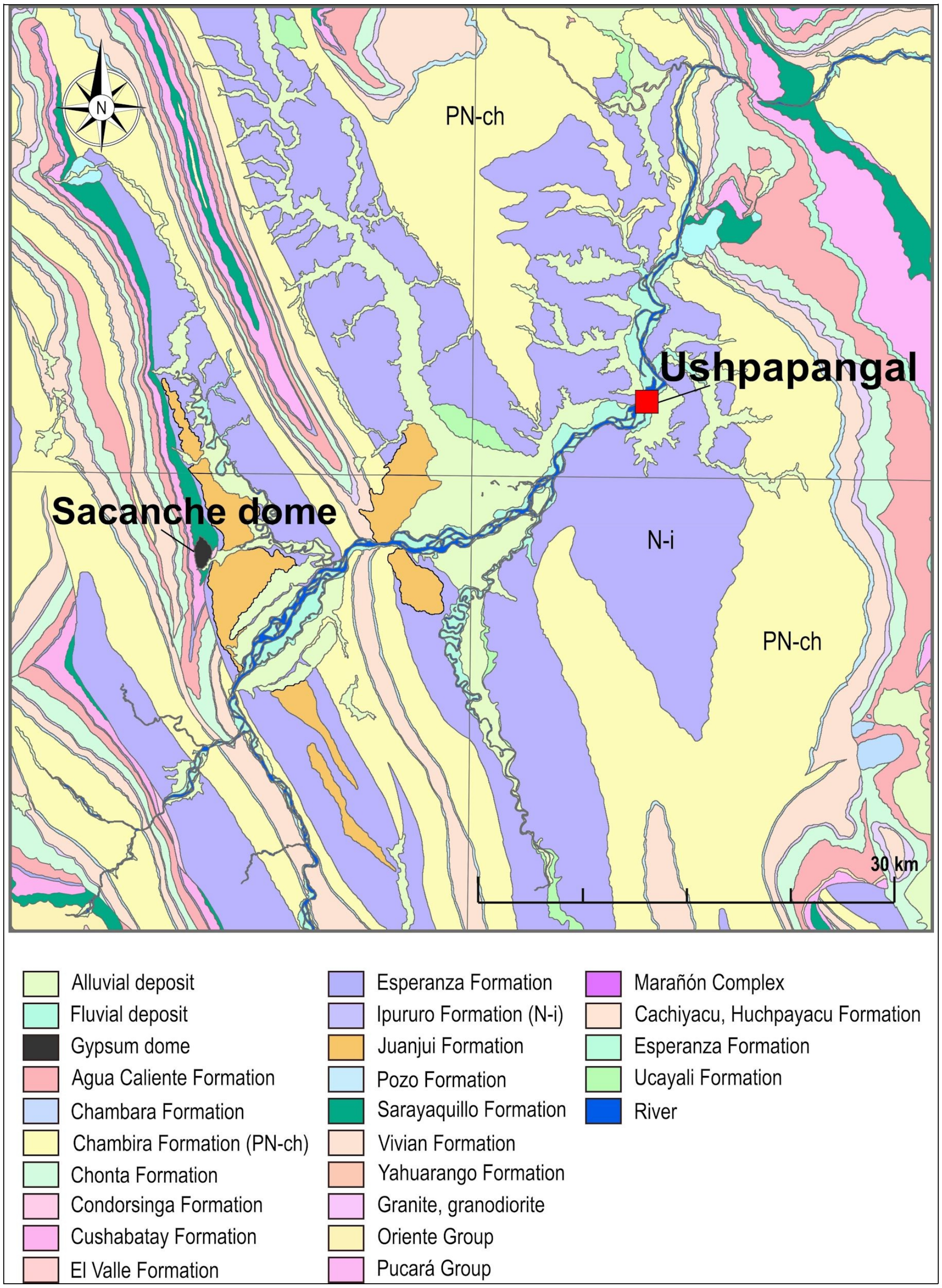

Figure 4. Map of the lithostratigraphic units in the vicinity of the Ushpapangal site. GIS map prepared from the national geological charts 14j, 14k, 15j and 15k available in the INGEMMET Peru geotcamin service.

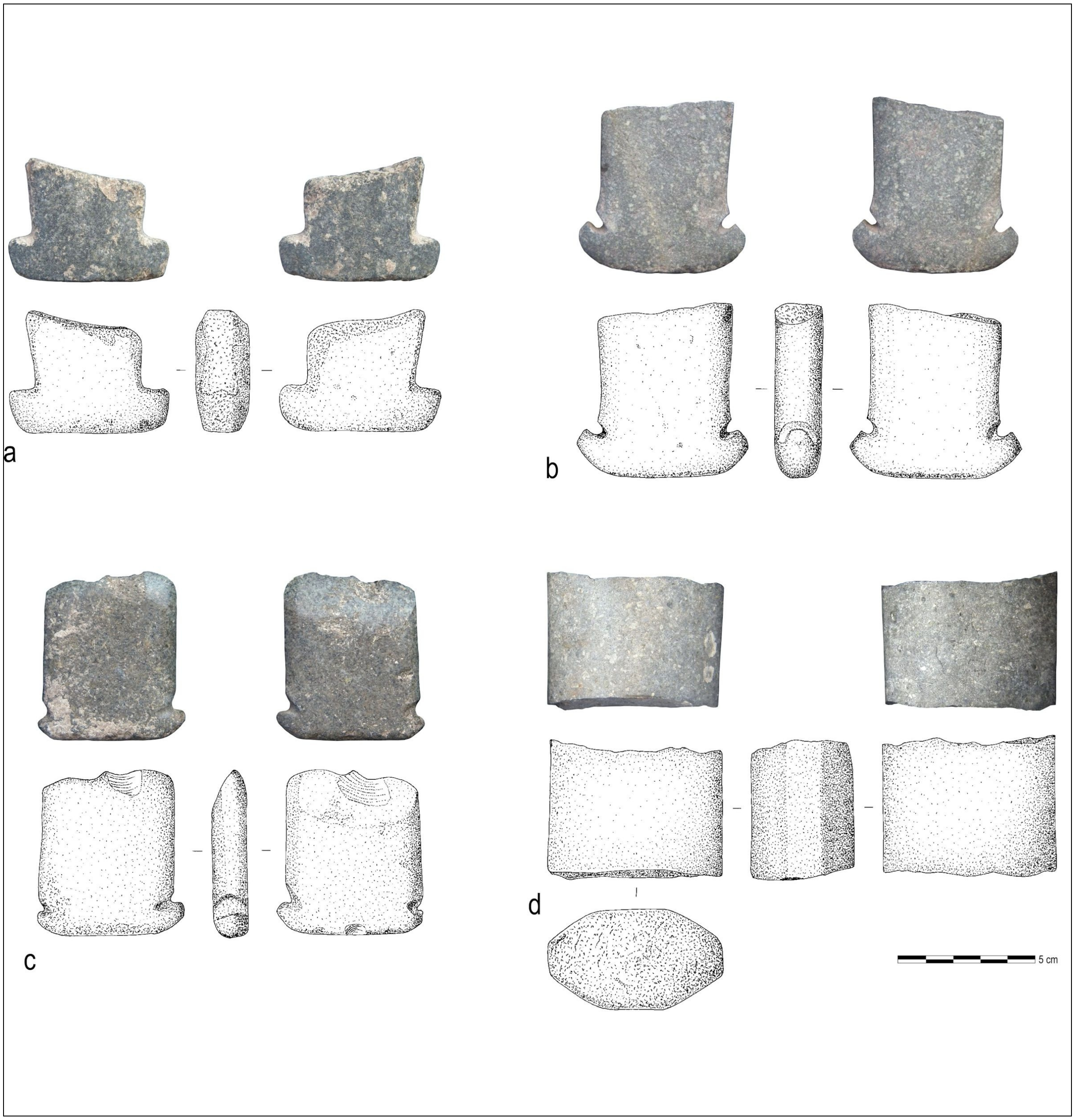

Figure 5. Some examples of the four types of lithic axes from different layers at the Ushpapangal site: (a) Type 1; (b) Type 2; (c) Type 3; (d) Type 4.

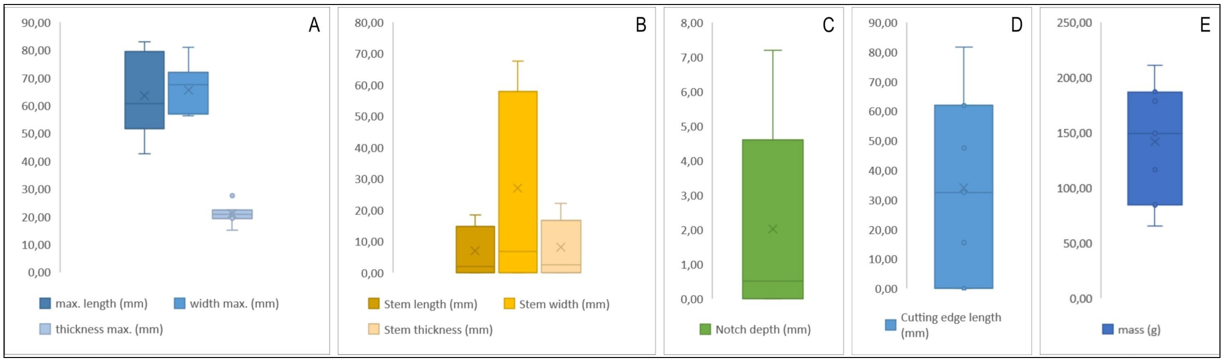

Figure 6. Main morphometric data of the Ushpapangal axes: (A) max. Length, width and thickness (mm); (B) stem length, width and thickness (mm); (C) notch depth (mm); (D) cutting edge length (mm); (E) mass (g).

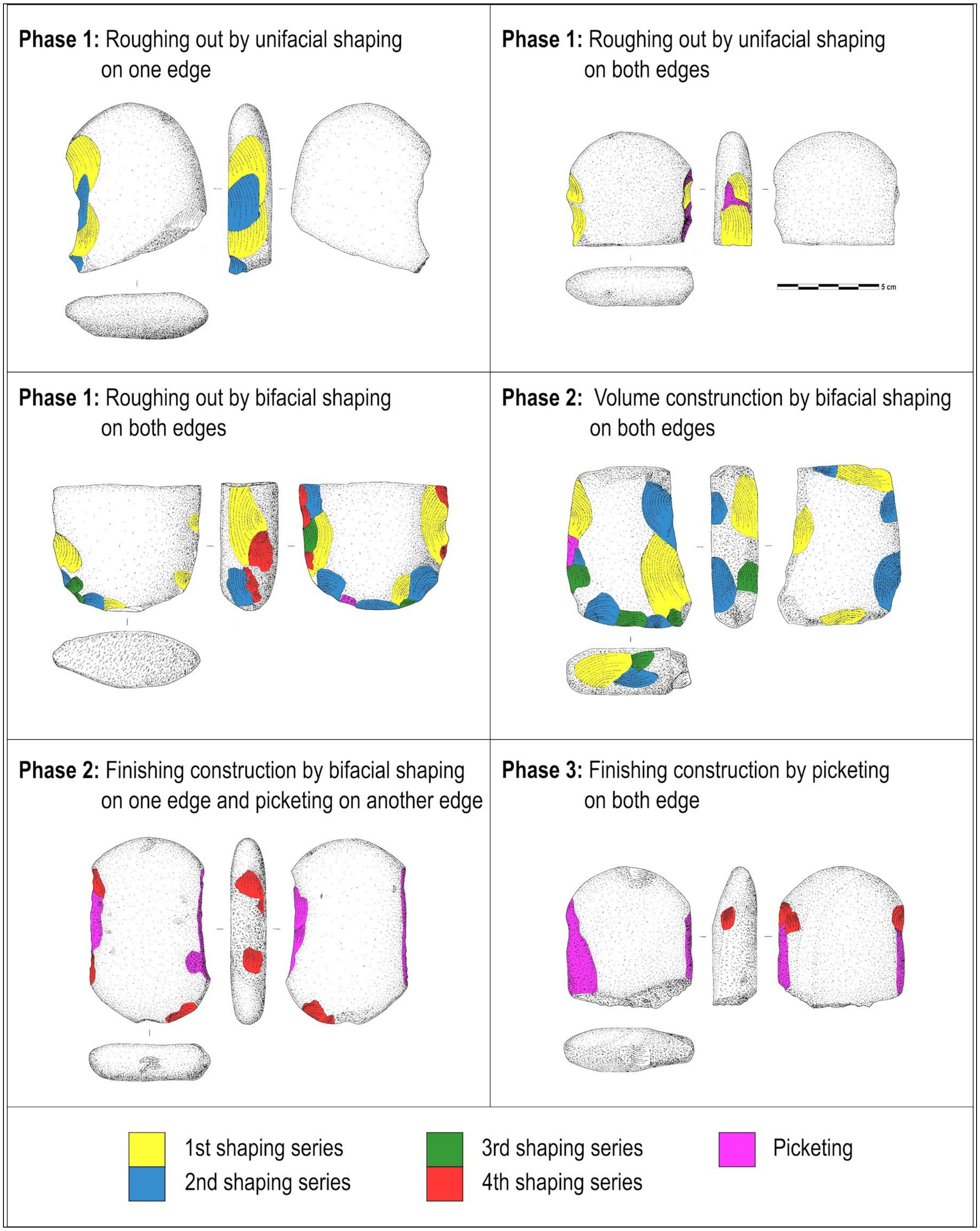

Figure 7. Reduction sequence of preforms identified at the Ushpapangal site.

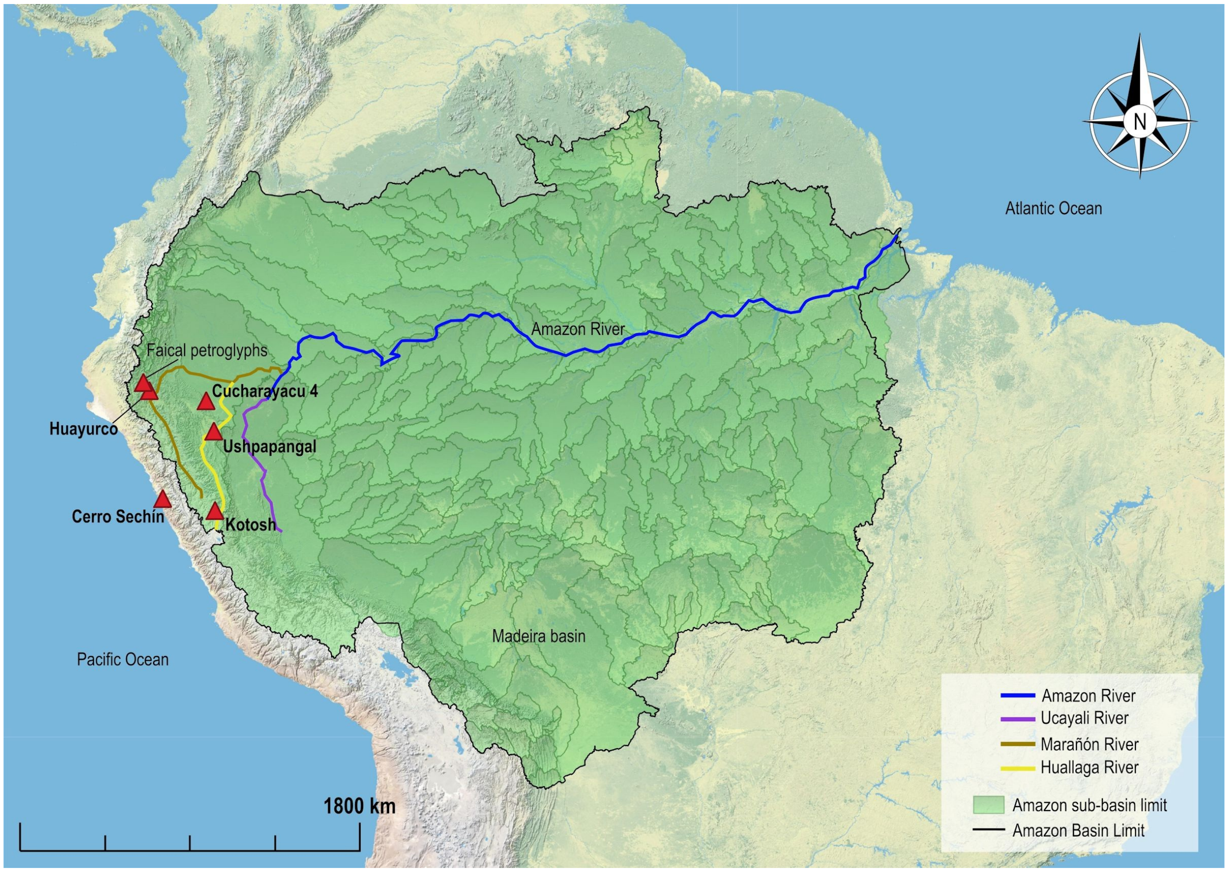

Figure 8. Main sites mentioned in this work within the framework of the Amazon Basin.