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A New View on the Late Pleistocene Lithic Remains from Pikimachay Cave, South Central Peru

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Abstract

Between 1966 and 1972, Richard MacNeish led the "Ayacucho Archaeological-Botanical Project" in the Ayacucho Basin, south-central Peru. Over the last decade, we reappraised the lithics recovered in this endeavor. As part of this research, we carried out a detailed review of the lithic remains from the lowest strata of Pikimachay Cave. We concluded that the lithics from layers tentatively dated at about 14,000 uncalibrated yr BP are human-made artifacts, while those from the underlying levels are not. Because of the anthropic nature of the flaked artifacts, their stratigraphic position, chronology, and similarities with other likely coeval lithic assemblages, the Pikimachay record seems to be a good candidate for witnessing possible Paleoamerican foragers living in Ayacucho during the Late Pleistocene.

Keywords

Paleoamerican, Stone Tool Analyses, Late Pleistocene, Ayacucho Basin, Andean Region, South America

1. Introduction

One of the main global centers for the emergence of complex societies was located along the Andean Cordillera, mainly in the Republic of Peru in South America. The archaeological evidence demonstrated that this process started in several places across the country (Mann, 2005; Sauer, 1950; Stanish, 2003; Towle, 1961). In this regard, Richard MacNeish's investigations in the southern Andes were closely linked to deepening this topic in New World archaeology. He conceived the research in Peru based on his previous work in Tehuacán, Mexico (MacNeish, 1964a, 1964b, 1974, 1978a, 1978b, 1992a), he reached important conclusions concerning the origins of agriculture and social complexity in Mesoamerica (MacNeish, 1967; MacNeish et al., 1967, 1970a, 1972). To compare with those results, MacNeish (1969: pp. 1-54, 1992a: pp. 37-74) searched for a nuclear area with both socio-cultural and ecological similarities. As a result, he carried out the "Ayacucho Archaeological-Botanical Project" in southeastern Peru between 1966 and 1972, under the patronage of the Robert S. Peabody Foundation (**Figure 1**). The initial goal was to do paleo-botanical investigations to obtain data to clarify the origin of agriculture in the Andean region as the second New World center for the domestication of plants and animals.

MacNeish's research transformed the understanding of archaeology in the New World in several ways. He promoted innovative fieldwork methods, and the materials analyses brought attention to the importance of interdisciplinary teamwork. His investigations influenced generations of archaeologists. The collections resulting from his intense integrative research constitute a significant part of his legacy; the anthropogenic and non-anthropogenic samples collected during his projects are significant legacy collections (e.g. King & Samford, 2019; St. Amand et al., 2020). Although occasionally receiving a brief review from archaeologists, MacNeish's collections have lain dormant for nearly four decades, especially those from his Peruvian research.

Beyond his initial project aims, MacNeish's research allowed him to propose a regional sequence of human occupations in Ayacucho from the Late Pleistocene to Inca times (MacNeish, 1969; MacNeish et al., 1970a). Flea Cave or Pikimachay was one of the main sites providing data about the earliest peoples in the Ayacucho Basin (MacNeish, 1969, 1971, 1979, 1992b; MacNeish et al., 1970a, 1970b, 1980, 1981). In this regard, despite difficulties in integrating the different kinds of current evidence (Dillehay, 2019), the data obtained by diverse lines of

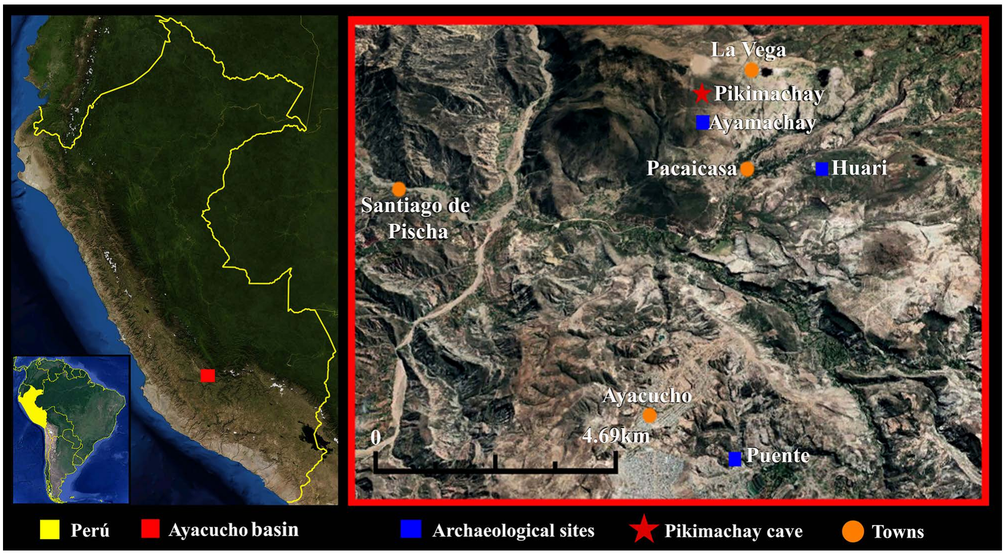


Figure 1. Location map of the Ayacucho Basin and the main sites investigated by the MacNeish project. The star indicates Pikimachay Cave.

investigations suggest that several colonizing events occurred during the Late Pleistocene in the Americas (Goebel et al., 2008; Meltzer, 2009, 2013; Becerra-Valdivia & Higham, 2020). In North America, a growing number of sites provides archaeological remains witnessing the presence of human occupations some millennia before Clovis (Halligan et al., 2016; Waters et al., 2011a, 2011b, 2018; among others). In South America, several localities have yielded evidence supporting a similar view of initial occupation prior to the foragers who used "Fishtail" or Fell projectile points, which are almost coeval with Clovis and other Paleoindian manifestations (Ardelean et al., 2020; Boëda et al., 2014, 2016; Bryan et al., 1978; Dillehay, 1997; Dillehay et al., 2015, 2017; Ochsenius & Gruhn, 1979; Politis et al., 2016; Navarro-Harris et al., 2020; among others). There are controversies over this evidence (e.g. Dillehay et al., 2021; Gruhn, 2020; Politis & Prates, 2021; among others), that include serious questions about the human origin of artifacts associated with some of the older claims (~≥20,000 uncalibrated radiocarbon years before present) (Bryan & Gruhn, 1979; Chatters et al., 2022; Fiedel, 2017; Gómez Coutouly, 2022; Meltzer et al., 1997; Meltzer, 2009). In this frame, Pikimachay cave was one of several South American sites that yielded possible pre-Clovis archaeological vestiges. Its lower layers provided supposedly man-made artifacts dated at ~≥14,100 years before the present (^{14}C years BP) (MacNeish, 1969, 1971, 1978b, 1979; MacNeish et al., 1970b, 1981). In the abundant literature about the site, the record of exhumed remains is incomplete, mainly lacking a comprehensive study, especially of those materials recovered in the Late Pleistocene layers (Dillehay, 1985). We based our study on the new approaches in lithic analysis developed since the publication of the project's final reports (e.g. Andrefsky Jr., 2005; Odell, 2003). We analyzed the legacy collection resulting from the aforementioned project complemented with new fieldwork in the area (Giesso et al., 2020; León & Yataco Capcha, 2008; Yataco Capcha, 2011, 2020; Yataco Capcha & Nami, 2016; Yataco Capcha et al., 2021). In addition, the senior author carried out an internship at the Robert S. Peabody Institute of Archeology, Phillips Academy, Andover, Massachusetts. There, being able to review Richard MacNeish's field notebooks and contextualize another part of the lithic and bone collection of the Pikimachay cave found in this institution. This paper reports the reappraisal of the stone remains from the lower strata, adding new lithic artifacts that due to the lack of contextual information were not previously reported (Yataco Capcha, 2011).

2. General Background

2.1. Summary of Environmental and Geo-Archaeological Background

Located in the south-central part of the Central Andes, the Ayacucho Basin is in the Marcahuillca Cordillera in the buttress of the Eastern Cordillera, and Vinchos that constitutes the continental watershed that passes through the upper area of the Western Cordillera. Its average heights range from 2500 to 4500 meters above sea level (Morche et al., 1995: p. 7). The landscape modeled by glacial action shows moraines, diverse erosive features, and glacio-fluvial deposits. It also presents several geotectonic and geodynamic processes (Yataco Capcha, 2020: pp. 39-47).

Pikimachay sits in a temperate, moderate, and rainy climate area, with temperatures ranging between 13˚C to 15˚C. It is placed in the inter-Andean region, consisting of a depression dissected by numerous rivers, rugged ravines with a steep slope. There, the main watercourse is the Cachi River, a source of the Marañón River, whose streams pass through the Ene and Ucayali rivers emptying into the Amazon. Southwest of Pacaicasa, the Cachi River joins with the Huarpa and Pongor rivers, forming various streams and high altitude steep valleys (Morche et al., 1995).

Geologically Pikimachay is located in the Molinoyoc formation, consisting of a sequence of dark lavas arising from several volcanic cones, among which stand out five made up of lava, slag, and ash spills reaching altitudes of approximately 3400 meters above sea level (see Giesso et al., 2020: Figure 2). In the Pacaicasa surroundings, there is evidence of whitish breccias and tuffs, colored lava streams ranging from gray to dark gray, with plagioclase and lapilli strata. To the south, the Molinoyoc formation is covered and surrounded by an irregular strip formed by alluvial deposits of wide distribution, composed of pebbles, cobbles, and partially angular-rounded medium-sized blocks in a matrix of fine gravel and silty-sand matrix. The Ayacucho formation extends just in front and to the east of Pikimachay Cave; this unit corresponds to a Miocene explosive volcanic phase and is composed of lapillitic tuffs interspersed with reworked tuffs, lithic clasts of andesite-granite, and pumice and lagoon sediments, among them, greenish silty argillite, diatomite, and pinkish siltstone (Morche et al., 1995: pp. 35-38).

2.2. Pikimachay Cave and Excavation Units

As mentioned above, MacNeish went to the Ayacucho basin to look for the origins of agriculture, searching for evidence for domesticated plants more than anything else. In this endeavor, nearly five hundred sites with evidence of human occupations were registered (MacNeish, 1969: p. 13; MacNeish et al., 1980: pp. 1-3). From the beginning of the surveys, it was presumed that the region had excellent archaeological potential (MacNeish, 1969: p. 6). For that reason, despite not finding botanical evidence, the team excavated eighteen different caves, yielding burials and long sequences with large amounts of lithic remains. Among them, Pikimachay Cave became one of the most important sites to shed light on the region's earliest human occupations. The cave was found during the first survey, in 1966, in one of the volcanic cones. It is located at 2925 meters about sea level, on the eastern slope of Marcahuilca Hill (13˚02'18.93"S. Lat., 74˚13'41.27"W. Long.), ~2 kilometers northwest of Paccaicasa town, Huanta province, Ayacucho department (**Figure 2(A)**, **Figure 2(B)**). Pikimachay cave measures 25 m long by 55 m wide, and 10 m in height at the entrance (**Figure 3(A)**). For excavation

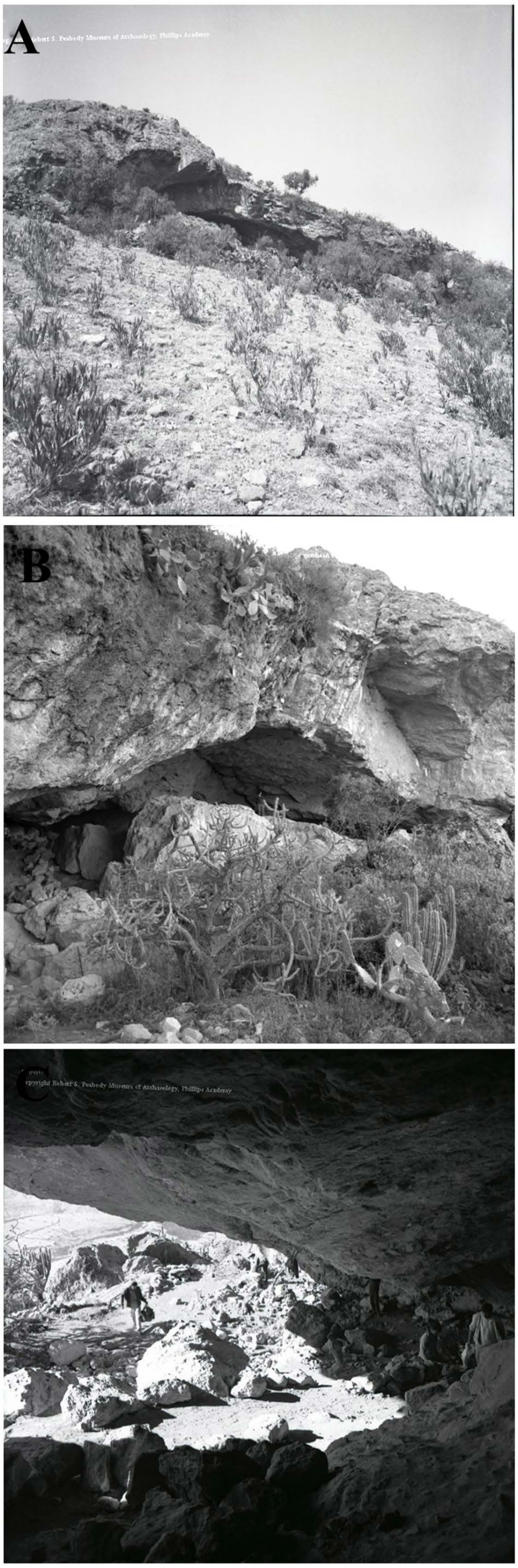


Figure 2. Historical images of the Pikimachay Cave taken by MacNeish in 1969. (A) (B) Two views of the site, (C) the southern portion near the entrance before the excavation. Photographs scanned by Marla Taylor.

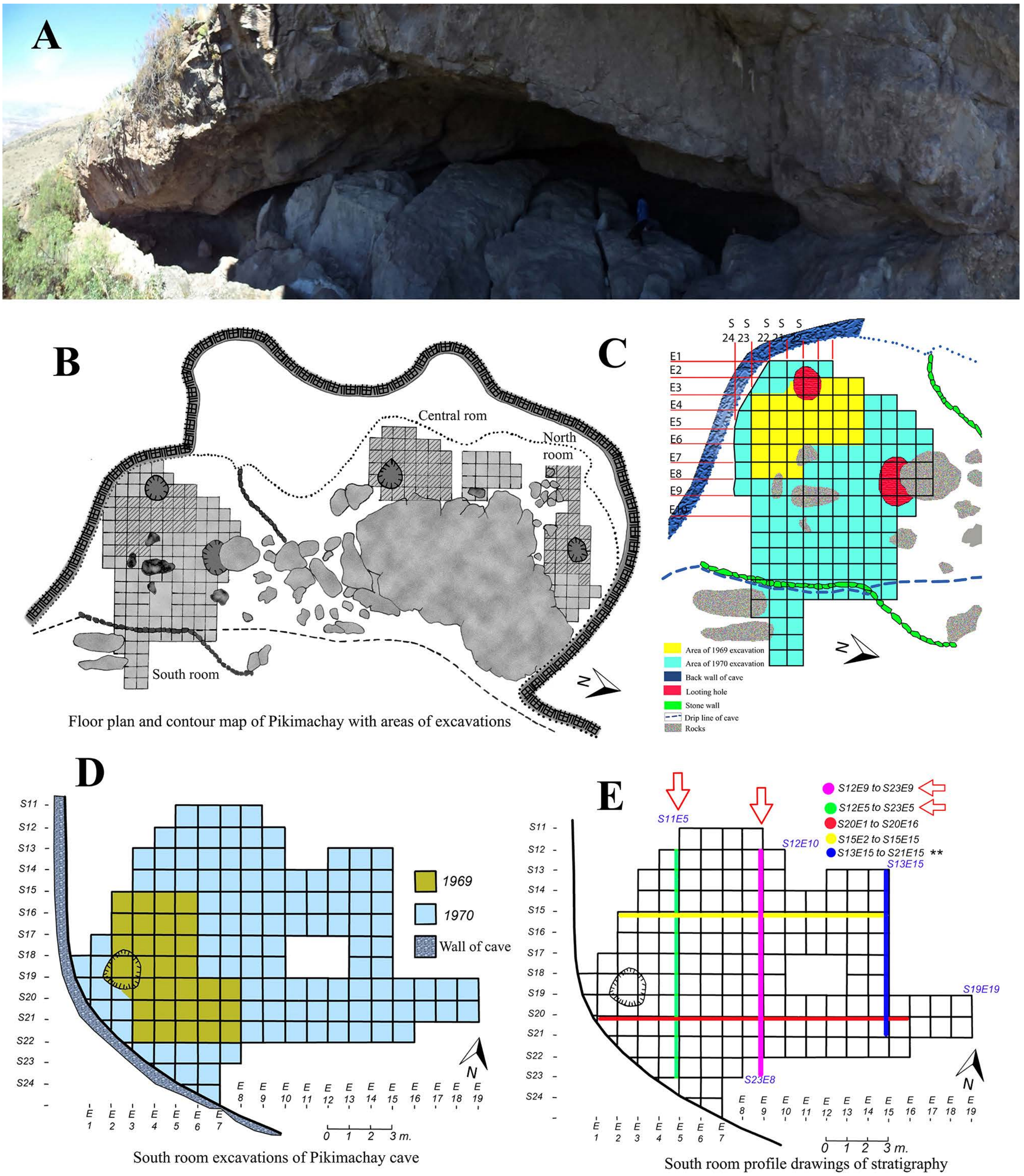


Figure 3. (A) Photograph of Pikimachay Cave showing the large rockfalls located in the entrance, (B) Floor plan of the site and locations of the excavated sectors, (C) details of the blocks and excavation grids in the south portion (denoted with a rectangle in b), (D) the excavated grids in the 1969 and 1970 field-seasons discriminated by colors, (E) locations of the stratigraphic sections recorded during the excavations. The arrow in (E) points to the stratigraphic sections depicted in **Figure 6(A)**. Image credits: (A) J. Yataco Capcha, B-E modified after MacNeish et al., 1981: Fig. 2-8 (B), 1981: Fig. 2-38; 2-39 (C), 1981 Fig. 2-8, 2-32, 2-33 (D-E).

purposes, the floor was divided into three sectors called the north, central, and south "rooms" (MacNeish et al., 1970a: p. 10; MacNeish et al., 1981: pp. 28-51).

From the cave's mouth and the drip line, the "rooms" are located from right to left respectively, around and behind the large blocks mostly found in the north-central portion of the entrance (**Figure 2(B)**, **Figure 3(A)**). The rockfalls from the cave walls and ceiling occurred in strata related to tabular volcanic flows and weak areas associated with tectonics and seismic activity (**Figure 3(B)**, MacNeish et al., 1981: pp. 27-28).

In the aforementioned "rooms", three excavation sectors named as North, Central, and South "trenches" were independently excavated, with separate records and stratigraphy profiles (MacNeish, 1979; MacNeish et al., 1981, 1983). During the first field-season between June and September 1969, the team excavated the central and northern sectors. The main excavation was done in the southern portion during the second field-season in 1970 (**Figure 3(B)**, **Figure 3(C)**). The grids were oriented along central north-south and east-west axes and labeled according to parallel lines of stakes; units south of this 0 axis were called E1, then E2, etc.; while those 1 m south were S1, S2. Thus, all were crossed by axis lines and had a double number; for example, S14E10 (**Figure 3(D) Figure 3(E)**). As seen in the historical images exhibited in **Figure 4**; **Figures 5(A)-(D)** and **Figures 6(B)-(E)**, excavations was carefully performed with trowels and brushes, leaving the findings in their place of discovery, documented by diverse methods, carefully mapped and recorded from datum (MacNeish, 1979: Fig. 11-19). Finally, the excavated sediments were carefully screened.

2.3. Stratigraphic Considerations

In some places, the Pikimachay sedimentary fill shows almost four meters depth, deposited between 500 to 25,000 years before the present. The layers—called "zones" by MacNeish (1969, 1979; among others)—were labeled according to the sectors of excavation (**Figure 6(A)**). Because the materials reported in this paper come from the south sector, we describe only the strata from this area. There, the sedimentary deposit showed sixteen layers identified with the letters *a* to *k* (**Figures 6(A)-(E)**). The sequence has some remarkable features. The blocks created by the collapse of the cave's ceiling constituted a clear-cut layer in the stratigraphy (MacNeish et al., 1981: p. 49). This event formed strata *g*, of about 1.5 m thickness, and composed of plant remains possibly deposited by rodents, and blocks of varied sizes (**Figure 6(A)**, **Figure 6(E)**). The blocks are mostly present in the north-central part of the south sector, and partially in the southern part of this sector (**Figure 5(A)**, **Figures 5(D)-(E)**). Because they overly an occupation level with projectile points dated at ~10,000 to 9000 years before the present (MacNeish, 1979: pp. 29-40; MacNeish et al., 1981: pp. 51-54), these rockfalls were possibly caused by a catastrophic episode that happened during the Terminal Pleistocene/Early Holocene; they covered the seven earliest strata (MacNeish, 1969: pp. 17-23; MacNeish, 1979: p. 8). The stratigraphy overlying this debris is confusing; it showed disturbances and intrusions due to modern human action, such as looters' pits, the construction of corrals, and animal activity (MacNeish, 1969: p. 23; MacNeish, 1979: p. 4).

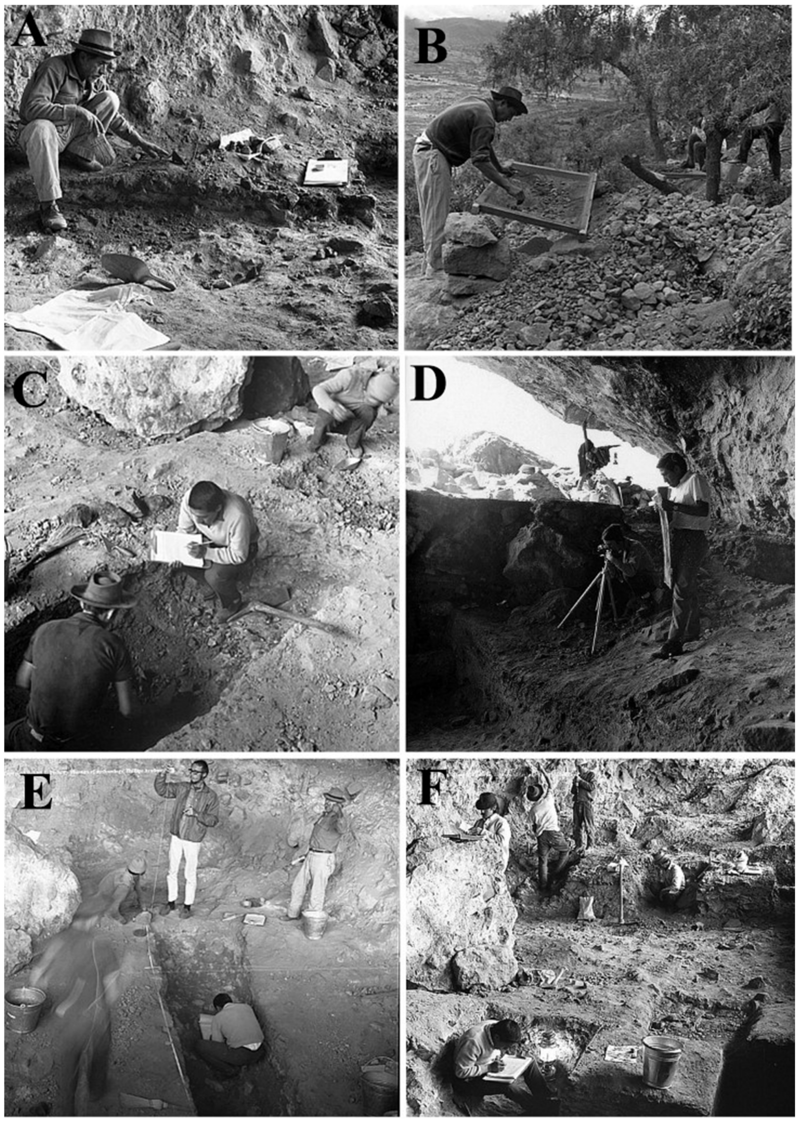


Figure 4. Images showing the methods and documentation techniques employed during the excavations in the south sector of Pikimachay Cave. Photographs scanned by Marla Taylor. ©Robert S. Peabody Institute of Archaeology, Phillips Academy, Andover, Massachusetts. All Rights Reserved.

It is necessary to point out that MacNeish was categorical in indicating that in the excavations carried out in 1969 on the southern section of the cave (**Figure 3(B)**, **Figure 3(D)**). He noted that underlying the modern dung and garbage found in layer *a*, there was a series of ash levels named *b* to *f*. These levels contained some Early Horizon pottery and showed some evidence of intrusions due to rats' nests and various kinds of modern excavated pits. Below these ash layers was a stratum varying from 1 to 2 meters thick of huge rockfalls, named "zone g". Within this layer were all sorts of mixed archaeological remains, mainly preceramic projectile points, modern pottery, a great deal of early pottery, and several heavy lithics. Underlying these rockfalls was a well-consolidated yellow clayey layer *h* (MacNeish, 1969: p. 23).

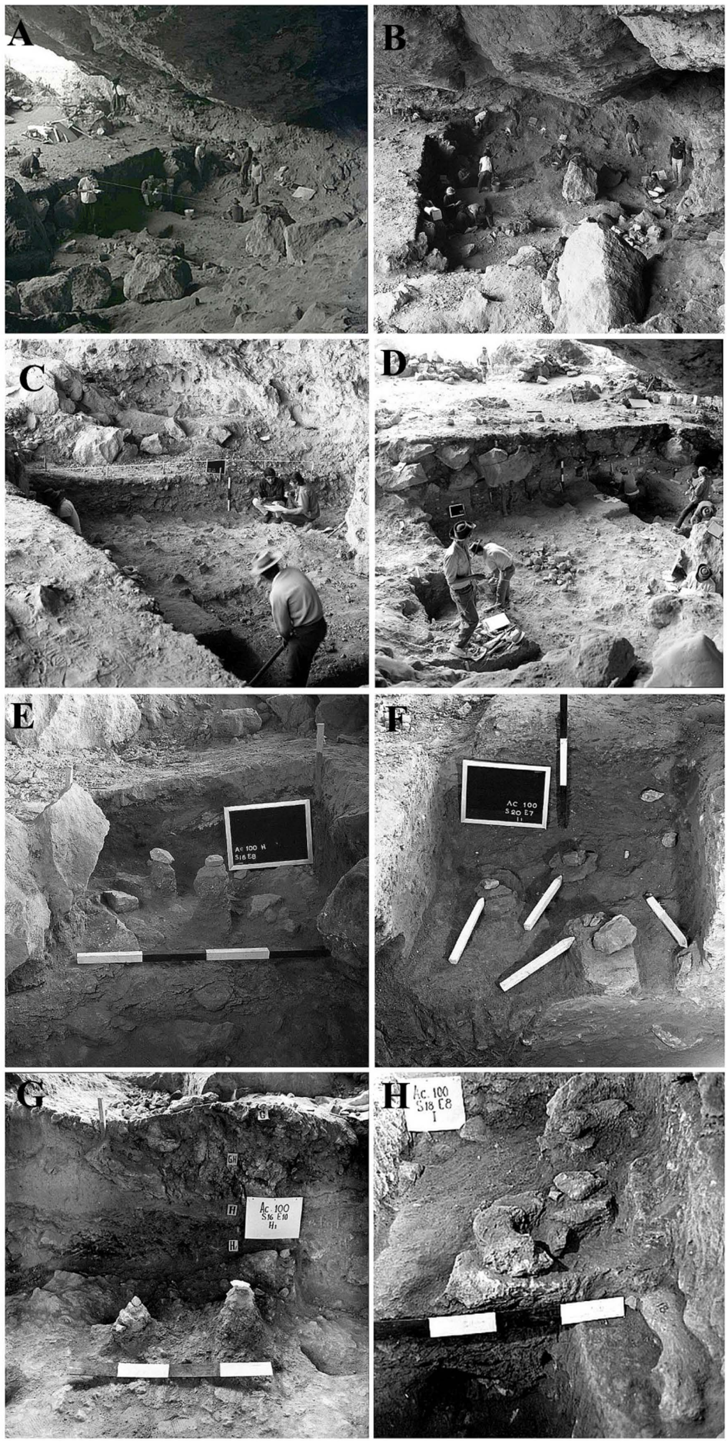


Figure 5. (A-D) Diverse stages of the excavation in the south sector of Pikimachay Cave, E-H) Examples of the finds left in place of discovery, with details of stratigraphic location. (Note the uniformity of the layers below the large blocks overlying and sealing the lower strata in D). Photographs scanned by Marla Taylor.

We believed that due to thickness of the deposits, some significant unconformities (Dott, 1963, 1983) may have occurred, mainly above the blocks. However,

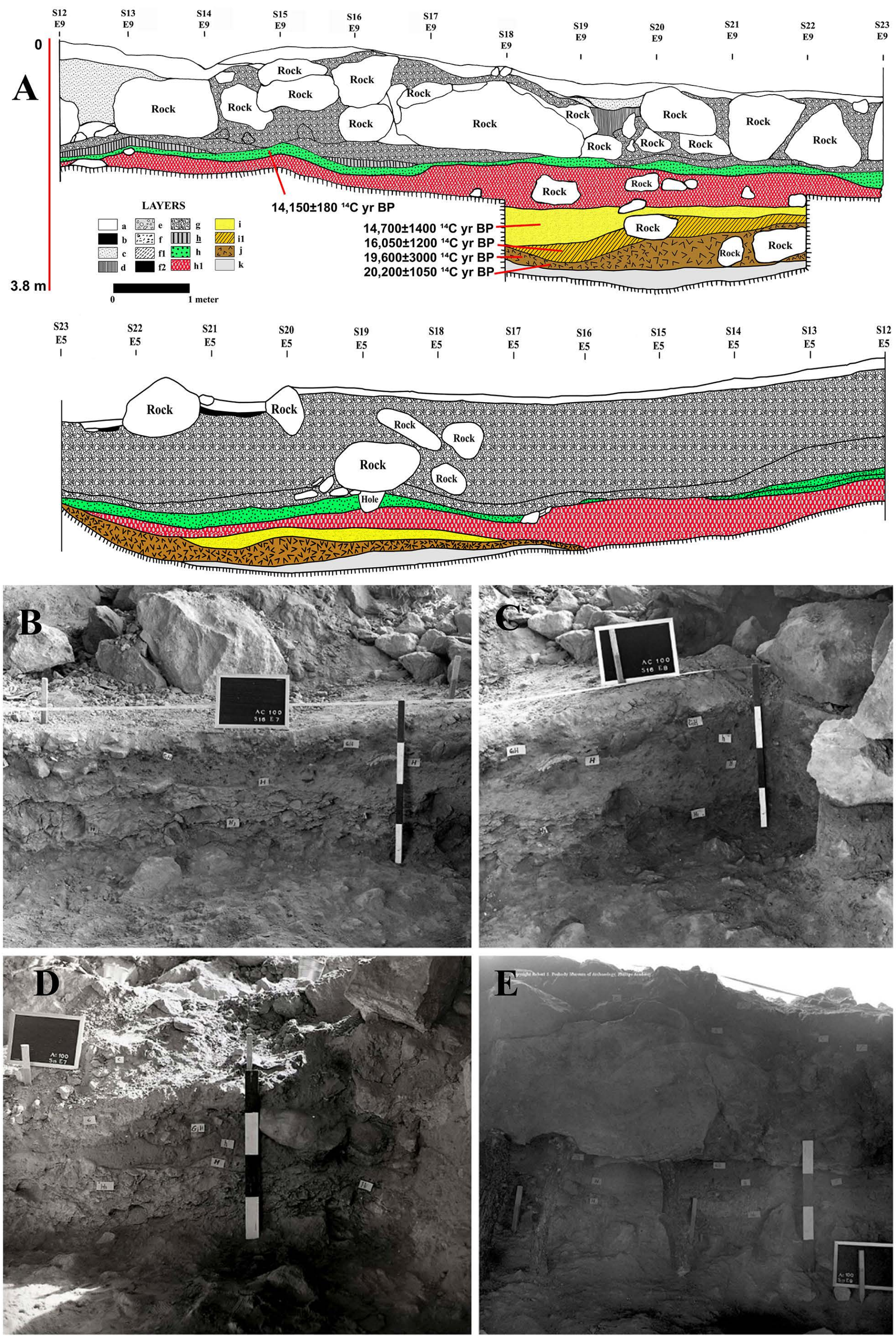


Figure 6. (A) Detailed stratigraphic sequence of Pikimachay Cave from S12E9 to S23E9 and S23E5 to S12E5 profiles, pointed with the stakes in **Figure 3(E)** (square S12E9) (modified after MacNeish et al., 1981: pp. 46-47); Images (B-D) Images show the lower levels in different sectors of the southern excavation squares S16E7 (Figure (B)), S16E8 (Figure (C)) and S24E7 (Figure (D)). Photographs scanned by Marla Taylor. ©Robert S. Peabody Institute of Archaeology, Phillips Academy, Andover, Massachusetts. All Rights Reserved.

the underlying strata show a moderately uniform horizontal deposition forming a deposit ≥ 1.5 m thick. These strata will be described due to the goal of our investigation (**Figure 6(A)**). At this point, it is worth pointing out the importance of the rockfalls in the integrity of the lower levels of the site and the archaeological formation process. From the cave mouth and the drip line, there are large blocks respectively located from right to left, around, and behind, mostly sited in the north-central portion of the entrance (**Figure 3(A)**, **Figure 3(B)**; **Figure 6(A)**). The rockfalls from the cave walls and ceiling occurred in strata related to tabular volcanic flows and weak areas associated with tectonics and seismic movements (**Figure 3(A)**, **Figure 3(B)**; MacNeish, 1979: pp. 8-9; MacNeish et al., 1981: pp. 27-28). The most significant rockfalls are over layer *h*, suggesting that the main event causing its collapse occurred during the Terminal Pleistocene and probably its transition to the Holocene. As seen below, similar events occurred at the same time in other places along the southern Cordillera. The rockfalls covered, protected, and sealed several sectors of the cave, mainly the sedimentary deposits underlying them, particularly the described layers that show a fairly horizontal deposition (**Figure 6(A)**). In contrast to the upper layers, they were not strongly affected by animal or human perturbations. In this regard the following paragraph from MacNeish (1979: pp. 8-9) is very illustrative: "Between 9000 and 10,000 years ago, a catastrophic event occurred, possibly an earthquake or a series of earthquakes. A major portion of the north and central parts of the basalt roof fell. The central portion of the fall partially covered the earlier, relatively level deposits to the south. Concurrently, in the north, large chunks dropped onto the sloping area below the shelf into the ashy stratum, and some of the fall plowed south into the deposit in the south room. The earlier deposits of the south room were completely covered".

The authors re-visited Pikimachay on several occasions and carefully examined the site, paying attention to and documenting the exposed Late Pleistocene sections remaining from the excavations, mainly the stratigraphic profiles from the southern sector. We observed that the stratigraphy in the Late Pleistocene deposit was made by sediments of exogenous and endogenous origin (Ones, 2003; Waters, 1992) displaced by wind and rain. The deposit mainly consists of silt, interspersed by very thin graded laminar layers of consolidated volcanic tuff indicating paleo reliefs formed by fine material eroded and displaced by wind and rain from the volcanic rocks of the regional geology (Dott & Howard, 1962; Dott, 1963).

According to geologist Carlos Toledo (UNMSM), these deposits were later consolidated through time by the effects of humidity and drought. Also, a paleomagnetic sample was taken from one of the exposed sections in the central room. A charcoal sample obtained from the sampled deposit and processed at the Gliwice Radiocarbon Laboratory (Poland) yielded a single conventional radiocarbon date indicating that the section belongs to the Late Holocene. We will publish the results of this research in the future. Additionally, obsidian samples found on the surface of the cave's talus were collected and subjected to XRF provenance analysis (Giesso et al., 2020). In addition, other caves excavated by the MacNeish and his team were revisited (e.g. Yataco Capcha & Nami, 2016; Yataco Capcha, 2020). Also, intense surveys were made to search for new sites that could be excavated and for lithic raw material sources (e.g. Giesso et al., 2020; Yataco Capcha et al., 2021).

The last layer deposited before the cave's ceiling fell were *h* and the overlying *h*. The latter is ~20 cm thick; and formed by a dusty, soft reddish-brown accumulation. It covered a small triangular surface of 21.75 m^2 approximately 6 × 6 m, in the north end of the excavation. Covering an area of 119.13 m^2 the most extensive stratum below the rock-fall was *h*, a slightly compact reddish-orange sediment. It varied from 5 to 10 cm along the cave wall to greater than 30 cm thickness near the cave's mouth. Below is the *h1* stratum, a highly compact yellowish deposit with a maximum thickness of ~40 - 50 cm, and an average ranging from 25 to 35 cm. It covers a surface of 122 m^2, and only 104 m^2 were excavated. The sediment of *h* was strongly acid, unlike *h1*, which was neutral (MacNeish et al., 1981: p. 49). Covering a surface between 50 to 60 m^2, *i* was a dark brown layer reaching a maximum of ~30 cm in thickness. Measuring ~7 - 8 meters with an East-West direction, *i1* was a compact reddish-brown stratum of ~30 cm maximum thickness. The excavation here covered an area of 20.5 m^2, and the unexcavated surface was 3.13 m^2. Extending between 8 to 14 m from east to west, stratum *j* is dark reddish-gray sediment which reached a maximum thickness of 40 cm. It covered an approximate area of 50 to 65 m^2, of which only 33.42 m^2 was exposed. Finally, overlaying the bedrock, *k* is a brownish-gray level with a maximum thickness of 30 cm. It covered a surface of 10 by 4 meters, with an excavated surface of 27.71 m^2. Due to the acidity of the sediments, no botanical remains were preserved in the Pikimachay sedimentary fill (Bryant, 2003).

In summary, in a sedimentary deposit of about four meters of depth, a turning point is the collapse of the cave's roof, witnessed by a significant number of blocks sealing the oldest strata. The layers above the rockfalls were non-uniformly deposited and perturbed by different animals and human agents (MacNeish et al., 1983: p. 136; MacNeish et al., 1981: pp. 49-50); the underlying strata showed a reasonable horizontal and uniform deposition, only disturbed by falling roof blocks in some places of *h* and *h* (MacNeish, 1979: pp. 33-41; MacNeish et al., 1981: p. 49). Another notable feature is that layers *h* to *k* show a highly compacted structure, almost lithified; and practically reaching a cemented stage in the sedimentary rock formation process (Blatt et al., 1980; Tarbuck & Lutgens, 1999; Yataco Capcha and Nami several pers. obs.). As the layers thickened, this part of the stratigraphy became harder (MacNeish, 1979: p. 18). Indeed, chisels were used for excavation, and their signatures are still visible in the remaining sections (**Figure 5(E)**, **Figure 5(F)**, **Figures 6(B)-(D)**). These sorts of hard layers seem to be present in other sites, such as the Puente rock-shelter. There, to excavate them, chisels were also used (MacNeish, 1969: Fig. 37). These kinds of highly compacted strata might have acted as a matrix sealing the embedded artifacts.

2.4. Radiocarbon Chronology

The Pikimachay radiocarbon chronology was one of the points criticized by the MacNeish's detractors. Principally, due to the lack of information regarding their precise association with the archaeological remains (Rick, 1987; Lynch, 1974, 1990a, 1990b, 1992). We know that the chronology of the cave and its findings have been called into question, generating one of the passionate discussions between Lynch (Lynch, 1974: pp. 365-366; Lynch, 1983: pp. 93-94; Lynch, 1990a: p. 25; Lynch, 1992: pp. 256-259; Lynch, 1990b: pp. 164-165) and (MacNeish, 1979: pp. 1-47; Lynch, 1992: pp. 243-246). Furthermore, Rick (Rick, 1987: p. 60, 63; Rick, 1988: pp. 12-17) addressed the same issue. In this regard, he gave a superficial review of some of the lithic materials. Considering the current standards of archaeological research, these kinds of old excavations lack studies on formational processes; also, it is necessary to refine the chronology (Borrero, 2011: p. 387). However, we believe that it is necessary to undertake a review and calibration of the available radiocarbon dates obtained by MacNeish, not to assert that they are accurate, but rather, to give us a referential idea of the age of the studied strata (MacNeish et al., 1981: pp. 40-54; MacNeish et al., 1983: pp. 136-153). Hence, based on the new research performed in the MacNeish's field notes at the Peabody Museum, **Table 1** depicts salient unpublished data regarding the samples and dates obtained in his excavations.

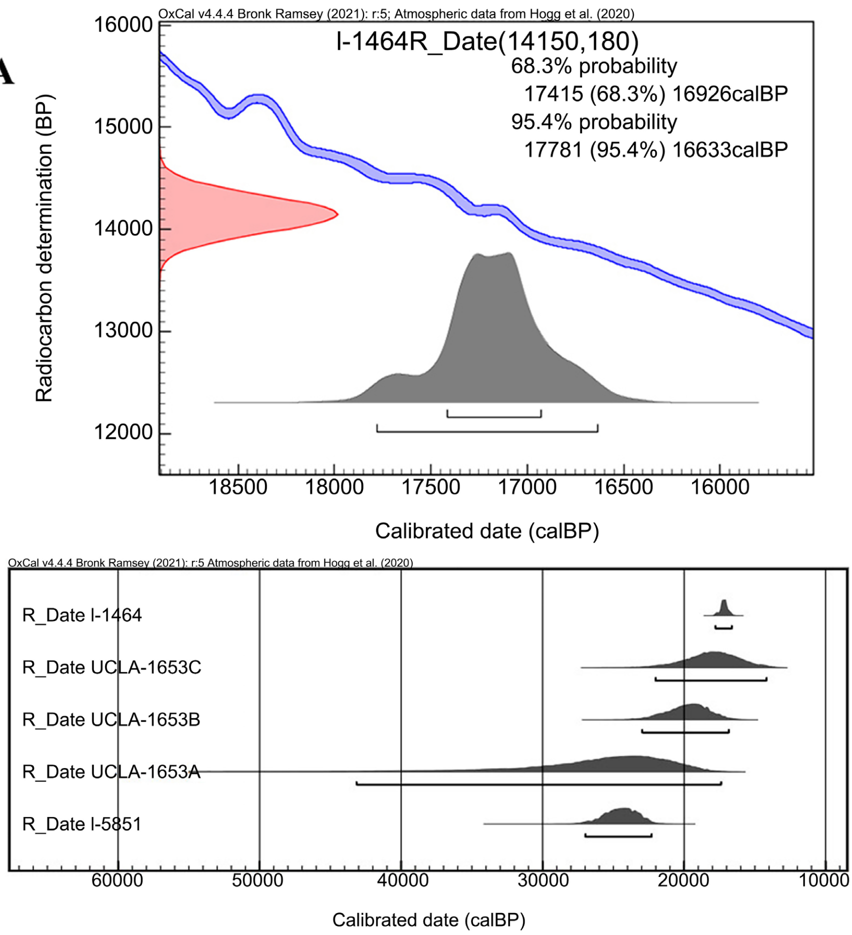
Five conventional radiocarbon assays dated the described stratigraphy. Lacking calibration curves at the time, they were reported as calendar years BC (MacNeish et al., 1981). However, the original dates were revised (see also MacNeish et al., 1970a: pp. 13-14; MacNeish et al., 1970b: pp. 975-977; MacNeish et al., 1981: pp. 51-54, pp. 208-209; Ziólkowski et al., 1994). The dates were processed using the

Table 1. Radiocarbon dates obtained at the lower levels of Pikimachay Cave. *Identification by R. Hoffstetter, **processed by Teledyne Isotopes, New Jersey, USA (Ziólkowski et al., 1994: p. 323), but mistakenly reported as UCLA-1464 (MacNeish, 1969: p. 23; MacNeish et al., 1981: pp. 22-23).

Material Dated	Grid	Layer	Depth (m)	Lab. Id.	Date (yr BP)	Calibrated range (yr BP) (95.4%)
Megatheridae or *Scelidotherium* bone*	S19.1E3	*h*	2.67	I-1464**	14,150 ± 180	16,663 - 17,781
Bone	S21.7E7.72; S20.25E6.75	*i*	3.37	UCLA-1653C	14,700 ± 1400	14,179 - 22,021
Megatheridae bone	S20.5E7.24; S20.3E7.6	*i1*	3.40/3.44	UCLA-1653B	16,050 ± 1,200	16,839 - 22,960
Bone	S22E9; S20.15E7.4; S20.2E8.98; S20.25E8.88.	*j*	3.52/3.73	UCLA-1653A	19,600 ± 3,000	17,385 - 43,148
Bone	S21.6E9.55	*j*	3.58	I-5851	20,200 ± 1,050	22,297 - 26,981

OxCal v4.4 program and the SHCal20 southern hemisphere calibration curve showing the calendar-calibrated ranges at the 95.4% probability level (Hogg et al., 2020: pp. 759-778). The results were kindly checked and processed again by Christopher Ramsey (pers. comm. 2022). The conventional radiocarbon dates and the calibrated results are given in **Table 1** and **Figures 7(A)-(C)**. Remarkable is the plot of samples from *h* showing a calibration curve without "plates" and alterations (**Figure 7(A)**).

A



B

C

Sample	Layer	Depth (meters)	Material	Comment
I-5851	j	3.52-3.73	Sloth bones of Megatheridae	Sample composed with remaining fragments of the bones dated by UCLA-1653A, combined with a fragment of long bone from S21.6E9.55 at a Depth 3.52 m and a spine of sloth vertebra from S18.58E6.3 at depth of 3.73m. (MacNeish et al. 1981: 208)
UCLA-1653A	j	3.58	Sloth bones of Megatheridae	Four pieces of sloth bone from square S22E9, a rib from S20.15E7.4, a vertebra from S20.2E8.98 and a vertebra from S20.25E8.88.
UCLA-1653B	i1	3.40-3.44	Bones of Megatheridae	Sample composed of two bone slivers from S20.5E7.24 and a nearby long-bone fragment from S20.3E7.6 (MacNeish et al 1981: 209).
UCLA-1653C	i	3.37	Bones of Megatheridae and carbon (Burned bone?)	Sample composed with two pieces of bones from S21.7E7.72 and a piece of carbon or burned bone from S20.25E6.75 (MacNeish et al. 1981: 208-209).
I-1464	h	2.67	Fragment of humerus of Megatheridae or Scelidotherium	Found at S19.1E3

Figure 7. (A) Plot of calibrated age from layer *h*, (B) Plots of calibrated ages using the Oxcal v4.4.2 (2020) program for the southern hemisphere SHCal 20 (Hogg et al., 2020), (C) Detailed information of the bone samples submitted by MacNeish for radiocarbon dating.

The Pikimachay dates are the results of the application of old conventional radiocarbon techniques; for that reason, some show wide ± sigma. Because of this, two bone samples from layer *h* and curated at the Robert S. Peabody Institute of Archaeology were submitted for AMS radiocarbon dating to Beta Analytic Inc. (Florida, USA). Unfortunately, both samples failed to yield a separable collagen fraction and cannot be dated. Because of the above, most dates remain problematic. Only the two from layers *h* and *i* are plausible, and only I-1464 comes close to the standards of the current radiocarbon dating. The others have very long distributional spans, probably because they were made on multiple bone fragments (Deviese et al., 2018; Haynes, 2015). Then, the most acceptable date is the one collected from layer *h*, which significantly overlaps with the assay obtained from the underlying strata *i*. Notwithstanding the above, until new data are available, they are still useful to provide a chronological framework for the stratigraphy containing the lithic sample studied. Judging by the dates obtained and the overlapping calibrated results, the layers *h* to *k* belong to the Post Last Glacial Maximum during the Late Pleistocene, in a period spanning 15,000 to 25,000 years before the present. Also, the chronological data suggest that there are no significant unconformities in the lower layers, mainly between *h* to *i*, whose deposit of ~≥1.5 meter thick spans ~≤1.000 years. The available radiocarbon information supports the interpretation that were chronological and stratigraphic unconformities in the deposit overlying the rockfalls (MacNeish et al., 1981: pp. 43-56), a situation that apparently did not occur in the lowest strata (**Figure 6(A)**).

Below, we will depict and discuss the remains coming from these lower levels, claimed to be the vestiges left by the oldest human occupations at Pikimachay. The lithics characterized as the "Ayacucho and Paccaicasa complexes" supposedly identified in the layers *h* and *h1*, and *i* to *k*, respectively.

3. Materials, Analysis and Observations

3.1. General Remarks

The studied materials at curated at the Museum of Anthropology and Archeology of the San Marcos University (MAA-UNMSM), Lima, Peru. A few pieces are at the National Museum of Archaeology, Anthropology, and History of Peru (MNAAHP). Finally, MacNeish's excavations field notes and documentation are in the Robert S. Peabody Institute of Archaeology (RSPIA), Andover, Massachusetts, USA.

Worth remembering that since the first reports (MacNeish, 1969, 1979; MacNeish et al., 1970b), the evidence of the claimed oldest occupations of Pikimachay were subject of many questions and doubts (Lynch, 1974, 1990a, 1990b, 1992). One of the main difficulties regarding the supposed Paleoamerican evidence was that in the final reports; the finds were not depicted with precision, and the stone artifacts, as well the raw material identifications, were not clearly defined and described (Dillehay, 1985; Rick, 1988). To elucidate this problem, we reevaluate the lithic artifacts from the oldest layers describe above.

3.2. Brief Statement of the Findings

The re-analysis allowed us to determine the number of materials exhumed at Pikimachay. They mostly consist of the stone finds and there are some faunal remains. In the earliest strata there were stone artifacts associated with Pleistocene animal bones (MacNeish et al., 1970b: pp. 975-977; MacNeish, 1971: pp. 36-46). To contextualize our specific study, we first assess the findings and observations noted from layers *h* to *j*. Among the most significant finds were an important number of complete (e.g. **Figures 8(A)-(J)**) and fragmented bones of extinct and extant fauna, which associated with the stone remains (MacNeish, 1969, 1971, 1979; MacNeish et al., 1980: pp. 309-321). With the aim of contextualizing our specific study, we firstly provide a glimpse of the findings and observations made on layers *h* to *j*. The following animals were present: *h*: rodents, and skunk, *h* to *i1*: horse, *h* to *k*: ground sloth, *i1*: mastodon, and possibly camelid, *h*: cougar, *h1*: perhaps saber-toothed tiger, *i1*: feline, and *j*: cervid. Despite the lack of a detailed paleontological study, MacNeish (1979) pointed out that some of the previously mentioned fossil bones are from the following species: *Scelidotherium tarijensis* (Miño-Boilini et al., 2014), *Megatherium tarijensis* (De Iuliis et al., 2009), *Equus* (*Amerhippus*) *andium* (Prado & Alberdi, 1994, 2017). Furthermore, in an unpublished report, Wing (n.d.) identified the following species: *Eremotherium* (Pujos & Salas, 2004), Mylodontidae (Salas & Stucchi, 2005), and *Mastodon* (Salas & Stucchi, 2005).

The bones of extinct fauna and the stone tools exhumed in layers *h* and *h1* suggest that they were coeval and, in some cases, related to each other (MacNeish, 1969, 1971, 1979; MacNeish et al., 1970b). The sample of osseous remains curated at the MAA-UNMSM and at the RSPIA were recorded; the most significant bones were documented in detail (Yataco Capcha, 2011, 2020), mainly those showing diverse kinds of marks and alterations that might be signs of human agency (MacNeish et al., 1970b: pp. 975-977, MacNeish, 1971: pp. 36-46; Yataco Capcha, 2011, 2020). Discriminated by layers, the samples of osseous remains from the MAA-UNMSM collections are as follows: *h* (n = 16), *h1* (n = 4), and no bone remains from *i* to *k*. However, 35 pieces curated at the RSPIA are recorded as coming from layers *h* (n = 8), *h1* (n = 3), *i* (n = 10), *i1* (n = 12), *j* (n = 1), and *k* (n = 1). Several displayed diverse types of fractures, modifications, and marks on their surfaces. The most notable specimens showing alterations and modification were carefully analyzed, and some preliminary and tentative interpretations were proposed (Yataco Capcha, 2011, 2020). Nevertheless, bearing in mind the complexity of natural and cultural modifications acting on the bones after their deposition, and that the marks, fractures, and alterations may be due to different causes, it was crucial to perform a specialized taphonomic study to get a better sense of their origins and characteristics. Detailed descriptions of the taphonomic observations and discussions are given elsewhere (Nami et al., 2021).

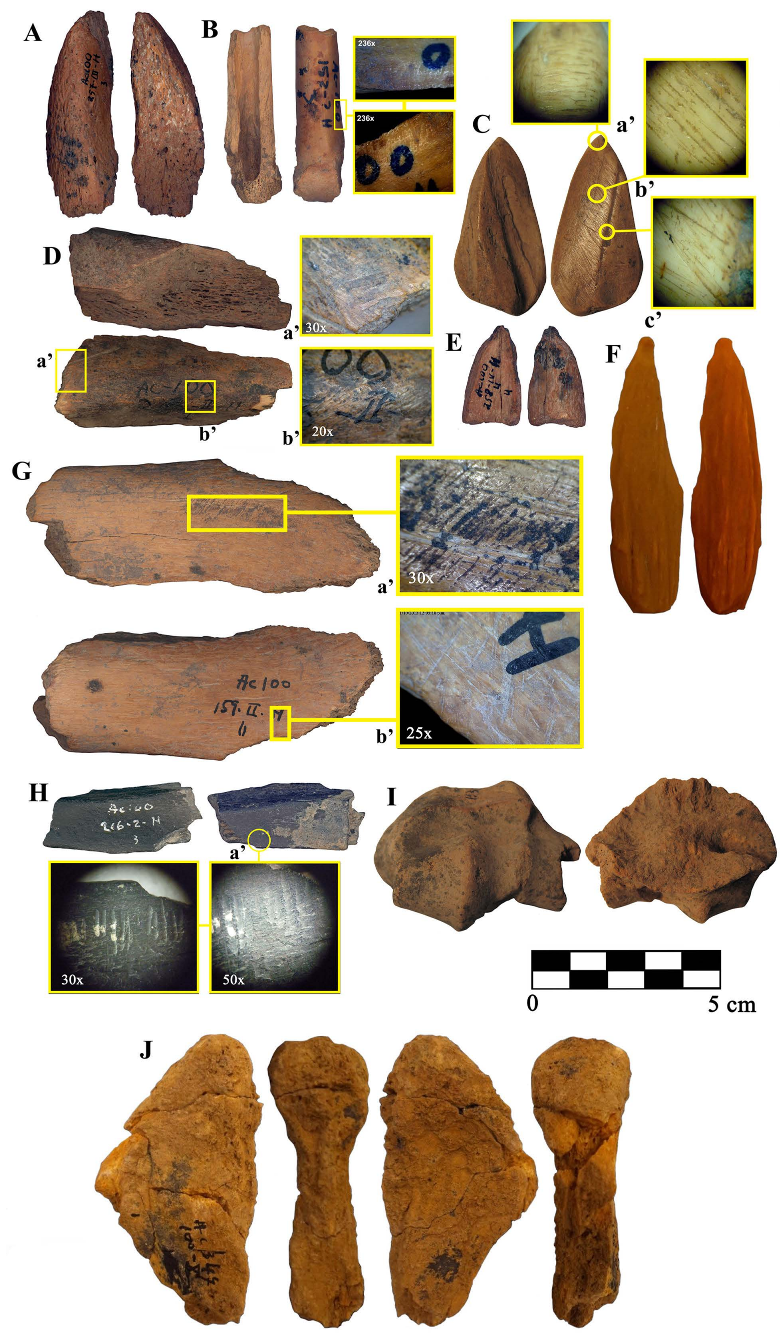


Figure 8. Bone specimens from layer *h*: (A) Fossil sloth rib (Ac100 257-III-H3, S19E7) (MacNeish et al., 1980: p. 314, Fig. 8-3); (B) fossil phalange (Ac100 152-?-H3, S21E6) (MacNeish et al., 1980: 314, Fig. 8-4); (C) fossilized horse metapodial with microphotographs showing the striae resulting from fashioning a tool (Ac100 264-II-h, S20E1); (D, G) fragmented osseous remains (d: Ac100 205-II-HI, S20E2; g: Ac100 159-II-HII, S21-22E7); (E) bone fragment (Ac100 258-IV-H4, S19E8) MacNeish et al. (1980: p. 309, Fig. 8-1); F) Plastic resin cast of object described by MacNeish as: "deer antler" (cf. MacNeish et al., 1980: p. 313, Fig. 8-2), deposited in RSPIA, catalog 219.3.2; (H) ungulate rib (label: Ac100 216-2-H3, S24E5), detail shown with stereomicroscope Stemi 2000-C; Layer *h1*: (I) camel radius, Ac100 153-III-H1, S23E7; Layer *k*: (J); Sloth jaw Ac100 347-X, S21E10, deposited RSPIA catalog 2018.10.585. Except when otherwise indicated, the photographs and drawings illustrated in the following figures were made by J. Yataco Capcha.

However, for this paper, some general statements can be made. Concerning the general state of preservation, the taphonomic scrutiny showed a clear difference between the bone remains from *h* and *h1* and those from the underlying layers. Those bones from *h* and *h1* show good preservation with details of anthropogenic and non-anthropogenic features (**Figures 8(A)-(H)**). The most important are trampling (**Figure 8(D)**, **Figure 8(G)**), manganese staining (**Figure 8(D)**, **Figure 8(H)**), cracking, and cut marks (**Figures 8(A)-(C)**, **Figure 8(E)**); besides, most cortical surfaces are sediment-free. The specimens showing human modifications are the result of cutting activities and bone breakage, mainly for marrow extraction. Furthermore, two fragments were identified as probable tools (**Figure 8(C)**). The bony remains from *i* to *k*, are more likely to be covered or coated with hard sediment, and more manganese staining is observed. In some cases, there are small osseous pieces encrusted in compacted sediment, such as those from layer *i* or *j*. On other occasions, the bones are embedded in sediment, like the material from *i1* and *k*, although in a few cases, the cortical surface is exposed. They are generally covered with manganese, cracking, or surfaces that are not well-preserved. The bones from layers *i* to *k* do not show anthropogenic actions (Nami et al., 2021).

Due to the spatial distribution of the bones, possible hearths, and the claimed human-made stone remains, the cave's excavators (MacNeish, 1979; MacNeish et al., 1983: pp. 136-153) suggested the existence of several "activity areas" corresponding to the above mentioned early "cultural complexes." However, several authors criticized these interpretations in a variety of ways (Bonavia, 1991: p. 89; Lynch, 1983: pp. 93-94; Rick, 1988: pp. 12-17), particularly questioning the anthropogenic origin of the layers assessed in this paper (Lynch, 1974: pp. 365-366).

3.3. Lithic Analysis

Discriminated by strata, the analyzed sample (n = 81) of lithic remains is as follows: *h* (n = 48), *h1* (n = 18), *i* (n = 5), *i1* (n = 2), *j* (n = 4), and *k* (n = 4). In addition, 16 pieces were recorded at the MNAAHP but only four have been determined as anthropogenic and published by Veronica Ortiz (MNAAHP, 2015) (**Figures 9(A)-(D)**). A morpho-technological study of each specimen was made to distinguish the human made artifacts. Hence, the collection was reviewed in detail, evaluating the material macroscopically, and, when possible, microscopically. General guidelines were employed in this analysis (Andrefsky Jr., 2005; Bordes, 1981; De Sonneville-Bordes & Perrot, 1956; Inizan et al., 1995; Merino, 1994; Piel-Desruisseaux, 1989); as well as a survey of a great deal of specific literature, mainly resulting from middle-range research to understand prehistoric lithic technologies (Callahan, 1979; Nami, 1986; among others). Also considered were the different natural agents causing ambiguous stone objects, a topic that was crucial in this investigation (Ellen, 2011; Grayson, 1986; Raynal et al., 1995; among others). The sample was carefully documented with photographs, as well as technical drawings that helped visualize some attributes that were difficult to

Figure 9. Photographs of the lithic artifacts in layer *h* curated at the MNAAHP, photos by M. Jhong and V. Ortiz (MNAAHP).

capture with photographs alone. The majority of the sample is depicted in Figures 9-12 and Figures 14-16.

With the new inventory of the Pikimachay collection we elaborated the lithic typology of the studied artifacts from layer *h*, *h1* and *i1*, identifying 67 anthropogenic artifacts (Table 2). To the previously reported sample (n = 52, Yataco Capcha, 2011: p. 263), we were able to add fifteen additional pieces because the field notebooks at the RSPIA help identify artifacts curated at the MAA-UNMSM. The morpho-technological studied sample identified tools (n = 33), bifaces (n = 2), lithic waste (n = 21), cores (n = 8), as well manuports and ecofacts (n = 3). The totals of the studied sample are given in the Tables 3-6. They provides, the artifacts' location in the excavations giving the catalog numbers, square and their individual figures in the main text of this paper (Table 3), raw materials distinguished by artifacts and layers (Table 4), the average measurements by artifact class (Table 5), and a list of chunks and geofacts and layers (Table 6). These sorts of information have been never reported before in such a detailed and organized manner.

Table 2. Pikimachay Cave lithics by layers.

Categories	Layers					
	h	%	*h1*	%	*i1*	%
A. Unifacial tools						
A.1. Flakes with marginal retouch	11	22.91%	1	5.50%	-	-
A.2. Knife	3	6.25%	1	5.50%	-	-
A.3. Denticulate	5	10.41%	3	16.60%	-	-
A.4. Perforator	1	2.08%	1	5.50%	-	-
A.5. End-Scraper	3	6.25%	2	11.10%	-	-
A.6. Chopper	2	4.16%	-	-	-	-
B. Bifacial artifacts						
B.1. Early bifacial stage and preform	2	4.16%	-	-	-	-
C. Pebble implements						
C.1. Manuports and ecofacts	-	-	3	16.60%	-	-
D. Flaking wasted						
D.1. Flakes and shatters	16	33.33%	5	27.70%	-	-
D.2. Cores	5	10.41%	2	11.10%	1	**100%**
Total	**48**	**100%**	**18**	**100%**	**1**	**100%**

Table 3. List of artifacts from *h*, *h1* and *i1* layers. References of their origin, definition of raw material, colors and figures from the south sector of Pikimachay cave.

Layer	Label	Square	Definition	Raw Material	Munsel Color	Color description	Figures in the mai paper
h	Ac100 277-V-dd(h)	S24E7	Flake	Quartz	5Y 4/1	olive gray	Figure 9(A)
h	Ac100 166-VIII-d(h)	S20E3	Flake	Chert	5Y 8/1; N9	Yellowish gray; white	Figure 9(B)
h	Ac100 216-12dd	S24E5	Flake with marginal retouch	Volcanic tuff	5R 3/4	Dusky red	Figure 9(C)
h	Ac100 VIII-H	S20E3	Flake	Chert	5YR 4/1	Brownish gray	Figure 9(D)
h	Ac100 206-2-1	S23E3	Perforator	Jasper	10YR 5/4	Moderate yellowish brown	Figure 10(A), Figure 10(A')
h	Ac100 274-Ia	S22-20E3-1	Knife	Quartz sand-stone	5Y 8/4	Moderate orange pink	Figure 10(B), Figure 10(B')
h	Ac100 216-2	S24E5	Early bifacial stage	Volcanic tuff	5G 5/2	verde amarillo moderado	Figure 10(C), Figure 10(C')
h	Ac100 207-1n	S23E6	Denticulate	Chert	5YR 5/6	Light brown	Figure 10(D), Figure 10(D')
h	Ac100 264-II-SS10	S20E1	Flake with marginal retouch	Chert	5B 7/1; N1	Light bluish gray; Black	Figure 10(E), Figure 10(E')
h	Ac100 220-2d-d1	S21E2	Flake with marginal retouch	Quartz	10R 4/6; 10YR 8/2	Modderate reddish brown; very pale orange	Figure 10(F), Figure 10(F')
h	Ac 100 231-VII dd	S18E5.50	Early bifacial stage	Volcanic tuff	10YR 8/2	Very pale orange	Figure 10(G), Figure 10(G')
h	Ac100 345-II	S15E13	Scraper	Obsidian	N1	black	Figure 10(H), Figure 10(H')

Continued

h	Ac100 251-VII-ss	S18E8	Denticulate	Volcanic tuff	5GY 8/1; 5Y 8/1	Light greenish gray; yellowish gray.	Figure 10(I), Figure 10(I')
h	Ac100 217-6d2	S17E6-4	Scraper	Volcanic tuff	5P 6/2	Pale purple	Figure 10(J), Figure 10(J')
h	Ac100 159-Ie	S21-22E7	Chopper	Basalt	5Y 4/1	olive gray	Figure 10(K), Figure 10(K')
h	Ac100 280-III-ee	S25-26E6	Knife	Volcanic tuff	5B 5/1	medium bluish gray	Figure 10(L), Figure 10(L')
h	Ac100 293-V-nn4	S17E6	Denticulate abrupt	Quartz	5Y 8/1; 10R 6/6	Yellowish gray; Dark yellowish orange	Figure 10(M), Figure 10(M')
h	Ac100 259-IV-dd	S19E9	Scraper	Chert	N9; 5Y 8/1	White; Yellowish gray	Figure 10(N), Figure 10(N')
h	Ac100 264-II-nn	S20E1	Core	Jasper	10R 4/6; 10YR 7/4	Moderate reddish brown; Grayish orange	Figure 10(O), Figure 10(O')
h	Ac100 266-II gg9	S20E6	Shatter	Volcanic tuff	5RP 2/2; 5P 6/2	Very dusky purple; Pale purple	Figure 10(P), Figure 10(P')
h	Ac100 281-III-d1	S25, 26E7	Core	Quartz	5Y 8/4	amarilo grisáceo	Figure 11(A), Figure 12(A)
h	Ac100 231-7d3	S18E5.50	Flake	Volcanic tuff	5R 3/4	Dusky red	Figure 11(B), Figure 12(B)
h	Ac100 257-III-L2	S20E7	Flake	Quartz	5Y 8/1; N9	Yellowish gray; white	Figure 11(C), Figure 12(C)
h	Ac100 224-1LL1	S22E3	Flake	Volcanic tuff	5YR 6/1; N5	light brownish gray; medium gray	Figure 11(D), Figure 12(D)
h	Ac100 163-VII-L1-H	S19E5	Flake	Basalt	N3; N1	Dark gray; black	Figure 11(E), Figure 12(E)
h	Ac100 214-2nn	S15E8-9	Knife	Chert	5GY 8/1; 5Y 8/1	Light greenish gray; yellowish gray.	Figure 11(F), Figure 12(F)
h	Ac100 221-?d	S18E4	Flake	Basalt	N2	Grayish black	Figure 11(G), Figure 12(G)
h	Ac100 231-VII-nn	S18E5.50	Shatter	Chert	10YR 4/2	Dark yellowish brown	Figure 11(H), Figure 12(H)
h	Ac100 226-4dd	S22E9	Shatter	Quartz	5Y 8/1; 10YR 4/2	Yellowish gray; dark yellowish brown	Figure 11(I), Figure 12(I)
h	Ac100 264-II-nn	S20E1	Shatter	Chert	5YR 6/1; N5	light brownish gray; medium gray	Figure 11(J), Figure 12(J)
h	Ac100 161-VIII-dH1	S21, 22E5	Flake	Volcanic tuff	5RP 4/2	Grayish red purple	Figure 11(K), Figure 12(K)
h	Ac100 281-III-nn1	S25, 26E7	Core	Quartz	5Y 8/1; N9	Yellowish gray; white	Figure 11(L), Figure 12(L)
h	Ac100 266-II-dd8	S20E6	Shatter	Volcanic tuff	N5	Medium gray	Figure 11(M), Figure 12(M)
h	Ac100 165-VIII LH	S19E4	Flake	Volcanic tuff	5Y 8/1, N1	Yellowish gray, black	Figure 11(N), Figure 12(N)
h	Ac100 257-h	S19E7	Core	Volcanic tuff	10YR 8/6; 10YR 7/4	Pale yellowish ornge; Grayish orange	Figure 11(O), Figure 12(O)
h	Ac100 153-IIe4	S23E7	Flake	Volcanic tuff	5B 7/1	Light bluish gray	Figure 11(P), Figure 12(P)

Continued

h	Ac100 272-I-e1	S22E1	Denticulate	Volcanic tuff	5Y 4/1	olive gray	Figure 11(Q), Figure 12(Q)
h1	Ac100 231-VII ee	S18E5.50	Flake	Volcanic tuff	5Y 4/1	Olive gray	Figure 14(A), Figure 15(A)
h1	Ac100 231-7d4 ss10	S18E5.50	knife	Volcanic tuff	5YR 5/2	Pale brown	Figure 14(B), Figure 15(B)
h1	Ac100 276-III-ss//17	S24E6	scraper	Quartz	N9	White	Figure 14(C), Figure 15(C)
h1	Ac100 152-?-1	S21E6	Shatter	chert	10YR 7/4; 5Y 4/4	Grayish orange; Moderate olive brown	Figure 14(D), Figure 15(D)
h1	Ac100 303-IIIs1	S16E4	Denticulate abrupt	Chert	10YR 7/4; 5Y 4/4	Grayish orange; Moderate olive brown	Figure 14(E), Figure 15(E)
h1	Ac100 257-III-d2	S19E9	Flake with marginal retouch	Quartz	5Y 8/1	Yellowish gray	Figure 14(F), Figure 15(F)
h1	Ac100 210-I-1nn	S21E4	Core	Volcanic tuff	10YR 8/6; 10YR 7/4	Pale yellowish orange; Grayish orange	Figure 14(G), Figure 15(G)
h1	Ac100 217-7-III	S17E6-5-5-4	Ecofact	Quartz	N8	Very light gray	Figure 14(H), Figure 15(H)
h1	Ac100 231-VIII-L	S18E5.50	Ecofact	Basalt	N1; N5	Blanck; meddium gray	Figure 14(I), Figure 15(I)
h1	Ac100 217-6-d3	S17E6-5-5-4	Perforator	Volcanic tuff	5Y 8/1; 5YR 6/1	Yellowish gray; Light brownish gray	Figure 14(J), Figure 15(J)
h1	Ac100 161-VII-H1	S21-22E5	Shatter	Quartz	N9	White	Figure 14(K), Figure 15(K)
h1	Ac100 276-III-dd	S24E6	Flake	Chert	10YR 7/4; 5Y 4/4	Grayish orange; Moderate olive brown	Figure 14(L), Figure 15(L)
h1	Ac100 152-?dd	S21E6	Flake	Chert	10YR 7/4; 5Y 4/4	Grayish orange; Moderate olive brown	Figure 14(M), Figure 15(M)
h1	Ac100 276-III-ss	S24E6	Denticulate	Quartzite	10YR 2/2	Dusky yellowish brown	Figure 14(N), Figure 15(N)
h1	Ac100 228-II dd1	S23E2	Scraper	Chert	10Y 8/2, 10Y 6/2	Pale greenish yellow; Pale olive	Figure 14(O), Figure 15(O)
h1	Ac100 221-?d/SS53	S18E4	Denticulate abrupt	Quartz	10YR 7/4, 5Y 4/4	Grayish orange; Moderate olive brown	Figure 14(P), Figure 15(P)
i1	Ac100 218-7-f3	S21E8	Core	Quartzite	10YR 2/2	Dusky yellowish brown	Figure 14(Q), Figure 15(Q)

Table 4. List of lithic materials reported in this paper. Abbreviations: *Mohs scale. R: Regular, B: Bad, G: Good, E: Excellent. +: Typology code according **Table 1**. PF: Percussion flaking, PrF: Pressure flaking, BR: Bifacial reduction.

Variety of Lithic Materials	Rock	Origin	Hardness*	Range	Typology	Strategies and techniques	Figures in the main paper
Sedimentary	Quartz sandstone	local	3	R	A.2	PF, PrF	Figure 10: (B-B')
Metamorphic	Quartzite	local	7	R - B	A.3; D.2	PF	Figure 14: (N, Q), Figure 15: (N, Q)
	Diabase	local	6	R - B	D.1	PF	-
Igneous volcanic	Basalt	local	4.8 - 6.5	R - G	A.6; C.1; D.1; D.2	PF, PrF, BR	Figure 10: (K-K'), Figure 11: (E, G), Figure 12: (E, G), Figure 14 (I), Figure 15: (I)

Continued

	Volcanic tuff	local	7	R - G	A.1; A.2; A.3; A.4; A.5; A.6; B.1; C.1; D.1; D.2	PF, PrF	Figure 9: (C). Figure 10: (C-C', G-G', I-I', J-J', L-L', P-P'), Figure 11: (B, D, K, M, N, O, P, Q), Figure 12: (B, D, K, M, N, O, P, Q), Figure 14 (A, B, G, J), Figure 15: (A, B, G, J)
	Quartz	local	7	G - E	A.1; A.5; A.3; C.1; D.1; D.2	PF, PrF	Figure 9: (A), Figure 10: (F-F', M-M'), Figure 11: (A, C, I, L), Figure 12: (A, C, I, L), Figure 14: (C, F, H, K, P), Figure 15: (C, F, H, K, P)
Minerals	Chert	local	7	G - E	A.1; A.2; A.3; A.5; D.1	PF, PrF	Figure 9: (B, D), Figure 10: (D-D', E-E', N-N'), Figure 11: (F, H, J), Figure 12: (F, H, J). Figure 14: (D, E, L, M, O), Figure 15: (D, E, L, M, O).
	Jasper	local	6.5 - 7	G - E	A.1; A.4	PF, PrF	Figure 10: (A-A', O-O')
	Obsidian	not determined	5 - 7	G - E	A.5	PF, PrF	Figure 10: (H-H')

Table 5. Average measurements by artifacts classes. Q: Total quantity; L: Length; W: Width, T: Thickness (mm); We: Weight (gr); *lithic cast.

Artifacts' classes	Layers														
	h					*h1*					*i1*				
	Q	L	W	T	We	Q	L	W	T	We	Q	L	W	T	We
A.1. Flakes with marginal retouch	11	41.25	37.37	19	28.27	1	16	25	8	3.27	-	-	-	-	-
A.2. Knife	3	24	23.66	12.66	13.21	1	36	33	21	10.11	-	-	-	-	-
A.3. Denticulate	5	59.2	47.8	28.4	128.52	3	50	42	22	44.82	-	-	-	-	-
A.4. Perforator	1	53	51	17	*	1	51	51	13	20.88	-	-	-	-	-
A.5. End-Scraper	3	33.6	31	12	13.91	2	46.5	37	23	37	-	-	-	-	-
A.6. Chopper	2	70.5	63.5	34.5	153.48	-	-	-	-	-	-	-	-	-	-
B.1. Early bifacial stage and preform	2	58	36	13.5	28.37	-	-	-	-	-	-	-	-	-	-
C.1. Manuports and ecofacts	-	-	-	-	-	3	50.33	58	24.6	133.8	-	-	-	-	-
D.1. Flakes and shatters	16	40.13	36.2	14.6	27.06	5	28	28	10	18.58	-	-	-	-	-
D.2. Cores	5	64.8	57.6	36.8	216.19	2	46.5	42.5	29.5	67.94	1	57	74	50	219.48

Table 6. List of Chunks and geofacts from layers from layers *i*, *i1*, *j* and *K*. Dates of their origins of the exacavations. Definitions give by MacNeish according to the types numbers MacNeish (1979), MacNeish et al. (1980), Munsell (2009) colors and figures references of this research.

Layer	Label	Type	Square	Definition by MacNeish	Raw Material	Munsel Color	Color description	Figures in the main paper
i	Ac100 257-IV-3	SS50	S19E7	Tufa slab spokeshaves	Volcanic tuff	5Y 4/1	Gray olive	Figure 16(A)
i	Ac100 359-IV-n1	-	S19E10	-	Volcanic tuff	5B 7/1	Light bluish gray	Figure 16(B)
i	Ac100 267-III-d1	-	S20E7	-	Volcanic tuff	5Y 4/1; 10R 6/2	Gray olive; Pale red	Figure 16(C)
i	Ac100 162-VIII	SS58	-	Ayacucho Burin	Volcanic tuff	5G 4/1	Dark greenish gray	Figure 16(D)
i	Ac100	SS52	-	Large denticulate	Volcanic tuff	5Y 6/1	Light olive gray	Figure 16(F)

Continued

i1	Ac100 340-?-3	SS53	S22E10	Large denticulate	Volcanic tuff	5Y 6/1	Light olive gray	Figure 16(E)
j	Ac100 226-VII-f1	B20	S22E9	Hammer core chopper	Volcanic tuff	5Y 4/1	Gray olive	Figure 16(G)
j	Ac100 152-VII S1	B21	S21E6	Tufa flake chopper	Volcanic tuff	5Y 6/1	Light olive gray	Figure 16(H)
j	Ac100 226-VI-dd3	B21	S22E9	Tufa flake chopper	Volcanic tuff	5Y 6/1	Light olive gray	Figure 16(I)
j	Ac100 258-14 d1	B21	S19E8	Tufa flake chopper	Volcanic tuff	5Y 6/1	Light olive gray	Figure 16(J)
k	Ac100 267-VIII-K	SS50	S20E7	Tufa slab spokeshaves	Volcanic tuff	5G 6/1	Greenish gray	Figure 16(K)
k	Ac100 267-VIII-d1	SS50	S20E7	Tufa slab spokeshaves	Volcanic tuff	5YR 6/1; 5Y 6/1	Light brownish gray; Light olive gray	Figure 16(L)
k	Ac100 223-VIII-d4	SS55	S21E9	Pebble side scraper	Volcanic tuff	5B 5/1	Medium bluish gray	Figure 16(M)
k	Ac100 154-?-f6	SS53	S21E5	Large denticulate	Volcanic tuff	5B 7/1	Light bluish gray	Figure 16(N)

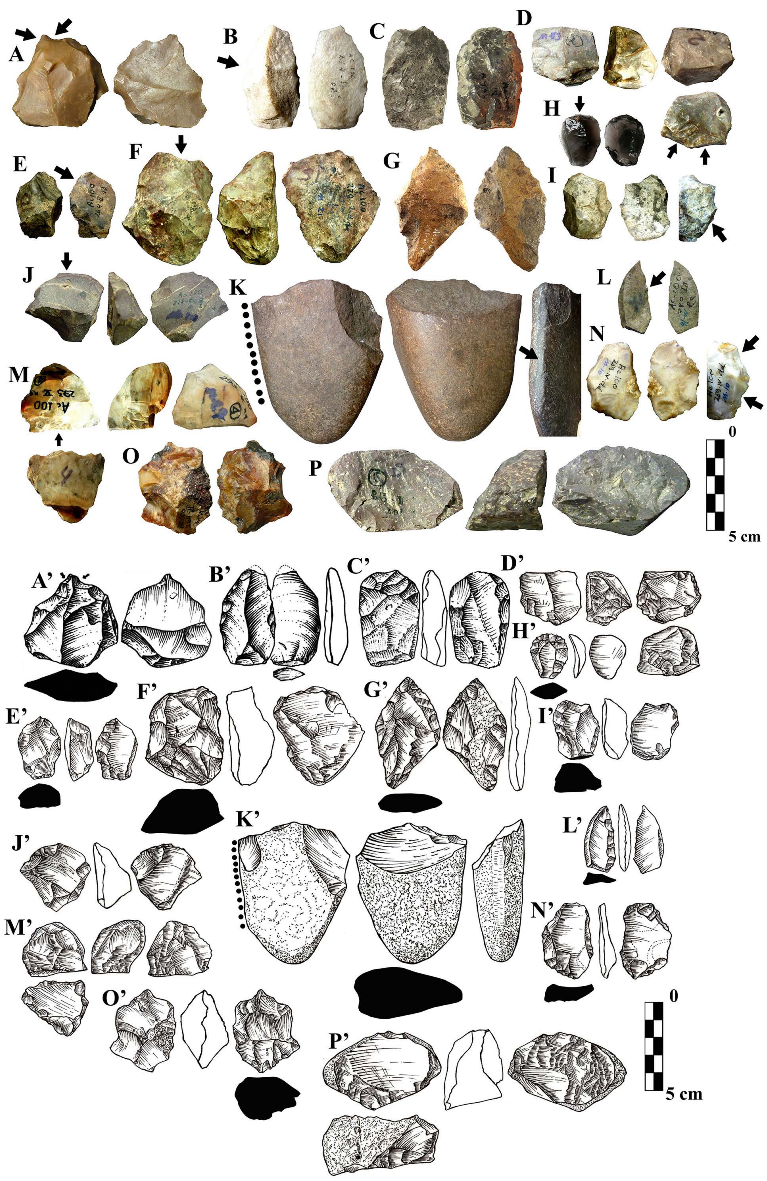


Figure 10. Photographs and drawings of selected stone tools from layer *h*.

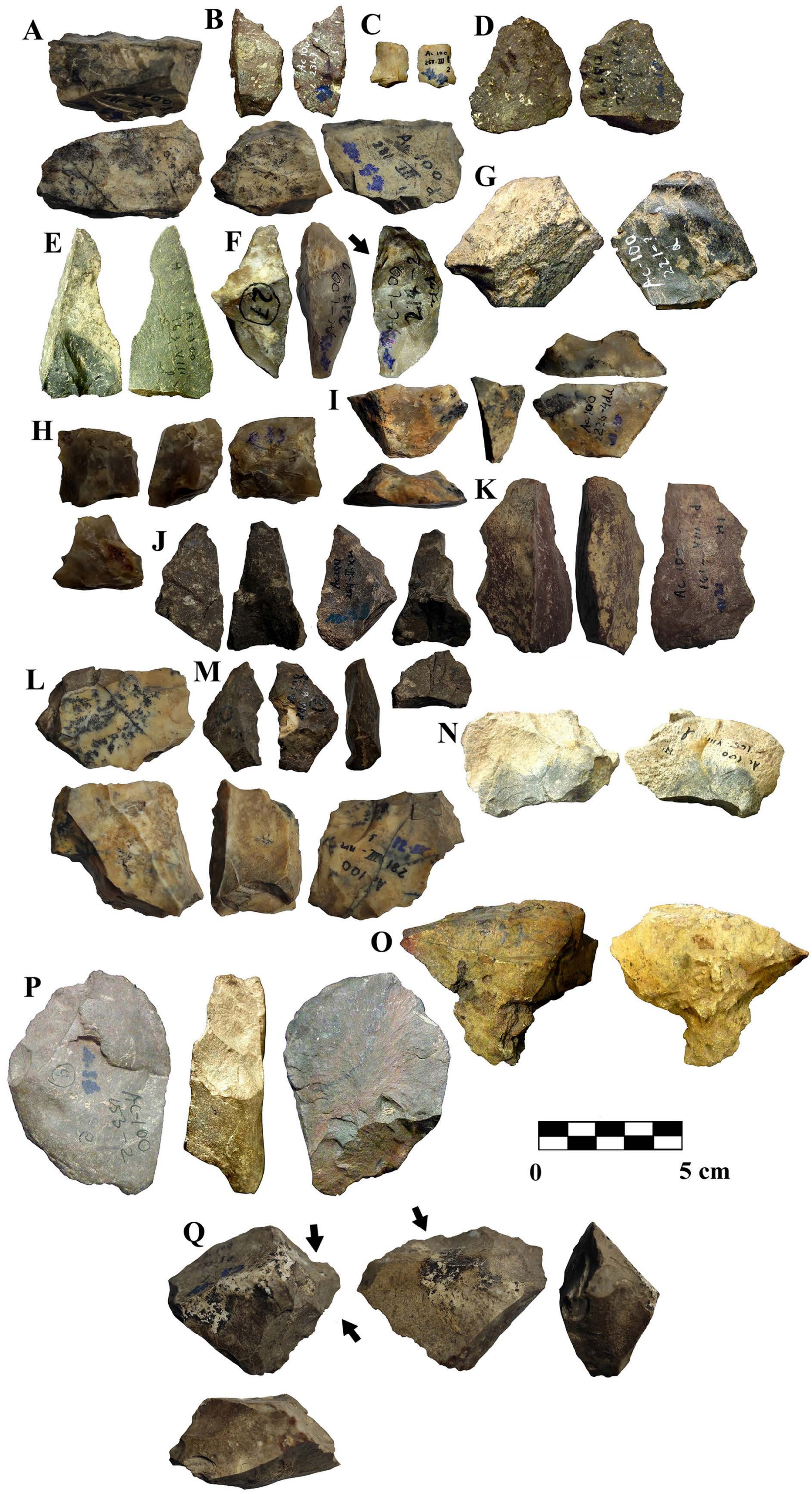


Figure 11. Photographs of the lithic artifacts from layer *h*. (A-Q). Stone tools housed at MAA-UNMSM.

Following is a summary of the individual analysis and observations of the most significant examples considering their location in the stratigraphic sequence. The raw materials used in making the flaked artifacts were identified by

Figure 12. Selected unifacial tools and flaking waste from layer *h*.

macroscopic petrographic analysis by the geologist Carlos Toledo, with the result a diverse selection of materials from sedimentary, metamorphic, and igneous rocks (Yataco Capcha, 2011; Yataco Capcha, 2020). The colors varied; in some cases, identified according to the Munsell (2009) geological rock-color chart, and its code is given in parenthesis (Yataco Capcha, 2020). The most used raw materials in the *h* and *h1* layers were volcanic rocks, mainly tuff (n = 25), basalt (n = 5), and minerals like quartz (n = 13), chert (n = 13) (**Figure 13(C)**, **Figure 13(D)**). From the layer *h*, made on basalt with a black coloration, were detected two waste flakes (**Figure 11(E)**, **Figure 11(G)**, **Figure 12(E)**, **Figure 12(G)**), one debris of pebble (**Figures 10(P)-(P')**), and a chopper (**Figures 10(K)-(K')**). Interestingly, the latter specimen has a strongly rounded and ground edge visible

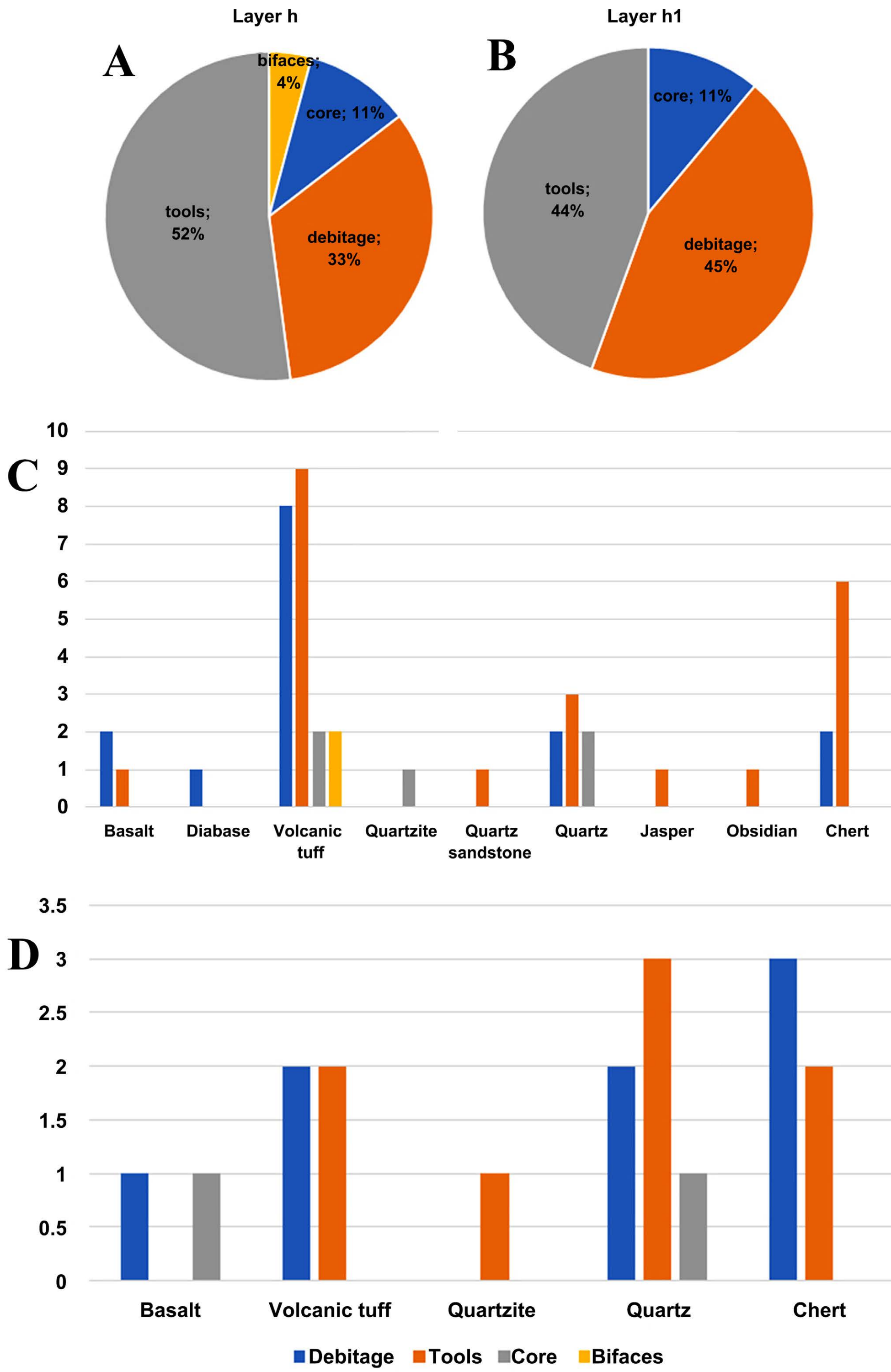


Figure 13. Frequency of lithic artifacts by percentages (A-B), and the raw materials from layers *h* (C) and *h1* (D).

to a naked eye (**Figures 10(K)-(K')**). Remarkable are nine shaped tools, among which are two made on flake-blanks of volcanic rock (**Figure 11(K)**, **Figure 12(K)**) and (**Figure 11(P)**, **Figure 12(P)**). Two multipurpose tools (Jodry, 1999;

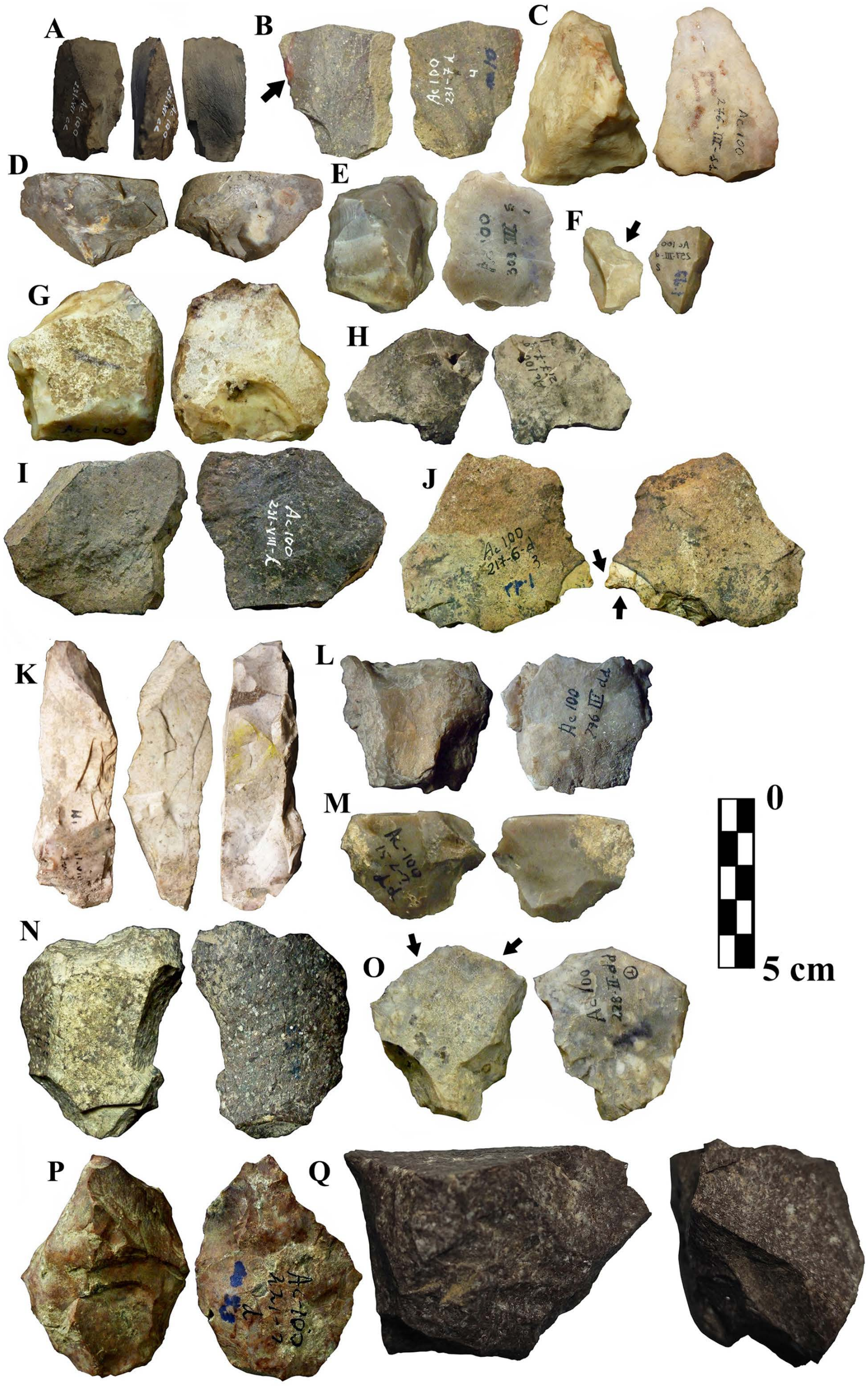


Figure 14. Flaked artifacts from *h1* (A-P) and *i* (Q).

Nami, 2019), probably used as knives or side-scrapers are illustrated in Figures 10(B)-(B'), Figures 10(L)-(L'); also, a denticulate tool with abrupt retouch (Figure 11(Q), Figure 12(Q)). The former is striking, showing a lateral edge with an angle varying between 50˚ - 70˚; also, one of these is manufactured on a laminar flake of gray-yellow (5Y 8/4) quartz sandstone (Figures 10(B)-(B')). Among the cores (n = 5) (see Table 3, Table 5), some deserve a comment. The

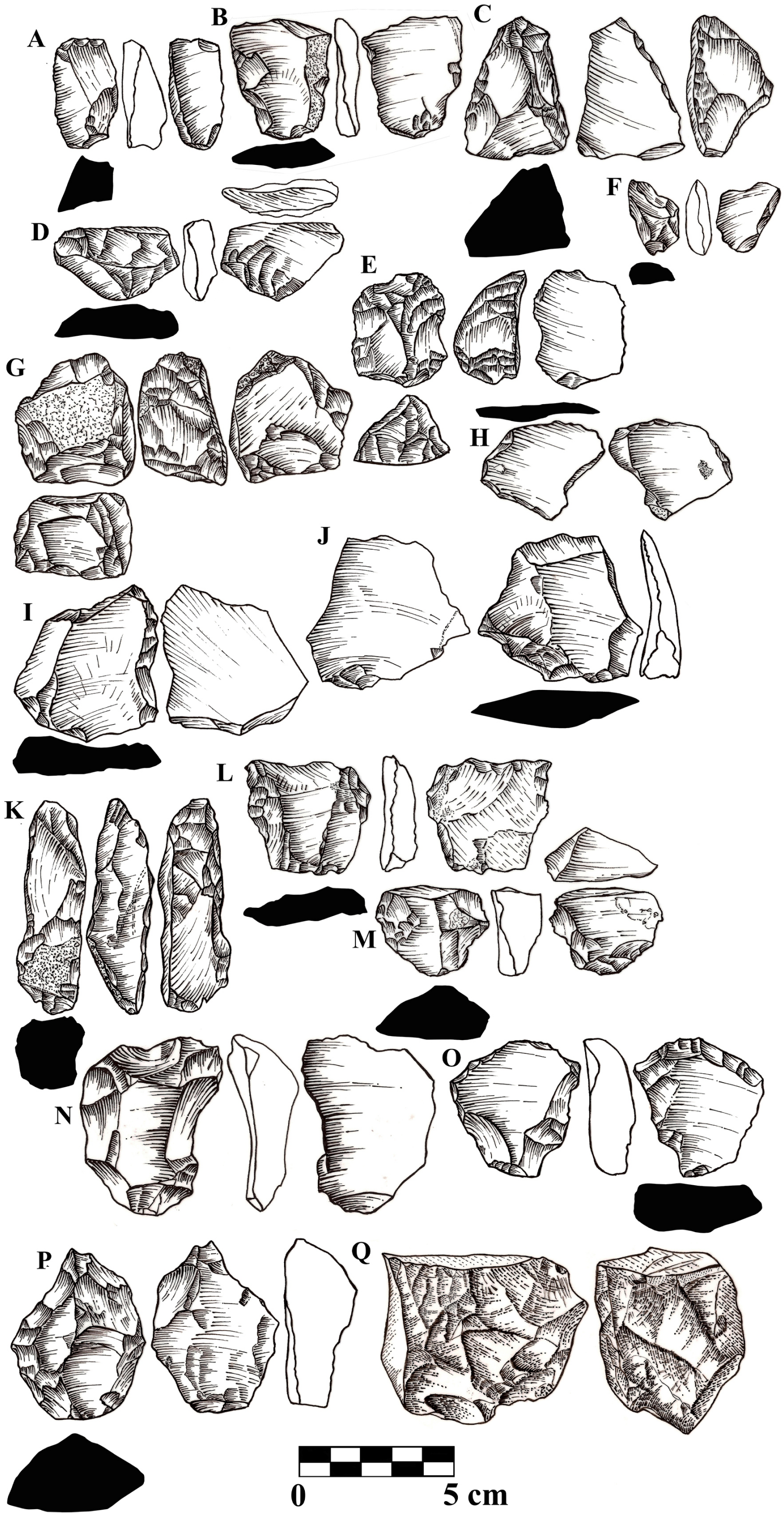


Figure 15. Detailed drawings of the flaked pieces from *h1* (A-P) and *i1* (Q).

pieces depicted in **Figure 11(L)**, **Figure 12(L)** was flaked on a grayish-yellow (5Y 8/4) dacitic metavolcanic material; others are flake fragments (**Figure 11(J)**, **Figure 11(I)**, **Figure 12(J)**, **Figure 12(I)**), a knife (**Figure 11(F)**, **Figure 12(F)**),

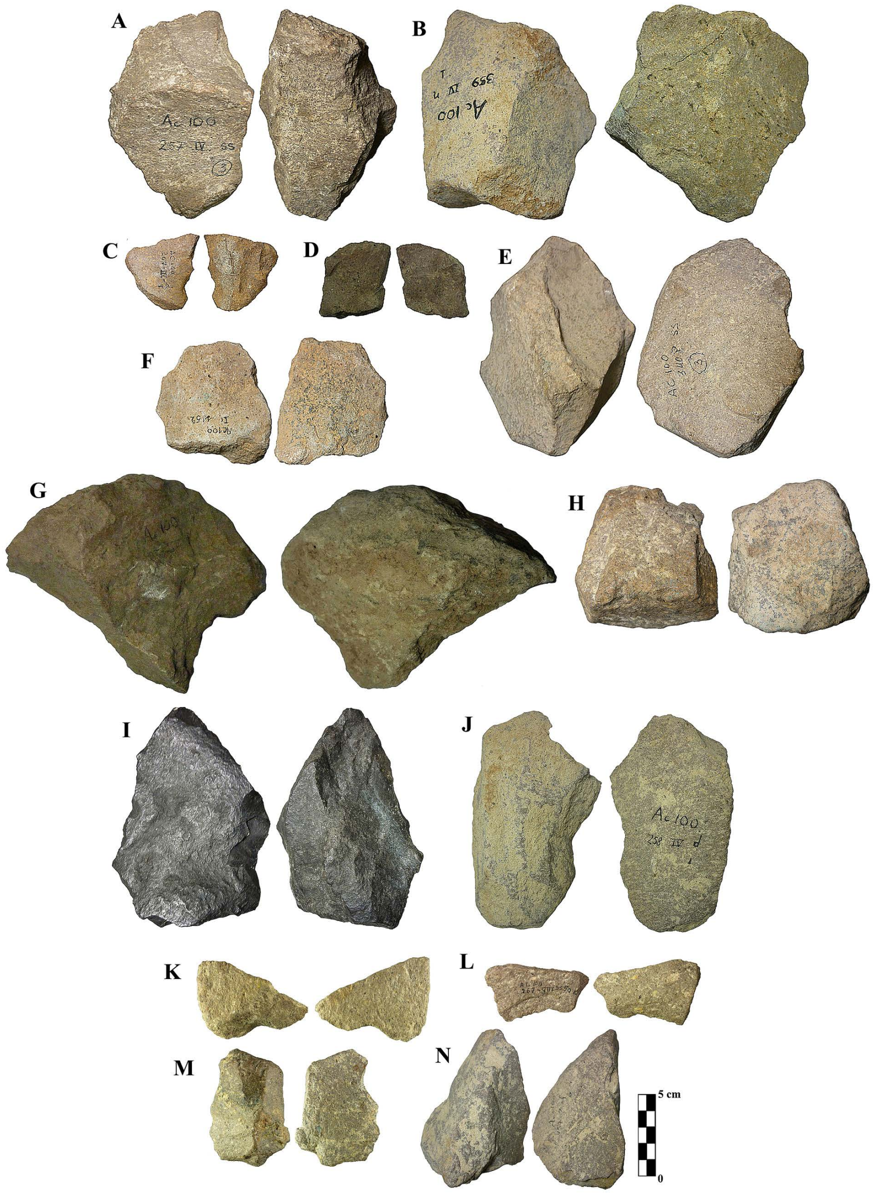


Figure 16. Chunks and geofacts from layers *i* (A-D, F); *i1* (E); *j* (G-J) and *k* (K-N).

and shatter (**Figure 11(H)**, **Figure 12(H)**) are made of chert. Interesting is a bifacial core made on a moderate reddish-brown (10R 4/6) marbled quartz with silica inclusions (**Figures 10(O)-(O')**), also in the same raw material is (**Figure 11(A)**, **Figure 12(A)**). All the described specimens seem exhausted, and two show a non-patterned distribution in removal of flakes. The one chipped on dacitic metavolcanic shows some parallel ridges (**Figure 11(L)**, **Figure 12(L)**), suggesting the possible detaching of laminar-flakes. Besides, the marked concavities in the mouth of the flake-scars and the flake shapes indicate that they were flaked by direct hard percussion. We also examined seven tools, including a scraper that stands out by its shape (**Figures 10(N)-(N')**), two modified flakes (**Figures 10(E)-(E')**, **Figures 10(F)-(F')**), and three denticulate tools (**Figures 10(D)-(D')**, **Figures 10(M)-(M')**, **Figures 10(I)-(I')**); and finally, a perforator (**Figures 10(A)-**

(A')). Remarkable is an end-scraper with an edge of 45˚ - 50˚ manufactured on a small tertiary angular flake of smoky black obsidian (Figure 10(H)-(H')). This example is significant because it shows the early presence of obsidian use in Ayacucho. What is more, another scraper on volcanic tuff is from the same context (Figures 10(J)-(J')).

Two partially flaked bifaces respectively (Figures 10(C)-(C'), Figures 10(G)-(G')) was flaked on a moderate yellow-green (5G 5/2) andesitic volcanic tuff rock with microfractures filled with milky quartz. It also exhibited some fissures and a non-regular conchoidal fracture. The latter, illustrated in the Figures 10(C)-(C'), Figures 10(G)-(G'), shows a diagonal -possibly a perverse fracture as defined by Crabtree (1972)—and one of its faces retains ~35% - 40% cortex of the blank used. By virtue of the flake-scars, they were likely chipped by direct hard-percussion flaking (Callahan, 1979; Nami, 1986, 2017) on a very pale orange (10YR 8/2) micro porphyritic volcanic tuff. As experimentally demonstrated, due to the raw material flaws and the fracture patterns, both were possibly rejected during the reduction process (Callahan, 1979; Nami, 1986, 1988, 2017; among others).

Most debitage consists of secondary and tertiary flakes of different materials (n = 14). Only two are primary flakes on basalt (Figure 10(G), Figure 12(G)), and three pieces of shatter on volcanic tuff (Figures 10(P)-(P'); Figure 11(B), Figure 11(M), Figure 11(O), Figure 12(B), Figure 12(M), Figure 12(O)). Also in at least six of these pieces, the cortex suggests that they were removed from pebbles of volcanic rocks, and result from initial stages of reduction chipped with hard percussion flaking (Figure 9(C), Figure 11(B), Figure 11(D), Figure 11(E), Figure 11(G), Figure 11(P), Figure 12(B), Figure 12(D), Figure 12(E), Figure 12(G), Figure 12(P). Due to its morphology, we suspect that only one thin flake was obtained using soft percussion (Figure 11(C), Figure 12(C)) (Callahan, 1979; Nami, 2017; Whittaker et al., 1998). Languette and Siret fractures in at least two flakes are due to detaching defects (Figure 11(P), Figure 12(P)) (Lenoir, 1975). This waste may indicate that on certain occasions the flaking of volcanic tuff, flint-like material, diabase, and basalt may have been carried out inside the cave. Very interesting also is the wide flake (Figure 11(N), Figure 12(N)) that displays in the proximal portion of its ventral face moderately deep flake-scars, likely made to eliminate the bulb of percussion. Finally, notable is a flake of chert with probable signs of wear on its distal edge (Figure 9(D)).

As show in Figure 13(A), a significant frequency of the sample is waste (44%), including cores (11%) and debitage (33%). This evidence of the first stages of stone tool production (Ericson & Purdy, 1984), implies that this part of the process was performed inside the site, as suggested by several archaeological, experimental, and ethno-archaeological investigations (Binford, 1986; Callahan, 1979; Toth et al., 1992). The most used materials were basalt, diabase, volcanic tuff, and granodiorite, followed by quartzite; also, sandstone, quartz, jasper, flint-like materials, and obsidian were used to a lesser extent (Figure 13(C)).

Concerning availability, we identified both primary and secondary sources as defined by Luedtke (1979). According to its frequency (52%, **Figure 13(A)**), the second most utilized rocks were colorful flint-like materials; apparently these were favorites for making tools. Their sources may have been local; in our surveys, a small outcrop of similar material was found on the slopes of the Molinoyoq volcano at ~300 meters from Pikimachay. However, it is worth considering that during several millennia the regional landscape was strongly modified by agricultural and harvesting activities, hence some sources may have disappeared. The analysis showed an intense use of volcanic rocks mainly made up of silicified tuff (n = 21), and to a lesser frequency basalt (n =3), and diabase (n =1) (**Figure 13(C)**). These rocks can still be found in the secondary sources existing nearby the cave, or in intermediate areas of the Cachi River, considering the wide distribution of volcanic material from at least three volcanoes in the surroundings of Molinoyoq (Yataco Capcha et al., 2021). The main obsidian quarries in the Ayacucho region are Quispisisa and Puzolana (Burger et al., 2000a, 2000b; Giesso et al., 2020; Matsumoto et al., 2018). On Marcahuilca Hill where Pikimachay Cave is located, we detected the presence of small nodules (~3 - 4 cm) of Puzolana obsidian (Giesso et al., 2020: Fig. 3a, 4d). We have no evidence to determine whether this resource was procured by direct exploitation, by exchange with other groups, or both.

Finally, despite the fact that no systematic functional analyses were made, it is worth mentioning that some pieces observed with a binocular microscope showed semi-lunar micro-flakes visible at 10× to 50×. Being aware that several causes may produce diverse micro-flakes on the edge of lithic implements (**Figures 10(L)-(L')**, **Figures 10(N)-(N')**), it is interesting to point out that similar damage on an edge might have been due to sawing and cutting (Tringham et al., 1974; Odell & Odell-Vereecken, 1980; Stemp et al., 2016: Fig. 1). Similarly, the strongly rounded and ground edge parallel observable on the chopping tool's edge (dotted line in **Figures 10(K)-(K')**) might have resulted from its use with abrasive particles (Brink, 1978a, 1978b; Hayden, 1979a).

From *h1*, the study of MacNeish's field-notes at the RSPIA allowed us to add two pieces to the previously examined materials identified as anthropogenic (Yataco Capcha, 2011: p. 260), resulting in a total of 18 pieces. Because these finds were the subject of controversy (Dillehay, 1985; Lynch, 1983; Rick, 1988) and never reviewed in detail, we provide their precise origin and descriptions. Five pieces of chipping waste were made on volcanic rocks (**Figure 14(A)**, **Figure 14(D)**, **Figure 14(K)**, **Figure 14(L)**, **Figure 14(M)**, **Figure 15(A)**, **Figure 15(D)**, **Figure 15(K)**, **Figure 15(L)**, **Figure 15(M)**. The shaped artifacts are tools (n = 8) and cores (n = 2); most are depicted in **Figure 14** and **Figure 15**. Two scrapers (**Figure 14(C)**, **Figure 14(O)**, **Figure 15(C)**, **Figure 15(O)**), made on bluish flint-like material and white-toned quartz, present edge angles ranging from 60˚ to 80˚. The silhouette of these pieces fluctuates between rectangular and triangular, their lateral shapes are convex and triangular concave, and their section ranges between triangular and trapezoidal. On the distal edge of one of these (Figure 14(O), Figure 15(O)), and the perimeter of the other (Figure 14(C), Figure 15(C)), the retouches are short, showing an irregular parallel form with abrupt angle and continuous distribution. As shown in Figure 14 and Figure 15 among the shaped specimens manufactured on secondary flakes, there are three denticulate tools on chocolate colored flint (Figure 14(E), Figure 15(E)), in marbled quartz (Figure 14(P), Figure 15(P)), and one (Figure 14(N), Figure 15(N)) in quartzite, presenting convex-concave delineation, with a continuous retouch of abrupt to semi-abrupt inclination, short extension, and sometimes located in the perimeter. Two of these pieces were previously reported (MacNeish, 1979: Fig. 22: 5, 6; MacNeish et al., 1980: p. 193). A notable core (Figure 14(G), Figure 15(G)) deserve attention. The former, made on marbled volcanic tuff, is probably exhausted. Displaying a trapezoidal shape, it still has about 50% cortex with facets, suggesting that the flint-knapper selected an angular rock as a nodule. Also, from layer *h1*, MacNeish's files helped us identify three waste flakes with possible soot stains, soot or exposure to fire, one of which is one clearly cracked as shown in Figure 14(A), Figure 14(H), Figure 15(A), Figure 15(H) (cf. Purdy, 1975).

Technological remarks can be made regarding the reduction sequence based on some of the artifacts described above (Tostevin, 2011). When recognized, the blanks for manufacturing the unifacial tools illustrated in Figure 14(A), Figure 14(B), Figure 14(D), Figures 14(G)-(J), Figure 14(L), Figure 14(M), Figure 15(A), Figure 15(B), Figure 15(D), Figures 15(G)-(J), Figure 15(L), and Figure 15(M), were pebbles, as well as primary, secondary, and tertiary flakes. In several flake-blanks, the cortex of the nodule remains on the dorsal face, suggesting that they were detached from pebbles (Figure 14(G), Figure 14(K), Figure 15(G), Figure 15(K)) and sometimes nodules with angular surfaces (Figure 14(G), Figure 15(G)); and due to the materials' characteristics, probably employing hard hammer percussion flaking (Callahan, 1979, 2016; Nami, 1986, 2000, 2015; among others). Also, on several ventral faces of some large flake-blanks—when present—the cones of force are flat or diffuse (Figure 14(D), Figure 14(E), Figure 14(M), Figure 14(O), Figure 15(D), Figure 15(E), Figure 15(M), Figure 15(O)). Flaking experiments on similar South American materials showed that this sort of attribute results from the use of hard hammer-stones (Nami, 2015). Due to the features observed on the dorsal faces, the percussion was randomly applied to different kinds of cores, including the bifacial and amorphous cores observed in the collection (Figure 14(G), Figure 14(K), Figure 15(G), Figure 15(K)). The percussion was applied on unmodified or previously flaked surfaces, which can be observed in the flakes as natural, plain, and dihedral butts of striking platforms (Figure 14(B), Figure 14(F), Figure 15(B), Figure 15(F)). Based on the extensive replication investigations on stone tool manufacture, we infer that the unifacial tools were easily made on the previously described blanks. It is highly probable that after the blank was obtained, the final shaping was performed by simply retouching its edges using the same technique, but with another variant and/or holding position (Young & Bonnichsen, 1984), and using hard, soft, or semi-soft hammer-stones (e.g. Nami & Civalero, 2017; Civalero & Nami, 2020). In some circumstances (**Figure 14(C)**, **Figure 14(E)**, **Figure 14(F)**, **Figures 14(N)-(P)**, **Figure 15(C)**, **Figure 15(E)**, **Figure 15(F)**, **Figures 15(N)-(P)**, the tool edges were possibly shaped by pressure flaking or by percussion with a soft implement, probably of organic nature, with high-density osseous tissue; like deer antler (Nami & Elkin, 1994). The retouch forms vary from short parallel (**Figure 14(C)**, **Figure 14(E)**, **Figure 14(M)**, **Figure 15(C)**, **Figure 15(E)**, **Figure 15(M)**) to scaliform (**Figure 14(H)**, **Figure 14(I)**, **Figure 14(P)**, **Figure 15(H)**, **Figure 15(I)**, **Figure 15(P)**), and when the dorsal and ventral faces are visible, most retouches are direct (**Figure 14(B)**, **Figure 14(C)**, **Figure 14(E)**, **Figure 14(H)**, **Figure 14(P)**; **Figure 15(B)**, **Figure 15(C)**, **Figure 15(E)**, **Figure 15(H)**, **Figure 15(P)**), and inverse in a few cases (**Figure 14(D)**, **Figure 14(M)**, **Figure 14(O)** and **Figure 15(D)**, **Figure 15(M)**, **Figure 15(O)**).

In layer *i*, the excavators reported three supposed activity areas containing bones, burned sectors, and lithic artifacts (MacNeish, 1979: pp. 27-29; MacNeish et al., 1983: pp. 141-143). To determine their possible human modification, each piece was reviewed with special care and detail. The scrutinized specimens were analyzed as shown in the **Table 6** (**Figures 16(A)-(D)**, **Figure 16(F)**). Finally, one were reported as "Ayacucho burin" (**Figure 16(D)**; MacNeish, 1979: p. 42, Fig. 21.5). They were carefully checked for striking platforms and impact points on their edges. Despite difficulties in determining the cause of fracture, we concluded that they were chunks of tuff coming from the rocks that fell down the cave's walls and roof, without intentional modification. Some present a few natural fractures on the edges (**Figures 16(A)-(F)**), constituting naturefacts or geofacts (Preston, 2019). We considered them as those rocks that exhibit a series of apparently morpho-technological features whose origin is due to geological processes. In our case study, these specimens are chunks and flake-like pieces detached from the cave outcrop mechanically and chemically altered by natural agents that in some cases show apparent intentionally made continuous, non-continuous, or random flake-scars. Hence, we decided to reject them as anthropogenic, and therefore conclude that no evidence of human activity comes from this stratum.

From layer *i1* (**Table 6**), one is curated at the MAA-UNMSM and described as a core on quartzite with angular surfaces (**Figure 14(Q)**, **Figure 15(Q)**); it is an artifact showing flake detachments by hard hammer-stones. As has been previously discussed, it is highly possible that this core comes from the upper levels, and it is not evidence to argue human activity in this lower stratum (Yataco Capcha, 2011: p. 258). Other possible stone tool was reported by MacNeish as a "sheared side knive" (**Figure 16(E)**), after reviewing it we have concluded that it is a natural rock.

Four pieces from layer *j* curated at the MAA-UNMSM are as follows: a "tufa flake chopper" (**Figure 16(H)**; MacNeish et al., 1980: p. 102, Fig. 3-1); a "hammer core chopper" (**Figure 16(G)**; MacNeish, 1979: p. 42, Fig. 21:1; MacNeish et al., 1980: p. 105, Fig. 3-3; MacNeish et al., 1983: p. 139, Fig. 5-4); and two "tufa flake chopper" (**Figure 16(I)**, **Figure 16(J)**; MacNeish et al., 1980: p. 102, Fig. 3-1). Careful analysis verified that they do not present any evidence of human modification, with only naturally produced fractures (**Figures 16(G)-(J)** and **Table 6**). An additional specimen is in the MNAAHP collection, whose cast is depicted in **Figure 16(I)**. This small sample does not present any evidence of human action. The material on which they were supposedly made was coarse grain volcanic tuff coming from the cave's wall and ceiling.

Finally, four specimens excavated from layer *k* were identified and carefully analyzed (**Table 6**). They were cataloged as by MacNeish as "tufa slab spoke-shaves" (**Figure 16(K)**, **Figure 16(L)**), "pebble side scraper" (**Figure 16(M)**) and "large denticulated" (**Figure 16(N)**). Like the previous pieces, the macroscopic and microscopic observations confirm that they are rocks originating from the cave's structure. They do not present human modification, and appear to be naturally fractured pieces (**Figures 16(K)-(N)**).

3.4. Results and Interpretations

From the study, we conclude that the largest number of stone remains coming from layers *h* and *h1* are human-made. They are morpho-technologically similar, without showing significant differences, and characterized by simply unifacially trimmed tools, mostly notched, and denticulate. In general, they are modified flakes of medium and large size, and larger than those found in the overlying layers *g* and *h*. The archaeological record from the latter belongs to the human occupations living in Ayacucho during the early Holocene (MacNeish et al., 1980; Yataco Capcha, 2011; Yataco Capcha et al., 2021). The artifacts from layers *h* and *h1* were crafted with similar traditional techniques for making stone tools (see Nami, 2019, 2021). The presence of a few artifacts flaked on both faces also suggests knowledge of bifacial flaking. We suggest that because of their simplicity, minimum work, time, and energy was invested for manufacturing the pieces. It is notable that the lithic artifacts from *h* and *h1* were made on diverse rocks, possibly selected for their flaking properties, varying from good to excellent, and obtained and transported from sources located outside the cave. The obsidian and the flint-like materials have the best quality for flaking; despite having good properties for making tools, the remaining material are not the most favorable from the viewpoint of workability (Callahan, 1979; Nami, 2015).

Concerning the remains from layers *i* to *k*, we conclude that they are rocky chunks that fell down the cave's walls and roof, and in a few cases, are nature-facts or geofacts. An exception is a core found in *i1* possibly mistakenly attributed to that layer, or the result of vertical migration from the upper levels (e.g., Cahen et al., 1979; Domínguez-Solera, 2010; Gifford-Gonzalez et al., 1985; Villa, 1982).

4. Discussion

With the available material, we try to get the most out of the legacy collection for the study. The materials were reordered, classified, and contextualized according to the records of the MacNeish excavations archived in the Peabody Museum, a task never done before by anyone. At the Peabody Museum, we were able to obtain data to control and contextualize the studied sample. Additionally, we add fifteen lithic pieces of anthropic nature exhumed in layers *h* and *h1* that were not previously recorded (Yataco Capcha, 2011: pp. 247-271). We have also had the opportunity to carefully document, contextualize, and review bone remains coming from the lower levels of the cave (e.g. **Figure 8**; Nami et al., 2021). Hence, the studies exposed above both in the materials and documents preserved in San Marcos University (Lima-Peru) and the Peabody museums (Andover-Boston), allowed us to contextualize most finds whose spatial origin and distribution was unavailable in the excavations' reports. As stated above, several authors pointed out this shortcoming (Lynch, 1983: p. 93; Lynch, 1990a: p. 25; Dillehay, 1985: pp. 193-203; Rick, 1988). It was also possible to re-organize the materials out of order in the Peruvian institutions. Hence, the restudy of the existing records, photographs, bones and lithics of the standing sections is worthwhile, even in the absence of new, more reliable dates, as long as this material has not been published with detail elsewhere. In addition, however, highly significant and crucial questions arise and emerge from this study. They are related to several issues regarding the new standards of evaluating archaeological excavations and vestige analysis, particularly with these kinds of sites (Haynes, 2015; Borrero, 2016). Because they cannot be addressed from legacy materials, these topics deserve further effort. Hence, it is vital to perform new fieldwork mainly directed to check the origin of the artifacts; and deepening the site formation process considering the cultural and natural transformations. Also, to obtain additional samples to perform necessary studies allowing to cope with early archaeological sites (Haynes, 2015). Despite this, our research was worth re-evaluating the materials exhumed in the lower levels of Pikimachay and opening new windows for future research.

Based on the finds from layers *h* and *h1* and *i* to *k*, from a cultural-history perspective, MacNeish respectively defined the "Ayacucho" and "Pacaicasa" complexes. Both constructs supposedly witnessed a South American human presence older than Clovis in North America (MacNeish, 1969, 1979; MacNeish et al., 1980, 1981). Hence, since the late 1960s and early 1970s, Pikimachay has been controversial (Lynch, 1974, 1992). Most critiques pointed to the poorly reported data, which lacked careful analysis and documentation (Dillehay, 1985; Rick, 1988).

We are aware of the limitations of studying collections from old excavations. However, this sort of appraisal is useful for addressing the peopling of South America (e.g. Chichkoyan, 2019; Chichkoyan et al., 2017; Cornero & Neves, 2011; Cornero et al., 2014; Neves et al., 1999; Neves & Piló, 2008; Politis et al., 2011). In our case, MacNeish's field-notes curated at the Peabody Museum were detailed enough to evaluate and contextualize the scrutinized sample with a high degree of temporal and spatial confidence. Besides, considering the aforementioned geological context, the records from the lowest strata have both stratigraphic and chronological coherence. Hence, a certain degree of integrity. In this regard, the Pikimachay sedimentary fill showed large blocks falling from the cave's structure during the Pleistocene-Holocene transition and Early Holocene. These blocks are significant because they sealed the cave's lower strata. A similar phenomenon occurred in other caves with evidence of early human occupations in South America, such as Fell Cave, Cueva del Lago Sofía, Cueva del Medio, all in Patagonia (Bird, 1946, 1988; Nami, 1987, 2019; Prieto, 1991), and other places in the Andean cordillera, such as Gruta del Indio and Agua de la Cueva (García, 1998, 2003; Lagiglia, 1977). Based on radiocarbon dates, apparently, there were no significant stratigraphic unconformities allowing the mix of materials from different occupations (e.g. Feathers & Nami, 2018). The available radiocarbon information shows no chronological discontinuity in the lowest strata. Also, their quasi-lithified and/or cemented state acted as a matrix embedding the findings, protecting them from further perturbations.

Stone tools analysis and classification has certain inherent biases and ambiguities (Whittaker et al., 1998), especially in those contexts attributed to the oldest human occupations in the Americas (e.g. Meltzer, 2009; Fiedel, 2017, 2022). After the examination of the lithic remains from Pikimachay, however, we conclude that the examined samples from *h* and *h1* are human-made. Important lines of evidence include the many blanks that show multiple flake-scars and ridges on their dorsal faces, with clear evidence of having been detached from cores, unambiguous shaped tools, and the presence of bifacial flaking. Extremely important too is the evidence that the ancient knappers carefully selected raw material from various sources. The analyzed samples from both layers showed morpho-technological homogeneity, likely resulting from a series of re-occupations of the cave over a certain period. These occupations are not distinguishable from each other. Conversely, the lithics from *i* through *k* are the product of natural actions (Peacock, 1991; Raynal et al., 1995), mainly chunks coming from the cave's walls and roof. Most of these objects show no flaking, and only some may have apparent flake-scars. They are isolated, however, lacking attributes that could indicate their human origin; among them, distinct patterns or continuity in their distribution of flaking. Hence, we considered these pieces as geofacts or naturefacts. Based on our analysis, the lithic artifacts coming from *h* and *h1* may have witnessed the presence of humans that inhabited Pikimachay during the terminal Pleistocene. It is significant to point out that they are absolutely different in shape and technology that the artifacts from the Early to Late Holocene human occupations both found at Pikimachay and other places in the Ayacucho Basin (León & Yataco Capcha, 2008; Yataco Capcha & Nami, 2016; Yataco Capcha, 2011, 2020; Yataco Capcha et al., 2021). Then, we reject the idea that the true flaked objects might come due to vertical migration from the upper levels. On the other hand, the fractured stones coming from the underlying layers are simple chunks and naturefacts or geofacts. Hence they do not represent evidence for an earlier human occupation. Presently, the available radiocarbon data suggest that the record from *h* and *h1* has a Terminal Pleistocene age. At least in *h* and *h1*, we do not know if the dated materials had an unequivocal human origin. However, we can presume that the archaeological finds from both layers would have been produced between the occurrence of the rockfalls at about 10,000 to 14,000 years before the present. However, as is usual in early archaeological contexts (e.g. Dillehay et al., 2012a, 2012b, 2015, 2017; Nami, 2019; Politis et al., 2019), to establish a reliable and precise chronology it is crucial to obtain new dates from both layers utilizing modern dating methods, especially for this kind of site (Deviese et al., 2018). Then, considering our unsuccessful attempts to re-date the layer *h*, until new radiocarbon data is obtained, the aforementioned chronology must be taken as not definitive. Diverse kinds of radiometric or geochronological dating with new methodological perspectives are necessary to cope with this issue (e.g. Feathers et al., 2010; Politis et al., 2019; Feathers & Nami, 2018, Nami et al., 2020).

As seen above, in association with the stone remains were Late Pleistocene fossil bones. In many cases, their primary relationship in archaeological sites is uncertain. Osseous remains are subjected to a myriad of modifications (Lyman, 1994); mainly by predators and scavengers involved in the site formation process (Binford, 1983). Experimental research showed that under certain environmental conditions, death assemblages in the wild may disappear without a trace when predators can move freely and feed without disturbance. However, some bone fragments survive at archaeological sites because they were possibly unintentionally protected by human presence. Actually, on occasions, their treatment made them less attractive to predators (Wadley, 2020). Considering this premise and the taphonomic observations (Nami et al., 2021) only some bones from the Late Pleistocene levels of Pikimachay Cave, layer *h*, showed human modifications. This fact reinforces the results of the lithics analysis presented above.

The colonization and spread of human in the Americas has always been a major field of archaeological interest. For several reasons, one of the most controversial issues is the timing of the events and the reliability of the evidence (see Meltzer, 2013; Politis et al., 2019; Politis & Prates, 2018, 2019). Specifically, this occurred during the last millennia of the Pleistocene and its transition to the Holocene at 10,000 years before the present (Gibbard & Head, 2010; Head & Gibbard, 2015; Walker et al., 2018), and ultimately the Americas were entirely inhabited from the northern to the southern ends, suggesting that the colonization process was practically complete at that time (Graf, 2013; Lothrop et al., 2011; Nami, 2014, 2021). The archaeological record shows that there was cultural and adaptive diversity in terms of subsistence and technological pursuits (Dillehay, 2008a, 2008b, 2009; Meltzer, 2009; Nami, 2014, 2019; Politis et al., 2016; Politis & Prates, 2018). In that period, with a broad distribution all across non-glaciated North America up to northern Mexico, Clovis was the oldest fluted point manifestation (Bradley et al., 2010; Ellis 2013). Almost coeval in its origins, and probably beginning in eastern North America, the "fishtail" or Fell points had an extraordinary distribution from Mesoamerica to the southern tip of South America (see Nami, 2021, and references cited there). Archaeological records witnessing human occupations prior to Clovis have been controversial for a long time (Adovasio & Page, 2002), mainly due to the ambiguities that some of the claimed earliest sites presented, especially those dating ≥15,000 to 20,000 years before the present (Borrero, 2016; Haynes, 2015; Politis et al., 2019; Politis & Prates, 2019).

Notwithstanding the above, a notable fact is that across the Americas several reliable sites are yielding pre-Clovis records, both in North and South America (Davis et al., 2019, 2020; Waters et al., 2011a, 2011b, 2018; among others). In South America, several sites have yielded evidence of human occupations older than ≥11,000 to 10,000 years before the present, a timeframe with indubitable broadly dispersed hunter-gatherers in this sub-continent. The comparison of artifacts from each one of these alleged pre-Fell sites (e.g. Boëda et al., 2014, 2016; Bryan et al., 1978; Dillehay, 1997, 2000; Dillehay et al., 2015, 2017; Ochsenius & Gruhn, 1979; Parenti, 2001; Politis et al., 2016; Pino & Astorga, 2020; Vialou, 2005; among others) is beyond the scope of this paper. Nevertheless, in the central and southern Andes, various sites pre-date the occupations with Fell points. During the last decades, a growing number of findings suggest there were foragers living there at a similar time. Then, in this section, our comparisons are made with assemblages dated by reliable laboratories in the last few years. Recent investigations at Huaca Prieta in northern Peru revealed a simple stone technology and other remains associated with uncalibrated radiocarbon dates ranging between ~12,400 and ~13,000 years before the present (Dillehay et al., 2012a, 2012b, 2017: Table 1). Also, El Jobo like armature tips and a point with contracting stem were found at the Monte Verde and Chinchihuapi localities, south-central Chile. There, most radiocarbon assays showed a range of ~12,000 to ~13,200 years before the present; however, some reach ages up to ~19,000 years before the present (Dillehay et al., 2017: Table 1). Nearby these locales, the Pilauco and Los Notros sites yielded remains of similarly simple and expedient technology (Pino & Astorga, 2020), with a chronology ranging between ~13,500 to 14,600 years before the present (Navarro-Harris et al., 2019, 2020). These sites are important in the discussion of the early entry of humans into South America (Dillehay et al., 2021). The finds presented here showed that most lithic pieces attributed to the "Ayacucho complex" (strata *h* and *h1*) were simple and expediently knapped, while others suggest certain kinds of advanced knowledge for making stone tools. Beyond the nicely bifacial flaked projectile points found at Monte Verde II and the nearby Chinchihuapi locality (Dillehay, 1997; Dillehay et al., 2015), the remaining lithic assemblage shows very simple manufacture. The artifacts consisted of roughly made unifacial tools and flakes (Collins, 1997; Dillehay et al., 2015: Fig. 6), resembling some of the artifacts from Pikimachay. Also, there are remarkable similarities among the unifacial tools from *h* and *h1* with the edge-trimmed flake-tools from the basal levels of Huaca Prieta (Dillehay et al., 2012a: Fig. 4), Pilauco, and Los Notros (Navarro-Harris et al., 2020). Particularly, at Huaca Prieta there are notably morphological similarities with several pieces coming from layers *h-h1*. Among them the "spockeshaves" (Dillehay & Bonavia, 2017: Figure 11.2c, g) and "scrapers" (Dillehay & Bonavia, 2017: Figure 11.2. e-f). It is worth mentioning that a slight difference with some of the artifacts from those sites might result from the use of bipolar flaking due to the small size of the nodules. Based on experimental baselines (e.g. Flenniken, 1981; Nami, 2000), we suggest the use of this technique in this early period based on the presence of columnar fractures, flat ventral faces, the location of the cones in some cores, and the strongly marked concentric ripples or cracking marks (e.g. Dillehay et al., 2017: Fig. 5; Navarro-Harris et al., 2019: Fig. 4; Navarro-Harris, 2020: Figs. 16.20-23). Like Pikimachay, the presence of exotic materials indicates the exploitation of non-local resources, coincidently of volcanic origin (Dillehay et al., 2017; Navarro-Harris et al., 2020). It is worth mentioning that ethno-archaeological research has demonstrated that simple stone tools are highly useful for working an array of complex tools made on diverse materials such as wood, bone, or leather (White, 1968, 1979; Gould et al., 1971; Hayden, 1977, 1979b; among others).

5. Conclusion

Despite the small sample size, the lithics from Pikimachay were made using distinct stone working techniques (Nami, 1994, 2010a; Schiffer & Skibo, 1987). In fact, they were made with a different traditional technological knowledge than the later known regional foragers used to construct well-made projectile points. Often, these later projectile point tool styles include well-executed lithic and bone tools (e.g. Cattáneo, 2006; Nami, 2010b, 2019; Yataco Capcha & Nami, 2016). Except for two pieces (**Figures 10(B)-(B')**, **Figures 10(G)-(G')**) that because their shapes might belong to occupations belonging to the last millennium of the Pleistocene (Yataco Capcha & Nami, 2016) the artifacts are very different to the lithic assemblages accompanying Fell points (Cattáneo, 2006; Nami, 2014, 2019). Such it has been discussed, they are quite similar to the pre-Fell artifacts from the Andean region in Peru, and Chile. These technical differences would represent a previous colonizing population sharing traditional technological knowledge with prevailing simply-made lithic implements. They may be accompanied or not by well-made projectile points or bifacial tools. They arrived before those foragers using the "fishtail" or just "Fell" points that—like Clovis in North America (Bradley et al., 2010)—stand out for its wide continental distribution (Nami, 2021). Initially, it was thought that these fishtail points were distributed from Mesoamerica to the southern tip of South America (e.g. Bird & Cooke, 1979; Nami, 2014). Recently, however, it was shown that the fishtailed points from eastern North America and fishtail points share remarkable techno-morphological similarities. Fishtail points exhibit a continuous distribution from where to at least northern South America and beyond the equatorial line (Nami, 2021) that following diverse paths—mainly along the Atlantic coast and the Andean Cordillera—with some variants even in southern Patagonia (e.g. Bird, 1946, 1988; Nami, 2014, 2021).

In summary, the appraisal of the legacy collection recovered a half-century ago at Pikimachay allowed us to conclude that the lithic remains from *h-h1* are anthropic, while those from the lower levels are not. Because of the true human-made nature of the flaked artifacts, stratigraphic position, the features of the sediments where they were embedded, likely chronology, and similarities with other possibly coeval lithic assemblages, the Pikimachay record might be a candidate witnessing possible Paleo American foragers living in Ayacucho during Post Glacial Maximum times in the South Central Andes and the pre-Fell times. We hope that further research at the legacy collections and field-work at Pikimachay will expand the sample of artifacts and faunal remains recovered, along with our understanding of early human colonization and lifeways in the South Central Andes.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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