A LITHIC ASSEMBLAGE FROM PUEBLO SAJAMA (ORURO DEPARTMENT, BOLIVIA)•

PATTINTOTT KŐESZKÖZ LELETEGYÜTTES PUEBLO SAJAMA TELEPÜLÉSRŐL (ORURO MEGYE, BOLÍVIA)

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"Some circumstantial evidence is very strong,

as when you find a trout in the milk."

Henry David Thoreau (1817-1862)

Abstract

In the following article, some volcanic rock finds from Pueblo Sajama (Oruro Department, Bolivia) will be presented. This small lithic assemblage contains 18 lithic artefacts, consists mainly of flakes without any culture-specific finds, therefore it is not possible to focus on the cultural relations of the assemblage. However, some typological and taphonomic features suggest an ancient origin of the finds. The available archaeological information on the study area is rather poor, the narrower environment of the Nevado Sajama is barely known. The short review should be regarded as a tool for raising awareness about the finds.

Kivonat

Az alábbi cikkben néhány Pueblo Sajama településen (Oruro megye, Bolívia) talált, vulkanikus kőzetből készült lelet kerül bemutatásra. A 18 leletből álló kis leletegyüttes főleg szilánkokból áll, és egyáltalán nem tartalmaz kultúra-specifikus leleteket. Az utóbbiak hiányában nem lehetséges a leletegyüttes kulturális kapcsolataira összpontosítani. Vannak azonban olyan tipológiai jellemzők, továbbá néhány tafonómiai sajátosság, amelyek inkább a leletek esetlegesen archaikus származását sugallják. A tanulmányozott területről rendelkezésre álló régészeti információk meglehetősen szegényesek, a Nevado Sajama szűkebb környezete kevéssé ismert, a leletanyag ismertetését egyfajta figyelemfelkeltésnek kell tekinteni.

KEYWORDS: BOLIVIAN ALTIPLANO, ARCHAIC PERIOD, RAW MATERIAL PROCUREMENT, BASALT

KULCSSZAVAK: BOLÍVIAI-MAGASFÖLD, ARCHAIKUS PERIÓDUS, NYERSANYAGBESZERZÉS, BAZALT

Environment and topography of the area of focus

The main focus area of this paper is the immediate surroundings of the Nevado Sajama, the highest peak in Bolivia. The mountain lies in the Western Andes of Bolivia in front of the Western Cordillera. It rises about 2.2 kilometres from the surrounding terrain to a height of 6,542 metres, making it the highest mountain of Bolivia. It is an extinct composite volcano with a stratovolcano on top of several lava domes. Nevado Sajama is part of the Central Volcanic Zone of the Andes, where volcanism is triggered by the subduction of the Nazca Plate beneath the South American Plate.

Changes in the subduction regime took place during the Oligocene and directed an increase of volcanic activity in the region.

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Volcanoes in the region have ages ranging from Pleistocene to Miocene and grew on top of earlier ignimbrites; the whole volcanic activity was controlled by faults. The volcano has erupted rocks ranging from andesite to rhyodacite, with the main stratovolcano formed by andesites that contain hornblende and pyroxene and various phenocrysts. The terrain is characterized by a continuous ice cover in the central sector of the mountain, exposures of bedrock, deposits and rock glaciers in some sites, alluvial fans and scree in the periphery and moraines forming a girdle around the upper sector of Sajama. At lower elevations, the whole volcano features glacially deepened valleys. Starting in the lake Laguna Huaña Kkota on the north-western foot of Nevado Sajama, the Tomarapi River flows firstly eastward, then east, south and southeast around the northern and eastern flanks of the volcano; the Sicuyani River which originates on Nevado Sajama joins it there. The southern flanks give rise to the Huaythana River which flows directly south and then makes a sharp turn to the east. Sajama River originates on the western side of the volcano, and it flows to the south and increasingly turns southeast before joining the Lauca River. Other rivers draining Nevado Sajama and its ice cap also eventually join the Lauca River and end in the Salar de Coipasa (Vuille 1999, 1579-1580; Javier & Rafael 2011, 163-168; MISS 2016).

Geological background

The names and terminology applied to several igneous rocks can be quite confusing for archaeologists. Various terms may refer to rock texture, mineral constituents, or chemical composition. Many names with vague or poorly defined meanings have been applied over the years to the great variety of rocks formed by cooling down from magma or lava. That is why sometimes incorrect terms can be found in the literature based on classifications made by naked eye concerning the igneous rocks (mostly volcanites). Below, we give a short, sketchy review on the known geological availability of several vulcanite types, other than basalt.

There are three monogenetic volcanic fields in which small volcanic centres containing a wide range of igneous rocks (basalt to dacite types) in the Bolivian Altiplano (Davidson & da Silva 1992; 1995, 388, Fig. 1b). The centres near Nevado Sajama are small cinder cones. They have a composition between trachyte and alkaline basalt. From the point of interest, there are two basalt occurrences which are very closely linked to the region of Nevado Sajama.

In connection with the Neogene magmatism (20.0–1.6 Ma) in the Bolivian Andes, Alain Lavenu and colleagues (1989) collected several samples from pyroclastic flows. According to the authors in the so-called Mauri Formation, in the Berenguela–Charaña region of the North-western Altiplano, basalts and basaltic andesites are common in the lower part, whereas dacitic tuffs and dacitic pumice clasts are dominant in the middle and upper parts. The Abaroa Formation crops out in the same area as the Mauri Formation and consists mainly of dacitic lava flows. As regards the Abaroa Formation, Néstor Jiménez and colleagues (1993) mentioned the presence of basalts and andesites, which have SiO_2 content ranging between 46 and 56%.

In **Fig. 1.** (see also Péntek & Faragó 2019, 120, Figure 4), after Alain Lavenu and colleagues (1989, 36-37, Fig. 1, Fig. 2) a simplified geological map of the Western Cordillera with the foothills near Charaña can be seen. Dot patterns show the Oligocene-Miocene sediments, the Mauri and Abaroa Formations separated. Numbered stars indicate the location of analyzed samples taken from pyroclastic lava flows.

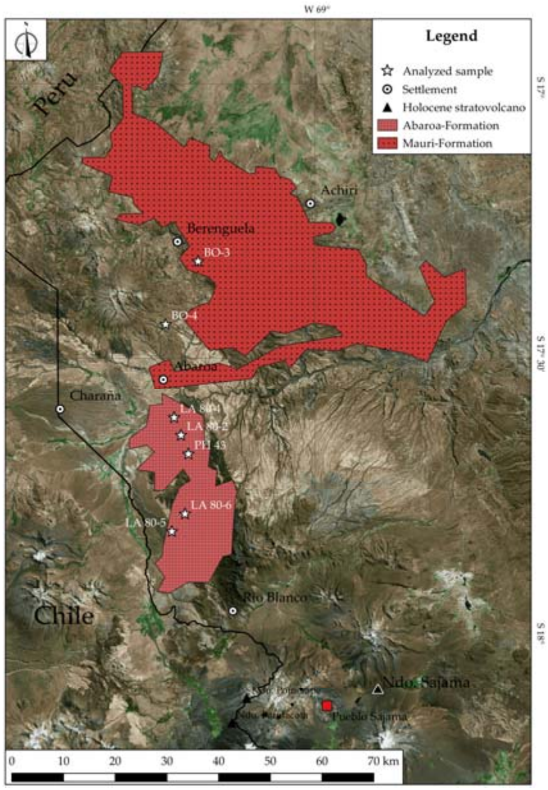

Fig. 1.: Analyzed volcanic samples by A. Lavenu and colleagues (1989) in Central Bolivia of the Abaroa and Mauri Formations. The analyzed volcanic samples are: BO-3 = E. Kusima, BO-4 = E. Sacacani, LA 80-2 = E. Abaroa, LA 80-4 = C. Lupijcala, LA 80-5 = E. Kolkhe Uma, LA 80-6 = E. Kolkhe Uma, PH 43 = Co. Canasita.

1. ábra: A. Lavenu és kollegái (1989) által vizsgált vulkanikus minták Középső-Bolívia területén az Abaroa és Mauri geológiai formációkból

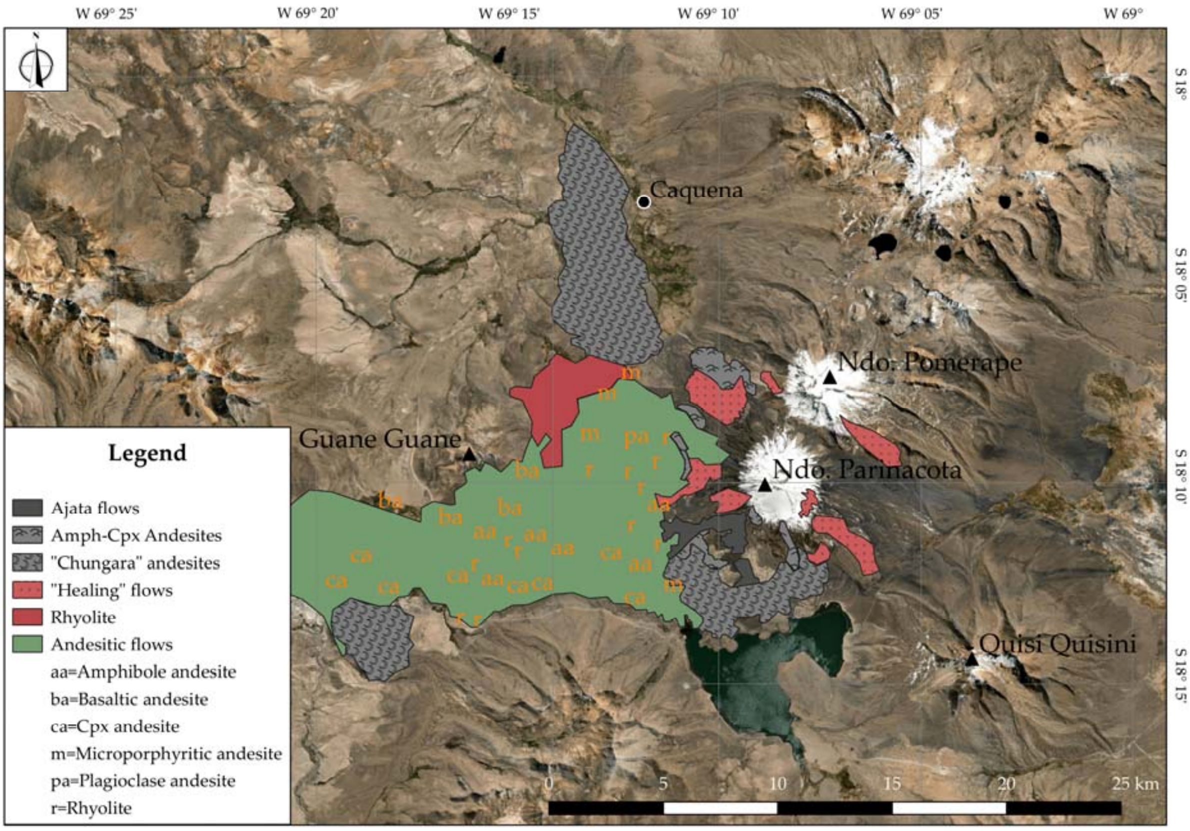

Fig. 2.: A simplified geological map of the subduction-related volcanism in the Nevados de Payachata region after G. Wörner and colleagues (1988)

2. ábra: A Nevados de Payachata régió szubdukciós vulkanizmusának egyszerűsített geológiai térképe G. Wörner és kollégái (1988) nyomán

The samples from top to bottom are as follows BO-3 (basalt lava flow), BO-4 (andesite lava flow), LA 80-4 (dacite lava flow), LA 80-2 (basalt dike), PH 43 (amphibolitic dacite lava flow), LA 80-6 (andesite lava flow), LA 80-5 (andesite lava flow).

In **Fig. 2.** (see also Péntek & Faragó 2019, 120, Figure 5), after Gerhard Wörner and colleagues (1988) a simplified geological map of the subduction-related volcanism in the Nevados de Payachata region of the Central Andes can be seen. According to the authors, this region "…comprises two temporally and geochemically distinct phases. An older period of magmatism is represented by glaciated stratocones and ignimbrite sheets of Late Miocene age. The Pleistocene to Recent phase (≤0.3 Ma) includes the twin stratovolcanoes Volcan Pomerape and Volcan Parinacota (the Nevados de Payachata volcanic group) and two small centres to the west (i. e. Caquena and Vilacollo)." The two Nevados de Payachata stratovolcanoes display continuous major- and trace-element trends from high-K_2O basaltic andesites through rhyolites (53-76% SiO_2) that are well defined and distinct from those of the older volcanic centres.

Archaeological background

Several archaeological chronologies of the Americas include an Archaic Period. According to Mark S. Aldenderfer's (2009, Fig. 5.1) chronological scheme for the South Central Andes, the term "Archaic Period" refers to human occupations situated approximately between, 10,950 and 3,900 cal BP. Geologically, this period ranges from the Late Pleistocene (Younger Dryas) to the beginning of the Late Holocene (Sub-Boreal). In his study, Marcos Michel (2000) shortly referred to the results of the field surveys of Jorge Arellano López and Danilo Kuljis (1986). These field surveys were carried out along the banks of the Mauri River, at a distance of about 60-75 km to the northwest from Pueblo Sajama. There lithic workshops and shelters in rocky eaves were located on old terraces of the Mauri River and in the Pampa de Charaña. The lithic material of the workshops is scattered on the surface of the pampas. On a location of up to two hundred square metres secondary flakes, fragmented bifaces, end-scrapers, and side-scrapers were identified. The collected artefacts were classified into the preceramic period with some doubts because they were found together with remains of the Late Intermediate period (Arellano & Kuljis 1986, 11). The artefacts in the sites of Pando and General Campero were identified with a wide formal typological diversity that would imply that the place was successively occupied. A detailed typology describes the lanceolate and triangular forms of this complex made of various raw materials, such as opal, dacite, basalt, rhyolite, and other raw materials possibly brought from the south. Recently, Vanessa Jiménez Balderrama (2013) reviewed the archaeological background of the Mauri River area in more details and described the lithic material of 24 Archaic Period sites, which were localized at the two PAM (Proyecto Arqueológico Mauri) Archaeological Complexes in the Markanasa Valley near Charaña. According to Vanessa Jiménez, a large variety of igneous rocks (andesite, silicified hornblende andesite, basalt, olivine basalt, dacite, silicified dacite, rhyolite, trachyte, trachyandesite) could have been found at the 24 archaeological sites; moreover, these volcanites dominated the raw material utilization. These types can be associated with the above-mentioned Mauri and Abaroa Formations.

The Archaic Period was followed by the Terminal Archaic (3,000-1,500 BC) and the Formative Period (1,500 BC-300 AD). In the direct surroundings of Pueblo Sajama, there is no clear evidence from this long period. However, it can be a possible result of a lack of field research.

The chiefdom of the Aymara tribe Caranga was one of the first developed cultural entities in the Altiplano of Bolivia. The Carangas Period lasted between 300 AD and 1200 AD, and it had its cultural foundation in the Formative tradition of the antecedent Formative Wankarani Cultural Complex. The study of Marcos Michel (2000) intended to be an introduction to the complex problem of the regional cultural developments of the Bolivian highlands. The study was based on archaeological field survey carried out in 1993. The roads to the Sajama region were taken as a reference for the evaluation, considering that these roads are crossing the region in different directions thus forming transects. A stratified sampling work was carried out in the vicinity of these roads which allowed the identification of 43 archaeological sites. Among the localized sites, there were some with lithic archaeological assemblages which correspond to the first hunter-gatherers of the Altiplano. Since the archaeological material is generally mixed on the surface without any sediment present or stratigraphic position, the chronological interpretation of the sites has encountered many problems. However, the comparisons of the lithic materials, to get comparative-typological dates, were always made concerning distant regions.

In **Fig. 3.**, beside the archaeological sites of the Sajama region, some archaeological sites belonging to the Archaic Period and the Formative Period Wankarani Cultural Complex are shown. The radiocarbon-dated sites and the basalt quarry sites at Lago Poopó are indicated. Chilean sites are signed by white site labels. According to this map, it is obvious that the archaeological sites are distributed rather sparsely over the central part of the Bolivian Altiplano.

There are only two radiocarbon-dated archaic sites in the wider environment of Pueblo Sajama. The site of Pumiri, URR-001, which is a rock shelter, was dated from a charcoal sample and resulted in a date of 4,846-5,271 cal BP (1σ) (AA96432) (Capriles & Albarracin-Jordan 2013, 52, Table 1). The site of Iroco KCH20, near Oruro, is significantly older and has two radiocarbon dates made from bone collagen. The date of AA91568 is 9,032-9,288 cal BP (1σ), the date of AA91569 is 8,728-9,087 cal BP (1σ) (Capriles & Albarracin-Jordan 2013, 52, Table 1).

Almost all archaeological sites belonging to the Archaic Period in North Chile are radiocarbon dated. The AMS date of 11,240–11,600 cal BP (UGAMS2953) indicates that the cave site of Hakenasa is the earliest known occupation site in the Altiplano of northernmost Chile. There is a complete list of the available radiocarbon dates in Santoro et al. 2011, 359-360, Table 1.

In **Fig. 4.**, the tight environment of Nevado Sajama and only the archaeological sites in the Sajama region described by Michel (2000) are represented. Blue lines indicate watercourses, rivers and streamlets. Since the available study of Michel does not contain any geographical information, the locations of the sites cannot be regarded as accurate, they are only indicative. At some of the sites, lithic material was also found.

Among the cave sites, the double-cave of Tomarapi should be highlighted. Both caves were used as habitat sites. A lithic workshop for the production of hoes, knives, arrowheads and other tools made of black basalt was located in the larger cave. The ceramics and lithic artefacts represent local characteristics of continuous occupation from a hunter's epoch to the times of Carangas and even of Inca occupation.

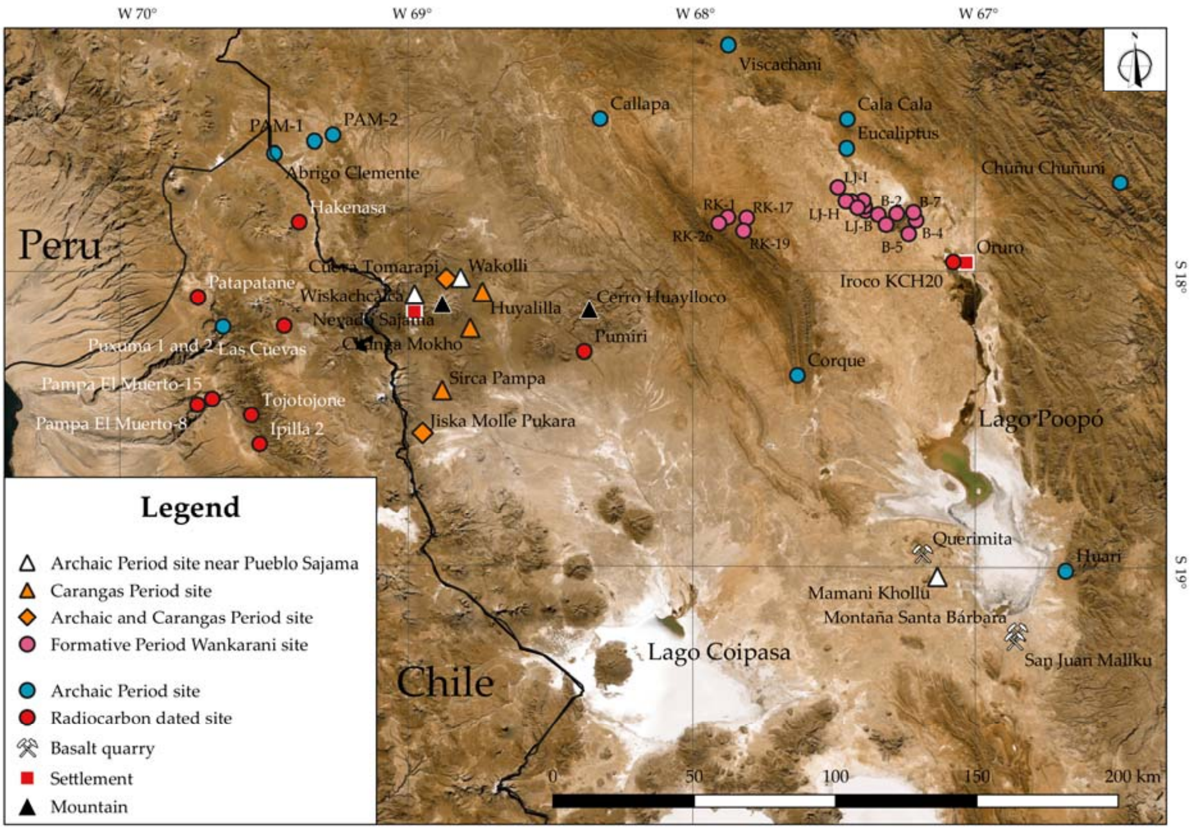

Fig. 3.: Archaeological sites in the Sajama region and some archaeological sites on the Altiplano belonging to the Archaic Period and the Formative Period Wankarani Cultural Complex

3. ábra: Régészeti lelőhelyek a Sajama térségben és az Altiplano területén található néhány, az Archaikus periódusba illetve a Formative periódusba (Wankarani kultúrális komplexum) sorolt lelőhely

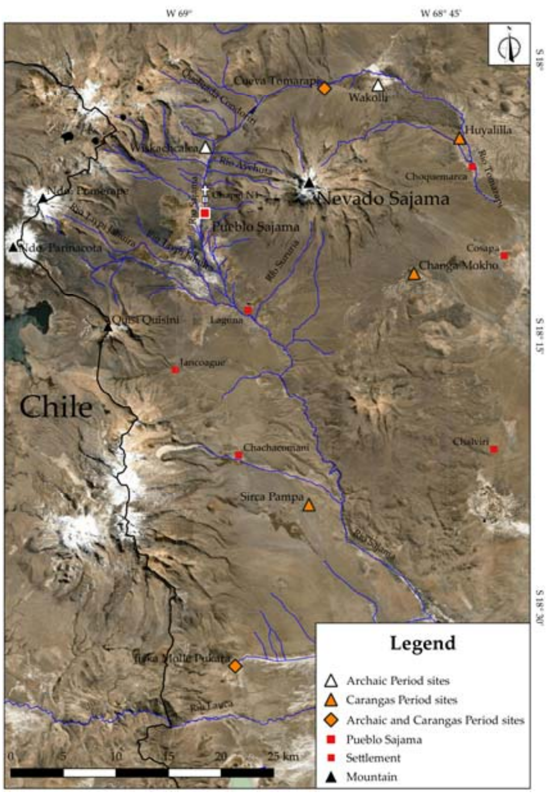

Fig. 4.: Archaeological sites in the Sajama region after M. Michel (2000).

4. ábra: Régészeti lelőhelyek a Sajama térségben M. Michel (2000) nyomán.

The lithic workshop at the foothills of the hill Jiska Molle Pukara is located south of Nevado Sajama. The site, covering an area of about one hectare (10,000 m^2), presents abundant remains of lithic material worked in black basalt: knives, side-scrapers, hoes, arrowheads, and remains of slabs and manufacturing waste: cores, flakes, debitage products. According to the characteristics of the lithic and ceramic material, it can be said that the site was occupied from the Archaic Period until the Carangas times.

Northwest of Patokho, at the small settlement of Wiscachcalca located at the lower part of a hill formed by several rocky outcrops, a projectile point was discarded during elaboration. It has a triangular form, stemmed with shoulders, made of volcanic quartz, and being similar to those associated to the „Patapatane" (Osorio et al. 2017a, 7, Fig. 3, A, Fig. 3, C; 2017b, 48, Fig. 4, 1-7) and „Tojo Tojone" (Dauelsberg 1983; Osorio 2013, 97, Fig. 17, 3-5; Osorio et al. 2016) phases in Northern Chile, which are dated by radiocarbon method from 9,500 to 6,000 BP. The projectile point of Wiscachcalca corresponds to the type of 1A, 1B in the typological list of C. Klink and M. S. Aldenderfer (2005, 29, Fig. 3.3, A-E).

At the site of Wakolli (Estancia Huacolli), although the majority of the archaeological finds are dated to the colonial period, several projectile points from the Archaic Period were also collected. The shapes of the collected projectile points are varied, but the majority are oval and elongated forms worked with bifacial retouching made by percussion technique, triangular forms with a semicircular base, or with a rectangular tongue and large ovoid forms with double wings and a central notch. This material has similar characteristics as the projectile points of the Archaic Period of Northern Chile. There are many large and small knives obtained by retouching and micro-retouching at the edge of the flakes.

The lithic workshop Changa Mokho (or Changa Moco) was a production area of lithic tools located in the lower southwest skirt of the pucara de Changa Moco (near a cave), the size of the site is 10 × 10 m. At that place, there are abundant remains of black basalt cores and flakes. This site possibly corresponds to the Carangas era (Michel 2000).

Regarding the lithic material from the archaeological field surveys carried out in 1993, M. Michel wrote (2000, 63) that the existence of lithic “batanes” (grindstones) made of sandstones and volcanic rocks is important in places such as “pucaras” (forts) and places of permanent habitation. Batanes and grinders were usually made from large rocks by knapping and polishing and vary in shape and size; some are very worn by use. They were probably used for the grinding of grains such as corn and quinoa (Chenopodium quinoa, a species of goosefoot grown as an edible crop). The majority of lithic artefacts such as arrowheads, hoes, polishers, knives, scrapers and the remains of debitage products (cores, flakes, etc.) were made of black basalt. At the same time, the presence of flakes and some artefacts made of flint, chalcedony, and silex is also important. The ease of access to basalt sources in the region, in addition to a long tradition of using this material (since the Archaic Period), makes its presence abundant in all sites that have lithic material. As in the preceding Formative Period, hoes or "tacllas" (spade/shovel) were the most common lithic tools of the Carangas territory. These bifacial tools were used for several functions, in tasks related to agricultural practices, for tilling, planting, cultivating activities, but the most important was presumably as hoes. The tools were used in other activities carried out in the residential base, like cleaning of garbage dumps and places of habitation, digging wells for storage of various products, and they were also used in activities related to fodder practices, such as pasture cutting. They were manufactured usually from black basalt slabs, and less commonly from other volcanic rocks. Some hoes reach sizes greater than 18 cm (up to 30 cm), but usually, they measure between 7 and 12 cm. They have an oval shape, with the lower end thinned almost in the shape of a tongue and the upper end in the form of a semicircle. Generally, the distal ends were bifacially abraded by the technique of direct percussion flaking. Sometimes, as a result of wear, the implements present polish on the upper end. The hoes were used for agriculture, being hafted at the top to a shaft. In some cases, fragments of lithic basalt hoes were used as polishers.

Adam Birge (2016; 2017) dealt with the issue of the so-called Sajama Lines in western Bolivia. The Sajama Lines are a web-like network of thousands of nearly perfectly straight paths etched into the ground continuously for more than 3,000 years by the indigenous people living near the volcano Sajama. During his field surveys in the environment of Pueblo Sajama, mainly in the valley of the Tomarapi River, 13 lithic artefacts were documented. Among these finds, there are five modified flakes, three preforms, and one core. The most common type of raw material was basalt, but two examples of obsidian and two white chert preforms are also reported. The lithic artefacts were distributed across different types of sites (Birge 2016, 87). In connection with the site of “Chapel N1”, Birge mentioned (2017, 7), that: “The site was also the only place where we found possible lithic projectile points.”

Description of the lithic assemblage

First of all, some terminological remarks, concerning technological and morphological characteristics of lithic artefacts and the issue of the natural alterations should have been taken.

Offset (déjeté) artefacts

According to the consensus in the technological research on chipped stones, artefacts are defined as offset (déjeté) pieces when the debitage axis is different from the morphological axis (Inizan et al. 1999, 138-145). Bryan F. Leach wrote (1969, 55-56) that there are many flakes which; when viewed dorsally with the striking platform in the horizontal, illustrate an angular displacement of the longitudinal axis either to the left or right (left and right skew respectively). Concerning the character of the axis displacement, the definition of Amèlia Bargalló and Marina Mosquera (2014, 44-45, Fig. 1) will be followed. When the detaching axis (debitage axis) from the impact point to the end of the piece leans to the right, the flake will be referred to as right-oriented, and if it leans to the left then left-oriented.

Creation of a lip

During knapping, especially when "direct percussion with soft hammer" technique is applied, the detached artefact may happen to remove a larger amount of material in the butt area. As a possible result, the proximal part shows a very broad butt (flake platform), an extremely diffuse bulb with a concave profile and a post-bulbar constriction. The slight projection of the ridge formed by the butt and the lower, the ventral face of the detached artefact, is called "lip". The specific cause of this knapping phenomenon is that the fracture initiates far behind the impact point of the hammer (Inizan et al. 1999, 36; 144). According to Jacques Pelegrin (2000, 77), the lip is more marked if the "angle de chasse" that is the angle between the striking platform and the upper (dorsal) surface of the artefact is more acute. This technique results in small butts, a flaking angle more than 90 degrees, and a diffuse bulb (Inizan et al. 1999, 74).

Measurement of the artefacts

Following the argumentation of Michael J. Shott (1994), flake morphology, as expressed in size and shape, is an essential aspect of variation to be investigated in lithic technological studies. The variation of blank morphology can be used to infer differences in core types (morphologies), which can further reveal technological traditions. Although the metric data of the small lithic assemblage to review have little statistical relevance, all lithic artefacts were measured. When the axis of flaking and axis of symmetry diverge from each other, the so-called "long axis method", proposed by Bryan F. Leach (1969), can be useful for the measurement. In other words, the length is taken as the distance on the interior face between the point of percussion (or apex) and the last point of detachment from the core (or vertex). The assumption is that the long axis method is a better reflection of the true outline than other measurement schemes.

The lithic assemblage from Sajama contains several flakes of irregular shape, so, despite the obvious presence of offset flakes, the so-called "box method" was used (Debénath & Dibble 1994, 19), by taking the maximum length and width measurements (Dogandžić et al. 2015, 7, Fig 3b). The maximum length represents the distance from the point of percussion to the distal end, following the axis of percussion (the debitage axis sensu Inizan et al. 1999, 138) (perpendicular to the striking platform width). Maximum width is taken at the widest point perpendicular to the length axis, and maximum thickness is recorded at the thickest point along the third dimension. Hereinafter, the measured maximum dimensions will be referred to in short form, only as length, width, and thickness. To get derived data, the length:width (L/W) and thickness:width (T/W) ratios were computed. In the case of an undamaged flake platform (butt), two additional morphometric data, platform width and thickness were measured as well.

Remarks on the quantitative descriptive attributes

The following descriptive attributes could be determined for the majority of the artefacts: length, width, thickness, interior and exterior platform angles (Whittaker 1995, 90-91), flake platform width and thickness.

All measured and derived data can be found in **Table 1.**; here some short explaining remarks will be made.

As John R. Cross stated (1993, 71), standardization and uniformity also emerge when we compare ratios of measurements (length, width, and thickness). Similarities and differences between collections are more often perceived by considering proportions and ratios rather than single measurements. There is a possibility to largely compare the morphometric data of the Sajama assemblage with analyzed assemblages from the Formative Period. In a detailed study, Martín Giesso (2010) tried to explain changing patterns in the organization of stone tool production among different social groups that occurred with the emergence and expansion of the Tiwanaku state. The focus of the research was to determine the characteristics of stone production and consumption in different social contexts during the Tiwanaku IV and V periods (ca. 400 to 1100 A.D.). The gathered information was compared to pre-Tiwanaku periods.

A) All measured basic data; length, width, thickness, flake platform width, and thickness are varied in rather wide ranges.

The length varies between 26.2 mm and 84.8 mm, with a mean value of 51.26 mm and a standard deviation of 14.6 mm. The coefficient of variation (also known as relative standard deviation) is 28.48.

The width varies between 21.7 mm and 69.0 mm, with a mean value of 46.1 mm and a standard deviation of 11.86 mm. The coefficient of variation is 25.72.

The thickness varies between 6.5 mm and 19.7 mm, with a mean value of 13.12 mm and a standard deviation of 3.36 mm. The coefficient of variation is 25.58.

In Table 8.1 (Giesso 2010, 160), there are average measurements of complete flakes from two Formative Period sites having the largest collections from the Tiwanaku III occupation of Lukurmata.

Table 1.: Quantitative, measurable data of the lithic artefacts

1. táblázat: A leletek mennyiségi, mérhető adatai

No	Maximum length (L) in mm	Maximum width (W) in mm	Maximum thickness (T) in mm	L/W	T/W	PW (Platform width in mm)	PT (Platform thickness in mm)	PW/PT	L/PW	W/PW
1	84.80	50.75	17.70	1.67	0.35	26.00	15.00	1.73	3.26	1.95
2	73.00	41.00	16.40	1.78	0.40	18.00	11.00	1.64	4.06	2.28
3	64.70	40.20	14.80	1.61	0.37	22.00	8.00	2.75	2.94	1.83
4	56.40	48.50	14.80	1.16	0.31	11.00	6.00	1.83	5.13	4.41
5	51.00	64.00	14.00	0.80	0.22	31.00	14.00	2.21	1.65	2.06
6	65.40	51.80	13.20	1.26	0.25	9.00	6.50	1.38	7.27	5.76
7	48.30	56.50	12.60	0.85	0.22	-	-	-	-	-
8	43.00	56.00	15.00	0.77	0.27	42.00	16.00	2.63	1.02	1.33
9	43.00	37.00	12.00	1.16	0.32	26.00	11.00	2.36	1.65	1.42
10	43.50	48.00	12.20	0.91	0.25	-	-	-	-	-
11	46.00	46.70	9.70	0.99	0.21	19.00	6.00	3.17	2.42	2.46
12	39.00	44.30	13.50	0.88	0.30	31.00	10.00	3.10	1.26	1.43
13	57.50	24.80	12.50	2.32	0.50	12.00	6.00	2.00	4.79	2.07
14	59.00	69.00	9.00	0.86	0.13	28.00	4.00	7.00	2.11	2.46
15	30.50	47.80	14.80	0.64	0.31	25.00	9.00	2.78	1.22	1.91
16	43.00	21.70	7.80	1.98	0.36	11.00	5.00	2.20	3.91	1.97
17	26.20	37.50	6.50	0.70	0.17	-	-	-	-	-
18	48.40	44.30	19.70	1.09	0.44	22.00	12.00	1.83	2.20	2.01
Min	26.20	21.70	6.50	0.64	0.13	9.00	4.00	1.38	1.02	1.33
Max	84.80	69.00	19.70	2.32	0.50	42.00	16.00	7.00	7.27	5.76
Mean	51.26	46.10	13.12	1.19	0.30	22.20	9.30	2.57	2.99	2.36
Std. deviation	14.60	11.86	3.36	0.48	0.10	9.16	3.80	1.34	1.76	1.18
Coeff. of variation	28.48	25.72	25.58	40.72	31.82	41.26	40.83	51.94	58.90	50.26

Both Formative Period sites are characterized by a very high density of quartzite (more than 90% of the lithic assemblage), while the Lukurmata site is more diverse in raw materials. The table contains data of length, width, thickness, weight, and platform width in millimetre and exterior platform angle (the angle between the platform surface and exterior surface) in degree. Unfortunately, the standard deviations of the measured data were not given. According to M. Giesso, comparing flakes from the Formative Period sites, it is obvious that their flakes are larger and heavier than those of Tiwanaku IV-V occupations. This phenomenon is parallel with changes that occurred in preceramic sequences in other regions of the Central Andes when flake size was diminished with time.

The greatest average values for length, width, and thickness vary between 37.0 mm and 41.2 mm, 39.6 mm and 41.0 mm, and 13.1 and 16.2 mm respectively. The flakes from the Formative sites have about the same average length and width. Interestingly enough, the flakes of the Tiwanaku III occupation of Lukurmata have a larger width than length; they are rather wide in form.

While the average thickness in the Sajama assemblage is less or equal than those given by M. Giesso, the average length and width are greater. That is, on the whole, the artefacts at Sajama are greater and more elongated. Even M. Giesso stated (2010, 183) that there is no formal blade industry in the Tiwanaku heartland. Very few cores have blade negatives and there are very few blades. The percentage of blades present in each area/site suggests technical expertise. The evidence indicates that blades were exceptional in the range of Tiwanaku knapping practices.

Table 1., cont.

1. táblázat, folyt.

No	Interior platform angle (degree)	Exterior platform angle (degree)	Figure	Petrological sample id.	Rock name	Texture
1	100	80	Fig. 5:1			
2	115	75	Fig. 6:1			
3	108	75	Fig. 6:2			
4	105	78	Fig. 7:1			
5	> 90	-	Fig. 7:2	PS 5	basaltic andesite	porphyric hialopilitic
6	90	90	Fig. 5:2			
7	115	85	Fig. 12			
8	> 90	-	Fig. 8:1	PS 14	andesite	porphyric hialopilitic
9	> 90	-	Fig. 8:3	PS 9	andesite	porphyric pilotaxitic/microholocrystalline
10	107	83	Fig. 9:1			
11	105	77	Fig. 9:3			
12	113	85	Fig. 10:2			
13	115	85	Fig. 11:1			
14	> 90	-	Fig. 10:1	PS 8	andesite	porphyric pilotaxitic
15	100	82	Fig. 8:2			
16	100	80	Fig. 9:2			
17	102	80	Fig. 11:2			
18	120	80	Fig. 11:3			

Ninety percent of all primary flakes found in Tiwanaku are either quartzite or metamorphic rock. This evidence suggests that other raw materials, both the finer- and coarser-grained materials, were more heavily reduced at the quarry. Table 10.11 (Giesso 2010, 183) illustrates the dimensions of primary flakes at Tiwanaku. There are few primary flakes, and they are generally short (90% measure less than 40 mm) and thin (62% measure less than 10 mm). These facts suggest that the removal of the first large primary flakes took place at the quarry.

B) The exterior platform angle (angle de chasse), the angle between the butt and the upper (dorsal) face was measurable for the same 14 artefacts. It is almost always acute, varying between 75 degrees and 90 degrees, with a mean value of 81.7 degrees, and a standard deviation of 4.25 degrees. The exterior platform angles given by M. Giesso vary in a narrower range, between 72.7 degrees and 80.6 degrees. As M. Giesso noted, short flakes have platform angles closer to 90 degrees. There is an inverse relation between exterior platform angle and flake length. As John D. Speth suggested (1981, 16), "For a given platform angle (measured between striking platform and exterior surface of prism or flake), a decrease in the size of the prism is accompanied by a decrease in terminal flake length, terminal flake width, and terminal platform thickness, and by an increase in the minimum ball diameter required to remove a flake.". In general, the closer the exterior platform angles to 90 degrees, with everything else held constant, the longer the flakes. If the exterior platform angle is around 90 degrees, the extracted flakes are likely short, and thick with pronounced hinge terminations (Whittaker 1995, 91-93). According to Martin Magne and David Pokotylo (1981, 36), "Dorsal angle reflects the morphology and the "core" of flake detachments rather than the angle of percussion used to detach the flake."

In the Sajama assemblage, the above-mentioned suggestion of J. D. Speth could not be observed, there is only an irrelevant very weak negative statistic correlation between exterior platform angle and flake length.

C) The interior platform angle (flaking angle, angle d'éclatement), the angle between the butt and the lower (ventral) face was measurable for 14 artefacts. It is almost always obtuse, varying between 90 degrees and 120 degrees, with a mean value of 106.79 degrees, and a standard deviation of 8.16 degrees. Controlled experiments by Harold L. Dibble and John C. Whittaker (1981, 284-287) suggested that production factors such as the angle of the blow, impact force, and platform thickness had no significant effect on interior platform angle. Brian Cotterell and Johan Kamminga (1987, 686-691) have observed that interior platform angles are close to 90 degrees for flakes with bending initiations and greater than 90 degrees for flakes with Hertzian initiations. Andrew W. Pelcin (1997, 1110) has subsequently demonstrated a bimodal distribution of flakes according to interior platform angle, which supports the claim that this variable can help to distinguish between bending and Hertzian (conchoidal) flakes (Cochrane 2003, 15). David Pokotylo (1978, 184) suggested that: "This angle should increase as the force is directed to the outer surface of the core and vice versa for inward force applications. The result of an inward-directed force would be the removal of a substantial flake mass, which would necessitate the application of a large amount of force. On the other hand, the results of outward-directed force are best reflected by bifacial thinning flakes which would exhibit the largest angles. Therefore, one would expect this angle to increase through the reduction sequence".

This suggestion implicates that there is an inverse relationship between the interior platform angle and flake length. In the Sajama assemblage, there is only an irrelevant very weak negative statistic correlation between interior platform angle and flake length. Furthermore, in the Sajama assemblage, no statistically relevant relation between the exterior and platform angle could be observed.

D) The platform width varies between 9.0 mm and 42.0 mm, with a mean value of 22.2 mm and a standard deviation of 9.16 mm. The coefficient of variation is 41.26, extremely high. As mentioned above, the application of "direct percussion with soft hammer" technique can result in a very broad platform. According to Carl J. Phagan (1976, 45), reduced platform width is indicative of platform treatment before force application, and lower values can be interpreted as more careful attention to such platform preparation. The platform width was found useful by D. Pokotylo (1978) in estimating where flakes occur within the reduction sequence. That is, flakes in late stages should be small and exhibit small striking platforms (butts) (Magne & Pokotylo 1981, 36).

According to M. Giesso (2010, 182-183), 69% of the primary flakes at Tiwanaku have platforms that are less than 10 mm wide, and 93% have platforms less than 15 mm wide. Wide platforms are extremely rare. This confirms that most of the cortex was removed at the quarry and that the products that were brought to the site were in advanced stages of processing. In the rural sites, there were few primary flakes, all of them of local raw materials, quartzite (70%), and metamorphic rock (22%). The types of most of the platforms suggest that these primary flakes were not the first to be extracted from the core, but there was previous preparation. Most primary flakes have narrow platforms, 72% of the platforms are less than 10 mm wide. This, together with the flat platforms (56%), suggests that several of these flakes were extracted in a later stage of core reduction (Giesso 2010, 192). In the Sajama assemblage, between the platform width and length values, no tendency was observable.

Platform thickness is measured from the interior to the exterior surface of the platform at the point of percussion. It represents neither maximum platform thickness nor the shortest distance from the point of percussion to the exterior surface (Dibble 1997, 153). In the Sajama assemblage, the platform thickness varies between 4.0 mm and 16.0 mm, with a mean value of 9.3 mm and a standard deviation of 3.8 mm. The coefficient of variation is 40.83, also very high. Platform thickness is an independent variable in flake formation because it is controlled by the knapper. It is highly correlated with maximum flake thickness (Speth 1981, 17). According to Harold L. Dibble (1997, 154), various controlled experiments have demonstrated that two aspects of flake platforms − platform thickness and exterior platform angle − have significant effects on flake size.

E) From the derived data, only the L/W ratio will be mentioned. It varies between 0.64 and 2.32, with an average of 1.19, and a rather high standard deviation of 0.48. The coefficient of variation is very high since its value is 40.72%.

The surface collection of the lithic artefacts at Sajama was not selective, so the lithic assemblage can be regarded as random, with some statistical relevance. Based on the above-described characteristics, no standardization in the manufacturing procedure seems to be indicated. On the contrary, the assemblages analyzed by M. Giesso show more or less clear evidence of standardization.

Natural alteration

Two important weathering processes can be differentiated, which can influence the surface conditions of a lithic artefact, these are the physical and chemical weathering. The mechanical or physical weathering involves the breakdown of part or parts of the lithic artefact through direct contact with atmospheric conditions, such as heat, water, ice, and pressure. At the same time, the chemical weathering involves the direct effect of atmospheric chemicals or biologically produced chemicals also known as biological weathering in the breakdown of part or parts of the artefacts. While physical weathering is accentuated in very cold or very dry environments, chemical reactions are most intense where the climate is wet and hot. However, both types of weathering occur together, and each tends to accelerate the other. The degree of surface modification (patina) is extremely variable; it may imply a change in colour, with or without a possible modification of the granularity of the texture, either solely on the surface (film) or more deeply (Inizan et al. 1999, 91). Gloss patina is a natural post-depositional surface alteration frequently present on lithic artefacts. Features of this patina include reduced surface topography, smoothness, and a pronounced lustre. The gloss is a shiny surface condition, which can have natural origin such as water, wind, friction due to vibration, etc. The gloss patina is distinct from the so-called desert polish, which is created by a combination of wind and sand (Perry et al. 2005). Although, there is a considerable amount of literature on the above-mentioned phenomena on flint (e. g. Glauberman & Thorson 2012, with a detailed reference list), comparatively little is known on these phenomena on volcanic rocks. Furthermore, as Lena Asryan and colleagues noted (2014), while many experimental studies have been done on siliceous and metamorphic rocks both use-wear and post-depositional surface modification events, little is known about such experiments on volcanic materials (other than obsidian), and on basalt in particular. Few authors have dealt with functional and micro-wear analyses on basalt or basaltic rocks (e. g. Rodríguez Rodríguez 1998; Clemente & Gibaja 2009) but little experimental work has been published, and the phenomenon of the natural alteration has not been discussed at all.

Qualitative, non-measurable descriptive attributes

The following descriptive attributes could be determined for the majority of the artefacts: the form and type of the butt, the presence of a bulb, the presence of bulb scars (Inizan et al. 1999, 36), the presence of a lip, the general form of the artefact, the presence of damaged and/or rounded edge(s), the presence of rounded ridges, and the relation of the debitage axis and morphological axis. We focus especially on two attributes, the presence of bulbar scars (negatives of removal, Inizan et al. 1999, 146; flake scars, Whittaker 1994, 15; negative bulb force; Crabtree 1972, 48) on the upper face and finally, the presence of a weathering layer or a shiny surface or rather their connection to each other. Due to the subjective nature of such attributes, in some questionable cases, no decision had been made and the determination remained open.

All qualitative, non-measurable data can be found in **Table 2.** The presence or existence of a given feature is signed by “x”, the lack of that one by “ ” (unfilled field). The fact if a given feature could not be determined is signed by “n.d.”, meaning no data.

Below some short summarizing remarks will be made.

A) For all artefacts but one, the type of the butt could be determined. Most of the artefacts have trapezoid or sub-trapezoid butts (13 pcs.), four butts have an irregular form, and one butt is oval. Most of the butts bear no traces of preparation. The plain (flat) butt has a clear dominance (10 pcs.), followed by the cortical (four pcs.), dihedral (two pcs.) and facetted (one pc.) butt.

B) If the bulb of the artefacts is present, it is generally very diffuse (10 pcs.). These flat undetermined bulbs are poorly defined and do not stand out on the ventral surface. In five cases the bulb is absent, in three cases it is almost absent, only slightly visible.

C) One-third (six pcs.) of the artefacts have flat bulb scar of variable size, in 12 cases there are no bulb scars visible by naked-eye.

D) The so-called lip is in 16 cases present, two artefacts have no lip. It is a strong implication for the application of the “direct percussion with soft hammer” technique.

E) There are some artefacts, which have a somewhat irregular silhouette viewed from above. This irregularity in the form is expressed by the diverging ends and the supposed bending/snap fractures (see e. g. **Fig. 7/2; Fig. 8/1; Fig. 10/1**). If there is no opposing force directly under the point of impact, a bending fracture will cause the flake to snap transversely. The force travels straight down from the impact point creating a 90-degree fracture angle (Jennings 2011, 3645, 3647, Fig. 2, b, d, e, and f). That is, the breakage surface is perpendicular to one of the main surfaces of the artefact. In the Sajama assemblage, the edges of the supposed broken parts are rounded, which can be the result of post-depositional mechanical effects. Bend-breaks or bending fractures via sediment consolidation occurs at high frequencies (Eren et al. 2011, 201).

F) Only one-third (six pcs.) of the artefacts have sharp, undamaged edges. The damaged edges are notched (scalloped), and usually rounded. These phenomena might have been caused by mechanical or physical weathering. Settling of the soil (due to solifluction, soil creep or simply compaction), does modify the surface of the artefact to a considerable extent. It is not only the abrasion which occurs, but also edge-damage and, in extreme conditions such as periglacial environments, the development of deep scratches, pressure cones, and cryoturbation retouch (Stapert 1976; Van Gijn 1989, 54).

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Table 2.: Qualitative, non-measurable data of the lithic artefacts

2. táblázat: A leletek minőségi, nem mérhető adatai

No	Interior platform angle in degree	Exterior platform angle in degree	General form	Butt	Form of the bulb	Bulb	Bulb scar	Demaged edge	Rounded edge	Rounded ridge
1	100	80	regular	plain	sub-trapezoid	almost absent	x	x		x
2	115	75	regular	cortical	trapeze	absent		x	x	x
3	108	75	regular	plain	trapeze	diffuse	x			
4	105	78	regular	plain	oval	absent				
5	> 90	n.d.	irregular	plain	trapeze	diffuse	x	x		
6	90	90	irregular	plain	trapeze	diffuse	x	x		
7	115	85	regular	cortical	trapeze	almost absent		x	n.d.	n.d.
8	> 90	n.d.	irregular	dihedral	irregular	absent		x		x
9	> 90	n.d.	regular	dihedral	sub-trapezoid	diffuse		x		x
10	107	83	regular	n.d.	irregular	diffuse		x		
11	105	77	regular	plain	irregular	almost absent	x	x		x
12	113	85	regular	plain	trapeze	diffuse		x		x
13	115	85	regular	plain	trapeze	absent				
14	> 90	n.d.	irregular	plain	trapeze	diffuse		x		x
15	100	82	regular	cortical	trapeze	diffuse	x			x
16	100	80	regular	plain	sub-trapezoid	absent				x
17	102	80	regular	facetted	irregular	diffuse		x		
18	120	80	regular	cortical	sub-trapezoid	diffuse				x

No	Shiny surface	Grayish weathering layer	General form	Debitage axis	Lip	Bulbar scar (Negative bulb force)	Figure
1	upper face	lower face	regular	right-skewed	x		**Fig. 5/1**
2		lower face	regular	left-skewed	x	x	**Fig. 6/1**
3		both faces	regular	centered	x	x	**Fig. 6/2**
4			regular	right-skewed	x	x	**Fig. 7/1**
5	n.d.	n.d.	irregular	centered	x	x	**Fig. 7/2**
6	both faces		irregular	left-skewed		x	**Fig. 5/2**
7	upper face		irregular	right-skewed	x	x	**Fig. 12**
8	n.d.	n.d.	irregular	right-skewed	x		**Fig. 8/1**
9	n.d.	n.d.	regular	left-skewed	x		**Fig. 8/3**
10	upper face	lower face	regular	centered			**Fig. 9/1**
11		both faces	regular	left-skewed	x	x	**Fig. 9/3**
12	upper face	lower face	regular	left-skewed	x	x	**Fig. 10/2**
13		lower face	regular	left-skewed	x		**Fig. 11/1**
14	n.d.	n.d.	irregular	right-skewed	x	x	**Fig. 10/1**
15	upper face	lower face	regular	centered	x		**Fig. 8/2**
16	upper face	lower face	regular	right-skewed	x		**Fig. 9/2**
17			regular	centered	x		**Fig. 11/2**
18	upper face	lower face	regular	centered	x	x	**Fig. 11/3**

Without use-wear analysis on the Sajama assemblage, it is hard to decide if some of the tiny splintering along the edges could have been created as a result of usage. The chipped, ragged edges might have been used for several functions, such as cutting, scraping, even without having been retouched.

G) Two-third of the artefact (12 pcs.) is offset, six of them are right-oriented (right-skewed) the other six are left-oriented (left-skewed). The variance between the debitage axis and morphological axis (the axis of flaking and the axis of symmetry) is varying approximately in the range of 20 degrees and 35 degrees. A probable cause of the presence of many offset flakes can be the fact that the flakes may have been struck from unprepared cores or raw material pieces. The plain (natural) and cortical butts of the flakes support this assumption.

H) Ten artefacts have clear observable bulbar scars (negatives of removal or flake scars) on their upper face, in most cases, there is only one scar. On **Fig. 11/3** the end-scraper made on a very thick, massive flake bears clean-cut traces of more than one small bulb scar. In the remaining cases, the determination is ambiguous. Bulbar scars are a very useful indication of the applied flaking techniques. Counts of the number of bulbar scars can provide a broad indication of the intensity of core reduction. Many scars and irregular distribution on the upper face of a flake suggest expedient technology. One or two straight-line scars indicate an advanced degree of core and blank preparation (Giesso 2010, 144).

The number of artefacts without bulbar scar may be explained by the fact that they were struck as primary flakes from raw material blocks of suitable size. It would suggest expedient strategy, tool manufacturing on the spot from raw material sorts of possibly local origin.

I) Eight artefacts have a greyish weathering layer (patina) on the lower face, two artefacts have both faces patinated. Four artefacts show no traces of patination and in four cases the presence of patina is questionable. Without having a detailed geochemical analysis, it is impossible to determine the cause and origin of this patina.

J) One-third of the artefacts (six pcs.) have a shiny upper face, and in one case both faces are shiny. One-third of the artefacts (six pcs.) have relatively dull, unglazed faces, and four cases are questionable. As regards a possible connection between the patinated and shiny faces, without having a detailed geochemical analysis, it is impossible to determine the cause and nature of the formation of the above-mentioned greyish weathering layer. It should be noted, however, that in five cases the artefacts have a shiny upper face and weathered lower face. In two cases, both faces have the greyish weathering layer. Taking into consideration the fact that the shiny surface is very likely the result of physical and mechanical weathering, such as eolic effects (referring to the action or the power of the wind), we should assume that the majority of the artefacts laid on the soil-surface on its lower, weathered or relatively matt face. Due to the wind erosion, which is very selective, carrying the finest particles particularly sand grains, the upper face of the artefacts might have been polished by these particles, creating a shiny, glossy surface. If the upper face of the artefacts is shiny then the ridges are rounded.

Some highlighted artefacts

It is important to review some artefacts in detail.

In **Fig. 5/1**, there is the largest artefact of the assemblage. Its dimensions are 84.8 mm × 50.75 mm × 17.7 mm. It has a plain butt with lip, the bulb is almost absent, but there is an oblong bulb scar. The artefact is a right-oriented offset piece; the degree of inclination is 20 degrees. On the upper face, there is a slightly curved, rounded ridge, so that the artefact has a sub-triangular cross-section. The upper face is shiny; the lower face has a moderate greyish patination layer. Both worn edges are bifacially retouched, but the retouch is irregular. The retouching detachments are not continuous. The edges are slightly rounded, either due to the usage or due to taphonomic effects. From a typological point of view, the artefact can be classified as an atypical double side-scraper or knife.

In **Fig. 6/1**, there is a large-sized artefact. Its dimensions are 73 mm × 41 mm × 16.4 mm. It has a cortical butt with lip, the bulb is absent, and there is no visible bulb scar. The artefact is a left-oriented offset piece; the degree of inclination is 30 degrees. On the upper face there is no continuous ridge, but two oblong flake scars, so that the artefact has a sub-trapezoid cross-section. The lower face has a very moderate greyish patination layer. The straight-lined left edge is relatively sharp. The curved right edge is partly rounded, that may be the result either of usage as unretouched knife or side-scraper, or taphonomic effects.

In **Fig. 6/2**, there is a large flake with dimensions of 64.7 mm × 40.2 mm × 14.8 mm. The conventional criterion for a flake of being a blade is that its length is at least equal to twice its width. Mainly in the English literature, there is a distinction between the true blade and blade-like flakes. A true blade shows traces of previous parallel removals on its upper face, and also has more or less parallel edges (Crabtree 1972, 42; Inizan et al. 1999, 130-131).

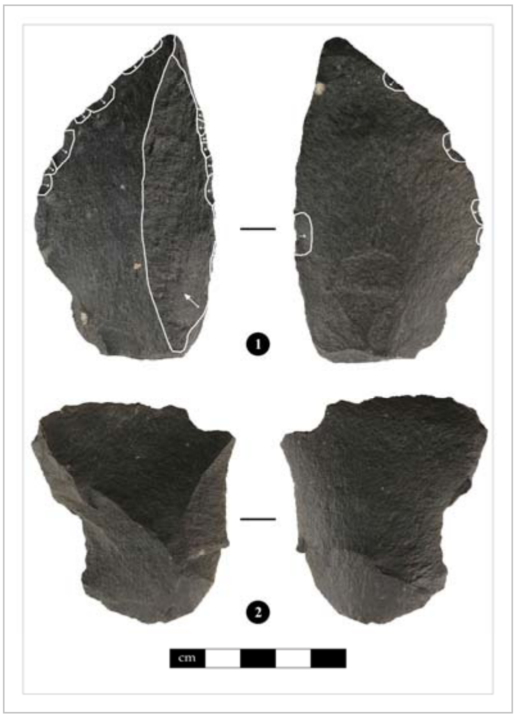

Fig. 5.: Selected artefacts. 1=Atypical double side-scraper or knife

5. ábra: Válogatott leletek. 1=Atipikus kettős kaparó vagy kés

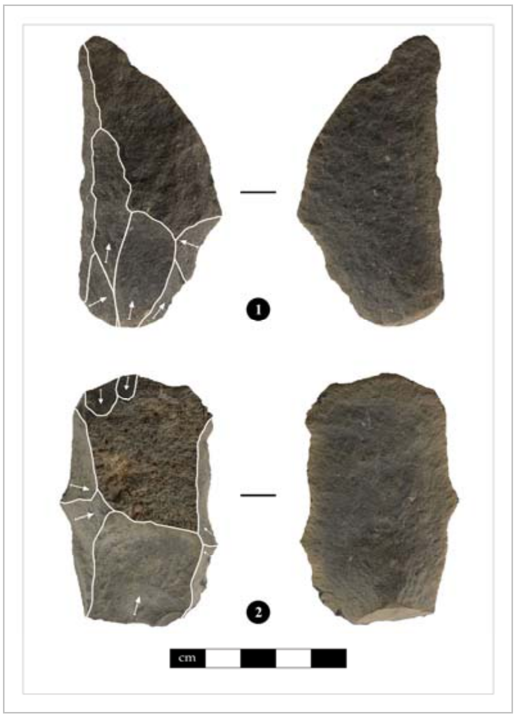

Fig. 6.: Selected artefacts. 1=Unretouched knife or side-scraper, 2= Elongated blade-like flake.

6. ábra: Válogatott leletek. 1=Retusálatlan kés vagy kaparó, 2=Nyújtott, pengeszerű szilánk

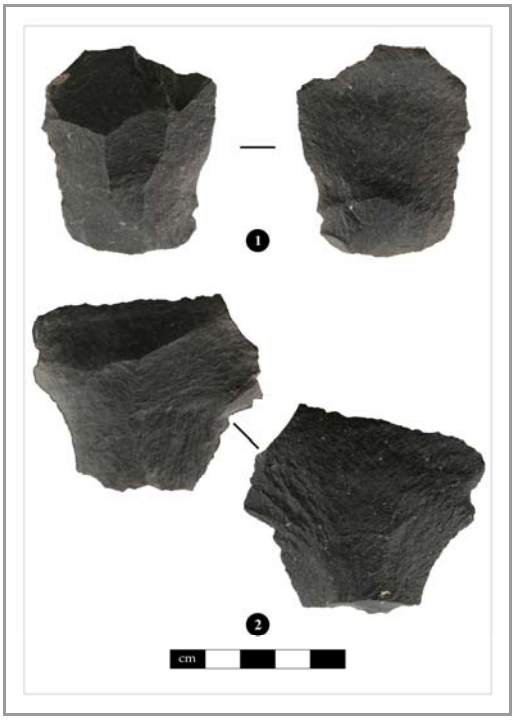

Fig. 7.: Selected artefacts

7. ábra: Válogatott leletek

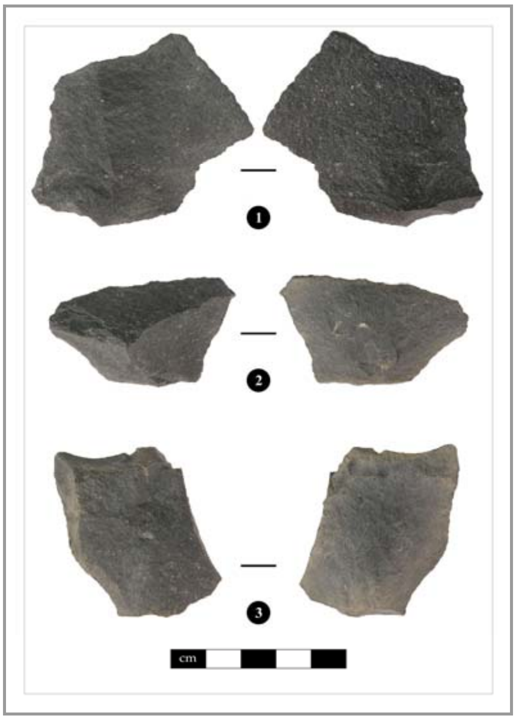

Fig. 8.: Selected artefacts

8. ábra: Válogatott leletek

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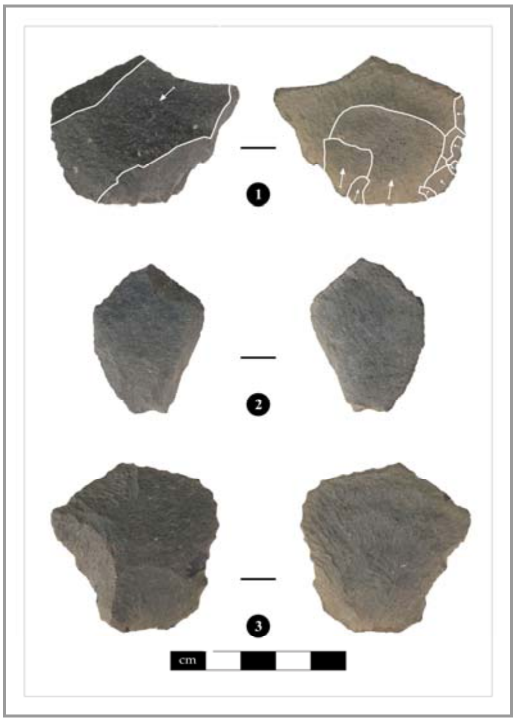

Fig. 9.: Selected artefacts. 1=End-scraper-like retouched tool.

9. ábra: Válogatott leletek. 1=Vakaró-szerű retusált eszköz.

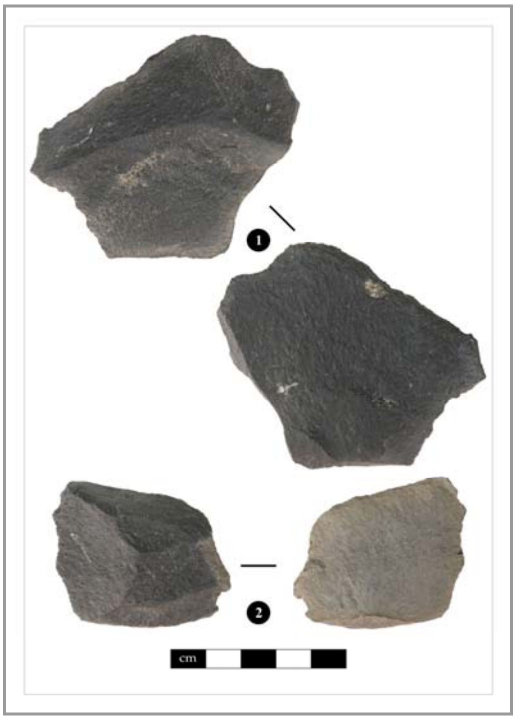

Fig. 10.: Selected artefacts. 1=Unretouched knife or side-scraper.

10. ábra: Válogatott leletek. 1=Retusálatlan kés vagy kaparó.

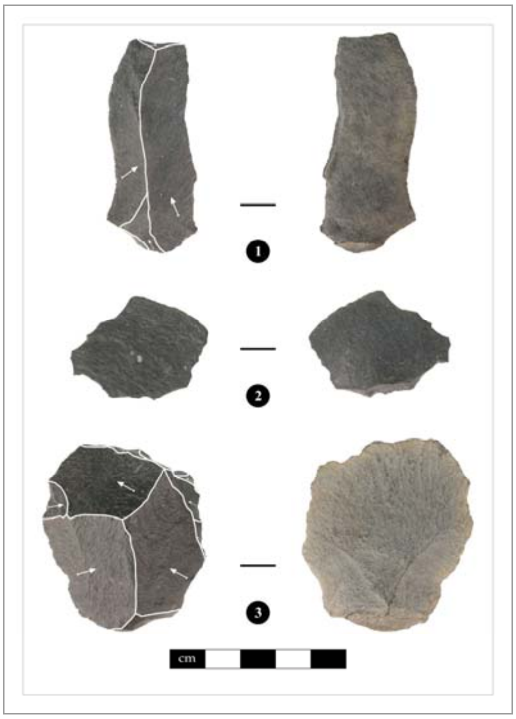

Fig. 11.: Selected artefacts. 1=Blade, 2=Core end-scraper

11. ábra: Válogatott leletek. 1=Penge, 2=Magkővakaró

Fig. 12.: Large-sized chunky flake

12. ábra: Nagyméretű vaskos szilánk

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The represented flake from Pueblo Sajama does not fulfil the criteria for being a blade (the L/W ratio is only 1.61), but from a technological point of view, it can be considered as a blade-like flake. The artefact was seemingly struck from an angular raw material block. It has a cortical butt with lip, the bulb is diffuse, and there is a small bulb scar to be seen. On both faces, there is a greyish patination layer. On the distal part of the artefact, there is the rest of the original cortex of the raw material block. The somewhat pitted surface may be the result of the above-mentioned sandblasting.

In **Fig. 9/1**, there is an intensely offset flake. The degree of inclination is about 35 degrees. The distal end of the artefact is broken a long time ago. Its dimensions are 43.5 mm × 48 mm × 12.2 mm. It has a hardly perceptible lineal butt without a lip. The bulb is absent, and there is no bulb scar. On the upper face, there is no obvious ridge; the artefact tends to follow the ridges on the surface of the raw material block. The artefact has an irregular trapezoid cross-section. The upper face is shiny, the lower face and the breakage surface at the distal end have pronounced greyish patination layer. The left edge originally may have been straight-lined. At the same time, the right edge is bent in 105 degrees. The rest of the left edge is damaged. The upper part of the right edge is chipped (scalloped), that may be the result of the use of the edge or taphonomic effects. On the lower face, near the base, the right edge shows some tiny inverse detachments in a length of 25 mm. Through these detachments, a scraper-like potentially working edge was created.

In **Fig. 11/1**, there is the sole blade in the assemblage. Its dimensions are 57.5 mm × 24.8 mm × 12.5 mm, the L/W ratio is 2.32. It is not clear enough whether the uneven distal end is broken or if it is the surface of the raw material block or core. Some kinds of raw material lend themselves to making blades. The edges and corners of tabular raw material often provide good ridges for starting a blade core (Whittaker 1995, 221). The represented artefact, despite its sinuous longitudinal profile, can be regarded as such a starting, primary blade. There is no bulb, but a lip. The right edge is damaged. On the lower face, there is a greyish patination layer.

Lastly, the artefact in **Fig. 11/3** should be mentioned. On the somewhat rounded edges, rough-and-ready traces of elaboration (retouch) can be seen, which allows the classification of the artefact as an end-scraper. It was made on a massive, chunky flake with dimensions of 48.4 mm × 44.3 mm × 19.7 mm. The flake is the thickest piece in the assemblage and may be the result of a knapping accident, because of which, due to an uncontrolled detachment an entire core-side was struck. The upper face is shiny, the lower face has pronounced greyish patination layer.

Petrology of the artefacts

Four rock samples, small-sized or mid-sized flakes having the least archaeological relevance have been studied (samples of PS5, 8, 9 and 14) to reveal their possible petrological connections. Macroscopically all samples have fine-grained aphanitic texture. Based on their dark greyish-black colour a mafic-neutral lava rock origin of the samples can be suggested. Samples of PS8 and 14 show stronger while PS5 and 9 weaker weathering crust.

Petrographic descriptions were carried out on polished thin sections with a Nikon YS2-T polarizing microscope (using NIS-Elements Br software) at the Department of Petrology and Geochemistry, Eötvös Loránd University (Budapest, Hungary).

Petrographical characteristics of the investigated samples

Terminological notes

Macrocryst: all kind of mineral crysts larger than 500 µm with a maximal size of ~1 mm are called as macrocrysts because their exact denomination (e.g. phenocryst, megacryst, xenocryst) and origin cannot be determined.
Microphenocryst: a considerable amount of mineral crysts which cannot be denominated as phenocrysts because of their smaller size ranging between 100-450 µm. Except for size parameters, they show strong similarities with macrocrysts.

Groundmass: the dominant component (~65-87 %) in all samples, it is made up of tiny crystals (usually smaller than 100 µm) and various amount of volcanic glass.

Minerals are listed in decreasing abundance in all case. Modal composition of each sample is shown in **Table 3.**

Sample PS5 (**Fig. 7/2**)

Rock name: basaltic andesite

Texture: porphyric hialopilitic

The rock consists of macrocrysts and cumulophyric clusters of plagioclase, augite, olivine, amphibole, biotite and magnetite (~2%); microphenocrysts of plagioclase, augite, olivine, magnetite and orthopyroxene (~33-34%) and groundmass made-up by plagioclase, augite, magnetite, orthopyroxene, apatite and volcanic glass (~65%) (**Fig. 5a-b**).

Table 3.: Modal composition of the investigated rock fragments. Three main categories are distinguished by size, they are indicated with bold characters, their detailed composition is given by italic characters. All components are given in volume %.

3. táblázat: A vizsgált kőzettöredékek modális összetétele. Méret szerint három fő kategóriát különbözettünk meg (félkövérrel szedve), az egyes kategóriákat alkotó fázisok arányát és nevét dőlt betűvel szedtük. Az egyes mennyiségek minden esetben térfogat %-ot jelentenek.

SAMPLE	PS5	PS8	PS9	PS14
Macrocrysts and cumulophyric clusters	**1.83**	**0.95**	**1.81**	**0.9**
plagioclase	*46*	*84*	*40*	*68*
olivine	*28*	*0*	*0*	*0*
orthopyroxene	*0*	*2*	*3*	*0*
augite	*19*	*9*	*56*	*32*
amphibole	*3*	*3*	*0*	*0*
biotite	*3*	*1*	*0*	*0*
magnetite	*1*	*0*	*1*	*0*
Microphenocrysts	**33.7**	**23.8**	**17.1**	**12.5**
plagioclase	*82*	*93*	*92*	*90*
olivine	*3*	*0*	*0*	*0*
orthopyroxene	*<1*	*<<1*	*<<1*	*<<1*
augite	*14*	*6*	*7*	*9*
magnetite	*2*	*1*	*1*	*1*
Groundmass	**64.5**	**75.3**	**81.1**	**86.6**
Glass in the groundmass	*25*	*6-8*	*<2*	*15*

Macrocrysts and cumulophyric clusters

Most common macrocryst is the subhedral-euhedral plagioclase. They often have a resorbed core or middle rim with strongly sieved texture and a euhedral, unaltered outermost rim. Oscillatory zonation is common. Augites are usually normal- and rarely sector-zoned, unaltered euhedral grains with a pale pinkish-brown colour. Olivines are eu- and subhedral, unaltered crystals often with a fine-grained clinopyroxene-plagioclase corona. Both augites and olivines contain small inclusions of magnetite, few olivine grains have Cr-spinel inclusions too.

Biotites are resorbed, partially or completely opacitized, anhedral grains. Amphiboles are anhedral, strongly resorbed and partially opacitized. The least common macrocryst is anhedral magnetite. Cumulophyric clusters consist of olivine+augite±plagioclase±magnetite; amphibole+plagioclase and biotite+plagioclase.

Microphenocrysts

The most common microphenocryst is plagioclase. They often have a sieved core and a euhedral outer rim, almost square-shaped sections are very common, largest grains show oscillatory zonation. Augites and olivines are eu- and subhedral, except their size (100-400 µm) they have the same characteristics as similar macrocrysts. Orthopyroxene is the least common microphenocryst; its columnar crystals have a maximal length of 150 µm. Augite overgrowth on orthopyroxene is common. Magnetite microphenocrysts (100-110 µm) are mostly anhedral, sometimes euhedral crystals, they are often connected to augite.

Groundmass

Plagioclase, augite, magnetite, olivine, orthopyroxene and accessory apatite can be found in the groundmass besides volcanic glass. Plagioclase and pyroxenes form dominantly elongated, euhedral crystals. Augite overgrowth on orthopyroxene is common. Euhedral-subhedral magnetite is evenly dispersed in the groundmass and it is often connected to augite. Euhedral-subhedral apatite has two types, a brownish-smoky and a colourless one. Volcanic glass is very abundant (~25 %), it has an orange-brown colour and it is rich in crystallites of clinopyroxene, plagioclase, magnetite and orthopyroxene.

Sample PS8 (**Fig. 10/1**)

Rock name: andesite

Texture: porphyric pilotaxitic

The rock consists of macrocrysts and cumulophyric clusters of plagioclase, augite, amphibole and biotite (~1%); microphenocrysts of plagioclase, augite, magnetite and orthopyroxene (~23-24%) and groundmass made-up by plagioclase, augite, magnetite, orthopyroxene, apatite and volcanic glass (~75%) (**Fig. 5c-d**).

Macrocrysts and cumulophyric clusters

Macrocrysts and cumulophyric clusters of subhedral-euhedral plagioclase often have a slightly resorbed core with sieved texture and a euhedral, unaltered outer rim. Oscillatory zonation is common. Augite macrocrysts are unaltered subhedral-anhedral grains with a pale pinkish-brown colour. They rarely show normal or patchy zonation, most of them are unzoned and all of them contain small inclusions of magnetite. Biotite and amphibole show strong resorption and they have an opacitized rim. Cumulophyric clusters consist of plagioclase; amphibole+biotite and plagio-clase+augite.

Microphenocrysts

Plagioclase microphenocryst often has a sieved core and a euhedral outer rim, larger grains show oscillatory zonation. Almost square-shaped sections of plagioclase are common. Augites are sub- and euhedral, except their size (100-180 μm) they have the same characteristics as similar macrocrysts. Magnetite microphenocrysts (100-150 μm) are mostly anhedral, sometimes euhedral crystals; they are often connected to augite. Euhedral orthopyroxene is the least common microphenocryst with a maximal length of 110 μm.

Groundmass

Plagioclase, augite, magnetite, orthopyroxene and accessory apatite can be found in the groundmass besides volcanic glass. Plagioclase and pyroxenes form dominantly elongated, euhedral crystals. Euhedral-subhedral magnetite is evenly dispersed in the groundmass and it is often connected to augite. Apatite is euhedral-subhedral; it has two types, a brownish-smoky and a colourless one. Volcanic glass is less abundant in the groundmass (~6-8%) than in sample PS5, it has a light orange-brown colour and it is rich in crystallites of plagioclase, clinopyroxene and magnetite.

Sample PS9 (**Fig. 8/3**)

Rock name: andesite

Texture: porphyric pilotaxitic/microholocrystalline

The rock consists of macrocrysts and cumulophyric clusters of augite, plagioclase, orthopyroxene and magnetite (~2%); microphenocrysts of plagioclase, augite, magnetite and orthopyroxene (~17%) and groundmass made-up by plagioclase, augite, magnetite, orthopyroxene, apatite and volcanic glass (~81%) (**Fig. 5e**).

Macrocrysts and cumulophyric clusters

Augite macrocrysts are unaltered subhedral-anhedral grains with a pale pinkish-brown colour. They rarely show normal or patchy zonation, most of them are unzoned and all of them contain small inclusions of magnetite. Macrocrysts and cumulophyric clusters of subhedral-euhedral plagioclase often have a fresh core, a slightly resorbed middle rim with sieved texture and occasionally a fresh euhedral outer rim. Anhedral, resorbed, slightly pleochroic (with a very pale pinkish-brown colour) orthopyroxene crystals are rare.

Cumulophyric clusters consist of plagioclase; plagioclase±augite±magnetite and augite+ortho-pyroxene. There are fine-grained, brownish patches in the groundmass around macrocrysts and cumulophyric clusters; they probably resemble completely opacitized crystals of amphibole or biotite.

Microphenocrysts

Plagioclase microphenocrysts often have a sieved core and a thin euhedral rim. The largest grains show oscillatory zonation. Almost square-shaped sections of plagioclase are rare. Augites are eu- and subhedral, except their size (100-380 μm) they have the same characteristics as similar macrocrysts. Magnetite microphenocrysts (100-250 μm) are mostly anhedral, sometimes euhedral; they are often connected to augite. Euhedral orthopyroxene is the least common microphenocryst with a maximal length of 200 μm.

Groundmass

Plagioclase, augite, magnetite, orthopyroxene and accessory apatite can be found in the groundmass besides volcanic glass. Plagioclase and pyroxenes form dominantly elongated, euhedral crystals. Euhedral-subhedral magnetite is evenly dispersed in the groundmass and it is often connected to augite. Apatite is euhedral-subhedral; it has two types, a brownish-smoky and a colourless one. Volcanic glass is rare (<2%), it has a light greyish-brown colour and it is rich in crystallites of clinopyroxene, plagioclase and magnetite.

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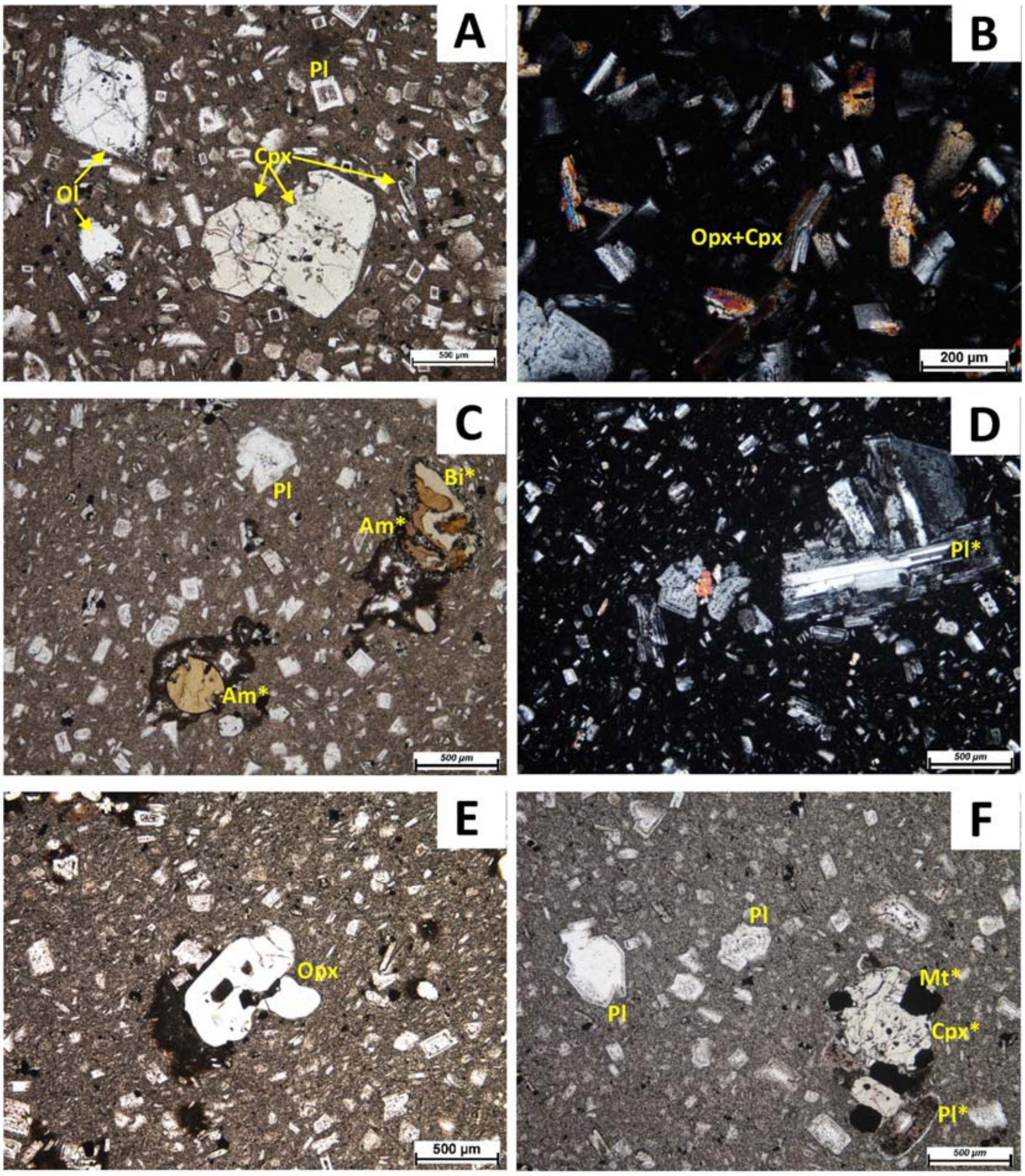

Fig. 13.: Characteristic microphotographs of the investigated samples. A – Large olivine and augite macrocrysts (possibly megacrysts), plagioclase microphenocrysts with sieved core and euhedral rim. Volcanic glass is very abundant in the groundmass (PS5). B – Clinopyroxene (augite) overgrowth on orthopyroxene microphenocrysts in the groundmass (PS5). C – Partially resorbed and opacitized amphibole and biotite megacrysts (PS8). D – Large plagioclase cumulophyric cluster of crysts with a more or less fresh core and a sieved rim (PS8). E – Large and resorbed orthopyroxene megacryst. Dark brownish areas in the groundmass could be completely opacitized crystals of amphibole and/or biotite (PS9). F – Cumulophyric cluster of augite, magnetite and plagioclase. Two generations of plagioclase microphenocrysts can be observed (fresh vs sieved core) (PS14).

A, C, E and F: PPL; B and D: XPL micrographs, Am – amphibole, Bi – biotite, Cpx – clinopyroxene, Mt – magnetite, Ol – olivine, Pl – plagioclase, * - crystal in cumulophyric cluster.

13. ábra: A vizsgált minták jellemző szöveti bélyegeit bemutató mikrofotók. A – Nagyméretű olivin és augit makrokristályok (feltehetően megakristályok), szivacsos magvú plagioklász sajátalakú peremmel. Az alapanyag kifejezetten üveggazdag (PS5). B – Klinopiroxén (augit) ránövekedés ortopiroxén mikrofenokristályokon az alapanyagban (PS5). C – Részlegesen visszaoldódott és opacitosodott amfibol és biotit megakristályok (PS8). D – Nagyméretű plagioklász kumulokristályokból álló "csomó", többé-kevésbé üde maggal és szivacsos szövetű peremi részekkel (PS8). E – Nagyméretű, rezorbeált ortopiroxén megakristály. Az alapanyagban megjelenő sötétbarna területek feltehetően teljes mértékben opacitosodott amfibolok és/vagy biotitok maradványai lehetnek (PS9). F – Augit, magnetit és plagioklász kumulokristályokból álló "csomó". A plagioklász mikrofenokristályok két generációsak (szivacsos vagy üde mag) (PS14).

A, C, E and F: 1N; B and D: +N felvételek, Am – amfibol, Bi – biotit, Cpx – klinopiroxén, Mt – magnetit, Ol – olivin, Pl – plagioklász, * - kumulokristályok ásványcsomóban.

Sample PS14 (**Fig. 8/1**)

Rock name: andesite

Texture: porphyric hialopilitic

The rock consists of macrocrysts and cumulophyric clusters of plagioclase and augite (~1%); microphenocrysts of plagioclase, augite, magnetite and orthopyroxene (~12-13 %) and groundmass made-up by plagioclase, augite, magnetite, orthopyroxene, apatite and volcanic glass (~86-87%) (**Fig. 5f**). A small dioritic xenolith (with plagioclase, clinopyroxene, magnetite and biotite) is observable in the sample.

Macrocrysts and cumulophyric clusters

The macrocrysts and cumulophyric clusters of subhedral-euhedral plagioclase often have a quite fresh, slightly resorbed core, a middle rim with sieved texture and a fresh euhedral outer rim. Oscillatory zonation is common. Augites are usually normally zoned, unaltered euhedral-subhedral grains with pale pinkish-brown colour and they contain small inclusions of magnetite. Cumulophyric clusters consist of plagioclase and augite±plagioclase±magnetite.

Microphenocrysts

Plagioclase microphenocrysts often have a sieved core and a euhedral rim; almost square-shaped sections of plagioclase are rare. The largest grains show oscillatory zonation. Augites are eu- and subhedral, except their size (100-420 µm) they have the same characteristics as augite macrocrysts. Magnetite microphenocrysts (100-150 µm) are mostly anhedral, sometimes euhedral crystals; they are often connected to augite. Euhedral orthopyroxene is the least common microphenocryst with a maximal length of 120 µm.

Groundmass

Plagioclase, augite, magnetite, orthopyroxene and accessory apatite can be found in the groundmass besides volcanic glass. Plagioclase and pyroxenes form dominantly elongated, euhedral crystals. Euhedral-subhedral magnetite is evenly dispersed in the groundmass and it is often connected to augite Apatite is euhedral-subhedral, it has two types, a brownish-smoky and a colourless one. Volcanic glass is abundant (~15%), it has a light greyish-brown colour and it is rich in crystallites of clinopyroxene, plagioclase and magnetite.

Discussion and petrological conclusions

The investigated rock samples have important common textural properties, namely the presence of various type cumulophyric clusters and relatively large individual grains called "macrocrysts", the dominance of plagioclase in all scale and the two-generation plagioclase crystals (fresh, euhedral overgrowth on sieved±resorbed cores in larger grains). The mineral assemblage of the rock samples is quite similar; however, there are some differences that could be crucial from petrogenetic point of view.

Textural features of macrocrysts and cumulophyric clusters (e.g. relatively large size, often strong resorption, sieved cores or middle zones of plagioclase, opacitization of amphibole and biotite) indicate that most of them were not in equilibrium with the melt (**Fig. 13c-f**). This suggests that these crystals represent a different geochemical environment and they were incorporated by the ascending magma. Olivine and augite in PS5 are the only macrocrysts which are almost completely fresh (**Fig. 13a**). Additionally, sample PS5 is unique in several other ways: it is the only that contains olivine (in all scales), olivine and augite cumulophyric clusters are fresh and slightly or not resorbed, augite overgrowth on orthopyroxene (**Fig. 13b**) is common and the groundmass is rich in orange-coloured volcanic glass.

Fresh olivine macrocrysts and the considerable amount of orange-coloured volcanic glass (**Fig. 13a**) in PS5 suggest that its parental melt was basaltic in composition and "dry"; it ascended very fast and cooled rapidly on the surface. The textural complexity of plagioclase- and the resorption and opacitization of biotite- and amphibole macrocrysts/clusters show that they were not in equilibrium with that basaltic melt, most likely they were incorporated by the ascending magma from the crust (dioritic rock fragments or crystal mush). The abundance of square-shaped sections of plagioclase microphenocrysts (**Fig. 13a,c**) may indicate a flow direction perpendicular to the plane of the thin section and more importantly a lava flow origin of the rock.

As it was written above, olivine is absent in all other rock slides. There are other important compositional differences between individual samples. The abundance of plagioclase microphenocrysts is increasing in the order of PS5, PS14, PS9 and PS8, whereas the abundance of clinopyroxene microphenocrysts is decreasing in the order of PS5, PS14, PS9 and PS8. In the case of macrocrysts and clusters, amphibole and biotite are resorbed and opacitized partially in PS8, completely in PS9 and absent in PS14. Plagioclase has a sieved core in PS5 and PS8 whereas they have a fresh core in PS9 and PS14.

Based on the petrogenetic assumptions of PS5 and the compositional/textural variations between the samples, the origin of the three other samples could be explained by differences in crustal contamination, magma ascent and cooling rate. We suggest that the ratio of the primary basaltic melt and the incorporated crustal material decreases in the order of PS5, PS14, PS9 and PS8 – following the augite and plagioclase content of the rocks. Ascent rate could be relatively fast of PS5, PS8 (based on unaltered olivines and not completely altered amphiboles and biotites) and could be slower of PS9, PS14 (based on the absence or total breakdown of amphibole and biotite). Lava cooling rate could be the fastest of PS5 and PS14, slower of PS8 and the slowest of PS9 (based on glass content). Orthopyroxene macrocrysts in PS8 and PS9 (**Fig. 13e**) could imply slight differences in the composition of the incorporated crustal material.

In conclusion, the four investigated rock samples are fragments of differently cooled lava flows with petrogenetically close origin characterized dominantly by various crustal contamination of a basaltic primary magma. Most probably they are parts of the same volcanic series and they were erupted by a single volcano in different eruptions or different stages of an eruptive phase.

There are three Quaternary monogenetic volcanic fields behind the Central Andean Arc in Bolivia and on the Bolivian Altiplano. Their little volcanic centres consist mostly of mafic or neutral rocks (basalt, andesite, basaltic trachyandesite, trachyandesite, rarely picrite) while more silicic rocks (dacite) are less frequent. None of them represents the primitive basaltic melt due to different degree of crustal contamination and/or fractional crystallization (Davidson & Silva 1992). The monogenetic fields (and their dominant rock types) are the following: 1) the northernmost field lies on the eastern flanks of the Nevado Sajama stratovolcano (olivine-augite-phyric trachyandesites); 2) the largest field lies on the south, around the Salar de Uyuni and Salar Coipasa basins (dacites and olivine-phyric basalts); 3) the smallest field lies to the west of the Lago Poopo (olivine-phyric basalts). In the basaltic rocks of the second monogenetic volcanic field, large plagioclase phenocrysts are abundant (probably from the underlying andesitic and dacitic formations), while the rocks of the third monogenetic field contain xenocrysts of quartz, orthopyroxene, apatite, kyanite, alkali feldspar and xenoliths of sillimanite gneiss (Davidson & Silva 1992).

Since all rock names mentioned by Davidson & Silva (1992) are based on geochemical analyses and more detailed petrographic descriptions of the formations cannot be found, the origin of the investigated lithic artefacts cannot be stated by absolute certainty. The lack of the metamorphic xenocryst assemblage in the basaltic and andesitic artefacts excludes the third monogenetic field (to the west of Lago Poopo) as provenance area. The second volcanic field is also not very likely as a source region because it consists dominantly of dacitic volcanoes. On the other hand, the basic mineralogical characteristics of the rocks from the northernmost volcanic field and of the artefacts are very similar. Additionally, the proximity of the archaeological site suggests that the monogenetic volcanic field on the eastern flank of the Nevado Sajama could be the most likely provenance of the artefacts; however, the exact location of the quarrying site cannot be named.

Discussion

According to Yara Lizarraga-Mehringer (2004, 90), it is possible to formulate hypotheses about the production process of lithic artefacts, although the surface artefacts may come from different periods. Besides, the rounded edges or patina of some artefacts reveal processes, to which they were subjected during sedimentation. In the cores, flakes and other stone artefacts, the production technique can be recognized. This theoretical approach is proper in a case of a relatively large lithic assemblage of some hundreds of artefacts, but it is hardly applicable for the little collection of Pueblo Sajama. However, there is an indirect possibility to try to determine the age and cultural affiliation of this assemblage, by taking into consideration some circumstantial evidence, such as the question of the utilized raw material, technological features, traceable typological features in the surrounding area that can imply cultural connections, and taphonomical aspects.

1) Concerning the raw material utilization, it is important to emphasize the fact that generally, the lack of cores and corticated primary flakes at a given archaeological site indicates rather the non-local origin of the utilized raw material. In the case of the small lithic assemblage of Pueblo Sajama, the indication of the non-local origin of the utilized basaltic-andesite cannot be stated with certainty. Both in the Archaic Period and the Formative Period, there are some lithic assemblages from archaeologically significant sites (e. g. Viscachani (Lizarraga-Mehringer 2004); Tiwanaku heartland (Giesso 2010); Jachakala (Beaule 2002)), where raw materials from 100 to 200 kilometres were often used. According to M. Michel (2000), the utilization of black basalt, as a typically long-distance raw material was common even during the Carangas Period.

2) In connection with the quantitative attributes, it was already mentioned that based on the characteristics, no standardization in the manufacturing procedure seems to be indicated. Neither the measured data nor the derived data show any statistical tendency. No correlation between any two of the attributes was observed. The assemblage seems to be a random collection of artefacts. The mentioned irregularities in the silhouette, aside from the supposed breaks, implicate that the flakes had not been struck off from prepared cores. On the contrary, it is very

likely that most of the flakes were core preparation and/or shaping flakes. It would by all means suggest that the collected little assemblage is only part of a greater lithic assemblage.

3) It is necessary to mention, as an important typological feature, the presence of the so-called "Patapatane" type leaf-points in the Nevado Sajama Region from the Wiscachcalca site and several projectile points from the Archaic Period at the site of Wakolli. These facts suggest that despite the certain research hiatus concerning the Nevado Sajama region, there are obvious traces of human occupation during the Archaic Period. The late phase within the Early Archaic period, located temporarily between 9,500 and 8,000 BP. According to some authors (Santoro & Núñez 1987; Santoro 1989, 40-46; Klink & Aldenderfer 2005, 32-33), the Patapatane projectile point is a strong indicator of a highly specialized bifacial and curator technology. This particular type of projectile point persisted for most of the early Holocene, suggesting some form of stability over time. The use of long-distance lithic raw materials, indicating distinct cultural connections and the obvious resemblance of projectile points gives a larger dimension to the sharing of technological know-how, subsistence strategy, settlement organization, and other cultural patterns of these early highland hunter-gatherer groups (Osorio et al. 2017a, 9).

4) As regards the surface alteration of the artefacts, such as the shiny, smooth, polished surfaces or the greyish weathering layer, the origin, and cause of these phenomena are unknown for the time being. It is not even possible to denominate properly these given phenomena. Recently, Paula C. Ugalde (2015) dealt with the issue of the weathering of superficial lithic assemblages in arid environments. In this case study, lithic assemblages of Holocene archaeological sites from different microenvironments in the Atacama Desert of Northern Chile were analyzed. Changes in polish, texture, shine, and colour were used as descriptive attributes to establish significant differences in weathering between different locations, such as interfluves and canyon sites. In our point of interest, this study is important due to the analyzed raw material, which is an igneous rock, supposedly having some similarities to the basaltic-andesite used at Pueblo Sajama. To control for internal factors of weathering and to facilitate comparisons between sites, only silicified ignimbrite lithic artefacts were selected. Ignimbrite is a high temperature acidic welded volcanic ash, composed of 70-75% SiO_2. Ignimbrite is a fine-grained vitreous raw material, and well suitable for knapping. The results suggested that for interfluve (a region between the valleys of adjacent watercourses, especially in a dissected upland; these environmental conditions are highly comparable with those of Pueblo Sajama) assemblages, three principal variables are positively and significantly correlated (polishing and texture, polishing and shine, and shine and texture are all significantly associated). This implies that as edges and ridges are further polished, the artefact surfaces become shinier and smoother. The same does not occur for canyon assemblages, for which only shine and texture variables are positively and significantly correlated, whereas polishing and shine are negatively correlated (Ugalde et al. 2015, 360). According to the authors, the sampled archaeological surface lithics were very likely deposited between 6,000 and 500 cal yr BP. Observations of "natural" clasts present in the interfluves surrounding the archaeological sites indicate that these are more extensively weathered than the archaeological artefacts. The differential weathering between the interfluves and canyon sites may be explained firstly by the fact that wind intensity is a major driver of the differences in weathering degree and type, as it less intense within the canyon than on the interfluves. The conclusion of the authors was, that

"*... relative chronological sequences can be constructed within specific localities based on artifact weathering, as long as they are complemented with other lines of evidence such as stratigraphy, technological features, typologies, and detailed knowledge of past environmental conditions*." (Ugalde et al. 2015, 364).

The cultural traits provide that the earliest human occupation belongs to the Late Archaic Period (ca. 6,000 to 4,000 cal yr BP). An AMS 14C age obtained from an excavation performed at the lithic cluster Chacarilla 15 places the very first human occupation at 5,529 cal yr BP (UCIAMS 84354; Santoro et al. 2011, 359, Table 1).

5) Based on petrological descriptions of the artefacts and on literature data (Davidson & Silva 1992) the most likely provenance of the stone flips is the mafic monogenetic volcanic field on the eastern flanks of the Nevado Sajama volcano.

In conclusion, we believe that the actual age and cultural affiliation of the artefacts can only be decided on a significantly larger lithic assemblage containing some characteristic culture-specific artefacts as well. To this end, it would be desirable to carry out systematic collection and documentation activities at the site and its direct vicinity.

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