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ARTICLE

First Assessment of a Pebble Tool Industry in the Pesqueiro River Valley, Upper Uruguay River Basin, Southern Brazil

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Abstract

This article presents the first findings of a topographic survey plotting the location of archaeological material and of a technological study of the lithic industry at the SC-CHA-030 open-air archaeological site along the Pesqueiro riverbank, located in the upper course of the Uruguay River Basin in southwestern Brazil. We analyzed raw material selection and the production of shaped/façonnage tools (unifacial, bifacial, and trihedral) associated with the production (debitage) of cortical and semi-cortical flakes that were then transformed into tools by simple retouch. From the geoarchaeological point of view, the spatial distribution pattern of the material is meaningful in the context of the geomorphic transition between foothills and alluvial plain. Our study of technological behavior and the formation of archaeological sites finds that raw material and shaped pebble tools are a crucial aspect of the industries on the Paraná Basaltic Plateau of southern Brazil.

Resumen

Este artículo presenta un estudio de los primeros hallazgos efectuados en el sitio arqueológico a cielo abierto SC-CHA-030, ubicado en la ribera del río Pesqueiro (curso superior de la cuenca del río Uruguay, suroeste de Brasil). Hemos realizado un levantamiento topográfico (ubicando de manera precisa la procedencia del material arqueológico) y un estudio tecnológico de la industria lítica, lo que nos ha permitido comprender mejor la selección de la materia prima, y la producción de herramientas (façonnage unifacial, bifacial y trihedral) asociadas a la producción (debitage) de lascas corticales y semicorticales, transformadas en herramientas por simples retoques. Desde el punto de vista geoarqueológico, observamos que el patrón de distribución espacial del material arqueológico es significativo en el contexto de transición geomórfica: vertiente y llanura aluvial. Este trabajo presenta un nuevo estudio exhaustivo sobre el comportamiento tecnológico y la formación de los sitios arqueológicos de la región, destacando que la materia prima y las herramientas talladas sobre cantos rodados son un aspecto crucial de las industrias líticas que se encuentran en la meseta volcánica del sur de Brasil.

Keywords: lithic technology; pebble tool industry; geoarchaeology; open-air site; Brazilian archaeology; southern Brazil archaeology

Palabras clave: tecnología lítica; industria de cantos rodados; geoarqueología; sitio al aire libre; arqueología brasileña; arqueología del sur de Brasil

Regional Archaeological Issues

Human occupations in the interior of southern Brazil are mostly found in the geomorphological unit related to the broad volcanic plateau, the Paraná Basaltic Plateau (PBP), which stretches across the Brazilian states of Paraná, Santa Catarina, and Rio Grande do Sul (Almeida 1956; Kröhling et al. 2014). The archaeological sites located on the PBP and along its main hydrographic basins (Uruguay and Paraná Rivers) have occupations ranging from ≈13 ky BP to the colonial period (Pereira Santos 2023). Based on their material culture, the literature has simplistically classified these occupations into two main groups: preceramic groups engaged in hunting and gathering (associated with dates from the Pleistocene–Holocene transition and the entire Holocene) and ceramic groups engaged in horticultural activities (linked to dates from the Upper Holocene to colonization; Araújo 2015; Bonomo et al. 2015; Iriarte et al. 2017; Lourdeau et al. 2016; Parellada 2008; Schmitz 1987).

Ceramic material culture in the region has been related to the Tupiguarani and Taquara/Itararé traditions. The Tupiguarani sites are identified in lowland areas close to the Uruguay River, whereas the Taquara-Itararé sites are in higher altitudes located far from the riverbanks (Carbonera and Loponte 2015; Carbonera et al. 2018; Schmitz 2011). These locations are consistent with the settlement models that consider the major hydrographic basin as routes of dispersion, with the Uruguay River representing the main access route for settlement and occupation in the southern area of the PBP (Bueno and Dias 2015; Pereira Santos 2023).

The lithic industries found in the interior of the PBP have traditionally been grouped according to the presence of a particular type of material used as a "fossil guide." The main drawback of using this classification is that the cultural, behavioral, and chronological significance of these traditions is poorly supported by the data. According to this view, the preceramic sites in southern Brazil are related to two main traditions, Umbú and Humaitá; this dichotomy is based on the presence or absence of projectile points, respectively, among the lithic tools found at each archaeological site. Thus, the sites where projectile points were found were grouped under the label Umbú; conversely, every site with an absence of projectile points but with lithic assemblages characterized by the presence of industry made of pebbles and blocks—choppers, flake, cores, large flakes from unidirectional cores, and a variety of big unifacial and bifacial tools—were grouped under the label Humaitá (Rohr 1966, 1968; Schmitz and Becker 1968). Sites characterized as belonging to the Humaitá tradition existed for thousands of years, from 8.6 to 0.3 ky BP (Kern 1982; Mentz Ribeiro 1999; Schmitz 1978); they were found across the Alto Paraná and the Alto Uruguay regions in Brazil, the Misiones Province in Argentina and in Eastern Paraguay (Schmitz and Becker 1968), and in the Corrientes region in Argentina where these archaeological assemblages were labeled as part of the Alto-Paranaense tradition (Menghin 1955).

In the last two decades this categorization of the archaeological material culture of southern Brazil has been challenged, especially regarding its use of the techno-typology of the lithic industry to classify traditions (Dias 2007; Dias and Hoeltz 2010; Hoeltz 2005). Currently, archaeological sites with knapped lithic industries that do not have bifacial projectile points or are not associated with specific pottery groups are no longer automatically considered to be part of the Humaitá tradition. These sites could have been occupied at any time within a period of 12,000 years of precontact archaeological documentation in southern Brazil. It is now clear that a deeper investigation of the entire collection of the site—not only of the fossil guide—and a greater understanding of the role of the site in the landscape are required to better understand human behavior and activities; this is especially true in the PBP region, which is rich in open-air archaeological sites that suffer from a poorly characterized chronology and poorly described stone tools.

This article presents the research carried out at the SC-CHA-030 site, which focuses on the lithic industries using pebbles and blocks that were found at sites located on river valley bottoms in the interior of the PBP. The initial aim was to understand the debitage and façonnage methods, as well as the technological objectives of the industry in relation to the characteristics of the raw materials. We then analyzed the spatial distribution of the lithic materials in two sectors of the valley (hillslope and floodplain) from a geoarchaeological perspective. This analysis addressed questions about the formation of the site and its archaeological significance in relation to local and regional geomorphological dynamics.

The SC-CHA-30 Archaeological Site

The SC-CHA-030 archaeological site is located on the left bank of the Pesqueiro River at about 370 m asl in the municipality of Jardinópolis (Figure 1). It consists of a surface dispersion of knapped lithic materials in an area of 12,300 m^2 of the alluvial plain: the entire alluvial plain measures approximately 163,000 m^2. The site is located on the shoulder of the slope and especially on colluvial-alluvial terrace (CAT) geomorphic surfaces near a meander in the lower course of the Pesqueiro River (Figure 1b). The topography of the plain is slightly inclined toward the river channel, with approximately 10 m of unevenness until it is interrupted by the river channel, which exposes the stratigraphic sequence of

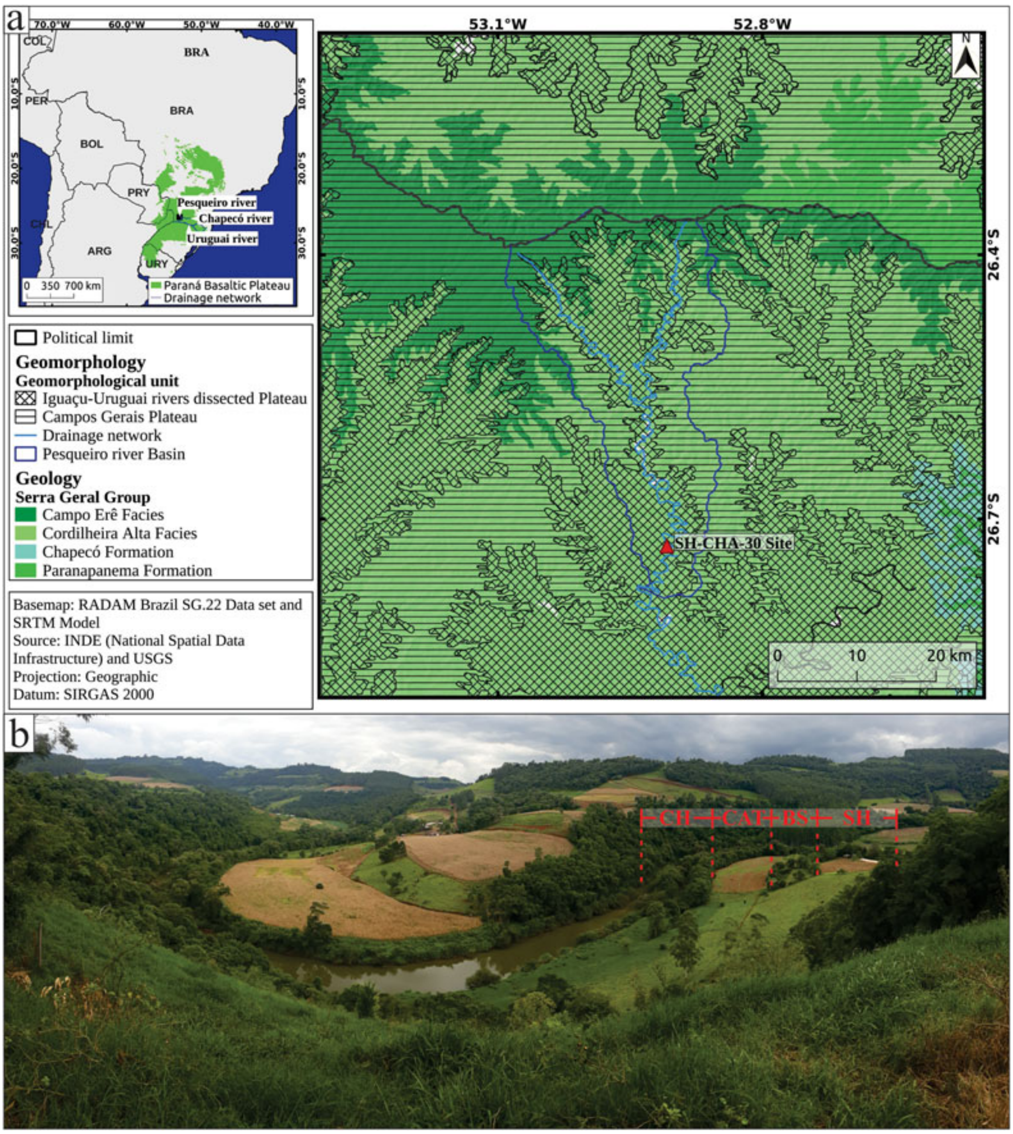

Figure 1. Location, geology, and geomorphology of the Pesqueiro River basin. (a) The dissected part is linked to the hydrographic systems of the Iguaçu (north) and Uruguay (south) Rivers and to the (b) bioarchaeological context. SH = shoulder; BS = Backslope; CAT = colluvial-alluvial terrace; CH = channel.

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the CAT, which is formed mainly of mud facies. The Pesqueiro River channel has central bars made of gravel that have high-capacity fluvial dynamics and provide lithic raw materials in that section of the river. Local communities have used the survey area for pastures and planting; consequently, the area has probably suffered historical disturbance by ploughing activities. The site was discovered in 2018, during the survey activities in the area of the Lambari hydroelectric power plant in the municipalities of Sul Brasil and Jardinópolis, Santa Catarina, in southern Brazil (Campos and Pereira Santos 2019).

The archaeological materials consist of large blanks (>10 cm^3) made of fluvial pebbles of reddish volcano-sedimentary rock of different morphologies. From the taphonomic point of view, some pieces have rounded edges and patina/neocortex formations, indicating their exposure to abrasion and dissolution by water flow or siliciclastic sediments (Howard 1999, 2002).

The lithic raw materials present in the drainage basin of the Pesqueiro River come from volcanic rock facies, labeled Cordilheira Alta and Campo Erê; both are from the Serra Geral Group of the Paraná Sedimentary Basin (Bergmann and Provenzano 2014). The Cordilheira Alta facies is made up of flood basalts and andesitic basalts with grayish to bluish tonalities. Hydrothermal lithotypes are sporadic and range from bluish green to red in color. Geodes filled with chalcedony and quartz are common, in addition to inter-spill volcano-sedimentary interaction features, such as fine to medium sandstone, conglomeratic sandstone, conglomerates, and peperites (Bergmann and Provenzano 2014). The Campo Erê facies consist of grayish andesitic basalts of microporphyritic and porphyritic or granular texture. Geodes filled with amethyst, chalcedony, and hyaline quartz can also be observed, in addition to inter-spill volcano-sedimentary interaction features, such as peperite and clastic dikes. Pegmatites and pyroclastic deposits can be found in the Pesqueiro River valley in both facies in tufts and breccia (Figure 1a).

From the geomorphological point of view, the area of the archaeological site is inserted in the dissected sector of the PBP, whose erosive agents are associated with the Paraná and Uruguay hydrographic systems (Paz and Collischonn 2008; Scheibe 1986). The drainage basin of the Pesqueiro River is part of the upper valley of the Uruguay River, in which there is a morphological individualization of stepped reliefs and incisive valleys with altimetric amplitudes between 190 and 260 m asl (Justus et al. 1986).

The Pesqueiro River basin has flat and convex tops, with straight and concave slopes with a gradient of 100 m (top about 450 m asl and base about 350 m asl). The slopes have shallow colluvial coverage, about 1 m thick comprising chaotic blocks and boulders together with a predominance of mud facies consisting of iron oxyhydroxides (Figure 1). This formation corresponds to regional sedimentary characteristics (Paisani et al. 2019).

The site area is associated with a subtropical climate, which is very humid, with rainfall ranging between 1,700 and 2,000 mm per year and an average annual temperature between 20°C and 23°C; the absolute minimum is between −4°C and −1°C, and the maximum is between 41°C and 44°C (Rossato 2011). The vegetation is marked by the meeting of two phytophysiognomies: Seasonal Deciduous Forest in the lower-altitude areas and Mixed Ombrophilous Forest in the higher-altitude areas (Klein 1972).

Materials and Methods

Survey Method

A systematic survey of the entire area of the alluvial plain and the slopes was performed, with test pits of 1 m in depth dug every 50 m. All the archaeological materials found were collected and their position registered. To establish the spatial distribution of the lithic materials, a study of the topography of the terrain was carried out, and the spatial positioning of the lithic pieces was recorded using GNSS receiver equipment in real-time kinematic (RTK), using a Topcon GPT 3200N Total Station and Garmin eTrex 20× GPS. The georeferencing of the local topography and lithic pieces was based on a UTM plane coordinate system in relation to DATUM SIRGAS 2000, 22 South zone. Spatial data processing was carried out using the Trimble Business Center and MAPGEO 2010 software, with correction of the points using the Excel software of Microsoft Office. The maps were prepared using the QGIS Release 3.10 program.

Lithic Technology and Techno-Functional Analysis

Raw materials were described using macroscopic petrographic criteria, supported by the study of the geological and geomorphological regional context. The lithic assemblage was examined macroscopically with a magnifying glass (20×) and divided into lithotypes (Kooyman 2001). The macroscopic petrography followed the descriptive criteria contained in Sgarbi (2012). In addition, we used parameters that had been used by Jerram and Petford (2014) for igneous and Tucker (2014) for sedimentary features. The nomenclature of rocks and minerals follows the lithological descriptions of the Serra Geral Group contained in Milani and colleagues (2007). When possible, the type of natural blank used for knapping was defined based on aspects of the cortex (block or fluvial pebble).

The lithic assemblage was analyzed using the technological approach (Boëda 2013; Inizan et al. 2017), and the attributes of each artifact were recorded in a database. All the lithic pieces were measured (length, width, and height) according to their morphological axes (i.e., the length is the major dimension of the piece). The volume of the material (V, cm^3) was calculated based on the method used to evaluate the volume of clasts in sedimentology (Nichols 2009).

We focused on the *debitage*—the process of lithic reduction carried out on a block of raw material, or core, the objective of which is the production of flakes—and *façonnage*, the configuration of a block or a portion of a block used to shape a tool. The flakes obtained during reduction are considered production waste, whereas the resulting modified block is the objective of the process (Inizian et al. 2017). In the case of façonnage, we also used the concept of *affordance*, sensu Boëda and others (2021), which refers to a characteristic of the initial block of raw material that is suited to the action that the knapper intends to perform. In other words, it consists of the selection of techno-functional criteria naturally present in the initial raw block that are to be maintained in the final object (Boëda et al. 2021).

The pieces were initially divided into four technological categories: cores, knapped pebbles (either core or tool), flakes, and fragments (broken, not orientable materials). The flakes were subdivided into cortical, semi-cortical, and acortical categories based on cortex quantities. The other features were the type of butt, the morphology and orientation of the removals, the role of the flake (opening stage or production stage), and whether there was a delineation of edge by retouch.

Knapped pebbles and cores were described according to the morpho-volumetric characteristics of the natural blank and exploitation patterns (Cunha-Ribeiro 2004; Cura 2014; Inizan et al. 2017). A problematic issue was how to differentiate the roles of knapped pebbles because these materials could be either tools or cores. Consequently, we analyzed them in the technological category of "knapped pebbles," and to distinguish their role as tools or cores, we considered the presence of an intentionally modified cutting edge, when possible. A diacritical analysis was carried out to understand the core reduction sequence, enabling the construction of hypothetical models of reduction and management of the blanks (Dauvois 1976).

The techno-functional analysis aimed to find the functional logic underlying the tool-making phase by looking for regularities and recurrences in the resulting adjustments and the technical consequences of these adjustments (Soriano 2000:131). This process was first theorized as *Théorie artisanale* (Lepot 1993) and then perfected by Boëda (2013). It has been applied in several South American contexts (Boëda et al. 2021; Da Costa 2017; Pérez et al. 2020).

The transformative techno-functional unity (UTF-t) is the part of the tool that is in contact and modifies the material. It is determined by homogeneous and regular technical parameters on a portion of the tool identified by considering the location, edge delineation, profile view, angles, and surface relations (Da Costa 2017). The prehensile techno-functional unity (UTF-p) consists of the handle; that is, the part of the tool that is in contact with the user (with or without an intermediary). The UTF-p is usually defined in relation to the UTF-t (Bonilauri 2010). The presence of macro-traces, indicating the potential use of the tool, was evaluated based on the presence of polish, abrasion, and minor removals (Inizian et al. 2017).

Results: Lithic Technology

Selection of Raw Materials

The lithic raw materials used at the site are volcano-sedimentary rocks (83.7%), volcanic rocks (7.5%), chalcedony (6.2%), and quartz (2.5%). Volcano-sedimentary rocks are aphanitic, felsic, leukocratic, and non-porphyric, which indicates an extrusive origin. They occasionally present small vesicles, whereas amygdales are rare. Some samples have dark spherical features (orbicular type) and locally occurring layering. Differences such as iron oxide impregnations, which mainly fill vesicles, are visible on the surface of some rocks.

From the petrographic point of view, the samples are part of the basic volcanic rocks of the Serra Geral Group, possibly basalts and andesitic basalts, in addition to having volcano-sedimentary interaction features. The volcano-sedimentary rocks present characteristics of fine sandstones and pelites, both with indications of silicification. The chalcedony and quartz come from geodes of the Serra Geral Group (Bergmann and Provenzano 2014).

Eleven lithotypes were defined based on granulometric characteristics and surface textural aspects: seven are volcano-sedimentary (V-S), two are volcanic (V), and two are minerals (chalcedony and quartz; Supplemental Figure 1).

V-S rocks made up 83% of the analyzed group of lithic materials at the SC-CHA-030 site; lithotypes 1, 2, and 3 represent 68% of this total. Although the macroscopic differences between them are subtle, it was possible to perceive two luster groups: those with a resinous appearance and those with a dull appearance (Supplemental Figure 1; Supplemental Table 1). The dull appearance is visible in 66% of the samples, and the resinous appearance is found in 25%. Minerals (chalcedony and quartz) account for 12% and volcanic rocks (basalt and andesitic basalt) 7% of the lithic materials.

The knapped natural blanks were predominantly river pebbles (72%), followed by blocks (12%), and geodes (6%). The residual percentage of cortex on the surface of pieces is relevant. Of the 80 pieces analyzed, 38% retained 5%–25% of cortex on their surface, 36% retained 25%–50%, and 7% of the samples retained 75%–95% of cortex. Only 12% of the pieces did not have cortex coverage (including V-S and rock crystals; Supplemental Table 1).

Technological Categories

The lithic industry of the SC-CHA-030 consists of 80 pieces, the majority being flakes, followed by knapped pebbles, cores, and fragments (which were not classified for the analysis; Supplemental Table 2). V-S lithologies are the most-used raw material (Supplemental Table 2).

Large dimensions and heavy weights characterize the analyzed lithic assemblage (Supplemental Figure 3). The knapped pebbles have an average weight of 984 g, with pieces weighing between 1,555 and 409 g. The cores have an average weight of 500 g, varying between 772 and 270 g. The flakes have an average weight of 276 g; there is more significant variability in their weight, which ranges between 1,285 g and 1 g. The subdivision of the flakes by cortical quantity, in decreasing order, is as follows: cortical with an average weight of 460 g (between 1,285 g and 34 g); semi-cortical with an average weight of 228 g (between 704 g and 4 g); and acortical with an average weighn of 42 g (between 102 g and 1 g). There are three distinct groups of flakes: those weighing more than 866 g (knapped pebbles and cortical flakes), between 772 g and 664 g (knapped pebbles, cores, and cortical and semi-cortical flakes), and less than 590 g, the most heterogeneous group comprising all identified categories.

Knapped Pebbles. All 15 knapped pebbles are made of volcano-sedimentary rocks. One of the pebbles was made on a block and the other 15 on fluvial pebbles. All the pieces were knapped using the direct percussion technique with a hard hammerstone. The percussion angle is semi-abrupt (30°–60°) in 67% of the knapped pebbles, followed by 20% with an acute angle (<30°) and 13% with an abrupt angle (60°–90°). Percussion platforms are primarily prepared (53%), followed by cortical (27%) and flat (7%). Finally, 13% of the pieces have two types of percussion platforms, prepared and cortical. The prepared platform is marked by scars from previous removals. The predominant exploitation intensity of the debitage surfaces is single (47%), followed by double (33%) and triple (20%).

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Based on how many faces of the block were exploited and the shape and geological nature of the initial block, we identified four main exploitation patterns for the knapped pebbles: trihedral oblong blanks, unifacial pebbles, bifacial pebbles, and bifacial rectangular pebbles.

Trihedral Oblong Blanks (Category 1). This category includes the knapped pieces made on elongated river pebbles and large flakes (Figures 2b and 3). Their average weight is 1,216 g, and the average volume is 374 cm^3. The percussion angle is predominantly semi-abrupt with three or more exploited surfaces. The percussion platform is prepared. The removal orientation is unidirectional and orthogonal, with different intensities of exploitation (single, double, and triple). The average number of removals is 14. The predominant type of exploitation is nonhierarchical, which implies that it does not have a surface used as a predominant percussion plane or as a debitage surface, resulting in bifacial and plano-convex sections. Macro-traces of use indicate a transformative part, opposed to a natural prehensive part. Based on this analysis, the pieces with this exploitation pattern are interpreted as tools made using façonnage. There is one piece knapped on an oblong river pebble but by bifacial façonnage (Figure 3a).

Unifacial Pebble (Category 2). This group consists of knapped pieces on oval river pebbles, characterized by a high degree of sphericity and low thickness (average thickness of 5.7 cm; Figure 4). The pieces have an average weight of 448 g and an average volume of 143 cm^3. They have only one explored surface, with a percussion angle between acute to semi-abrupt, and the percussion platform is cortical. The orientation of the removal scars is unidirectional, with different intensities (single, double, triple). They have, on average, five removals. The type of exploitation is hierarchical, resulting in concave and convex sections of the edge. The knapping technique is direct percussion with a hard hammerstone. Macro-traces of use were identified on the edge of the pieces, indicating a potential transformative part. This category of pieces has technical characteristics that could be related to both cores and tools.

Bifacial Pebble (Category 3). This category consists of knapped pieces made on oval river pebbles, with low and medium sphericities (Figure 5). These pieces have an average weight of 839 g and an

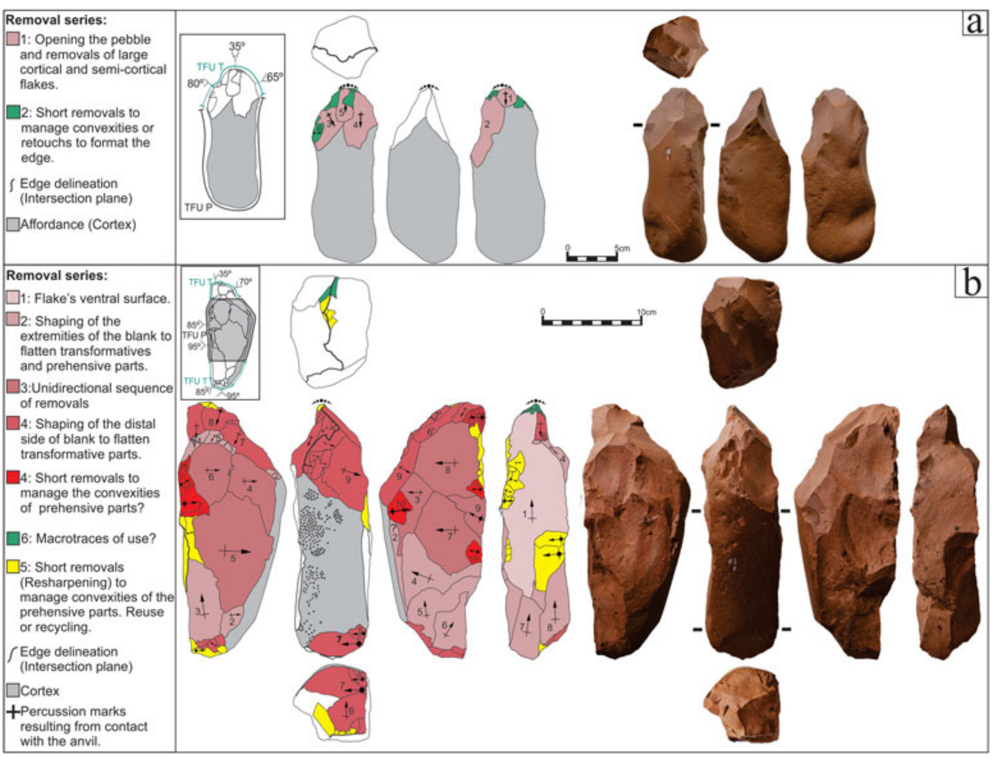

Figure 2. (a) Bifacial knapped tool, (b) trihedral knapped tool.

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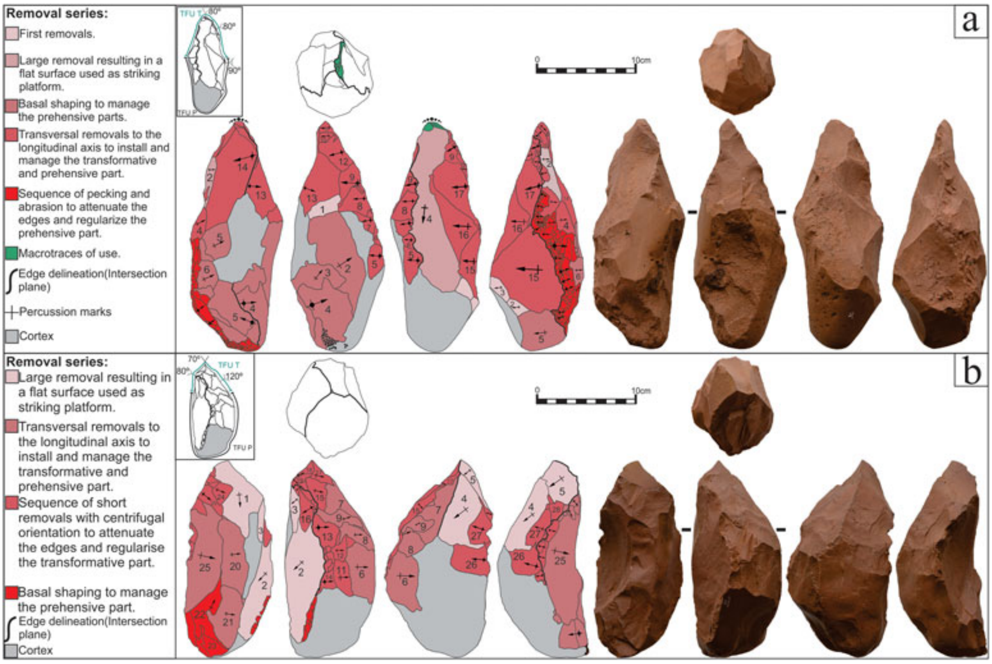

Figure 3. Trihedral knapped tools (a, b).

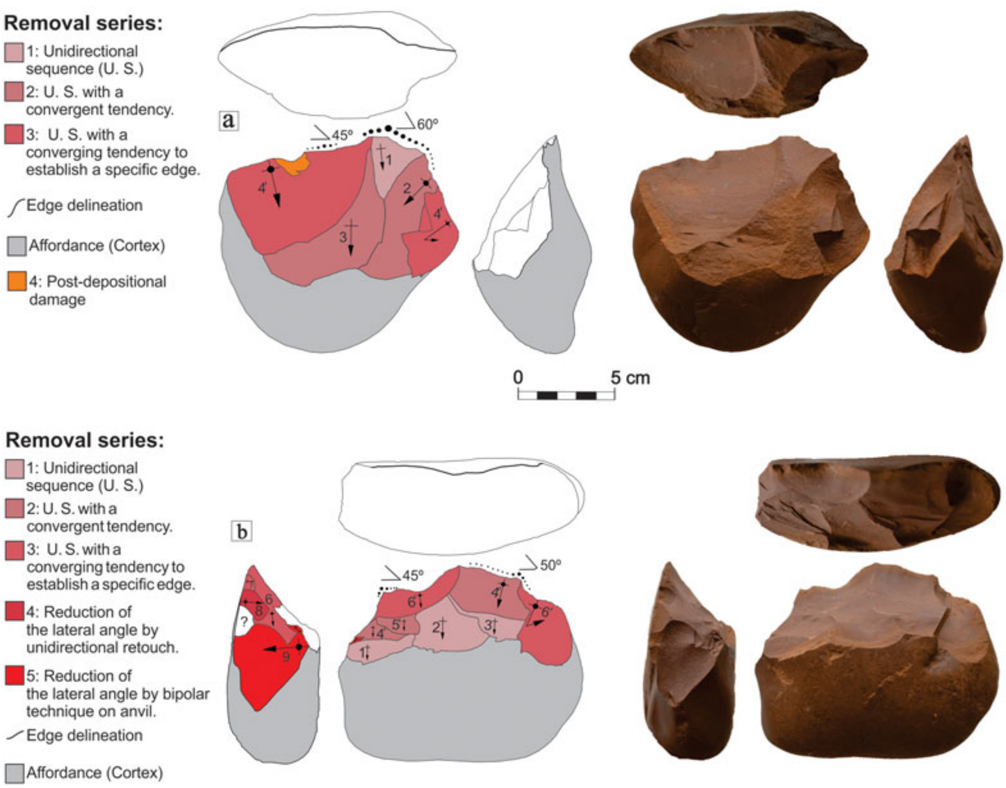

Figure 4. Unifacial knapped pieces (a, b).

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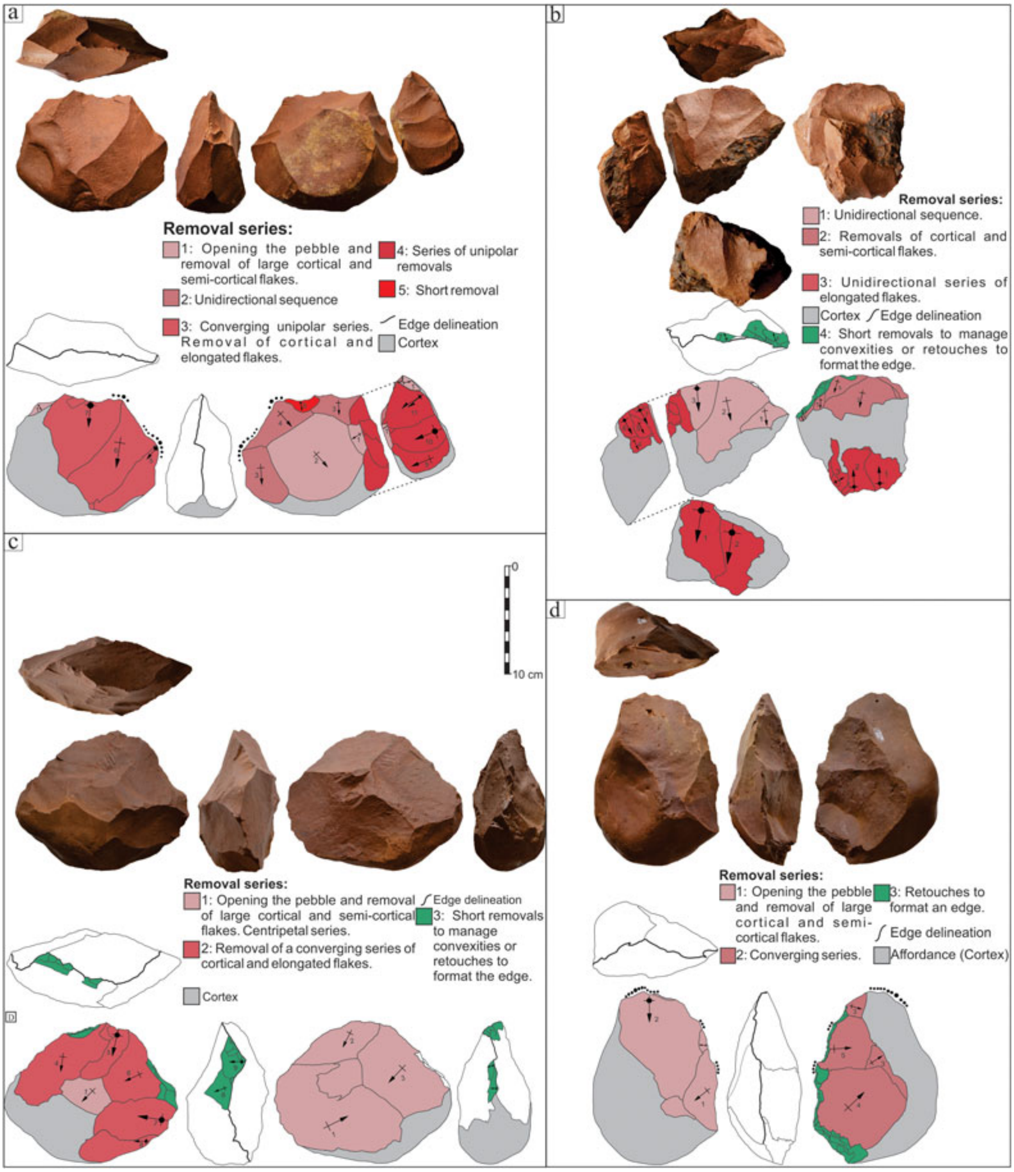

Figure 5. Bifacial knapped pieces (a, b, c, d).

average volume of 307 cm^3. They have two exploited surfaces with an abrupt and semi-abrupt percussion angle and prepared or flat percussion platforms. The removal orientation is unidirectional and punctually convergent, with single or double exploitation intensities. The average number of scars is eight. The predominant type of exploitation is nonhierarchical, resulting in biconvex and biconcave sections. The knapping technique is direct with a hard hammerstone. Bifacial exploitations are more heterogeneous than the other pieces, presenting different debitage plans (unifacial and bifacial). Macro-traces of use are present on the distal edges indicating transformative parts. This category of pieces has technical characteristics compatible with both cores and tools.

Bifacial Rectangular Pebble (Category 4). This group consists of knapped pieces made on river pebbles that tend to be rectangular, with low and medium sphericities and sub-rounded volume (Figure 6). Their average weights are 1,326 g, with an average volume of 388 cm^3. They have two exploited surfaces with a semi-abrupt percussion angle. Percussion platforms are prepared with unidirectional and

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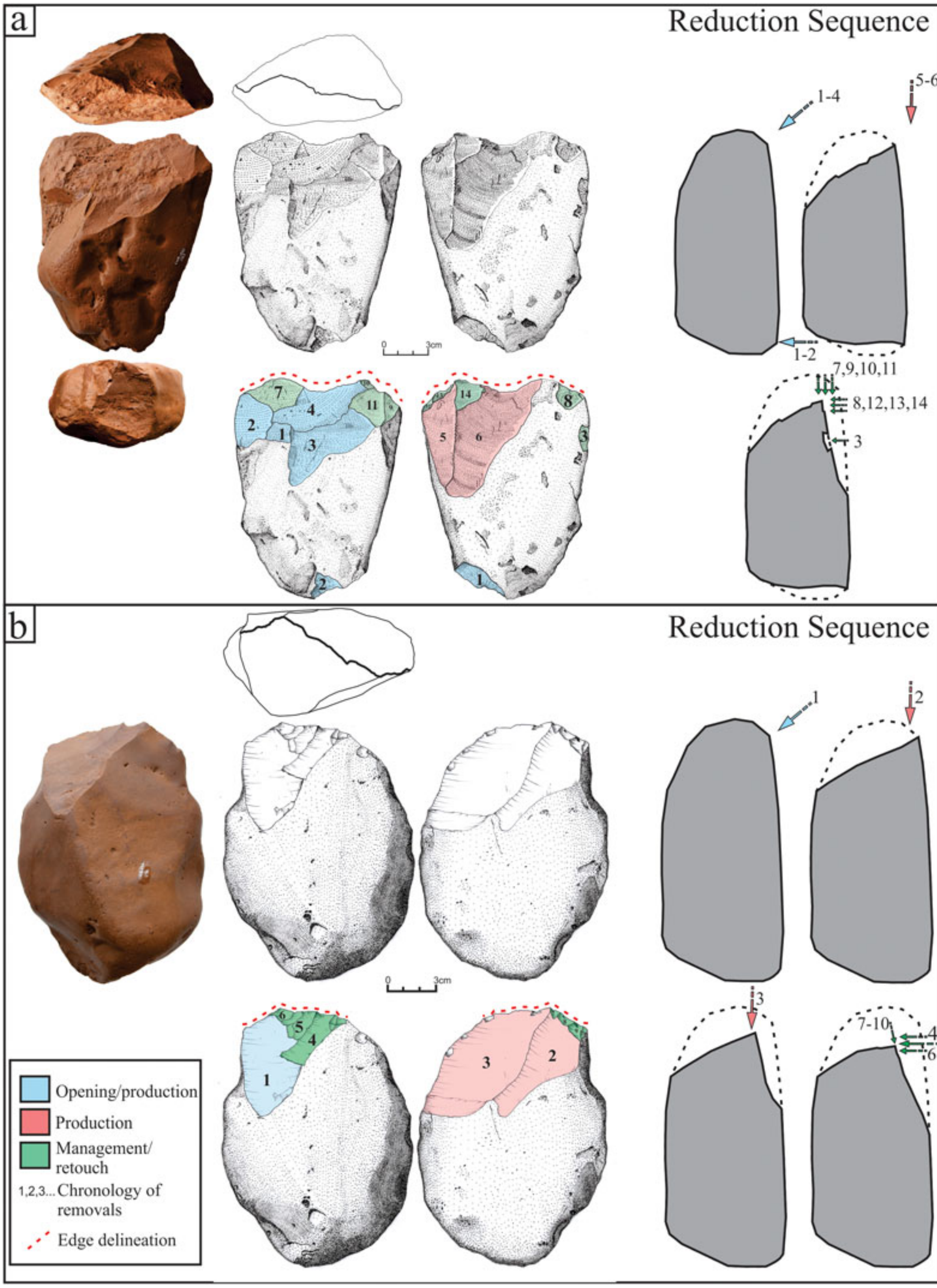

Figure 6. Bifacial knapped pieces (a, b).

orthogonal negatives and arranged in a single exploitation series. The average number of removals is four. The type of exploitation is nonhierarchical, resulting in biconvex and biconcave sections. The knapping technique is direct, performed with a hard hammerstone. This category has technical characteristics compatible with both cores and tools.

Cores. Seven cores were identified in the collection, representing 9% of the analyzed lithic pieces. The most-used raw material is V-S (five pieces), with one piece made from andesitic basalt

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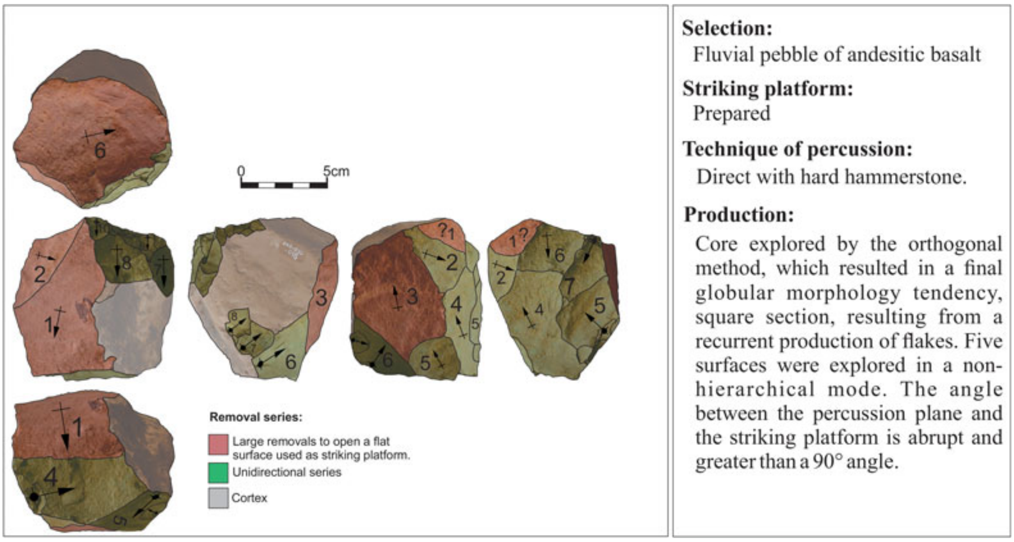

Figure 7. Core.

(Figure 7) and another from chalcedony. Four cores were made on pebbles, two on flakes, and one on a geode. Their morphologies are heterogeneous, and the cores took advantage of the volumetry of the blank. All cores were knapped using the direct technique with a hard hammerstone and the unidirectional method. The percussion platforms are flat or prepared. The general tendency is of nonhierarchical exploitation with few explored surfaces. Percussion angles are mostly semi-abrupt, and the numbers of removals are low, with an average of six scars (min. 1, max. 13).

The exploitation of the cores is nonhierarchical. For most, there is only a single series of production. In three cases, two or three independent series of removals are evident (Supplemental Table 3). These cores have a very diverse shape and present only a few removals, usually unidirectional. Only one core has a globular morphology, which is exploited by orthogonal planes. It is also the only one made of andesitic basalt and was found at a very advanced stage of exploitation to the point that it had lost the morphology of the initial blank (Figure 8). These pieces are very different from the knapped pebbles because they do not possess any functional portion or standardization and consequently are clearly defined as cores.

Flakes. The flakes represent 58% of the analyzed lithic industry. Semi-cortical flakes are most numerous, followed by cortical and acortical flakes. Inner natural fractures are present in 31% of the flakes; the position of these fractures is mostly on the proximal parts, which causes a high rate (48%) of flakes with absent butts. The predominant type of butt is flat. A total of 78% of the flakes were detached using internal debitage versus only 7% using secant percussion. The most-used technique was direct percussion performed by a hard hammerstone. However, in two flakes, the stigmata of the launched debitage can be observed (i.e., *percussion lancee sur percuteur dormant*; Bourguignon et al. 2016). The orientation of the removals is mostly unidirectional and less frequently convergent. The predominant morphologies are trapezoidal, triangular, and oval. Of the 52 flakes analyzed, 33 are retouched (Supplemental Table 4; Supplemental Figure 2). Their average weight is 311 g, with a considerable range between the heaviest (1,285 g) and the lightest flake (19 g). The average volume is 104 cm^3. The retouch is located on various parts of the flakes without showing any particular frequency. The position of the retouch is mostly direct. The inverse plus direct position is sporadically observed, and inverse retouch is rarely present (Supplemental Table 4).

The extension of the retouch is mostly marginal and very marginal (which may represent macro-traces); in only a few cases is it invasive. The angle of the active margin is variable, being semi-abrupt, abrupt, and acute. Retouching morphology is predominantly subparallel, scalariform, and, to a lesser

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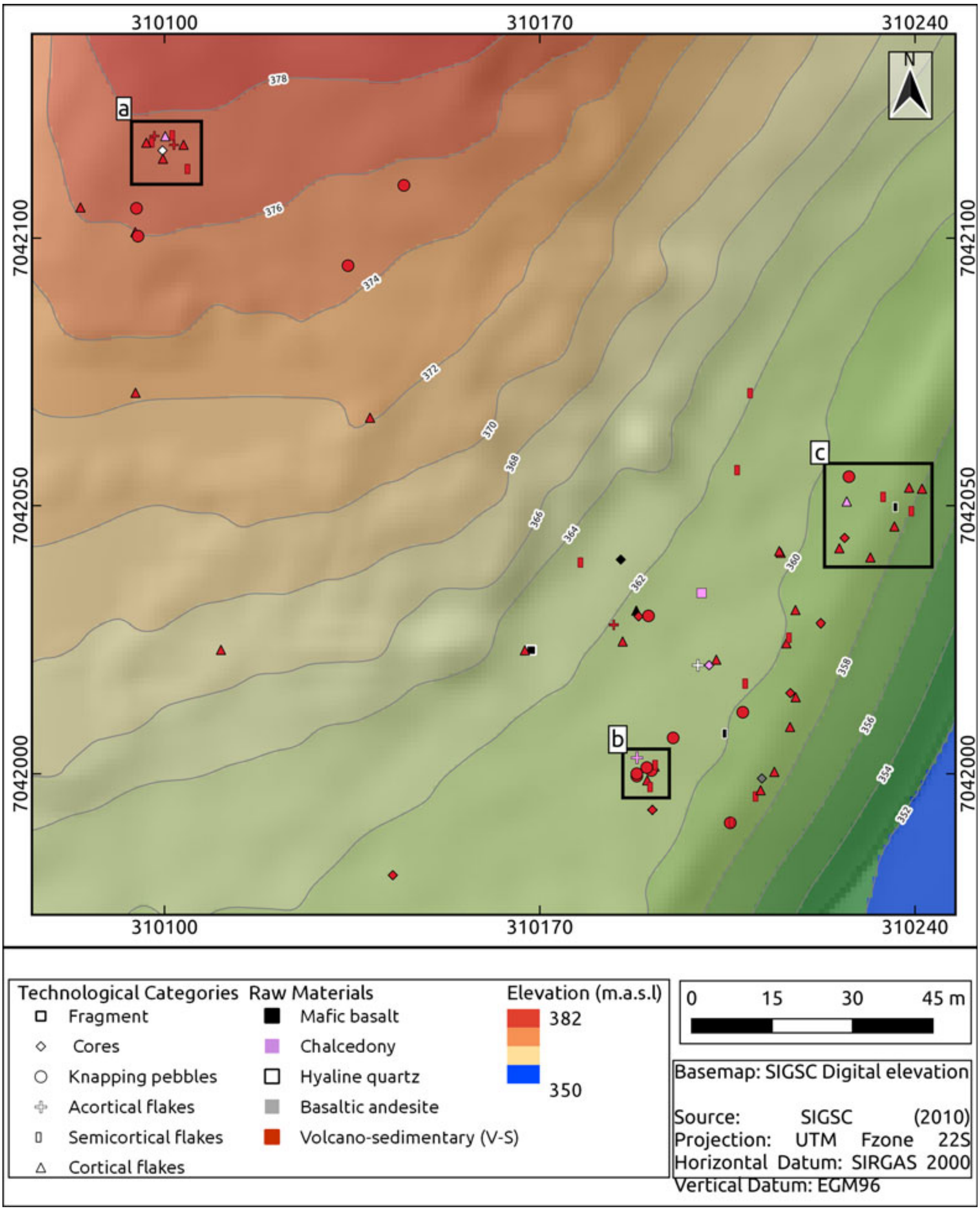

Figure 8. Spatial distribution of the lithic industry on the local geomorphic surfaces. The elevation levels from 374 m to 382 m correspond to the slope level. The elevation levels from 364 m to 374 m correspond to the inclined slope. The altimetric levels of 350–364 m correspond to the colluvium-alluvial terrace adjacent to the channel (floodplain). Letters a, b, and c correspond to clusters (larger quantity) of lithic materials.

extent, stepped. The distribution is mostly continuous. Exploitation intensity is mostly single (Supplemental Table 4).

The morphology of the retouched edge is heterogeneous. Some pieces have two or three different retouch morphologies. The most-represented morphology is rectilinear (31%), followed by convex (19%) and shoulder (13%). Point morphologies have also been identified, but these are always associated with other morphologies (concave, convex, shoulder, rectilinear). If only the margins with a pointed end are considered, they represent 31% of the total of the parts with secondary modification.

Spatial Distribution of the Lithic Industry

The 80 lithic artifacts were found in an area of 12,300 m^2 at the bottom of the valley. The SC-CHA-030 site is spread over two geomorphic surfaces: the slope level with elevations from 374 to 382 m asl and the colluvial-alluvial terrace at altitudes from 350 to 364 m. There is thus a difference of 18 m between the two surfaces (Figure 8), and the distance between the two clusters of materials is about 90 m. A slope with exposed rocky outcrops, low sedimentary potential, and an average inclination of 30° separates the materials (Figures 1 and 9). Thus, this local slope has a high potential for transporting sediments and archaeological materials and a low potential for sedimentary accumulation.

Most of the pieces (75%) and a variety of lithologies are found on the terrace. However, from a technological point of view, the sets of the pieces seem to have been produced by the same knapping concept. This technological homogeneity is perceived in the coherence of the technical characteristics of both flakes and knapped pebbles. Indeed, the initial debitage phases are documented as cortical and semi-cortical flakes, with knapped pebbles preserving a high percentage of cortex.

The six technological categories of the lithic industry are heterogeneously distributed on both surfaces, albeit with different densities (Figure 8). There are sparse knapped V-S pebbles on the upper surface (the slope level) and a clear grouping of flakes spread over approximately 70 m^2 (Figure 8a).

The greatest variety of knapped lithologies are found on the lower surface (the colluvial-alluvial terrace), and although the spatial distribution is heterogeneous, there are clusters. Cluster b (about 27 m^2) contains all the technological categories of the lithic industry analyzed in this article. In contrast, Cluster c is more widely spaced (about 271 m^2) and consists of cores, knapped pebbles, and flakes.

Given the position of materials on the mud facies at about 9 m above the channel, and a spatial distribution that is incompatible with the organization of sedimentary structures of gravel bars, we speculate that the genesis of the material is anthropic; in other words, people transported the pieces to the surface of the terrace. Yet, the volume and type of raw materials of the artifacts suggest that the raw material acquisition site was the channel bars of the Pesqueiro River near the site.

Discussion

Exploitation of Raw Materials

At the SC-CHA-030 site, the predominant raw materials are basalts and andesitic basalts resulting from flow in the magmatic province of the Paraná Basin. The anthropic choice of rocks at the site does not reflect the abundance of this raw material; that is, people selected raw material types that were present in lower amounts in the local geological formations. Indeed, precolonial groups chose the volcano-sedimentary or sedimentary lithologies (representing more than 90% of the lithic industry). The drainage basin of the Pesqueiro River catalyzes the volcano-sedimentary and sedimentary facies of the Capanema and Cordillera Alta facies, which, despite making up only 5% to 10% of the thickness of the magmatic flow, are the dominant materials in the lithic industry.

This choice of V-S lithologies shapes the lithic industry of the SC-CHA-030 site. This choice may be related to the silicification, fine-grained, and pelitic features of these lithologies, which enable better knapping control (Araújo 1992); thus, V-S material would have been preferred for knapping, instead of the more frequently occurring basalts. The cortex of the archaeological pebbles attests to their exposure to river transport. The pebbles' large size and weight indicate that people collected the raw materials from the alluvial channel deposits. It is possible that a reduction in the river flow level would have exposed the river pebble bars, enabling access to this raw material and its subsequent selection and collection by the local human groups.

Technical Behavior

The lithic assemblage of the SC-CHA-030 open-air site was created using two knapping operations: façonnage and debitage (Inizian et al. 2017). The façonnage method aims to produce bifacial and trihedral tools on oblong pebbles (Category 1). The technical structuring of these tools was carried out through two operations: affordance followed by façonnage. Affordance refers to the selection of techno-functional criteria naturally present in the initial blank that are maintained in the final object

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(Boëda et al. 2021). The natural features make up the functionality of the piece. Façonnage refers to the configuration of a portion of the tool. In this case, the distal portions of the pebbles were shaped to create transformative units suitable for use. These portions of the tool are areas that are worked to obtain techno-functional criteria that were not present in the initial natural volume (Boëda 2013).

In the lithic industry of SC-CHA-030, the operation of affordance is explicit in selecting pebbles with different volumes to produce individualized active margins, thereby modifying the natural characteristics of the supports through façonnage. Four categories of pebbles were selected. In Category 1, oblong pebbles were selected to generate a distal bifacial and trihedral edge, with biconvex and plano-convex sections and pointed and convex morphology. In Category 2, flat oval pebbles were selected to generate edges with convex morphologies and plano-concave and biconcave sections. In Category 3, there were oval pebbles with convex, straight, and pointed-edge morphology. Finally, in Category 4, there are rectangular pebbles with straight and convex edge morphology with biconvex and biconcave sections. Categories 2–4 may also have played the role of cores, in addition to serving as tools.

Debitage is characterized by the production of large flakes with an unprepared striking platform and a low degree of standardization, mainly resulting from unidirectional production. Large cortical and semi-cortical flakes prevail. These choices attest to rapid production, in which people chose pebbles with natural convexities that enabled flaking and production was done without any volumetric preparation of the core. The analyzed assemblage is devoid of technological categories with standardized morphologies, although there was the possibility of obtaining potentially usable products with recurring characteristics: thick blanks, convex and shoulder cutting edges, prominent bulbs, and pieces with considerable volumes and weights. Retouching is simple, marginal, or very marginal.

Archaeological Context of the Paraná Basaltic Plateau

In the region of the PBP there are several sites characterized by the façonnage of robust tools, such as unifacial and bifacial instruments, as well as flakes made by simple unidirectional debitage. However, these sites usually lack chronological references; thus, it is unclear whether these sites belong to the preceramic or the ceramic occupation. In addition, greater attention is usually given to formal tools, and the role of debitage in these contexts is poorly described.

An overview of the well-dated archaeological occupation of the area follows in chronological order. The oldest occupation is dated between 10,500 and 9,500 years BP in the southern sector of the PBP (Upper Uruguay River valley) in the Foz do Chapecó archaeological area (Hoeltz et al. 2015; Lourdeau et al. 2014, 2017; Pereira Santos et al. 2021). There was high technical variability in the knapping method, technique, and objectives. Lithic pieces included an original blade production (first identified in Brazil), together with several tools (i.e., façonnage of bifacial projectile points, small bifacial pieces, and large bifaces); the debitage of large and medium flakes by the unidirectional method using direct percussion; and the debitage of small flakes using the bipolar technique on an anvil. The production of flakes and bifacial tools continued after 9.5 ky cal BP, but laminar production ceased (Lourdeau et al. 2016; Pereira Santos et al. 2021).

In the northwestern sector of the PBP, several open-air and subsurface lithic sites dating to about 7 ky BP have been observed. The lithic assemblages of these sites consist of the production of large flakes, façonnage of small unifacial and bifacial tools, and massive bifacial tools made on large blanks (Chmyz 1969; Chmyz and Chmyz 1986; Novasco et al. 2018; Parellada 2004, 2008, 2013a, 2013b; Parellada et al. 1996).

In the southwestern region of the PBP—more precisely in the Basaltic Hills of the Misiones Province, Argentina—a preceramic level dating between 4.4 and 3.9 cal ky BP was found. Its archaeological record includes fauna typical of the subtropical environment and large bifacial tools typologically known as “bomerangóides” (boomerang shape; Loponte et al. 2023). Similar industries have also been observed in the region of Corrientes, Argentina (Menghin 1955) and are distributed throughout the upper Paraná and Uruguay areas in Argentina and Eastern Paraguay (Schmitz and Becker 1968).

In the northern sector of the PBP, open-air lithic assemblages contain unifacial and bifacial tools made on blocks and pebbles, and a simple production of flakes using unidirectional debitage is recorded in the ethnographic record of the Xetá Indigenous groups (Merencio 2015); those groups are part of the Tupi-Guarani linguistic family, Mbyá branch (Rodrigues 2011; Vasconcelos 2008).

Thus, in the upper Uruguay River valley, the unifacial and bifacial exploitation of lithic industries on pebbles and large flakes in volcano-sedimentary lithologies was recorded and correlated with the Middle Holocene (Lourdeau et al. 2016). However, in the various archaeological sites associated with occupations throughout the Holocene, pebbles modified by unifacial or bifacial shaping were consistently recorded (Dias and Hoeltz 2010). The lithic assemblage of SC-CHA-30 is characterized by both unidirectional debitage and massive bifacial and trihedral façonnated tools. Similar findings have been described in different contexts in southern Brazil; however, there are not yet sufficient data to sustain a chronological and archaeo-cultural correlation for the site.

Conclusions

The raw material usage and the analysis of debitage and façonnage at the SC-CHA-30 site enabled contextualization of this open-air assemblage in the cultural variability of southern Brazil. The lithic assemblage of the SC-CHA-30 site consists of the debitage of large flakes and the façonnage of unifacial, bifacial, and trihedral tools made on volcano-sedimentary lithologies. The lithic raw material predominantly used corresponds to blanks of volcano-sedimentary rocks, which present good knapping quality; the use of chalcedony and quartz in the form of geodes from the Serra Geral Group (Sedimentary Basin of Paraná) was also observed. We suggest that the abundance and use of these raw materials are intrinsically associated with the petrogenetic features of the geological structure of the Pesqueiro River basin. The human groups of this period intentionally selected the raw material for knapping, a choice that considered both the shape of the block to be flaked and the lithology. It is interesting to note that the most abundant raw material is volcano-sedimentary rocks, which were not the predominant raw material on the landscape: basalt of poor knapping quality is much more abundant in the region. We argue that a factor that may have increased the interest of human groups in occupying this area is the presence of the bars of the Pesqueiro River, where a source of good-quality raw material—volcano-sedimentary rocks—was observed.

Although studies on mobility in the area of the Uruguay River tributaries are scarce, the data retrieved from SC-CHA-030 in the area of the Pesqueiro River may inform a logic of exploitation by human groups: the availability and accessibility of lithic raw materials in the settlement areas may have been determining aspects of human behavior regarding mobility (Valde-Nowak and Cieśla 2020). Sites marked by expedient exploitations in vast areas are associated typically with more intense or repetitive local occupations (Clark and Barton 2017). Thus, the spatial and technological pattern of the lithic industry of SC-CHA-030 may reflect human behavior marked by exploiting the landscape in the search for specific lithic resources, typical of hunter-gatherer societies based on forage economies (Dillehay 2011).

Because this is the first record of an archaeological site along the Pesqueiro River basin, this study directly contributes to the ancient human history of the region. These results also contribute to the broader technological understanding of lithic industries on pebbles and blocks at sites located in river valley bottoms in the interior of the PBP of southern Brazil. The data on the exploitation of raw materials, lithic technology, and spatial distribution collected so far have shown that the area where SC-CHA-030 is located has great archaeological potential and is worthy of further study.

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Data Availability Statement. The archaeological materials are housed in the Arqueosul laboratory. After completion of the final study, the materials will be housed in the Memory Center of Western Santa Catarina, University Unochapecó. Additional photographs of artifacts are available on request to the authors.

Competing Interests. The authors declare none.

Supplemental Material. The supplemental material for this article can be found at https://doi.org/10.1017/laq.2023.67.

Supplemental Figure 1. Lithotypes defined in the lithic industry of the SC-CHA-030 site.

Supplemental Figure 2. Retouched flakes at the SC-CHA-030 site.

Supplemental Figure 3. Dispersion of the volume (cm^3) and weight (g) values of the technological categories at the SC-CHA-030 site.

Supplemental Table 1. Surface Appearance and Amount of Cortex of the Lithotypes Found at the Site SC-CHA-030.

Supplemental Table 2. Technological Categories and Lithotypes at the SC-CHA-030 Site.

Supplemental Table 3. Exploitation of Cores at the SC-CHA-030 Site.

Supplemental Table 4. Volumetry and Secondary Modification of the Flakes from the Lithic Industry of the Site SC-CHA-030.

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