Tool production and indicators of polyvalent economies during the Upper Holocene in the Jericoacoara 1 archaeological site, Jericoacoara Coastal Plain, West Coast of the State of Ceará, Brazil

Produção de ferramentas e indicadores de economias polivalentes durante o Holoceno Superior no sítio arqueológico de Jericoacoara 1, planície costeira de Jericoacoara, litoral oeste do estado do Ceará, Brasil

Thalison Santos[I] | Henry Socrates Lavalle Sullasi[I]

[I]Universidade Federal de Pernambuco. Recife, Pernambuco, Brasil

Abstract: The main goal of this study is to offer a preliminary characterization of the lithic industry of Jericoacoara 1, an Upper Holocene archaeological site located in the dune fields of the Jericoacoara National Park on the west coast of the state of Ceará. The present study analyzed 1,320 lithic artifacts collected in 2010 and 2017 after superficial surveys and three excavations conducted on two of the six areas of vestige dispersal composing the site. This industry's investigation involved applying lithic technology principles, emphasizing the transformative unit tools. This approach made it possible to identify some variants of production by percussion and shaping, sometimes associated with the practice of retouching. The implementation of the transformative units of these tools indicates adaptations and recycling that could be related to specializations involving the activities of hunting, gathering, and fishing food resources in the coastal plain. This seems to be one of the characteristics of a polyvalent technological culture within an economic system.

Keywords: Jericoacoara 1. Lithic industry. Polyvalent technology. Production systems.

Resumo: O objetivo principal deste estudo é oferecer uma caracterização preliminar da indústria lítica de Jericoacoara 1, sítio arqueológico do Holoceno Superior, localizado nos campos de dunas do Parque Nacional de Jericoacoara, litoral oeste do estado do Ceará. O presente estudo analisou 1.320 artefatos líticos, coletados em 2010 e 2017, após levantamentos superficiais, e três escavações realizadas em duas das seis áreas de dispersão de vestígios que compõem o local. A investigação desta indústria envolveu a aplicação de princípios de tecnologia lítica, colocando ênfase nas unidades transformativas dos instrumentos. Essa abordagem possibilitou a identificação de algumas variantes de produção por debitagem e façonagem, por vezes associadas à prática de retoques. As implementações dessas unidades transformativas indicam adaptações e reciclagem, e podem ser relacionadas a especializações envolvendo as atividades de caça, coleta e pesca. Isso pode ser, ainda, entendido como uma das características de uma cultura tecnológica polivalente, associada ao sistema econômico.

Palavras-chave: Jericoacoara 1. Indústria lítica. Tecnologia polivalente. Sistemas de produção.

Santos, T., & Sullasi, H. S. L. (2022). Tool production and indicators of polyvalent economies during the Upper Holocene in the Jericoacoara 1 archaeological site, Jericoacoara Coastal Plain, West Coast of the State of Ceará, Brazil. *Boletim do Museu Paraense Emílio Goeldi. Ciências Humanas*, *17*(3), e20210040. doi: 10.1590/2178-2547-BGOELDI-2021-0040

Autor para correspondência: Henry Socrates Lavalle Sullasi. Universidade Federal de Pernambuco. Arqueologia. Centro de Filosofia e Ciências Humanas. Av. da Arquitetura, s/n, 10º andar. Cidade Universitária. Recife, PE, Brasil. CEP 50740-550 (henry.lavalle@ufpe.br).

Recebido em 12/05/2021
Aprovado em 10/03/2022
Responsabilidade editorial: Fernando Ozório de Almeida

INTRODUCTION

Since 2008, extensive areas with archaeological remains have been identified in the Jericoacoara National Park, on the municipality of Jijoca de Jericoacoara, west coast of the state of Ceará. They are found in aspersion zones, blowouts and wind corridors, and are very common erosion features of the dune fields that dominate the coastal plain landscape.

One of these areas corresponds to the Jericoacoara 1 archaeological site (also known as *Serrote*), which consists of six large concentrations of remains exposed over approximately 1 km^2 of area (Figure 1). The stratigraphic sequence in the site generally summarizes at least five dune generations (V. Viana et al., 2016, p. 234; Claudino-Sales, 2005) that cover the period between 5,000 and 400 years BP (Meireles & Raventos, 2002; Claudino-Sales, 2005).

In Concentrations 1 (C1) and 6 (C6) there is a dark layer lying between dune generations 2 and 3 (D2 and D3) in the stratigraphy cut by the Aeolian erosion that formed the blowout hollowed area. Along a north-south segment in the C1 stratigraphic sequence, this dark layer – L03 – presents records of bonfires, black earths, charcoal, tiny shells and some rare and small lithic artefacts, mostly retouched flakes. Other lithic artefacts and ceramic fragments also appear in the interface between the L03 and the sterile sediments underneath it.

In 2010 and 2017, archaeological excavations and surface surveys conducted in the site unearthed a set of 1,320 lithic artefacts, about 6,000 ceramic fragments, and approximately 430 shell remains. This assemblage presents the opportunity to investigate the relationship between the economic and technological systems in the coastal plain of Jericoacoara, in order to identify behavioral patterns in the material culture. The first step is to understand the processes involved in the site formation, followed by the characterization of the ceramic and lithic industries (V. Viana, 2018; Santos, 2018).

In this paper, culture is considered as a means of adaptation in which different subsystems such as politics, economics, tool production techniques, among others, would be interrelated (Binford, 1965). In this way, a lithic study is seen as one of several pieces of evidence of the relationship that existed between the economy and production techniques in pre-colonial coastal societies. A technique is considered a transversal phenomenon that expresses itself in every subsystem. Aside from these principles, lithic technology includes the way technique develops tool designs, related to activities like cutting, grinding, scraping, crunching, fracturing, polishing, drilling, digging, etc., to support economic life, reflecting cultural adaptation.

The relationship between economics and production technique is represented here by the hypothesis of economic and technological polyvalence. Societies with a multipurpose-based economy are assumed to have occupied the coastal plain of the state of Ceará from 5,000 to 1,000 years BP. Those sociocultural systems subsisted on the exploitation of diverse fluviomarine and terrestrial resources through hunting, gathering and fishing. Therefore, an equally multipurpose lithic industry would have appeared in this economy, allowing for sociocultural maintenance.

This study was based on the concepts, methods and techniques proposed by established approaches of lithic technology investigation (Inizan et al., 1995), along with some other procedures borrowed from the techno-functional approach (Lepot, 1993; Soriano, 2000; Lourdeau, 2006; Boeda, 2014; Lucas, 2014) that helped in the tools' characterization. It is important to mention that this research does not intend to make a techno-functional analysis; it only takes important concepts from this approach in order to support the recognition of tools and to differentiate them from other categories.

The techno-functional view defends that tools possess a functionality that is fully technical, therefore tools are seen as an independent system (Boeda, 2014) that does not have a necessary relation to activities typical of subsistence. The idea defended in this paper is slightly

different. It argues that the tools have technically induced transformative units, which are projected according to the activities that characterize the subsistence modalities, because the tools are conceived to fulfill the adaptive necessities demanded by culture. Therefore, the technique is not a self-intended fulfillment, and does not create features on the tools for no reason. In this way, this research seeks to contribute to the development of an integrated interpretative model, which includes the technology and the economy of societies that occupied the Jericoacoara coast in the late Holocene.

ENVIRONMENTAL SYNTHESIS OF THE AREA UNDER INVESTIGATION

The geology of the Jericoacoara coastal plain is represented by typical lithologies of the crystalline basement, such as those of the *Granja* Complex dated to the lower Paleoproterozoic, and the *Martinópole* group of Neoproterozoic age. In the latter, the *Covão* (top), *Santa Terezinha* (intermediate) and *São Joaquim* (base) formations are especially represented by quartzites, phyllites and shale-quartzites, making up the whole massif locally known as the *Serrote* hill (Julio et al., 2012, p. 3).

In this area, the *Martinópole* group is overlaid by the *Barreiras* Formation, a Miocene and lower Pleistocene continental and marine sedimentary cover (Suguio & Nogueira, 1999; Arai, 2006; Nunes et al., 2011), dating from 23 Ma, at the deepest levels, up to 781,000 years BP in the more superficial layers of the stratigraphic sequence (Pleistocene) (Cavalcante et al., 2003). In this domain, there are sandy-clayey sediments, iron oxide-cemented sandstones, silicon sandstone facies with ferruginous cementation, and conglomerates that make up the coastal cliffs (Cavalcante et al., 2003; Figueiredo Filho et al., 2014, p. 22).

Some 30 km inland from the shore line, Quaternary sediments forming Pleistocene and Holocene dune fields overlap the *Barreiras* terrain. These sediments are characterized by the presence of grains of quartz, clay (with significant marine contribution) and feldspar-conglomerates settled in alluvial deposits, river plains and fluviomarine systems (Dantas, 2009; Julio, 2012). Eustatic events have often exposed the continental shelf in Jericoacoara, favoring the processes of deflation and sediment mobilization and accumulation that form the dune fields (Meireles & Raventos, 2002; Julio, 2012; EMBRAPA, 1973).

The Jericoacoara beach extends from the continent to the sea creating a small cape referred to by early 17th century Portuguese and French colonizers as *Cabo da Tartaruga* or *Cap de la Tortue* (Abbeville, 1975 [1614]; Evreux, 2002). A promontory of Neoproterozoic lithology (the *Serrote*) outcrops in this small cape, and a line of pre-coastal cliffs, mostly covered by Quaternary sands, follows the shoreline. The main geomorphological units found in the area are the beach proper, an aspersion plain, riverbank deposits, mangroves, sand banks, a tidal plain, dune generations, interdunal lagoons, a barrier formation, an abrasion paleoplatform, a dome relief (*Serrote*) (Meireles & Raventos, 2002) and other wind erosion features such as blowouts and wind valleys (Figure 1).

FIELD RESEARCH AND OCCUPATION ANTIQUITY

In 2010, archaeological research in Jericoacoara 1 focused on Concentration 1, where a squared pit and a trench were excavated. The objective was to identify archaeological materials for spatial and temporal contextualization. Ceramic fragments and lithic arte facts were identified at 110 cm below the surface level in Trench 1. A burnt pebble-structured bonfire pit was identified at the same level, a finding that allowed for the sampling of charcoal remains, which have been dated to 1055-924 Cal BP (1110 ± 30 BP - Beta 290953) (Figure 3) (V. Viana et al., 2016, p. 237).

In the 2017 archaeological campaign, investigations were carried out at the same sector, where Squared-pit 2 (4 m^2) and Excavation 1 (62 m^2) were unearthed. In the Concentration 2 sector, Trench 2 (14 m^2) and Squared-pit 3 (4 m^2) were also excavated, followed by

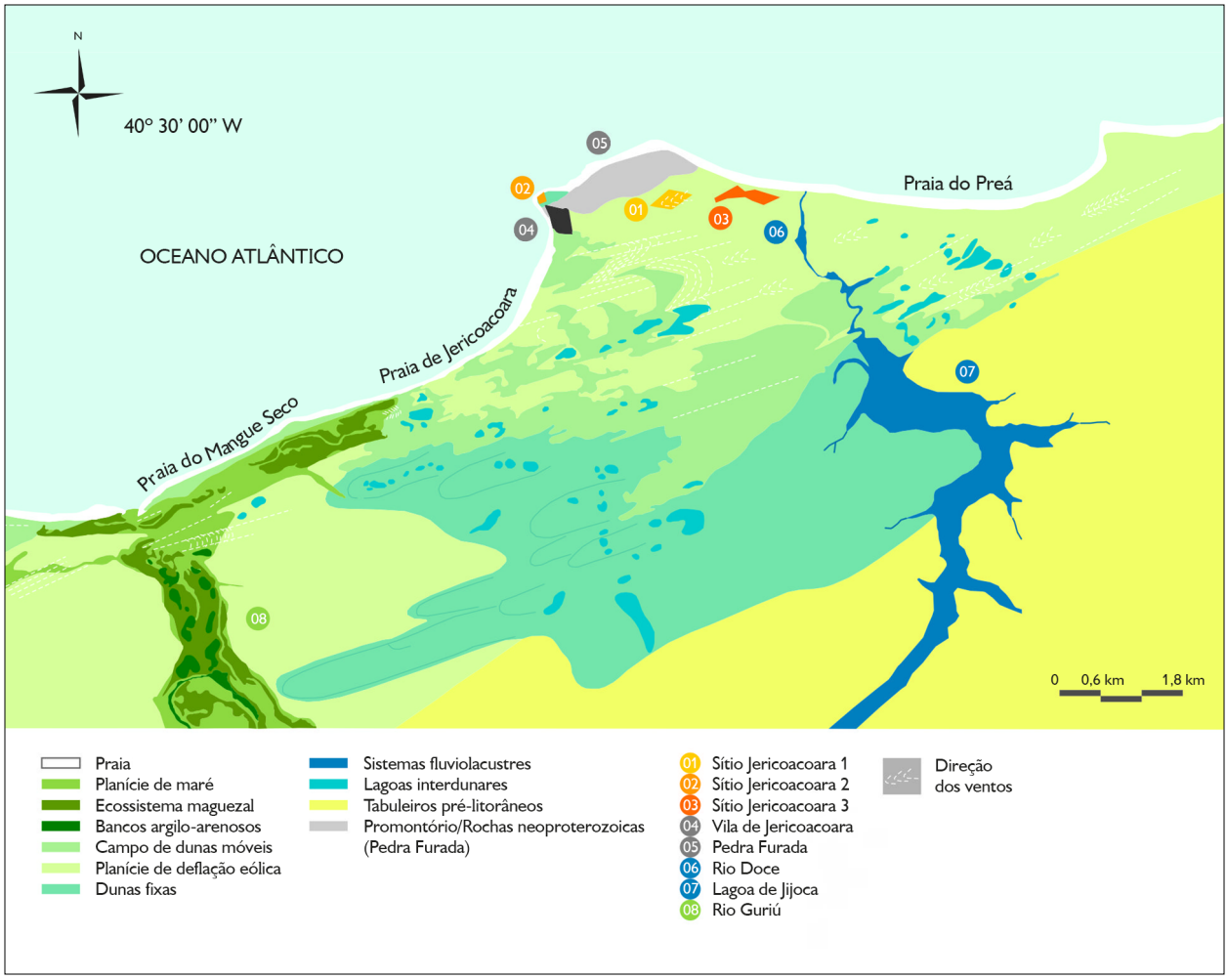

Figure 1. Archaeological sites in the Jericoacoara beach over geomorphological chart. Source: modified after Meireles et al. (2018).

the excavations of Squared-pits 4 and 5 (4 m²) at the Concentration 3 and 4 (C3 and C4) sectors, respectively (Figures 2 and 3).

That campaign's main goal was to identify archaeological layers and recovery of cultural remains for laboratory studies and dating procedures, as this archaeological record was about to disappear due to the intense Aeolian erosion. Another aim of the campaign was to verify whether L03 (the dark stratigraphic layer), outcropping in Concentration 1 due to erosion, extended to the neighboring sectors in Jericoacoara 1, such as C2, C3 and C4.

Figure 2. Visual of Squared-pit 2 over the L03 at Concentration 1. Photo: Santos (2018).

Figure 3. Trench 1, Squared-pit 2 and Excavation 1 at Concentration 1 (A, B and C) and Trench 2 at Concentration 2 (D). Photos: Santos (2018).

Excavation 1 was carried out in a location where the wind had already removed large masses of sterile sediment and was sweeping into L03, forming a slight slope towards the center of the blowout that encompasses Concentration 1. Some cultural remains were identified in the levels 4 and 5 of this excavation, including 11 cortical flakes, 13 non-cortical cortexes, five tools and lithic waste. The levels with archaeological materials were dated to 1526-1367 Cal BP (1590 ± 30 BP - Beta 504658).

Squared-pit 2 in the northern part of C1 covered about 3 m^2 intercepting the wall of the stratigraphy made by the Aeolian erosion. Its excavation removed about 2.5 m of sterile sediments until it reached the top of the L03, the paleosol located between the D2 and D3 dune generations (Figure 2). The L03 had a thickness of about 30 cm and its excavation consisted of the removal of several artificial levels, 5 cm thick. The L03 layer revealed eight small cortical flakes and six tiny non-cortical flakes, the results of retouching processes and edge sharpening, as well as a tool on a support-flake and a debris. *A priori*, this small assemblage seems to indicate that tool finalization took place in this portion of the site. This assemblage is associated with a shell dated to 1487-1285 Cal BP (1630 ± 30 BP - Beta 504659).

Trench 2 was excavated from the center of a dark spot present on the blown surface of a wide wind corridor in Concentration 2. This corridor links the eastern wind-blowing plain to the shore line, from which sand particles are transported in suspension and deposited in the dunes at the west side of the Jericoacoara small cape. Lithic tools and ceramic fragments with incised decorations were identified on the surface level and in the first 20 cm of digging. Other findings include pebble-structured bonfire pits surrounded by malacofauna, and ceramic fragments with soot sprinkled on their external surfaces. In Trench 2, lithic tools were unearthed in the more superficial levels, including 23 cortical flakes, 23 non-cortical flakes, 6 tools, 1 core, 2 hammerstones and 1 debris. This assemblage is radiocarbon dated to 2007-1877 Cal BP (2030 ± 30 BP - Beta 478973).

Another archaeological investigation in Concentration 2 was in Squared-pit 3, located about 50 m from the central Trench 2. It covered a cobble-structured bonfire projecting on the surface. Similar findings were unearthed in Squared-pit 4, in Concentration 5. Squared-pits 3 of C2 and 5 of C5, as well as Trench 2 revealed the same stratigraphic pattern in which cultural remains cease to appear after the first 20 cm below the actual surface. Another interesting data point concerning Squared-pits 3 and 5 is their contemporaneity as indicated by radiocarbon dates of charcoal found below the cobble-structured bonfire pits. In both cases, the ages are 1267-1070 Cal BP (1290 ± 30 BP - Beta 478976 and 478975) (Table 1).

Table 1. Chronology of the Jericoacoara 1 site.

Archaeological investigation	Sector	Material	Date	Calibrated dates[1]	Type of dating	Reference
Trench 01	C1	Charcoal	1110 ± 30	1055-924 Cal BP	AMS	Beta 290953
Squared-pit 02	C1	Shell	1630 ± 30	1487-1285 Cal BP	Conventional C14	Beta 504659
Excavation 01	C1	Charcoal	1590 ± 30	1526-1367 Cal BP	AMS	Beta 504658
Trench 02	C2	Charcoal	2030 ± 30	2007-1877 Cal BP	AMS	Beta 478973
Squared-pit 03	C2	Charcoal	1290 ± 30	1267-1070 Cal BP	Conventional C14	Beta 478976
Squared-pit 04	C5	Charcoal	1290 ± 30	1267-1070 Cal BP	AMS	Beta 478975

CHARACTERIZATION OF THE CERAMIC INDUSTRIES

Three types of ceramic industries were found in Jericoacoara 1. Two of them show similarities with the Papeba phase and the Mina tradition, and the third one corresponds to the Tupiguarani tradition (V. Viana, 2018). The Papeba potteries are small and present thin walls that sometimes are decorated with reddish patinas applied to internal and external surfaces or even on both sides of the vessels (Nasser, 1974; V. Viana, 2018). Perforated appendixes are also common in these ceramics and they were reserved to tie a twine (Nasser, 1974; V. Viana, 2018) that could ease transportation. In addition, small perforations are frequent in these potteries, which could have the same function of the appendixes. There is a lithic industry associated with these ceramics and includes siliceous raw materials forming sidescrapers, endscrapers, burins, polished axes, hammerstones and grinders (Nasser, 1974; V. Viana, 2018).

According to V. Viana (2018) the ceramics, possibly Papeba, appear in Jericoacoara 1 with low plasticity pastes that received fine, middle, and coarse sands as additives, as main characteristics. Sporadically, iron and roots were used with the same purpose. The manufacturing was done by cording and modelling, and the finishing techniques included rough smoothing, polishing, burnishing and red painting. Most of the fragments come from medium sized bowls with diameters between 25 and 30 cm. This set of ceramics was found in the surface and in the stratigraphy of Concentration 1, in level 04 of Excavation 1 dated to 1526-1367 Cal BP; in level 08 of L03 of Squared-pit 2 it dated to 1487-1285 Cal BP; and in level 08 of Trench 1 it dated to 1055-924 Cal BP.

The second type of ceramics present some similarities with the Mina tradition, although a detailed affiliation still lacks. This industry is found mostly in Concentration 2, and is associated with the date of 2007-1877 Cal BP. Most of the vessels' fragments present medium plasticity, while in several this quality appears more developed. The paste received sands, dried clay pieces and milled pieces of ceramics as additives, as well as iron minerals, and smaller amounts of organic matter such as roots, charcoal and shells. The manufacturing was conducted through cording. The modelling strategy was used with less intensity. The finishing techniques comprise smoothing and polishing, burnishing, painting and engobe. Pieces with two types of finishing also appear in the assemblage and include polishing and the incision, painting and polishing, incision and engobe, and incision and painting. The paint is sometimes polychromatic and consists of red, yellow and grey hues. These incised ceramics in Jericoacoara present a diversity of abstract decorational motives. The fragments originated from bowls with diameters between 20 and 50 cm. It is important to mention that the Mina tradition

[1] The dates in Table 1 were calibrated with Oxcal online. Two curves were used: the SHCal20 from Hogg et al. (2020) for charcoal dates and Marine20 from Heaton et al. (2020) for shell dates. The local delta-R of -236 ± 62 from Bahia de Todos os Santos was taken from the Calib database.

is found in the state of Maranhão associated with TL/OSL dates of 5800 ± 1100 in the Bacanga shell midden, and 5730 ± 1640 BP in the Panaquatira site (Bandeira, 2016). In the state of Alagoas this ceramic is related to occupations dated around 2000 ± 60 BP (Klokler et al., 2020). There is a lithic industry associated with these ceramics, but a technological characterization is still absent.

The third type of ceramics in Jericoacoara 1 is clearly affiliated with the Tupiguarani tradition. In the state of Ceará the earliest dates of this ceramic industry include ages between 3000 and 2000 BP, and its production continued until contact with European colonizers. V. Viana (2018) identified a set of about 50 fragments with low plasticity and thicker walls measuring between 0.6 and 1.9 cm. The ceramics' pastes received dried pieces of clay, pieces of milled ceramics and sands as additives. The vessels were manufactured exclusively by cording and the finishing techniques consist of smoothing, polishing, engobe, and painting. Fragments originated from oval and circular bowls that were heavier than the other types identified in the site. A spindle is present in this assemblage suggesting the development of weaving, and probably horticulture. The Tupiguarani industry is very common in other places along the coast of Ceará, however, its inexpressive presence in Jericoacoara could mean a sporadic passage of groups with this technology, or even the acquisition of those ceramics due to other processes such as commerce and warfare. There is a lithic industry associated with the Tupiguarani ceramics, but a technological characterization still lacks in sites of the state of Ceará.

ANALYTICAL CRITERIA AND CONCEPTS

The analysis of the Jericoacoara 1 lithic industry aimed for the characterizations of the modes of production. The following technological aspects were observed: the raw material procurement (approvisionnement strategies); the forms of exploration (percussion and shaping); possibility of utilization (tool performance); and abandonment and recycling (Inizan et al., 1995). The notion of a transformative unit was taken from the techno-functional approach (Boeda, 1997, 2001, 2014; Fogaça & Lourdeau, 2008) in order to perceive the implementation of a tool. This was the main criteria applied to distinguish a tool from other categories of lithic artefacts.

In this study, a tool is defined as any volume that has been put into action (Boeda, 2014), in which a transformative unit is assigned to satisfy a human need through the transformation of materials (Lepot, 1993). In turn, a transformative unit is the portion of a tool that makes contact with other materials (Lourdeau, 2006); it is assumed that it is created to accomplish a task, which is generally integrated in the economic system. Thereby, the production of a tool has to be strictly linked to its function and use. A tool is a system organized by three distinct parts (Soriano, 2000; Boeda, 2014) that articulate its social life in relation to the producers, the users and to other materials brought to the social system. These parts are the transformative, the handling, and the energy-receiving techno-functional units (Boeda, 1997, 2014). However, most of the relations are conducted by the transformative units, in which features such as penetration platforms and sharp edges are structured to be able to modify other materials.

In this investigation, the notion of method (or modes governing the lithic production) was considered as the management of sequential gestures leading to specific objectives, validated by culture and maintained by knowledge transferring systems adopted by these artisan societies (S. Viana et al., 2014; Inizan et al., 1995). The techniques are defined as the physical means used in artificial rock fractionation that create particularities within a method (S. Viana et al., 2014). They comprise three basic aspects: a) the means of force application, such as the either unipolar or bipolar direct percussion or pressure; b) instrument types used in the force application, such as the organic, soft or hard hammerstones; and c) the technique gestures or applied force trajectory, such as straight or tangential movements (Inizan et al., 1995; Lucas, 2014).

For the characterizations of the Jericoacoara beach lithic production, tools, and their technically induced functions, observations were conducted according to the following attributes: the stigma of the production modes, especially percussion and shaping; marks of use and function; the application of direct and indirect percussion techniques; and the definition of the transformative units.

The analysis was carried out on a set of 1,323 lithic artefacts collected in Concentrations 1 (529 items) and 2 (794 items) of the Jericoacoara 1 site during the archaeological investigations conducted in 2010 and 2017. This set of artefacts was initially described as containing pre-forms, cores, volumes with impact, abrasion and polishing stigma, products of knapping, adornments and tools in their strict sense. Subsequently, the tools were analyzed in order to identify their modes of production, technique application, and definition of transformative units (Table 2).

RAW MATERIAL PROCUREMENT

Despite being associated with tool production, rock and mineral volumes that were acquired, transported and modified at the Jericoacoara 1 site were also used in other social activities, e.g., for the structures of bonfires and for the production of adornments related to the aesthetical use of the body (and quite possibly expressing a marker of group/communal identity). However, the considerable number of materials designated for tool production at Concentrations 1 and 2 suggests at least two strategies of raw material procurement: one opportunistic, in which naturally fractionated angular stones and singular pebbles were selected in the sandstones and conglomerate sequences of the *Camocim* formation; and another one, probably planned, involving the mining of quartz veins and shafts outcropping in the quartzite and migmatite sequences of the *Martinópole* Group, in which better quality quartz structures can be found. These had been fractionated in smaller quadrangular volumes, transported to the campsites and submitted to knapping and shaping. The negatives left in the cores present a smooth-like consistency, macro-crystalline ribs and nervures that distinguish them from the pebbles chosen in the opportunistic strategy.

Table 2. Preliminary classification of the lithic artefacts.

Lithic categories	Quantity
Anvil	2
Anvil/hammerstone	1
Necklace bill	2
Hammerstones	54
Hammerstones/grinders	10
Fragment	65
Tools	142
Flakes with cortex	426
Flake with cortex/hammerstone	1
Flakes without cortex	309
Cores	92
Grinders	17
Pre-forms	5
Unidentified	197

In the opportunistic strategy, the most common in Jericoacoara 1, the selection of volumes occurred mainly due to the occasional finding of certain technical characteristics that facilitate the unipolar and bipolar percussion upon support and shaping. As it has already been highlighted in other studies, the most sought-after volumes displayed corners and vertices forming angles of approximately 90 degrees and relatively plain faces, which were targeted as percussion surfaces (Boeda, 2014).

The sources of raw materials in this area are distributed along the coastal plain, in the surroundings of the Jericoacoara 1 site. The main sources are the aforementioned promontory, in which schists, quartzites and migmatite lithologies are present, and the coastal *Camocim* formation sandstones and conglomerates that outcrop in the eastern beaches (Costa et al., 1979; Projeto RADAMBRASIL, 1981). In the *Malhada* beach, the *Camocim* formation extends to the bathing area and its surroundings, where another archaeological site with lithic industry has also been found.

The materials obtained from these coastal conglomerates consist mostly of round quartz and quartzite pebbles and boulders with a rough light-grey matrix, along with other materials with a ferruginous increment. However, in the southeastern beaches, these materials present angular and subangular extremities, indicating marine desegregation of the *Barreiras* Group (Dantas, 2009). Pebbles with the above-mentioned characteristics are more susceptible to direct percussion and shaping. On the other hand, a portion of the round, oblong and ogive pebbles were modified with bipolar percussion upon anvil supports (Prous et al., 2012), yielding products such as the splits and orange bud-like flakes (Boeda, 2014). Besides providing quartz and quartzite pebbles, the *Barreiras* Group was also the main provider of silicon-based materials for the lithic industry in Jericoacoara 1, although these are less common than the former ones.

The practices of material acquisition at Jericoacoara 1 led to frequent observations of at least 16 types of raw materials in Concentrations 1 and 2: coastal sandstones, siliceous sandstones, basalt, unidentified concretion, gneisses, granites, ferruginous materials, mica schists, migmatite, amazonite, quartzite, quartz, hyaline quartz, white quartz, flints and siltstones.

THE PRODUCTION OF TOOLS IN JERICOACOARA 1

The analysis of the Jericoacoara 1 lithic assemblage allowed for the identification of seven variants of tool production by percussion and shaping. Percussion was also linked to two distinct goals of the producers: to produce transformative units and to achieve ready-to-use tools. The shaping occurred in accordance with the distinct types of exploration, such as the unifacial and the bifacial exploration. The identified variants are as follows:

a) Bipolar percussion on anvil supports: identified from the presence of anvils and relatively standardized products (Prous et al., 2012), such as the splits and orange-bud flakes. In some cases, the splits were used as supports for instruments, while some of the orange-bud flakes seem to have been used directly as tools. Bipolar percussion is confirmed due to the presence of some raccords binding splits and impact initiation points. In addition to this, other three asymmetric volumes suggest the aim to obtain splits to support tools. Four quartz and granite pebbles were used as anvils, in which percussion points and wear spots can be observed on the supporting surfaces;

b) C-type non-standardized knapping[2]: confirmed by the presence of certain flakes, cores and tools. The objective of this practice was mostly related to the acquisition of flakes to support tools, or to achieve ready-to-be- used tools. Some of these products displayed splintered tracks along the preparation of percussion surfaces. The cores present a reduction series of at least three or four removals;

c) Slicing-like percussion[3]: recognized from the standardized circular or semicircular flakes. These products can be positioned in the initial and intermediary series of reduction. Some raccords involving initial and intermediary flakes and cores confirm this type of exploration;

d) Unifacial shaping: attested by the presence of tools in which the shaping extends on a single face of the volumes in order to implement transformative units composed of projected convexity and triangular sections. This type of shaping is observed in angular stones, in pebbles, and in thick flake supports. In order to display sharp edges, some of the tools were also explored through retouching. This type of exploration also occurs as lateral shaping in which the exploration occurred only on the flanks of oblong, flatten and quadrangular pebbles. This exploration trend generally results in flank-penetration platforms covering the whole thickness of the pebbles. These platforms were submitted to retouching;

[2] This type of pebble knapping is described in Boeda (2014).
[3] This type of knapping is described in S. Viana (2006) and Rodet et al. (2007).

e) Bifacial shaping: a set of pebbles was submitted to this exploration mode in order to create transformative units forming double bevels. Some tools have shown more than one double bevel transformative unit in distal and proximal extremities of the volume. The absence of distinct patinas suggests that these transformative units were probably contemporary.

Having presented the variants, it is clear that the lithic industry of the Jericoacoara 1 site is characterized by relatively short exploring sequences involving deliberated, yet fast technical procedures to produce proper tools or tool supports. For instance, the cores display a maximum of three or four flake removals, even in volumes that present a surplus of useful mass, which is normally required for prolonging the series of exploration. Angular or relatively round stones were frequently reduced with the C-type non-standardized knapping. This technical choice was applied mostly in volumes displaying relatively flat surfaces, which were used as a plan for fracture initiation. A good quality of the raw materials was not a sought-after characteristic, as most of the selected volumes display internal fracture lines and debris, i.e., an apparent poor quality.

Percussion products analyzed in this study were distinguished according to the methods used for their removal. Thereby, it is possible to observe unipolar, bipolar, and shaping flakes, along with small flakes resulting from retouching, and those obtained by slicing-like and non-standardized C-type exploration. In order to identify techniques and situate these products in the exploration series, stigmas, such as fracture initiation points, hammering beads, waves, nervures and the presence/absence of a cortex, were also analyzed. In the case of the slicing-like percussion, due to the identification of sequential raccords, it was possible to clearly position some flakes at the initial, secondary and, most frequently, at the intermediary stages of the reduction series. These findings suggest that percussion in the site was used to produce flakes that were later used as support to structure transformative units, and also to be used directly as tools.

Flakes resulting from retouching processes are present in high frequency, suggesting that the practice of creating transformative units in the tools has also taken place in Concentrations 1 and 2 (C1 and C2). It was also possible to observe the presence of a cortex in these products, which indicates that the structuring of the transformative units occurred in volumes less, or even not at all, reduced. The cortex was also observed in intermediary flakes, especially those produced with slicing-like percussion. Most of them rarely display prominent bulbs and do not show well-defined plans of impact.

The flakes and cores often present a dihedral hammering bead and indicate the occurrence of internal percussion with a hard hammerstone. However, a few of the flakes, especially those resulting from retouching processes, reveal the occurrence of marginal percussion also carried out with a hard hammerstone, which caused splintered hammering beads. Thirty-four hammerstones displaying various dimensions and weights were recovered from the Jericoacoara 1 site. Such variation suggests different uses and objectives in the reduction sequences. The bigger hammerstones might have been used in mining explorations, the mid-sized ones for tool support production, and the smaller ones for final retouching. A few cores in the lithic assemblage weigh 8-12 kg, an indication that specific hammerstones existed to allow for their mining (Figure 4).

Some pebbles have displayed marks other than of impact, such as abrasion, grinding and polishing bands concentrated in the flanks, and related to the use as hand-polishers, probably in the finalization process of axes and handaxes. Many of these hand-polishers were simultaneously used as hammerstones and cores as well, and some of them even received transformative units, becoming a tool. This finding confirms the multiple uses of a single given volume to fill different roles in tool production, as well as their potential for adaptation that could be bonded with the requirement for the fulfillment of instantaneous activities.

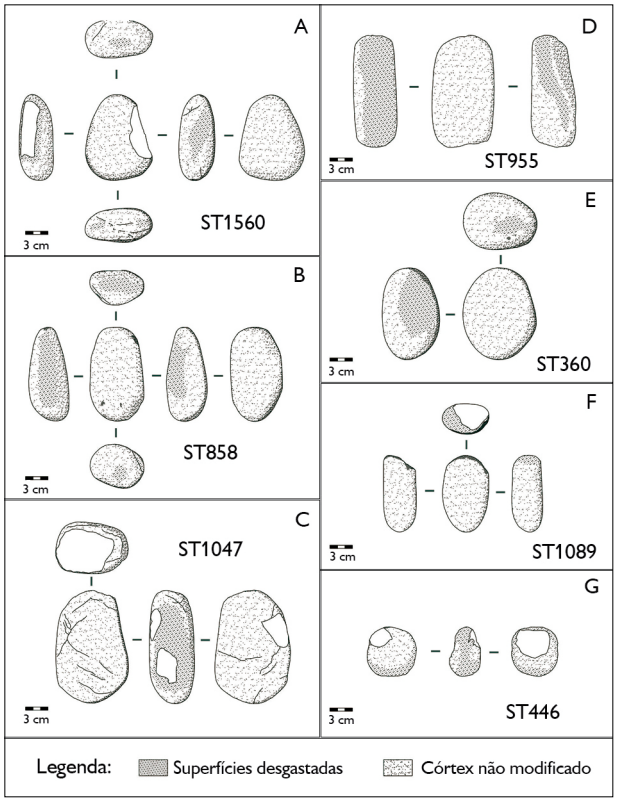

Figure 4. Hammerstones of Jericoacoara 1. Credit: Santos (2018).

The shaping in the site resulted in the production of thin flakes that were wider than long, with no designated or proposed use in the production process. They are usually absent of hammering beads and bulbs, although vestiges of the latter can be found in some specimens. Another important feature is the presence of nervures and crests due to prior flake removal, which generated shallow and small negatives on the dorsal faces. However, some of the shaping flakes present cortexes accompanying the dorsal convexities. These observations indicate that the shaping process was carried out on at least four anatomically distinct types of volumes: 1) round and oblong pebbles; 2) angular pebbles and stones; 3) quadrangular and thicker support flakes without cortex; and 4) initial support flakes and splits.

The implementation of transformative units on the Jericoacoara 1 tools resulted in at least eight tool groups found in both Concentrations 1 and 2:

Unifacial shaped tools upon a flat surface: tools produced by shaping projecting volumes from a flat surface. They display convergent flake removals superimposing to each other. The transformative unit comes up with an abrupt penetration platform with inclined angles between 25 and 35 degrees (Figure 5).

Lateral shaped tools: a set of tools displayed a tendency to lateral shaping. This exploration trend can be considered as a variation of unifacial shaping. It utilized the implementation of transformative units in the flanks of pebbles, which generally received a few removals in bands connecting the ventral and dorsal faces. Depending on the inclination and the trajectory of percussion, the transformative units may create more or less abrupt penetration platforms with shallow negatives. It is common that penetration platforms are inclined about 20 and 30 degrees. The volumes used can be flat, round, or oblong, and the shaping in the larger ones may extend to one of the extremities. This shaping extension seems to be associated with the volumes' mass and robustness. Sometimes, some retouching was applied in these transformative units without changing much of the cutting line initially defined with the first reduction series. The edges can change according to the volumes' dimensions. In some small tools, they look rectilinear or

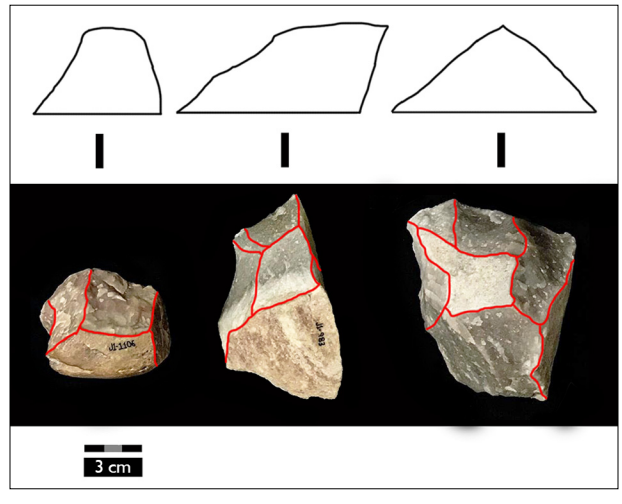

Figure 5. Unifacial tools on a flat surface. Photo: Santos (2018).

barely curved, while in bigger ones they appear steeply curved. Along the cutting lines, and in the negatives of retouching, some macroscopic use-wears can be opportunely detected, such as shrapnel points and tiny polished lines and bands (Figure 6).

Bifacial shaped tools: two designs were observed – one in which the shaping concentrates in the proximal or in the distal ends of pebbles with oval, oblong and ogive shapes, remaining cortical in their mesial portion of the volume. Another trend appears through semicircular marginal shaping of relatively round and flattened pebbles. In the first design, shaping intended the creation of transformative units forming a double bevel. This happened through short reduction series involving around six or seven flake removals. In the second case a double bevel is also sought through a series of marginal reduction in both faces of the pebble. Sharp cutting lines can be curved and rectilinear in both types of tools. Some tools possess more than one transformative unit. Two hypotheses are possible: the first one considers the recycling of the same volume, although there are no patinas in the stigma indicating different ages of the reduction series. The second possibility defends the implementation of a tool with two transformative units at both ends of the pebble, structured at the same time (Figure 7).

Retouched tools on natural stone fragments: the use of naturally eroded angular and natural quartz and quartzite volumes was detected in the production of a few tools. In this case, the natural anatomy of the volumes has been used to create the transformative units. In other

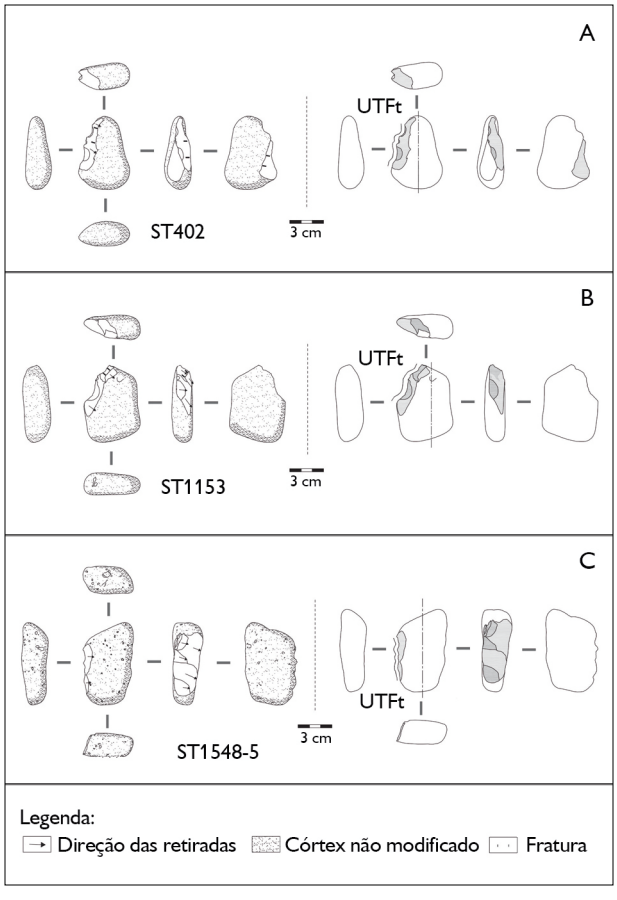

Figure 6. Lateral shaped tools. Credit: Santos (2018).

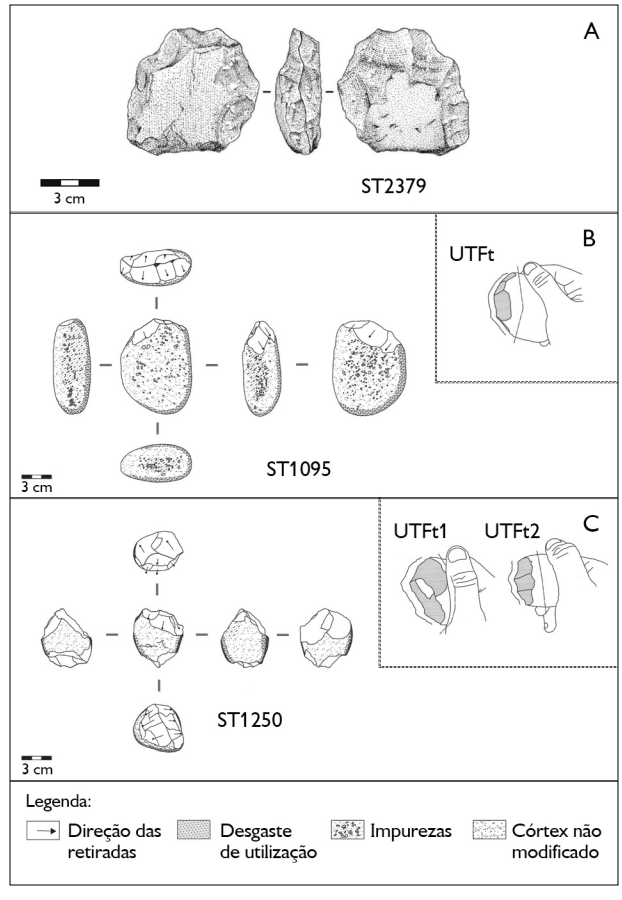

Figure 7. Bifacial shaped tools. Credit: Santos (2018).

words, these tools may present diverse morphologies, including trapezoids, pyramidal or quadrangular shapes, in which one or more transformative units is created by retouching, resulting in a penetration platform some 20 degrees inclined. It creates a simple bevel with the cutting line following their natural anatomy. Some retouching was taken receding the cutting line under a projected band creating an abrupt cut. These findings may indicate sharpening recycling. Macroscopic use-wear marks in the negatives of retouching may be found in some of the tools (Figure 8).

These natural volumes that received transformative units include quartz, siltstone and flint. Some of those are very thin, measuring about 1 and 3 cm thick. Sometimes, shaping and retouching were applied in order to create one or two transformative units composing simple bevels with rectilinear and denticulate cutting edges. The juxtaposing of small negatives creates beak zones from which the cutting lines are projected. It seems that the shaping was applied in order to decline a simple bevel penetration

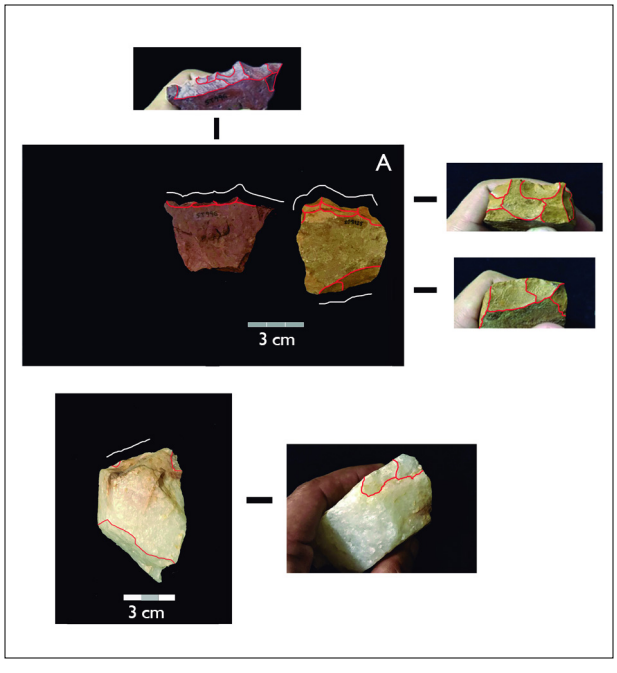

Figure 8. Transformative units implemented on natural volumes. Photos: Santos (2018).

plan, followed by lateral retouching. One of these tools presented macroscopic use-wear at the penetration platform (Figure 8).

Shaped and retouched tools on flake supports: composed of two groups – one with tools that received shaping in the transformative unit followed by retouching, and the other with flakes that received only retouching. There were no preferences related to these supports as they can have multiple morphologies and result from initial and intermediary series of percussion. These supports are normally longer than wide and display large planes of percussion, about 1.5 to 2.5 cm long. The transformative units were mostly structured by shaping in the ventral faces followed by retouching along the edges (ST899, ST1301, J1-1252-5, J1-922, J1-886-1, ST1331-1 and J1-986). This process creates an abrupt recession interrupting the natural declination of the flakes' ventral faces, forming a penetration platform with about 35 degrees of inclination. The cutting lines are mostly denticulate (Figures 9 and 10).

Flakes used directly as tools: a large number of flakes obtained through different percussion modes were directly used as tools by the artisans. This is the case of blades as well as a thermic lanceolate point, and the orange-bud bipolar flake. Some of these tools presented macroscopic use-wears (Figure 11). It is possible that C-type debitage managed the production of some of these tools, but the thinner flint blades probably resulted from laminar percussion.

Polished axes: composed of axes of several dimensions that seem to be handled, as their anatomy suggests. These tools present lateral recesses in their proximal extremities, which is followed by a bottlenecked body towards the distal extremities, creating a double bevel and concave sharpened edge that represents their transformative unit. At the same point of these recesses, a chamfer surrounds the whole instrument body, indicating the use of fibers to tighten the connection between the handler and the body of the tool. This section articulates both the units of energy

transmission and prehension. Some of the tool bodies may be elongated while others are shorter. It seems that the most important phase of their production was the stone selection of generally ferrous materials extracted from the *Martinópole* Group geological sequences. The selected stones underwent simple transformative procedures involving a few flake removals at the edges, by the same point of the proximal chamfer, which gave them the aspect of pre-forms that were later brought to the site (attested by the finding of two pre-forms in C2). At later stages of the process, they were then submitted to shaping, in order to reduce the volume, and, finally, to procedures such as grounding, abrasion and polishing to achieve more regular surfaces and sharpen the cutting lines. The grounding step seemed to have been practiced through dry friction with stone surfaces, while the polishing stage involved the use of water and sand (Figure 12).

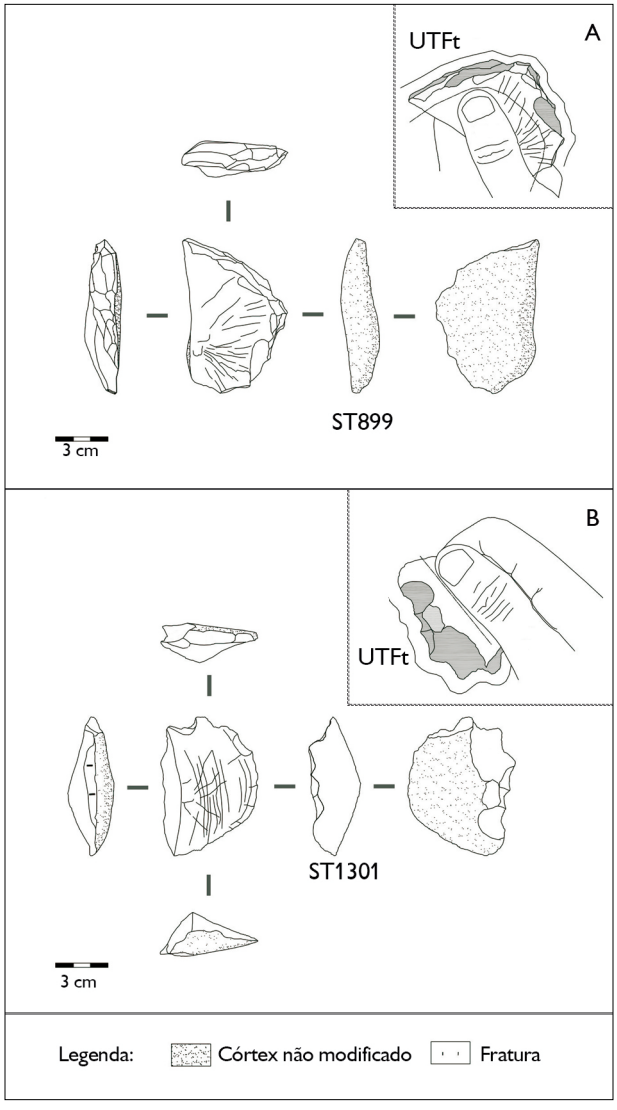

Figure 9. Tools on flake supports with more developed transformative units. Credit: Santos (2018).

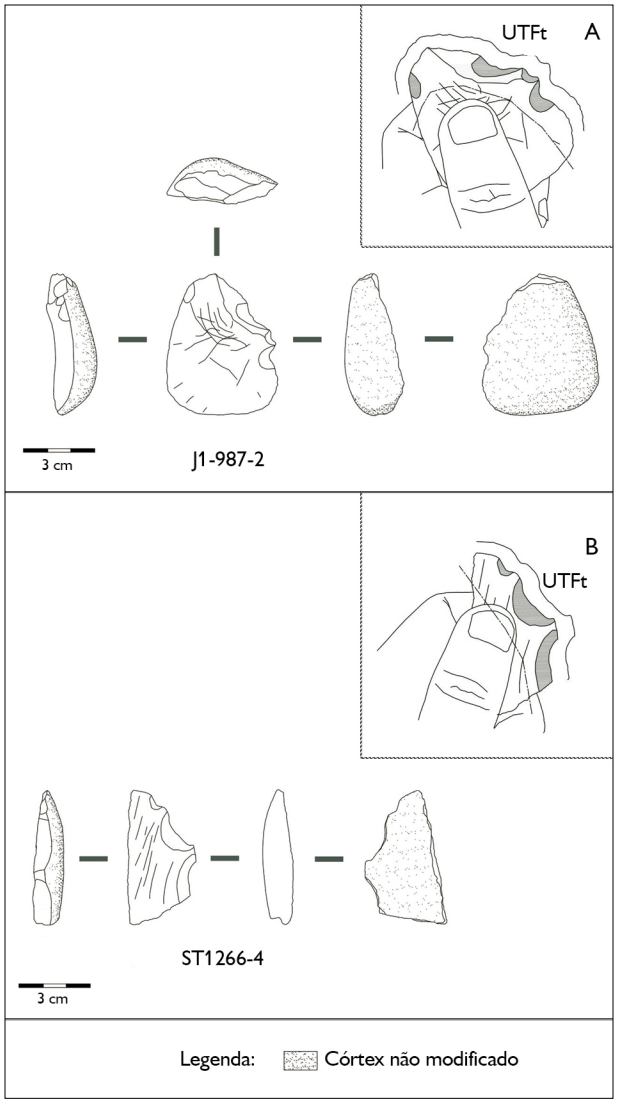

Figure 10. Tools on flake supports with few removals. Credit: Santos (2018).

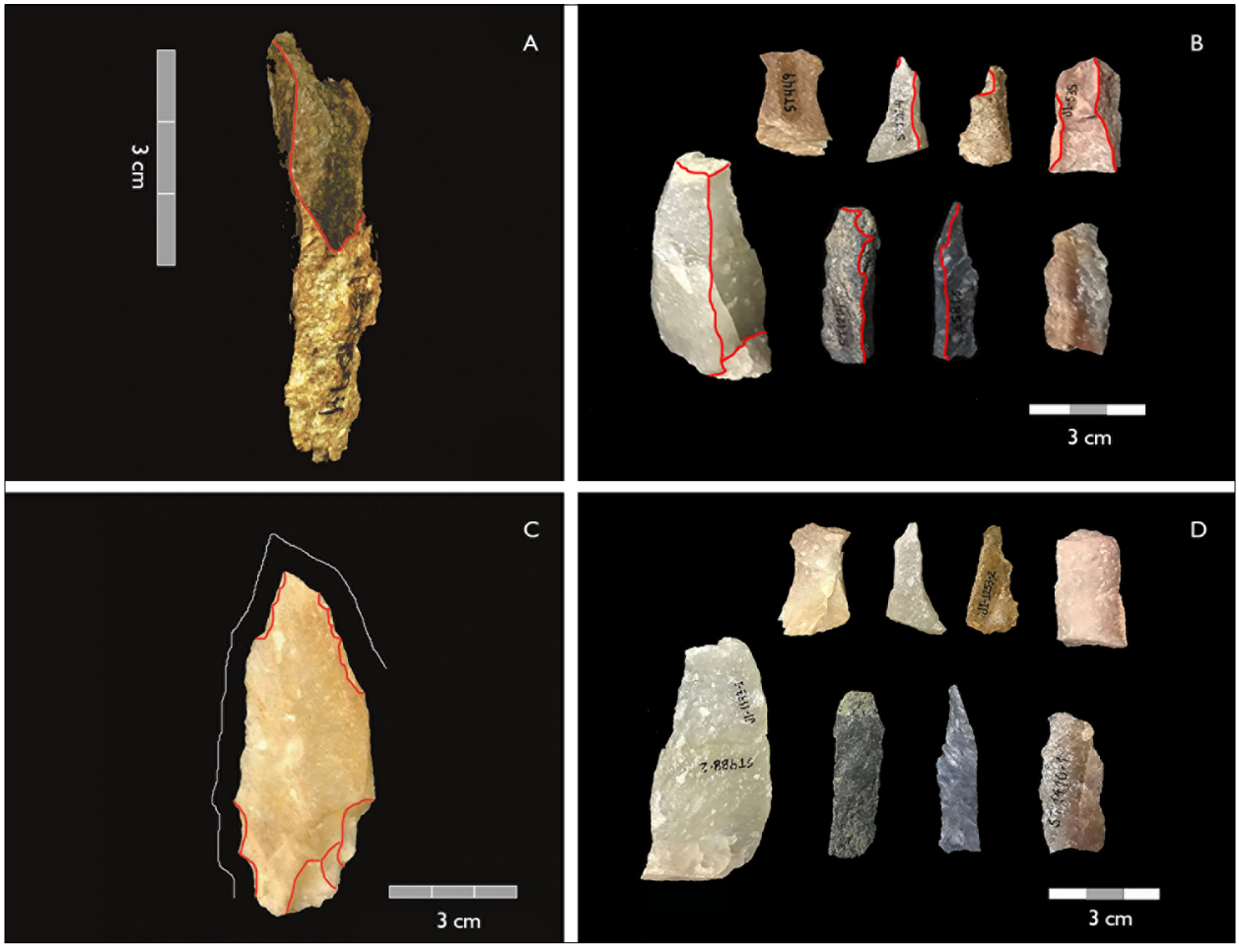

Figure 11. Blades and a thermic lanceolate point (A3). Photos: Santos (2018).

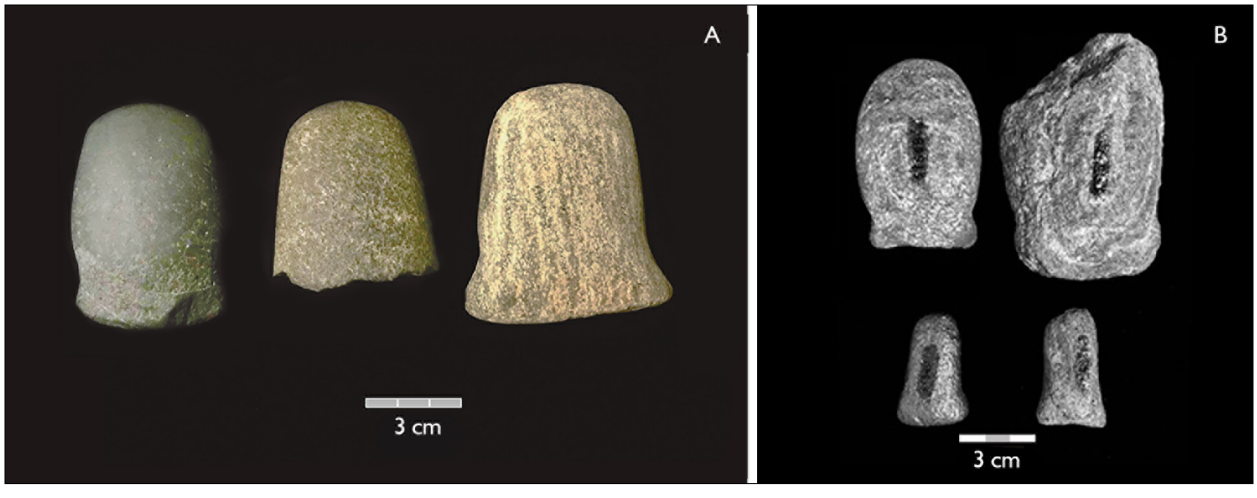

Figure 12. Finalized and used axes (A1) and pre-forms (A2). Photos: Santos (2018).

FINAL CONSIDERATIONS

The scarcity of tools in the excavations of the Jericoacoara 1, as well as the absence of rich stratigraphic layers affirms that there is not a techno-stratigraphic pattern in the lithic industry. This is probably due to the intense Aeolian dynamic that is continually eroding some areas of the site and depositing sediment in other parts. The wind may have blown the sedimentary matrix as well as the lighter archaeological remains embedded, and caused the vertical displacement of the heavier materials such as the lithic tools and ceramic fragments found on the deflation features. This compromised the stratigraphy and the original position of cultural remnants abandonment.

The diversity of the ceramic industry indicates that the archaeological record of the site results from palimpsests. This could be the main contributor of the apparent diversity of the industry expressed by the modes of production of tools and their design variability. Another indicator of palimpsests is the chronology of the settlement which shows the existence of time gaps of hundreds of years, separating some sets of remains in different sectors. In the context of an intensive Aeolian dynamic, typical of dune fields, hundreds of years are enough time to produce substantial changes in the archaeological record, extinguishing some categories of materials and completely mixing some others.

In the absence of stratigraphic sequences with archaeological vestiges, palimpsests can still be expressed in the technology (Machado, 2015). This could explain the presence of distinct modes of production in Jericoacoara 1, whose origins are chronologically distant in the history of technological development, such the as the slicing-like and the C-type debitages or even the bipolar percussion on anvil supports, and the laminar percussion. The coexistence of these modes in the studied sample could mean at least three human groups as has been suggested by the ceramic industries.

The recycling of tools, the implementation of multiple transformative units and the distinct roles performed by the volumes in the production suggest that this industry is about rapid manufacture and is possibly related to short and seasonal camping. Other traits such as the short series of unipolar percussion and the simple bipolar percussion on anvil supports also agree with this hypothesis. The same applies to the non-standardized use of products, as they were utilized as supports to set up transformative units, while some others with sharp edges were put into action directly as tools.

Shaping at Jericoacoara 1 was expressed through the presence of three variants: the unifacial and the lateral concentrated shaping, as well as the bifacial. These modes were applied in order to implement transformative units with simple (unifacial tools) and double bevels (bifacial tools) on pebbles. The same pattern is verified in some flake-supports. Unifacial lateral shaping, however, adds a particularity to this stone industry, as it suggests a different manner by the artisans of viewing tools and their utilizable surfaces to implement transformative units. This is not associated with empirical categories of opposition, such as front and back, up and down, left and right, etc. This particularity in the mode of exploration of pebbles is in some degree different from typical unifacial shaping, which advances more on one surface of the volumes. The tools produced in this manner are then lateral shaped tools, and present transformative units with abrupt penetration platforms that were sometimes recycled, creating ingrown volumes over the cutting lines.

The demand for transformative units in Jericoacoara 1 does not reflect a specific use of a particular type of volume that represented a final and special type of tool. A given volume could fill distinct roles in the technical development of tools, for example, as hammerstones and anvils, then, as cores and tools, and could later return to be used as hammerstones and so on without a specific preference. In addition, a single tool may possess more than one transformative unit, confirming that different production lines could be applied to the same volume regardless of the notion of a tool as a closed system. This finding can be related to the idea of a polyvalent technology, in which distinct methods of exploration, as well as supposed functions, objectives and

use-schemes are imposed on the tools in order to achieve multiple active parts of the same volume . In summary, it is not the type of volume that determines a tool in this industry, but the transformative unit's efficacy within a use-scheme. This idea resembles that of a Swiss army knife, in which distinct transformative units are implemented, but each one is intended to fill specific roles.

The tools in Jericoacoara 1 were viewed as continuously changeable indexes, subject to receive transformative units to perform distinct tasks in lithic production and in economic life. Activities like cutting, grinding, scraping, crunching, fracturing, polishing, drilling, digging, etc., could have had their own transformative units. A use-wear study could give more clues on this hypothesis. This adaptability of the industry seems to be a feature of societies with multipurpose subsistence modalities, which were intended for the acquisition and processing of a variety of resources, including mollusks, crustaceans, fish and mammals living along the coastal plain in the late Holocene.

The remains of mollusks are very abundant in Jericoacoara 1, especially *Turbinella laevigata*, which appears associated with the tools, ceramic fragments (including the bases of bowls with fire soot), bonfire pits and stains of fire on the soil. These elements denounce the use of mollusks as an alimentary resource. Although these materials could be exploited as both tools and body adornment, the consumption as food is most evident in the studied site. The presence of a C-shaped standard fracture in the shells of *Turbinella laevigata* seems to be related with the use of the stone tools. Other sites presenting the same type of fracture include the Picada Nova and Traça 2, located in the neighboring municipalities of Barroquinha and Itarema. This last site revealed bones of a manatee with use-wears associated with mollusks. Another site identified in the community of Preá in the Jericoacoara archaeological area presents remains of fish and crabs associated with mollusks (V. Viana, 2018). Remains of mammals like armadillos and rodents appear in the archaeological records of the sites Sabiaguaba 01 and 02, in the coastal plain of Fortaleza dating to 4,610 ± 30 BP (Beta 290952) (Souza, 2011). The presence of these terrestrial and fluviomarine species on the archaeological sites along the coastal plain of Ceará indicates their exploitation within a human mobility framework involving these environments.

It is important to mention that the economic interpretation defended in this manuscript does not base itself only in the particularities revealed by the transformative unities of tools. It has to do with the geographical incision of the settlement in the coastal plain and the presence of contexts indicating the exploitation of several species as food. In addition, the conception of a tool or a transformative unit that is not related to the economic system in precolonial times seems to be not plausible. The tools were made by the technique and the technique is not a self-granted and independent system defining transformative units for no reason. The technique in past societies did not work as an academic school promoting the creation of characteristics away from the practical life of tools and from the systems of exploration and processing of resources. This type of interpretation does not fit with the principle adopted in this paper, which states that culture is an extra somatic means of adaptation (Binford, 1965).

This manuscript presents the first lithic technological study in the area of Jericoacoara. It naturally lacks much data that is not possible to cover by a single paper or with a preliminary observation of the tools. In any case, hypotheses need to be proposed because this is the way one is going to push the interest in this unexplored area in order to establish the bases for further research. Other investigation topics to be considered in this zone include the complementary tools' characterization, use-wear analysis, identification of lithic assemblages associated with the ceramic industries, and the analysis of micro-vestiges in the sediments of the L03 layer and in ceramic internal walls.

ACKNOWLEDGMENT

This study was financed in part by the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil* (CAPES) .

REFERENCES

Abbeville, C. (1975 [1614]). *História da missão dos padres capuchinhos na ilha do Maranhão e terras circunvizinhas* (Coleção Reconquista do Brasil). Editora da Universidade de São Paulo.

Arai, M. A. (2006). A grande elevação eustática do mioceno e sua influência na origem do grupo Barreiras. *Geologia USP – Série Científica*, *6*(2), 1-6. https://doi.org/10.5327/S1519-874X2006000300002

Bandeira, A. M. (2016). A cerâmica mina no Maranhão. In C. Barreto, H. P. Lima & C. J. Betancourt (Orgs.). *Cerâmicas arqueológica da Amazônia: rumo a uma nova síntese* (pp. 147-157). Ministério da Cultura.

Binford, L. (1965). Archaeological systematics and the study of culture process. *American Antiquity*, *31*(2), 203-210. https://doi.org/10.2307/2693985

Boeda, E. (1997). *Technogenèse de systèmes de production lithique au Paléolithique inférieur et moyen en Europe occidentale et au Proche Orient* [PhD thesis, Université de Paris X Nanterre].

Boeda, E. (2001). Détermination des unités techno-fonctionnelles de pièces bifaciales provenant de la couche acheuléenne C'3 base du site de Barbas I. In D. Cliquet (Ed.), *Les industries à outils bifaciaux du Paléolithique moyen d'Europe occidentale, Actes de la Table Ronde internationale, Caen, 14-15 octobre 1999* (pp. 51-75). Eraul.

Boeda, E. (2014). Deve-se recear as indústrias sobre seixo? Análise comparativa entre as indústrias pleistocênicas da Ásia Oriental e da América do Sul. In A. Lourdeau, S. A. Viana & M. J. Rodet (Eds.), *Indústrias líticas na América do Sul: abordagens teóricas e metodológicas* (pp. 11-35) Editora UFPE.

Cavalcante, J. C., Vasconcelos, A. M., Medeiros, M. F., & Paiva, I. G. (2003). *Mapa geológico do estado do Ceará*. CPRM. Escala 1:500.000.

Claudino-Sales, V. (2005). Os litorais cearenses. In J. B. Silva, T. C. Cavalcante & E. W. C. Dantas (Eds.), *Ceará: um novo olhar geográfico* (pp. 231-260) Fundação Demócrito Rocha.

Costa, M. J., França, J. B., Lins, C. A. C., Bacchiega, I. F., Habekost, C. R., & Cruz, W. B. (1979). *Geologia da Bacia Jaibaras; Ceará, Piauí e Maranhão: Projeto Jaibaras*. Departamento Nacional de Proteção Mineral.

Dantas, L. C. M. (2009). *Relatório do meio físico: plano de manejo do parque nacional de Jericoacoara, Jijoca de Jericoacoara, Ceará* (Unpublished report). Instituto Chico Mendes de Conservação da Biodiversidade/Ministério do Meio Ambiente.

Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA). (1973). *Levantamento exploratório de reconhecimento de solos do Ceará* (Série Pedologia, Boletim Técnico 28). Empresa Brasileira de Pesquisa Agropecuária.

Evreux, Y. (2002). *Voyage dans le nord du Brésil: fait durant les années de 1613 et 1614* (5. ed.). Librairie A. Franck.

Figueiredo Filho, O. A. D., Araújo, A. G. M., Santos Junior, V., Marques, M., Oliveira, D. L., & Mutzenberg, D. (2014). Que pedra é essa? A natureza do material lítico na pré-história do Rio Grande do Norte. *Fumdhamentos*, *11*(1), 3-24. http://fumdham.org.br/wp-content/uploads/2018/08/fumdham-fumdhamentos-xi-2014-_643290.pdf

Fogaça, E., & Lourdeau, A. (2008). Uma abordagem tecno-funcional e evolutiva dos instrumentos plano-convexos (lesmas) da transição Pleistoceno/Holoceno no Brasil Central. *Fumdhamentos*, *7*(1), 260-347.

Heaton, T., Köhler, P., Butzin, M., Bard, E., Reimer, R. W., Austin, W. E. N., . . . Skinner, L. C. (2020). Marine20 - the marine radiocarbon age calibration curve (0–55,000 cal BP). *Radiocarbon*, *62*(4), 779-820. https://doi.org/10.1017/RDC.2020.68

Hogg, A., Heaton, T. H., Hua, Q., Palmer, J., Turney, C., Southon, J., . . . Wacker, L. (2020). SHCal20 Southern Hemisphere calibration, 0–55,000 years cal BP. *Radiocarbon*, *62*(4), 759-778. https://doi.org/10.1017/RDC.2020.59

Inizan, M. L., Reduron, M., Roche, H., & Tixier, J. (1995). *Technologie de la pierre taillée*. Meudon CREP/CNRS.

Julio, K. D. (2012). *A ponta de Jericoacoara e seu potencial como sítio geológico do Brasil no Patrimônio Mundial (World Heritage Comitee UNESCO)* [Master thesis, Universidade Federal de Ceará].

Julio, K. D., Magini, C., Maia, L. P., & Castro, J. (2012). Ponta de Jericoacoara, CE - Belo promontório de rochas neoproterozóicas associadas a praias e dunas quaternárias com registros de variações do nível do mar. In C. Schobbenhaus, D. A. Campos, E. T. Queiroz, M. Winge & M. Berbert-Born (Eds.), *Sítios geológicos e paleontológicos do Brasil* (pp. 1-15). CPRM.

Klokler, D., Almeida, F. O., Bowser, B., Botelho, E., & Camargo, P. B. (2020). The impacts of coastal dynamics on the Saco da Pedra shell midden in Northeast Brazil. *Quaternary International*, *584*(2020), 93-105. https://doi.org/10.1016/j.quaint.2020.10.074

Lepot, M. (1993). *Approche techno-fonctionnelle de l'outillage lithique Mousterien: essai de classification des parties actives en termes d'efficacité technique: application a la couche M2e sagittale de Grand Abri de la Ferrassie* [Master thesis, Université de Paris X Nanterre].

Lourdeau, A. (2006). A pertinência de uma abordagem tecnológica para o estudo do povoamento pré-histórico do Planalto Central do Brasil. *Habitus*, *4*(2), 685-710. http://dx.doi.org/10.18224/hab.v4.2.2006.985-710

Lucas, L. O. (2014). *Mudanças técnicas da transição Pleistoceno-Holoceno ao Holoceno Médio no interior do nordeste* [Master thesis, Universidade Federal de Pernambuco].

Machado, J. R. (2015). A coleção lítica de superfície e o palimpsesto no sítio arqueológico Praça de Piragiba (Bahia). *Teoria & Sociedade*, *23*(1), 41-72.

Meireles, A. J., & Raventos, J. S. I. (2002). Um modelo geomorfológico integrado para a planície costeira de Jericoacoara/Ceará. *Mercator*, *1*(1), 79-94.

Meireles, A. J., Gorayeb, A., & Pereira Filho, N. S. (2018). Campos de dunas em Jericoacoara: intervenções humanas como possível indicador de mudança na dinâmica morfológica. *Confins*, *1*(34), 1-20. http://doi.org/10.4000/confins.12884

Nasser, N. (1974). Nova contribuição à arqueologia do Rio Grande do Norte. Programa Nacional de Pesquisas Arqueológicas - PRONAPA, 5. Resultados preliminares do quinto ano, 1969-1970. *Publicações Avulsas do Museu Paraense Emílio Goeldi*, (26), 155-164.

Nunes, F. C., Silva, E. F. D., & Vilas Bôas, G. S. (2011). *Grupo Barreiras: características, gênese e evidências de neotectonismo* (Boletim de Pesquisa e Desenvolvimento, 194). EMBRAPA.

Projeto RADAMBRASIL. (1981). *Folha SA. 24 Fortaleza: geologia, geomorfologia, pedologia, vegetação, uso potencial da terra* (Vol. 21). Departamento Nacional de Proteção Mineral/Ministério das Minas e Energia.

Prous, A., Souza, G. N. D., & Lima, Â. P. (2012). A importância do lascamento sobre bigorna nas indústrias líticas do Brasil. *Arquivos do Museu de História Natural do Jardim Botânico da UFMG*, *21*(2), 260-283.

Rodet, M. J., Duarte, D., Cunha, A., Diniz, L., & Baggio, H. (2007). Os métodos de "fatiagem" sobre seixo de arenito/quartzito do Brasil Central: exemplo do sítio arqueológico de Buritizeiro, Minas Gerais. *Proceedings of the 14th Congresso da Sociedade de Arqueologia Brasileira*.

Santos, T. (2018). *Tecnologia lítica e economia no Sitio Serrote de Jericoacoara: caracterização de uma indústria do Holoceno recente* [Master's thesis, Universidade Federal de Pernambuco].

Soriano, S. (2000). *Outillage bifacial et outillage sur* éclat *au Paléolithique ancien et moyen: coexistence et interaction* [PhD thesis, Université de Paris X Nanterre].

Souza, L. D. A. (2011). *Ocupações ceramistas na praia de Sabiaguaba - Ceará* [Master thesis, Universidade Federal de Pernambuco].

Suguio, K., & Nogueira, A. C. R. (1999). Revisão crítica dos conhecimentos geológicos sobre a Formação (ou grupo?) Barreiras do Neógeno e o seu possível significado como testemunho de alguns eventos geológicos mundiais. *Geociências*, *18*(2), 461-479.

Viana, S. (2006). Variabilidade tecnológica em sistemas de debitagem: sítios lito-cerâmicos do vale do rio Manso (MT). *Habitus*, *4*(2), 797-832. http://dx.doi.org/10.18224/hab.v4.2.2006.797-832

Viana, S. A., Lourdeau, A., Hoeltz, S., & Gludiy, M. F. (2014). Esquemas operatórios de produção lítica na pré-história do Brasil. In A. Lourdeau, S. A. Viana & M. J. Rodet (Eds.), *Indústrias líticas na América do Sul: abordagens teóricas e metodológicas* (pp. 143-169). Editora da UFPE.

Viana, V., Santos, T. D., & Buco, C. (2016). Dinâmica costeira e registro arqueológico na praia de Jericoacoara, Jijoca de Jericoacoara-Ceará-Brasil. In F. D. L. R. Listo, D. Mütezenberg & B. D. A. C. Tavares (Eds.), *Ebook do I Workshop de geomorfologia e geoarqueologia do Nordeste* (pp. 227-240). Gequa.

Viana, V. (2018). *Dinâmicas culturais e ambientais na praia de Jericoacoara, Jijoca de Jericoacoara, Ceará, Brasil* [PhD thesis, Universidade Federal de Sergipe].

AUTHORS' CONTRIBUTION

T. Santos contributed to conceptualization, formal analysis, funding acquisition, investigation, methodology, and project administration; and H. S. L. Sullasi to conceptualization, investigation, supervision, and writing (original draft, review & editing).