

## RESEARCH REPORT

# Lithic Technology and Prehistoric Settlement in Central and Northeast Brazil: Definition and Spatial Distribution of the Itaparica Technocomplex

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The first dense settlement in central and northeast Brazil, starting ca. 13,000 cal yr BP, is often associated in the literature with the “*Itaparica tradition*.” This assumed homogeneous technocultural group was defined typologically by the presence of unifacially shaped lithic tools called limaces, plano-convex tools, or unifaces. In this article, the results of a techno-functional analysis of the lithic assemblages from the site of GO-JA-01 are presented and compared with those from Toca do Boqueirão da Pedra Furada and Toca do Pica-Pau. It appears that unifacially shaped artifacts correspond to a new technical concept, based on unique structural, productional, and functional principles. These artifacts are part of a technical system within which they have a complementary relationship with the other tools. The comparison between the assemblages from the three sites studied and other sites described in publications sheds light on the geographic uniformity of this technical system. We can conclude from this that the Itaparica technocomplex definitely exists in central and northeast Brazil during the Pleistocene–Holocene transition and the early Holocene, corresponding to the first phase of dense settlement in the region.

**Keywords** prehistory of Brazil, lithic technology, Itaparica technocomplex, early Holocene

## 1. Introduction

Archaeological material suggesting an initial peopling of Brazil prior to the Pleistocene–Holocene transition has been discovered at different sites. However, such evidence of human occupations before 13,000 cal yr BP remains relatively isolated. It is only during the Pleistocene–Holocene transition and the early Holocene that the presence of humans becomes dense. For this period, the sites discovered are much more common and their distribution across the territory appears to correspond to the establishment of new spatial dynamics. The abundant data recovered have enabled consideration of the definition of different cultural groups.

In central and northeast Brazil, this initial dense settlement is generally associated with the *Itaparica tradition*. This was first defined in 1972 as a local group based on material recovered at the Gruta do Padre in Pernambuco (Calderón 1972; Martin 1998). But by the end of the 1970s, it took on the value of a broad archaeological culture, covering the entire

central and northeastern regions of Brazil during the Pleistocene–Holocene transition and the early Holocene (Hurt 1988; Schmitz 1981, 1987). This cultural unit was proposed on the basis of typological traits of the lithic industry and in particular the presence of unifacially shaped artifacts, generally called “limaces,” “plano-convex tools,” or “unifaces,” particularly associated with flake tools. This lithic industry was produced by human groups whose subsistence was based on the hunting of small- and medium-sized prey and the gathering of different plants on the tropical Brazilian savannah (Schmitz 2002).

The definition of the Itaparica tradition is based on tools, particularly the unifacially shaped artifacts and not projectile points. Indeed, one of the particularities of this technological group is the rarity of bifacial shaping of points. These occur in the Itaparica tradition at many sites, but always in minor proportions, and so far these bifacial artifacts do not appear to correspond to a specific form or type.

The lithic industry in central and northeast Brazil has nonetheless rarely been studied in detail and

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through a technological perspective. Technological analyses have begun to focus on the definition of industries at certain sites (Fogaça 2001, 2006; Fogaça and Lourdeau 2008), but so far, we have been aimed essentially at the study of unifacially shaped artifacts, leaving aside the rest of the production system, so that no systematic comparisons between sites in the region have been accomplished to evaluate the degree of similarity or difference between collections. So, the technological homogeneity of what is designated the Itaparica tradition, in other words its existence as a technocultural group, has only been suggested by the presence of unifacially shaped artifacts, not by rigid analysis.

In this article, after a bibliographic synthesis of the lithic industries in central and northeast Brazil, I present the results of the technological analysis of the lithic industry from the GO-JA-01 site in Goiás, considered to be one of the type-collections for the definition of the Itaparica tradition. I then compare these results with those obtained from the sites of Toca do Boqueirão da Pedra Furada and Toca do Pica-Pau in Piauí, to evaluate the technical relationships between these assemblages and thus address the homogeneity of sites associated with the Itaparica tradition.

## 2. Regional setting

### 2.1 Natural environment

The region studied includes central and northeast Brazil. This zone has a moderate relief, mainly between 200 and 1000 m above the sea level, and relatively open vegetation. In the center, where the climate is slightly humid to sub-humid, this is open woodland savannah or *cerrado*. In the northeast, the vegetal cover is dominated by thorny bushes called *caatinga*, and the climate is sub-humid to semi-arid (Théry and Mello 2003).

### 2.2 State of knowledge of lithic productions prior to 8000 cal yr BP

#### 2.2.1 LITHIC INDUSTRIES PRIOR TO 14,000 CAL YR BP

Although controversial, because they do not fit the dominant explanatory model for the initial peopling of the Americas, sites prior to the Pleistocene–Holocene transition in Brazil have yielded archaeological data of technological importance. The lithic artifacts discovered at these sites correspond to industries clearly differentiated from those dating to more recent periods.

In Piauí, in the early layers at Toca do Boqueirão da Pedra Furada (no. 22 in Figures 1–3) dated between ca. 50,000 and 17,000 cal yr BP, Toca do Sítio do Meio (no. 24) between 29,500 and 14,000 cal yr BP, Vale da Pedra Furada, between 22,500 and 15,000 cal yr BP (no. 47), and Toca da Tira-Peia

between 22,000 and 13,000 cal yr BP (no. 48), the lithic artifacts are produced on quartz and quartzite cobbles available near these shelters. Such cobbles are either shaped into massive tools by unifacial or bifacial removals or knapped to produce flakes. Such reduction is simple and includes short series of removals. Most flakes obtained are cortical. These blanks sometimes have short retouch (Boëda et al. 2013, 2014; Felice 2002; Lahaye et al. 2013; Melo 2007; Parenti 2001).

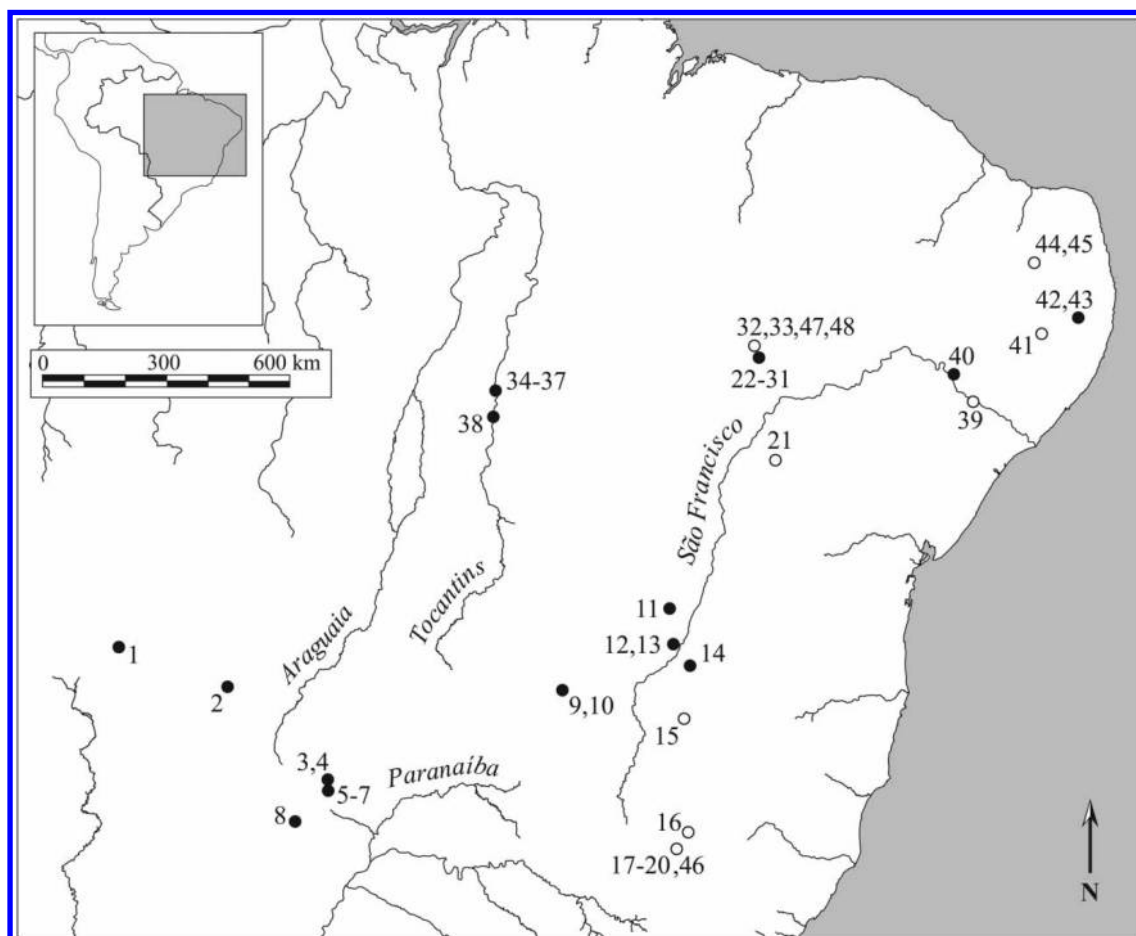
At Santa Elina (Mato Grosso) (no. 1), the tools from assemblage III, dated ca. 27,000 cal yr BP, are made on limestone plaquettes and, less often, limestone flakes. The latter are obtained from simple reduction. The blanks are sometimes retouched, generally abrupt, to obtain concave or denticulated working edges (Vilhena Vialou 2005, 2007).

At Lapa Vermelha IV (Minas Gerais) (no. 17), the flakes from the lower levels and dating between 27,000 and 18,000 cal yr BP are too few to identify the industry in the assemblage (Cunha and Guimarães 1978; Laming-Emperaire 1979; Neves et al. 1999; Prous 1986, 1992: 129–131).

The tools from the lithic assemblages dating to the Pleistocene are thus essentially produced on untransformed natural blocks on which only the working edges were prepared. Tools are sometimes made on flakes. These result from reduction in which a short series of flakes is removed from the cores without advance preparation. They are generally only slightly transformed by retouch. Unifacial shaping is absent in these industries.

#### 2.2.2 INDUSTRIES DURING THE PLEISTOCENE–HOLOCENE TRANSITION AND THE EARLY HOLOCENE IN CENTRAL BRAZIL

Between 14,000 and 8,000 cal yr BP, a period during which the sites discovered are much more numerous, there appears to have been a clear change in technological production. It is during this period that unifacial shaping first appears and develops across central and northeast Brazil. It is used to make tools called “limaces,” “plano-convex tools,” or “unifaces,” depending on the author. These are elongated artifacts symmetric along the longitudinal axis produced on large flakes or, more rarely, plaquettes. These blanks were shaped on one face along the entire periphery. When the blank is a flake, shaping is always done at the expense of the dorsal face, the ventral face remaining untouched. Raw material does not appear to be a determining factor in obtaining these flakes, because they can be sandstone, flint, and quartzite. Detailed analysis remains limited, but significant variability in these artifacts apparently exists (Fogaça and Lourdeau 2008; Lourdeau 2012). Unifacial shaping is always associated in the archaeological levels with flake production from blocks of quartz, sandstone,



**Figure 1** Distribution map of the principal archaeological sites in central and northeast Brazil prior to 8,000 cal yr BP. Black circles indicate sites where at least one layer has yielded unifacially shaped artifacts. White circles indicate sites lacking such tools. (1) Santa Elina, (2) MT-SL-31 (Mato Grosso), (3) GO-JA-01, (4) GO-JA-02, (5) GO-JA-03, (6) GO-JA-14, (7) GO-JA-26 (Goiás), (8) MS-PA-02 (Mato Grosso do Sul), (9) Lapa do Gentio II, (10) Lapa da Foice I, (11) Lapa do Dragão, (12) Lapa do Boquete, (13) Lapa do Bichos, (14) Lapa do Boqueirão Soberbo, (15) Lapa Pequena, (16) Santana do Riacho, (17) Lapa Vermelha IV, (18) Cerca Grande VI, (19) Lapa das Boleiras, (20) Lapa do Santo (Minas Gerais), (21) Abrigo do Pilão (Bahia), (22) Toca do Boqueirão da Pedra Furada, (23) Toca do Pica-Pau, (24) Toca do Sítio do Meio, (25) Toca do Bojo I, (26) Toca do Baixão do Perna I, (27) Toca dos Coqueiros, (28) Toca da Baixa das Cabaceiras, (29) Toca da Cerca do Elias, (30) Toca do João Leite, (31) Toca do Pau Dóia, (32) Toca do Paraguai, (33) Toca Nova do Inharé (Piauí), (34) Miracema 1, (35) Miracema 2, (36) Lajeado 18, (37) Mares 2, (38) Capivara 5 (Tocantins), (39) Justino (Sergipe), (40) Gruta do Padre, (41) Furna do Estrago, (42) Pedra do Caboclo, (43) Chã do Caboclo (Pernambuco), (44) Pedra do Alexandre, (45) Mirador (Rio Grande do Norte), (46) Lapa do Sumidouro, (47) Vale da Pedra Furada, (48) Toca da Tira Peia.

flint, or quartzite. The flakes obtained are often retouched into tools.

Unifacially shaped artifacts are produced after 13,000 cal yr BP. The earliest evidence is found at Lapa do Boquete (Minas Gerais) (no. 12), between 14,000 and 8,500 cal yr BP (Fogaça 2001; Prous 1991; Rodet 2006). In the northern part of Minas Gerais, several rock shelters seem to have yielded similar industries dated between 13,000 and 9,000 cal yr BP: Lapa dos Bichos (no. 13) (Kipnis 1998; Rodet 2006: 409–31), Lapa do Dragão (no. 11) (Prous et al. 1996/97), Lapa do Boqueirão Soberbo (no. 14) (Menezes 2000), Lapa do Gentio II (no. 9), and Lapa da Foice I (no. 10) (Dias Jr 1976/77, 1978/79/80, 1991). But the best documented region and where the lithic industry is richest in unifacially shaped artifacts is the archaeological area of

Serranópolis in southeastern Goiás. This material was discovered in rock shelters, in levels dated between ca. 12,500 and 9,500 cal yr BP: GO-JA-01, -02, -03, -14, and -26 (nos. 3–7) (Schmitz et al. 1989, 2004). In the middle valley of the Tocantins River, unifacial shaping is also well represented in layers at several open-air sites dated between ca. 12,500 and 10,000 cal yr BP: Miracema I and II, Lajeado 18, Mares 2, and Capivara 5 (nos. 34–38) (Bueno 2007). In the states of Mato Grosso and Mato Grosso do Sul, some assemblages contain unifacially shaped artifacts, including the MS-PA-02 rock shelter (no. 8), where the assemblages are dated between 12,500 and 12,000 cal yr BP (Veroneze 1992), the MT-SL-31 rock shelter dated around 12,000 cal yr BP (no. 2) (Wüst and Vaz 1998), and the intermediate levels at

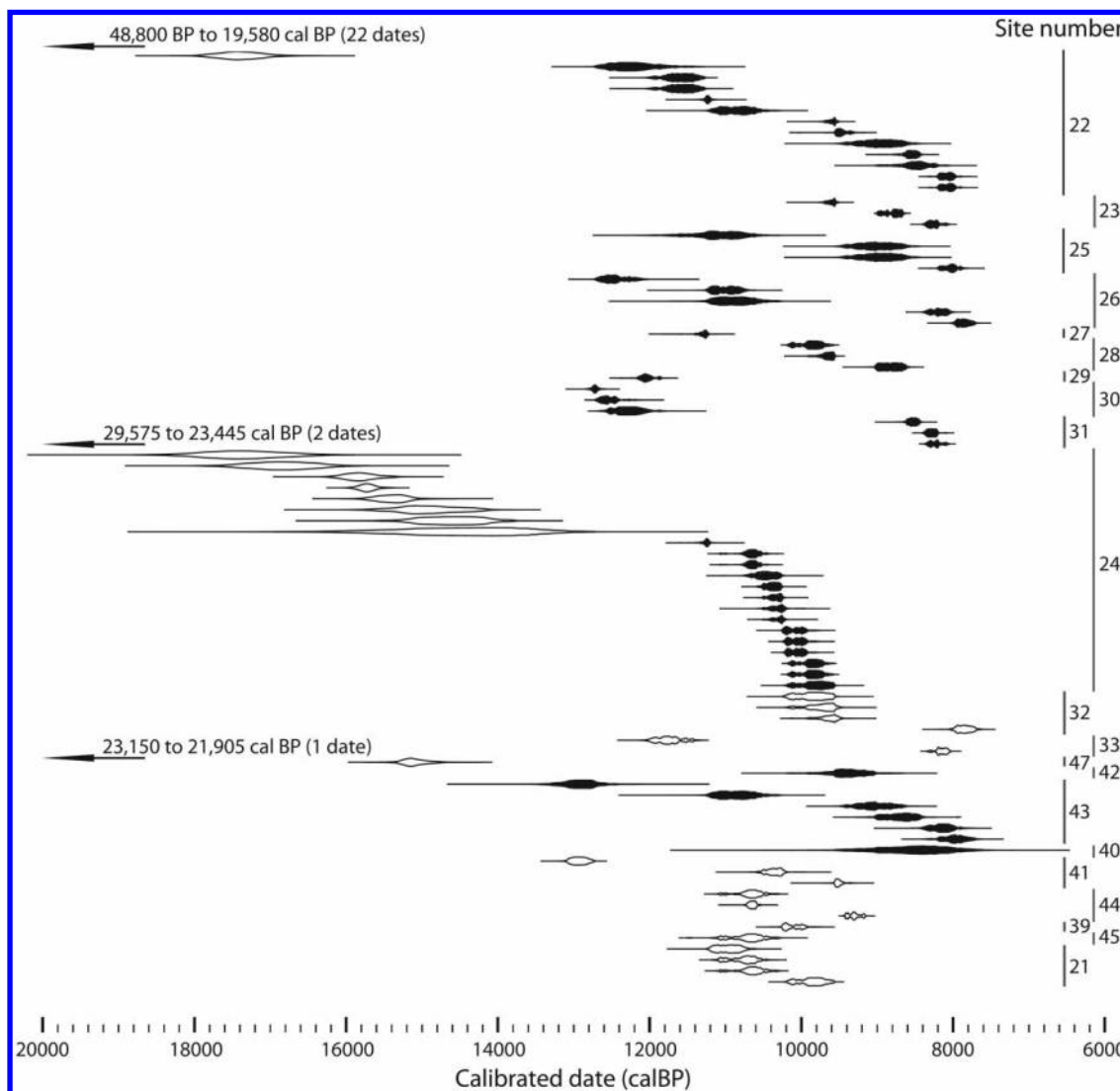
with the period between 9,000 and 8,000 cal yr BP (no. 1) (Vilhena Vialou 2005), an especially recent date in comparison to the other data published for central Brazil (Figure 3).

The only region in central Brazil with clearly different industries is southern Minas Gerais. In the Lagoa Santa region, collections from the sites of Cerca Grande VI (no. 18) (Hurt 1986; Hurt and Blasi 1969; Neves et al. 2004), Lapa do Sumidouro (no. 46) (Bueno 2012), Lapa das Boleiras (no. 19) (Araujo and Neves 2010; Araujo et al. 2008; Bueno 2012; Hurt and Blasi 1969; Pugliese 2007), and Lapa do Santo (no. 20) (Bueno 2012; Pugliese 2007), dated between ca. 12,000 and 9,000 cal yr BP, are characterized by the dominant reduction of quartz blocks and crystals using unipolar or bipolar-on-anvil techniques. The small flakes obtained vary in shape and are rarely retouched. In the early Holocene industry at the Santana do Riacho rock shelter (no. 16), quartz

reduction also dominates quite clearly, using bipolar-on-anvil percussion or unipolar percussion. Several quartzite tools finely retouched on one face are also present, but this does not seem to be strictly unifacial shaping (Prous 1992/93; Prous and Malta 1991). Somewhat to the north, the site of Lapa Pequena (no. 15) has also yielded an industry dating between 9,000 and 8,000 cal yr BP, based essentially on simple flake production from quartz and flint blocks. These flakes are small and not often retouched (Bryan and Gruhn 1978). Thus, in the southern part of Minas Gerais, no lithic assemblage has shown evidence of unifacial shaping.

**2.2.3 INDUSTRIES DURING THE PLEISTOCENE–HOLOCENE TRANSITION AND EARLY HOLOCENE IN NORTHEAST BRAZIL**

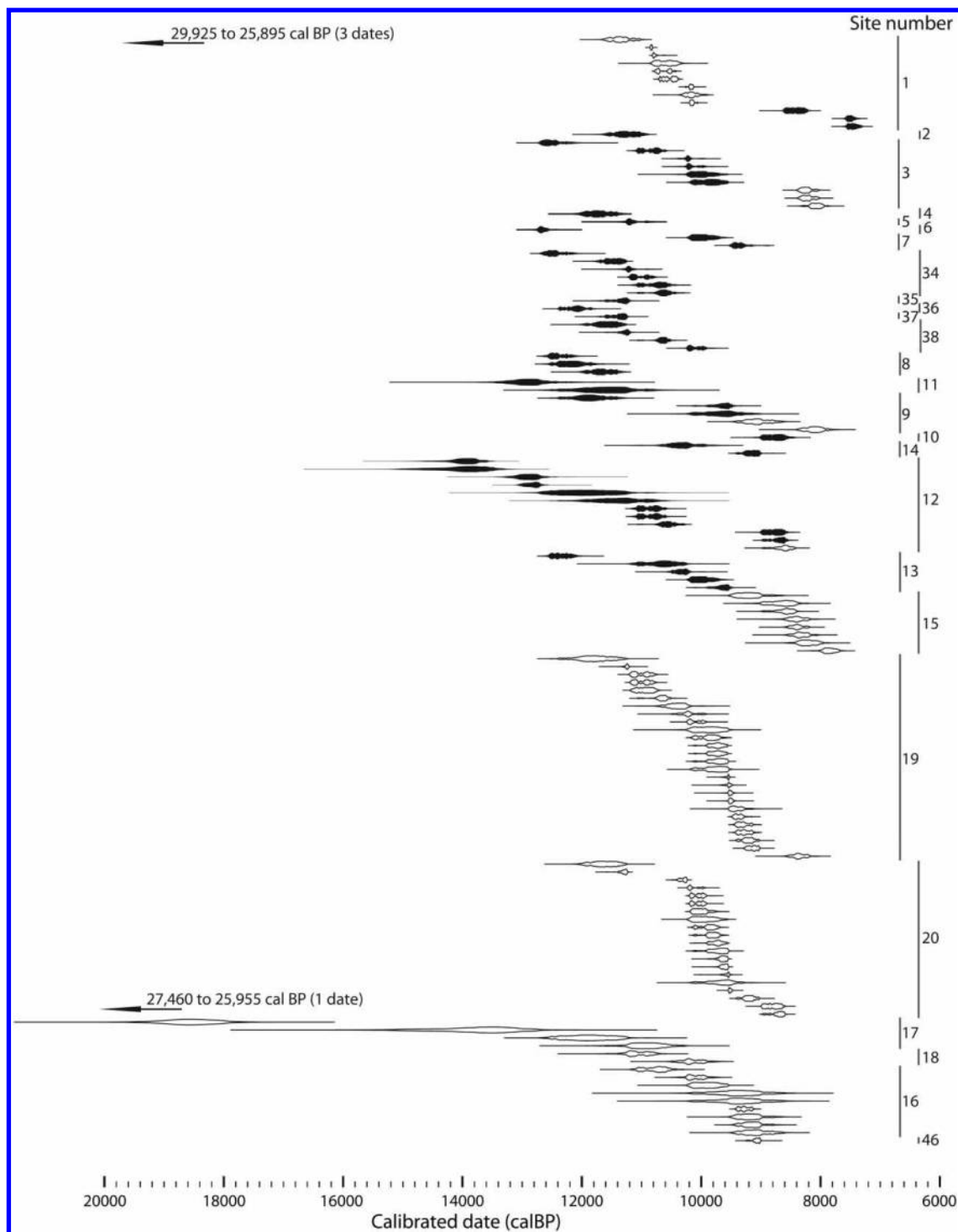
In the northeast, evidence for unifacial shaping is particularly abundant in southeastern Piauí. More than a dozen sites dated between 13,000 and ca.



**Figure 2 Radiocarbon dates prior to 8,000 cal yr BP in northeast Brazil. In black: occupations with unifacially shaped artifacts; in white: occupations without unifacially shaped artifacts. Numbers correspond to the sites listed in Figure 1. Dates calibrated with OxCal v4.2.3 (Bronk Ramsey 2013) and the r:5 IntCal13 atmospheric curve (Reimer et al. 2013). For more details, see Online Supplementary Material I.**

8,000 cal yr BP have yielded this kind of industry. These include, for example, the intermediate levels at Toca do Boqueirão da Pedra Furada (no. 22) (Parenti 2001) and Toca do Sítio do Meio (no. 24) (Melo 2007), the lower levels at Tocas do Pica-Pau (no. 23) (Guidon et al. 2007; Lourdeau 2010), dos Coqueiros (no. 27) (Guidon et al. 1998), do Bojo I (no. 25) (Guidon 1978/79/80, 1981), do Baixão do

Perna I (no. 26) (Guidon 1989; Melo 1994), and do João Leite (no. 30) (Guidon et al. 2009). In Pernambuco, unifacially shaped artifacts have also been found in contexts dating between 13,000 and 8,000 cal yr BP, at the site of Gruta do Padre, the eponymous site for the Itaparica tradition (no. 40) (Martin 1998; Martin and Rocha 1990; Martin et al. 1986), but also at the sites of Pedra do Caboclo



**Figure 3** Radiocarbon dates prior to 8,000 cal yr BP in central Brazil. In black: occupations with unifacially shaped artifacts; in white: occupations without unifacially shaped artifacts. Numbers correspond to the sites listed in Figure 1. Dates calibrated with OxCal v4.2.3 (Bronk Ramsey 2013) and the r:5 IntCal13 atmospheric curve (Reimer et al. 2013). For more details, see Online Supplementary Material I.

(no. 42) and Chã do Caboclo (no. 43) in Bom Jardim (Laroche 1970, 1975; Laroche et al. 1977). The production of unifacially shaped artifacts is thus contemporaneous overall in central and northeast Brazil, but appears to have persisted somewhat longer in the northeast (Figures 2,3).

Moreover, some lithic industries in the northeast are set apart by a lack of evidence for the use of unifacial shaping. These are characterized either by the production of generally unretouched quartz flakes, as at Furna do Estrago (no. 41) (Lima 1985, 1991; Santos 2006) and Justino (no. 39) (Jerônimo and Cisneiro 1997; Vergne 2005), and sometimes other raw materials, as at Abrigo do Pilão (no. 21) (Bryan and Gruhn 1993: 75–109) and Pedra do Alexandre (no. 44) (Martin 1995/96, 1996). It can also involve the exploitation of quartz and quartzite cobbles shaped by a few removals or knapped to produce flakes, as at Toca do Paraguaio (no. 32) (Arnaud et al. 1984; Guidon 1981, 1985) and Toca Nova do Inharé (no. 33) (Guidon et al. 2007). Dates for these sites range between 13,000 and 8,000 cal yr BP (Figure 2). We thus have assemblages with and without unifacial shaping during the same period and across the same space in the northeast, but we cannot as yet determine whether the lack of unifacially shaped artifacts is due to the existence of one or more groups for whom the technical system differs by the lack of unifacial shaping (cultural explanation), or whether this is the result of a specific use of the sites by groups producing unifacially shaped artifacts (functional explanation).

### 2.3 Synthesis and research question

Data on lithic industries available in the literature thus appear to suggest that a certain technological particularity in knapped stone production existed between 14,000 and 8,000 cal yr BP in central and northeast Brazil. The presence of unifacial shaping at most of the sites is the most striking trait, particularly since it is not clearly present before or after this period, and since it is much rarer in the neighboring regions of southern Brazil and the Amazon Basin. Such a finding echoes the supporters of the existence of the Itaparica tradition as indicative of a certain archaeological reality well circumscribed in time and space. In addition, while these assemblages with unifacially shaped artifacts do not correspond to the earliest occupation in central and northeast Brazil, it seems, however, to represent the first significant human settlement of the region.

This information on the importance of the use of unifacial shaping in central and northeast Brazil between 14,000 and 8,000 cal yr BP does not, however, enable evaluation of the homogeneity of these lithic productions. Indeed, other than the lack of detailed studies of unifacially shaped artifacts, it

should be emphasized that their proportion within assemblages is quite variable from one site to another. Some sites contain hundreds while others have only two or three. And these artifacts are never the sole objective of production in the assemblages discovered. They are accompanied by retouched flake tools and, sometimes, worked cobbles. The published typologies differ from one author to another, so much so that it is difficult to obtain an overall view.

So, the presence of unifacial shaping alone remains a limited argument for defining the “Itaparica technocomplex.” The existence of such a technocultural group remains to be demonstrated through detailed technological analyses of the available lithic collections. In the next section, we present the results of one such analysis of the assemblages of three sites in central and northeast Brazil.

## 3. Material and methods

### 3.1 Material studied

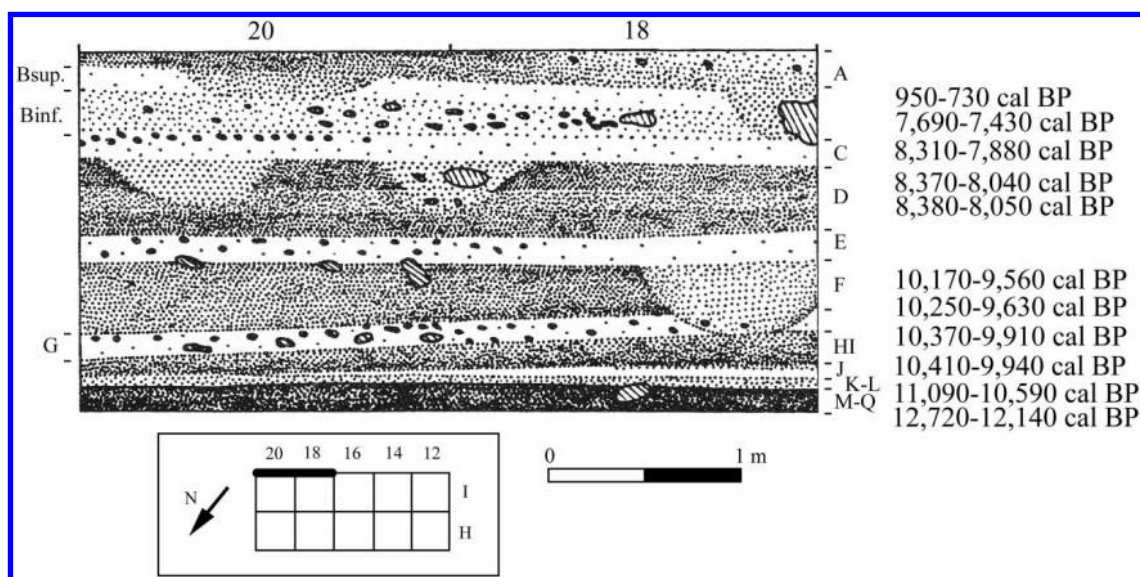
The data set selected for the present study is composed of collections from the Pleistocene–Holocene transition and the early Holocene at the sites of GO-JA-01, in Goiás, and Toca do Boqueirão da Pedra Furada and Toca do Pica-Pau, in Piauí. The choice of GO-JA-01 is based on the richness of its archaeological layers in lithic artifacts and in particular unifacially shaped artifacts, which enables us to examine variability within this artifact class. The study of the two sites from Piauí, more than 1,500 km from GO-JA-01, opens the possibility of evaluating the degree of spatial homogeneity of industries with unifacially shaped artifacts using a comparative approach with the assemblage from Goiás.

#### 3.1.1 GO-JA-01

The GO-JA-01 site is found in Serranópolis. It is a vast rock shelter in a sandstone wall, excavated between 1975 and 1980 by P. I. Schmitz and A. S. Barbosa (Schmitz et al. 1989: 33–48, 2004: 71–102). The main excavation sector has an area of 40 m<sup>2</sup> and a depth of nearly 2 m. This work revealed a stratigraphic sequence of 17 levels composed of sand mixed in varying proportions with ash and charcoal (Figure 4). Assemblages with unifacially shaped artifacts are present only in the lowest layers (strata F to Q) dated between 12,500 and 10,000 cal yr BP. These strata yielded nearly 40,000 knapped lithic remains including 517 tools and 27 cores (Online Supplementary Material IV.1, IV.2). The raw material used is a fine-grained silicified sandstone available directly around the shelter. A few flint artifacts were also found.

#### 3.1.2 TOCA DO BOQUEIRÃO DA PEDRA FURADA

Situated in Coronel José Dias, this very large rock shelter at the foot of a sandstone cliff was excavated



**Figure 4** South stratigraphic section of the principal excavation sector at GO-JA-01 (detail), Serranópolis, state of Goiás (after Schmitz et al. 1989, figure 8, modified). Strata F–Q have yielded lithic assemblages with unifacially shaped artifacts. Dates calibrated with OxCal v4.2.3 (Bronk Ramsey 2013) and the r:5 IntCal13 atmospheric curve (Reimer et al. 2013). For more details, see Online Supplementary Material I.

from 1978 to 1988 by N. Guidon and F. Parenti (Parenti 2001). The excavation extended across a large area of around 900 m<sup>2</sup> with a depth of more than 4 m. At the scale of the shelter, the stratigraphy is not uniform. To establish the chronostratigraphy of the site despite the discontinuity of the sedimentary layers, F. Parenti relied on a relative chronology of the many structures (hearths and concentrations of stones). This relative chronology, coupled with the absolute date for some of the structures, made it possible to distinguish six archaeological phases. The one studied here is the Serra Talhada 1 phase, dated between 12,500 and 9,000 cal yr BP. The assemblage is composed of 956 artifacts, including 111 tools and 44 cores (Online Supplementary Material IV.1, IV.2). Raw materials used are flint, acquired a few kilometers from the site, and quartz and quartzite cobbles found in the immediate proximity of the site.

### 3.1.3 TOCA DO PICA-PAU

This rock shelter in João Costa is found about 25 m from Toca do Boqueirão da Pedra Furada. It was excavated in 2005 by N. Guidon, covering a 15 × 5 m area to a depth of more than 4 m. The fill is composed of sandy sediments fairly uniform throughout the sequence. A single dense archaeological layer was found at a depth between 2.50 and 3.50 m. It dates between 9,500 and 8,000 cal yr BP and has yielded more than 1500 lithic artifacts, including 33 tools and 22 cores (Online Supplementary Material IV.1, IV.2). Raw materials exploited are quartzite, silicified sandstone, and flint.

### 3.2 Method of study: techno-functional analysis

Techno-functional analysis integrates the functional intentions and the ultimate and fundamental objectives of knapping actions, with the technological analysis of the production and retouching of blanks (Boëda 1997, 2013; Lepot 1993; Soriano 2000). It involves a macroscopic study of the lithic material based on the reading of knapping scars in the entire assemblage and a structural approach for the tools produced. As a technological approach, it enables the examination of prehistoric assemblages with a technocultural approach by demonstrating the concepts behind knapping activity.

#### 3.2.1 DETERMINATION OF OPERATIVE SCHEMES

Operative schemes are the preliminary concepts underlying all technical activity (Boëda 1991; Inizan et al. 1999: 15; Pelegrin 1995). They are realized by the sequence of actions necessary to achieve the intended goal: the *chaîne opératoire* (Leroi-Gourhan 1964). The theoretical stages of a *chaîne opératoire* for lithic production are as follows: (1) acquisition of raw material; (2) blank production; (3) confection (or retouch) of the blank to create a tool; and (4) utilization and resharpening of the tool until its abandonment. Each step involves a group of methods (“orderly sequence of actions carried out according to one or more techniques, and guided by a rational plan” (Inizan et al. 1999: 145)) and knapping techniques (material means established to carry out the method (Tixier 1967)).

The blank-production phase consists of working the raw material to obtain a specific volumetric form. The blanks may be obtained by simple selection, by shaping, or by *débitage* methods. Shaping is used here to qualify “a knapping operation carried out for the purpose of manufacturing a single artifact by sculpting the raw material in accordance with the desired form” (Inizan et al. 1999: 155) (the stage of *façonnage* in French-language literature). *Débitage*, instead, is used “to denote the intentional knapping of blocks of raw material, in order to obtain [flakes] that will either be subsequently shaped or retouched, or directly used without further modification” (Inizan et al. 1999: 138).

For uniaxially shaped artifacts, blank production involves a “*débitage* then shaping” combination. These tools are shaped on blanks that are flakes produced during a preceding *débitage* process. Their final volumetric traits come from both the *débitage* phase of the initial flake and the shaping phase that follows.

Confection, or retouch, constitutes the final stage resulting in a finished tool that is ready to use. This involves making the blank “functional” (Boëda 1997, 2001).

Knapping techniques are identified by meticulous observation of the knapping scars on each lithic artifact and comparison with known experimental reference data sets. Methods, in their turn, are addressed by physical or “mental” refitting of artifacts (Pelegrin 1995; Tixier 1978: 39), taking into account all of the technological classes (flakes, cores, and tools) and organizing them dynamically.

Mental refitting consists in reconstructing the phases of production of the artifacts studied via a two-step analysis of the material. First, a detailed technological analysis is done for each artifact, based on examination of knapping traces left on the surface [...]. Second, a synthetic approach to the totality of the data recorded in the first step is used to propose a precise idea of the different phases in the *chaîne opératoire* corresponding to the industry analyzed. (Lourdeau et al. 2014)

### 3.2.2 STRUCTURAL APPROACH TO TOOLS

The classical approach to study tools generally concentrates on their form. While this morphological criterion can sometimes prove to be useful in the definition of stone tools, it is only one of many elements underlying the structure of lithic artifacts (Boëda 1997: 8). During a techno-functional analysis, “a tool is considered as a technical object integrating a group of technical elements, each describable according to a number and variety of technical traits”

(Soriano 2000: 124 (author’s translation)). A tool is structured by three components, called techno-functional units (UTFs) (Boëda 1997). First, the transformative UTF (UTFt) is the part entering into contact with the material being worked during the action. It corresponds to the element called the “working edge:” a dihedral angle with a sharp edge, and a two-surface and section profile. Second, the prehensile UTF (UTFp) is the part of the tool held by the user. Third, the receptive UTF (UTFr) is the part receiving the energy emitted by the user and transmitted to the UTFt.

Unlike the use-wear approach, a techno-functional analysis does not provide arguments to reconstruct the functions or specific uses of lithic tools. The techno-functional approach to tools in a lithic assemblage allows the definition of techno-functional groups. Artifacts within a single techno-functional group share similar volumetric structures and “functional potentials” (Boëda 1997; Soriano 2000). So, in opposition to the “types” found in a typology, these groups are defined by technical and functional criteria by taking into account tools in their entirety. Such an approach enables comparison between different data sets. The structural analysis of tools consists of an integrative approach of the volume of blanks, the location and extension of the UTFs on a blank, the traits of these UTFs, and, in particular, the edges (surfaces, angles, and delineations) and tool confection schemes. The identification of a UTFt depends on three or four criteria: a raw material with cutting properties, an edge formed by the regular translation of the section profile, an angulation adapted to cutting activities, and, when the UTFt is obtained by retouch, a coherent confection scheme.

## 4. Results

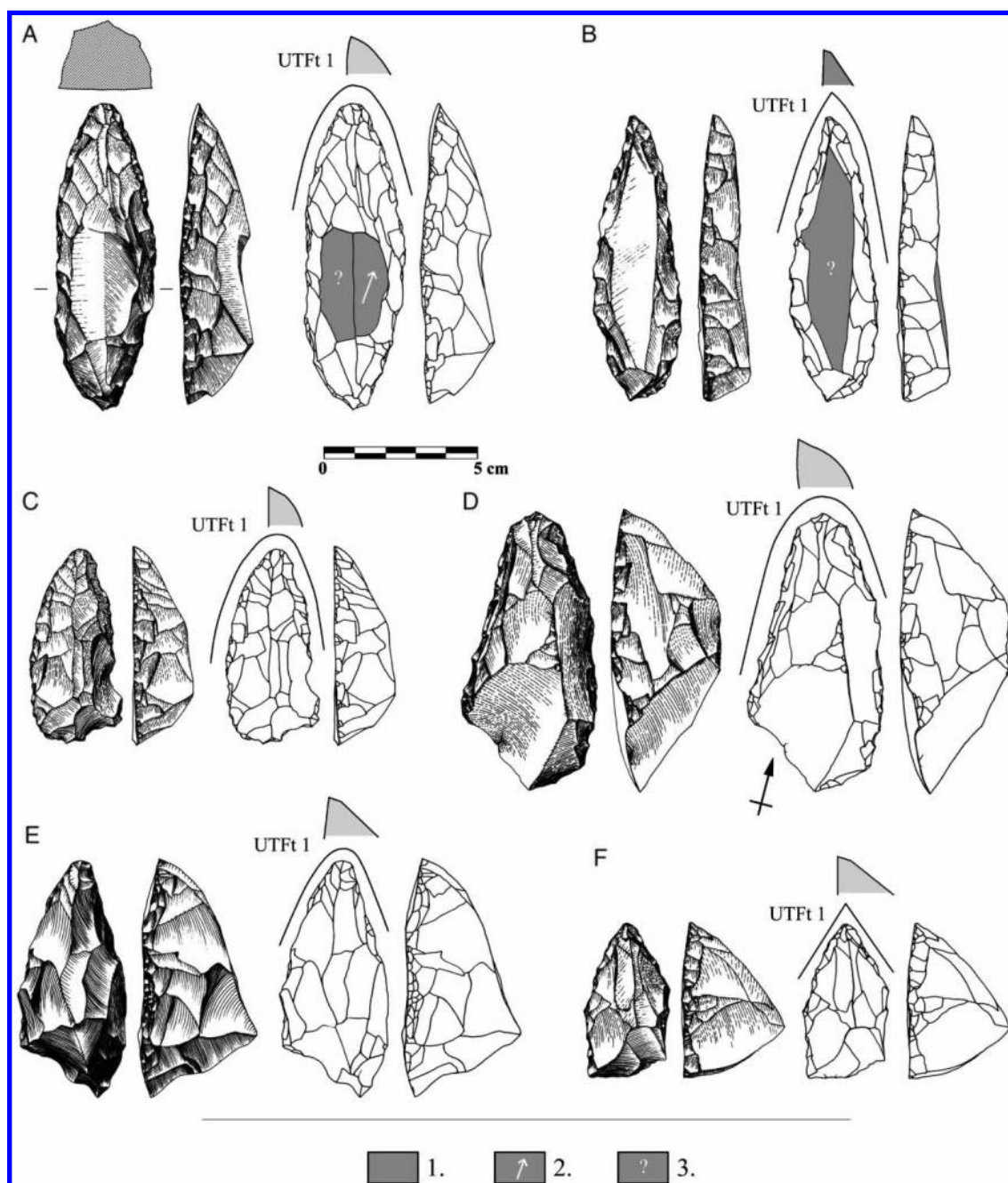
### 4.1 Techno-functional analysis of the GO-JA-01 assemblage

#### 4.1.1 UNIFACIALLY SHAPED ARTIFACTS

Uniaxially shaped artifacts are extremely numerous at GO-JA-01. There are 377 of them, whole or broken (Online Supplementary Material IV.3). This large concentration offers an exceptional occasion to address the range of variability in these tools.

The volumetric structure of the uniaxially shaped artifacts at GO-JA-01 is elongated and symmetric along the longitudinal axis. It is formed of two asymmetric faces: one flat opposed to a non-flat face. The flat face is a fundamental element of this structure. It is the ventral face of a flake and was never modified by shaping flakes. The non-flat face shows some variability in both the profile of the artifact and its transverse section. Three categories of profiles exist: (1) the symmetric profiles of type 1, for which thickness is constant all along the artifact (Figures 5A–C,





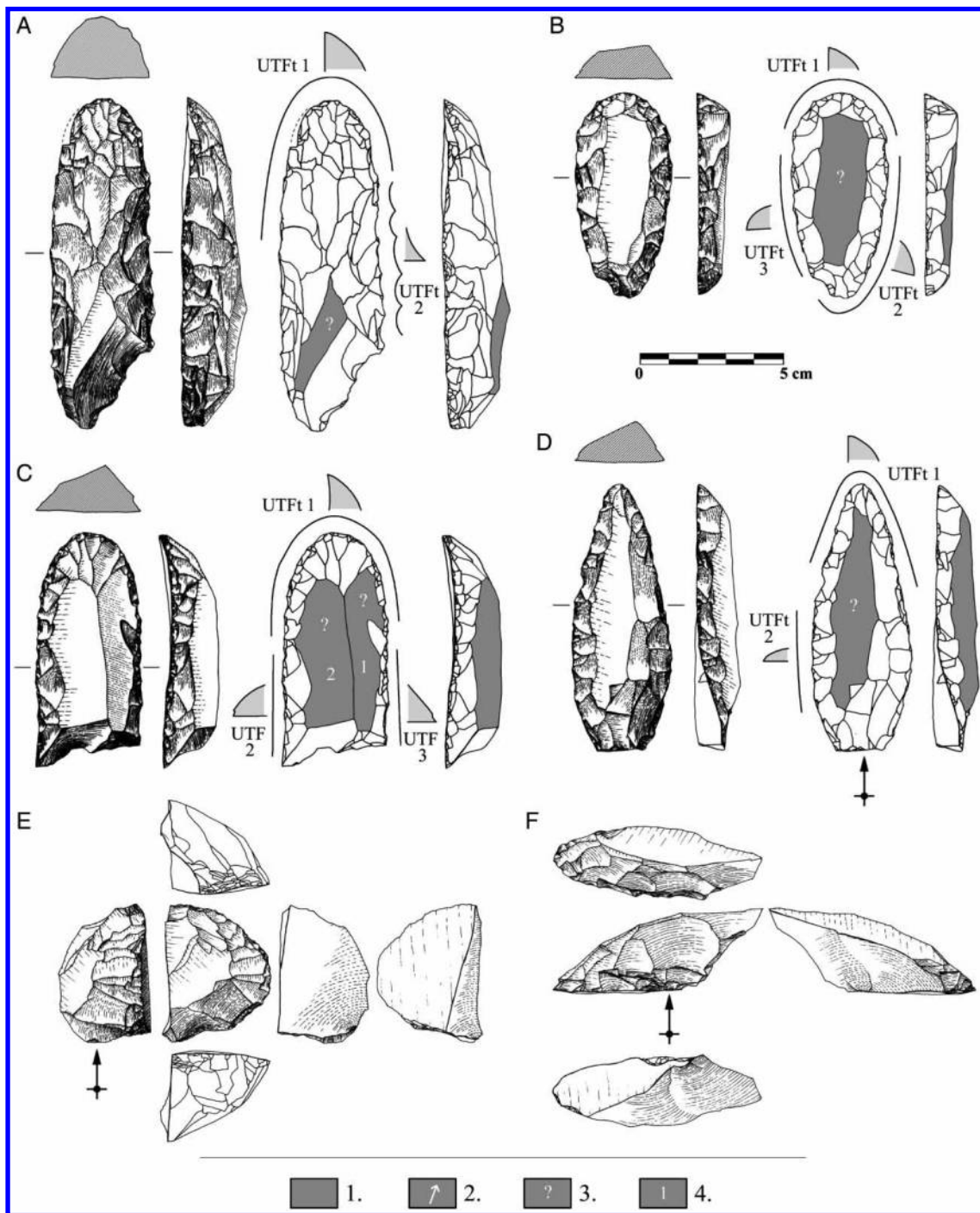
**Figure 5** Unifacially shaped artifacts from GO-JA-01: “tool objects” (A,B,C,D,F) silicified sandstone; (E) flint). Legend: (1) scar previous to flake-blank production; (2) removal direction of the scar previous to flake-blank production; (3) indeterminate removal direction of the scar previous to flake-blank production.

6A–D); (2) the symmetric profiles of type 2, for which the maximum thickness is found in the middle of the artifact and decreases equally toward the ends (Figure 5D); and (3) the asymmetric profiles, for which one half is clearly thicker than the other (Figure 5E,F). The transverse section can be triangular (Figure 6C,D), trapezoidal (Figures 5B,6B), or semi-circular (Figures 5A,6A).

From a functional viewpoint, we observe an absolute recurrence among the unifacially shaped artifacts at GO-JA-01: the systematic presence of a UTFt at one of the ends of the structure. It is symmetric along the longitudinal axis and was often especially

carefully prepared. These artifacts, however, are not all conceived as a unique tool type. Important variability exists in the transformative parts, and in many cases, several UTFts were made on a single blank.

Most of the unifacially shaped artifacts have one to three UTFts. Five principal examples are present: (a) a single UTFt was made on the apical part (Figure 5); (b) apart from the apical UTFt, a lateral UTFt, functionally independent from the first, is present (Figure 6A,D); (c) apart from the apical UTFt, two lateral UTFt functionally independent from the first are present, each one on a different side (Figure 6C);



**Figure 6** Unifacially shaped artifacts from GO-JA-01, all of silicified sandstone: (A–D) “tool-blank objects”; (E–F) resharpening flakes from unifacially shaped artifacts. Legend: (1) scar previous to flake-blank production; (2) removal direction of the scar; (3) indeterminate removal direction of the scar; (4) chronological position of removal of the scar.

(d) two UTFt on the ends were shaped, one opposite the other; and (e) two UTFt on the ends were shaped, one opposite the other, as well as a lateral UTFt functionally independent from the first two (Figure 6B). In terms of means of use, this implies that each artifact corresponds in general to one, two, or three tools. The location of each UTFt requires a specific type of grasping, either axial or lateral. The UTFts on the ends are particularly variable. They can have a rounded, pointed, or, more rarely, transverse rectilinear delineation. The surfaces and angles

forming the dihedral edge also present an obvious variability. Lateral UTFts, when present, have a rectilinear linear, rectilinear denticulated, or convex linear delineation. Except when both ends have a UTFt, the end opposite to the UTFt has a prehensive and/or receptive UTF (UTFp/r) characterized by an abrupt removal corresponding to a fracture surface, the platform of the flake-blank or, most often, a truncation.

The volumetric and techno-functional traits of the unifacially shaped artifacts studied allow us to

assemble them into 17 distinct techno-functional groups (Online Supplementary Material II).

Two broad categories of techno-functional groups can be isolated: groups of “tool objects” and groups of “tool-blank objects” (Boëda 1997, 2001). A “tool object” is conceived to contain only a single tool, with specific techno-functional traits, in other words only a single UTFt–UTFp/r pair: the artifact is the tool. A “tool-blank object” is a blank on which different tools can be made, successively or simultaneously: the artifact is a matrix. Tool objects have a volume shaped so that an apical UTFt can be a product on one end (Figure 5). These are generally fairly short artifacts for which the lateral sides are often convergent in the apical part. Their profile can be symmetric 1, symmetric 2, or asymmetric. The GO-JA-01 assemblage contains eight techno-functional groups of tool objects (Online Supplementary Material II). Tool-blank objects are generally more elongated and their lateral sides are often parallel (Figure 6A–D). Such morphology offers the potential space for the creation of one or more lateral UTFt. These artifacts always have a symmetric 1 profile. Nine techno-functional groups of tool-blank objects are present at GO-JA-01 (Online Supplementary Material II).

The operative schemes of production for uniaxially shaped artifacts are distinguished by their originality. The complementarity of the *débitage* phases of the flake-blank followed by shaping of the dorsal face is a key element. At GO-JA-01, the phase of flake-blank production is poorly known, because it did not take place at the site itself. Some information can, however, be obtained on the tools themselves: the intended blanks are large, generally longer than wide, obtained by direct percussion applied to the stone. Based on the evidence remaining on the dorsal face of the flake-blank, the uniaxially shaped artifacts can be separated into four groups: (a) I.A., the scar(s) that remains creates a central flat surface parallel to the ventral face (Figures 5B,6B); (b) I.B., the scar(s) creates a central flat surface oblique in relation to the ventral face (Figure 6D); (c) II, the scar(s) creates two oblique surfaces in relation to the ventral face for which the intersection creates a longitudinal ridge in the middle of the flake (Figures 5A,6C); and (d) indeterminate, no scar previous to shaping remains on the non-flat face of the artifact (Figure 5C–F) (Online Supplementary Material V).

Three broad modes of uniaxial shaping thus can be identified as follows:

- mode 1: only the zone near the edge has been modified, by short, often sub-parallel, removals, in one or two rows; shaping serves to complete the traits of the non-flat face already in place when the flake-blank was produced;
- mode 2: the shaping phase is realized by several successive rows of short removals, detached from each side; the role of shaping here is major since it significantly modifies the traits on the dorsal face of the flake-blank;
- mode 3: the final mode can be termed “mixed mode,” since one side is prepared using mode 1 and the other by mode 2.

It appears that the shaping methods are linked to the transverse section of the final tool (Online Supplementary Material VI). Artifacts with trapezoidal sections obtain, as soon as the flake-blank is produced, a determining element: the flat central surface. Shaping operations mainly follow mode 1 (Figures 5B,6B). There is thus strong similarity between the original flake-blank and the final intended volume. When the section is semi-circular, in contrast, the shaping phase plays a predominant role in establishing the structural criteria. Indeed, uniaxial shaping always significantly modifies the blank (mode 2) (Figures 5A,C,6A). Similarity between the original flake-blank and the final intended volume is low. Structures with a triangular section are found, in terms of importance of the transformations of the blank, in an intermediate situation between the two above cases. Mode 1 is represented when the flake-blank is of type II (Figure 6C). Mode 2, the complete shaping of the flaked face, is also present (Figure 5C). There exists, moreover, a situation unique to these artifacts: laterally differentiated shaping (mode 3) using type I.B flakes (Figure 6D). The relationship between the original flake-blank and the final intended volume is thus variable.

The number of criteria established by *débitage* and shaping of uniaxially shaped artifacts thus varies by the distance between the criteria required to obtain an intended structure and those already present on the flake-blank.

Several arguments suggest that the use-time of uniaxially shaped artifacts is a long process and that different procedures were used to maintain their functional potential after different phases of use. Evidence of resharpening the transformative parts is abundant. It is attested in particular by flakes typical of this phase and concerns both the apical part (Figure 6E,F) and the lateral edges of the tool. Apart from resharpening, fractures constitute a very common process of modification of uniaxially shaped artifacts during their use. These successive preparation stages can culminate in the exhaustion of the tool (Online Supplementary Material IV.3, VII). Uniaxially shaped artifacts are thus part of a long technological process during which their functional potential changes, as do their structural properties.

4.1.2 FLAKE TOOLS

At GO-JA-01, 123 flake tools were recovered in the same levels as the uniaxially shaped artifacts (Online Supplementary Material IV.2). These are tools in which the original flake is retouched, but not shaped; its original volumetric traits are preserved. With respect to the production mode of such flakes, although the cores found at the site are too small to have produced the flake-blanks for uniaxially shaped artifacts, their size is consistent with that of most of these flake tools (Online Supplementary Material IV.6). Such cores were always part of *débitage* systems in which the knapper relied on natural characteristics on the flaking surface to obtain one or more short series of flakes. There was no preparation of

the raw blocks prior to *débitage*, except for sometimes the opening of a striking platform. The removal of short series of two to six flakes, generally unidirectional, was carried out (Figure 7D). Based on the initial volume and degree of exploitation of the cores, these can vary in morphology but all come from the same unipolar *débitage* method, repeated or not on the block.

The functionalization of the blanks was done by retouching a UTFt and sometimes a UTFp/r. In general, a single UTFt, and thus a single tool, was made on each artifact (Figure 7A–C). The techno-functional traits of the UTFt of these flake tools reflect different functional potentials. Nineteen techno-functional groups were defined (Online

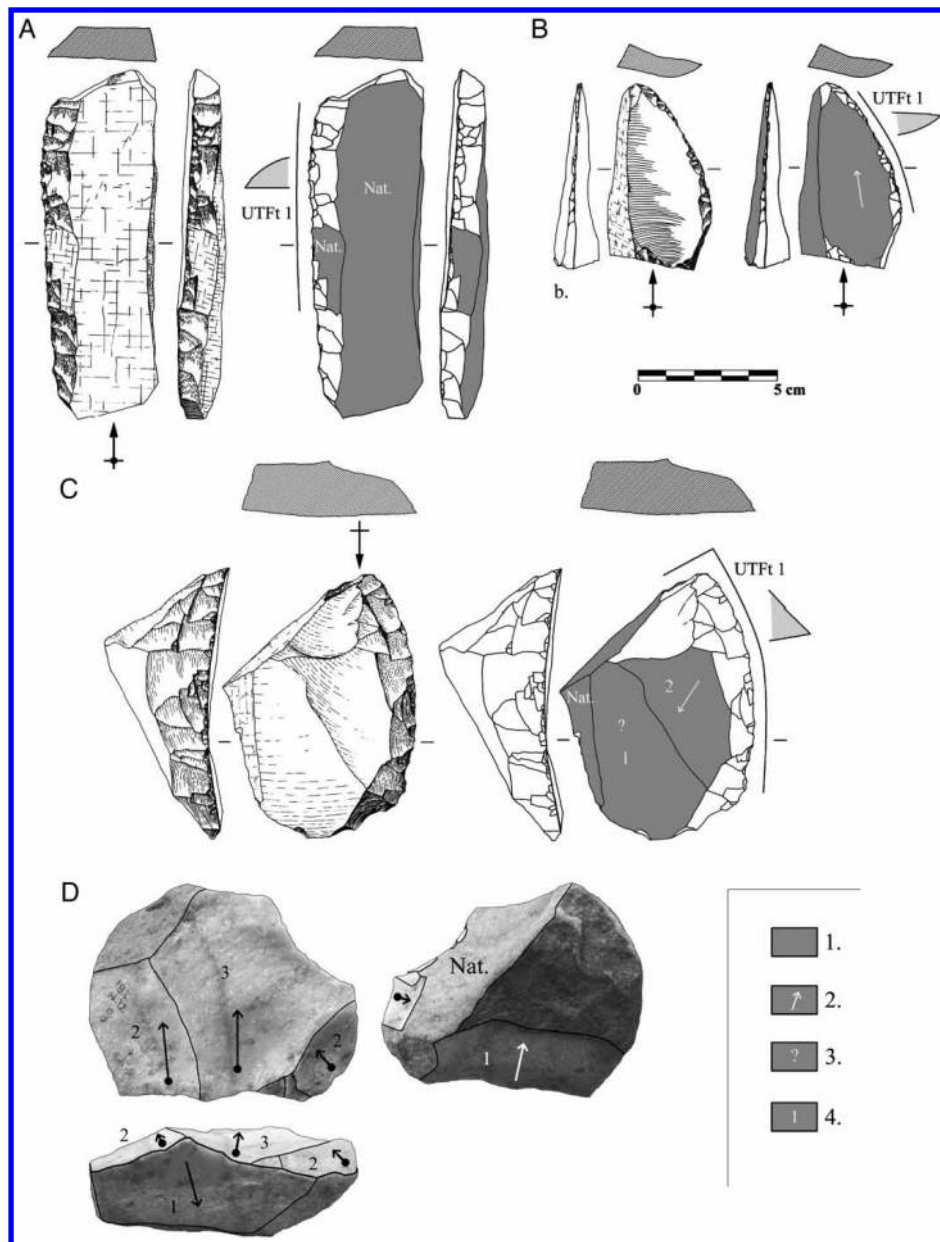


Figure 7 Lithic artifacts from GO-JA-01: flake tools (A–C); core (D) (silicified sandstone (A,C,D); flint (B)). Legend: (1) scar previous to flake-blank production; (2) removal direction of the scar; (3) indeterminate removal direction of the scar; (4) chronological position of removal of the scar; Nat., natural surface.

Supplementary Material III). Delineations are linear rectilinear or slightly convex, denticulated rectilinear, and concave. However, there is an obvious structural homogeneity in these tools. Most flake tools are made on elongated blanks. The UTFt is located along the length of one of the edges, opposite a UTFp/r on the other edge, formed by an abrupt or oblique scar. This configuration reflects the predominance of lateral grasping for flake tools.

#### 4.2 Comparison with the assemblages from Toca do Boqueirão da Pedra Furada and Toca do Pica-Pau

The operative schemes and *débitage* objectives in the assemblages at Toca do Boqueirão da Pedra Furada and Toca do Pica-Pau are very similar to those observed at GO-JA-01. In these two assemblages from the state of Piauí, unifacially shaped artifacts have the same volumetric and general techno-functional traits as those discussed above and were obtained by similar technical modes. In addition,

although these tools are much less common (13 at Toca do Boqueirão da Pedra Furada and 8 at Toca do Pica-Pau), the same range of variability as at GO-JA-01 is observed. We find all of the broad volumetric and techno-functional classes (Figure 8A,C) (Online Supplementary Material IV.4). These tools have equivalent functional potentials at all three sites studied. As for the quantitative disparity of the unifacially shaped artifacts between the sites, this may be explained by site function, the way in which the tools were used and the varying duration of occupation.

The flake tools found at Toca do Boqueirão da Pedra Furada and Toca do Pica-Pau also have structural and techno-functional traits similar overall to those observed at GO-JA-01. For example, 14 out of 19 techno-functional groups defined in the GO-JA-01 assemblage are represented at Toca do Boqueirão da Pedra Furada (Online Supplementary Material IV.5). Once again, most of the flake tools are elongated and have a lateral UTFt opposed to an abrupt or oblique scar (Figure 8B,D). The blanks for these

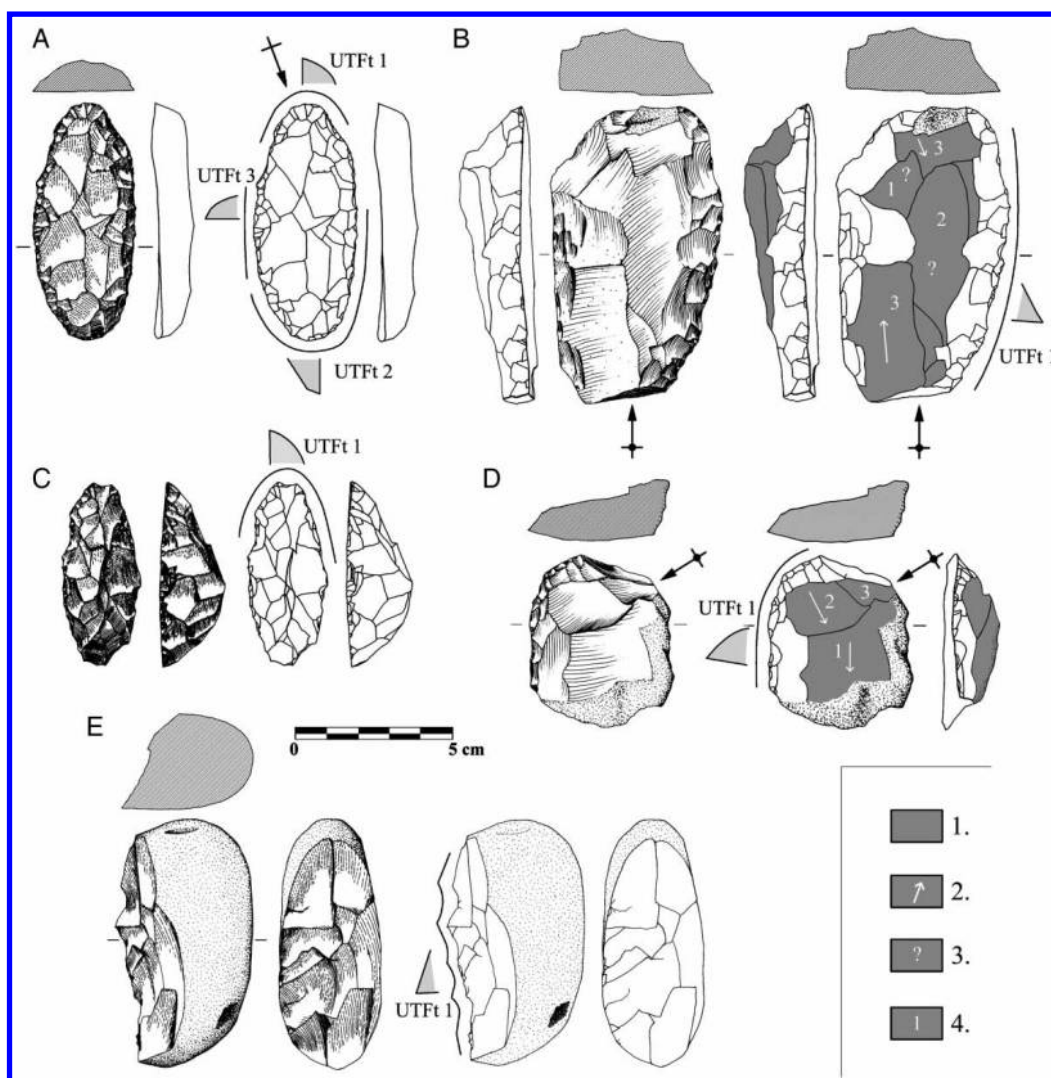


Figure 8 Artifacts from Toca do Boqueirão da Pedra Furada and Toca do Pica-Pau: unifacially shaped artifacts (A,C); flake tools (B,D); cobble tool (E) (silicified sandstone (A,C); flint (B,D); quartzite (E)). Legend: (1) scar previous to flake-blank production; (2) removal direction of the scar; (3) indeterminate removal direction of the scar; (4) chronological position of removal of the scar.

tools were obtained by *débitage* based on the realization of one or more short series of unidirectional removals from unprepared cores.

A bifacial projectile point was discovered at each of these sites in Piauí (Online Supplementary Material VIII). Such artifacts are absent in the principal area excavated at GO-JA-01, but P. Schmitz's team has discovered a bifacial projectile point in a small test pit at this shelter, in a level dating to the early Holocene (Schmitz et al. 2004). In these three sites, typical bifacial-shaping flakes are absent. As we have stressed, it is not rare that bifacial points are discovered in the same levels as unifacially shaped artifacts, but they are always in very small quantity.

The originality of the lithic assemblages at Toca do Boqueirão da Pedra Furada and Toca do Pica-Pau in comparison to GO-JA-01 lies essentially on the presence of worked cobble tools, entirely absent at the latter site. This reflects a different mode for tool production, in which the general volume of the tool comes not from the *débitage* or shaping schemes, but by selection of the cobble in its natural context. However, looking at functional traits, our analysis enables relativization of these differences between the sites of Piauí and Goiás. Indeed, many cobble tools have a structure and a UTFt similar to some techno-functional groups of flake tools at GO-JA-01 (Figure 8E). The structure of most of these tools is comparable with flake tools with a lateral UTFt opposite an abrupt scar.

## 5. Discussion

The techno-functional analysis of the early Holocene lithic assemblages at GO-JA-01, Toca do Boqueirão da Pedra Furada and Toca do Pica-Pau thus reveals the technological proximity of the unifacially shaped artifacts produced at these three sites, despite the great distance separating them. Similarities between the flake tools in these three assemblages are also pointed out. The technological relationship between these collections is thus not limited to the common presence of the remarkable class of remains known as unifacially shaped artifacts. The three data sets demonstrate the existence of identical knapping objectives and similarity in the production schemes used to meet them. These lithic assemblages result from the same technological system.

These observations, which support the strong conceptual homogeneity of these assemblages, are reinforced by data published for several other sites in the region. For example, at Lapa do Boquete (no.12 in Figures 1,3) (Fogaça 2001; Rodet 2006) or at sites in the Lajeado region (nos. 34–38) (Bueno 2007), unifacially shaped artifacts are produced by the same modalities as at the three sites previously studied, and they show the same volumetric range in profiles and transverse sections. Based on published drawings, we also note the existence of a UTFt on the ends of these artifacts with rounded,

pointed, or transverse rectilinear delineation. Finally, the *débitage* schemes used to obtain blanks for the associated flake tools are always described as simple, without core preparation, and by series of mainly unidirectional removals.

These data tend to strongly confirm the existence of the Itaparica technocomplex as a vast technocultural group distributed in central and northeast Brazil during the Pleistocene–Holocene transition and the early Holocene.

## 6. Conclusion

The technological relationships between assemblages in central and northeast Brazil between 14,000 and 8,000 cal yr BP, long suspected by the nearly systematic presence of unifacially shaped artifacts, are confirmed by the present study. The Itaparica technocomplex appears to be a technological system based on the functional flexibility of unifacially shaped artifacts and a complementarity between this tool class and flake tools.

The existence of such technological homogeneity across such a vast area implies a cultural relationship between the groups peopling the entire region, which supports the unity of the phenomenon of population dispersal or technological diffusion at the start of the Itaparica technocomplex.

In Brazilian prehistory, the period when the Itaparica technocomplex appears corresponding to the earliest phases in which a relatively dense and uniform occupation is attested, during the Pleistocene–Holocene transition. The cultural unity of this technocomplex suggests that this initial moment of significant occupation of space corresponds to a unique and coherent phenomenon. The issues of the origin of the Itaparica technocomplex and explanation for its sudden increase in number of archaeological sites remain open. This could be an indicator of migration from other regions or technological development and local population increase from Pleistocene occupations in the region.

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