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RESEARCH REPORT

New Data on a Pleistocene Archaeological Sequence in South America: Toca do Sítio do Meio, Piauí, Brazil

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Sítio do Meio, discovered in the 1990s, showed a sedimentary sequence clearly composed of two sets of deposits separated by a zone of large rockfall from the massive collapse of the shelter’s overhang. The bottom set, slightly more than 60 cm thick, was trapped between the bedrock (upon which it rested) and the lower part of the roof fall (reaching more than 1 m in the excavation area), and yielded some charcoal without other archaeological material. New excavations, however, have revealed the presence of artifacts, additional charcoal, and an alignment of sandstone blocks providing clear boundaries for the artifact concentration. The typological and technological composition of the artifacts is classic, with tools made by shaping high-quality quartz pebbles and tools made on shaping chips or on chips obtained by bipolar percussion of quartz blocks. Quartzite was also used, but only in the manufacture of larger tools, of certain types. The toolkit is made of several convergent pieces, denticulates, rostres, scrapers, and end scrapers. Radiocarbon dating results indicate a Pleistocene age, corresponding to the end of the mid-Upper Pleistocene (MIS3). These dates confirm that Sítio do Meio is the seventh Pleistocene stratigraphic sequence known from a 20-km-radius zone, coming from different sedimentary horizons, testifying to a human presence that extends from MIS3 until the middle Holocene, in this region of Piauí. Particularly, we observed that this occupation still has periodic gaps, with phases of occupation occurring in either short or long periods. With the new data, we are able to consider the cultural specificities of each set in the context of climate data to better understand the diversity of occupation within a single territory, for example behavioral variation in the management of space, adaptive responses to environmental pressures, or potentially both at the same time.

**Keywords** Brazil, Pleistocene, artifact, Sítio do Meio

The theme of the first settlements in the Americas, specifically that of South America, has been the subject of many heated debates, the heyday of which occurred during the years 1980–1990 following the discovery of several sites, the most important being the Sítio do Boqueirão da Pedra Furada in Piauí, Brazil (Guidon 1989; Guidon and Delibrias 1986; Parenti 2001; Parenti et al. 1996, 1999), Monte Verde in southern Chile (Dillehay 1997; Dillehay and Collins 1988; Dillehay et al. 2015), Taima Taima in Venezuela (Cruxent 1967, 1979; Ochsenius and Gruhn 1979), and Meadowcroft (Adovasio et al. 1990) and Cactus Hill (Johnson 1997; McAvoy and McAvoy 1997) in the eastern United States. These sites revealed archaeological sequences whose ages exceeded the dates of 11,000–12,000 \(^{14}C\) yr BP, at the time considered to be the limit post quem of what should be “Clovis first”, in other words America’s colonization since the end of the last glacial maximum (end of MIS2). This hypothesis, still in force until a few years ago, is no longer the object of such a consensus. Several discoveries and less dogmatic rigidity have reopened the “pre-Clovis” debate, although we cannot say that it is fully appeased. Rather than fall into an argument repeatedly presented in several dozen articles just in the last decade (e.g., Boeda et al. 2013, 2014a, 2014b; Dillehay et al. 2012, 2015; Gilbert et al. 2008;
Goebel et al. 2008; Goodyear 2005; Joyce 2013; Lahaye et al. 2013, 2015; Vialou 2005; Waters et al. 2011), here we contribute to this dossier new facts obtained from a new excavation and multidisciplinary studies.

1. Prolegomena

When considering current South American geography, we cannot do anything but marvel at its extreme diversity. This geographic patchwork, in the light of ethnology, is a factor in human behavioral diversity. But how do we realize potential diversity in the long time, beyond all modern memory? Like everything directly unknown to us through oral tradition, we rely on our perception and our senses. And even under the cover of “quantitative objectivity”, the “subjective” perception remains the basis of our information. This explains why in a large majority of cases, technical objects are recognized by their silhouette, even if it is familiar or if it evokes a singularity. This is the case of the three great traditions of South America. Along the western and northern coasts it is the bifacial tradition (Dillehay 2013) characterized by the presence of “fishtail” points and “El Jobo” points as well as the edge-trimmed tradition characterized by “unifacial and core flake tools” (Bryan and Gruhn 2003). Along the Atlantic coast, it is the Itaparica tradition (Bueno 2007; Schmitz 1980, 1987; Schmitz et al. 1989, 2004) characterized by what in the past have been animalistically called Lesmas, by us now referred to as unifacial objects. The rest of the industry in each of these traditions has been the subject of few descriptions, and in some cases it is regarded as a technical expression of expeditious or conjunctural behaviors and thus not expressive of a tradition. In other words, on the one hand we focus on an object on the grounds that it reports a memory which reflects our own (although we know that the subject has no meaning except among his), while on the other hand through technical analysis we consider other objects under the guise of cognitive simplicity (e.g., Lourdeau 2015).

Thus our perception of technical reality, if we can call it that, is more than limited and cannot in any case take account of a behavioral diversity which has to be everywhere, in view of what is happening around the world. The level-scale analysis is not relevant in any way. On the contrary, it is strongly distorted and cannot produce anything but infinite scenarii, each more original than the other but not at all heuristic (Renfrew and Zubrow 1994). In fact, what we believe to see, constantly, is nothing more than what we want to see. What “is” nothing more than what it should be, reintroducing then the problem of the observer and his/her subjectivity to the extent that it is rooted within the living world and within the actor him- or herself. Thanks to the senses, empiricism only retains the timing of sensitive presence. Perception is not an objective event, it is a subjective act. The object appears to the observer and the observer represents the object. It is this representation that will give sense to the object (Boëda 2015).

The object, then, cannot be reduced to its perceived qualities, at just the moment when it is realized. Perception is therefore an intellection leading to an overall insight beyond the set of perceived qualities. In other words, the knowledge of an object which in extent is unknown to us, is built by the aggregation of other experiences which have nothing whatsoever to do with the perceived object, but that become a “virtual” paradigmatic fact replacing the epiphylogenetic’s memory of such an object (Boëda 2015). The epiphylogenetic memory of an object includes the fruit of experience (epi), a personal memory that knowledge of gestures produces and makes the object work, as well as the result of transmission (phylum) by a group, an inheritance/culture (Stiegler 1994). It is under such a phylo-analogical approach that the Piauí industries could not be considered as human, instead only as the consequence of either natural production (Meltzer et al. 1994) or monkeys (S. Fiedel, quoted in Bower 2013), hence preventing any epistemological reflection on our capacity to report on an epiphylogenetic memory that stands out from our own field of memory and does not follow any model.

The Piauí industries have the originality of being produced on quartz! But is this truly a sufficient reason to delete them from the potential record of past humans? Without going into a detailed analysis, we simply cite the fact that in many areas of the world, for example in West Africa (Soriano 2003) and East Asia, and even in the vicinity of the Mediterranean during the MIS3 and MIS2, quartz was always a material of human exploration and use. In the same way in Brazil throughout the early and middle Holocene its use is current (Prous and Lima 1986; Prous et al. 2009; Rodet et al. 2014). In Brazil, we face to an industry of quartz, of Pleistocene age, and silhouettes of instruments not “recognizable” and then, different from those called choppers.

Thus it is necessary to reverse common archaeological reasoning and build our identity through recognition of what is the “other” and not what pertains to us. The debate on the Pleistocene industries of Piauí illustrates the difficulty of imagining the other possibility. Recognition of what is different disappears under a “unifying” approach. Acceptance of another possibility is recognized in the other — a fortiori what I do not know calls into question its uniqueness, its identity, its own values.
It is these differences that are extremely interesting in that they reflect the existence of another possible adaptation to raw material which, through a response to its mineral structure, led to technical answers that became the foundation of local technical progress. The pioneer populations that settled, perhaps with different technical traditions, were faced with another reality that contributed new technical answers that became the foundation of their technical skills (technicité).

The works that we carried out since 2008 at Piauí have aimed to demonstrate, on a larger scale than that of a site, the existence of an important technical phenomenon since the end of the Pleistocene. To do this, we investigated the sites where we have the sedimentary conditions which potentially contained quartz assemblages. We currently have eight stratigraphic sequences of Holocene/Pleistocene or only Pleistocene age in different sedimentary contexts. These include sites in open-air piedmont or terrace positions — Vale da Pedra, Livierac, and Esperanza, sites in rockshelters — Sítio do Meio, Boqueirão da Pedra Furada, and Tira Peia e Antônio norte; and a site in a cave — la Pena (Boëda et al. 2013, 2014a, 2014b; Clemente-Conte et al. 2015; Lahaye et al. 2013, 2015) (Figure 1). In this article we present a review of the data pertaining to the lower levels of the Sítio do Meio, enriching the data on human presence in the south of Piauí before the last glacial maximum (MIS2).

2. Sítio do Meio: Environmental context
Sítio do Meio, with a length of at least 90 m, was discovered in 1973 by Niède Guidon (Guidon and Andreatta 1980) and excavated by sectors between 1978 and 2012 (Aimola et al. 2014; Boëda 2013; Guidon and Andreatta 1980; Guidon and Pessis 1993; Guidon et al. 2014; Pinheiro de Melo 2004b). The site is located at the foot of the rocky walls of the cuesta front, southeast of the Serra da Capivara National Park. The difference between the top and the base of the cuesta front varies between 200 and 250 m. In its upper part, there is an overhang of rectilinear morphology, where the rock is bare. Below, the front has a concave morphology, totally covered with unconsolidated sediments, including a large amount of the detached roof blocks (Figure 2). These sediments are concentrated in the form of colluvial cones from the top or front of the middle part to its base. This is the case of the sediments from Sítio do Meio. The wall there reaches 500 m high, and the morphology of the terrain in its inclined portion favors the accumulation of sediment in gravity flows that are not channeled. A step in the lower third of the escarpment, however, allowed the deposition and preservation of these sediments over the course of time. It is this step that was occupied by the first occupants of the Sítio do Meio. The formation of this deposit is the product of erosion of Paleozoic sandstone located at the top of the wall. Within the site there were two main colluvial deposition events separated by a layer of fallen sandstone blocks (Figure 3). The lower layer of colluvium rests on the sandstone bedrock of Paleozoic age. It and the upper layer of colluvium are intersected by the ceiling fall episode featuring quartz pebbles and sandstone blocks in a somewhat homogeneous sandy matrix (Santos 2007; Santos et al. 2012).

Despite the detailed excavation of more than 250 m² and the importance of the excavated surfaces, it was difficult to realize fine stratigraphy across the whole site and even more difficult to correlate stratigraphically within the archaeological occupation, except through the approximation of radiocarbon dates. Fortunately the dynamics of formation allowed us to easily distinguish two large separate sedimentary temporalities divided by the horizon of large quadrangular blocks corresponding to the massive fall of the shelter’s overhang (Guidon and Andreatta 1980; Pinheiro de Melo 2004a, 2004b) (Figure 3). The sedimentary unit that concerns us is the one that is between the base of the shelter (bedrock) and the base of this rock-fall stratum. This lower sedimentary unit was trapped on the bedrock’s horizontal surface, where it was preserved from all subsequent changes by the massive fallen rock. A large surface of 120 m² was freed of its blocks at different times during the excavations between 1978 and 2000 (Pinheiro de Melo 2004b), but only about 40 m² was excavated into the lower colluvium. The transect of this excavation area between the bottom and the outside of the shelter indicates a horizontal bedrock surface at 3 m depth and gradually declining to the current shelter plumb and heightening beyond this limit. About 50 cm above the bedrock surface, the deposit thickens on the slope zone to reach a little more than 1 m thick. During the early excavations charcoal was recovered from under the fallen blocks, as well as hearth features and some artifacts (Guidon and Andreatta 1980). Two charcoal samples yielded a date of $20,280 \pm 450 \text{ }^{14}C \text{ yr BP}$ (Beta-65350) (Guidon and Pessis 1993) and $25,170 \pm 140 \text{ }^{14}C \text{ yr BP}$ (Gif/LSM-9542). In reality, however, the documentation of these data is almost nonexistent, which has put in doubt the presence of artifacts (Aimola et al. 2014). Likewise, the presence of traces of “fires” has not been further documented (Guidon et al. 2014).

Faced with some evidence of visible artifacts in the preserved stratigraphic cut, we decided to open a new 4-m² test excavation (Figure 4). Like the rest of the shelter, the surface of this area had been covered...
Figure 1  Location of the southern area of Parque da Capivara, showing positions of the main sites excavated by our team and referred to in the text, including sites in the cuesta area (Boqueirão da Pedra Furada, Vale da Pedra, Livierac, Meio) and sites in limestone area (North Antonião, Tira Peia, La Pena).

Figure 2  Overview of the excavation of Sítio do Meio during the resumption of excavations in 2012, with people indicating the place of the current excavations. All clearing of upper deposits was accomplished during the previous excavations. To the right of the walkway, note the fallen cornice that sealed the lower deposit over bedrock and allowed the deposition of the upper deposit in the corridor created between the fallen ceiling and the base of overhang.
before the years 1990/1991 with large fallen blocks. The choice to not open more than a small area was because we considered it sufficient to confirm or not the presence of artifacts. The excavation was done by the successive stripping of 5-cm thick artificial levels parallel to the surface of the bedrock. Each artifact was plotted in three dimensions with a graphical location of parts. A sieve with 1-mm mesh was applied by 50-cm horizontal quadrant, allowing us to recover all non-anthropic products of quartz and quartzite for a technical and taphonomic analysis.

The lower set of sediment in the excavation area reached 50 cm thick. We distinguished at least three “sheets” of artifacts in the excavated area; however, given the sandy nature of the sediment their horizontal limits remain to be determined across a much larger surface. Analytically, the artifacts are considered as a single assemblage, even though there may be differences in the artifacts’ techno-typological compositions. For example, in the upper and middle sheets we respectively found a greater number of large artifacts as well as a higher proportion of sandstone blocks than expected, aligned with a concentration of wood-charcoal and artifacts (Figure 5). Micromorphological analyses are still in progress by X. Villagran, so we cannot here make any interpretations about its formation.

3. Radiocarbon analysis

Four charcoal samples from the lower sedimentary deposit were dated. The first came from the old excavations of 1993. Even though its sedimentary origin has no doubt, it is difficult to position it in relation to our own area of excavation. Also, it seems that it was found in a “bonfire structure” (Parenti et al. 1999). The three remaining samples were wood-charcoal collected in the 2013 4-m² block, from three
different excavation levels (the second, fourth, and twelfth, with the last being the lowest, on the level of contact with bedrock). The samples were prepared following a standard procedure (Dellibrias 1985) in the LSCE laboratory (Gif/Yvette). They were treated following the acid/base/acid method then burnt at 900°C in the presence of oxygen. The radiocarbon activity was finally measured through the use of CO₂ gas, the 1993 sample at the underground Modane (LSM) laboratory in the French Alps (Fontugne et al. 1994) and the three 2013 samples at the Saclay (LMC14) radiocarbon measurement laboratory. The radiocarbon ages are expressed in years BP: Before Present, Present corresponding to the year 1950, with an analytical error of one sigma. Conventional radiocarbon ages are expressed in years before present (BP), with a 1σ error. Ages were calibrated using OxCal v4.2.3 (Bronk Ramsey and Lee 2013): r5 IntCal 13 atmospheric curve (Reimer et al. 2013). The southern hemisphere correction was not applied since the Vale de Pedra site is close to the equator and is influenced by the north and central Atlantic Ocean. Furthermore, this correction is variable through time and no data exist for ages older than 12,500 cal yr BP (Hogg et al., 2013).

The calibrated ages are presented with a 95.4% confidence interval. The δ¹³C values used for the calculation of the conventional ages were integrated by isotopic fractionation produced during the graphitization steps of CO₂ to C, so they could occur in the course of the measuring process. They have no meaning to the paleoenvironment and are not presented in the table. Conversely, the isotopic composition of the Gif/LSM-9542 sample was measured using a VG-optimal mass spectrometer directly from CO₂ gas obtained by combustion of the charcoal (Table 1) and is thus representative of the δ¹³C of the original charcoal.

The calibrated dates obtained for Sítio do Meio are relatively homogeneous, with a maximum range of 28,100–28,600 cal yr BP (95.4 per cent confidence interval) and maximum of probability densities of 29,365–28,553 cal yr BP.

4. Technical and functional analysis

The lithic assemblage recovered from our excavation at Sítio do Meio includes more than 1500 artifacts, among which a little less than a hundred are tools façonnées and/or retouched. The raw material used consists of 95 per cent quartz, then quartzite on some large instruments (Figures 6 and 7). Quartz occurs in two micro-crystalline forms: a milky white quartz with very few fractures and a translucent quartz with a network of more marked fractures. Some rare rounded macro-fragments of quartz crystals were also recovered. This qualitative specificity in artifacts recovered does not reflect the diversity present in the immediate environment of the site, which is much more diversified, comprising of all sorts of quartz of various qualities. Experimental tests performed have shown that the quality used by knappers is particularly good, but that this quartz occurs infrequently in the immediate environment of the site. That is, our archaeological sample reflects a selection that has to do with the skills of chipping and using stone. Despite this selection, though, as precise as it is, it does not necessarily mean that the realized technical schemes we observed perfectly followed the intended schemes of the original knappers. Fissures in the stones that are often undetectable to the naked eye frequently stopped the operational process, resulting in the over-abundant production of waste. This could lead to the interpretation that the site represents a place of intensive production; however, to us this does not seem to have been the case. Furthermore, if we compare the ratio of the quality of the quartz pebbles that produced these mistakes to the intentional technical scheme identified, we observe the same principles of selection. In other words, considering the micro-crystalline nature of the waste, all of it reflects the same qualities, with barely detectable defects (to the naked eye). These observations were easily confirmed through the numerous experimental tests that we performed.

The selection of pebbles according to their mechanical properties and technical characteristics is, then, one of the most important components of the industries of the Sítio do Meio. This observation is broadly generalizable to all other Pleistocene industries of Serra da Capivara that we have studied (Boëda et al. 2013, 2014b). But this does not prevent the observation of variability in the choice of technical features selected.

The instruments are made of chips and pebbles at a ratio of about two-thirds to one-third. A very small proportion of the chips and hemi-pebbles were obtained by bipolar percussion, contrary to what we observed in the Pleistocene layers of the Vale da Pedra site, where this fracturing technique is notably more frequent. In the case of the artifacts from Sítio do Meio, the chips are from unipolar percussion; however, we cannot determine the debitage operations more specifically, because we do not have more than one core. Perhaps they were produced off-site, as part of a continuity of operations of debitage sensu stricto and then introduced, but it is very likely that, in light of their technical characteristics, these chips come from the in situ configuration (aménagement) of instruments on pebbles, under the continuity of operations of the type façonnage.

The reintroduction of façonnage chips in the manufacturing processes of instruments is something we often find in all of the Pleistocene lithic sets of the cuesta, particularly at Vale da Pedra and Boqueirão.
da Pedra Furada (new excavation). This practice occurs less commonly in the Holocene deposits, where unipolar debitage sensu stricto represents the majority of the production of the instruments’ blanks (Lourdeau and Pagli 2014).

There do not seem to be additional (assitiomnant) recycling operations of later times, but rather, an “integrated” process of chipping. The dichotomy between debitage and façonnage forces us to create distinctions which, in the case that concerns us, are no longer operational. This integrated feature is especially visible on the small set of instruments where the characteristics of the blanks — chips or pebbles — are technically very close. The choice of pebble to be reduced (façonné) is no longer a simple option among others, but an act that integrates different possible outcomes to the same potential purpose.

The size of the instruments on chips rarely exceeds 3 cm. The sizes of chipping tools on pebbles are, in comparison to above, a bit varied, between 2 and 10 cm (Figures 6 and 7). These deviations are related to the different categories of instruments. The larger pebbles of quartz and quartzite were objects of shaping (aménagement) of a jagged edge, while the smaller pebbles (essentially of quartz) served as blanks for various instruments (Figures 6, 7A–B). The morpho-technical characteristics of pebbles, and in particular the smaller pebbles, are rather strict. A parallel-sided (volumetric) “rectangle” was consistently favored (Figure 6D–E, G, K–L, P, V, X–Y). The silhouette was more rounded and the shape bulkier, along with an ever present flat surface upon which was exerted the configuration (aménagement) of the transformative portion of the instrument, which was selected to have a transverse edge (Figure 6S–U, Z).

The instruments are easily recognizable for the most part, because they are easily categorizable. The category most present includes the converging instruments, which we subdivided into two distinct types. The first type includes small instruments with retouch on two edges creating a robust bulge more than 1 cm deep (Figure 6A–H). Traceological analysis (Figure 6A–C) demonstrated that the trihedron of convergence was used to pierce hard/medium material, probably wood. The second type has a convergence of two edges made by the formation of two adjacent removed chips (Figure 4I–L). Typically the depth of the point (bec) is less than 5 mm.

The second major category that is opposed to the first includes those instruments whose retouched area (or front) is not convergent. Among these we distinguished the following sub-categories:

- The worked area (front) is denticulate rectilinear, most commonly obtained by direct retouch (Figure 6M–R, AA–BB) and rarely alternating retouch (Figure 6V, CC);
- The worked area (front) is denticulate convex (Figure 6Q–R), along with denticulate rectilinear having come into contact with a hard indeterminate material of an animal through cross-scraping;
- The worked area (front) is called rostres (Figure 6N–P). By rostre we mean the instruments that have a break (not converging) along the main retouched line. This exteriorized relief may come with different technical and morphological characteristics that correspond to a different set of functions which we do not detail in this article (see Clement et al. 2015b).

Traceological data of the latter objects attest to
different functions. For example, the artifact shown in Figure 6T was used to grind an indeterminate medium-hard to hard matter (wood or bone). The artifact shown in Figure 6U was created through some activity linked to the scraping of a hard material of animal origin (Figure 7). The artifact shown in Figure 6Y was worked during butchery activity (Figure 8). The opposite of the edge is configured (aménagée), creating a square silhouette for the instrument; this silhouette, selected and/or configured...
(aménagée), is often found on different categories of instruments, testifying to some form of hafting.

The instruments created on pebbles in a larger dimension occur in small quantities. We find among them jagged edges that are rectilinear or slightly convex, for example a single converging piece (Figure 9A–C). The traceological analysis of these pieces (Figure 9A) attested to the use of traits linked to percussion cutting and carving or fracturing of a hard material, probably linked to contact with bone.

5. Discussion
The ages obtained for this sedimentary set is no exception in our study area. Other sites such as those of Boqueirão da Pedra Furada and the Vale da Pedra Furada located within a 2 km radius have ages ranging through MIS3 until the beginning of MIS2 (the end of MIS3 is set around 25,000 cal yr BP) (Bond et al. 1993; Stuiver and Grootes 2000). The suite of radiocarbon ages from these sites, only covering our period of interest us, the MIS3-2 transition, is shown in Figure 10 and in Tables 1 and 2. From a global perspective, with the set of radiocarbon values, we discern in the current data two temporally separate occupations separated by several thousand years between 27,000 and 24,000 cal yr BP.

The first occupation has no noticeable break between 35,000 and 27,000/28,000 cal yr BP, during which this area seems to have been occupied regularly. Conversely, if we consider the data with a shorter time scale our perception changes. The occupations could occur with time intervals of several hundred years with or without contemporaneous placement. However, there appears to be a time of longer human absence from the area between 27,000/28,000 and 24,000 cal yr BP. This lack of occupation is most visible at Boqueirão da Pedra Furada, where the presence of humans was more constant, over a long time.

The second period of occupations started around 24,000 cal yr BP and did not last more than a few thousand years (Boëda et al. 2014b; Lahaye et al. 2015; Parenti et al. 1999). Re-occupation then did not occur until 16,000/17,000 cal yr BP, when occupations occur almost continuously until the early Holocene.
When we seek a greater environmental cause for this suspension of human occupation between 27,000/28,000 and 24,000 cal yr BP, we do not observe any correlation to the great major climate events such as Heinrich 3 or the beginning of MIS2. But this does not mean that at a finer scale, more minor climate events did not have brutal environmental consequences of short duration. This disparity of occupation over a long time can also be approached from a behavioral point of view. As we mentioned earlier, the site Boqueirão da Pedra Furada occupies a special place because of its more constant use by humans, unlike the two other sites mentioned which, let us recall, are located within a radius of 3 km. The exceptional topographical situation of Boqueirão da Pedra Furada (a rock shelter in a high position) and the occurrence of uniform sedimentary deposits are important reasons for it being more often occupied and well-preserved.

The site Vale da Pedra is an open-air site located 100 m downstream of the Boqueirão da Pedra Furada site. Stratigraphy indicates a succession of different sedimentary events ordered rhythmically with three major phases of occupation separated by barren sedimentary horizons (Boëda et al. 2014b). The earliest occupation is currently represented by a single layer, while the next, ranging from 24,000 to 23,000 cal yr BP, has five successive archaeological "moments". The third and last phase is situated between 16,900 and 14,700 cal yr BP (Lahaye et al. 2015). The site of the Vale is interpreted to represent a housing site frequented discontinuously according to local conditions of accessibility and/or other anthropogenic reasons. According to the provided dates (Table 2), proximity to the site of Boqueirão da Pedra Furada does not seem to have favored direct complementarity, not because the Boqueirão da Pedra Furada was frequented because the Vale da Pedra site was, too, except for a short time and in the early stage. Technical and traceological data from Vale da Pedra do not seem to represent specialized technical and functional activities that could explain an intermittent operation of the site in connection with Boqueirão da Pedra Furada. On the contrary, we observe a synchronization of the occupation of such sites with sedimentary changes, but this does not mean that there was a direct relationship with a larger climate event. Purely local conditions could be the cause.

Sítio do Meio is a different case, containing a “geologically” sudden event which interrupted a series of occupations which, according to radiocarbon data, represents less than one thousand years (Table 1). Moreover, it is possible that this event was catastrophic, contemporary to the last human occupation. Humans do not appear to have returned to the site.
until ten thousand years later (13,100 ± 50 14C yr BP (Gif-9410) (15869–15360 cal yr BP)) (Parenti et al. 1999), long after the chaotic surface of the fallen rock had been covered. The entire site has not been excavated, however, so it is possible that this perception of occupations does not reflect the totality of reality.

To conclude, on the plan of occupation we can say that, with the exception of Boqueirão da Pedra Furada, the other two sites were occupied discontinuously at different time intervals, and it seems like every occupation was for a very short period, on the long-time scale.

The reasons for this disparity in occupations of the same place are not well-understood. The climatological approach may be important to consider, because we know that in our intertropical study zone the MIS3 and MIS2 cooling stages, particularly during Heinrich episodes (Arz et al. 1998; Leduc et al. 2007; Wang et al. 2004), there was more marked moisture. But, if the correlations are likely, it is necessary to delimit clearly the analysis scale. For example, we know that the Sertão, our area of work, which is one of four areas that subdivide the northeast of Brazil, today has half the annual precipitation and the most inter-annual irregularity for the region. It is, therefore, extremely sensitive to small variations in climate intensity, in one direction or another. Was it the same situation during MIS3 and/or the LGM? The presence of megafauna and, in particular, large herbivores attests that during the Pleistocene the area had sufficient vegetation to support the food needs of these animals. Besides that, we know nothing of the consequences of unstable rainfall on this fauna in those ancient times. A growing collection of wood-charcoal from the various Pleistocene archaeological sequences could address this problem, but these data remain understudied. To conclude, we would say that the record of human occupation during the MIS3 and MIS2 are related to important moisture stages making these areas conducive to human occupation, but we know too little about the paleoenvironmental record to propose any models about human management of climatic and environmental change.

The corpus of available chronological data, although important, is also a limiting factor in our interpretations. The variations in occupations, especially the chronology of Boqueirão da Pedra Furada (Parenti 2001; Parenti et al. 1999), are important to consider in all discourse on the mobility of these occupants. Moreover, we deliberately excluded from our reflections here the limestone areas less...
than a few kilometers distant (Lahaye et al. 2013), which were occupied at least since 27,000 cal yr BP. These sites, which we will report shortly, will be important in our interpretations of mobility, not just because of their locations but also because of the presence of megafauna. As a result, according to the scale of time and space that we consider, we are susceptible to perceive different realities. We must therefore remain extremely cautious. For now, only a long-term scale can be used to indicate plausible trends. The reality is far more complex and urges us not to connect just one effect to one cause. We infer that the sites were occupied repetitively, but at different times from one place to another. Similarly, there appears to have been a familiar set of technical production options and functional activities (working non-wood and woody materials, soft and hard animal matter), but still disparities in the qualitative and quantitative aspects of the toolkits of different sites and different layers within the same site. Despite these differences, we should expect to observe the introduction of a totally new instrument design at the end of the Pleistocene, for example the “slug” shaped unifacial tools (Lesmas) added to

Figure 10 Statistical representation of radiocarbon data from three sites: Boqueirão da Pedra Furada (BPF, blue), Vale da Pedra (VdP, green), and Toca do Sítio do Meio (TdM, red) (from data presented in Tables 1 and 2). The set of dates used for the dating of BPF comes from old excavations (Guidon and Parenti), except for 13107 Gif date, which comes from the new excavations since 2011.
correspond to samples measured by AMS. The graphical representation of these measures is shown in Figure 10.

*The dates associated with Gif and GIF supported by the CEA.

Acknowledgements

We thank the French Minister of Foreign Affairs and FUMDHAM (Fundacão Museu do Homem Americano) for annual financing of the Franco-Brazilian mission in Piauí. We wish to thank the French National Facility for ¹⁴C Measurements (LMC14) for performing ¹⁴C activity measurement of the “SacA-” referred samples. The ¹⁴C work was supported by the CEA.

Notes

1 A transcontinental comparative analysis shows that the modes of production connected with quartz are virtually universal. However, the instruments to complete universal functions such as cutting, carving, scraping, slicing, and drilling are different. The expression of the difference lies mainly in terms of instruments and in a lesser extent in terms of production modes.

2 All recovered products, whether inferred to represent human-made artifacts or not, were the subject of a comparative technical analysis. This allowed us to highlight the characteristics of naturally occurring fractures derived from depositional processes as well as from anthropogenic processes (Boëda et al. 2014b).

3 The quotation marks are of our own because the difference between a zone of scattered charcoal and a fire combustion zone was not documented by Parenti et al. (1999).

4 The traceological analysis tested independently the instrument categories on 13 artifacts. In the sample, ten artifacts had functional traits recognizable of a function and/or an action, one artifact where it was not possible to determine the function and two artifacts with marks from post-depositional changes (Clement-Conte 1997) (Figure 6 (O, BB)).

5 In the context of this comparison we introduced old dates from the excavations (Parenti and Guidon) of Boqueirão da Pedra Furada (Parenti et al. 1999). Our own excavations have not yet reached these levels of charcoal. The earliest level we have reached in 2015 corresponds to the sample BPF 13107 (layer C6).

6 One of the dates comes from old excavations of the site Boqueirão da Pedra Furada (Parenti et al. 1999). The other comes from the Vale da Pedra site (Gif-13101) (C7 gamma: rich archaeological layer that is technically different-type from the upper layers). Excavations of this site are underway. The stratigraphy can be exposed only during a survey. These chronological data must then be completed during the opening of a larger surface. However, the chronological discontinuity (sedimentary and

The dates associated with Gif and GIF laboratories were performed through proportional counting of gas, while Gif/SacA dates correspond to samples measured by AMS. The graphical representation of these measures is shown in Figure 10.

Table 2

Radiocarbon dates prior to 19,000 ¹⁴C yr BP for the Boqueirão da Pedra Furada and Vale da Pedra Furada

<table>
<thead>
<tr>
<th>Lab number</th>
<th>Sample identification</th>
<th>Conventional age [¹⁴C yr BP] (1σ)</th>
<th>Calibrated age intervals [cal yr BP] (2σ)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toca Do Meio Gif-13097 / SacA 37770</td>
<td>201318 - F28 - 12ème décapage</td>
<td>24,520 ± 170</td>
<td>[28,924–28,138]</td>
<td>This work</td>
</tr>
<tr>
<td>Gif-13096 / SacA 37769</td>
<td>201306 - D28 - 2ème décapage</td>
<td>24,850 ± 190</td>
<td>[29,380–28,497]</td>
<td>This work</td>
</tr>
<tr>
<td>Gif-13098 / SacA 37771</td>
<td>201350 - D28 - 4ème décapage</td>
<td>25,110 ± 180</td>
<td>[29,581–28,735]</td>
<td>This work</td>
</tr>
<tr>
<td>Gif/LSM-9542</td>
<td>41145--5.88m Ext</td>
<td>25,170 ± 140</td>
<td>[29,575–28,845]</td>
<td>This work</td>
</tr>
<tr>
<td>Gif-13107 / SacA 37780</td>
<td>238245</td>
<td>19,940 ± 100</td>
<td>[24,279–23,702]</td>
<td>This work</td>
</tr>
<tr>
<td>Gif-6158</td>
<td>Couche XX n°268 (3110, 3113)</td>
<td>25,200 ± 320</td>
<td>[28,501–27,071]</td>
<td>Parenti et al. 1999</td>
</tr>
<tr>
<td>Gif-6309</td>
<td>Couche XIX Ech. 2425 &amp; 2437</td>
<td>26,300 ± 800</td>
<td>[32,083–28,723]</td>
<td>Parenti et al. 1999</td>
</tr>
<tr>
<td>Gif-5963</td>
<td>Couche XIX Ech. 2445 &amp; 2431</td>
<td>26,300 ± 600</td>
<td>[31,391–29,176]</td>
<td>Parenti et al. 1999</td>
</tr>
<tr>
<td>Gif-5962</td>
<td>3129 Couche XIX</td>
<td>26,400 ± 500</td>
<td>[31,295–29,500]</td>
<td>Parenti et al. 1999</td>
</tr>
<tr>
<td>Gif-6308</td>
<td>N°247 (Carnet 3063)</td>
<td>27,000 ± 800</td>
<td>[33,127–29,508]</td>
<td>Parenti et al. 1999</td>
</tr>
<tr>
<td>Gif-12823 / SacA 30852</td>
<td>232097 &amp; 099 - G7g</td>
<td>19,700 ± 100</td>
<td>[24,018–23,441]</td>
<td>This work</td>
</tr>
<tr>
<td>Gif-12837 / SacA 28290</td>
<td>192448 - C6base/l13</td>
<td>19,970 ± 100</td>
<td>[24,313–23,743]</td>
<td>This work</td>
</tr>
<tr>
<td>Gif-13100 / SacA 37773</td>
<td>236687</td>
<td>19,990 ± 110</td>
<td>[24,349–23,749]</td>
<td>This work</td>
</tr>
<tr>
<td>Gif-12836 / SacA 28289</td>
<td>192455 - I13/C6 inférieure</td>
<td>20,070 ± 100</td>
<td>[24,408–23,868]</td>
<td>This work</td>
</tr>
<tr>
<td>Gif-12706 / SacA 25554</td>
<td>192448 - C6base/l13</td>
<td>20,090 ± 120</td>
<td>[24,465–23,858]</td>
<td>This work</td>
</tr>
<tr>
<td>Gif-13100 / SacA 37774</td>
<td>237199</td>
<td>29,820 ± 310</td>
<td>[34,584–33,447]</td>
<td>This work</td>
</tr>
</tbody>
</table>

*The dates associated with Gif and GIF/LSM laboratories were performed through proportional counting of gas, while Gif/SacA dates correspond to samples measured by AMS. The graphical representation of these measures is shown in Figure 10.

the toolkit of the previous periods. This early Holocene technical episode, which we call Itaparica, was not synchronous with a long, large climate event like those observed for periods of previous occupations.

In conclusion, the lower sedimentary deposit from Sítio do Meio enriches the data corpus of Pleistocene industries of southern Piauí, reinforcing the fact that human occupation of the Americas began at least during MIS3 (Rabassa and Ponce 2013). The occupation of our study area witnessed an almost continuous occupation over a long time; however, on a shorter time scale behavioral differences are detectable.

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archaeological) that we observed with the upper levels is very present in this survey.

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