A new late Pleistocene archaeological sequence in South America: the Vale da Pedra Furada (Piauí, Brazil)

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The date of the first settlement of the Americas remains a contentious subject. Previous claims for very early occupation at Pedra Furada in Brazil were not universally accepted (see Meltzer et al. 1994). New work at the rockshelter of Boqueirão da Pedra Furada and at the nearby open-air site of Vale da Pedra Furada have however produced new evidence for human occupation extending back more than 20 000 years. The argument is supported by a series of ¹⁴C and OSL dates, and by technical analysis of the stone tool assemblage. The authors conclude that the currently accepted narrative of human settlement in South America will have to be re-thought.

Keywords: Pedra Furada, Serra de Capivara, settlement of the Americas, taphonomy, lithic technology, cobble tools, quartz tools, dating methods

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Introduction

Late Pleistocene human occupation in South America has been the focus of incessant debate for more than 20 years. Human presence in South America before 11,000 cal BC is now, as in North America, widely accepted by most of the scientific community (Miotti 2003; Bonnichsen et al. 2005; Waters & Stafford 2007, 2013; Goebel et al. 2008; Dillehay 2009; Collins et al. 2013). In addition to the celebrated Chilean site of Monte Verde (Dillehay 1997), several sites now show the occupation of South America during the Late Pleistocene, including Taima-Taima in Venezuela (Ochsenius & Gruhn 1979; Ranere & López 2007), Arroyo Seco 2 in Argentina (Steele & Politis 2009) and Huaca Prieta in Peru (Dillehay et al. 2012).

Acceptance of sites dating to earlier than 14,000 cal BC, however, seems to be much more difficult (Roosevelt et al. 2002; Dillehay 2008; Goebel et al. 2008). All discoveries made have been systematically and legitimately discussed, which is justified, but also systematically and surprisingly rejected, without exception. This has occurred, in particular, for sites in north-eastern Brazil, in the Serra da Capivara region (Meltzer et al. 1994; Meltzer 2009; Fariña et al. 2014).

Is there some sort of curse that affects the common sense both of archaeologists making the discoveries, and their colleagues, at the announcement of an age older than 14,000 cal BC? In hypothetico-deductive reasoning, verifiable hypotheses are constructed on the basis of a series of assumptions, the confirmation of which would support the postulates or premises on which the hypotheses are based (Clark 1968). In other words, if one questions the assumptions, the construction of the hypothesis must also be questioned. Why then, despite abundant and varied data collected during the last two decades, are the new results systematically rejected? Is the importance of the hypothesis greater than the validity of the assumptions? Has the hypothesis become a paradigm with its own structure of thinking?

Another issue concerns the value given to the initial assumptions when it comes to stone tools. Indeed, it would appear that when tool types familiar from later periods, like spear or arrow points, are found with Pleistocene ages, a multitude of objections are immediately raised concerning both the ages obtained and the stratigraphy. In contrast, when artefacts are outside our modern memory references, it is their human origin that is questioned and not the stratigraphic context or dating. From a strictly scientific viewpoint, this attitude is quite unsettling, raising the question that if scientific criteria are valid for the Holocene, why would they not be equally valid for late Pleistocene periods?

Despite such difficulties, research in the São Raimundo Nonato region (Piauí, Brazil) continued after the discovery of the Upper Pleistocene and Holocene sequence at Boqueirão.
Figure 1. Location of Vale da Pedra Furada and adjacent sites.

da Pedra Furada in the 1980s (Guidon & Delibrias 1986; Guidon 1989; Parenti et al. 1996; Parenti 2001) with the discovery of three new sites (see online supplementary material for further details): Tira Peia (Lahaye et al. 2013), Sítio do Meio (Guidon et al. 1994) and Vale da Pedra Furada, providing new Pleistocene and Holocene sequences with artefacts and dates (Figure 1). We present here the study we conducted at Vale da Pedra Furada. The site is located in the São Raimundo Nonato region on the edge of the Serra da Capivara. It was discovered in 1998 during a campaign of test excavations on the immediate periphery of the site of Boqueirão da Pedra Furada (Felice 2000, 2002). At a depth of more than two metres, a few artefacts were recovered along with wood charcoals that have been dated to c. 20 000 cal BC (see Table S4). A second date on charcoal, from a layer at least one metre below the surface, provided an age of c. 13 000 cal BC (see Table S4). In 2011, we reopened this test excavation (Boêda et al. 2013).

Excavations at Vale da Pedra Furada in 2011

Vale da Pedra Furada is an open-air site on the left bank of the Baixão da Pedra Furada Valley. It is located at the base of a talus of sandstone rockfall resulting from erosion of a cuesta which here is more than 30m away and survives as a residual ridge (Figure S1). The rocky talus, with a slope of 10–35°, is composed of sandstone blocks ranging in size from monumental to considerably smaller. These blocks are mixed with sediments formed
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by quartz and quartzite cobbles, as well as sand resulting from both regressive erosion of
the cuesta and the marine conglomerate overlying the Devonian sandstone (Pellerin 1983).
Erosion of this conglomerate continues on the valley floor, but no longer contributes to the
talus within the area of the site. Only during rainy years do two caldeirões (waterfalls) drain
the plateau surface waters onto the valley floor. The larger of these creates every year an
intermittent creek that changes slope from around 10° in this first 10m to become much flatter
well before reaching the valley floor. The site is located on the left bank and at a
distance of 15m from this ephemeral creek (Figure S1).

The excavated surface was located over the earlier 30m² test excavation, including its south
and east stratigraphic profiles, and continued into the unexcavated lower layers (Figure S2).
All of the lithic artefacts, knapped or not, were recovered. Three-dimensional coordinates
were recorded for knapped artefacts, and the location of non-anthropic objects logged by
quarter-metre in 50mm thick spits. Systematic sieving to 2mm enabled recovery of abundant
small fragments of knapping debris and retouch flakes.

Each charcoal fragment was individually recorded to better discern the sequence of
burning. Within the 2.6m stratigraphy, eight sedimentary layers have been identified,
although the base of the archaeological sequence has not yet been reached. The first layer—
C1—is about 0.2m thick and corresponds to the modern surface. Below this, from bottom to
top there is a succession of coarse and fine deposits that can be grouped into two broad units.
The upper unit, 0.8–1m thick, contains a single layer—C2—dominated by siliciclastic silty
sands, without visible lamination or other internal synsedimentary structures (Figure 2). The
lower unit, currently excavated to a depth of 1.5m, includes six sedimentary layers, from C8
to C3, showing the alternation between episodes of fine, essentially sandy sedimentation
(C8, C6 and C4) and episodes of coarser deposition (C7, C5 and C3) composed of a
mixture of gravel with some cobbles and boulders in a sand-granule matrix.

The three sandy layers are of different colours, evidence of different depositional and
post-depositional processes. Layer C8 (base not yet reached) is powdery, resulting from the
disintegration of large sandstone blocks on the talus against which the site is set. The base of
layer C6 (>0.3m thick) contains, depending on the area excavated, several thousand wood
charcoal fragments (mm and cm in size) concentrated in certain zones and making the
sediment grey in colour. Sandstone blocks of different sizes (50–200mm) are present at the
base of layer C6, lying directly on gravelly layer C7 or separated from it by a sandy ash layer
a few centimetres thick (Figure S3). No quartz or quartzite cobbles, except for artefacts, are
associated with these sandstone blocks. The origin of these blocks, some of which weigh
3–4kg, is problematic. Indeed, their presence cannot be explained exclusively by colluvial
processes because other lithic materials would have been associated with them. Some blocks
show evidence of heating that caused their breakage, which indicates a temporal correlation
with the charcoal. A disc-shaped block some 150mm thick, currently being analysed, shows
traces of use including smoothing/polishing and areas of pecking on the upper surface. Layer
C4 varies in thickness (0.3–0.4m) depending on location and is defined uniquely by redder
sand.

Layer C7, 0.3m thick, differs from the preceding sandy layers by the more varied size of
the cobbles it contains (some more than 0.3m across), and by their more diversified raw
material. Quartzite cobbles, nearly absent in this layer, are found in the upper gravel layers.

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The matrix surrounding these cobbles is of quartz granules and bright yellow sand different from all other layers. Quartz cobbles, almost exclusively found only in layer C5, are varied in size but rarely more than 50–60mm long, yet in this layer, which is at most 100mm thick, we find a few rectangular sandstone blocks 5–8kg in weight. Such difference in mass (more than 1:100) cannot be explained by the same depositional process, and this supports the hypothesis that they are manuports. There are no macro-traces to indicate any sort of modification of their surfaces. Layer C3, 0.8m thick, is composed of an interstratification of gravels with granular and/or sandy lenses 50–100mm thick. The cobbles are rarely more than 40–50mm long. It is of interest in this kind of tropical environment to note the shortage of clay, both in the Pleistocene sediments and in the soils, where sand and silt dominate. There is no detailed local information about the Pleistocene palaeoclimate, but the source of the sediments, such as the Devonian sandstone of the cliff and the overlying marine conglomerate, may provide a viable explanation. There are few local materials with a mineralogical composition that would produce clays by weathering.

The original colluvial deposits are concealed by the arrangements made for the archaeological conservation and display of the more recent rock paintings in the lower part of the cliffs. It is hence not possible to observe the actual and natural processes of alluvial reworking. At this stage of the research, however, we deduce that the deposition...
of the sediments was not a continuous process. It coincided rather with sporadic humid periods, during which enough water was running from the upper sections of the cliffs for local alluvial deposition that reworked the colluvium near the base of the cliffs. There are no structures such as lenses with cross-stratification or imbrication of the clasts that would indicate medium to high energy sedimentation environments. Thus, the energy of ephemeral streams was not sufficient to move the coarse material, producing lag deposits where the only remobilised sediment was the sand. This was followed by a long dry period without deposition, during which humans occupied the site. The large boulders are not genetically related to the alluvium, and represent either remains of earlier colluvium or human transport. The alternation between periods of no deposition and those with very low energy colluvium reworking by ephemeral streams would allow the preservation of the archaeological remains, including perhaps hearths. It is even possible that intense human activity broke down the original sedimentary structure of these deposits. Several archaeological layers have been identified. Artefacts were discovered in both the upper and lower units. The upper unit, excavated over an area of 5m², contains two sparse archaeological horizons (C2a and C2b), separated by a 0.2m-thick sterile horizon (Figure 3). The two horizons are associated with extremely abundant charcoal scatters that in themselves do not suggest any human involvement. The archaeological material consists only of lithics and includes worked quartz and quartzite cobbles and flakes. The lower unit is much richer. Sedimentary unit C3, excavated over an area of 2m², includes a minimum of four archaeological horizons (C3a to C3b) separated by sandy lenses. The archaeological material is generally found at the interfaces, but given the loose sandy context, the clear demarcation between each horizon and the thickness of the sandy lenses, the deposits are more or less easy to follow. A few charcoal fragments are also present in the archaeological horizons. Horizon C5a is found in gravel layer C5. It contains rectangular sandstone blocks weighing several kilograms (Figure 2) that cannot be explained by natural deposition processes. Unit C7 includes three distinct horizons (7a, 7b and 7c) of artefacts, separated by sterile horizons. The first horizon, 7a, excavated over an area of 6m², directly overlies gravel layer C7. It is contained in sandy, charcoal-rich sediment forming the base of C6 in places and reaching a thickness of 100mm. This horizon has partially overlapping concentrations of charcoal fragments (several thousand per m²). A large number of sandstone blocks and chunks are scattered across the ground. Some show evidence of exposure to fire. The presence should be noted of two slabs (0.3×0.3m) with highly altered upper surfaces, unlike the surfaces of other smaller blocks. The two remaining archaeological horizons (7b and 7c), excavated over an area of 1m², are completely different from each other and separated by sterile deposits. Horizon 7c includes an ashy concave elliptical zone (0.4×0.6×0.1m) at its centre with abundant charcoal and artefacts around its periphery. Unlike horizon 7a, no sandstone blocks or chunks are present. The ashy and charcoal-rich concentrations of horizons 7a and 7b differ in intensity of burning and in their structure. Those of horizon 7a do not appear to have been structured while horizon 7b has a central depression with abundant charcoal. Are all of the burning zones in layers 6base and 7 due to human activity, as our initial observations suggested? That cannot yet be definitively determined but we are awaiting the results of taphonomic and anthracological analyses of the charcoal, as well as sedimentary data from these zones.
The lithic assemblage

The artefacts from Vale da Pedra Furada are mainly made on quartz cobbles, more rarely on quartzite. The raw material comes from the dismantling of the marine layers above.
the Devonian sandstone that has accumulated at the base of the cliff in the mass of fallen rocks, dispersed by intermittent run-off fed by the caldeirões. But this proximity of the raw material does not imply that the procurement territory was so restricted. Technological analyses have demonstrated that the selection was based on the quality of the quartz and quartzite blocks and on very specific morphological criteria that are much less common than one would believe, as we have verified by experimentation. Poor-quality flint is available in the Piauí terraces a few kilometres away but was not exploited, although it was present in low quantities in the Holocene industries where it is used for the production of specific tools such as lesmas.

It may be recalled that the artefacts from Boqueirão da Pedra Furada were considered the products of natural breakage when they fell from the cliff, despite scientifically rigorous technical and taphonomic arguments by Parenti (2001) confirming their human origin. To avoid once again becoming embroiled in endless discussions, we decided to extend the original study by undertaking four associated analyses: taphonomic, technological, experimental and functional.

The source of the cobbles at Vale da Pedra Furada is clearly the same as for Boqueirão da Pedra Furada, although the site is further from the cliffs. Taphonomic analysis was carried out first on material from Boqueirão da Pedra Furada. (Details of the method can be found in the online supplementary material.) We were then able to compare these results with the material from Vale da Pedra Furada. It should be noted that throughout the excavation of Vale da Pedra Furada and regardless of sedimentary context, all objects greater than 20mm (fractured or not) were kept, sampled, weighed and technically analysed, forming an assemblage of several thousand objects. Through this comparison a series of 294 objects could be identified by the presence of technical traits that showed them to be different from those that taphonomic analysis had demonstrated to be of natural origin. This considerable work allows us to assert with confidence the undeniably human origin of the artefacts recovered from Vale da Pedra Furada.

We also analysed the technology. Three processes have been identified in each of the archaeological assemblages: one involving shaping and two involving knapping. Analysis of the artefacts from the different Pleistocene layers shows the diversified production of tools on flakes and cobbles. Two methods dominate: bipolar reduction sensu stricto, and a reduction scheme to shape cobbles that had been carefully selected on the basis of certain criteria. The assemblages differ from one layer to another, evidencing differences in site function and/or different cultural facies (Figures 4 & 5, and supplementary Figures S7–S10).

Functional analysis was also conducted to complete the study (Semenov 1964). Using low- and high-power magnification, we analysed a sample (n = 18) of quartz artefacts from Vale da Pedra Furada, from archaeological horizons C3 and C7. This experimental method allows us to analyse tools made on different raw materials and from all chronological periods (Keeley 1980; Keeley & Toth 1983; Clemente-Conte 1997). Some artefacts from both C3 and C7 present evidence of butchery activities. Some have marks linked to sawing and scraping of medium-hard materials such as wood. Some of the C3 artefacts also present marks showing they had been used to perforate hard animal materials and others show traces of activities on soft to medium materials such as hide (Figure 6). These results confirm that the artefacts were humanly shaped and were used by people in their everyday activities.
Chronology

Another goal of the project was a detailed chronological analysis of Vale da Pedra Furada. Different charcoal samples were collected for this purpose from the different concentrations. Horizons C2a, C2b, C3, C4 and C6base/C7 were thus dated by radiocarbon at the Laboratoire des Sciences du Climat et de l’Environnement in Gif-sur-Yvette, France. In parallel, we collected sediment samples in all of the accessible units, from C2a to C8. These materials were then dated by optically stimulated luminescence (OSL) at IRAMAT-CRP2A at Université Bordeaux 3, France. Details of the materials and methods used to establish the chronology of the occupations are included in the online supplementary material.

The chronological data obtained by both methods (radiocarbon and OSL) are reported in Table S6 and Figure 3. We first note the very good coherence of the OSL ages in relation to the depth of the sediments (Figure S16). No stratigraphic inversions are observed. We also remark the good correlation between the radiocarbon and OSL results, wherever both methods could be applied. The small discrepancy between the OSL and ¹⁴C results from layer C3 may result from the underestimation of the annual dose rate of the OSL C3 sample (BR2011-11). This sample was situated at the limit between fine and coarser sediments (Figure S13). The remainder of the values are coherent, and the chronology of the site is well defined by the combination of OSL and ¹⁴C ages. Finally, the absolute values of the ages obtained should be noted: OSL and ¹⁴C together situate layer C2 around 6000 BC,
layer C3 between 12 500 and 17 500 BC, layer C4 between 15 000 and 17 000 BC, and finally layers C6 and C7 at around 22 000 BC.

**Conclusion**

The site of Vale da Pedra Furada is a succession of open-air human occupations near monumental sandstone blocks at the base of a cliff and next to an intermittent stream. The combination of $^{14}$C and OSL dates situate the upper and lower units during Oxygen Isotope Stages 1 and 2. The upper unit is an early Middle Holocene deposit laid down between 9000 and 7000 BC. The artefacts within it cannot be attributed to a specific techno-cultural facies. The lower unit is clearly late in age, OIS 2, during the Last Pleniglacial. Two sedimentary deposits (C3 and C7) from this unit contain nearly all of the archaeological assemblages. Their $^{14}$C and OSL ages correlate them with two humid phases at 15 000 and 24 000 BP documented by marine core GeoB 3104-1 (Behling *et al.* 2000). These observations are corroborated by results obtained from nearby sites: Sitio do Meio (new excavations) (Boëda *et al.* in press), Tira Peia (Lahaye *et al.* 2013) and Boqueirão da Pedra Furada (new
excavations). The occupations seem to be concentrated during these two periods, although this does not preclude the possibility of occupations at other times. Human presence is continuous, but of variable intensity.

It is not yet possible to comment on the cultural attribution of these artefacts because the assemblages are not sufficiently large. However, several observations can be made. The toolkits from the different Pleistocene layers from the Vale da Pedra Furada are broadly similar, with certain characteristic tools such as single or double bevelled pieces and rostres. In contrast, differences appear in the statistical representation of tools, in blank selection (knapped or shaped) and in size. More generally, features of the assemblages from Vale da Pedra Furada are shared by the other Pleistocene sites. Some disappear during the Early Holocene, other persist into the Holocene. This transcendence of a common set of tools from the Pleistocene to the Holocene supports continuity in patterns of lithic resource management in this micro-region.

With respect to function, the analyses show evidence of processing wood, hide, hard animal materials and other materials yet to be identified. The high acidity of the sediments has destroyed faunal remains, although these are present at sites in the limestone zones. Only charcoal and large numbers of hearths are available to provide evidence of human activities.
These hearths have not been found in all of the archaeological assemblages and those that have vary in appearance.

These results give the strong impression that each assemblage does not necessarily indicate the same functionality or the same duration of occupation. This is clearly evident for layer C6base, which is particularly rich and appears to be a palimpsest. The other assemblages occur in small clusters, as we observed at Boqueirao da Pedra Furada, located about 100m downstream, when we reopened excavations in the remaining part of the site. These similarities extend to the typo-technological and functional composition of the assemblages that we have recently recovered. Yet, having reached only the layers dated to 14580 BC, it is still too early to conclude complete similarity between the sequences. Comparison of artefacts from Vale da Pedra Furada with the artefacts from the previous excavations shows a high degree of technological similarity, but as the excavation techniques were not the same, we can compare only artefacts with artefacts and not assemblages as a whole. In addition, we have only recently reached the uppermost Pleistocene layers.

For broader comparison, it is impossible to include Santa Elina in Brazil (Vilhena Vialou 2005) because of the very low number of lithic artefacts there. The sites of Monte Verde in Chile (Dillehay 1997), Arroyo Seco and Los Toldos in Argentina (Cardich et al. 1973; Miotti & Salemme 2004; Steele & Politis 2009), Huaca Pietra (Dillehay et al. 2012) in Peru and Taima-Taima in Venezuela (Ochesnian & Gruhn 1979; Ranere & López 2007) are too geographically distant to allow useful comparison; further, the raw materials are different. The problem of raw materials in the Piauí region has often been used as a reason to reject human modification of the material. Why were quartz cobbles used while much better materials could be found elsewhere? We respond to this with several arguments:

1) Regardless of period or place, groups exploit only raw materials from the immediate proximity; so why not quartz at Piauí? In East Asia, Europe and Africa quartz was commonly employed by Palaeolithic societies, yet does not present a problem for researchers.

2) The fallacy that considers cobbles synonymous with archaic, and thus the Lower Pleistocene, prevents us from realising that the cobbles are above all as much the basis for a tool as are shaped or retouched blades and flakes.

3) The term quartz covers a wide diversity of material and tools are made on the best-quality quartz.

4) The taphonomic analysis has demonstrated that it is impossible to confuse natural breakage and human production.

We should consider the world of cobbles, and quartz in particular, as the expression of one technological option among others. This technical orientation existed at different places and at different times. It is thus quite difficult to reconstruct possible population dispersals and their cultural links from their lithic artefacts. We can, on the other hand, identify the geographic limits of different technological options.

Such is the case for the Capivara region, where we have an increasing number of exceptional sites located within a 10km radius and beyond, in different sedimentary contexts. The $^{14}$C and OSL dates, while not directly dating the humanly modified materials, allow us to situate these industries in time and thus to compare different periods. As already
observed, the Pleistocene industries from the sites currently known between 25,000 and 15,000 years of age are typo-technologically and functionally homogeneous. Some of their characteristics persist and are found in Holocene industries, while others disappear. They reveal both the technological innovations that follow one another and typify a group of archaeological assemblages within a single time frame, and the continuum of technical traditions and the long-term rootedness of successive populations. In general, these new results indicate a complex history that is still difficult to explain owing to the lack of data. We now need to accept that North and South America were occupied as a result of successive migration events that were irregular. Only the most striking of these waves of migration remain visible in the archaeological record. Yet the visibility of these events should not obscure the others. Indeed, the term ‘migration’ is too loaded with meaning and gives the impression of mass population movements. Ethnology and history show us that population movements can take many forms, some of which leave no visible traces at the archaeological scale of interpretation and discovery.

Such may be the case for the very first migrations, which obviously did not involve the massive and systematic invasion of these two continents. If that had occurred, we would already have found significant evidence for it. The image proposed is rather of patchy occupations disseminated across space with few visible links between them. We are dealing with small groups over long time periods, dispersed across vast areas without significant contact owing to the very low demographic densities. Cultural differentiation would have been all the stronger. Ethnological data all point in this direction, so why should that not apply to more ancient populations?

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References


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Standards and expectations

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Archaeological site candidates like Vale da Pedra Furada, Boqueirão da Pedra Furada (Parenti 2001) and others (e.g. Dillehay & Collins 1988; Guidon et al. 1994) in South America present different empirical and interpretative problems in the study of the first Americans. These candidates date earlier than the generally accepted age of c. 14 500 cal BP for human entry, contain unifacial assemblages unlike anything in North America, and exhibit few, if any, food remains and traditional features (e.g. hearths, artefact clusters). If we judge them by North American standards (e.g. Haynes 1973), they also rarely exhibit clearly defined multi-component cultural strata with discrete use surfaces and reductive lithic industries associated with abundant debitage. Since these candidates do not meet all expected site criteria, what do they represent and how do we assess them? Are they valid archaeological sites indicative of small, highly mobile populations equipped with expedient technologies that left behind ephemeral records? Were they places produced exclusively by natural phenomena (e.g. flooding, falling rocks) that mimicked human activities? Are they specific depositional contexts (e.g. springs) associated with a palimpsest of co-mimicking natural and cultural forces? What is needed is a better empirical understanding of early site candidates and a reconsideration of the standards and expectations employed to judge them.

When I first visited Boqueirão da Pedra Furada (BPF), I had hoped it was an early residential site. I expected it to exhibit recognisable use surfaces, stone tools, hearths, bone remains and artefact clusters. For various reasons, the locality did not meet expected site criteria and its archaeological validity was questioned (Meltzer et al. 1994). Now, after having visited more early localities in South America and in other parts of the world (e.g. unifacial sites in Australia and China), my expectations have changed. I am more open to the idea that portions of BPF were used as quarries and/or short-term campsites by small groups of mobile people. There are three reasons for a shift in my thinking. First, I have examined the unifacial assemblages from other Brazilian site candidates and have become more convinced that some cobbles (similar to a few at BPF) were shaped or knapped by humans. Second, I recently excavated similar early unifaces (made on exotics) and associated burned features at Monte Verde, Chile (Dillehay 2014). And third, I agree with Boeda et al. that we need more contextual and technological options in evaluating early site candidates.

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Standards and expectations

This does not necessarily imply that all criteria traditionally used to judge site candidates should change. Yet, the earliest human record in South America is more diverse and, in several ways, different from that in North America and should be viewed with more flexible standards and expectations.

In turning to questions regarding Vale da Pedra Furada (VPF), the authors are to be commended for their interdisciplinary study of another potential early site. Although aspects of VPF appear to be archaeologically valid, I am concerned about some issues. There is no discussion of the specific horizontal locations of the knapped/shaped stone tools and charcoal concentrations. Do the lithics and charcoal form discrete use surfaces and activity areas? Are the grey (ashy?) sediments underlying these concentrations burned? How much micro-debitage is associated with knapped stones? Does some debitage conjoin? Although elements of the SEM study of the stones are convincing, I am dubious of use-wear analysis on quartz. Although use-wear can be demonstrated, it is difficult to assign specific functions to quartz implements. In regard to stones in the culturally sterile sediments between ‘archaeological horizons’, do they have sharp chipped edges? If so, how do they differ from the designated ‘cultural’ stones? Also, why was VPF selected as a site location? These and other questions need more detailed reporting.

The authors state that the long distances between VPF and other early candidates in South America prohibit an inter-site comparison of their stone tool industries. I disagree. Regardless of the irregular movement and small size of early populations, people had contact and exchanged technologies across vast areas of the continent, as suggested by genetic, skeletal and artefact evidence (e.g. Battaglia et al. 2013). Some quartz assemblages from pre-14 500 cal BP candidates are comparable, especially those with selected morphological traits for knapping. As the authors note, these types of localities appear to represent ephemeral, discontinuous and functionally different episodes of human activity resulting in low levels of archaeological visibility. If this is the case for most of the earliest South American record, then we must redefine our standards and expectations.

References


The number of radiocarbon dates for the late Pleistocene and early Holocene periods in South America has greatly increased in recent years, due to the widespread availability of AMS dating, and the growth of academic research done by South American archaeologists. A recent review of the period between 13,000 and 8000 14C years BP showed the continuous occupation of major biomes and the emergence of regional cultural and economic variation. Before this period the evidence is weak, sparse and discontinuous. It comes from sites that exist in spatial and temporal isolation from the surrounding regions, and invariably are subjected to intense debate. The critical approach to this data is not a simple signal of a ‘curse’ or an ideological barrier to be fought, as suggested by Boëda and colleagues. It simply demonstrates the difficulty of incorporating this data into a geographically comprehensive demographic model for the early peopling of South America (Bueno et al. 2013a & b).

Pleistocene radiocarbon dates have been obtained for several sites in Brazil (Schmitz 1990; Prous & Fogaça 1999). Although the validity of these data had been questioned for many reasons, Boqueirão da Pedra Furada, in Piauí State, and Santa Elina, in Mato Grosso State, remained key pieces in this puzzle, justifying the importance of the continuing investigation of these areas (Parenti 1992; Vialou 2003). Their importance goes beyond the dates of over 20,000 years BP obtained for both sites. They represent the first clues to the pioneering phase of the colonisation of South America. This process would have created an archaeological record of low population density, but concentrated in physically distinctive places that could have been frequently re-occupied. Boqueirão da Pedra Furada and Santa Elina also point to the importance of the riverine routes, such as the São Francisco and La Plata basins, in this initial settlement process, connecting the continental interior to other contemporaneous settlement routes of the North Atlantic coast and the eastern side of the Andean chain (Dias & Bueno 2013).

The article by Boëda and colleagues summarises the research conducted in the Vale da Pedra Furada open-air site; and it can be compared to other two Pleistocene sites recently investigated by the authors in the same region, Toca da Tira Peia and Sítio do Meio (Boëda et al. 2013; Lahaye et al. 2013). The preliminary results presented in these papers have the same problematic, unresolved issues as those that the Boqueirão da Pedra Furada debate brought to light in the pages of Antiquity in the 1990s: a) a lack of information about the contextual relationship between dated samples and artefacts; and b) a lack of specific palaeoenvironmental, geoarchaeological and formation process studies to support a better understanding of the cultural and natural differences between the occupational phases of the Serra da Capivara region (Meltzer et al. 1994; Guidon et al. 1996; Parenti et al. 1996).
Besides, the authors do not analyse how other Pleistocene findings in South America, and in particular in Brazil, can be related (or not) to Pedra Furada, arguing that geographical distances or the low densities of artefacts make comparisons difficult.

The discussion presented by the authors is mainly focused on the criticism raised about the ‘archaic’ nature of the lithic industries of Pedra Furada (and, by extension, of other non-bifacial/pre-Clovis industries in the Americas). Arguments are presented extensively in the supplementary material to ‘prove’ the human origin of the materials. Yet it is not clear to us why Boëda and colleagues did not use the abundant Holocene data from the São Francisco Basin to support their hypothesis. One example is the Lagoa Santa region, at Minas Gerais State, where quartz was used as the main raw material between 10 000 and 8000 BP. Furthermore, the same technological strategies related to the exploitation of local raw materials are present at Santa Elina, suggesting a similar cultural strategy for the pioneering exploitation of new territories.

A true dialogue with the ‘native’ academic community would have certainly added more interesting arguments to this debate than the validity of dating methodologies, the expertise of the ‘technologists’ in charge of the analysis, or the comparisons with ancient East Asian and African technologies. As presented here, the new data from Pedra Furada are old news for us: it is just more of the same old game between rocks and dates. It has little to say about how people creatively made their living in new territories, but says a lot about how modern academic politics works.

References


New World, new models
Hubert Forestier*

The dominant current paradigm for the expansion of modern human populations (Homo sapiens sapiens) is largely driven by the historical development of prehistory and palaeoanthropology. It has been established mainly on the basis of only European and African data. The epistemology underlying the present article implies that the facts and European certainties are far from being universal.

Whether focusing on the latest co-existence of two particular hominins (Neanderthal and modern) or the very significant transition from Middle to Upper Palaeolithic, the history of these disciplines has projected as a universal model what concerns in fact only a continental dead end, that of old periglacial Western Europe. The co-existence of several hominin species was the common mode for several hundred thousand years, and the Neanderthal episode was long considered the last and was certainly the most discussed of the hominin extinctions: raising the question why them and not us? (Lévéque et al. 1993; Hublin et al. 1996; d’Errico 2003; Finlayson 2004; Stringer et al. 2004; Smith et al. 2005; Lorenzo et al. 2012; Lowe et al. 2012; Bates et al. 2013).

For the past decade, following the discovery of the Flores hominin that disappeared towards 17 ka (Brown et al. 2004; Morwood et al. 2004) and the recognition of several subspecies of Homo sapiens in Southeast Asia (Zeitoun et al. 2010), the co-existence of several hominin species has become again the ‘normal’ vision. To this purely anthropological view may be added developments in prehistoric research outside Europe that show there are regions where the universalist pan-European model does not apply. These include notably the powerful example of the cobble tool industry that was present 2 million years ago in China (Hou & Zhao 2010) and persisted until around a millennium ago in Southeast Asia (Forestier et al. 2013). Southeast Asia was marked by a subtropical environment, and the major contribution of plant materials to Hoabinhian technology from 30 to 3 ka was hence only to be expected (Gorman 1970; Solheim 1972; Hutterer 1977; Forestier 2003). Indeed:

“to obtain a proper insight into the Palaeolithic of the Tropics, account should be taken of climatic conditions, and of the special properties obtaining in tropical forests, which for example enabled the nomadic food-gathering tribes to develop an elaborate folk culture based on the availability of bamboo, hardwood and rattan” (van Heekeren 1972: 77).

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The field data from the South American site of Vale da Pedra Furada show that the inhabitants either retained or developed a local industry on cobble tools at a relatively early period. These new data are supported by a coherent chronological framework that has been established from two independent methods. They entail the description and identification of a hitherto unknown episode in the human colonisation of this continent. The ‘psychological’ barrier evoked by the authors also holds because the cobble tool assemblages are described according to the simplified, restrictive and very functional European model based on Modes 1, 2, 3 and more (Clark 1969; Carbonnell et al. 2010; Barsky et al. 2013). Preceding the Acheulean assemblage (Mode 2), Mode 1 is supposed to reflect a certain archaism and early date for cobble/pebble tool cultures with small flake tools, cultures that are connected with the African emergence through to the earliest settlement of Europe. Nevertheless, in several tropical regions of the world this equation is no longer respected, as for example in Southeast Asia with the Hoabinhian (Foretiers 2000; Zeitoun et al. 2008), in the Philippines (Pawlik & Ronquillo 2003), in Korea (Yi 2011) or in western Africa (Soriano 2003).

The results of the typo-technological and functional analysis show that the stone tools from Vale da Pedra Furada were undoubtedly knapped and used according to specific technical criteria. Partly geographical determinism and partly cultural choice, this South American case is an anthropological response to the environment (both climate and geology/raw material sources) and the ecology.

To understand them objectively, these lithic assemblages from the Late Pleistocene archaeological sequence in Brazil must be studied outside the constraints of the European model. They must be recognised as an authentic Brazilian techno-functional convergence without any biological, cultural and chronological connection with the Old World. To conclude, the Vale da Pedra Furada site (Piauí, Brazil) allows us to glimpse a new geographical area conquered by modern humans where the dominant bio-cultural paradigm built in Europe may not be valid. Indeed, the latter appears to be an exception which does not work in other regions. It is precisely that which is important about this paper, especially from a fundamental epistemological perspective.

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Is dating an issue?

James Feathers*

Few areas have been the target of such persistent efforts to demonstrate a human presence in the Americas during the Last Glacial Maximum as the region in and around Serra da Capivara National Park in Piauí, north-eastern Brazil. This reflects the 30 years of research in the area by Niède Guidon, who first brought attention to the possibility of evidence for early humans at Boqueirão da Pedra Furada in the 1980s (Guidon & Delibrias 1986; Guidon 1989). The current paper by Boèda et al. on the open-air site of Vale da Pedra Furada follows close on the heels of another from the nearby Toca da Tira Peia site by Lahaye et al. (2013), both claiming human presence by c. 20 ka.

My contribution to this discussion stems from my application of luminescence dating to Palaeoindian sites in Brazil (e.g. Araujo et al. 2008, 2013; Feathers et al. 2010; Bueno et al. 2013; Vialou et al. in prep.). I have also done luminescence work in Serra da Capivara, but only of Holocene-age sediments (unpublished). Both Boèda et al. and Lahaye et al. employed optically stimulated luminescence (OSL) dating on sediments to date their sites, and I will briefly review their work. Both used relatively fine grain sizes (20–41 μm) of quartz and both employed the commonly used single aliquot regenerative dose (SAR) protocol for determining equivalent dose (De). In neither case did the aliquots for each sample display much spread in values, even for Lahaye et al., who employed smaller, 1mm diameter aliquots. The quartz was sensitive and dominated by the fast-bleaching component, which is typical for Brazilian quartz (Feathers et al. 2010; Guedes et al. 2013). An argument could be made that with sensitive quartz, even 1mm aliquots might suffer from signal averaging among individual grains, so that the true dispersion in De values is hidden and can only be properly evaluated with single-grain data. In other words, evidence for mixing of different aged grains might not be detectable without single-grain analysis. On the other hand, the OSL dates in each case are in the correct stratigraphic order, and in the case of Boèda et al. are in agreement with some 14C dates. But an argument for mixing at either site, however unlikely, is not really germane to the whole debate, because the issue has never been about dating.

Rather, it has been about the nature of the artefacts and whether they can unambiguously be attributed to human origin (Meltzer et al. 1994). Boèda et al. and Lahaye et al. (2013) make at least two arguments. First, that the breakage patterns on the ‘artefacts’ are different from those on natural cobbles; and, second, that no geologic process can account for the position of ‘artefacts’ of certain size and shape. Boèda et al. make additional technological
and functional observations. I do not have the expertise to evaluate these arguments, but I can make a few comments. First, much of Brazil has a long unifacial lithic tradition, where bifaces or other distinctive diagnostics are rare. Clovis sites, on the other hand, are defined by a very distinctive kind of biface: fluted points. This puts any argument about early sites in Brazil at a distinct disadvantage. Even if the lithics at the Serra da Capivara sites are artefacts, their defenders have an uphill battle demonstrating that. But they can well point out that the most a Clovis-first argument can really say is that Clovis is the first diagnostic artefact (an observation with a long history; see Krieger 1964). Second, the Serra da Capivara sites have some support from Santa Elina rockshelter in Mato Grosso state, central Brazil (Vilhena Vialou 2005; Vialou et al. in prep.), also dated by OSL (by the author) to the same time period. Here the lithics are also difficult to distinguish from natural breakage, and the same arguments are made about natural versus human patterning and the exogenous nature of the artefacts. But also recovered from Santa Elina are two perforated osteoderms, for which a better case can be made for human origins.

Third, an underpinning of the original Clovis-first argument was that colonisation of the New World was not really possible prior to Clovis, because of continental glaciers. But this assumption has steadily been eroded, because of the potential of coastal migrations, either Pacific (Dixon 2013) or Atlantic (Bradley & Stanford 2004), and because of evidence that the ‘ice-free corridor’ may have been open much earlier than originally thought (Munyikwa et al. 2011). If there is no reason to cling to a Clovis-first argument, then the potential for understanding New World colonisation widens considerably. I think this is the point Boëda et al. make in their prefatory remarks. Perhaps age should no longer be the defining parameter of the debate, because with the restrictions of Clovis-first removed, the search for the oldest site seems less meaningful (Waguespack & Kelly 2014). Rather, unless evidence to the contrary comes to light or the arguments about the human origins of the artefacts are shown to be specious, we should give Guidon and her colleagues the benefit of the doubt, and begin to research a larger problem: how the record of these few earlier sites, such as Santa Elina, Toca da Tira Peia and Vale da Pedra Furada, evolved into the much more abundant record of c. 13 ka and later. That is a gap that has not been filled but if it could be, that would put these sites into much better context and the controversy around them would be lessened.
Boëda et al.’s paper reports the results of an archaeological re-investigation in north-eastern Brazil, an area where previous attempts to identify South American pioneer settlements earlier than 14 000 cal BC have been disqualified and rejected. Not least have arguments based on the analysis of lithics been questioned; as this paper makes clear, that is still the case. Boëda and colleagues returned to this area to re-analyse the sequences discussed previously through a new excavation. They have, to my mind, convincingly argued for the presence of artefacts situated in a closed stratigraphic sequence extending as far back as 25 000 years. Within the excavated sediment a series of discrete layers with assumed quartz and quartzite cobble and flake tools have been identified. I will not discuss further the stratigraphic sequence: I assume it to be correctly dated and the chronological logic of the sequence speaks in favour of that.

Since the dating of the sequence thus seems unproblematic, the key remaining problem is one that is well known to archaeologists in general and to lithic analysts more specifically. Underlying it is the social evolutionary thinking that permeates Western thinking, which was shaped within the eighteenth- and nineteenth-century intellectual climate and which still, after all these years, albeit mostly on an unconscious level, has consequences for archaeology; simple technologies belong to archaic humans.

A second fundamental problem concerns the archaeological construction of data; more specifically the long-standing conflict between the doxa of flint typologies and a more dynamic view of technology which sees lithic assemblages as the result
of a sequence of manual acts, as illustrated by the debitage from the process of production.

A third problem, familiar to the present author, concerns the clash between academic traditions as they are reproduced within different university classrooms. Perhaps more importantly, there is the conflict that arises when flint types hammered out over a century of archaeological classification are used to classify and interpret assemblages of other raw materials. This clash has become most obvious when ‘flint thinking’ is used to understand quartz assemblages (see Knutsson 1998 for a discussion).

The problems discussed in the article and supplementary online material by Boëda and his team illustrate all these points well and show that decades of archaeological work on the lithic analysis of non-flint material has somehow gone unnoticed in some quarters. It must be noted, however, that the controversy surrounding the origins of the first settlers of the Americas has put a special strain on the researchers and the power of their transparent analyses.

From this point of departure I offer comments on several of the themes raised in the paper, keeping to my area of competence, lithic analysis. One of the problems encountered by Boëda et al. and others in the region is the assumed ‘archaic character’ of quartz assemblages. This is a universal problem related to the above-mentioned strands of evolutionary thinking which are still part of Western thought. Quartz is the dominant edged-tool raw material during the Stone Age in central and northern Scandinavia. The typical assemblage has low formal variability and contains some bipolar cores or platform cores and a few ‘scrapers’. At first glance it does indeed look simple and ‘archaic’. Fracture analysis (Callahan et al. 1992; Tallavaara et al. 2010) and use-wear analysis of unmodified flakes and flake fragments (Knutsson 1988a) show, however, that a varied set of tools are to be found in the group of informal ‘debitage’ that consists mostly of fragmented flakes (Knutsson 1988b; Knutsson & Knutsson forthcoming). There are basically no formal tools; the sharp edge was the primary selection criterion. Today we know through well preserved sites that the bone, antler and wooden tools produced by these quartz-using societies were of the same technological and formal quality as those among groups where flint was the dominant raw material for tools. There is therefore nothing ‘archaic’ about non-formal quartz assemblages including cobbles with flaked edges. In Scandinavia they are found throughout prehistory from probably egalitarian hunter-gatherer groups in the Early Mesolithic to stratified societies in the Late Neolithic.

Another classic question concerns embedded technologies. To put it simply, what do you expect groups of prehistoric hunter-gatherers to do if flint or flint-like materials are not available? As Boëda and his team suggest, why not use quartz instead? It is omnipresent in most places on earth. Furthermore, that is also exactly what happened during the pioneering colonisation of Scandinavia by groups of hunter-gatherers from the eastern European taiga in the Late Pleistocene/Early Holocene. They came with a tool set built upon a complex pressure blade technology in flint, entering present-day Finland and the Fennoscandian shield, an area devoid of naturally occurring flint but dominated by quartz (Rankama & Kankaanpää 2011). Within a few centuries they had adapted to the local conditions and built their entire edged-tool technology on a very simple flake technology in quartz (Jussila et al. 2012). Quartz flakes are used in the same way as flint flakes are in the

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rest of Scandinavia, often as insets in slotted bone points. Quartz is, to my knowledge, therefore a perfect substitute for flint: you just have to look beyond the technology and see what it actually was to be used for. There is no such thing as a ‘better material’ than quartz—it simply represents another way of making a stone tool. I am sure that the inhabitants of Pedra Furada soon found out how to do it. I totally agree with the arguments presented by the authors of this paper: if quartz is available, why not use it, it works.

Quartz, as the authors observe, varies considerably in quality. Splitting beach nodules or taking materials directly from the quartz vein does not normally yield good enough material for creating strong and sharp edges on tools. As an experienced quartz knapper I can testify that what began as a one-hour trip for knappable quartz to the nearest esker normally ended as a tiresome quest over several days to find a good piece. It is not surprising then that the quartz material found on excavated prehistoric sites is of perfect quality for tool-making. It is obvious that the prehistoric tool makers have carefully selected the material they used. Quartz is therefore not used by desperate people trying to survive despite the lack of flint; it was systematically selected for and used by knowledgeable tool makers.

Another issue raised by the authors concerns classification. How do you discriminate between a naturally broken quartz cobble and the result of human production? Quartz is hard to read even for a skilled lithic analyst (Callahan et al. 1992; Tallavaara et al. 2010). It is even harder to convince non-specialists, as the authors of this paper have experienced. Their discussion of taphonomy and technical analysis in the supplementary online material is, in my view, well designed and convincing, since they compare the qualities of natural cobbles with quartz from the individual layers in the sequence, the latter assumed to be of human origin. The qualities indicating human manufacture are the character of the striking platform, the number and contiguosity of the flake scars and the duration of the flaking sequence indicated by the flake scars. Since the natural and human-worked quartz material differs in these respects, the human origin of the assumed prehistoric tool material seems obvious.

The study of bipolar anvil reduction, split cobbles and worked pebbles seems to be at an early stage but adds to the general picture of human modification of the cobbles from the different layers in the sequence. The final typological classification into pieces with different edge qualities is reasonable, although hard to evaluate at this point. The illustrations help to evaluate the feasibility of their arguments that show convincingly that the worked cobbles must be the result of a planned sequence of gestures based on a mental template. The secondarily modified flakes are mostly Siret flakes; that is, flakes split during knapping. This may not necessarily be a systematic selection criterion: it is simply the way quartz naturally fractures during knapping and thus there will be a high frequency of this type of flake in the assemblage. Intact complete flakes are the exception. Microwear analysis of a number of quartz assemblages from Sweden and Finland actually shows that these split flakes can be used as knives, the right-angle break being a natural ‘backing’ (Knutsson & Knutsson forthcoming).

The functional analysis further strengthens the argument that the tools are human-made, but is hard to evaluate from the illustrations and details provided. The references to previous...
work on use-wear on quartz are very general in character and include partially incompatible methods (the Keeley method and the Knutsson method). To evaluate the microwear analysis, the micrographs must be presented at greater size than here, and the specific features used in the argument must be identified and described in relation to relevant experimental background material. From my experience of used, unused and weathered quartz, the micrographs seem to illustrate strongly weathered surfaces, and it is difficult to distinguish what might be the result of use and what is a result of weathering. To be of real value a microwear analysis must follow basic principles of documentation, analysis and description. This is not the case here.

To round off my comment, however, the microwear analysis is not essential to the argument for the human origin of the quartz assemblage in layer 7 at Vale da Pedra Furada. If the dating of this layer is correct, the authors have convincingly shown that South America was already settled before 20 000 cal BC... by knowledgeable toolmakers.

References


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The peopling of South America: expanding the evidence

Eric Boëda¹, Christelle Lahaye², Gisele Daltrini Felice³,⁴, Niède Guidon³, Sirlei Hoeltz⁵, Antoine Lourdeau¹,⁶, Anne-Marie Pessis³,⁶, Sibeli Viana⁷, Ignacio Clemente Conte⁸, Mario Pino⁹, Michel Fontugne¹⁰, Marina Pagli¹ & Amélie Da Costa¹

The objective of the Franco-Brazilian mission, established in 2008 at the request of and in collaboration with Brazilian researchers, was to address the issue of the earliest peopling of South America as evidenced in north-eastern Brazil. Such early settlement had been suggested, and in our view demonstrated, by the previous research undertaken at the site of Boqueirão da Pedra Furada. Yet like any discovery, this occurred at a particular point in the history of research. Its acceptance depends on many factors that have often been difficult to accommodate as the evidence has unfolded. Still more fundamental has been the reasoned argument presented by the discoverers, since that is the basis of knowledge. The increasing number of sites and the conjunction of multiple approaches—stratigraphic, taphonomic, experimental, technological and functional—play a key role in the construction of this argument. Whether or not it is accepted will be part of the history of science. With the sites of Boqueirão, Sítio do Meio, Tira Peia and now Vale, we know that the settlement of this region of Piauí began more than 20–25 000 years ago, and occupation persisted throughout the entire Holocene period. When the data from these sites are compared with those from Santa Elina in the Mato Grosso, the antiquity of human settlement is confirmed and the area occupied at this early period is expanded.

Another step has been taken; further steps must clearly follow in order to advance further. We now need to orient our questions differently by addressing behavioural issues.

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Future fieldwork, by enlarging the excavated areas exposed at the sites, will focus on the patterns of occupation seen in each archaeological horizon. The functions, activities and spatial patterns of occupation are all issues that will be addressed by our team in the future. Palaeoenvironmental reconstruction will be a priority, especially since the results of functional use-wear analysis clearly shows (as expected) an interaction between tools and animals and plants. Reconstructing modes of tool production and use through experimentation is a line of research that we have followed for several years. Quartz is a complex material that was subject to technological investment at different places and times, but simply to state that is not enough. Broader comparative analysis of this technological phenomenon is needed to recognise that more than one technological option or process exists.

In reality, the discussion of quartz focuses the question on one point that is certainly important, but not crucial. The underlying and more significant question concerns the concept of cobbles—their form and volume, and the ways in which natural features of the raw material may have been incorporated in reduction sequences leading to tool production. This is essentially a qualitative question that requires technological and technical analysis that cannot be reduced to simple numbers and graphs. The cobble conceived as a tool-producing matrix becomes a technological solution with its own potential for variability and its own constraints. It is thus not only a technological option, but becomes a structuring element in the knowledge of a human group. Recent analyses, such as those undertaken by a member of our team in the Palestina region in the state of Goiás, have identified technological behaviours identical to those seen in the Holocene. The technological tradition of the Final Pleistocene industries in our study region is thus not unique, but rather is one possibility among many and was shared by other groups. In reality, these industries are set apart only by their age. It is clear that the number of absolute dates will increase and the chronology will be further refined, but henceforth the data go beyond the old paradigm. Our next challenge is to describe more fully the technological and behavioural facies of the earliest human populations in South America.