Dating human occupation at Toca do Serrote das Moendas, São Raimundo Nonato, Piauí-Brasil by electron spin resonance and optically stimulated luminescence

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ABSTRACT

Excavation of Toca do Serrote das Moendas, in Piauí state, Brazil revealed a great quantity of fossil wild fauna associated with human remains. In particular, fossils of a cervid (*Blastocerus dichotomus*) were found, an animal frequently pictured in ancient rock wall paintings. In a well-defined stratum, two loose teeth of this species were found in close proximity to human bones. The teeth were independently dated by electron spin resonance (ESR) in two laboratories. The ages obtained for the teeth were 29 ± 3 ka (thousands of years) and 24 ± 1 ka. The concretion layer capping this stratum was dated by optically stimulated luminescence (OSL) of the quartz grains to 21 ± 3 ka. As these values were derived independently in three different laboratories, using different methods and equipment, these results are compelling evidence of early habitation in this area.

Introduction

Among the most controversial questions in the field of paleoanthropology is the spread of modern humans to the New World. The Clovis paradigm suggests that the first humans arrived in the New World via the Bering Land Bridge around 12,000 years ago. They developed the Clovis culture, exemplified by tool types found at Clovis, New Mexico (Hoffecker et al., 1993). This has been repeatedly challenged by the discovery of sites that suggest human occupation that predates any Clovis material (Waters and Stafford, 2007; Waters et al., 2011). Most of these sites rely on material evidence such as lithics and hearths, as actual human remains are

scarce, and have been rejected by other paleoanthropologists on the grounds that the material evidence has no clear human link (e.g., Meltzer, 1995). The most compelling evidence of pre-Clovis human occupation currently comes from examination of coprolites containing human DNA at Paisley Cave, Oregon, dated to 14,600 years ago (Gilbert et al., 2008), although these have in turn been challenged (Sistiaga et al., 2014). Here we present evidence of pre-Clovis human occupation from human skeletal remains found at Toca do Serrote das Moendas in Serra da Capivara National Park, Piauí, Brazil (Fig. 1).

'Serrotes' are calcareous massifs, residual relief forms of meta-calcareous rock. They are seen in the landscape as a sequential set of small mountains, apparently isolated on the surface but linked in the subsoil, belonging to the same karstic system. As with any karstic system, complex hydrodynamics leading to dissolution of carbonate has resulted in the formation of rock shelters and
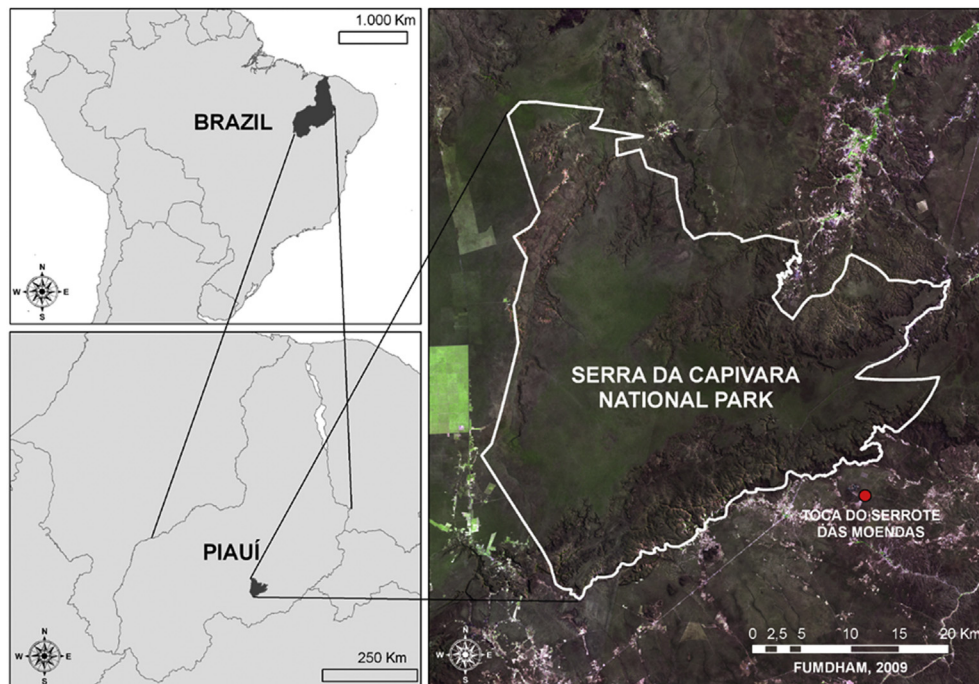
Figure 1. Map of the location of the archaeological site Toca das Moendas, São Raimundo Nonato, Piauí State, Brazil (UTM N 9025182 and UTM L 0785222).

caves, in which archaeological remains can be found. Excavations at the cave of Toca do Serrote das Moendas have yielded a wealth of megafaunal remains, lithic and other artifacts, as well as rock art and, most notably, three human skeletons. Dating this site is therefore of great importance in establishing the chronology of human occupation of this region, and by implication, other areas of the New World. Although repeated efforts to date human bones found at the site by ^{14}C were not successful, as it was not possible to recover enough ^{14}C to perform the analysis, other methods may yield reliable information. Thus electron spin resonance (ESR), with results obtained from two independent laboratories, was used to date two cervid teeth associated with the human remains, and optically stimulated luminescence (OSL) was used to date sediments from this site.

The excavations and archaeological finds

Toca das Moendas is a large cave, approximately 35 m in length and 23 m at its widest point (Fig. 2, which shows the position of the fossil paleofauna, stone tools, and three human skeletons when found). The cave floor slopes sharply downwards from NW to SE, falling some 9 m in all. In addition, roof fall has left large limestone blocks in many places. The site stratigraphy is diverse, depending on location within the cave. The components of the sediments include a silt matrix with small amounts of clay and sand, limestone fragments, and concretions. These concretions are a type of calcrete in which carbonate has been added to sediment post-depositionally as a result of water transport within the cave. The creation and extent of this formation depend on climate, with a period of calm environment being ideal for extensive calcrete formation. In addition to concretions, there are deposits of calcite over the surface in some areas. The inside of the cave was divided into five sectors (numbered 1—5) containing human bones and shells. Here we will be discussing in detail only Sector 2.

The first human skeleton found, below a concentration of blocks in sector 2, consisted of an incomplete set of the bones of a child, approximately two to four years of age. It was found in the same level as skeleton 3, approximately 2.5 m away. The recovered elements of skeleton 1 included several teeth. Electron spin resonance dating of immature teeth has been problematic in the past, and an attempt to date one of these teeth was not conclusive. The second skeleton of a child, also incomplete, was found in sector 3. The presence of sediment of different colors around and below the skeleton indicates that it was deposited in a pit. The third human skeleton, incomplete and very fragmented, was found in sector 2, in a friable layer of sediment (Layer B, Fig. 3) just below a concretion layer (Layer A, Fig. 3) consisting largely of calcite. Although only about two dozen bones or fragments could be assigned to skeletal parts, the bones of the hand were closely associated, as would be expected for elements in situ. Along with this skeleton, two teeth of a large deer, *Blastocerus dichotomus*, were found. Fig. 4 details the relative position of all of these elements. No artifacts were directly associated with the skeleton.

The stratigraphic sequence of sector 2 is shown in Fig. 4. The sequence is taken next to the cave wall and has six levels. The uppermost level (F) is a carbonate sediment followed by a concretion of calcite and sediment 30 cm thick (A). As shown in Fig. 3, the concretion extended over the area where the skeleton and teeth were found. The third layer (B) is characterized by 15 cm of a silt, sand and clay compacted sediment and a friable sediment of silt, sand and clay that is 40 cm thick, beginning at approximately at 45 cm depth. It is in this layer that skeleton 3 was found. Another concretion level (D), 10 cm thick, forms the fourth layer and this is followed by another friable layer 15 cm thick. The lowest layer found appears at a depth of 110 cm and is again characterized by compacted sediment. Bedrock was not reached during the excavation, so the total depth of the stratigraphic sequence is still unknown.

Dating considerations

Electron spin resonance is well established as a method to date dental material (Skinner, 2000) and is therefore appropriate for use with the cervid teeth found associated with the human material. While ^{14}C is the preferred method for determining ages in this time