



Survey and Explorations of the Prehistoric Sites in the Highlands of Southwest Angola

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Abstract

The area of the escarpment of Angola between Namib and Huíla Province, about 150 km from the Atlantic coast, yields abundant evidence for human activity throughout the Stone Age. There is a high concentration of open-air sites with stone tools classified as Early (ESA) and Middle Stone Age (MSA) by past explorers. At the top of the plateau, the Chela group rocks and particularly the Leba dolomites yield a series of caves and fissures infilled with deposits ranging from the Early Pleistocene to recent times. Considering the background information, a new project was developed to establish new proxies, we set out to revise this cultural landscape and set the stage for archaeological testing of Stone Age sites. In 2018–2019, our survey documented 45 sites including caves, rock shelters, and open-air locations with evidence of fossil and cultural deposits, including Middle and Later Stone Age (LSA) stone artifacts, faunal remains, pottery, and human burials. A complete map of distribution of caves and their underground topography is presented. Active and fossil speleothems, important for paleoclimatic reconstructions and absolute dating, were found at the caves of Malola and Tchivinguiro. Fossil occurrences were relocated at Tchíua and Cangalongue. Our study shows there is intense recent activity, historical remains, and the use of at least of three caves as burial sites of past herding populations living at the Humpata plateau. Our field assessment shows there is potential to pursue several lines of evidence to reconstruct past human lifeways and environments in this region.

Keywords Survey · Pleistocene · Stone Age · Hunter-gatherers · Humpata Caves · Escarpment of Southwest Angola

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Introduction

Research on the evolutionary paths of Pleistocene populations and ecosystems in southwest Angola may be of relevance for current paleoanthropological debates on complex social structures and cultural and ecological diversities within Africa (e.g., Roberts & Stewart, 2018; Scerri et al., 2018). The profusion of Quaternary age deposits holds the possibility to address the general time span between 500,000 and 30,000 years (Breuil & Almeida, 1964; Clark, 1966; de Matos and Pereira, 2020; Gutierrez and Benjamim, 2019; Jorge, 1975; Mason, 1976; Nicoll, 2010; Pickford et al., 1990; Ramos, 1982). This timeframe encompasses the Early (ESA) to Middle Stone Age (MSA) transition, the biological emergence of *Homo sapiens*, and the archaeological expression of the MSA, accounting for the significant changes and processes that took place throughout this time period and contributed to the development of our current species (Scerri and Will, 2023).

The country of Angola lies between the tropical rainforests of the Congo River and the Namib Desert biomes of the Cunene River, bordering the country of Namibia. From the coast to the interior, geomorphology and climate conditions progressively transition from lowland semi-desert environments to savannas, woodlands, and grasslands of the interior elevated plateaus. The Zambezi River marks the border between Zambia and Botswana at east.

The southwestern region of Angola encompasses 1000 km of the Atlantic coast and is characterized by raised beach deposits of Miocene and Pleistocene age (Corvinus, 1983; Feio, 1964; Mason, 1976). In certain locations of the coast, the terraces yield thick and rich sequences of Stone Age assemblages (Davies, 1976, 1962). In Benguela, the raised beach deposits of the coast were valuable to obtain absolute ages on Acheulean implements associated to stranded whale remains (Gutierrez et al., 2010; Gutierrez and Benjamim, 2019). Excavations by the National Archaeology Museum in the river terraces of Baía Farta, Benguela, uncovered a context (Dungo V) that suggests human use of coastal resources by scavenging stranded whales as early as 600,000 years ago (Lebatard et al., 2019; Mesfin et al., 2023).

Indeed, the high density of Acheulean assemblages across the southern coast of Angola was noted long ago as well from later ages (Breuil & Almeida, 1964; Clark, 1966; Davies, 1962; Ervedosa, 1980). Thousands of lithic artifacts produced in local raw materials were discovered across Angola and more frequently in the southwest by the colonial offices and international associates (Arambourg and Mouta, 1952; Breuil & Almeida, 1964; Clark, 1966; Ramos, 1980) and are currently housed in museum collections (de Matos et al., 2021b). Many of these assemblages were initially classified as transitional cultures between the ESA and the MSA or local traditions of Later Stone Age (LSA) cultures somewhat affiliated to the South Africa lithic taxonomies but retained archaic features and crude appearance (Allchin, 1964; Clark, 1966). For a long time, these assemblages were included in the “Kalinian” and “Sangoan” industries/techno-complexes (Camarate-França, 1964; Davies, 1976; Janmart, 1953), two names that are still used by some authors to refer to western Africa sequences

with late expressions of ESA tools (Douze et al., 2021; Doyendze, 2021; eg. Ssemulende et al., 2021).

In the case of southwestern Angola, some authors insisted on a cultural affinity of the early MSA assemblages including large cutting tools with the Final Acheulean and “Fauresmith” tool-makers (Allchin, 1964; Ramos, 1974, 1970). Ramos collected thousands of lithic artifacts from two levels at the site of Capangombe-Velho. The basal unit was characterized by the higher frequency and large cutting tools, flakes and blades, classified as MSA of “Acheulean tradition,” a term derived from the controversial “Mousterian facies” defined by François Bordes (1961) for the Middle Paleolithic in Europe. The overlaying unit was classified as “evolved MSA” dominated by blade-point knapping sequences (Ramos, 1981). The term would be equivalent to the “Upper Acheulean” of Clark (1966). As no charcoal was found in the combustion features excavated at Capangombe-Velho, no radiometric dates are available.

Ramos’ (1982) synthesis of southwestern Angolan Stone Age proposed a post-Acheulean sequence of traditions with close affinities with the western and northern Cape lithic sequences of South Africa. A major problem is the fact that chronological conclusions are based solely on lithic findings. Since then, no archaeological projects have been dedicated to these sites or to establish a relationship with the faunal remains of Pleistocene age found in carbonated features at the western edge of the Huíla province, where the Humpata Plateau is located.

The Humpata Plateau is a hilly and mountainous area at the western edge of Huíla province. The plateau connects the deserts of the Atlantic coast with the vast plains of central Angola. The area is characterized by a mosaic of environments at different altitudes remarkable for their biodiversity (e.g., Huntley et al., 2019) and geo-heritage (Tavares et al., 2015).

The Humpata karst consists of a cluster of caves, solution morphologies, and carbonated features in a dolomitic bedrock of Precambrian age with stromatolite structures, called the Leba formation (De Carvalho et al., 2000; Pereira et al., 2013).

Quaternary fossil-bearing fissures and caves were found at the Humpata caves during quarrying activities of the late 1940s. The first collection was an assemblage of primate skulls identified as cercopithecids (Arambourg and Mouta, 1952; Delson et al., 2000; Pickford et al., 1992). These contexts were considered analogous to other locations in South Africa and Namibia where numerous mammal fossils including hominids and early *Homo sapiens* were found (Brain, 1981; Bruxelles et al., 2018; Dart, 1950; Kuman, 2007; Mason, 1976; Williamson and Sutton, 2014).

In 1950, excavations at Leba Cave identified a sequence of six geological horizons associated to faunal remains. The brief report left by the excavator described a basal unit of red marl with cleavers and flakes (VI), followed by a sterile unit (V) that underlies a red marl with abundant faunal remains of primates and bovids associated to a “generic MSA” assemblages composed of blades and points (H.IV) (Camarate-França, 1964). The author also described combustion features at the interface with a gray sandy unit with mostly small quartz implements (H.III), covered by modern debris.

Later the assemblages from horizons VI to III were studied using a technotypological methodology defining three cultural stages ranging from an early MSA of

with large cutting tools (MSA-I), a generic blade-point industry in local cherts and claystones (MSA-II), to an industry dominated by quartz implements associated to a late MSA or LSA (Camarate-França, 1964; de Matos and Pereira, 2020; de Matos, 2013).

The sequence described for the Leba and the background on semi-desert karst fossil deposits offer the chance to find stratified sequences. In order to address this challenge, new field research was developed at the Humpata Plateau (de Matos et al., 2021a; de Matos and Pereira, 2020; de Matos, 2022).

Landscape work was pursued to understand how the karst systems and the surrounding environments to Leba Cave developed and evolved over time. Survey work at the Humpata Plateau initially aimed at mapping the distribution of cave systems and potential for Stone Age research. We also investigated areas/waterbodies to identify locations for implementation of limnological protocols. The initial targets were two lakes, the Catende and Nuantchite lakes, located 15 km south from the Humpata village. These lakes were preliminarily identified using geological maps and aerial photography. In the field, the lakes were effectively dry.

Five local waterbodies on the Humpata Plateau, including cold springs and rivers, were investigated for hydrochemistry and preservation of diatoms (Robakiewicz et al., 2021). Data were collected on the cations and anions present in the water, the isotopic composition of the water, and the algal communities, with a particular focus on diatoms, a siliceous alga often used as a water quality/pollution proxy and valuable for paleoclimate reconstructions. These investigations were used to determine how water moves through the karstic systems and explore potential locations for future sampling of waterlogged sediments. By understanding how variable the hydrochemistry and diatom communities of these water bodies might be today, we can better understand potential deviations in the past how these environments were shaped across time. This continues to set the stage for longer term coring and environmental reconstruction projects and provide necessary information to understand how these cave systems, biomes, and prehistoric communities all interacted.

In this paper, we present one of the phases of our fieldwork in Angola dedicated to mapping the cave systems and survey of rock-shelters and open-air sites with artifact concentrations. Geographical and topographical data as well as information on fossil and cultural findings is presented here. We finally discuss this preliminary study in light of Stone Age research in Angola and specifically about the last 100,000 years in southern Africa.

Materials and Methods

Between 2018 and 2019, surveys were carried out in a 30-km radius around the town of Humpata. The objectives were to map surface finds of artifacts and ecofacts, conduct a survey for MSA sites similar to Leba Cave (de Matos and Pereira, 2020), and create a topographical database for the deep cave sites.

Our initial investigation concentrated on reports, photos, and published and unpublished evidence from earlier explorations of the plateau. At the University of

Lisbon's Tropical Research Institute (IICT-PRISC), we had access to the geographic and photographic archives.

Planning the surveys at the Capangombe and Zooténica was aided by the GIS mapping of the assemblages preserved by the IICT-PRISC relating to previous archaeological investigations in Angola which has been presented in de Matos et al. (2021b); however, there was a chance of an offset between 1 and 5 km from the coordinates recorded in the database. We additionally have access to Pickford and Senut's unpublished PaleoKart Afrique Project reports. These records helped prepare for the survey at five main areas known for caves and/or fossil bearing sites: Leba Cave, Tchíua quarries, Malola-Ufefua quarries, Tchivinguiro, and Cangalongue.

In the field, interacting with the local population helped locate the cave entrances and find other areas of interest. The Soba of Leba and his associates, as well as the community leaders and Humpata's administration, guided the work.

In some areas, difficulties were encountered in doing walk surveys, particularly between Bimbe and Senhora do Monte. It was also not possible to cover the area between Bata-Bata and Cangalongue, due to poor roads and risk for rockslides in some areas. Nonetheless, these are also areas with dolomite outcrops and likely there are caves and other carbonated features here as well (Correia, 1976; eg. Lopes et al., 2016)

The sites were defined using the assumption that "sites are not what we are looking for; they are the locations where we have found things" (McCoy, 2020). This frequently means that areas and landscape elements such as karst shapes or infillings were taken into account, even though anthropogenic materials were not implied.

This database also includes the waterbodies (lakes, springs) where water and sediment samples for diatoms were obtained for hydrochemistry and pollution analysis (Robakiewicz et al., 2021). Geographic information was gathered at cave openings, fissures, rock shelters, springs, and lakes, as well as areas where stone tool concentrations were discovered.

Deep caves and solution chambers were surveyed to their maximum extent identified with safety gear. Topographical data was collected inside the caves using electronic distance measurement techniques.

Descriptions focused on geological setting, risk, state of preservation, and occurrence of paleontology, archaeology, or geo-heritage. Descriptions follow the literature on earth surface morphologies and formation of archaeological deposits. (eg. Huggett, 2016; Karkanis & Goldberg, 2018). The terminology used for the caves corresponds to the lexicon internationally applied in the literature about karst systems (Ford & Williams, 2007; Parise et al., 2018; States, 2002; Travassos, 2019).

Results

A total of 44 sites were identified by our survey team, and topographical data was collected during deep cave explorations of the main systems found at the plateau. (Fig. 1). These are mostly concentrated around the Leba, Caholo, and Cangalongue villages.

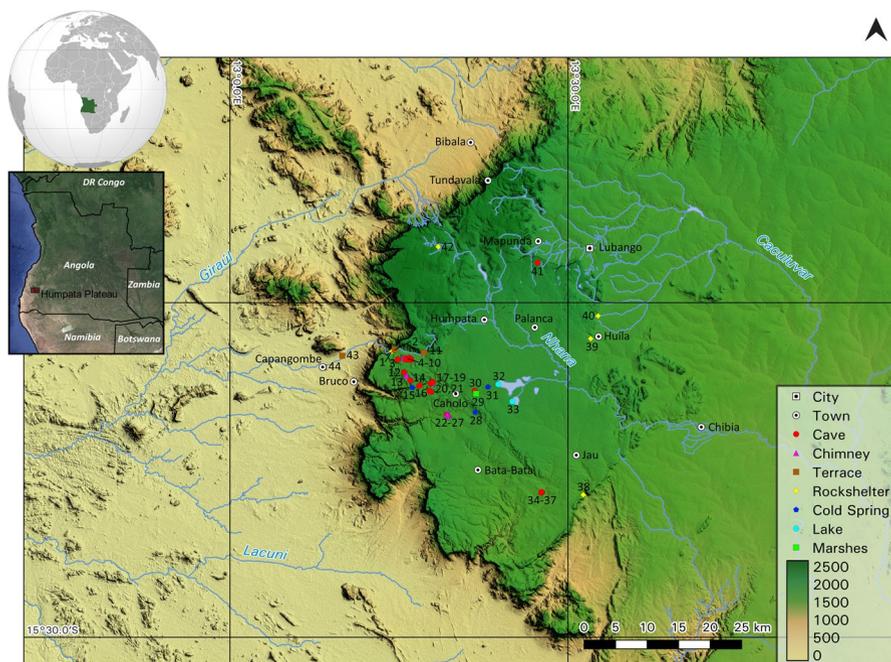


Fig. 1 Elevation model of the Humpata Plateau, in southwestern Angola with location of sites surveyed and mentioned in the text: 1, Leba Cave; 2, Leba I; 3, Leba falls; 4, Leba valley 1; 5, Leba valley 2; 6, Zootecnica falls; 7, Omukongo I–II; 8, Tchaticuca I; 9, Tchaticuca II; 10, Tchaticuca III; 11, Lemagama Cave; 12, Leba Quarry I; 13, Molo/PROCAL quarry; 14, Tchíua cave; 15, Ondimba da Tartaruga/Algar Tchíua I; 16, Mewó/Tchíua-Ufefua; 17, Umbutu 1; 18, Catende 1; 19, Nuatechite 1; 20, Nandimba I/ Tchivinguiro Spring; 21, Tchivinguiro I; 22, Tchivinguiro II; 23, Tchivinguiro III; 24, Tchivinguiro IV; 25, Tchivinguiro V/Sumidouro “Candimba Cocufima”; 26, Tchivinguiro VI; 27, Malola I; 28, Malola II; 29, Malola III; 30, Malola IV; 31, Malola V; 32, Malola Quarry/kiln 1; 33, Nkangalongue cave; 34, Cangalongue Quarry 1; 35, Cangalongue Quarry 2; 36, Cangalongue Quarry 3; 37, Hunguéria falls; 38, Munhino Falls; 39, Hufla Falls; 40, Cavidades/Nascente do Tchivinguiro; 41, Lapa da Unandjava; 42, Rio Umbutu/Unandjava; 43, Capangombe river; 44, Capangombe Velho; 45, Pseudo-karst Senhora do Monte

The vast majority of sites were caves or chimneys with clastic material. We also inspected solution chambers that were open by the quarry like Tchaticuca I and III. These sites mainly presented chemogenic sediments with peculiar calcite mineral formations and karst fluvial residual clays but no infillings or traces of activity prior to the quarry.

The database also includes cold springs, some of them with large endokarstic lakes like Tchivinguiro. There are also waterholes (ponds), seasonal lakes, rock shelters, and river terraces. These were identified for the presence of Quaternary sediments with fossils or artifacts. A complete inventory can be found in the Supplementary Information.

Caves and Fissures

Caves are mostly concentrated between the Leba valley and Tchivinguiro, near Caholo, on the southwestern flank of the Humpata Plateau where carbonated rocks are present (Fig. 1). A total of 30 caves were surveyed, many of them consisting of solution chambers only exposed by the quarry, or chimneys completely infilled by red sands. From these sites, a total of 16 yielded paleontology or evidence for human use (Table 1).

The Humpata cave sites are located at the foothills, usually between 6 and 15 m above the river thalwegs. These hills are cupula-shaped and contain labyrinths of chimneys and tubules connecting to a main chamber (a phreatic tube or gallery) and adjacent solution chambers. Most of the cave entrances observed in the Humpata Plateau were exposed during the Quaternary by erosional retreat of the slopes, such as at Leba or Malola cave systems.

In other locations, like Tchaticuca or Cangalongue, the galleries were connected to the surface through narrow chimneys and exposed only after a horizontal entrance was created during quarrying activities. Columns and pinnacles are evident from a distance. They are frequently covered by dense shrubs typical of the southwestern bushveld. Species of the genera *Brachystegia*, *Julbernardia*, *Ficus*, *Aloe*, and *Euphorbia* are some of the most frequent vegetation types observed in the cave surroundings.

Along the Leba river valley on the southern flank, several caves were exposed during the 1940's and 1950's quarrying activities. Many more were likely destroyed by dynamite during the twentieth century for mining purposes. For instance, the paleontological site of Molo referenced by Mason (Mason, 1976) and Pickford (Pickford et al., 1992) has, for the most part, disappeared due to quarrying.

From Leba falls to the ruins of the Leba Farm, about 2 km east of Molo, chimneys and pipes, some of them completely infilled by red sands and dolomite debris, can be observed on the hills on the left bank of the river valley. For instance, the Tchaticuca I is a small cave consisting of a single chamber shaped by fractures associated with a fault with orientation NE-SW, a development of 11.8 m and a depth of 2.6 m, a maximum width of 8 m by a height of 3.8 m. The roofs show fractures with detrital infills and breccias, sealed with sheets of travertine. Abundant eccentric flowstones cover the walls but no archaeological or fossil infill has been observed.

On top of the hill, Tchaticuca II is a chimney following the fracture orientation completely infilled by red sands. Tchaticuca III is similar to Tchaticuca II but with a S-N orientation, a development of 11.43 m and a maximum drop of 3 m. The cave has two chambers: the first with a wide mouth exposed to sunlight by dynamite quarrying and the second, which is accessed through a narrow channel. Small pressure tubes and fluting, as well as developed stalactites, dripstones, and other flowstones, are abundant inside. A thin layer of guano suggests the recent use by birds and bats since the quarrying. The morphology and absence of breccia deposits indicates these solution chambers were not exposed during the Pleistocene, but there may still be other chambers with clastic materials overshadowed by debris and vegetation.

Table 1 Summary of faunal and cultural findings in caves (complete inventory can be found in the Supplementary Information)

Site	Summary	Culture
Omukongo I–II	Unconsolidated: gray silt and dung	Pottery
Lemagoma Cave	Unconsolidated: gray silt and dung	Human burials
Leba Quarry I	Unconsolidated: Hyrax middens. Cemented: Pink breccias with mammal fauna, flowstones	-
Molo/PROCAL quarry	Relicts of pink and grey breccias	Isolated flakes
Tchitua cave	Collapsed caves with cemented infillings: Pink breccias with bovids; yellow breccias with primates and gray breccias with rodent fauna	Isolated flakes
Malola II	Unconsolidated: gray silt and dung	Disturbed burials and commingled human and canid remains, pottery, baskets
Malola III	Unconsolidated: gray silt and dung	Human burials
Malola IV	Unconsolidated: gray silt and dung	Pottery
Malola V	Unconsolidated: gray silt and dung	Human burials
Malola Quarry/Kiln 1	Collapsed gallery	-
Nkangalongue cave	Unconsolidated: gray silt, charcoal and guano; relicts of pink breccias	Human burials, pottery
Cangalongue Quarry 1	Pink breccias with mammal fauna	-
Cangalongue Quarry 2	Pink breccias with mammal fauna	-
Cangalongue Quarry 3	Yellow and pink breccias with mammal fauna	-
Cavidades/Nascente do Tchivinguuro	Solution chambers and cascade tufas	Isolated flakes
Pseudo-karst Senhora do Monte	Unconsolidated: gray silt and dung	Pottery, bovid remains, recent rock sculptures

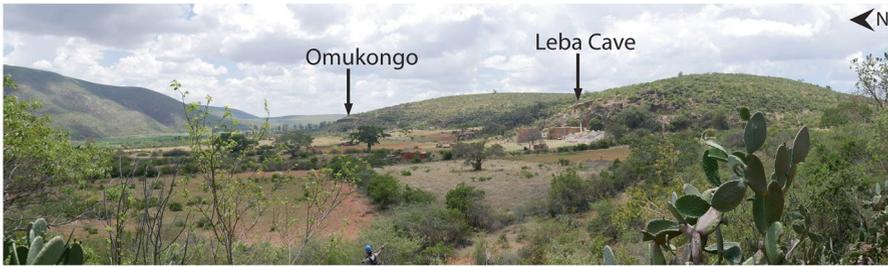


Fig. 2 View of the Leba Valley from west with the location of Leba cave and Omukongo cave, note the cupula-shaped morphology of the dolomite outcrops where the caves are located

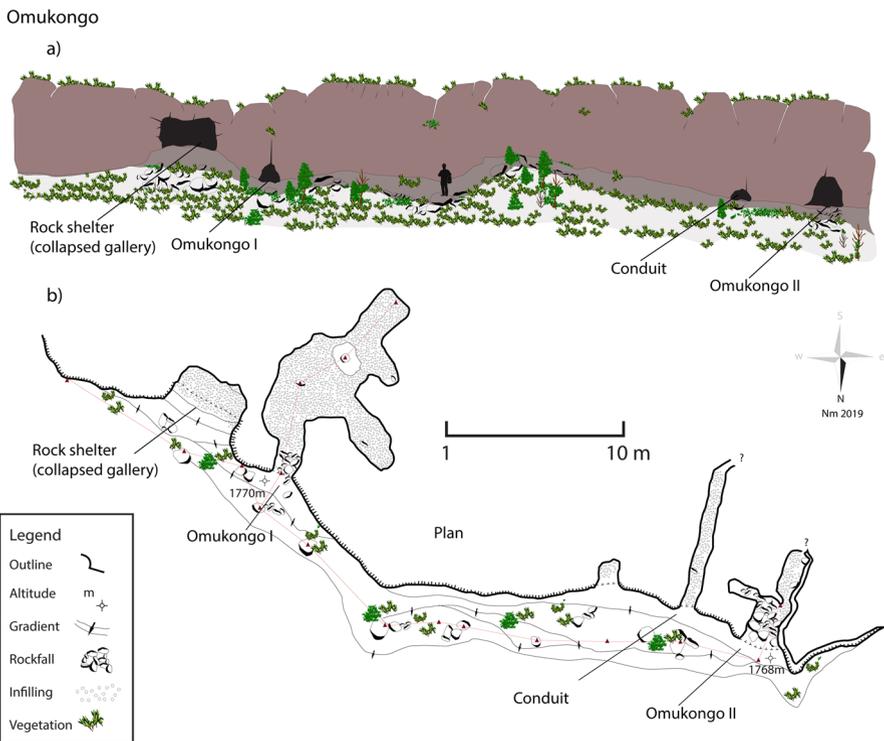


Fig. 3 The Omukongo caves: **a** Schematic representation of the front view (top); **b** plan of the caves (lower) (topography work and drawings by R. F. And D.M.) (adapted from de Matos et al., 2021a)

The Omukongo caves (Figs. 2 and 3) are located about 300 m east of Leba Cave, also on the southern Leba riverbank. Two small phreatic tubes are part of a system that is mostly collapsed and disappeared by slope retreat and which was likely connected in the past. Omukongo I is the larger of the two caves, with N-S orientation and development of 12.39 m consisting of a solution chamber, dry

and dusty. Gray silts and guano cover the floor. Many potsherds were observed scattered around the floor as well as bone fragments including a bovid tooth and shafts but also skeletons of rodents. Porcupine quails and hyrax dung was also observed. While the hyrax middens can potentially offer paleoenvironmental information, indicators of porcupine presence can raise difficulties in interpretation of archaeological sites because they are active taphonomical agents disturbing archaeological sites (Bountalis and Kuhn, 2014; Doran et al., 2015).

Omukongo II is a narrow conduit with 1.90 m of horizontal development, 1.50 m of width, and 1.50 m of height, and is densely infilled by gray silts and guano, few fragments of mammal bone, and abundant potsherds visible at the surface, suggesting recent use similar to what is observed at Omukongo I. Fragments of flowstone were also observed in the debris. Adding to the natural processes of erosion and slope retreat, it is clear that the cliffs were also quarried in the past. These facts suggest that parts of the cave (and its infillings) have been removed, and if there are MSA materials, they are buried under the guano beds.

About 4 km south of Omukongo, the Tchúia site consists of a series of collapsed galleries mined for lime sinter. In the field, two quarries were found (Fig. 4). Quarry 1 is a fissure with 52 m of horizontal development and 20 m width with a general orientation N-S, and quarry 2 is located following the same fissure and has 25 × 15 m size. These sites were previously located by Pickford et al. (1990). Quarry 1 is also called the “monkey quarry” because of the cercopithecoid fossils that were found here in a yellow breccia (Jablonski, 1994). This location seems to correlate with the fossils previously found by F. Mouta and J. Camarate-França (Arambourg

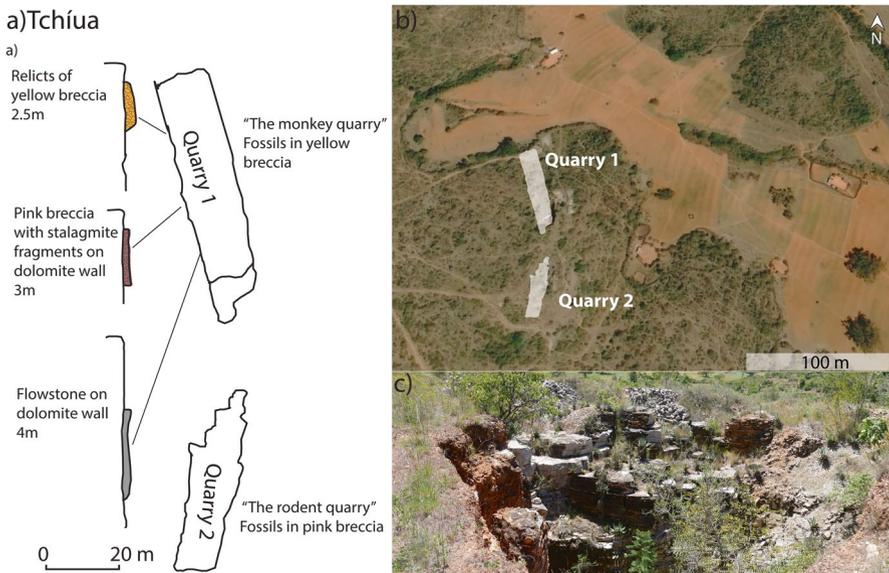


Fig. 4 The Tchúia caves. **a** Schematic representation of the infillings and plan of the quarries with profiles surveyed by Pickford et al. (1990), adapted; **b** view of the valley and location of the caves; **c** view of Quarry 2 from above (photograph by D.M.)

and Mouta, 1952; Mouta, 1953) and later published by other authors (Delson et al., 2000; Gilbert et al., 2009; Telles Antunes, 1965).

These fossils have been at the heart a debate on its taxonomic classification, They were associated to various taxa, including *Dinopithecus ingens*, *Parapapio* sp., *Papio (Dinopithecus) quadratiostris*, or *Soromandrillus quadratiostris* (e.g., Gilbert, 2013; Pugh & Gilbert, 2018). According Jablonski 1994, who studied the last fossils collected by Pickford, the Humpata cranial remains bear the largest number of similarities to *Theropithecus baringensis* described by Leakey (1969). Taphonomical analysis of these specimens have also suggested these accumulations relate to raptor predation by *Stephanoaetus coronatus* (Gilbert et al., 2009). Cercopithecids went extinct in the Middle Pleistocene. From a biostratigraphical standpoint, the yellow breccia and its accumulations would be associated to the Plio-Pleistocene, whereas the pink breccias relate to a later stage of accumulations (Clark, 1966).

Further south, in the upper stream of the Cudeje River (Bruco), located in the Malola-Ufefua area, the dolomite hills are mostly residual and were heavily explored for hydraulic lime. Some of the fissures referenced by Pickford (1992, 1990) for yielding Plio-Pleistocene breccias were already dismantled by the quarry. Nonetheless, significant development of the endokarst was observed in the area, and five caves were explored by our team (de Matos and Pereira, 2020).

Malola I Cave is a wide cave with vertical and semi-vertical developments, only accessible using safety gear and speleological techniques. The cave is 25 m deep and extends for about 48 m. The entrance is a large oval mouth in the roof, surrounded by dense shrubs. A talus debris develops from the mouth to the floor. The chamber walls are irregular with abundant flowstones. Guano and silts cover angular debris and rock fall across the entire room floor. Inside there are human remains that appear to have been purposely deposited here and may relate to more recent ages.

Malola II is located in a blind valley with a cave mouth about 4 m wide, with a development of 74.67 m, maximum width of 14 m, and height of 8 m (Fig. 5). The entrance is located right under two *Strychnos spinosa* trees which have a fruit called “maboque.” This a food staple for the San groups living in the region of Huíla Province (Ferreira, 2018). The entrance has a maximum gradient of 22 m. A vertical entrance with a talus cone of guano and silts leads to a large chamber where the floor is covered by monoliths and boulders of roof spall and guano.

A few stalagmites are visible forming over the roof spall blocks which suggests a stable environment with high humidity and temperature inside the chamber after rock fall. Currently, the environment is dry and dusty, and active drippings were not detected. The chamber connects with a labyrinth of other galleries upward where eccentric flowstones and dripstones cover the walls, but no traces of human occupation or paleontological remains were found in the inner galleries.

On the other hand, the main gallery appears to be a burial context, although disturbed by recent exploration of guano for commercial purposes. The disturbed burials were previously identified in a cave survey in 2010 by one of the members of our team (R. Francisco) as well as by archaeologists in the 1970s (Jorge Sá Pinto, pers. comm.) long before the civil war, but the site was never published. A few pictures from the 2010 expedition showed there were several individuals in articulation

a) Malola II

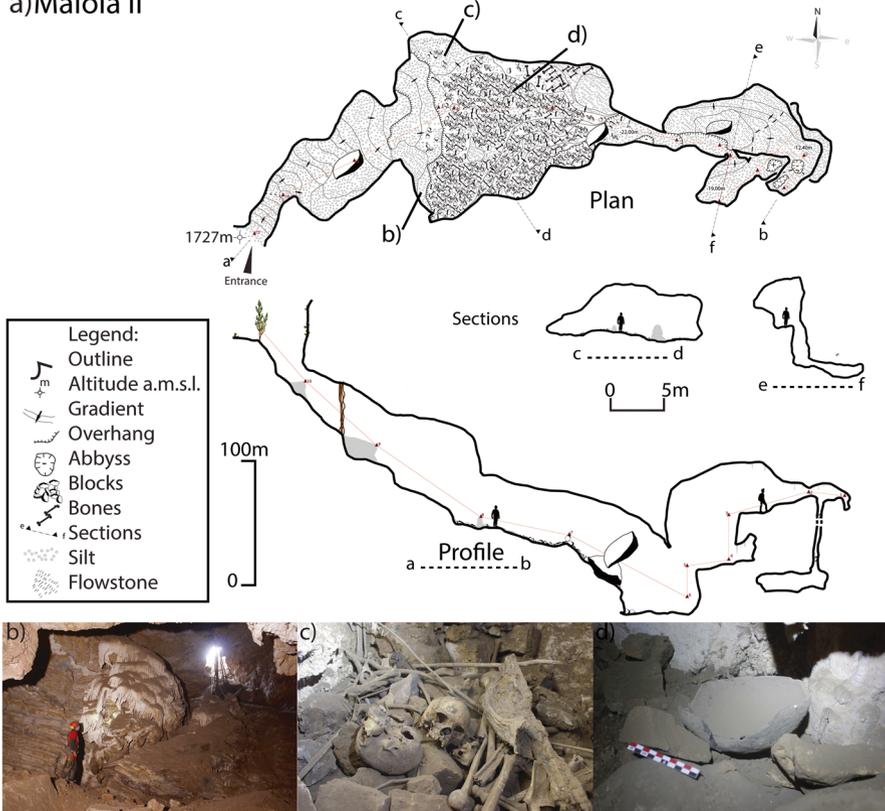


Fig. 5 Cave topography of Malola II and artifacts **a** commingled human burials; **b** ceramic bowl (topography by R.F. and J.F., photographs by D.M.)

covered by bull's hides and thick guano but such deposits were not observed intact at the time of our survey in 2019.

According to our field observations, the individuals we encountered are all adults, the human remains are co-mingled, and they may not have been deposited at the same time. During our survey, the population acknowledged that guano extraction took place a few months before, and one of the workers who took part in this exploration stated that 36 crania were counted by the workers, implying a minimal number of individuals.

Abundant artifacts, such as basketry and ceramics including some almost complete small bowls, were observed by our team in 2019. The site appears to have been an important burial location for past populations in the area. Despite the destruction and co-mingling of skeletal material, the site has potential for research.

Other two caves were identified in the Malola-Ufufua valley showing also signs of exploration of guano beds.

Malola III is a small cave associated with one or more fractures and enlarged by dissolution processes. The entrance is horizontal and wide with a minimum development of 44 m, maximum width of 2.50 m by a height of 4 m, and mostly occupied by bats. Malola IV is a deep cave that requires specialized equipment and safety measures to access the inner channels. Two large rooms were explored and contain human burials with different degrees of preservation and likely different ages.

Our walking surveys across the Malola-Ufefua valley were intensive but did not find any stone tool occurrences. Instead, tufa deposits are found occasionally with fossils.

Mewó is a cold spring located about 1.2 km south of Tchíua at the confluence of three streams collecting groundwater from the valleys of Tchíua, Ufefua, and Malola.

The groundwater springs from a limestone semicircular fissure infilled with yellow tufas preserving vegetal fossils. The fissure infillings partially eroded by a stream located 2 m downstream, and runs west towards Bruco, following an E-W fault that crosses the Humpata Plateau (Lopes et al., 2016). The valley is sourced by seasonal streams and torrential waters that flow from Malola and Ufefua. During the rainy season, the dissolution of the carbonate rocks across the plateau enriches the flood waters and streams are highly charged with dissolved calcium carbonate. Their formation is often mediated and influenced by plants and microbes growing within the streams.

Along the walls of the Mewó fissure, a 6 m thick deposit of phytoclastic rudstone presents with negatives of logs, branches, and leaves. This is a unique site in the area, but tufa deposits are common occurrences in karst regions of semi-desert biomes (Camuera et al., 2015; Doran et al., 2015; Karkanias et al., 2021; Mocke et al., 2022).

In the area of Tchivinguiro, several springs are local touristic hotspots and yield freshwater hypogean fauna. The endokarst is controlled by structural faulting system composed of a main fault and a series of radial fractures. This structural morphology delineates the weathering of the Tchivinguiro Depression and the development of an underground network.

Tchivinguiro Cave is located at the foothill of Nandimba, a spring with a lake developing underground a dolomite cupula. The hill has a low gradient. Chimneys and narrow sinkholes can be observed and give access to subterranean chambers. These chimneys are frequently obscured by thick thorn bushes, and the channels are choked by pink-red muds and bedrock debris, which are also observable inside the cave.

Within the cave, temperatures range from 25 to 28 °C, with a relative humidity over 90%. The floors are covered with boulders of roof spall. Stalagmites often cover the upper surface of these blocks, suggesting long periods of closed warm and humid environment. Some speleothems exceed 5 m in height and there are a few columns in the larger rooms. The underground network surveyed at Tchivinguiro extends about 1 km but is likely longer, with a few chimneys connecting to the surface mostly blocked by red sands.

The freshwater reservoir forms an outer pool locally known as the Nandimba spring, the outflows of which are channeled for agriculture. During survey inside the

interior pools, areas of suction were observed indicating pipes and chimneys connecting to lower levels of the lake which the existence of different micro-environments and possible isolated conditions for biodiversity. Apart from a recent rodent skeleton and modern debris deriving from tourists, no fossils or artifacts were found inside the cave during our explorations. Outside the area is highly populated, and there are many dwellings and fenced crop fields surrounding the spring and creek which prevented extensive walking survey. The possibility for finding archaeological sites can be traced back to artifacts collected by previous researchers accounting for 166 pieces reportedly MSA and LSA tools (de Matos et al., 2021b).

Other solution chambers were observed downstream; near the Tchivinguiro schools, about 3 km west from the Nandimba spring, these were partially destroyed to build a public pool.

In the southern flank of the dolomitic formation, the Nkangalongue Cave (or Cangalongue), first described by do Amaral (1973), is widely known locally and frequently visited (Fig. 6). Access to the site may be rather difficult because the roads have collapsed, taking about 4 h to reach the location from Lubango city center. Numerous archaeological findings were recorded in the area Jau during the colonial

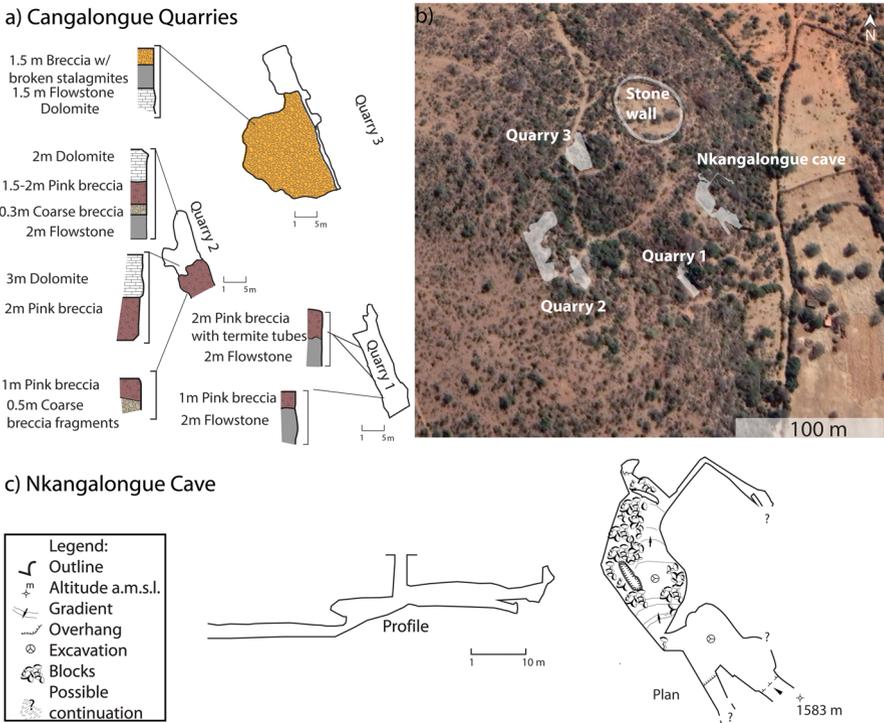


Fig. 6 a–b Location and topography of the Cangalongue Quarries and main caves with stratigraphy identified by Pickford et al. (1990), adapted. c Topography of the Nkangalongue cave (topography By R.F. And D.M.)

missions (e.g., de Matos et al., 2021b). Lithic tools assigned to late Acheulean or early MSA were collected by J. Desmond Clark (Clark, 1966; Ervedosa, 1980). Clark also tried to date the travertine interbedded with red-brown breccia containing much fauna of Upper Pleistocene age from Cangalongue but never published this data. The dates disclosed by the laboratory report a sample from Cangalongue 3 which yielded an age >34,000 BP (Berger and Libby, 1969).

When quarrying activities were initiated at the caves and fissures, fossil infillings and relicts of breccias with abundant mammal bone including primates, rodents, and bovids were identified here (Pickford, 1990; Pickford et al., 1992; Pickford and Fernandes, 1989). The three specimens of *Metridiochoerus andrewsi* found by Pickford et al. (1990) at Cangalongue (quarries 2 and 3) were associated to deposits in east Africa dated to 1.8 to 1.3 Ma. In the faunal list of fossils collected by Pickford et al. (1990), other species such as the *Serengetilagus* and the *Gigantohyrax* are also included. The *Gigantohyrax* is a genus of herbivorous hyrax-grouped mammals from the Pliocene and early Pleistocene already found at Shungura in Ethiopia and Makapansgat in South Africa were interpreted as corroboration of such chronologies. At Shungura Formation, the proposed ages for mammalian fauna are ca. 3.4–1.9 Ma (Alemseged, 2003; Barr, 2015; Pickford, 2005; Skinner and Chimimba, 2005). For these authors, this is considered enough evidence to suggest an Early Pleistocene or even late Pliocene age for the earliest faunal accumulations in the Nkangalongue fissures.

However, inside the cave, material observed at the surface relates to much younger ages. Similarly, to Malola II, the site has been compromised by recent extraction of guano at industrial scale but still presenting thick beds. On the other hand, this work opened other passages and galleries within the system.

The original entrance of the cave was a 4 m chimney, and this would have been used to deposit the human remains that we found scattered in the main room. The location was used by past local communities as a burial site but no association with present population in the surroundings was found in our enquiry. A rounded stone wall or enclosure a few meters next to the vertical cave mouth on the hilltop (Fig. 4) relates to this chronology (Almeida and Camarate-França, 1960).

The cave was much altered since the opening of a horizontal entrance by the quarry. At the time, the exploration encountered dozens of funerary deposits inside the cave and most of the human remains were remobilized or exhumed. A large community of bats was observed in the inner corridors.

The Nkangalongue cave is a complex and sensitive site. It will require additional exploration and testing to understand its infilling, while contextualize the assemblages and structures from very different time frames.

Rock Shelters and Open-Air Sites

Surveying for open-air sites can be challenging in certain areas of the plateau. Around the Humpata town, populational density is high, and there are extensive farms, industry, and fenced areas with cattle. Walking surveys covered the river

Table 2 Summary of findings in open air locations and rock shelters (*T* terrace, *RS* rock shelter)

Site	Summary	Culture
Capangombe Santo-Antônio	Lower terrace on river stream with cobble-pebble beach	Prepared core technology flakes and blades; cleavers and picks (“Fauresmith”/MSA)
Zootecnica falls rockshelter	Compact dark brown silt and sand	Prepared core technology flakes and blades; cleavers and picks (“generic MSA”)
Leba valley 1	Lower terrace on river stream with cobble-pebble beach	Prepared core technology flakes, blades and Levallois points
Leba valley 2	Upper terrace on river stream with cobble-pebble beach	Isolated flakes and points and unretouched points
Huñía Falls Rockshelter	Unconsolidated: gray silt and dung	Isolated flakes

valleys surrounding the main cave systems on the western flank on the plateau where the dolomites are located. In our surveys, we occasionally found isolated stone tools in Leba river valley or around Tchivinguiro. Five main locations showed higher concentrations of lithic artifacts (Table 2). Near the Leba fall, artifacts observed on the surface included unifacially retouched lithic points and blades can be typologically assigned to the MSA. Radial cores in the local siliceous rocks (claystones, mudstones, and cherts) were identified by the survey team on both sides of the river bank.

Only a few rock shelters were identified by our surveys across the Humpata Plateau. These are almost always semi-circular chambers adjacent to a waterfall such as the case of Estação Zootécnica, Huíla, Munhino, or Hunguéria. All of these sites have traces of frequent use and are considered tourist attractions. Nonetheless, archaeological materials such as stone tools have been observed at the surface of the sites and in their surroundings.

Estação Zootécnica refers to an area located about 15 km north of the Humpata town which was used as an experimental farm for veterinary studies. In the farm, there is a colonial palace built in the 1920s and a series of buildings dedicated to health control of cattle and dairy products locally produced. For irrigation of the pasture and crop fields, two small dams or weirs channel a creek. The spring is located a few kilometers north at an altitude of about 2200 m a.s.l. in Alto Bimbe. About 700 m southwest of the palace, there is a rock shelter with a waterfall known locally as a touristic hotspot originally called Katchillwa falls but informally known as Cascatinha da Zootécnica.

The rock shelter of Estação Zootécnica consists of a chamber with 20 m of width and overhang of 7 m on a bedrock of pale yellow-pink quartzite-sandstone from the Chela group rocks (Pereira et al., 2011). The rock shelter is located under a waterfall with a drop of about 14 m forms a pool and a creek. The front of the chamber is partially covered by trees and vines.

Abundant knapped material was observed on the floor of the rock shelter in a dark brown silty sediment. A sample of 62 lithic artifacts was collected and measured on site. The lithic pieces observed at the site were manufactured with local raw materials dominated by pink and brown quartzites, red claystones, gray cherts, and white milky quartz. Knapping strategies were focused on water worn pebbles and cobbles but knapped implements inside the rock-shelter appeared fresh (Fig. 7). Convergent flakes (or points) are also common, but “pseudo-Levallois” rectangular flakes and points were most notable. The assemblage is comparable to others observed in the area associated to the generic MSA (de Matos and Pereira, 2020; Gibson and Yellen, 1978; Ramos, 1981). The area was surveyed in the 1950s by the Anthropological Mission of Angola, and many lithic artifacts were collected at the time. In the deposits of the Tropical Research Institute (IICT) in Lisbon, there are a total of 243 lithic artifacts from 17 locations around the waterfall or upstream (de Matos et al., 2021b). These are mostly terrace deposits associated to the river currently channeled for irrigation. Cultural attributions in the database of the IICT are generally unclear. Some of the assemblages were classified as late Acheulean (previously “Stellenbosch”) or “Faure-Smith” (Clark, 1966; Ramos, 1982, 1981), but part of the materials from the rock

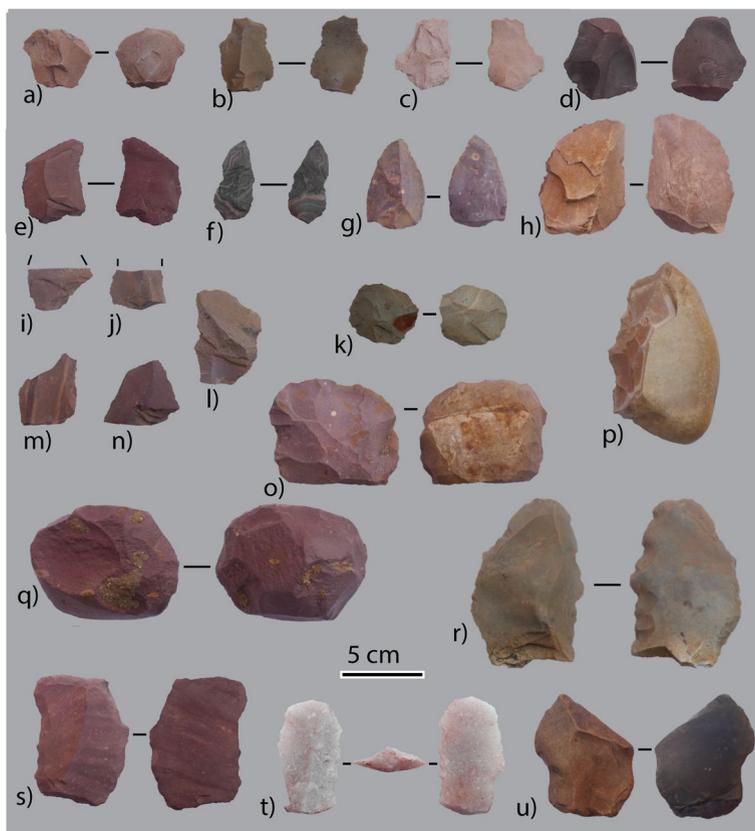


Fig. 7 Lithic artifacts from Estação Zootécnica. Rock shelter findings: **a–d** Levallois flakes in local brown chert and pink-gray quartzite and mudstones; **e–f** “pseudo-Levallois” flakes; **g** “Levallois” point; **h** pseudo-Levallois point; **i–j** proximal fragments of levallois flakes; **k** discoidal core; **l, m, n** flakes and proximal fragments; **o** discoidal core; **p** chopping tool in quartzite river cobble; **q** multipolar core in claystone; **r** scraper on Kombewa flake; **s–t** flakes in gray ortoquartzite and red claystone; river beach finding, **u** pseudo-Levallois flake, note the water-worn surface (photographs by D.M. and edits by D.N.)

shelter and around the waterfall were classified as MSA and LSA (de Matos et al., 2021b). In our surveys, we did not detect large cutting tools or extensive production sequences, nor did we find any bifacial shaped tools. The presence of Levallois knapping strategies is suggestive of typical MSA behavioral traits, but their sole presence is not conclusive of chronological attribution on its own.

Slope retreat and seasonal flooding events can cause extreme changes on the landscape here. It is possible the lithic artifacts may have been transported downstream from the hilltop terraces during flooding events.

Similar occurrences were recorded on the eastern flank of the dolomites, near the Munhino-Huíla falls. The rock shelters in both cases were damaged to channel water supply to the crop fields, but stone tools have been discovered in stream beds a few meters below the waterfall. This is the location of Munhino

Mission-Hula, which G. D. Gibson surveyed in 1971. The collection was separated into two assemblages, one of which remained at the Museu de Angola in Luanda and the other of which was moved to the Museum of Natural History in Washington D.C. (Gibson and Yellen, 1978). The latter accounted for a total of 328 pieces dominated by claystones abundantly available as cobbles and pebbles across the valley. The majority of artifacts are large retouched pieces and flattened disc cores. Unidirectional cores, bipyramidal cores, multidirectional cores, blade cores, “core-axes,” and small quadrilateral flakes were interpreted as MSA comparable with other locations of Namibia (Gibson and Yellen, 1978).

About 10 km east from Estação Zootécnica, other solution morphologies were found in a quartzitic bedrock on the eastern flank of the plateau facing Lubango city. A cluster of small circular depressions, narrow chimneys, and fissures give access to underground galleries and mazes, forming an intricate network leading to the spring of Senhora do Monte. Permission from the local administration is absolutely necessary due to risk of landmines in the surroundings. The “pseudo-karst” of Senhora do Monte has a total of 23 entrances, but only two of them exhibit easy horizontal access. Specialized equipment is necessary to access these galleries, which usually show vertical development with maximum drops of 60 m. Lower solution chambers may occur below these galleries at the phreatic level. The accessible chambers are fissures developing in joints, forming narrow passages and halls. No flowstones were observed. Thick guano deposits cover the floors, and large concentrations of bats roost in the ceiling of interior rooms.

Recent use of these caves is evident by the graffiti and recent litter. No stone tools or apparently prehistoric artifacts were found. Pottery and peculiar anthropomorphic stone sculptures are likely very recent as there are a lot of recent graffiti on the walls. These caves are located in a strategic position overlooking the extensive basin where Lubango City is located.

We also surveyed the areas surrounding two lakes that were detected during the preparation phase. In the geological map of southwest Angola (Matias, 1980), there were two waterbodies located at 12 km south of the town of Humpata called Nuatchite and Catende. During our visits, we concluded the lakes were effectively dry and seasonal recharge was channeled for irrigation of extensive crop fields and fruit orchards for industrial purposes.

Most of our findings relate to permanent rivers and perennial streams, like at Leba, Estação Zootécnica, and Capangombe. In the upper terrace on the northern margin of the Leba stream, we detected unifacially retouched points, blades, prismatic, and radial cores produced in the local claystones, quartzites, and cherts. The stream beds are dominated by cobbles and pebbles derived from the Chela group rocks, and the location is especially attractive as raw material source.

The area with the highest concentration of artifacts was effectively the area around the Capangombe village at 554 m of elevation where a colonial fort was converted into a middle school. Between the middle school and the water deposit is a Boer cemetery of the nineteenth century where we observed Levallois flakes scattered on the surface and pathways.

High concentrations of stone tools were found in stream bed gravels across the valley of Capangombe. Blades, flakes, cleavers, and retouched implements were



Figure 8 Surface material at the site of Capangombe Santo António: **a** cleaver or “Proto-Hachereau”; **b** blades and retouched flakes (photos by D.M.)

observed in these beds but also scattered across the fields surrounding the village (Fig. 8). This is not surprising as these sites are very near the locations studied by Ramos in the 1960s, such as the site Capangombe-Santo Antonio and the site Capangombe-velho (Ramos, 1981, 1974, 1970).

Past excavations at Capangombe-velho, a site located about 2 km south of the school, revealed two archaeological horizons. The lower horizon was laid on an iron crust altered granite and a total count of 45.877 pieces with low frequency of large cutting tools of Acheulean typologies was collected. From the upper horizon, a total of 56.555 pieces were collected dominated by flakes and unretouched points. He interpreted this horizon as an “evolved” MSA. The author also identified two combustion structures but no charcoal associated. The site would also relate to another surficial collection at Capangombe-Santo Antonio. The site is located south of the granite inselberg and about 2.5 km northeast of the school. Ramos collected a sample of 1700 pieces dominated by local raw materials and high frequency of large bifacial tools.

A recent study of the assemblage showed a clear predominance of cleaver and handaxe morphologies as well as flakes and large blades from prepared cores (Piquete, 2021), Piquete et al. (2023) with close affinities with the “Fauresmith” assemblages of Southern Africa (Kuman et al., 2020; e.g., Underhill, 2011). The industries are usually proveniente from open-air sites and are associated to an early stage of the MSA with age estimations ranging from 500,000 to 110,000 years (Kempson, 2007; Kuman et al., 2020; Porat et al., 2010; Wilkins and Chazan, 2012). “Fauresmith” sites are mostly concentrated at the Northern Cape. Also in Namibia, factory sites such as Neuof-Kowas, Ibenstein-Witkoei, Gamsberg, and Waterberg were classified as “Victoria West” and “Fauresmith” technocomplexes (Viereck, 1957). This would mean that Capangombe and the sites at the Namib desert are potentially the northernmost occurrences of “Fauresmith” tools.

Discussion and Conclusions

The fieldwork in and along the Humpata Plateau yielded a more complete map of the distribution of cave sites, rock shelters, and open-air locations of interest for research about Pleistocene biodiversity and hunter-gatherers. As most of these sites remain to be tested and studied in-depth, our field assessment mostly highlights the potential of this area to study prehistoric environments and cultures.

Our survey of the Humpata Plateau was critical in mapping the distribution of deep caves and gaining insight into the formations. The caverns are located on the Humpata Plateau, where karst features developed due to a mix of lithology, tectonics, and climate conditions. The caves are located where carbonate is prevalent, which is limited to the expansion of dolomite outcrops on the plateau's western side. However, karst-like formations and fissures were discovered in quartzite sandstone bedrocks on the plateau's eastern edge.

Guano was found sometimes in fairly thick deposits. The recent clearance of guano beds 2–4 m thick at Malola II and Cangalongue uncovered and disturbed human remains and artifacts indicating that these caves were used as burial sites during the Late Holocene. This allowed us to see that the guano beds cover enormous boulders and monoliths of roof debris, and that Pleistocene sediments may be beneath them.

Site caves at Malola are likely the more sensitive sites as they present several human burials which require different approaches in excavation and conservation.

Many of these caverns also have historical relics and testimonies of very recent use. This is also the area more at risk because of quarrying.

In blind valleys, caves with wide chambers are common. Large roof collapses frequently obscure these entrances. In areas like Leba and Tchíua, the caves are frequently complex systems with different levels of infilling forming through river incision and erosion of the plateau. Other earlier sediments may potentially be buried beneath the roof spall, but further investigation is required. Geophysical work could be useful to figure out the extension of the solution chambers and their infillings. Systematic studies are needed to establish the chronology and understand the formation history of these locations.

The great majority of deep cave locations had surface evidence of human activity. The existence of pottery and grinding tools suggests that these were related to extremely recent settlements. These kinds of materials are typically associated with a “ceramic LSA” or Iron Age cultural period. Although disturbed, sites such as Malola I, Malola II, and Cangalongue were used as burial grounds. They are sites of symbolism and yield critical evidence about the tribes of southwestern Angola.

Late Pleistocene–Early Holocene sediments may be buried beneath thick silty-guano strata or trapped in joints, cracks, chimneys, or galleries closer to the surface.

Fissure infillings and fossil breccias are also important sources of knowledge about the region's previous biodiversity. Breccias can be found in all of the major cave systems and galleries at sub-surficial conditions. Vertebrate fauna was observed *in situ* at Leba, Tchíua, and Malola associated to pink breccias. According to the datasets observed the pink breccias are likely associated to the Late Quaternary ages and thus to the timeframe of the

MSA. As previously noted by Pickford, the pink breccias with fauna are the result of near surface genesis, composed of detrital material frequently coarse and bedrock rubble. This would imply that cementation and precipitation of calcium carbonate causing induration occurred later. Flowstones yield the potential for age measurements of carbonate crusts sealing fossil breccias with bones and tools. Faunal material particularly teeth prevent from fossil accumulations at Tchíua, Malola, Cangalongue, and Leba can be dated using electron spin resonance and uranium/thorium series. For rock shelters and open-air locations, challenges in preservation of organic material may require the use of other Quaternary dating methods based in luminescence or cosmogenic nuclides of minerals. These have already been tested in the region (Lebatard et al., 2019; Nicoll, 2010).

Future selective testing of the caves and rock-shelters will provide a better understanding of the site formation of these sites and how past hunter-gatherers developed highly specialized strategies to explore the mosaic of landscapes of Africa during the Pleistocene (Roberts and Stewart, 2018). This will help establish a well-informed local evolutionary model and to compare with other regions of Africa.

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Declarations

Conflict of interest The authors declare no competing interests.

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