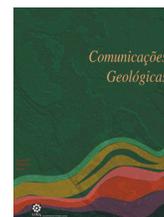


New Quaternary fossil sites from the Middle Atlas of Morocco

Novas jazidas fossilíferas do Quaternário do Médio-Atlas de Marrocos

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Abstract: The paleontological richness of Morocco has been scientifically known since at least the early 20th century. The region of the Middle Atlas, more specifically the Boulemane area, has been however only sparsely studied since the 1960s when it provided vertebrate fossils from the Middle Jurassic.

In September 2013, a Moroccan-Portuguese expedition to the village of Taghrouit, Boulemane, made excavations in a Pleistocene fossil site that once was a small high-altitude sedimentary basin, uncharted in previous geological maps. The excavations yielded bone material from large mammals, the most common findings are elephants ascribed to *Elephas*, but artiodactyls, turtles, and in-situ Acheulean tools were also collected.

This represents a new and important paleontological and archeological site. In addition to the discoveries of Taghrouit, the expedition also retrieved Quaternary vertebrate material from a nearby cave and found new Jurassic localities, with arcosaur bones and dinosaur footprints, in El Mers.

Keywords: Middle-Atlas, Morocco, Pleistocene, Proboscidea.

Resumo: A riqueza paleontológica do Marrocos é conhecida pelo menos desde o início do século XX. A região do Médio Atlas, mais especificamente a área de Boulemane, foi todavia pouco estudada desde a década de 1960, quando foram descobertos fósseis de vertebrados do Jurássico Médio.

Em Setembro de 2013, uma expedição marroquina-portuguesa a Taghrouit, Boulemane, fez recolhas numa jazida fossilífera do Plistocénico que foi outrora uma pequena bacia sedimentar de elevada altitude, não cartografada em mapas geológicos anteriores. A escavação recolheu ossos e dentes de mamíferos de grande porte, sendo os achados mais comuns atribuídos a elefantes do género *Elephas*, tendo sido também recolhidos artiodáctilos, tartarugas e ferramentas acheulenses.

Esta jazida representa um novo e importante sítio paleontológico e arqueológico. Além das descobertas em Taghrouit, a expedição também recolheu vertebrados quaternários de uma gruta nas proximidades e encontrou novas localidades jurássicas, com ossos de arcossauros e pegadas de dinossauros, em El Mers.

Palavras-chave: Médio-Atlas, Marrocos, Plistocénico, Proboscidea.

1. Introduction

The Anchrif quarry is located 1.5 Km West of the village of Taghrouit, 33° 29.117'N, 4° 36.548'W (Fig. 1), in the province of Fès-Boulemane Province in the Kingdom of Morocco. Morocco presents a number of rich vertebrate fossil localities, like the well-known Kem Kem beds from the Upper Cretaceous (McGowan & Dyke, 2009). Taghrouit however is scarcely mentioned and the one of the few mentions to it is that of the French paleontologist Albert de Lapparent, in 1955, in which work is described a *Cetiosaurus* specimen consisting in several limb bones, a pectoral girdle, pelvis and a series of vertebrae (Lapparent, 1955). The Anchrif locality however does not seem to be documented in previous works in the area.

In March 2013 a preliminary visit to the Anchrif locality, near the village of Taghrouit, was made by Moroccan-Portuguese expedition after some reports of fossil bones were made by villagers in 2003. That initial trip, in March of 2013, collected some bones and teeth and recognized them as elephants (Mateus, 2013). Such findings motivated a dig season in September of the same year that excavated a number of fossils, including more elephant bones as well as artiodactyl and turtle bones and a acheulean hominid tools, most likely Pleistocene in age. Besides Anchrif, the team also visited the surrounding region and other vertebrates were discovered. The most relevant of the new sites include a cave with quaternary mammal and reptile fauna, and two Jurassic dinosaur footprint localities and one bone-layer at El-Mers.

2. Geological and paleoenvironmental interpretation of the Anchrif locality

The underlying Middle Jurassic rocks of Skoura Basin accommodate a Pleistocene paleo-lake deposits of the small Anchrif Basin (50 000 m²) that bear vertebrate fossils here studied.

Geology in the area of Taghrouit is characterized mostly by Middle Jurassic deposits, more specifically Bathonian in age. These deposits, although limited throughout the Middle-Atlas accumulate in depressions of the syncline located around the El-Mers, Skoura and Marmoucha (Soufiani & Fedan, 2002). These Mesozoic basins formed

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due to the compression caused by the approximation of Europe and North Africa at the time (Arboleya *et al.*, 2004).

The uplift of the mountains themselves happened in the Cenozoic (Babault *et al.*, 2008).

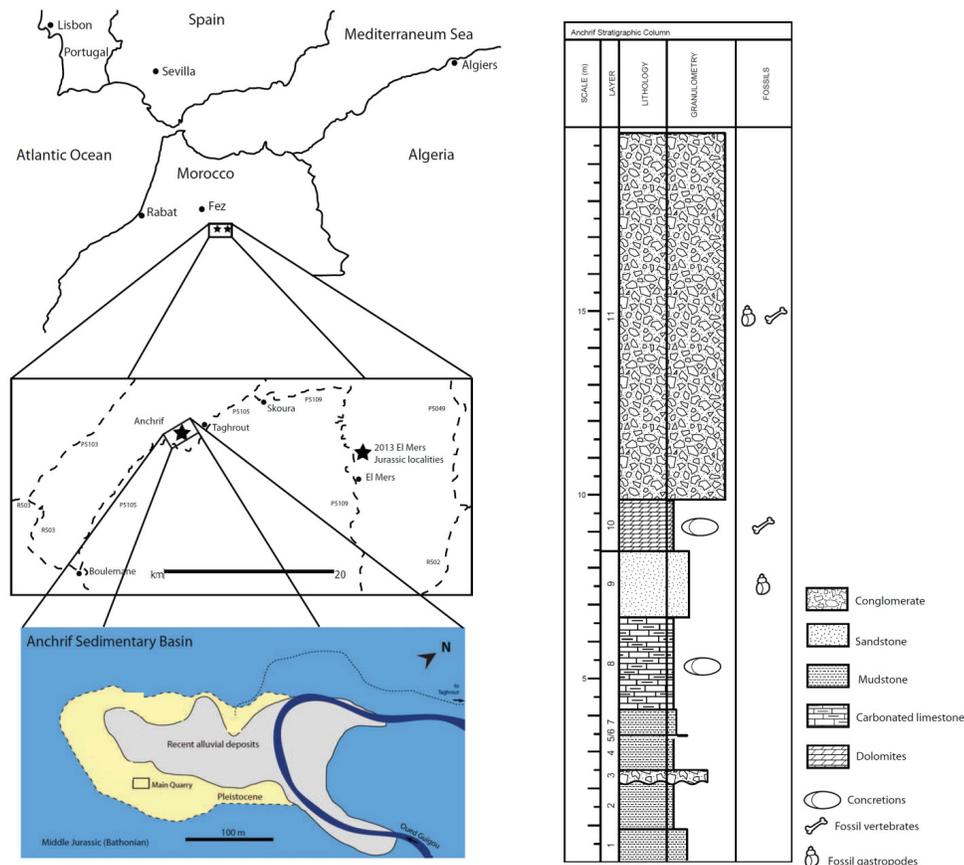


Fig. 1. Left: Location of the quarries and geological map of Anchrif (bottom left). Right: Stratigraphical column of Anchrif.

Fig. 1. Esquerda: Localização das jazidas e mapa geológico de Anchrif (no fundo à esquerda). Direita: Coluna estratigráfica de Anchrif.

The Quaternary sediments in Anchrif were deposited in the bottom of a paleo-lake whose dimensions should correspond roughly to the size of the valley that we have today, taking in account that is surrounded by modern valley topography of the Jurassic rocks.

The small Pleistocene Basin of Anchrif is located in a valley in the north-western edge of the El-Mers syncline, within Middle Jurassic rocks valley. The outcrops are located in a valley west of a bent in the river Oued Guigou at South of Taghrouit. The quarry is around 20 meters higher than the current level of the said river.

This small basin was previously uncharted by geological studies and it is not present in geological charts until the present date. The deposits are distributed in a relatively remote area of around 50 000 square meters.

The Pleistocene layers succession is as follows:

Layer 1: 0.9 m; Fine mudstone, coarser at the base with four sandstone intercalation laminae (0.5-2 cm). One unsorted conglomerate intercalation with slightly angular clasts up to 4 cm. Yellowish-grayish coloration

Layer 2: 1.30 m; mudstone with more than 13 very finely grained intercalations. Gradual change at the base and erosional at the top. Gray to yellow.

Layer 3: 0.30 m. Coarse conglomerate up to 20 cm unsorted and slightly angular clasts. Finer towards the top. Gray coloration.

Layer 4: 0.9 m; Mudstone with non-laminated sandstone intercalations. Gradual transitions (except when bordered by thin iron concretions). The sandstone laminae coarsens towards the base. Occasional clasts in the mudstone up to 5 cm.

Layer 5: 1 m; Marly mudstone, with two fine sandstone intercalations at the base. More than ten ferruginous intercalations with varying thickness (0.1-3.0 cm), parallel lamination. Three one meter lenses of unsorted conglomerate (clasts up to 2 cm) that prograde laterally into mudstone. Unconformably sealed at the top by layer 6.

Layer 6: 0.04 m. Laminated sandstone, iron color, from bright rust to grey.

Layer 7: 0.7 m. Marly mudstone with up to five ferruginous laminations (0.1 to 0.5 cm) in the

lower half. Intercalation of conglomerate lenses and laminae with very fine sandstone (up to three).

Layer 8: 2.5 m: Siltstone with carbonate laminae (up to 5 cm) intercalations. Bioturbations in the bottom face of the carbonate (siltstone/carbonate interface). Light gray coloration.

Layer 9: 1.8 m. Marly sandstone with pulmonata gastropod shells. Some lamination. Coarser to the top. Irregular ceiling due to carbonated concretions. Yellowish gray coloration.

Layer 10: 1.8 m. Carbonated layer dominated by concentric concretions that form vertical tubes (up to 20 cm) with rounded bottom end. Elephant bones in the entire layer. Occasional snail shells.

Layer 11: 10 m: Conglomerate with fine sandy matrix and intercalations of sandstone and siltstone. Unsorted with clasts up to 30 cm. Pulmonata shells and elephant bones. Erosive surface at the top. Gray coloration.

The strata of the quarry have a slight inclination pending in the direction of the center of the Pleistocene Anchrif Basin. Associated with the recent age of the basin it can indicate that the margins of the lake were at the time the carbonates were forming the top of the formation as steep as they are today. The inclination of the ground could have provided a natural trap for large mammals such as the elephants.

3. Elephantini of Morocco and Anchrif

Living proboscideans are restricted to two genera: *Loxodonta* (the African elephant) and *Elephas* (the Asian elephant). Proboscidea was however much more diverse in the past (Roth, 1992; Todd, 2010). The clade is one of the oldest of placental mammals and its origins can be traced to Africa with the oldest remains were found in the Early Paleocene of Morocco, belonging to *Eritherium azzouorum* (Gheerbrant *et al.*, 2002; Gheerbrant, 2009). In the Plio-Pleistocene, proboscidean species in Morocco include the genera *Anancus*, *Mammuthus* (the species *M. africanavus*) and *Elephas*.

Elephas taxa in Morocco include the species *Elephas recki* Dietrich 1915, a widespread Pleistocene African species that ranged from Eritrea (Martínez-Navarro *et al.*, 2004) to the Atlantic coast of Morocco (Arambourg, 1979). Fossil finds of the *Elephas* genus were described since the 60's in the localities in Casablanca but not figured in the original reports (Arambourg, 1979).

Quaternary quarries in mountainous terrain such as Anchrif seem to be rare in Morocco although there were other localities with material from the species *Elephas antiquus* found in similar altitude, such as in the island of Crete where remains of this species were found at 1000 meters above sea level (Poulakakis *et al.*, 2002).

The elephant remains of Anchrif (Fig. 2) include: one skull, two tusks, two ilia, one scapula, several ribs and cervical vertebrae, one patella, a femur, a molar, and a possible radius and ulna. The most complete tusk is 1.30 m

in length and presents the hollow cavity for the teeth pulp at its base. The bones collected correspond to at least three adults and one juvenile.

The remains are tentatively classified as the genus *Elephas* due to the tusks being almost completely straight, the lack of losangular pattern of the molar enamel as in the genus *Loxodonta*, enamel thickness between 1.5 and 2 mm and almost absent enamel folding. The enamel pattern and most of the characters are similar to the species *Elephas recki* and *Elephas iolensis* (Maglio, 1973; Todd, 2010). Since fossil preparation of these specimens is still underway as of this date further work will be required in order to determine the exact species the elephant material from the quarry in study with a detailed phylogenetical analysis.



Fig. 2. Elephantid *Elephas* from Anchrif, Morocco: A, molar in apical view; B, tusks in lateral view.

Fig. 2. Elefantídeo *Elephas* de Anchrif, Marrocos. A: molar em vista apical. B: presas em vista lateral.

4. Fossil Fauna and Flora of Anchrif and surrounding region

Besides the proboscideans of the Anchrif quarry, the locality and the surrounding region of the Middle Atlas the expedition of September 2013 provided more fossil material from the Pleistocene of Taghrouit, Middle Jurassic of the El-Mers Formation and possibly Holocene from a cave less than 400 m South of the Anchrif Basin.

In the Middle Jurassic outcrops around Anchrif several other fossils can be seen, including abundant bivalve and brachiopod shells, plant remains and at least one layer presenting theropod dinosaur tracks, here reported by the first time.

The area surrounding Skoura and Boulemane is known since the 1920s to have localities with Jurassic vertebrate, with the main locality being El-Mers, 15 Km SE of Taghrouit. The main work about this subject was made by the French paleontologist Albert F. de Lapparent in 1995. This article describes three main fossiliferous quarries and several smaller discoveries in a radius of about 20 Km around Anchrif. The material described for the area includes various dinosaur remains, crocodylians and fishes. The half-day prospection near El-Mers allowed the discovery of one site with three track layers (tridactyl and sauropod) and fossil bones, maybe belonging to a crocodylian, which show the potential that area regarding fossil sites.

The Pleistocene fauna of Anchrif include the elephantids, artiodactyls, chelonians and various species of land snails. The gastropod fauna from today is almost

identical to the Pleistocene one with most species that were collected during the expedition being present in both. A fossil seed from the tree *Celtis australis* was also found associated with the elephant material.

The Holocene material from the Anchrif cave includes bovids (possible *Syncerus* sp.), small artiodactyls, hares (*Lepus* sp.), felids and tortoise shell fragments. There are also evidence of the presence of porcupines (*Hystrix* sp.) based on teeth marks, a quill and one coprolite.

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