

A brief approach about the ornithopod dinosaurs from the Papo-Seco Formation (Cabo Espichel, western central Portugal)

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Resumo

Apresenta-se um conjunto de novos restos fósseis de ornitópodes da Formação Papo-Seco (Barremiano inferior, Cretácico Inferior), localizada a cerca de 2.5 km a norte do Cabo Espichel. Nesta formação existem registos sedimentares marinhos, lagunares e estuarinos, constituídos por calcários, argilas, areias e conglomerados, que conservaram vestígios fósseis de dinossáurios e de outros vertebrados fósseis. Os restos de dinossáurios desta formação são conhecidos desde o século XIX. Pesquisas paleontológicas recentes encontraram vários restos de diversos vertebrados, incluindo fragmentos de carapaças e de ossos de tartaruga, dentes de crocodilo e de peixes e dentes e ossos de pterossauros. Estes estudos também identificaram pegadas, ossos e dentes de dinossáurios ornitópodes. Estas novas descobertas são um importante contributo para o conhecimento da diversidade dos dinossáurios ornitópodes do Cretácico Inferior português.

Palavras-chave: Cretácico Inferior, vertebrados, dinossáurios, Cabo Espichel, Portugal.

Abstract

New ornithopod remains are reported from the Papo-Seco Formation (Lower Barremian, Lower Cretaceous) at the Espichel Cape, western central Portugal, south of Lisboa. Marine, lagoonal and estuarine sedimentary rocks, consisting in limestones, marls, sandstones and conglomerates, have yielded fossil remains of dinosaurs and other vertebrates since the 19th century. Recent field work has found new vertebrate remains, including turtle shell fragments and isolated crocodylian teeth, fish bones and pterosaurs. Bones and teeth of large ornithopod dinosaurs have also been identified. These new discoveries are an important contribution to the knowledge of the ornithopod diversity from the Portuguese Cretaceous.

Key-words: Early Cretaceous, vertebrates, dinosaurs, Espichel Cape, Portugal.

1. INTRODUCTION

The Papo-Seco Formation, stratigraphically located between the Areias do Mastro Formation and the Boca do Chapim Formation and assigned to the Lower Barremian, is 18.5m thick and characterized by marls and green silty clays with lignite and gypsum, interbedded with sandstones, displaying horizontal stratification (Manuppella *et al.*, 1999). It is situated about 40 km south of Lisbon, in the SW of the Setúbal Peninsula, near Sesimbra (Fig. 1). The field work area is located at the bottom of the coastal cliffs of the Cabo

Espichel anticline. The fauna from the Papo-Seco Formation consists of vertebrate fossil remains found in the coarser sandstone layers, and invertebrates (bivalves and gastropods) and ostracods in marls. The upper part of this formation is composed of bioturbated calcareous silty layers with ostreid remains (Manuppella *et al.*, 1999). Sedimentological and palaeontological features point to open estuarine environments at the base of the Papo-Seco Formation, passing upwards to a less energetic lagoonal setting where several fossil remains of marine and terrestrial vertebrates were found (Manuppella *et al.*, 1999; Rey *et al.*, 2003; Figueiredo *et al.*, 2015, 2016; Dinis *et al.*, 2016).

Vertebrate fossils from Cabo Espichel are known since the 19th century. Dinosaur and crocodile teeth were reported from the Papo-Seco Formation, at Boca do Chapim (Sauvage, 1897-1898). Later, turtle remains and crocodile teeth and bones, as well as dinosaurian remains were described. Among these remains are two tooth fragments which were referred to Megalosauridae by Lapparent and Zbyszewski (1957), and later classified as Carnosauria *incertae sedis* (Galton, 1994). Some herbivorous dinosaur remains have also been reported and referred to *Iguanodon* and cf. *Pelorosaurus* (Lapparent and Zbyszewski, 1957; Figueiredo, 2000). The remains of *Iguanodon* are from the axial (two vertebrae) and appendicular (a distal fragment of a femur) skeleton. In addition teeth were attributed to *Iguanodon mantelli* by Lapparent & Zbyszewski (1957); later, this material was referred to *Iguanodon* sp. by Antunes and Mateus (2003), and to *Iguanodon atherfieldensis* by Crespo (2001). Jaw fragments found at Boca do Chapim were referred to *Suchosaurus girardi* by Sauvage (1897-1898). These remains were later studied by Buffetaut (2007); based on similarities with the holotype of *Baryonyx walkeri* from the English Barremian, this author concluded that these jaws are from *Baryonyx* (Buffetaut, 2007). Recently, Mateus *et al.* (2011) have referred skull remains and postcranial bones of *Baryonyx walkeri* (Mateus *et al.*, 2011).

In the scope of the palaeontological investigations carried out by the Centro Português de Geo-História e Pré-História (CPGP), new data have been reported. In Boca do Chapim, a preliminary analysis of the discovered material identified several bones of an ornithopod dinosaur (Figueiredo, 2010, 2014). In the Areias do Mastro Formation vertebrate bone fragments and teeth belonging to a diverse fauna,

including bone fish (cf. *Lepidotus* sp.), crocodiles (cf. *Anteoptalmosuchus* sp.), pterosaurs (Ornithocheiridae indet. and Ctenochasmatoidea indet.) and dinosaurs (*Baryonyx* sp., *Mantellisaurus*, Iguanodontoidea indet. and Sauropoda indet.) have been described. At Praia do Guincho, a natural cast of an ornithopod footprint was reported (Figueiredo *et al.*, 2015, 2016, 2017).

The purpose of this paper is to present the ornithopod dinosaur remains found by the CPGP team in the Papo-Seco Formation.

2. MATERIALS AND METHODS

The ornithopod material, which comes from several sites, consists of: Areias do Mastro site - two teeth (CPGP.01.01.2; CPGP.01.03.3) and a fragment of maxilla (CPGP.01.99.7); Praia do Guincho site - a small coarse grained limestone block with a natural cast of a medium size three-digit footprint (CPGP.03.11.1) and a fragment of a diapophysis from a vertebra (CPGP.03.13.8); and at Boca do Chapim site - a set of bones from the axial and appendicular skeleton (CPGP.02.07.1). These fossils are kept in the palaeontology collection of CPGP. The remains result from prospecting at the cliffs of the Areias do Mastro site (1998-2003) and the excavation of four clay layers in the lower part of the cliffs (2004-2009). The palaeontological research coordinated by the senior author (S.F.) is part of a wider project that includes the study of the pre-historic archaeology of the whole Espichel Cape area.

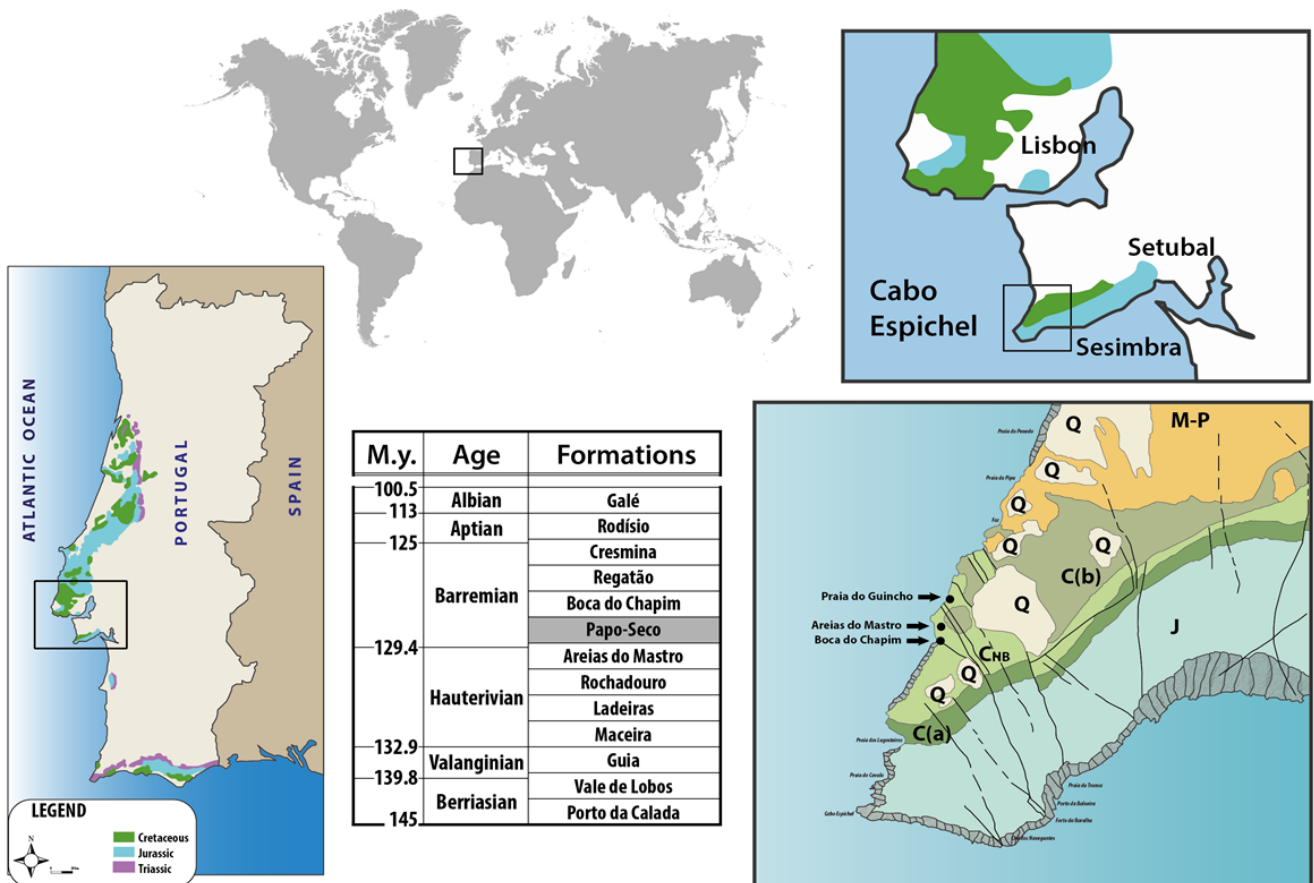


Fig. 1 – Localization and geology of the studied sites. Adapted from Figueiredo *et al.* (2015, 2017). (J – Jurassic; C(a) – lower Berriasian to lower Hauterivian; Chb – lower Hauterivian to lower Barremian; C(b) – upper Barremian to Aptian; M-P – Miocene to lower Pleistocene; Q – middle to upper Pleistocene and Holocene).

3. GEOLOGICAL, STRATIGRAPHICAL AND PALAEOENVIRONMENTAL SETTINGS

The area where the ornithopod fossils have been found is located between the Boca do Chapim and Praia do Guincho sites. These localities are situated at the coastal cliffs, about 2,5 – 4 km to the north of Cabo Espichel (Fig. 1), in the municipality of Sesimbra, SW of Setubal Peninsula, about 40 km south of Lisbon (Portugal, western Iberia).

The studied Lower Cretaceous sedimentary beds of the Papo-Seco Formation are part to the Lusitanian Basin, and located on the Western Portuguese Margin.

The Papo-Seco Formation crops out on a cliff and is about 60m thick. The cliff exposes a sedimentary succession which includes limestones, marls, sandstones and conglomerate levels, deposited in shallow marine, lagoon and estuary environments. The Papo-Seco Formation is considered to be lower Barremian (Lower Cretaceous) (e.g., Rey, 1972; Manupella *et al.*, 1999; Aillud, 2001; Dinis *et al.*, 2008; Rey *et al.*, 2003; Figueiredo *et al.*, 2020) (Fig. 1).

The lowest layers of the Papo-Seco Formation from the Boca do Chapim site at the southernmost entrance to Areias do Mastro have been studied. The initial layers are topped by a further two layers of thin yellowish sandstones (Fig. 2).

4. RESULTS

4.1. Areias do Mastro

In the Areias do Mastro site, two isolated teeth and an ornithopod maxillary fragment were discovered and published in 2015, being attributed to *Mantellisaurus atherfieldensis* (the fragment of the maxilla and a tooth) and to Ornithopoda indet. (a tooth) (Figueiredo *et al.*, 2015).

CPGP.01.99.7 is a left maxilla with a robust appearance and preserves five teeth (two with the crown completely above the alveolar parapet, one with the apex above and two still within the alveoli). Two teeth have triangular crowns and two other teeth have a semi-rectangular crown. Some features observed in the teeth are typical of basal Iguanodontia (Norman & Weishampel, 2004; Paul, 2007, 2011; Norman, 2011, 2013), i.e., only one replacement tooth per tooth position (clearly observed in X-Ray), the labial surface of the crown is thickly enamelled with a strongly denticulate margin, having a very large primary ridge arising from the base of the crown and grooves or lines and a second ridge, less prominent. On the lingual surface, the teeth do not display any ornamentation. From X-Ray analysis, it was possible to distinguish the dental alveoli, which are wide and deep, revealing a long root. The estimated length of the maxilla (approx. 30 cm), considering the size of the teeth, places it near the size of that of *Mantellisaurus atherfieldensis* (27 cm, according to Norman & Weishampel, 2004) (see Figueiredo *et al.*, 2015).

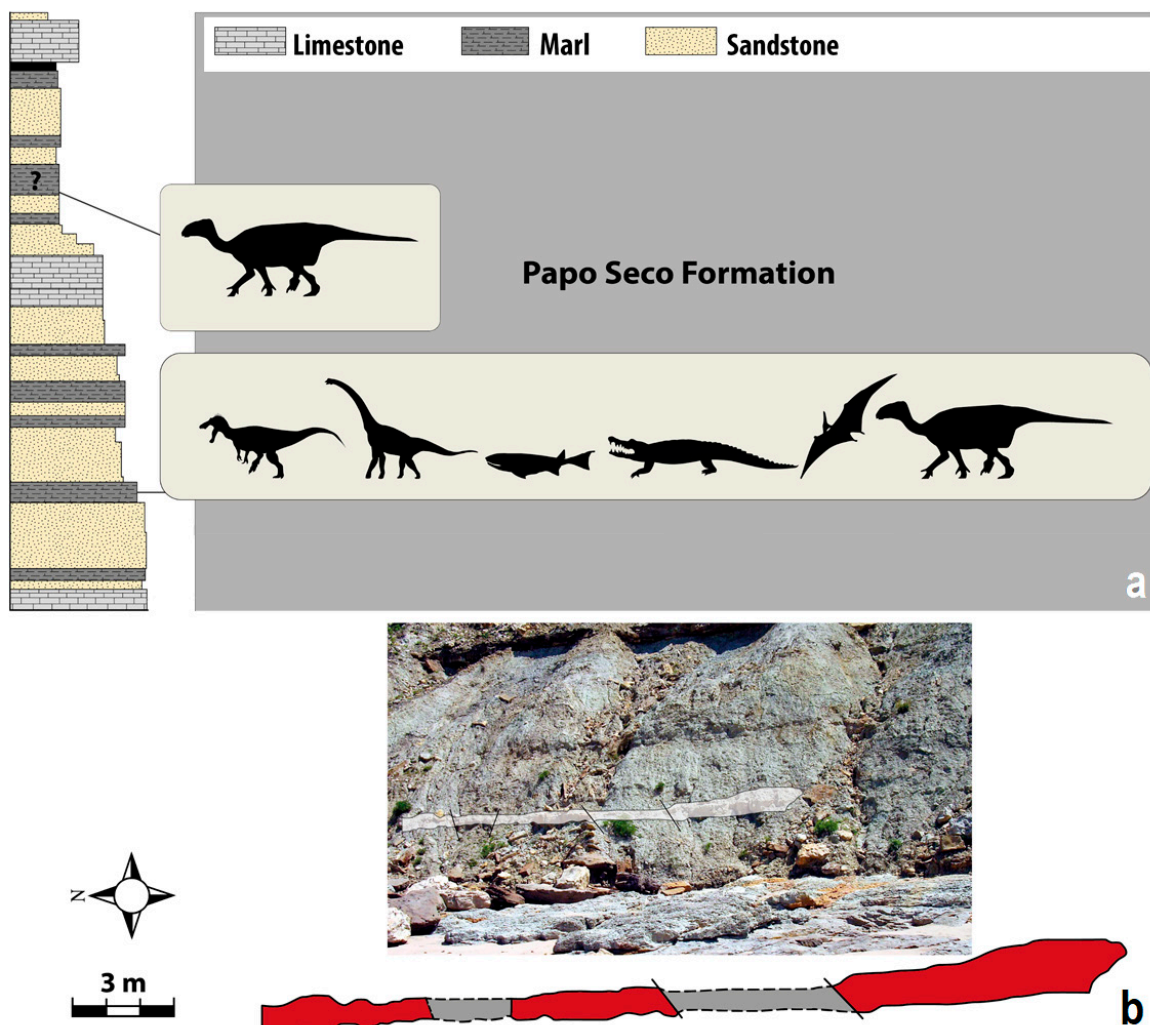


Fig. 2 – The Areias do Mastro site:

a) Sedimentary log showing the vertebrate-bearing units;

b) Photograph of the site showing the fossiliferous bed.

In red - the exposed areas of the layer.

Adapted from Figueiredo *et al.* (2015).

4.2. Praia do Guincho

At Praia do Guincho site, ornithopod fossils consist of a natural cast of a footprint and a fragment of a diapophysis of a vertebra (Figueiredo *et al.*, 2017). The footprint (found in a small coarse-grained limestone block) is tridactyl, produced by a medium-sized ornithopod, with a length slightly greater than the width (29.7 cm length and 28.4 cm width, respectively). It appears to be slightly deformed. The print corresponds to a right foot and has a plantigrade and rounded morphology, with short fingers, rounded digits well defined and blunt ending, the heel area has a wide and rounded form, without the mark of the heel. It presents plenty symmetrical relative to the axis formed by the digit III. The general form, the morphology of short and rounded digits and the overall outline of the footprint with a rounded appearance suggest ornithopod features (Figueiredo *et al.*, 2017). It could be related to the ichnogenus *Iguanodontipus* or *Caririchnium* (see Sarjeant *et al.*, 1998; Díaz-Martínez *et al.*, 2015).

4.3. Boca do Chapim

At Boca do Chapim site, two bones of a large ornithopod were discovered in 2007. Later, between 2008 and 2013, an area of 6m² was excavated and skeletal remains from a single individual were found as disarticulated bones, including several vertebrae and chevrons, a rib, pelvic bones, and a phalanx (Fig. 3a). The bones were deposited randomly and not aligned (Fig. 3c), which suggests that the remains of this individual were deposited in a lagoon environment, in a sub-environment of stopped water. The fossils are still in the

process of restoration and study and so they have not been published in detail yet (Figueiredo, 2010, 2014). Theropod bite marks (Fig. 3b) have been identified on a caudal vertebra, suggesting feeding behaviour. The preliminary study of the ornithopod bones shows similarities, especially in the ischium, with Spanish Barremian ankylopollexians (Ruiz-Omeñaca *et al.*, 2011; Gasulla *et al.*, 2015).

5. CONCLUSIONS

During the Early Cretaceous, large ornithopods had a wide geographical distribution with a global range including Europe, North America, Africa, Asia and Australia. Their remains mainly occur in lowland, marshy and estuarine environments (Norman, 2012). These palaeoenvironments are compatible with the sedimentary succession of the Papo-Seco Formation, which constitutes a transgressive unit deposited in a valley excavated during a local sea level drop (Rey *et al.*, 2003; Dinis *et al.*, 2008).

Ornithopod fossil remains, specially bones and teeth, are rather scarce in the Lower Cretaceous record of Portugal (Figueiredo, 2014). Lapparent and Zbyszewski (1957) cited the presence of *Iguanodon* in Boca do Chapim. Recent discoveries in the Papo-Seco Formation support the presence of iguanodonts, which are represented by bones and teeth (Figueiredo, 2010, 2014; Figueiredo *et al.*, 2015, 2016). The natural cast of an ornithopod footprint is also known in this formation. These finds increase the fossil record and diversity of ornithopod dinosaurs from the Portuguese Lower Cretaceous.

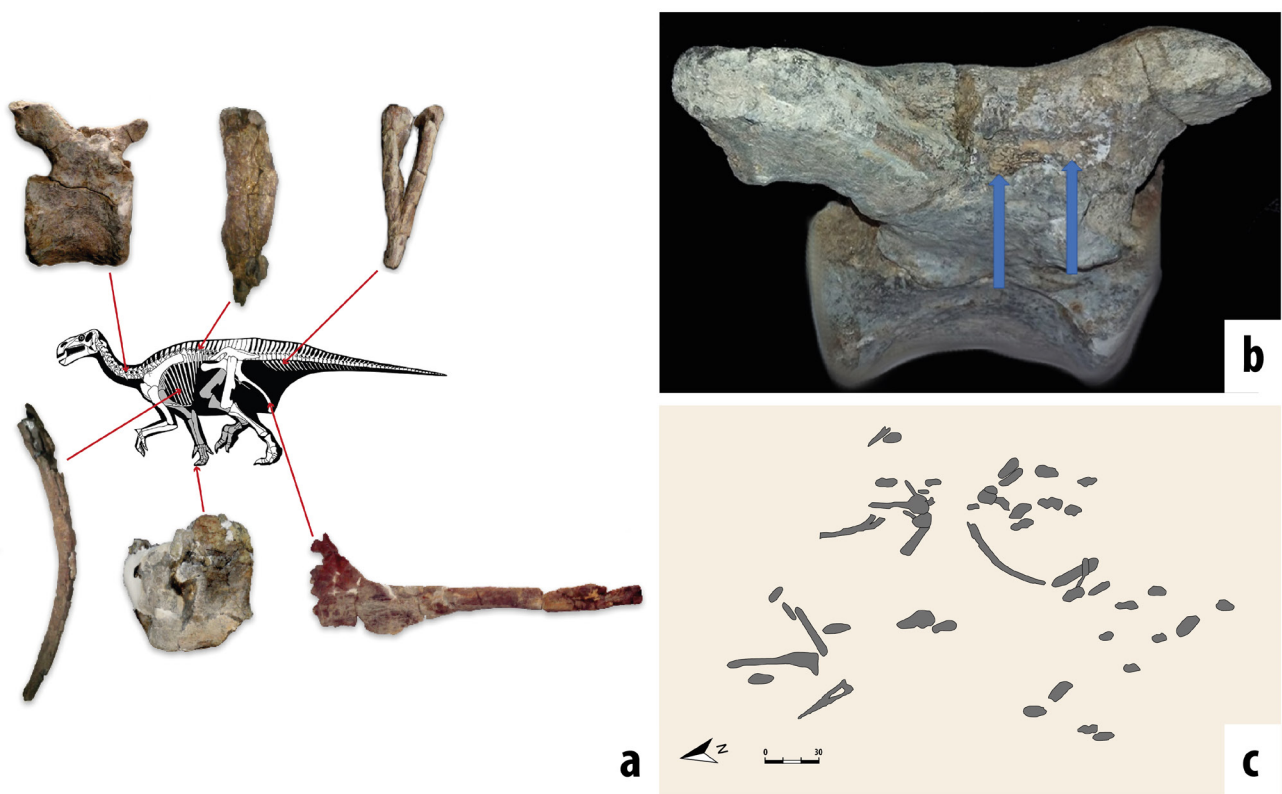


Fig. 3 – a) some bones already traded and its localization on an ornithopod skeleton; b) Teeth marks in an ornithopod vertebra from the Boca do Chapim site (photo: Edmundo Rijo); c) excavation plan with the location of the bones in the field.

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