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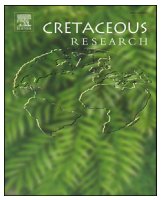

Short communication

Sauropod dinosaur remains from the Papo-Seco formation (lower Barremian, Lusitanian Basin, Cabo Espichel, Portugal): Previous and new discoveries

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A B S T R A C T

Previous and new fossils of sauropods are reported from the Papo-Seco Formation (lower Barremian, Lower Cretaceous) at Cabo Espichel, south of Lisbon, Portugal. The fossils were collected from the Boca do Chapim and Praia do Areia do Mastro sites. The sauropods and other vertebrate fossil remains from the Papo-Seco Formation occur in marls, sandstones and some conglomerates in a sedimentary succession interpreted as deposited in lagoonal and estuarine environments, under a tropical climate. The study of the available specimens, including teeth and postcranial remains, suggests the occurrence of Titanosauriform sauropods.

1. Introduction

Vertebrate fossils from Lower Cretaceous successions at Cabo Espichel, south of Lisbon (Portugal), have been known since the 19th century. Fossils of dinosaur, turtles, pterosaurs, fishes and crocodile teeth and bones have been reported from the Papo-Seco Formation, at the Boca do Chapim site (Lapparent and Zbyszewski, 1957; Sauvage, 1897–1898), at the Praia do Areia do Mastro site (Figueiredo et al., 2015) and from the Praia do Guincho site (Mateus et al., 2011; Mateus and Estraviz-López, 2022). In those sites, sauropod, ornithopod and theropod footprints were also described (Figueiredo et al., 2017, 2021; 2022a).

Herbivorous dinosaur teeth from Boca do Chapim site were identified by Sauvage (1897–1898) as the ornithopod *Iguanodon mantelli* and the sauropod *Pleurocoelus valdensis*. The sauropod teeth have subsequently been referred to *Astrodon valdensis* (Galton, 1981; Lapparent and Zbyszewski, 1957) or Sauropoda indet (Antunes and Mateus, 2003). Detailed investigation of previous fossils and new discoveries allow for a more accurate taxonomic identification of these sauropod remains.

This study presents the sauropod remains from the Papo-Seco Formation, at Cabo Espichel (Portugal), including a review of previously described fossils from the Boca do Chapim and Praia do Areia do Mastro sites and the description of two articulated dorsal vertebrae and a cervical rib, recently discovered at Praia do Areia do Mastro site. These data increase the current knowledge of Portuguese Early Cretaceous sauropods.

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Institutional abbreviations: CPGP, Centro Português de Geo-História e Pré-História (Golegã, Portugal); MG, Museu Geológico (Lisbon, Portugal).

2. Geological setting

The Papo-Seco Formation outcrops between Boca do Chapim (in the south) and Praia do Guincho (in the north; Fig. 1) sites. The fossils studied in this work come from Boca do Chapim and Praia do Areia do Mastro sites (between the coordinates: 38°26′02″N, 9°12′45″W and 38°26′45″N, 9°12′47″), which are located about 2 km north of Cabo Espichel (Sesimbra municipality), on the coastal cliffs of the Espichel anticline, located ~40 km south of Lisbon, in the SW side of the Setúbal Peninsula (Fig. 1).

The lithostratigraphic term Papo-Seco Formation was proposed by Rey (1992), but in older geological literature, it is known as "Grès marneux à grands sauriens" (Choffat, 1904) and "Grès à Dinosauriens" (Rey, 1972). Previously, Sauvage (1897–1898), Choffat (1904) and Lapparent and Zbyszewski (1957), regarded this unit and fauna as Aptian-Albian. The Papo-Seco Formation is currently attributed to the lower Barremian (ca. 123–126 Ma) (Manupella et al., 1999; Rey, 1992). It is stratigraphically located between the Areia do Mastro Formation and Boca do Chapim Formation (Fig. 2). Locally, the Papo-Seco Formation is 18.5 m thick and is composed of marls and green silt clays with lignite and gypsum levels, interbedded with sandstones (Manupella et al., 1999). Fossils of diverse fauna collected from the Papo-Seco Formation mainly consists of vertebrate remains, found in the coarse sandstone layers, and invertebrates (bivalves, gastropods and ostracods) from the marls. The upper portion of this unit comprises bioturbated calcareous silt layers with ostreid remains (Manupella et al., 1999). Sedimentological and palaeontological features generally indicate a low energy paleoenvironment, being an open estuary to a lagoon (Dinis et al., 2016; Figueiredo et al., 2015, 2016, 2017, 2020a; Manupella et al., 1999; Rey et al., 2003).

Four sedimentary units outcrop at the Praia do Areia do Mastro site: Areia do Mastro, Papo-Seco, Boca do Chapim and Regatão formations. The sauropod fossil remains were discovered in the lowermost beds of the Papo-Seco Formation, overlain by two strata of thin yellowish sandstones. From the lower to the uppermost portion of the exposed succession of the Papo-Seco Formation, the sedimentary deposits consist of grey marls, grey carbonate silts and lenses of fine sandstones, with fossils of brackish/marine gastropods and bivalves. At the Praia do Areia do Mastro site, a diverse fauna, including fossils of crocodyliformes, pterosaurs, turtles and dinosaurs, was reported by Figueiredo et al. (2015, 2016, 2017, 2020).

3. Materials and methods

Sauropod fossils from the Papo-Seco Formation consist of cranial and postcranial remains from several individuals. Cranial remains are isolated teeth; postcranial elements include neck rib and vertebral remains. The sauropods reported here include specimens previously published (Figueiredo, 2000; Figueiredo et al., 2015; Lapparent and Zbyszewski, 1957) and other fossils, including five teeth from the Boca do Chapim site, housed at the Geological Museum (MG); a caudal vertebra from Praia do Areia do Mastro site and four unidentified bone fragments and a metacarpal fragment, housed at the CPGP collection; two articulated vertebrae, two dorsal ribs and several gastroliths, discovered in Praia do Areia do Mastro housed in the collection Carlos Marques.

The study of these new fossils was conducted in the Laboratory of Archaeozoology and Palaeontology of the CPGP. The osteological nomenclature followed the standardized anatomical nomenclature based on the Handbook of avian anatomy (Baumel and Witmer, 1993) and the Nomina Anatomica Veterinaria (NAV), by World Association of Veterinary Anatomists (WAVA). The nomenclature for the vertebral laminae follows Wilson (1999), with modifications from Salgado et al. (2005) and Wilson et al. (2011). The nomenclature for the vertebral pneumatic structures follows Wedel (2003) and Wilson et al. (2011). The nomenclature for the rib follows Osborn and Mook (1921) and Klein et al. (2012).

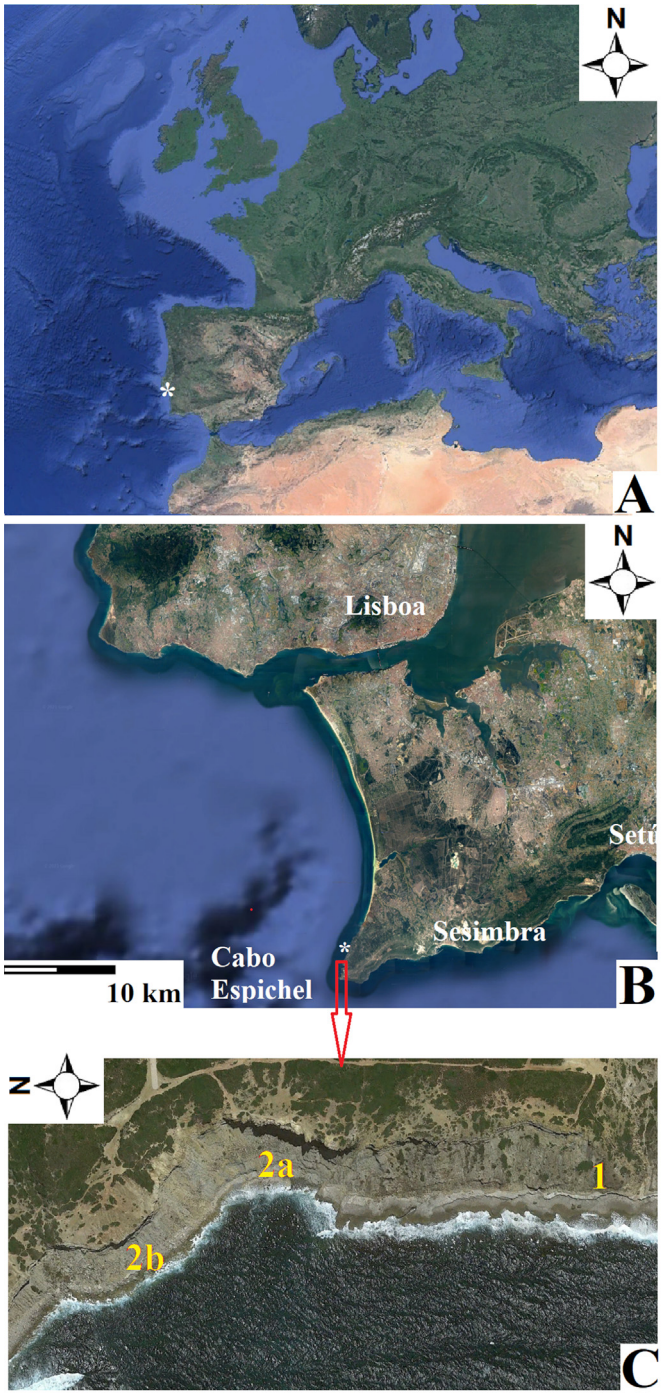

Fig. 1. The locality Praia do Areia do Mastro and Boca do Chapim: A: location (*) in Europ Map; B: – location of Boca do Chapim and Praia do Areia do Mastro sites, in Setúbal Peninsula; C – location of Boca do Chapim (1) and Praia do Areia do Mastro (2). Source: Google Earth (Images taken September 10, 2022).

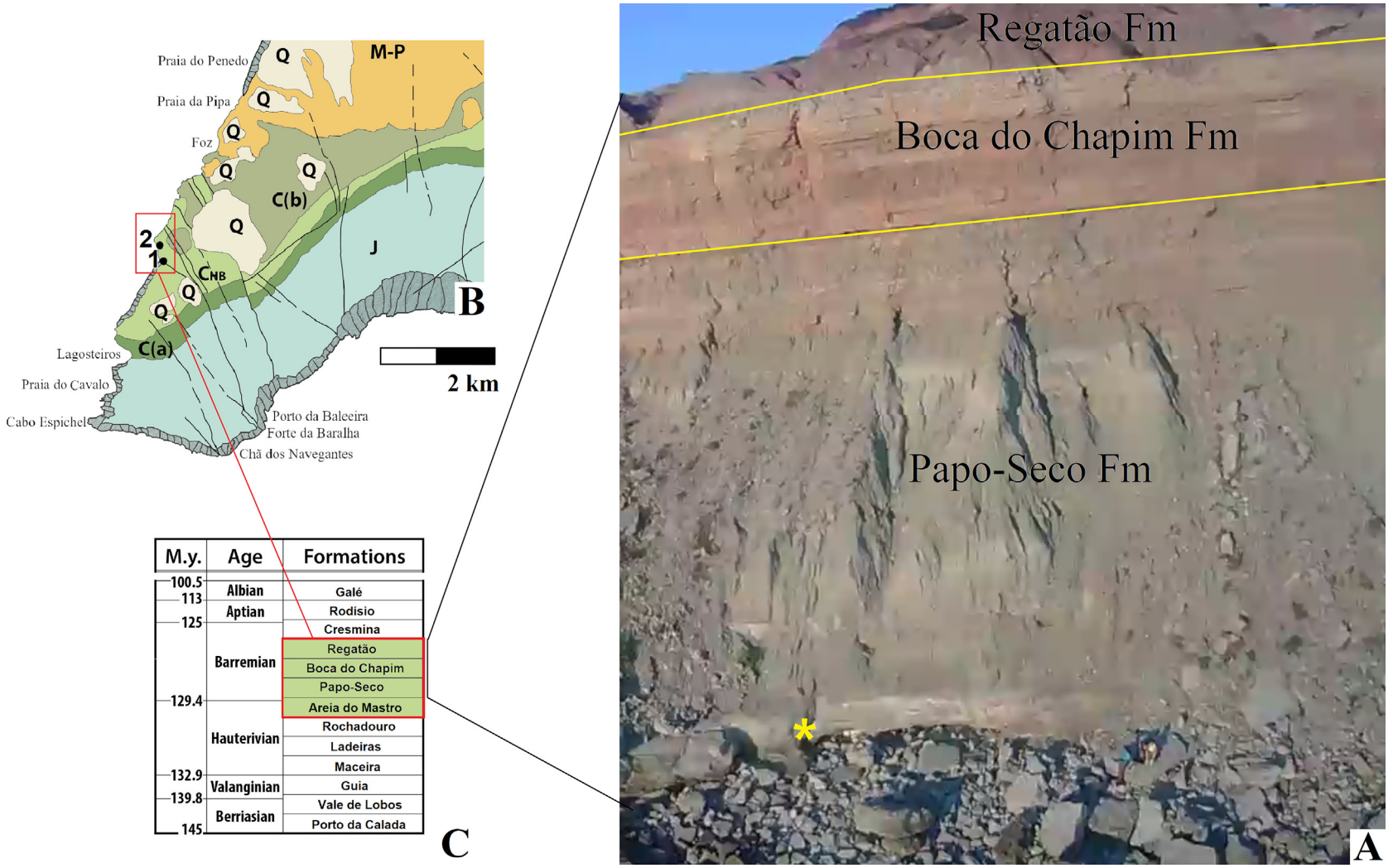

Fig. 2. Sedimentary formations which occurs in the Areia do Mastro site. A, sedimentary formations at the north area of the Areia do Mastro site (* = location of the CPGP(CM).21.1, CPGP(CM).21.2 and CPGP(IMR).21.1.); B, geology of the Cabo Espichel (excerpt from the Carta Geológica de Portugal, sc. 1:50,000, Folha 38 B: Setúbal). Abbreviations: J: Jurassic; C(a): Cretaceous (Berriasian and Valanginian); CHB: Cretaceous (Hauterivian and Barremian); C(b): Cretaceous (Apatian and Albian); M– P: Miocene and Pliocene; Q: Quaternary; C - geological formations of the Cabo Espichel. The red square and the green highlight represent the geological formations that occurs on this study area.

4. Systematic Palaeontology

Dinosauria Owen, 1842.
Saurischia Seeley, 1888.

Sauropoda Marsh, 1878.

Sauropoda indet.

Material: MG 25198.2, is a fragment of an isolated tooth crown (Fig. 1.C.1; Fig. 2.B).
Locality and horizon: Boca do Chapim; Papo-Seco Formation, Barremian.

Eusauropoda Upchurch, 1995

Eusauropoda indet.

Material: *MG10*, is an isolated poorly preserved tooth crown (Fig. 1.C.1; Fig. 3.A).
Locality and horizon: Boca do Chapim; Papo-Seco Formation, Barremian.
Description: MG10 is a poorly preserved and damaged tooth crown. It has a convex labial side and concave lingual surface, which gives it a D-shaped cross section (Fig. 3). The crown has a spatulate shape in lingual and labial view, which is a feature commonly found in basal eusauropods (Holwerda et al., 2015).

Titanosauriformes Salgado, Coria & Calvo, 1997

Titanosauriform indet.

Material: MG25198 (Fig. 3B), a fragment of tooth crown; CPGP.1.05.25, CPGP.1.05.26, CPGP.1.05.27 and CPGP.1.05.28 (Fig. 1.C.2a; Fig. 4.A). Four fragments of a vertebra; CPGP.1.06.33 (Fig. 1.C.2a; Fig. 4.B). A right fragment of a centrum of a caudal vertebra. A fragment with portion of the proximal end and the middle of shaft of a left metacarpus IV CPGP.1.22.10 (Figs. 1.C.2a; 4.C), discovered by João Santos.
Locality and horizon: Praia do Areia do Mastro; Papo-Seco Formation, Barremian.
Description: MG25198.2 is a fragment of tooth crown. It preserves only the apex. The lingual surface only preserves a small portion of the enamel. The labial surface has all the enamel. It has the border worn. CPGP.1.05.25, CPGP.1.05.26, CPGP.1.05.27 and CPGP.1.05.28 are four *periosteum* and compact bone fragments with an internal texture spongy, with large and open internal cells, and a honeycomb-like, tubular structure of the weathered surface of the bone.
CPGP.1.06.33 is a right side of the centrum of a distal caudal vertebra with the base of the neural arch, collected in the same bed and near of the specimens CPGP.1.05.25, CPGP.1.05.26, CPGP.1.05.27, CPGP.1.05.28. The entire specimen has 114 mm length and 83 mm height. It is longer and lower, it has a subcylindrical shape and it is laterally and ventrally concave. The neurocentral suture is visible as a slightly, jagged and thickened line and it is slightly displaced dorsally. The base of the neural arch extends for approximately half of the length of the vertebral centra. The central zone of the lateral

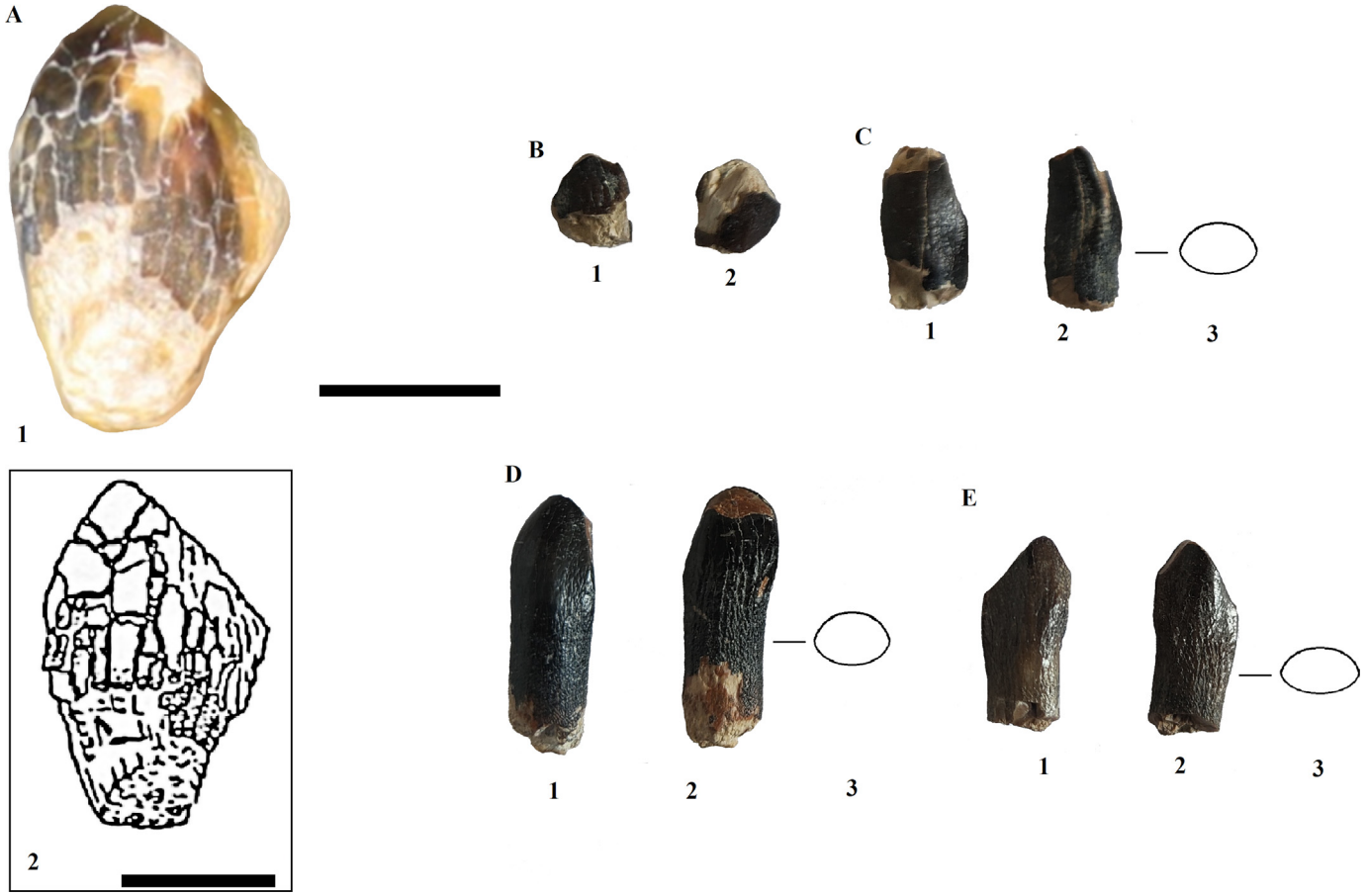

Fig. 3. Sauropod teeth of Papo-Seco Formation, housed in Museu Geológico: A – tooth MG10 not found anymore (1 – photo; 2 – draw, in Figueiredo, 2000); B – MG25198.2; C – MG25198.1; D – MG19.1; E – MG19.2.1 – labial view; 2 – lingual view; 3 – cross section drawn. Scales: 2 cm.

surface has a large and lower prominence with a horizontal ridge (Figueiredo et al., 2015). The articular faces are flat with concave anterior and posterior articular surfaces. It has a spool-shaped centrum that is relatively long and amphicoelous.

Description: CPGP.1.22.10 is a fragment with portion of the proximal end and the middle of shaft of left metacarpus. It is robust, with a sub-triangular section. It has maximum length of 11.8 cm; maximum width of 81 mm and a maximum thickness of 64 mm. It has well-developed concavity along the ventrolateral margin as identified in the Brachiosauridae by Mannion et al. (2017) and Poropat et al. (2015). It presents a large and pronounced crest (medial flange) along the medial facet. In anterior view is lateromedially wide in the proximal area, becoming distally thinner. In the lateral view, CPGP.1.22.10 curves proximally and shows a crest that crosses the surface in a proximodistal direction. These characteristics are observed in titanosauriform *Europatitan* (Torcida Fernández-Baldor, et al., 2011). It is becoming weaker and sharper distally, as occurs in *Europatitan* and in other titanosauriforms (Apesteguía, 2005; Hocknull et al., 2009; Torcida Fernández-Baldor, et al., 2011).

Neosauropoda Bonaparte, 1986.
Macronaria Wilson and Sereno, 1998.

Titanosauria Bonaparte and Coria, 1993.

Titanosauria indet.

Material: CPGP(CM).21.2 two articulated dorsal vertebrae (Figs. 1.C.2b, 2, and 5.A): one complete and the other only preserving the neural arch and the neural spine. CPGP(CM).21.1, a cervical rib; CPGP(IMR).21.1, a distal fragment of a dorsal rib; They were discovered by Carlos Marques and Isabel Morais Rosa.

Locality and horizon: Praia do Areia do Mastro; Papo-Seco Formation, Barremian.

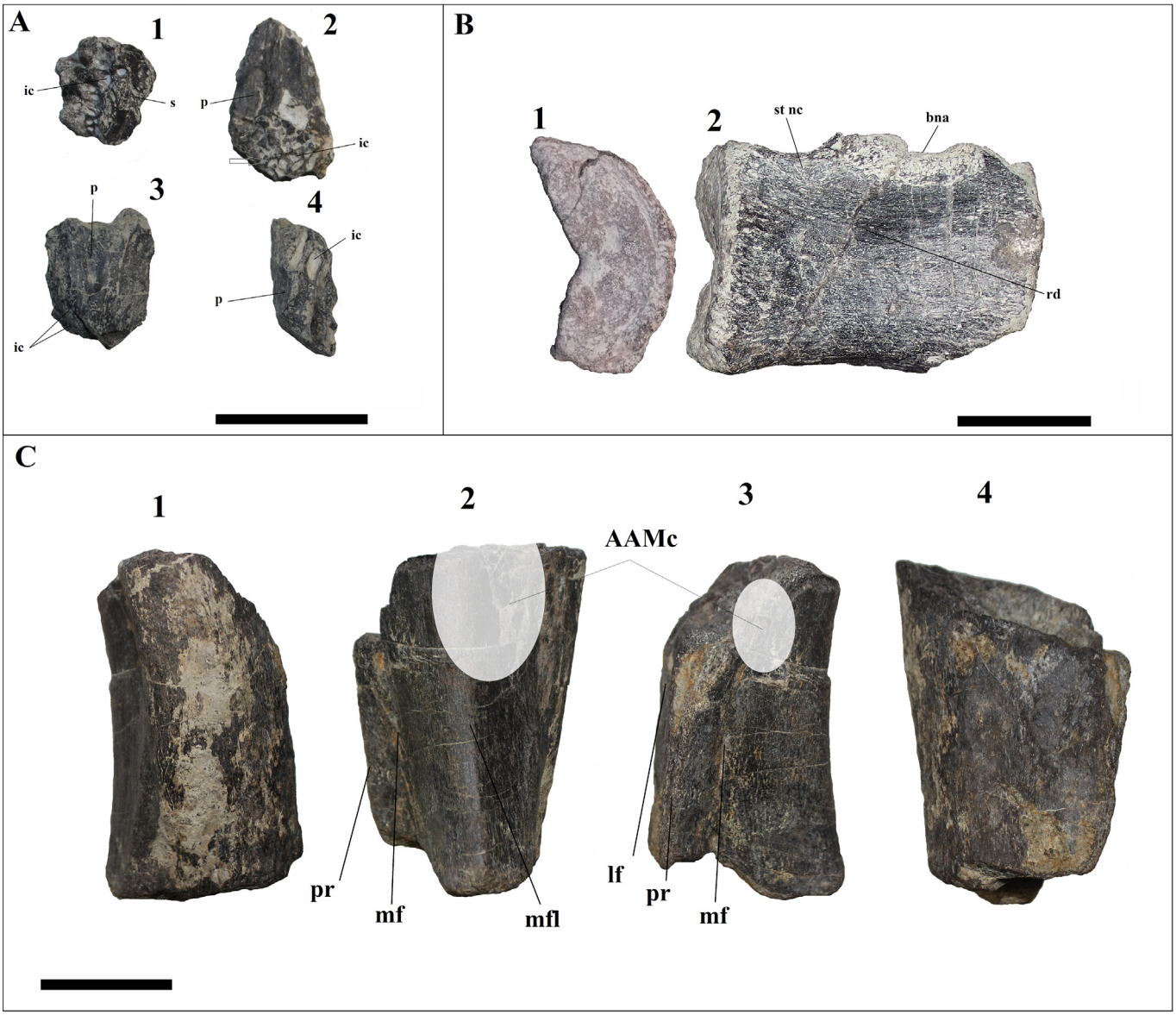

Fig. 4. A, Vertebrae fragments of an indeterminate sauropod. 1 - CPGP.1.05.25; 2 – CPGP.1.05.26; 3 – CPGP.1.05.27; 4 - CPGP.1.05.28. Abbreviatures: ic, internal cells; p, *periosteum* s - texture spongy. The grey arrow shows the honeycomb-like structure. B, CPGP.1.06.33, right fragment of a centrum of a caudal vertebra. (1 – proximal view; 2 – lateral view). Abbreviations: bna, base of neural arch; st nc, neurocentral suture rd - horizontal ridge. C, Metacarpal fragment (CPGP.1.22.10). 1, anterior view; 2, lateral view; 3, medial view; 4, posterior view. Abbreviations: lf, lateral fossa; mf, medial fossa; mfl, medial flange; pr, palmar ridge. AAMc, articular area with metacarpal. Scale: 5 cm.

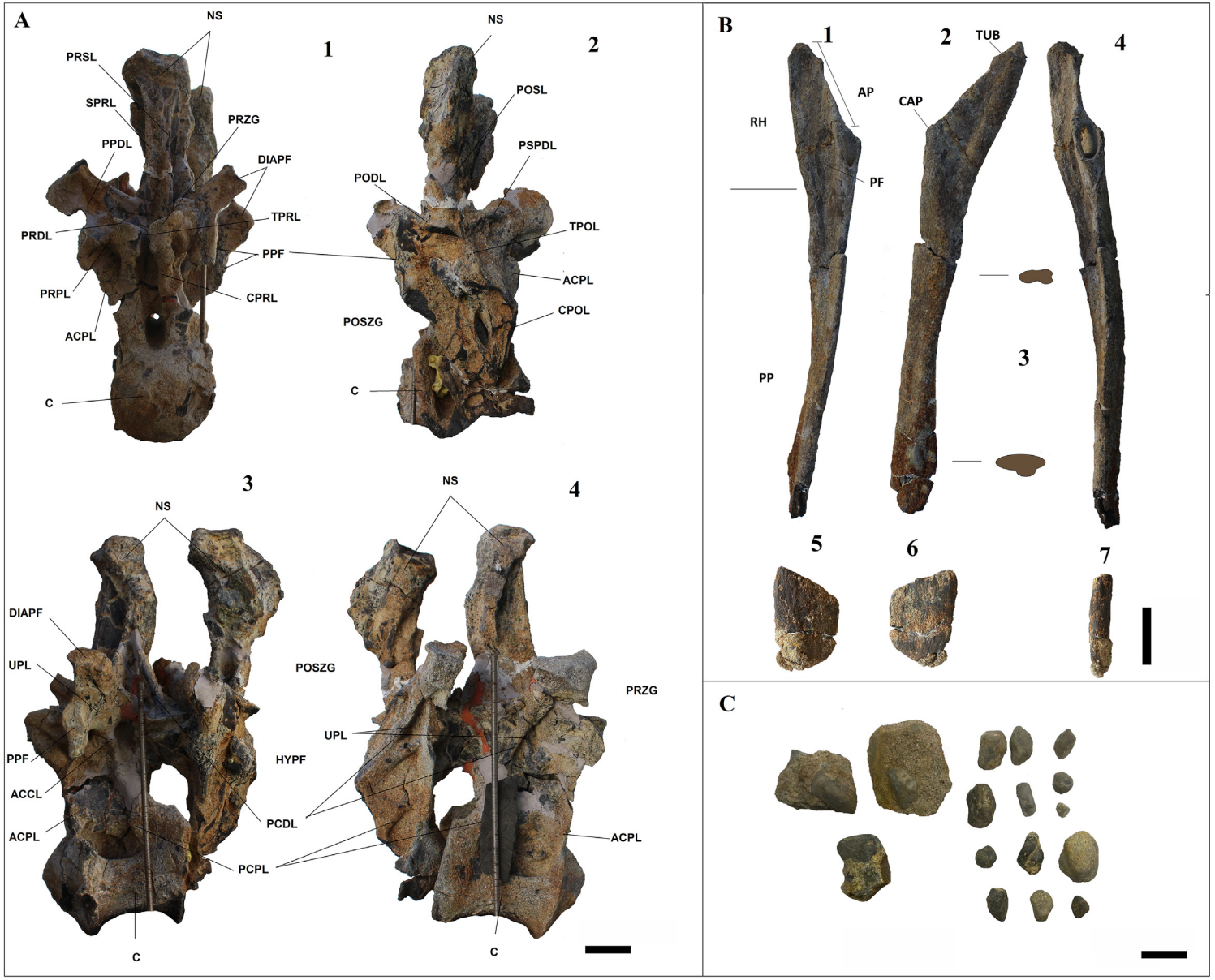

Fig. 5. A – Dorsal vertebra (CPGP(CM).21.2): (1) anterior view. (2) posterior view. (3) left lateral view. (4) right lateral view. ACCL, accessory lamina; ACPL, anterior centroparapophyseal lamina; C, vertebral centrum; CPOL, centropostzygapophyseal lamina; CPRL, centroprezygapophyseal lamina; DIAPF, diapophysis; HYPF, hyposphenum; NS, neural spine; PCDL, posterior centrodiapophyseal lamina; PCPL, posterior centroparapophyseal lamina; POSL, postespinal lamina; PODL, postzygodiapophyseal lamina; PL – Pleurocelo; POSZG, postzygapophyses; PPDL, prezygaparadiapophyseal lamina; PPF, parapophyses; PRDL, prezygodiapophyseal lamina; PRPL, prezygaparapophyseal lamina; PRSL, prespinal lamina; PRZG, prezygapophyses; PSPDL, posterior spinodiapophyseal lamina; SPRL, spinoprezygapophyseal lamina; TPOL, intrapostzigapophyseal lamina; TPRL, intraprezygapophyseal lamina; UPL, unnamed parapophyseal lamina; B –- Dorsal ribs: 1–4: CPGP (CM).21.1 dorsal posterior rib (3 - cross-sections). AP, anterior process; PP, posterior process; RH, rib head; CAP, capitulum; TUB, tuberculum; PF, pneumatic fossa; 5–7: CPGP(IMR).21.1 distal fragment of a dorsal rib. A – posterior view; B – anterior view; C – lateral view (scale: 5 cm); C - set of gastroliths founded near the rib (scale 5 cm).

Description: CPGP(CM).21.2 (a,b) are two posterior dorsal articulated vertebrae with no sedimentary compression (Fig. 5.1). CPGP(CM).21.2a has a total height of 530 mm; its maximum width is 195 mm; the diameter of its articular facet of centrum is 125 mm; 139 mm height and 167 mm long; the CPGP (CM).21.2b did not preserve the vertebral centrum, it preserves only the neural spine. It has a total height (neural spine) of 256 mm and the maximum width, in neural, spine is 95 mm. These two dorsal vertebrae have the neural spine long. The vertebral centrum is opisthocoelous with a very marked concavity in its posterior articular face, and convex in the anterior face. The ventral surface of the centrum is concave in its anterior part. The centrum is longer than wide and the articular surfaces are round. In lateral view, the centrum is very concave and possess an oval pneumatic fossa (pleurocel), that although striking is relatively small. The spinoprezygapophyseal laminae (sprl) follow a trajectory parallel to the prsl on the neural spine, until they disappear dorsally, as occurs in Titanosauria (e.g. Campos et al., 2005; Curry Rogers, 2009; Martínez et al., 2004). The parapophyses are situated at the height of the prezygapophyses and join the diapophyses via the paradiapophyseal lamina (ppdl). One of the laminae (pcdl) is parallel and situated dorsal to the centroparapophyseal lamina (pcpl), between the parapophysis and the pcdl. The other accessory lamina (accl), ventral to the upl runs between the acpl lamina and the pcdl lamina.

CPGP (CM).21.1 is a left dorsal posterior rib (Fig. 5.B). Despite being broken in two pieces, it is complete. The rib has a lateromedially flattened shaft. As in posterior ribs of sauropod dinosaurs this rib has a short projection anteriorly, the tuberculum is very short and dorsally projected, whereas the capitulum is much larger and longer, medially projected and has an elongate posterior projection, as in most titanosauriform ribs, deep pneumatic fossa is developed at the base of the capitulum (Fig. 5.B) (Gallinaa and Apesteguía, 2015). In posterior view, a larger depression starts very shallow at the rib head and deepens in distal direction along the shaft. The rib cross-section is ovoid proximally, becoming elliptical distally, although it presents in the distal extremity a mesial protuberance (Fig. 5.B,3). The posterior process (Fig. 5.B) is complete, reaching a length of 41 cm. CPGP(IMR).21.1 (Fig. 5.B–4-6), is a distal fragment of a dorsal rib with 9.7 cm length and 5.8 cm wide (see Table 1).

Neosauropoda Bonaparte, 1986.
Macronaria Wilson and Sereno, 1998.
Titanosauriformes Salgado et al., 1997.
Titanosauria Bonaparte and Coria, 1993.
Titanosauria indet.

Material: MG19.1, MG19.2 and MG25198.1 are three isolated tooth crowns (Fig. 1.C.1; Fig. 3.C-E). Two of them (MG19.1 and MG19.2) were described by Lapparent and Zbyszewski (1957). The other one (MG25198.1), a tooth classified in the inventory of MG as an indeterminate dinosaur tooth, is now identified as a titanosaurian sauropod tooth.

Locality and *horizon*: Boca do Chapim; Papo-Seco Formation, Barremian.

Description: MG19.1, MG19.2 and MG25198, are three small tooth crowns. MG19.1 and MG19.2 are two complete crowns. MG19.1 have the apex worn in the lingual surface, MG19.2 has the apex totally worn. MG25198.1 is a fragment of a crown, with the apex broken. In all these three crowns, the cross-section is oval, with a lemon-like outline (Fig. 3.3C, 4C, 5C). Those three teeth have parallel-sided, slightly labiolingually curved crowns, and show an apical wear facet. The crowns have both mesial and distal ridges that run from the apex up to approximately half the length of the crown. The crowns are straight, but lingually directed and show mesial/distal wear facet. The enamel is slightly wrinkled, with smooth longitudinal ridges. They show regularly scratches oriented parallel to the apico-basal axis of the apical wear facet. These characteristics were observed in Morphotype B of Titanosaurian teeth from the Upper Cretaceous from Cuenca, Spain (Díez Díaz et al., 2014).

5. Discussion

Titanosauriforms is the most diverse sauropod clade in the Cretaceous, and it is represented on all continents (Aldirene et al., 2004; Carvalho et al., 2017; D'Emic, 2012, 2013; Mannion et al., 2010, 2013, 2017; Salgado et al., 2006). Titanosauriforms have the largest range of body size of any sauropod clade and includes both the largest known sauropods and some of the smallest (Wilson, 2006). They are also the most represented group of sauropods in the Cretaceous of the Iberian Peninsula (Ortega et al., 2006; Mannion et al., 2011; Mannion, 2013).

Except for one tooth, the sauropod remains from Papo-Seco Formation seem to indicate that they are Titanosauriform sauropods. Initially attributed to an Iguanodon (MG.10), in the MG inventory, this tooth crown was analysed and attributed to a sauropod dinosaur (Figueiredo, 2000). It was probably an inventory error because the number MG10 was later assigned to an ornithopod tooth initially described by Lapparent and Zbyszewski (1957) and recently review by Figueiredo et al. (2022b). On a recent visit to the MG, it was not possible to find this sauropod tooth. MG19.1 and MG19.2 were described by Lapparent and Zbyszewski (1957) as *Pleurocoelus valdensis*, based on the characteristics of these teeth and the comparisons with the North American and European (Wealden Formation, England) Upper Jurassic and Lower Cretaceous sauropod remains.

CPGP.1.05.25, CPGP.1.05.26, CPGP.1.05.27 and CPGP.1.05.28 present the internal cells and honeycomb-like, tubular structure of those bone fragments, which are a characteristic observed in sauropod vertebra (e.g. Kozaric et al., 1996; Dalla Vecchia, 1998; 1999; Royo-Torres et al., 2017). Although these vertebrae remain are very fragmented, it is possible to observe that they have a high degree of pneumatization and the internal tissue structure is somphospondylous/camellate, which would be consistent with the

Table 1
Measurements (in cm) of osteological elements.

Measurements in cm	CPGP.1.22.10	CPGP.1.06.33	CPGP(CM).21.2a	CPGP(CM).21.2b	CPGP (CM).21.1	CPGP(IMR).21.1
Length	11.8	11.4	16.7		41	9.7
Width	8.1		19.5			
Width (neural spine)				9.5		
Thickness	6.4					
Height (total)		8.3	53			
Height (centrum)			13.9			
Height (neural spine)				25.6		
Diameter (centrum)			12.5			

identification of a titanosauriform. The vertebral fragment (CPGP.1.06.33) was described as sauropoda indet. by Figueiredo et al. (2015). It has a spool-shaped, long and amphicoelous centrum, similar to titanosaurians (e.g. Harris, 2006; Ksepka and Norell, 2010; Fernández-Baldor et al., 2017). Although there are other remains of titanosauriforms in the Papo-seco Formation having an amphicoelous caudal centrum, that is the plesiomorphic condition, but does not support identification as a titanosaur. However, as it was found together with the fragments of vertebrae above-mentioned (CPGP.1.05.25, CPGP.1.05.26, CPGP.1.05.27, CPGP.1.05.28), we consider the possibility of belonging to the same individual of those and consequently the possibility to be a titanosauriform. The metacarpal CPGP.1.22.10, despite being a fragment, it presents several characteristics in the proximal zone of metacarpals described in various titanosauriforms and brachiosauridae: in dorsal view, CPGP.1.22.10 displays little transverse expansion of its proximal end; the outline of the proximal end is created by a transversely convex dorsal margin, longer and nearly straight lateral margin, and moderately concave medial margin; In lateral view, it curves proximally and shows a crest that crosses the surface in a proximodistal direction; it forms a thick, prominent tubercle proximally (Fig. 4C), becoming weaker and sharper distally, as occurs in other titanosauriforms (e.g. Apesteguía, 2005; Hocknull et al., 2009; Mannion et al., 2017; Poropat et al., 2016; Torcida Fernández-Baldor, et al., 2011). It shows also a long intermetacarpal articular surfaces, which is a characteristic of Neosauropoda and are present in diplodocoids, *Camarasaurus* and Titanosauriformes (Wilson & Sereno, 1998). For this reason, the assignment of this fossil to an indeterminate Titanossauriformes, it seems to be the most appropriate.

The set consist of two articulated vertebrae, one rib, a distal fragment of a rib and several gastroliths found in the same layer and in the same area, so it is possible that they can belong to the same individual. In CPGP(CM).21.2, the pneumatic fossae are larger, deeper and more elaborated than those of the basal sauropod (Campos et al., 2005; Dalla Vecchia, 1998; Martínez et al., 2004; Wings et al., 2011). A similar lamina of the paradiapophyseal lamina in CPGP(CM).21.2 has been described in *Neuquensaurus* as upl (D'Emic, 2012), and it is present in other titanosaurians (Salgado et al., 2005). The relatively small dimension of pleurocel is a titanosaur condition and not a brachiosaurid, camarasaurid or diplodocid characteristic, which have a large pleurocel. According to its curvature, shaft diameter and rib head shape and angle of CPGP(CM).21.1, it is probably a posterior dorsal rib. A fracture that the rib presents is probably the result of lithostratigraphic pressure that the bone suffered after its deposition.

6. Conclusions

The Papo-Seco Formation yield several sauropod dinosaur fossils from cranial, axial and appendicular skeleton. Most of these remains belonged to relatively small size sauropods. Sauropod fossils from the Papo-Seco Formation were discovered from two sites: Boca do Chapim and Praia do Areia do Mastro. The remains were collected from the lower beds of this formation, at the base of the cliffs. The material consists of cranial remains (isolated teeth) and postcranial (vertebrae and a cervical rib).

The specimens of Praia do Areia do Mastro (CPGP.1.05.25; CPGP.1.05.26; CPGP.1.05.27; CPGP.1.05.28, CPGP.1.06.33 and probably CPGP.1.22.10), collected in the basal beds exposed at the beach (PS6 layer) are very fragmented, which indicates that they were deposited in a place far from the death local, suffering intensive transport and consequently fragmentation. The findings at the north zone of the beach (CPGP(CM).21.1; CPGP(IMR).21.1 and CPGP(CM).21.2) come from another level of marly sandy clay corresponding to a carbonate marginal marine environment. They are complete, and in the case of the vertebrae, in anatomical connection, which suggests that their provenance was not distant, thus suffering little transport.

Until this study, only three teeth and a vertebra from the Papo-Seco Formation were described. With the new sauropod material described in this study, the record and knowledge of this group of dinosaurs in the lower Barremian of Portugal increased.

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