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# Dinosaurs and other tetrapods in an Early Cretaceous bauxite-filled fissure, northwestern Romania[1]

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**Abstract**

The bauxite mine at Cornet near Oradea in northwestern Romania produced thousands of bones in an excavation in 1978, mainly from ornithopod dinosaurs and rarer pterosaurs. Bird specimens reported previously from this fauna are equivocal. The fossils are disarticulated bones in good condition which occur highly concentrated in lenses within bauxite clays, which are dated as Berriasian (earliest Cretaceous). The bauxite represents detrital material washed into deep fissures and caves formed within a karst of uplifted Tithonian (latest Jurassic) marine limestones. The bones are generally uniform in size and shape, and they are abraded, evidence for considerable transport and for winnowing of the deposit. The area was one of several islands on the northern shore of Tethys, and it was inundated by the sea later in the Early Cretaceous. There is evidence for insular adaptations in the dinosaur faunas. The ornithopod dinosaurs may include several taxa, but they are smaller on average than an assemblage of typical Wealden ornithopods, perhaps because of dwarfing on the island. In addition, sauropods are absent and theropods are barely represented in the fauna. The fauna is geographically significant since it shows relationships with western Europe and with Asia. © Elsevier Science B.V. All rights reserved.

*Keywords:* Cretaceous; Bauxite; Dinosaur; Palaeokarst; Pterosaur; Wealden

## 1. Introduction

The bauxite mine at Cornet near Oradea in northwestern Romania has produced thousands of bones over the past fifteen years of excavation. The bones came from a single concentration in lens 204, one of several hundred lenses of bauxite in the Pădurea Craiului mountains that have been exploited commercially by the S.C. "Bauxita Min" SA Dobreşti company. The lens was identified by borehole, and it was blasted in July, 1978. While bauxite was being extracted for smelting, miners Ioan Bumb and Petru Lele first noticed three vertebrae in the bauxite, and the mine director Emil Fechete, as well as the geologist Emilia Tallódi and engineers D. Noje and I. Popa, confirmed that the sediment was packed with bones. Palaeontologists from the Muzeul Ţării Crişurilor in Oradea, Tiberiu Jurcsák and Elisabeta Popa, visited the site on 13th July, 1978, and then worked in the mine for three months, extracting 10 tonnes of bauxite with bones. This represented about one-

[1]In memoriam: Tiberiu Jurcsák (1926–1992).


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third of the bauxite removed from the lens. Dan Patrulius and Florian Marinescu, geologists from the Romanian Geological Survey, were also shown the specimens, and a collection was taken to the offices of the Institute of Geology and Geophysics in Bucharest.

Since 1978, small-scale hand excavation up to 1983, when the mine closed, yielded further material. In addition, E.P. has prepared most of the 1978 collection, and this has yielded 10, 000 identified bones. Many of the larger bones were found to be broken, perhaps by the mine blasting that revealed the bone-bearing lens in the first place. More substantial excavation was carried out by the authors of this paper in July–August, 1995. Large blocks of bauxite were removed by hand in an attempt to limit damage to the bones.

The 1978 collections include many reptile and supposed bird taxa, and a number of publications were produced (Jurcsák and Popa, 1978, 1979, 1983a,b, 1984; Jurcsák, 1982; Patrulius et al., 1983; Kessler, 1984; Kessler and Jurcsák, 1984a,b, 1986; Jurcsák and Kessler, 1986, 1987, 1991; Marinescu, 1989). Specimens are lodged in the Muzeul Ţarii Crişurilor, Oradea (MTCO). The purpose of this paper is to describe the unusual sedimentary setting of this unique fauna, and to compare the fossil vertebrates with those from the classic Wealden of western Europe and from other locations.

## 2. Location

The bone-bearing lens 204 (in the Mine Brusturi I) lies in the Cornet bauxitic zone, 4 km south of the mining buildings of the Cornet branch of the S.C. "Bauxita Min" S.A. Dobreşti company. Cornet (22°24′ E, 46°57′ N) lies in the Comuna Aştileu, located in the Padurea Craiului mountains in the eastern part of Judetul (Province) Bihor. The locality is 40 km ESE of Oradea (Fig. 1), the main city in the region. Bauxite has been mined in the area since the 1950s, and it is processed to make aluminium in factories in Oradea.

Mine adits and shafts were constructed in the vicinity of lens 204 to gain access to a number of nearby bauxite lenses. Lens 204 was identified by borehole, and adits (Fig. 2) were constructed to it in 1978. The lens is located 40 m below the level of the entrance to the Brusturi Mine I. The main adit slopes steeply down the Ward's Plane which carries a light rail track, and side adits enter bauxite-rich horizons. Lens 204 is estimated to measure 35 × 20 m, and it represents the infill of a discoidal subcircular cavity of Aston type (Pop and Marza, 1977) in the Tithonian-age Cornet limestone. The lens is divided in half by a normal fault which has downthrown the eastern bone-rich portion by more than 40 m.

The bauxite in lens 204 was blasted in July 1978 and, as usual, the debris was loaded into wagons that were hauled by a motor-operated wire system along a light rail track out of the access adit. The adit (Fig. 3) is located on a hillside, and bauxite was dumped from the rail wagons into trucks that took it to the processing plants. This adit is the access point to the bone-bearing lens, and fossiliferous bauxite is washed first in the Mnierei River lying in the foot of the valley below the adit.

## 3. Geology

The bauxitic formation of the western Carpathians is an extensive continental soil deposit, sandwiched (Fig. 4A) between marine limestones of latest Jurassic age (Tithonian–? earliest Berriasian) below and mid-Early Cretaceous (Barremian–Aptian) above (Grigorescu, 1993). The bauxite formation lies on an extensive karst surface, formed after uplift of the underlying limestones, providing clear evidence of subaerial erosion and tropical conditions of soil development. The bauxite occupies karst depressions to a depth of several metres, often filling caves and fissures.

The sequence of sediments, as recorded by Patrulius et al. (1983) in the centre of lens 204 shows 3 m of bauxite lying on top of the karst surface. The underlying Cornet limestone is white in colour and massive, and contains abundant fragmentary fossils, including crinoids, corals, bryozoans, gastropods, ammonites and other typical reef organisms. The limestone is capped by largely crystalline calcite (spathite) and a 0.1–0.2 m thick zone of lightly bituminous blackened lime-

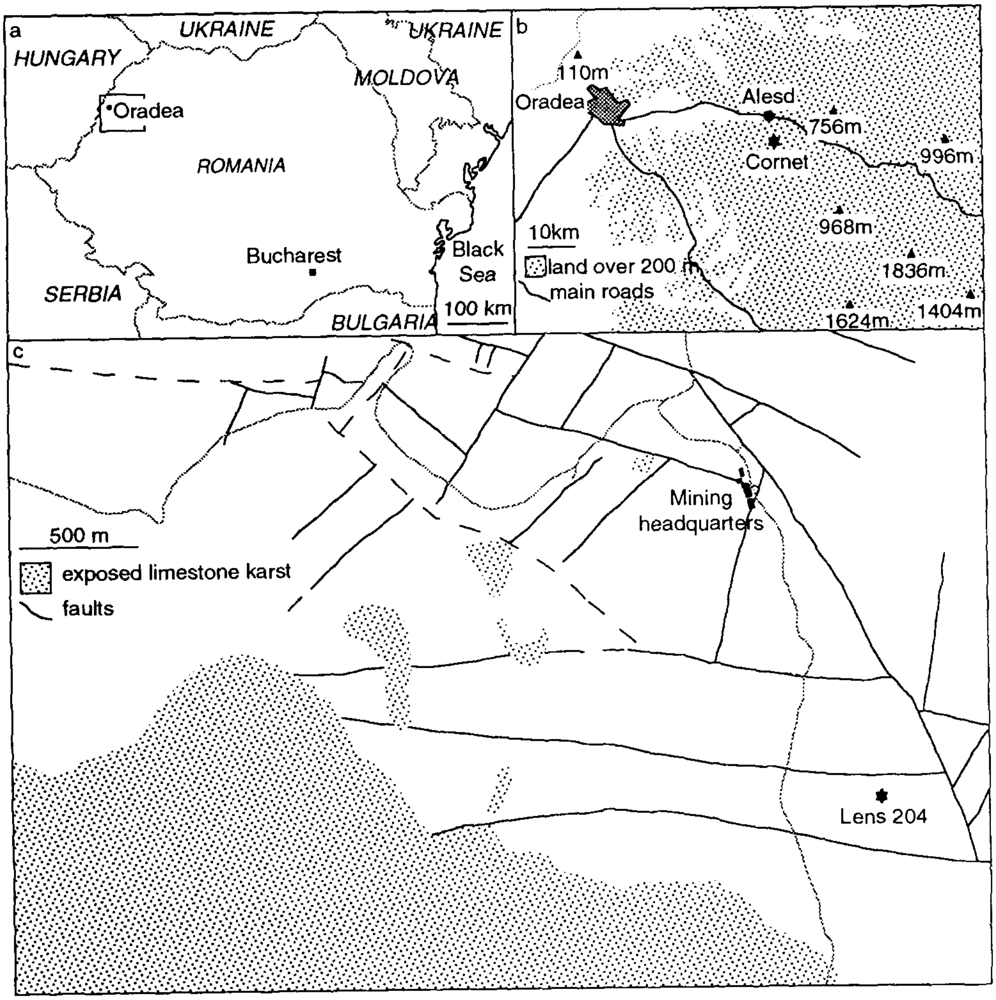


Fig. 1. The location of Cornet. (a) Simplified map of Romania, showing the location of Oradea. (b) Location map of Judetul Bihor, showing Oradea and Cornet. (c) Locality map of the Cornet area, showing the mining buildings and the site of lens 204. The access road is indicated, as well as rivers and streams. The outline geology is indicated, Jurassic and Cretaceous limestones blank and Quaternary sediments shaded. Faults are marked with heavy lines. Modified from a map in Valenaş (1985).

stone, according to Patrulius et al. (1983). This is succeeded by 3 m of red-brown boehmitic bauxite (Fig. 4B), consisting of alternating 300 mm thick beds of structureless mud-grade bauxite and 40–100 mm thick arenitic or arenitic/ruditic units, which were clearly visible in the mine in 1995. The bauxite is capped by 0.5 m of laminated kaolinitic clay of mottled yellow and red colour, and this is topped in the mine by limestone.

The bones occurred in greatest concentration in a 0.6 m thick band in the middle of the lens (Jurcsák, 1982), which has now been removed. Here, the bones made up nearly 50% of the volume of sediment, representing an astonishing degree of concentration, in some places virtually a bone-supported conglomerate (Fig. 5). Patrulius et al. (1983) indicate that bones were found in the mud-grade bauxites in the lower 1 m of the section in lens 2. Many specimens in the Oradea collection are associated with a matrix of this sort, but the majority are preserved in the fine-grained conglomerate (arenitic–ruditic bauxite). Collecting in 1994

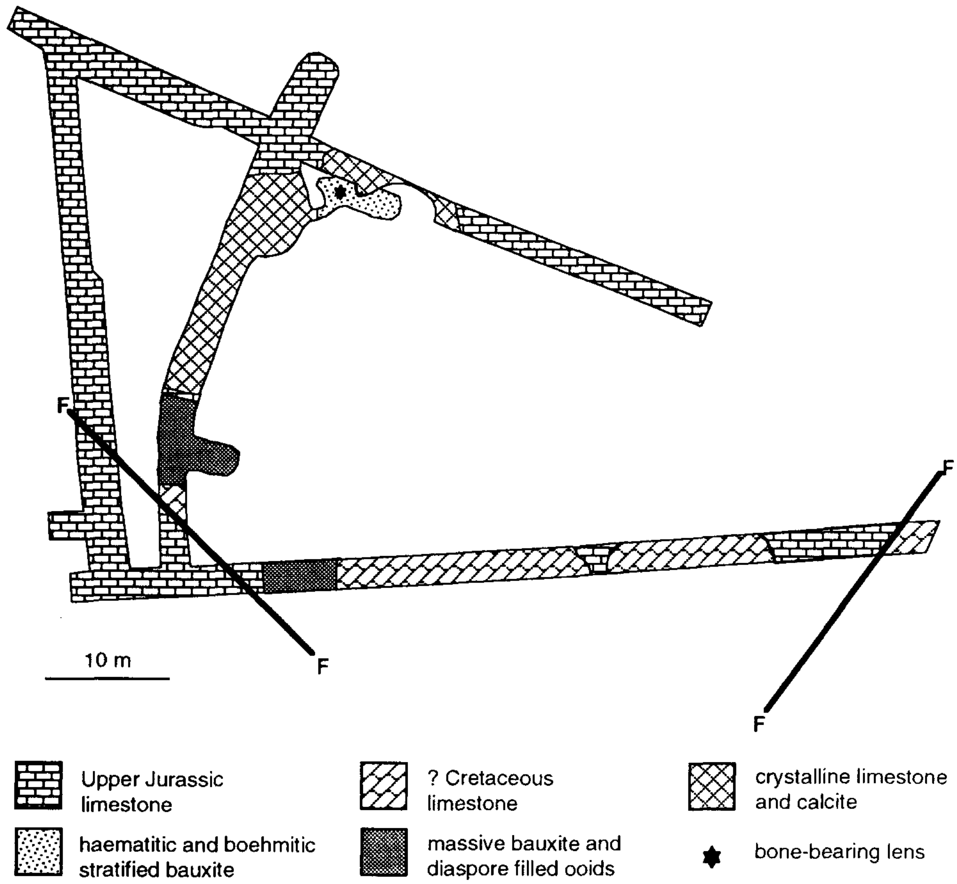


Fig. 2. Plan of the Mine Brusturi I, showing the location of lens 204. Mine adits are indicated, together with generalised geology observed along their walls. Based on Jurcsák and Kessler (1991).

and 1995 confirmed that bones are found now, in peripheral parts of lens 204, in the fine conglomerate, at a height of 1.5–2 m above the karst floor of the mine.

Patrulius et al. (1983) note the presence of charophytes both rarely within the bauxite of lens 204 (Fig. 4), but also abundantly in the lacustrine limestones that cap the thick bauxites throughout the Pădurea Craiului region (Fig. 6). These, and other fossils, provide evidence of dating of the processes of limestone deposition, uplift, karstification, lake formation, and finally marine transgression. The underlying limestones are dated as mid Tithonian to early Berriasian (*Euxina* Zone) by their included marine fossils (Patrulius et al., 1983). The mid Tithonian age (= Kimmeridgian/Portlandian boundary in British usage) is indicated by the presence of rare ammonites such as *Neoglochiceras pseudocarachteris* (Favre) found at locations nearby, while the younger age for the top of the limestone is suggested by the presence of *Clypeina jurassica* Favre and *Calpionella alpina* Lorenz (Grigorescu, 1993). The charophytes in the bauxite of lens 204 and the charophytes and ostracods in the overlying lacustrine limestones offer only "conjectural" ages (Patrulius et al., 1983). Cerithid gastropods in brackish-water limestones between the lacustrine limestones and the overlying marine limestones, suggest a Hauterivian age (Grigorescu, 1993). Finally, the pachydont bivalve *Requienia minor* Douvillé, found in the capping marine limestones

Fig. 3. Photograph of the entrance to the Mine Brusturi I, lying above the Mnierei river. Bone-bearing sediment is brought out of this main adit on small rail wagons.

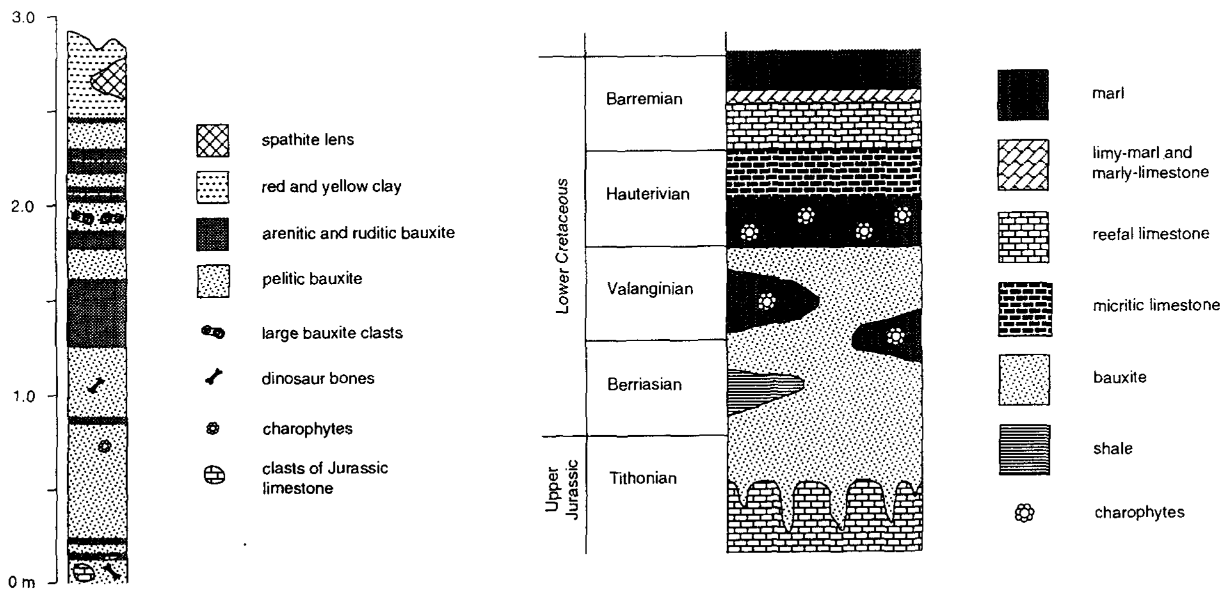


Fig. 4. Stratigraphy of the Upper Jurassic and Lower Cretaceous of the Cornet area (A), and sedimentary log recorded in the fossiliferous zone of lens 204 (B). (A, Based on Grigorescu, 1993; B, based on Patrulius et al., 1983.)

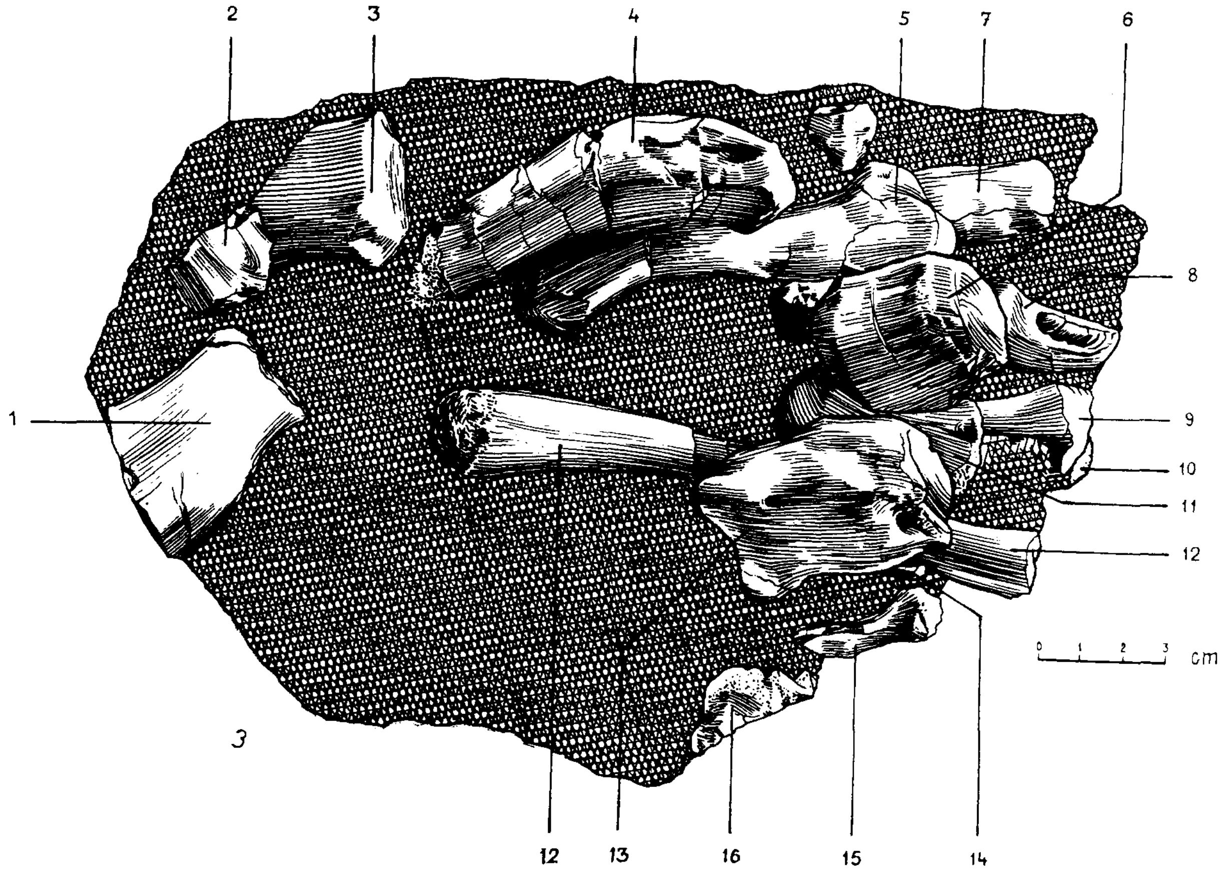


Fig. 5. Drawing of a block of bone-bearing bauxite from the middle of lens 204, showing the close packing of specimens, and some apparent current alignment. These are all elements of an ornithopod dinosaur. Numbered elements are: *1* vertebral spine; *2* caudal vertebra; *3* presacral centrum; *4* metapodial; *5* metatarsal II; *6* caudal centrum; *7* fragment; *8* terminal phalanx; *9*, *10* fragments; *11* cervical centrum; *12* tibia; *13* phalanx; *14–16* fragments. (Drawing by Szabo Barna.)

some 10 m above the contact with the bauxites, indicates an early Barremian date for the marine transgression (Patrulius et al., 1983).

The continental interval, represented by karst development, bauxite formation and lacustrine-brackish limestones, lasting from late Berriasian to earliest Barremian times, represents 17 Ma (Grigorescu, 1993) or 21–22 Ma in some zones, such as Osoiu hill, where bauxite formation began in the late Tithonian.

Patrulius et al. (1983) present a three-phase model for the development of the karst and bauxite infills at Cornet (Fig. 7). The first phase (Fig. 7I) occurred after emergence of the marine limestones, when shallow fissures and caverns were formed, some vertical, others discoidal in shape with an elevated water table (phreatic conditions). These filled with massive fine-grained bauxite, haematitic in composition, and rarely bauxitic.

In the second phase (Fig. 7II), much deeper caverns were formed, initially under phreatic conditions, and then vadose. They were filled with vadose spathite, and then (Fig. 7III) by boehmitic and haematitic bauxite of mud and sandstone grade, white and yellowish kaolinitic clay, and occasional detrital fragments of marine limestone. The sediments contain freshwater fossils such as large ostracods and gastropods. The lower 2.5 m of sediments in lens 204 are characteristic of this phase of filling.

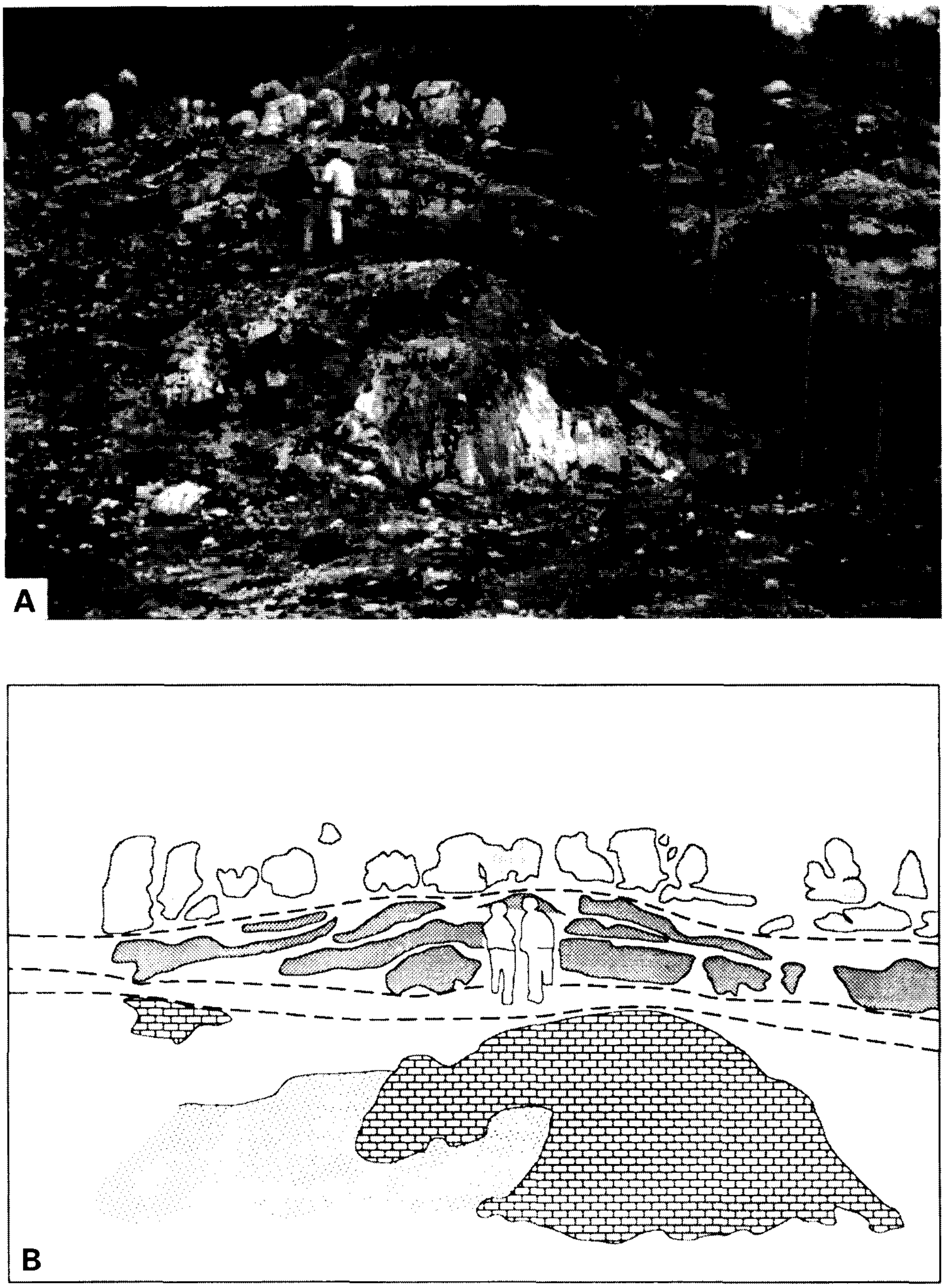


Fig. 6. Full development of the karst and bauxite in the Pădurea Craiului mountains. (A) Photograph of the site of lens 186, near the Cornet mining headquarters, showing a lower horizon of marine Tithonian limestone, penetrated by caverns to a depth of 3 m, and filled with detrital bauxite. On top lies 1 m of coarse brecciated bauxite, then several freshwater limestone horizons, punctuated by thin paleosols (2 m), and topped by 3 m+ of marine Cretaceous limestone. (B) Interpretive diagram. Shading key: brick pattern, Tithonian limestone; coarse stipple, detrital bauxite; intense stipple, freshwater limestones; medium stipple, marine Cretaceous limestone.

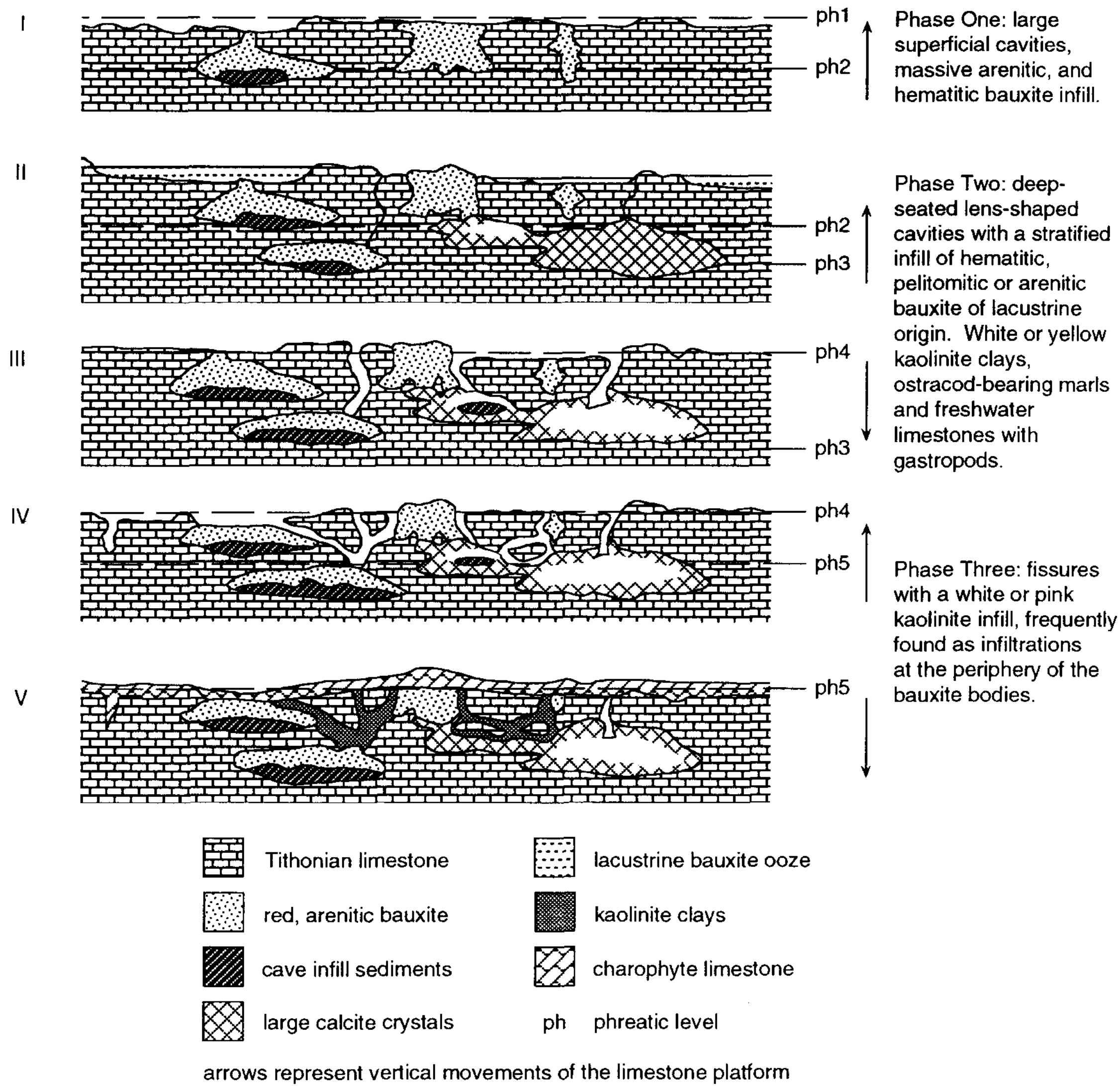


Fig. 7. Model for development of the Early Cretaceous karst in the Pădurea Craiului Mountains, and for its infill with bauxite. (Based on Patrulius et al., 1983.)

In the third, vadose, phase, karst fissures formed (Fig. 7IV), and they were filled (Fig. 7V) mainly by white and pink kaolinitic clays, with boehmite here and there. These sediments fill the upper part of the cavern of lens 204.

The bauxite and its contained fossils probably washed into the caverns from a considerable surrounding hinterland. Patrulius et al. (1983) suggested that all of the bauxite was derived from neighbouring lakes, and this is confirmed by some of the fossils, such as charophytes and ostracods, and a freshwater gastropod figured by Jurcsák and Kessler (1991). However, the earliest Cretaceous topography suggests that this was not entirely the case. The karst palaeorelief shows that lens 204 was then one of three sink holes lying on a small plateau at a height of 492 m on the southern slope of a low hill (Jurcsák and Kessler, 1991). Valleys drained down the hillside towards these sink holes, and it is likely that the contained sediments and fossils derived from a variety of continental settings.

Bauxite is typically regarded as the product of humid tropical-belt climates, and the Pădurea Craiului island in Early Cretaceous times lay close to the palaeoequator. Bauxite soils presumably accumulated on the karst, as a result of intense erosion of neighbouring igneous and metamorphic rocks. Surface waters were channeled down the low karst hills, and filled the caverns with bauxite and tetrapod bones.

## 4. Preparation

The collections of bone-bearing bauxite made from Cornet lens 204 in 1978 have undergone preparation continuously since then, and they have yielded 10,000 identified bones (Fig. 8). The preparation has been time-consuming because of the intractable nature of the enclosing bauxite sediment. Jurcsák and E.P. first washed all the material as it came out of the mine in a nearby river, and they collected some 2000 bone-bearing blocks (Jurcsák and Popa, 1978). Then, each block was prepared mechanically with a vibrating needle drill by E.P. in the Palaeontology Laboratory in the Museum in Oradea. Chemical treatments, such as attempts to dissolve the bauxite matrix in acid, were fruitless. Many of the specimens have been removed completely from the matrix, and others have been exposed in surface relief. Specimens were reinforced with nitrocellulose diluted in 10% acetone.

## 5. Palaeontology

The commonest fossils are ornithopod dinosaurs, and there are rarer ankylosaurs and theropods, as well as pterosaurs and supposed birds. Reviews of the fauna hitherto, such as Jurcsák and Kessler (1991), have listed six dinosaurian taxa, as well as three pterosaur species, and three bird species, but these are probably overestimates.

Remains of ornithopod dinosaurs far outweigh those of all other taxa (Jurcsák and Popa, 1979; Figs. 9 and 10). Most of the specimens belong to a small species of camptosaurid, and the larger hypsilophodontid *Valdosaurus* is represented by a partial femur, as well as several metatarsals and vertebrae. Earlier accounts gave rather different interpretations. Jurcsák and Kessler (1991) identified specimens of *Hypsilophodon* and *Valdosaurus*, as well as the iguanodontids *Iguanodon* and *Vectisaurus*. Patrulius et al. (1983) identified the ornithopod remains as those of *Camptosaurus* and *Iguanodon*, and they were later named as the iguanodontid *Bihariosaurus bauxiticus* by Marinescu (1989). These determinations were based on published descriptions of Late Jurassic and Early Cretaceous hypsilophodontids and iguanodontids, but the bulk of the material (vertebral centra, phalanges, metapodials) lacks diagnostic characters of these families and genera.

An ankylosaur is represented by an armour spine (MTCO 297; Fig. 11A) and a number of flattened metapodia. It was first recognised by Jurcsák and Kessler (1991).

The rarity of theropod dinosaur remains is extraordinary. Isolated theropod teeth are common in most dinosaur deposits, but such specimens have not been found at Cornet. The only unequivocal theropod fossils are two sharp ungual phalanges (MTCO 1631 and unnumb.), from a modest-sized predator, perhaps 2–3 m in length. Traces of carnivore activity are evident, however, in the form of tooth marks on some bones. Jurcsák (1982) and Jurcsák and Popa (1983b) identified some vertebrae (MTCO 16499, 17245; Fig. 11B, C) as cervicals and caudals of the theropod *Aristosuchus*, known from the Wealden of England. The Cornet specimens, if correctly identified, come from a larger animal than the English *Aristosuchus*.

Pterosaurs are represented by about 100 hollow limb bone shafts, a few of which have diagnostic pterosaurian characters. Pterosaur remains were first reported from Cornet by Jurcsák and Popa (1983a, 1984). These include (Fig. 12) limb bones identified as those of *Gallodactylus* and of an ornithocheirid, and a partial snout of *Dsungaripterus* sp. The humeri (Fig. 12A–D) are unequivocally pterosaurian, but they are relatively small elements, 50–60 mm in length, presumably belonging to one or more taxa with wing spans of 0.7–1 m, rather smaller than many other Early

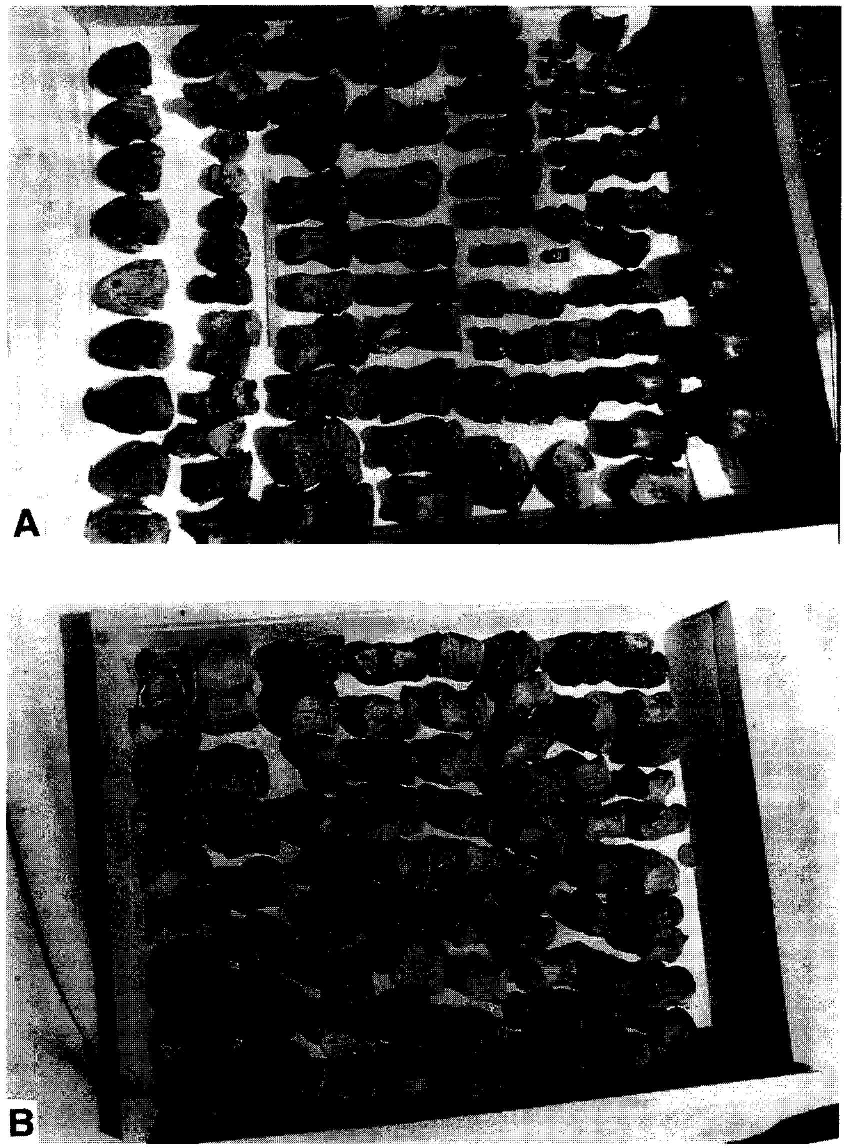


Fig. 8. Part of the Cornet fossil collection. Ornithopod phalanges (A) and vertebrae (B) of various sizes are the commonest fossils.

Cretaceous pterosaurs. These elements cannot, however, be identified to generic level. The snout fragment of *Dsungaripterus* sp. (MTCO 9651; Fig. 11E) is comparable in detail with that genus, known otherwise only from China. The preserved fragment is only a part of the snout, and it suggests a skull length of 0.4 m, a measurement at the low end of the range of skull sizes seen in Chinese *Dsungaripterus*, and scaling to a wingspan of 3.0 m.

The records of three fossil bird taxa from Cornet cannot be confirmed. Birds were noted by Jurcsák and Popa (1983a,b) and Kessler (1984), and the specimens were described in more detail by Kessler and Jurcsák (1984a,b, 1986) and Jurcsák and Kessler (1986, 1987). These authors identified isolated specimens of *Archaeopteryx*, *Palaeocursornis biharicus* Kessler and Jurcsák, 1986, a flightless ratite (palaeognath), and *Eurolimnornis corneti*

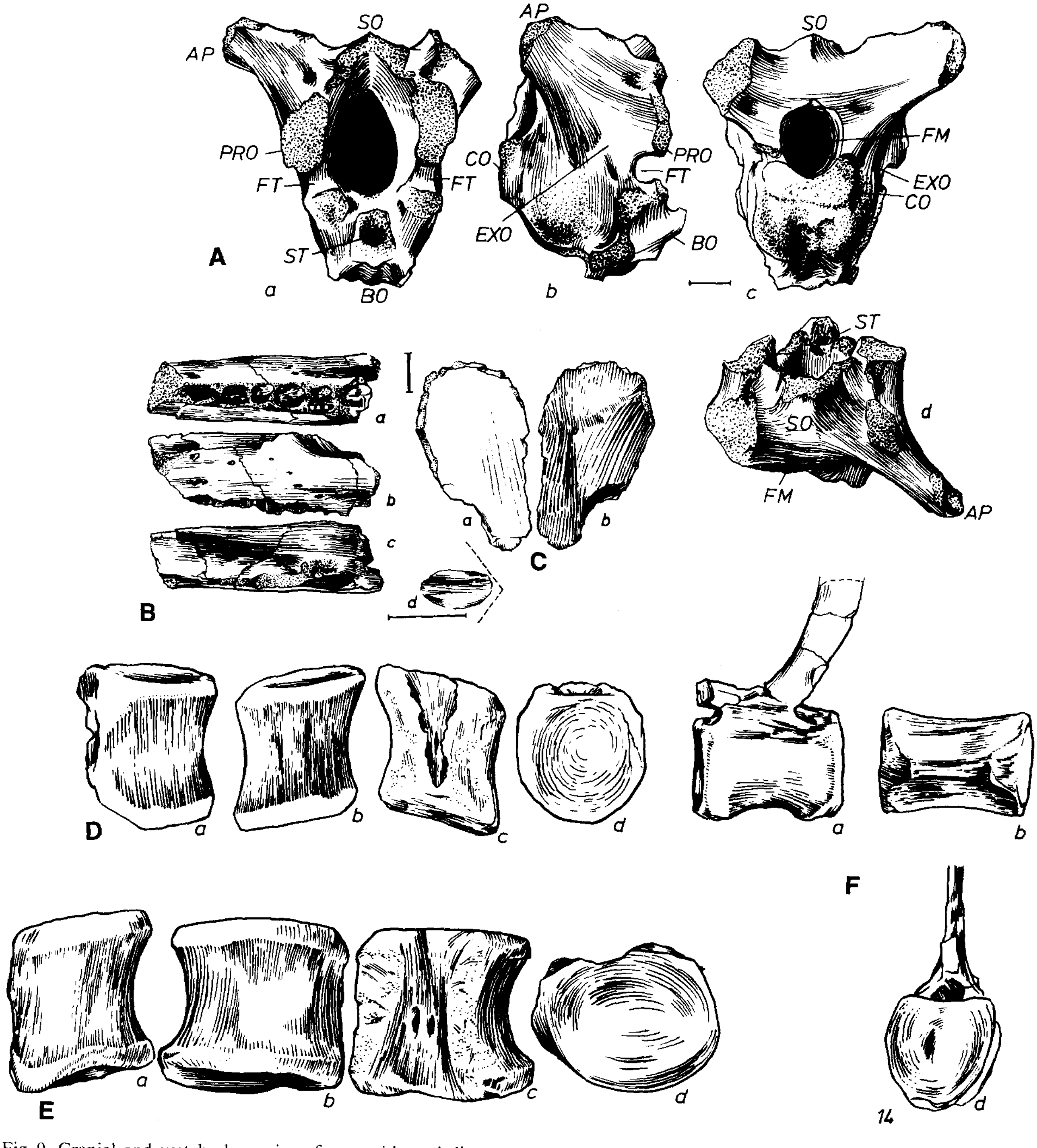


Fig. 9. Cranial and vertebral remains of an ornithopod dinosaur (camptosaurid) from Cornet. (A) Occipital fragment of a skull, MTCO 7601, in anterior (a), right lateral (b), posterior (c) and dorsal (d) views. (B) Left maxillary fragment, MTCO 359, in occlusal (a), lateral (b) and medial (c) views, (d) imprint of a tooth. (C) Fragment of a frontal bone of a dinosaur, MTCO 7661, in dorsal (a) and ventral (b) views. (D–F) Vertebrae in lateral (a), ventral (b), dorsal (c) and posterior (d) views. (D) Thoracic centrum, MTCO 1438. (E) Sacral centrum, MTCO 821. (F) Caudal vertebra, MTCO 2402. Abbreviations: *AP* paroccipital process; *BO* basioccipital; *CO* occipital condyle; *EX* exoccipital; *FM* foramen magnum; *FT* trigeminal foramen; *PRO* prootic; *SO* supraoccipital; *ST* sella turcica. Scale bar is 10 mm. (Drawing by Szabo Barna.)

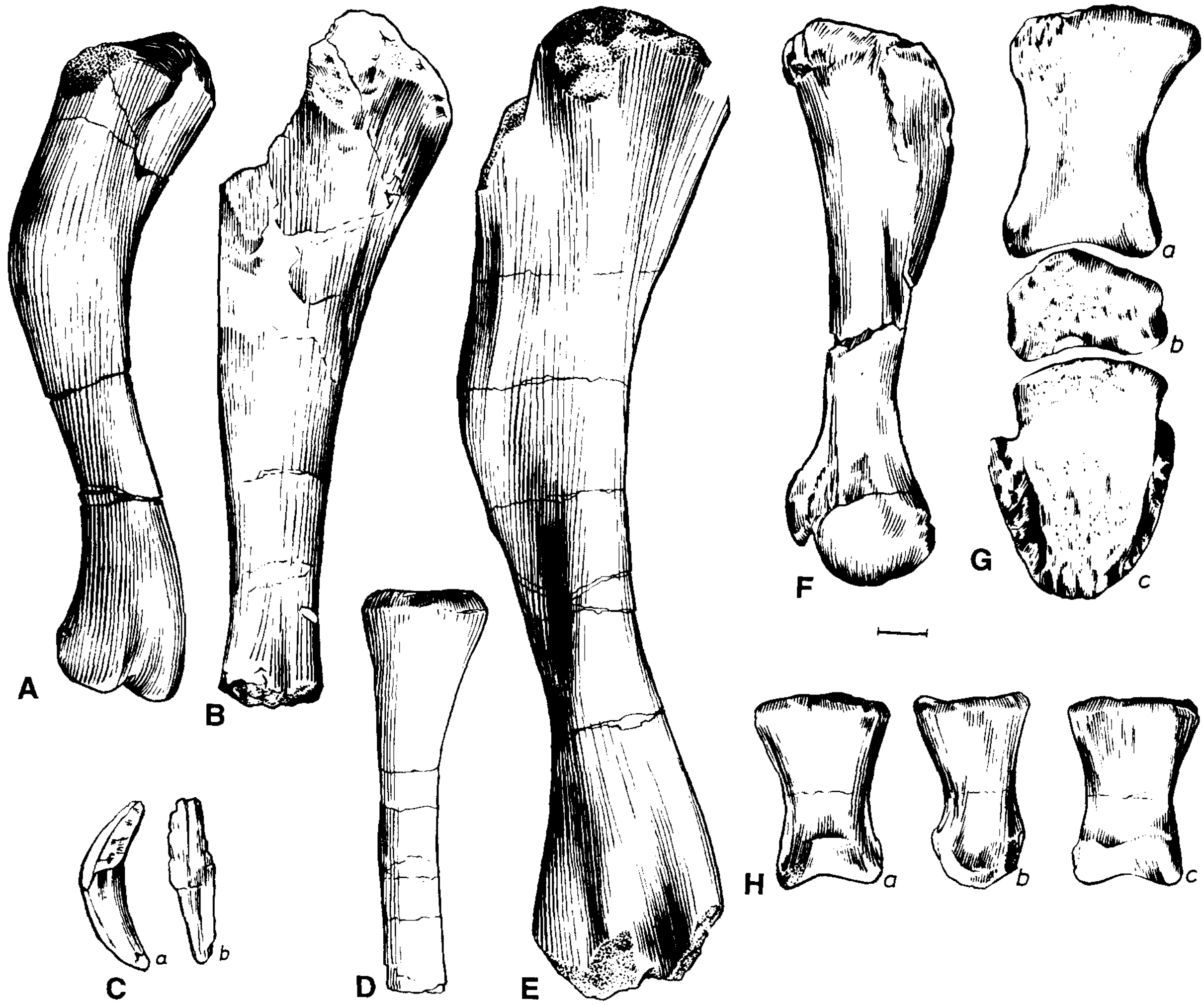


Fig. 10. Limb bones and a tooth of an ornithopod dinosaur (camptosaurid) from Cornet, formerly identified as hypsilophodontids (A, B) and iguanodontids (C–H). (A) Left humerus, MTCO 6001, in lateral view. (B) Right humerus, proximal fragment, MTCO 32, in lateral view. (C) Tooth, MTCO 1345, in lateral (a) and anterior (b) views. (D) Radius, proximal fragment, MTCO 7834. (E) Left humerus, MTCO 5284, in lateral view. (F) Metatarsal III, MTO 1700, in lateral view. (G) Tarsal phalanges of left toe II, MTCO 8809 (a), MTCO 646 (b), MTCO 2380 (c), all in dorsal view. (H) Phalanx 2 of toe I, MTCO 2091, in dorsal (a), lateral (b) and ventral (c) views. Scale bar is 10 mm. Drawing by Szabo Barna.

(Kessler and Jurcsák, 1984), a grebe-like bird (neognath). Bock and Bühler (1996) reviewed the rather tangled nomenclatural history of these specimens, concluding that the type species of *Palaeocursornis* is in fact *P. corneti*. If these identifications were sustained, the Cornet avifauna, though sparse, would be astonishingly important: three bird taxa in one earliest Cretaceous locality, and including the oldest palaeognath and the oldest neognath.

We cannot confirm the avian nature of the supposed bird specimens, although we cannot prove that some are not from birds. The partial left humerus ascribed to *Archaeopteryx* sp. (MTCO 1503; Fig. 13A) is comparable in size and shape to the classic materials of that genus from

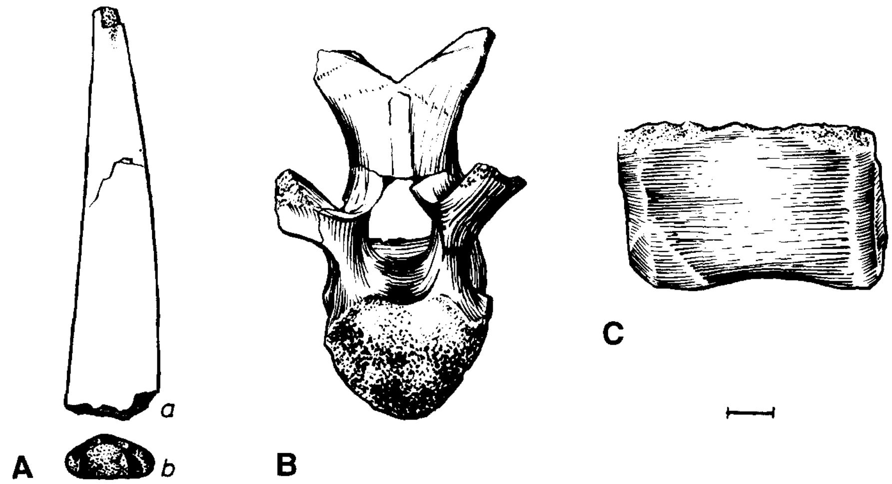


Fig. 11. Rare remains of non-ornithopod dinosaurs from Cornet. (A) Armour spine of an ankylosaur, MTCO 1631, in side (a) and basal (b) views. (B) Cervical vertebra, MTCO 16499 and (C) caudal centrum, MTCO 17245, ascribed to the Wealden theropod *Aristosuchus*. Scale bar is 10 mm. Drawing by Szabo Barna.

the Tithonian of Solnhofen, Germany, but the Cornet bone cannot be unequivocally ascribed to that genus, and could indeed come from a small theropod dinosaur. The holotypes of *Eurolimnornis corneti*, a distal right humerus (MTCO 7896; Fig. 13C) and of *Palaeocursornis biharicus*, a distal left femur (MTCO 1637; Fig. 13E), are associated with other more fragmentary elements identified as avian (Fig. 13B, D, F, G). These two specimens, and the others identified as avian, are probably archosaurian, but could just as well come from theropod dinosaurs or pterosaurs (Benton and Unwin, in prep.).

## 6. Taphonomy

The Cornet fossils show signs of scavenging, little evidence for weathering, but strong indications of winnowing and post-depositional distortion. The fossils are all disarticulated, except for a pair of ornithopod vertebrae found in association (MTCO 695-5).

A number of specimens show evidence of predator activity, pits and grooves on the surface of the bone produced by biting, as noted by Jurcsák and Popa (1979). Several vertebrae and phalanges show isolated tooth marks, low ovoid depressions, where the bone surface has been crushed down 1–2 mm, with slight cracking around the margins of the impression. One vertebra (MTCO 78/21122) shows paired tooth marks, others (MTCO 78/1399, 80/ 5758) show elongate gouge-marks across the bone surface.

The bones show little evidence of weathering. Only one rib (MTCO 9463) shows surface cracking that is characteristic of weathering by exposure to changes in temperature and humidity on the surface of the paleosol.

Physical transport was important, as shown by the alignment of elements, the uniform shapes and size distribution of the commonest specimens, and abrasion. Rare larger blocks show evidence of alignment of elongate elements, parallel to each other and to other clasts (Fig. 5). In addition, the distribution of bone sizes shows strong evidence for physical sedimentary sorting. Nearly all the bones are compact robust elements, vertebral centra, metapodials, and phalanges of ornithopods (Fig. 8), of comparable dimensions, namely 20–70 mm maximum diameter. Larger limb bones are broken into segments rarely exceeding 100 mm in length, although the complete elements would have been 300–450 mm long. The delicate pterosaur bones, some 100 segments of limb shafts, and rare ornithopod

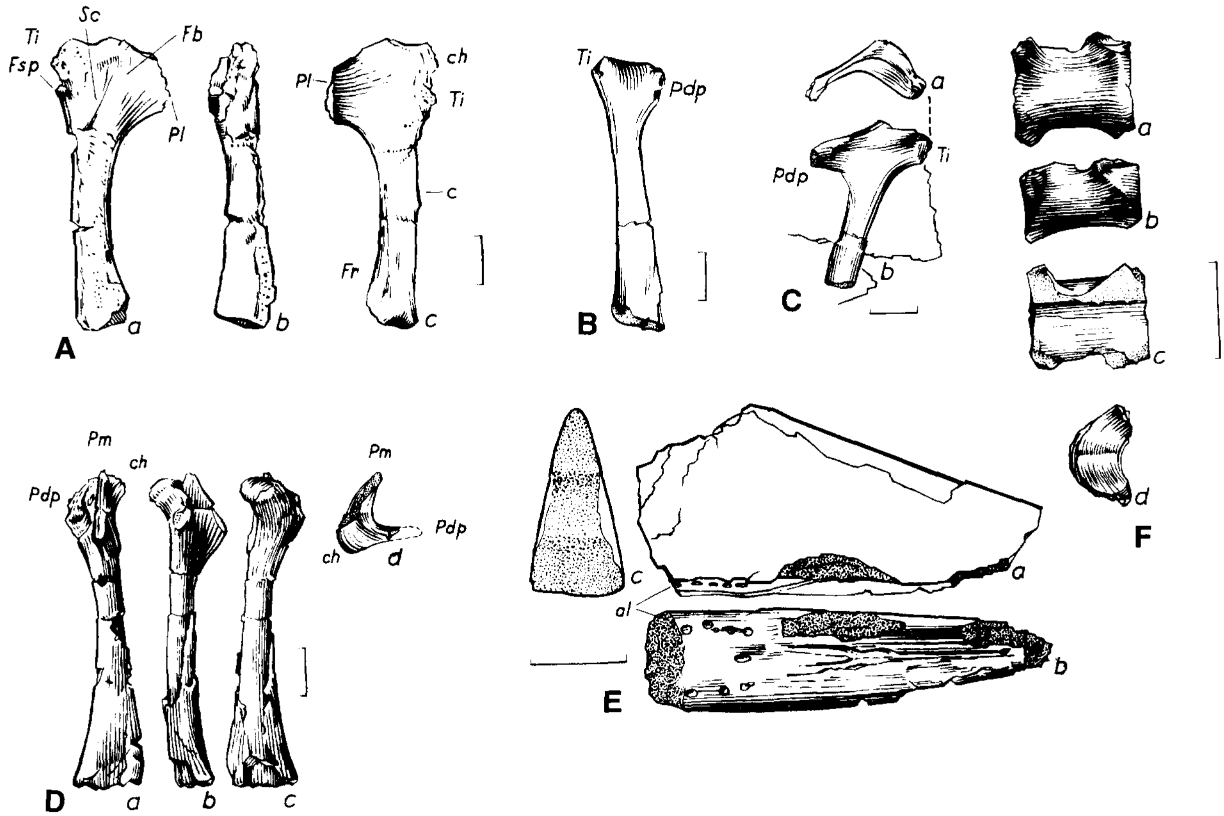


Fig. 12. Pterodactyloid pterosaur bones from Cornet. (A) Right humerus, MTCO 1628, in ventral (a), lateral (b) and medial (c) views. (B) Left humerus, MTCO 9682, in medial view. (C) Right humerus, MTCO 1914, in proximal (a) and medial (b) views. (D) Right humerus, MTCO unnumb., in medial (a), lateral (b), dorsal (c) and proximal (d) views. (E) Tip of the snout of a dsungaripterid pterosaur, in right lateral (a), occlusal (b) and posterior (c) views. (F) Thoracic vertebra, MTCO 9402, in ventral (a), lateral (b), dorsal (c) and anterior (d) views. Scale bar is 10 mm. Drawing by Szabo Barna.

teeth, are surprisingly well preserved, perhaps by having been caught up in spaces between the larger more robust elements.

Further evidence for physical transport of the bones is that most elements are abraded to some extent, clustering around abrasion stage 2 (slight rounding) of Fiorillo (1988). The vertebrae, for example, typically show rounding of the margins of the articular faces, and loss of projecting processes of the neural arch. The centra usually retain the lower portions of the neural arch that surround the neural canal, but the transverse processes and neural spine are often missing. The majority of the collection consists of isolated centra, with no trace of the neural arch, and isolated neural arch elements have not been found. These were presumably further broken up by physical transport processes, or they may have been largely winnowed out of the deposit.

There have been two alternative explanations for the uniform size and shape of elements in the Cornet deposit. Patrulius et al. (1983) suggested that the ornithopod bones were broken down by scavengers which fed on the ornithopod carcases as they lay on the shores of a lake, and split the long bones for the marrow. The reduced remnants of the bones were then supposedly dissociated and washed into the caves "probably during seasonal storms". A second suggestion, by Marinescu (1989), was that the larger elements were kept out of the caves by some kind of filter formed by tree trunks and rocks trapped in the entry passages.

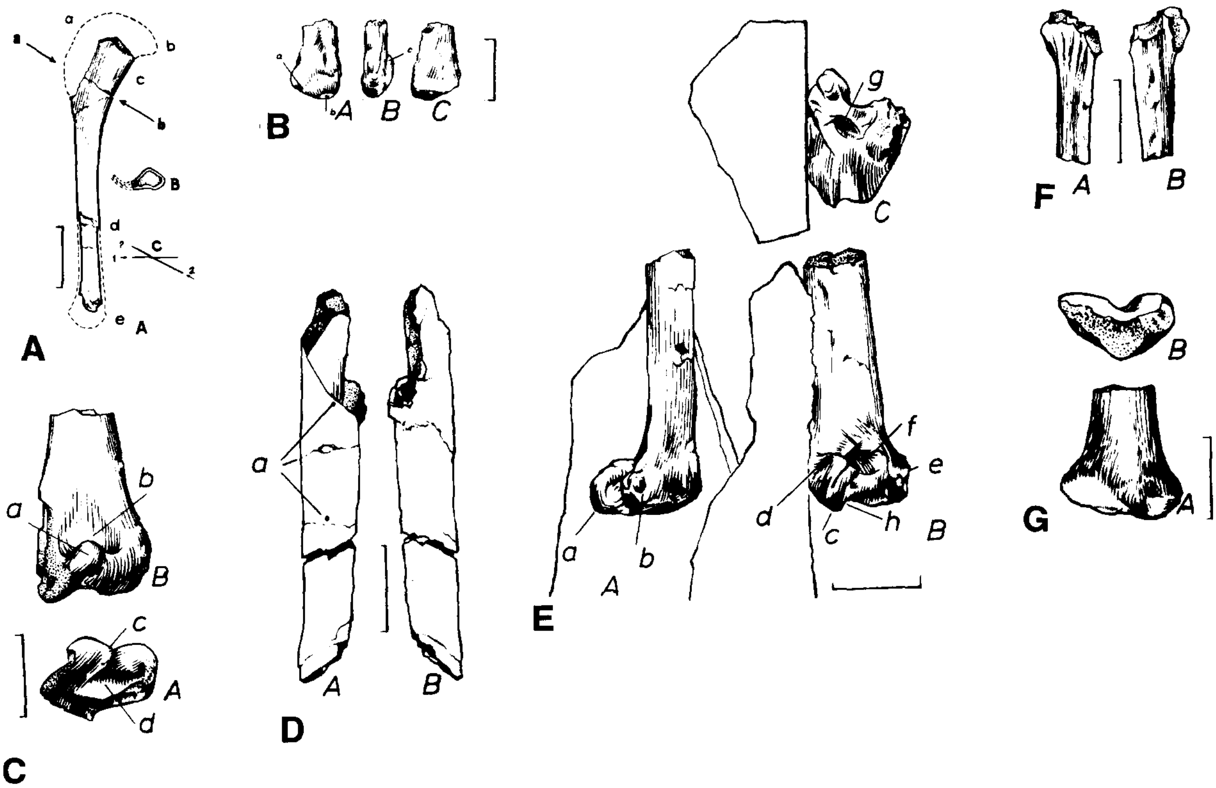


Fig. 13. Postulated bird bones from Cornet, as identified by Jurcsák and Kessler (1991). (A) Left humerus, previously identified as *Archaeopteryx* sp., MTCO 1503, in dorsal (A) and proximal (B) views. (B) Distal end of a left ulna, MTCO 1912, in ventral (a), medial (b) and dorsal (c) views. (C) Distal right humerus, MTCO 7896, holotype of *Eurolimnornis corneti*, in ventral (A) and distal (B) views. Abbreviations: *a* trochlea; *b* supratrochlear ventral trochlea; *c* external tricipital groove. (D) Fragment of shaft of right ulna, MTCO 6966, showing possible feather insertion points (*a*). (E) Distal fragment of left femur, MTCO 1637, holotype of *Palaeocursornis biharicus*, in medial (A), ventral (B) and distal (C) views. Abbreviations: *a* external condyle; *b* internal condyle; *c* fibular condyle; *d* fossa; *e* epiphysis gastrocnemial intercondylar; *f* fossa poplitea; *g* deep fossa; *h* intercondylar fossa. (F) Right carpometacarpus, MTCO 207, in dorsal (A) and ventral (B) views. (G) ?Distal fragment of humerus in lateral (A) and distal (B) views. Scale bar is 10 mm. Drawing by Szabo Barna.

These two alternative explanations are unlikely for several reasons. First, the patterns of abrasion indicate extensive tumbling of the bones during physical transport. Second, the direct evidence of scavenging is limited, and no specimens of long bones have been found split to the marrow. Third, there may originally have been larger bones in the deposit. Some limb bones show signs of old breakage surfaces, produced presumably during ancient transport processes. Others, however, show fresh breaks, almost certainly produced by the explosion in 1978 that revealed the bone-bearing lens. Physical transport, within an ancient cave system, and simple abrasion and winnowing, seem to be the most likely interpretations of the origins of the Cornet deposit.

The fourth major taphonomic process, post-depositional distortion and crushing, is evident in about half the Cornet specimens. Vertebrae are typically twisted slightly so they are no longer perfectly symmetrical in axial views, or the vertebra is rotated 20–30° when viewed from the side. Many metapodials show similar evidence of rotation after deposition, and some elements show cracking and crushing, presumably also associated with compaction.

## 7. Palaeogeography

The location of the Cornet fossil fauna, in the far east of Europe, is unique, and local palaeogeography suggests the site was on an island, one of an extensive archipelago in the region today divided between northwestern Romania and eastern Hungary. The topography of the island was presumably a more exaggerated representation of the modern topography of the Padurea Craiului mountains, hence forming a roughly circular island, some 30–40 km in diameter. The surface was composed of hilly karst country with many lakes and marshes (Pop and Marza, 1977).

Regions south and east of the Carpathians, the Moesian, Scythian and Moldavian platforms, also experienced continental conditions during the Jurassic/Cretaceous interval. Lacustrine algal and pellet limestones and sabkha-type evaporites and soils accumulated between early Tithonian and early Valanginian times, during a phase of substantial regression, corresponding to the regression that denuded the Cornet area (Grigorescu, 1993). Emergence of land occurred throughout much of eastern Europe. In parts of southern Hungary lying 500 km to the southwest of Cornet, giant basalt volcanoes emerged from the sea during the Early Cretaceous up to the Valanginian, and they were rimmed by atoll-like reefs (Császár and Turnsek, 1996).

The dsungaripterid pterosaur is an intriguing Asiatic element in a fauna that seems dominated otherwise by western European Wealden-type dinosaurs. The commonest dinosaur represented at Cornet may be a camptosaurid, a group known otherwise mainly in North America and western Europe. Hypsilopodontids are known worldwide, including western Europe, North America, China and Australia.

## 8. Comparison of the Cornet fauna

Dinosaurs and other tetrapods are not commonly reported from bauxites. An equivalent discovery consists of bones and a crocodilian tooth from Early Cretaceous (? Albian) bauxites of Bakony, near Gant, in eastern Hungary (Kretzoi and Noszky, 1951). These units in Hungary may correspond in mode of formation to the Cornet bauxites.

Early Cretaceous tetrapods are not so well known as those of the Late Jurassic and Late Cretaceous. The most extensive suites of Early Cretaceous faunas are those of Europe, and in particular those from the Wealden of southern England, and contemporary deposits of France, Belgium, Spain and Germany. The only substantial continental vertebrate faunas of Berriasian age are from the Purbeck of southern England, but the taxa preserved there are quite different (turtles, lizards, crocodilians, rare dinosaurs).

The Cornet fauna is like those of the younger Wealden beds (Valanginian–Aptian) of southern England, Belgium, northern Germany and France in the dominance of ornithopod dinosaurs. However, the absence of crocodile, turtle and fish remains, common in all of those regions, is unusual. The absence of such freshwater elements is surprising also in view of the presence of freshwater ostracods and charophytes in lens 204 and in associated units.

The rarity of theropod specimens in the Cornet collection is also unusual. A theropod tooth, termed *Megalosaurus dunkeri* Koken, was, however, reported by Simionescu (1913) from Early Cretaceous (Valanginian?) limestones near Cochirleni, south of Cernavodă, in the Dobrogea region of eastern Romania. Indeed, theropod remains are not abundant in the classic English Wealden, but complete skeletons of large predators, such as *Baryonyx* and an allosaurid have been found, as well as isolated bones and teeth of smaller theropods (Benton and Spencer, 1995).

The supposed bird remains from Cornet post-date *Archaeopteryx* from the Tithonian of Germany by some 14 Ma, making the Romanian specimens potentially the second-oldest birds in the world. In addition, several avian taxa have been identified, making the Cornet assemblage the oldest bird fauna. The next oldest bird remains include recent discoveries from China, Spain and South America, but these all date from later in the Early Cretaceous (Sanz and Bonaparte, 1992; Sanz and Buscalioni, 1992; Sereno and Rao, 1992; Wellnhofer, 1994). If the specimens termed

*Palaeocursornis* and *Eurolimnornis* have been correctly assigned to ratites and grebe-like forms, then these represent by far the oldest palaeognathous and neognathous birds respectively. The next-oldest specimens of each of these modern sub-classes are Late Palaeocene (Thanetian) and Late Cretaceous (? Campanian) in age (Unwin, 1993).

## 9. Dwarfing and insularity

The Cornet fauna gives evidence for its insular nature. This is expected, since Cornet was an island, probably one of dozens that emerged from the Late Jurassic seas that flooded eastern Europe. The nearest major land masses lay in Germany and Russia, many hundreds of kilometres distant, and any terrestrial fauna on the Romanian and Hungarian islands must have island-hopped some distance.

The first evidence for insularity is that the Cornet fauna is depauperate. It consists of perhaps four species of dinosaur and two or more species of pterosaur. This is much smaller than the classic Wealden faunas of similar age which typically consist of up to ten species of dinosaurs and numerous other reptiles and mammals (Benton and Spencer, 1995). Islands classically have fewer species than mainlands (Williamson, 1981) for two reasons: (1) islands are small and the number of species depends to some extent on land area, the species-area effect and (2) the distance from the nearest mainland means that many terrestrial species cannot disperse across the sea.

The composition of the Cornet fauna is also evidence for insularity. The only animals present are flying forms (pterosaurs and possible birds), which would have had little trouble in reaching the island, and a small array of dinosaurs, two ornithopods, a possible ankylosaur and a shadowy theropod. Typical Purbeck and Wealden continental faunas include freshwater fishes, turtles, and crocodilians, as well as rarer amphibians, lizards, and mammals (Benton and Spencer, 1995). In addition, Wealden faunas include a full array of ornithopods, ankylosaurs, theropods, and rare sauropods. Evidently, small and medium-sized freshwater fishes and tetrapods were unable to colonise the Cornet island, and the same was true for sauropod dinosaurs, lizards and mammals. Theropods and ankylosaurs were also much rarer than might have been expected.

Finally, the dinosaurs from Cornet appear to be dwarfs, and this is another typical feature of islands (Williamson, 1981). The commonest dinosaur, the camptosaurid, is represented by thousands of vertebrae, phalanges, and other elements. These indicate an animal that was rather smaller than *Camptosaurus* from the Late Jurassic of England (body length, 3.5 m, Galton and Powell, 1980) and considerably smaller than *Camptosaurus* from the Late Jurassic of North America (adult body length, 5–6 m, Marsh, 1894; Dodson, 1980). Vertebral centra and phalanges of the Cornet camptosaurid are typically 40–50 mm long, which compares with lengths of the same elements in the English *Camptosaurus* of 70 mm, and 75 mm in the American form. The left humerus of the Cornet animal, MTCO 5384 (Fig. 10E) is 210 mm long, which compares with lengths of 300–400 mm in adult American *Camptosaurus*. The Cornet camptosaurid is then perhaps two-thirds to half the linear dimensions of typical relatives from elsewhere. This would equate to a body mass of one third or one quarter of typical relatives. This is not such dramatic dwarfing as seen in the Late Cretaceous hadrosaur *Telmatosaurus* from Haţeg Island, Romania, which was about one-tenth of the body mass of typical hadrosaurids from elsewhere (Weishampel et al., 1991). Nonetheless, the Cornet dinosaurs had perhaps not been present for long on the island, and dwarfing might not yet have become as striking as could happen over a longer interval of time.

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