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THE DINOSAURS OF PORTUGAL

by

ABBEY ALBERT F. DE LAPPARENT

Professor at the Catholic Institute of Paris

and

GEORGES ZBYSZEWSKI*

Geologist of the Geological Services of Portugal

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SUMMARY

INTRODUCTION

Since the beginnings of Portuguese geology, toward the middle of the last century, the existence of dinosaur remains have been noted in various works under the names “saurian bones” and “reptile bones”.

Carlos Ribeiro, F. J. Nery Delgado and later Paul Choffat mentioned them successively. But no monographs were published before Sauvage’s (1897-98), which until now has remained the basic work on the dinosaurs of Portugal.

Since 1942, several discoveries by H. da Costa Cabaço were conducted on the part of the Geological Services of Portugal by methodical researches in the littoral region between Foz do Arelho and Praia de Santa Cruz, which permitted one of us (G. Zbyszewski) to recover abundant material that will be described soon.

In the present work, the osteological study of the elements is the work of the first author (A. de Lapparent). The stratigraphic study of the localities as well as the majority of the discoveries is that of the second author (G. Zbyszewski). The drawings of the bones were executed by O. da Veiga Ferreira.

In addition to the pieces preserved at the Geological Services Museum of Portugal, which are the most numerous and among which are found the largest specimens, it was possible for us to study the objects that formed part of the collection of the Geology Laboratory of the Faculty of Sciences of Lisbon and those that belonged to the Superior Technical Institute.

We address our sincere thanks to professors C. Torre de Assunção, C. Teixeira and D. Thadeau, who accorded us all the facilities to study, draw and photograph all the specimens from their museums that could be interesting to our study.

Thanks to the chronology of the Jurassic formations, we have taken the works and successive classifications of Paul Choffat as a basis, while bringing corrections that appeared necessary following the recent geological studies executed by geologists Tzerniowski and Seifert in the service of the Petroleum Company of Portugal.

CHAPTER I — THE DINOSAUR LOCALITIES

Numerous dinosaur localities are known today in Portugal. Many of them produced only incomplete bones, most often indeterminable. In contrast, others have provided the very rich fauna described below. We will give here the summary description of the principal work sites, especially those where the excavations were executed by one of us (G. Zbyszewski).

A map (fig. 1) will give data on the locations of these diverse localities within littoral Beira and Estremadura provinces.

A — **LIASSIC**

A fragment of the maxilla of *Lusitanosaurus*, whose provenance is unknown, was found in the collections of the Museum of Geology and Mineralogy of the Faculty of Sciences of Lisbon. This specimen is found in a block of dark gray, sandy limestone, a little greenish, that greatly resembles the Liassic formations of the same nature known at S. Pedro de Muel. It was not possible for us to further specify the position of the locality. The only written indication accompanying the specimen shows that the piece was found in the Liassic.

B. — **UPPER LUSITANIAN**

In the Upper Lusitanian, a vast gulf opened toward the southwest and extended over the Torres Vedras, Lisbon and Sintra regions.

The marine series of this period, studied by Choffat, was represented according to him by two superimposed complexes that are very visible in the Torres Vedras region:

b) the coral limestones of Amaral
a) the Abadia beds

According to this same author, it is equivalent to the Sequanian (*Streblites tenuilobatus* zone).

The Amaral limestones are reef limestones, often oolitic. Their thickness varies between 0 m and 40 m. Some sandy limestone intercalations exist toward their upper part.

The Abadia beds are represented by marls, sandy clays and micaceous sands. Intercalations of oolitic limestones are found locally.

The Upper Lusitanian fauna shows the presence of the following species: *Streblites tenuilobatus* (OPP.), *Taramelliceras trachynotum* (OPP.), *Litacoceras unicomptum* (FONT.), *Aspidoceras sesquinodosum* (FONT.), *Simoceras macerrinum* (QUENST.), *Rhopaloteuthis argovianus* (C. MEYER), *Belemnopsis hastatus* BL., *Terebratula insignis* (ZITT.), *Terebratella pectunculoides* (SCHL.), *Terebratulina substriata* (SCHL.), *Rhabdocidaris delgadoi* P. DE L., *Rh. orbignaya* (AG.), *Diplocidaris giganteus* (AG.), *Acrocidaris nobilis* AG., *Pseudocidaris lusitanicus* P. DE L., *Cidaris choffati* P. DE L., *Cidaris marginata* GOLDF., *Antedon choffati* P. DE L., *Thiollierocrinus ribeiroi* P. DE L., and *Millecrinus mespiliformis* SCHL.

Recently, geologists Tzerniowski and Seifert, in the service of the Vacuum Oil Co. and the Petroleum Company of Portugal, were able to verify that the succession of two terms of the series defined by Choffat were not established in most cases. Whereas the coral limestones of

Amaral are well represented at the top of the series at Torres Vedras, where they rest on the Abadia beds, further to the east they are progressively reduced and disappear in the middle of a sand-clay series. In the Amaral type locality, the reef limestones would not correspond laterally with the coral limestones of Torres Vedras, but with a less elevated level in the series, intercalated within the Abadia beds.

On the northern slope of the Serra de Montejunto in the Pragança and Rocha Forte region, the coral limestones and marls of the Abadia series have been wrongly considered as beds of different ages. In reality there was a coral reef giving passage to different lithologic zones according to their position in front or behind the coral barrier.

At the current time, the geological works executed by the geologists in the service of the Petroleum Company of Portugal permit localizing a reef zone to the Upper Lusitanian that passes sensibly by the Vimeiro, Serra de El Rei, Rio Maior, Ota, Alenquer, Vila Franca de Xira regions and rejoins the Tage la Serra de Arrabida to the south.

A calm littoral zone is extended behind this "barrier reef" along a continent where dinosaurs lived, which was found further north and east.

A second marine gulf must have extended into the Caldas da Rainha, S. Martinho do Porto, Leiria and Figueira da Foz regions. It was bordered by a littoral zone where the influences of the nearby continent were felt. Some brackish and lagoonal formations were disposed there. Dinosaurs lived there as well, as we can ourselves account for by the discovery of bones or footprints.

In the following lines we describe the principal localities by enumerating them from north to south.

1 — **Buarcos (Cap Mondego)**

In 1884 J. P. Gomes was informed of the existence of curious fossils in the nearby maritime cliff by one of the directors of the Cap Mondego coal mine. A little after, this geologist was returned to the indicated place and observed the presence of 15 dinosaur footprints there. These were found on the removed lower floor in a bed of blackish marly limestone belonging to the coal roof. Today these prints are preserved in the Museum of Geology and Mineralogy of the Faculty of Sciences. They are formed by a yellowish, coarse-grained sandstone.

In 1951, having visited the old work site which was easy for us to retrace, we noted that other prints of the same type were still found there in the sandy limestone, one of which could be viewed in cross-section.

As we will see further on, these dinosaur footprints, left initially on the still-soft mud of an estuary, but in the process of consolidation, must have been covered again very rapidly by sand before being again covered by other layers of mud.

The presence of these first prints incited us to look for others in the vicinity, which led us to the discovery of the prints cited further on, which can be attributed to *Megalosaurus*.

2 — **Alfeizerão**

This locality, which in 1908 produced the remains of *Omosaurus* described later, was found about 1.5 km east of the Alfeizerão church. It corresponds to an old exploratory coal shaft, and opens into a ravine emerging into the plain immediately south of the curve that marks

the beginning of the rise on the route to Alcobaça. The geologic cross-section of the locality shows the following succession, from top to bottom:

C.4 — Kimmeridgian sand
C.3 — Lignite lens with *Omosaurus lennieri* bones
C.2 — Clay with remains of plants (*Davalia delgadoi* (SAP.) TEIX. and conifers resembling *Brachyphyllum*)
C.1 — Lusitanian limestone with crinoids, sea urchins, etc.

3 — **Salir do Porto**

Three mutilated vertebrae of *Megalosaurus insignis* were found in the upper part of the maritime cliff northeast of Salir do Porto, on the surface of a limestone bank cut by small faults.

4 — **Praia de S. Bernardino**

This locality produced 16 caudal vertebrae of *Apatosaurus alenquerensis* that were discovered in February 1946 by H. da Costa Cabaço. These vertebrae were found in place in a large block of sandstone that had crumbled off the nearby cliff and split into two parts. The base of the block was formed by a very thick gray sandstone with small pebbles. The upper part of the block was formed by a fine micaceous sandstone.

The cut of the cliff at the locality site shows the following succession, from top to bottom:

C.6 — Gray marls with intercalations of small micaceous sandstone lenses (10-12 m)
C.5 — Thick gray sandstone (1 m)
C.4 — Very thick, poorly lithified sandstone containing gravels
C.3 — Yellowish sandstone with fossil wood (1-1.5 m)
C.2 — Fine yellowish-gray sandstone (5-10 m) with estuarine stratification, inclined, with black lignitic trails, fossil wood, coal, pebbles of gray clay and dinosaur bones
C.1 — Variegated gray and red-violet clay, alternating with gray micaceous sandstones and other thicker sandstones with small pebbles (around 10 m)

All these beds incline toward the southwest at an angle of 10 to 15°. On the beach, they are cut by a fault inclined at 70° in the direction N12°E. Under the walls of the ancient monastery of S. Bernardino, the cliffs of the same beach have produced a femur of *Omosaurus lennieri*, which we cite later and which is found today in the geology laboratory of the Superior Technical Institute of Lisbon, along with some remains of indeterminable ribs.

5 — **Moinho do Carmo (Alenquer)**

This locality was discovered by the American geologist Harold Weston Robbins, who worked during this period for the Portuguese Petroleum Company account. The bones outcropped in the middle of a country path, several dozen meters north of the ruined windmill named Moinho do Carmo, situated about 1,500 m south of Alenquer.

After a visit to these places in the company of this geologist, excavations were executed in June 1949 by Geological Services personnel under the direction of one of the present authors (G. Z.). They produced the rich material that we will describe later.

The cut of the hill passing by the locality is as follows:

C.6 — Yellowish sandy limestones with *Trichites, Perna*, etc.
C.5 — Fine sandstones
C.4 — Stratified red clays
C.3 — Gray and rose clays with *Apatosaurus* bones
C.2 — White limestone with pisoliths
C.1 — Feldspathic yellowish sandstones with rose, mauve or violet zones, often containing pebbles of quartz, Lydian stone, etc.

The thickness of this series is around 80 to 100 m. The beds plunge toward N40°E, at an angle of around 35°. But the inclinations vary when the slope of the hill is ascended.

The arrangement of the elements at the moment of their discovery is indicated in figure 2.

C. — **KIMMERIDGIAN AND PORTLANDIAN**

During the Kimmeridgian, the marine environment is now in the Torres Vedras region, although the oceanographic conditions were slightly varied and the banks were moved.

The Kimmeridgian is formed by the following series:

e) Reddish clays and marls with *Trigonia lusitanica* (80 to 100 m)
d) Sandstones and lumachelle limestones with *Isognomon rugosa* (2 to 4 m)
c) Clays, marls and sandstones (60 to 100 m)
b) Calcareous conglomerates (1 to 3 m)
a) Clays and marls, sandy, micaceous, gray, brown, etc., with sandstone intercalations and oolitic limestones. Total thickness 70 to 120 m.

The total thickness of the Kimmeridgian in the Torres Vedras region was calculated at around 220 to 300 m.

The fauna noted in the Kimmeridgian comprises the following species: *Belemnitopsis hastatus* (BLAINV.), *Rhopaloteuthis argovianus* MAYER, *Mytilus acinaces* LEYM., *M. morrisi* SHARPE, *M. subaequiplicatus* ROEM., *Avicula credneriana* P. DE L., *A. gessneri* THURM., *Trichites thurmanni* CHOF., *Gervilleia sobralensis* SHARPE, *G. tetragona* ROEM., *Isognomon rugosa* MUNST., *Lima pseudo-alternicosta* BUV., *Ostrea catalaunica* P. DE L., *O. multiformis* K. & D., *Trigonia lusitanica* SHARPE, *Cyprina securiformis* (SHARPE), *Lucina rugosa* P. DE L., *Unicardium crassum* CHOF., *Cardium dissimile* SOW., *Corbula edwardsi* SHARPE, *Pholodomya multicostata* AG., *Thracia impressa* CHOF., *Thr. incerta* ROEM., *Nerita bicornis* (SHARPE), *Natica gigas* STROMB., *N. hemisphaerica* ROEM., *N. marcousana* D'ORB., *Cerithium septemplicatum* ROEM., *Harpagodes oceani* (DE LA B.), *Nerinea turbinata* SHARPE, *Nerita bisinuata* BUV., *Terebratula lusitanica* SUESS, *Rhabdocidaris arsenensis* P. DE L., *Rh. lusitanicus* P. DE L., *Hemicidaris agassizi* ROEM., *Pseudocidaris spinoza* P. DE L., *Diplopodia planissima* (AG.), *Holectypus corallinus* D'ORB., *Echinobrissus arsenensis* P. DE L., and *Echinobrissus lusitanicus* P. DE L.

The inferior beds of the Kimmeridgian complex (beds with *Lima pseudo-alternicosta*) comprise the following beds from top to bottom, according to Choffat:

Bed with opisthobranchs — Formed generally by an agglomeration of milliary, sometimes marly oolites with *Nerinea turbinata* SHARPE, *Cyprina securiformis* (SHARPE), *Orthostoma*, etc.

Lower bed represented by the following formations:

b) Marly facies with polyps (*Montlivaultia*)

a) Milliary oolites sometimes occurring with micaceous sandstones with *Lima pseudo-alternicosta* BUV. and *Isognomon polita* (SHARPE).

The fauna of the *Lima pseudo-alternicosta* beds includes the following species: *Perisphinctes* sp., *Rhopaloteuthis argovianus* C. MAY., *Belemnopsis hastatus* BLAINV., *Nerita bicornis* (SHARPE), *N. georgiana* D'ORB., *Natica semitalis* P. DE L., *Cerithium septemplicatum* ROEM., *Isognomon polita* SHARPE, *Lima pseudo-alternicosta* BUV., *Trigonia ribeiroi* CHOF., and *Pseudocidaris lusitanicus* P. DE L.

The position of the *Lima pseudo-alternicosta* beds is in the course of being reviewed. They may have belonged to the Upper Lusitanian.

The Portlandian of the Torres Vedras region is formed by grayish, yellowish and reddish sandstones, micaceous and sometimes sandy clays, marls, and marly limestones. Some conglomerates exist in the upper part. The thickness of the Portlandian varies between 0 m and 200 m.

The Portlandian fauna includes the following species: *Mytilus morrisi* SHARPE, *Avicula credneriana* P. DE L., *Gervilleia lorioli* CHOF., *Isognomon espichelensis* CHOF., *I. rugosa* SOW., *Ostrea catalaunica* P. DE L., *Trigonia freixialensis* CHOF., *Tr. kobyi* CHOF., *Astarte discus* SHARPE, *Cyprina securiformis* SHARPE, *Lucina rugosa* P. DE L., *Corbula lusitanica* CHOF., *Natica hemisphaerica* P. DE L., *N. marcousana* D'ORB., and *Spirocyclina choffati* MUN. CHALM. var. *lusitanica* CHOF.

The marine Kimmeridgian and Portlandian series of Torres Vedras passes progressively into brackish formations and detrital deposits toward the north and east that are often difficult to separate from the Upper Lusitanian complex due to the lack of fossils.

After the Lusitanian, there are incontestably the brackish Kimmeridgian and Portlandian beds that produced the rich dinosaur fauna. We cite the principal following localities in geographic order from north to south, giving their geologic section summaries:

1 — **Murteiras (Foz do Arelho)**

In July 1945, a good dinosaur locality was discovered by the collector P. Carreira de Deus in the Murteiras ravine, which terminates on the maritime cliff north of Foz do Arelho.

The emplacement of the excavation is found around 550 m N10°E of the ruined Eirinhas windmill and 1.075 m W10°S of the Bouro geodesic signal.

The section of the cliff passing by the locality is as follows, from top to bottom:

C.7 — Yellowish sandstones with plant remains (5 m)
C.6 — Gray clays (2 m)
C.5 — Yellowish sandstones with plant remains (8 m)
C.4 — Gray clays (0.50 m)

C.3 — Yellowish sandstones with plant remains (6 m)
C.2 — Gray clay with dinosaur, crocodilian, chelonian, fish (*Lepidotes*) and plant remains (5 m)
C.1 — Yellowish sandstone, visible at the base of the cliff

The dinosaur remains recovered in this locality belong to *Megalosaurus insignis* and *Omosaurus lennieri*.

As seen in the section which will be given, the Kimmeridgian series here is formed by an alternation of sandstones and clays in often lenticular beds that plunge toward the ocean.

Further south, a bed of pale gray, micaceous sandstone produced remains of sauropod vertebral processes NE of the Facho Hotel.

2 — **Baleal**

Discovered in August 1942 by H. da Costa Cabaço, this locality is found at the summit of the Pedras Muitas cliff, around 1,500 m east of Baleal. It produced remains of *Omosaurus armatus* [ZBYSZEWSKI 1946] and a sauropod. The fossiliferous bed is a clayey and micaceous sandstone of yellowish-gray tint. The Kimmeridgian complex of which it is part includes multicolored greenish-gray and red marls, tied to wine and clear-gray, yellowish and rosy sandstone banks, often containing the remains of plants and carbonized or silicified wood. This group of beds is inclined toward the east and bears reddish detritic beds in its upper part.

Ten years after we first explored, the sea had uncovered the beach sand that had been found at the foot of the cliff. This allowed us to find the missing part of the pelvis of *Omosaurus* that, taken in an ancient crumbling, was buried under the sand.

3 — **Praia da Areia Branca**

The environs of Praia da Areia Branca, north of the Lourinhã river, produced a rather large number of whole, incomplete or only fragmentary bones in April 1947. We note the proximal part of a large femur of *Brachiosaurus atalaiensis*, discovered close to the first houses northeast of the village. Another, smaller sauropod femur was found close to Vale de Frades. Some *Omosaurus lennieri* vertebrae were recovered in a ravine that notches the cliff north of Lagôa.

In the same region we have old notes referring to some fragments of saurian bones, 400 m N70°W of the Zambujeiro windmill. But it is the maritime cliff with its ravines that is shown as the richest in bones. 6 dinosaur localities are currently known, of which several were discovered by Dr. Jaime Pinto, to whom we address our thanks for the pieces that he offered to us and for the information that he very much wanted to give us on the locations of his works.

4 — **Atalaia (Lourinhã)**

The principal locality of Atalaia was discovered in April 1947 by the collectors M. de Matos and P. Carreira de Deus. It is situated on the edge of a path that descends from the hamlet of Portela toward the Peralta beach. It is found about 750 m NW of the geodesic windmill-signal of Montoito.

The bones were found enclosed in a large clay lens forming part of the Kimmeridgian complex, of which we give a schematic section below. This first point of work gave us the best

remains of *Brachiosaurus atalaiensis*, a vertebra of *Astrodon pusillus*, and teeth of *Megalosaurus insignis*. Moreover, the fossiliferous bed contained scales of *Lepidotes*, crocodilian and turtle plates, as well as remains of fossil wood, some of which are silicified. The upper beds of the locality produced numerous *Perna polita*.

A second locality is found on the flank of a ravine occurring south of the Montoito windmill which emerges at the southern end of the Peralta beach. It produced a pelvis and femur of *Omosaurus lennieri*. It is the same geological level.

The local geological series belongs to a very uniform Kimmeridgian complex that is found all along this coast. The principal locality was found as stated above, on the edge of the path, showing the possibility for some ends of broken bones. According to the information given to us, the men who worked some twenty years earlier at the opening of the path destroyed a great number of bones and vertebrae that have fallen to the sea from the height of the cliffs.

The distribution of the principal bones that were recovered at the locality is represented in figure 3.

5 — **Vale do Portinheiro Section at Carrasqueira**

This section, made on 20/6/1863, is located on the coast between Praia das Carreiras and Porto de Barcos (Lourinhã). It comprises the following succession, observed by Carlos Ribeiro.

C.15 — Gray brown, slightly micaceous, fine sandstone with calcareous cement.
C.14 — Greenish sandstone with *Cyprina securiformis, Perna lusitanica*, etc.
C.13 — Very micaceous, greenish, fissile sandstone with marly cement.
C.12 — Fine sandstone passing into a thick, dark greenish-gray limestone.
C.11 — Greenish-gray micaceous clay with dinosaur bones and teeth, chelonians, fishes, and various mollusks.
C.10 — Dark greenish-gray, slightly micaceous sandstone with marly cement, having produced *Cyprina securiformis, Gervilleia tittoni, Perna lusitanica* and a saurian vertebra.
C.9 — Dark greenish-gray, slightly micaceous sandstone with marly cement and a coal-bearing zone.
C.8 — Hard, slightly micaceous sandstone with calcareous cement, grains of feldspath and various gray or greenish clay fragments.
C.7 — Blackish-gray marl having produced a fragment of saurian bone, some limestone-petrified wood, and mollusks (*Corbula edwardsi, Cyprina securiformis, Perna lusitanica, Mytilus morrisi*, etc.).
C.6 — Fine, micaceous, greenish-gray sandstone with marly cement.
C.5 — Fine violet sandstone with greenish-gray stains and marly cement.
C.4 — Ash-gray, slightly micaceous sandstone with calcareous cement, containing numerous feldspath grains.
C.3 — Fine sandstone with marly cement, dark violet with greenish stains.
C.2 — Fine, micaceous, fissile, greenish-gray sandstone with marly cement.
C.1 — Slightly micaceous sandstone with calcareous cement, with numerous feldspath grains. Ash-gray color.

D. — **ALBIAN-APTIAN**

These terrains, poor in dinosaur remains, have until now furnished only several teeth and bones found in the single locality of Boca do Chapim, north of Cape Espichel.

Boca do Chapim

According to Choffat, the Cape Espichel section was notably as follows. The cliff south of the semaphore is formed by the dolomitic Bajocian that plunges toward the north at an angle of 70°.

The Bathonian and Lusitanian lacking at the Cape, the Bajocian is covered directly by limestone beds with *Cyrena securiformis*, nerines, etc. (Upper Jurassic).

The marls and sandstones of the Pterocerian outcrop with an inclination of 35° toward the ravine that passes a hundred meters NE of the semaphore. Then a very complete Lower Cretaceous comes north of the Cape. The red Jurassic marls are surmounted by some sandstones and conglomerates, then by the following series that includes from top to bottom:

	Limestones with orbitolines
Aptian……..	Limestones with *Toucasia* and large nerines
	Clayey, very fossiliferous sandstone, more than 100 m thick
	Alternation of sandstones and limestones (30-35 m)
Barremian…	Bank with nerines
	White or gray limestones with *Requienia, Pseudocidaris clunifera*, etc. (20 m)
	Yellow limestone (3 m)
Hauterivian…	Gray and yellow marls with ferruginous plates and *Exogyra couloni* (25 m)
	Yellow-ochre limestones with ferruginous oolites (5 m)
Valanginian…	Thick sandstone (100 m)

E. — **SENONIAN**

The Senonian, well defined by its flora and brackish fauna, is known only in the low valley of Rio Mondego and especially north of this river. Until now the single locality having produced dinosaur remains is that of Viso, situated northeast of Serra de Boa Viagem.

Viso

We find some references to this locality in the memoirs of P. Choffat and Sauvage. According to the description that CHOFFAT gives [1900, p. 229], at 20 km on the railway begin some clear-gray clays with green parts, containing nodules of brown marl, small pieces of coal, small quartzite pebbles, coprolites and numerous partly worn, partly well-preserved bones. The inclination of the beds is on the order of 3° toward the east. The weakly extended outcrop is surrounded by Pliocene sandstones. The locality has given many plants and vertebrates, among which we cite:

Clastes lusitanicus SAUV.
Clastes pustulosus SAUV.
Microdon sp.
teleostean vertebrae
Clupea arazedi SAUV.
Bufo sp.
Megalosaurus cf. *pannoniensis* SEELEY
Crocodilus blavieri GRAY
Chelonia sp.
and remains of a pterosaurian.

The flora of this locality is more or less the same as that of C. dos Bernardos, in addition with 3 or 4 species of *Quercus*, a *Dewalquia*, a cycad fruit, and some unstudied leaves.

CHAPTER II — PALEONTOLOGICAL STUDY

Apart from the ceratopsids, known exclusively from the Upper Cretaceous of North America and Mongolia, all the dinosaur groups are well represented in the fossil reptilian fauna of Portugal. The lizard-hipped order (= Saurischia) includes on the one hand the carnivorous theropods, and on the other the herbivorous sauropods where giant forms are close to dwarf forms. The bird-hipped order (= Ornithischia) includes the suborder Ornithopoda with the classic *Iguanodon*, and an abundance of stegosaurians bearing bony armor.

In the present chapter, all the pieces from the Portuguese Jurassic and Cretaceous found up to this day will be described, of which here is the list.

Theropods

Megalosaurus insignis DESLONGCHAMPS & LENNIER	Lusitanian, Kimmeridgian
Megalosaurus pombali nov. sp.	Lusitanian, Kimmeridgian
Megalosaurus superbus SAUVAGE	Aptian
Megalosaurus cf. *pannoniensis* SEELEY	Senonian

Sauropods

Apatosaurus alenquerensis nov. sp.	Lusitanian, Kimmeridgian
Brachiosaurus atalaiensis nov. sp.	Lusitanian, Kimmeridgian
Pelorosaurus humerocristatus HULKE	Lusitanian, Kimmeridgian
Astrodon pusillus nov. sp.	Kimmeridgian
Astrodon valdensis LYDEKKER	Aptian

Ornithopods

Iguanodon mantelli	Albian, Aptian

Stegosaurians

Lusitanosaurus liasicus nov. gen. nov. sp.	Liassic (Sinemurian?)
Omosaurus armatus OWEN	Lusitanian, Kimmeridgian, Portlandian
Omosaurus lennieri NOPCSA	Lusitanian, Kimmeridgian, Portlandian

1 — THE CARNIVOROUS THEROPODS

The Jurassic and Cretaceous of Europe have furnished some remains, although often very incomplete, of carnivorous theropods [HUENE 1926] that are all arranged at least provisionally in the genus *Megalosaurus* or, it is better to say, in the vast family Megalosauridae. We have 4 species in Portugal.

MEGALOSAURUS INSIGNIS DESLONGCHAMPS & LENNIER

LUSITANIAN-KIMMERIDGIAN

TEETH. — Isolated theropod teeth, which are not very rare in the Upper Malm of Europe (Lusitanian-Kimmeridgian-Portlandian), are ordinarily attributed either to *Megalosaurus dunkeri* KOKEN or *Megalosaurus insignis* DESL., the type of which comes from the cliffs of Havre. In fact rather numerous teeth have been recovered in Portugal that are well referred to *M. insignis*:

Atalaia……..……	8
Foz do Arelho……..……	6
Portinheiro……..…….	5
Pombal……..……..	4
Colmeias……..……	1
Ourém……..……	1
Montoito……..……	1
Porto de Barcas……..…….	1
	27

being a total of 27 teeth, of which 4 are anterior (1 left, 3 right) and 8 alveolar.

The caniniform teeth, of which the largest attains 60 mm in length and 25 mm in width (Pl. XII, fig. 8), bear fine denticles that descend more or less far on the anterior side. Sometimes they are limited to the upper third, sometimes they reach half or two-thirds. This is what was figured by SAUVAGE [1897].

As has already been remarked previously [LAPPARENT 1943], teeth such as those recovered at Atalaia, and which belonged without doubt to a single individual, cannot be classified according to this single character.

We attribute some clearly asymmetrical specimens (Pl. XII, fig. 14) to anterior teeth. They were not fixed in the premaxillae, always small and very particular according to the study published by WOODWARD [1910] on the skull of *Megalosaurus bradleyi*, but rather were the sort of canines undoubtedly placed at the anterior edge of the maxillae, at the turning of the jaw. These specialized teeth hardly appear to have been mentioned in *Megalosaurus* until now, and they have no analog in crocodilian teeth.

The alveolar teeth, still incompletely disengaged from their alveoli, are proportionally narrower. We figure two of them. The first (Pl. XII, fig. 9) is 38 mm long. The second (Pl. XII, fig. 10) is 25 mm long. Both come from Atalaia (Lourinhã) and are thus probably from the same individual as the teeth reproduced in Pl. XII, fig. 8 and 14.

VERTEBRAE. — Some discoveries made in various localities have furnished undoubted theropod vertebrae that, by their moderate size and their rather slender form, are probably referable to *M. insignis*, the smallest of the two Jurassic theropods of Portugal.

Initially we note a posterior dorsal from Casal de Labrusque (Lourinhã). It measures 5 cm long; the vertebral face has a widely triangular shape with the point below, and its largest width is 6.5 cm.

From the Ourém locality come two sacral vertebrae, recognized by the depth of the ventral excavation and by the edge of the two anterior and posterior faces that results from it (Pl. XV, fig. 42). The largest measures 9 cm long, 9.5 cm wide and 10.5 cm tall; posteriorly it is fused to a fragment of the following vertebra, which confirms its attribution to the sacral region. The dimensions of the second, having belonged to a smaller individual, are: length 8, width 6.5, height 7 cm (Pl. XXX, fig. 123).

From the same locality are three posterior caudals, very elongated and very excavated ventrally. Only the posterior half of the largest is present: 5.5 cm wide and 6 cm tall. Another, situated farther posteriorly, is complete (Pl. XIII, fig. 28) and is 9 cm long, 4.5 cm wide and 5 cm tall. It was figured by SAUVAGE [1897, p. 4, fig. 6, 7, 8] under the name *Morosaurus marchei* nov. sp.; but it is very certainly not a sauropod vertebra. Finally, half of another, still more elongated caudal vertebra measures 4 cm wide and 4.5 cm tall. The very visible neural canal on this specimen has a nearly circular 1 cm opening.

Two small posterior caudal vertebrae were recovered previously in the Lusitanian 800 m S65°W of Fervença (Alcobaça). They measure: the first (Pl. XIII, fig. 27) is 54 mm long, with diameters 40 x 41 mm; the second (Pl. XXX, fig. 21) is 51 mm long, with diameters 32 x 33 mm.

From Areia Branca, a good series of caudal vertebrae is reported from a single individual. A block of gray micaceous sandstone contains a group of 5 anterior caudals (fig. 4 a, b, c), all close to the same size (length 8 cm; height 7 cm) and bearing their neurapophyses. Although not disturbed, the vertebrae are separated from one another by some sandstone of about 1 cm thickness; the sediment must have taken the place of the unossified vertebral discs that connected the vertebrae together. The same observation was made on the caudal vertebrae of *Ceratosaurus* [GILMORE 1920, pl. 22].

Two other joined anterior caudals are attached to the same group (Pl. XIV, fig. 34 and Pl. XV, fig. 40); they are of slightly greater size and should be placed preceding them (length 6.5 cm; height 8.5 cm). A posterior caudal that is very elongated (7.5 cm) for its height (4.8 cm) also belongs to the same lot.

A middle caudal vertebral centrum from Cesareda is referred to the same species (Pl. XXV, fig. 87): length 76 mm, diameters: 78 mm x 68 mm.

Finally, three caudals come from Salir do Porto, in poor condition but recognizable by their ventrally excavated form; they are also referred to *Megalosaurus insignis* by their size.

FORELIMB. — A very mutilated end of an ulna from the Lusitanian of Ourém seems to be referable to *Megalosaurus insignis* (Pl. XIV, fig. 37).

CLAWS. — Two small forelimb claws from a small theropod (perhaps a juvenile?) come from Vale de Portinheiro (Coll. Fac. Sci.). The largest (Pl. XII, fig. 22) measures 15 mm, but it lacks the point, which should make 17 mm for the complete element; the two grooves are well marked and symmetrical on each side. The smallest is 12 mm long (Pl. XII,

fig. 18). In contrast to the preceding specimen, it is strongly asymmetrical and only bears a groove on one side; it is also proportionally stronger at the base; it should belong to digit I.

HIND LIMB. — The base of a femur, 13 cm wide and preserving 16 cm of its height, could belong to *M. insignis*. It comes from a point located between Porto das Barcas and Ponta do Guindaste. The cross-section of the shaft measures 7.5 cm x 7 cm (Coll. Fac. Sc.).

MEGALOSAURUS POMBALI nov. sp.
LUSITANIAN-KIMMERIDGIAN

TEETH. — It seems to us that three megalosaurid teeth, from the Vale de Portinheiro, Pombal (Pl. XXVII, fig. 105) and Ribamar localities, must be put aside. They differ initially from those of *M. insignis* by their size. The largest is preserved as 81 mm long and must have been 110 cm when it was complete (Pl. XII, fig. 17). But this character, which itself is insufficient, is not the only one. The teeth are in effect thicker and much less flattened. The anterior edge is only serrated on its upper third, and this in a constant manner; below the point where the serrations stop, the anterior edge is bent and rounded, not flattened. In total, the tooth remains narrow and long, such that even if the caniniform teeth of *M. insignis* sometimes attained the same size [SAUVAGE 1874, pl. I, fig. 1; LAPPARENT 1943, pl. I, fig. 1], they differ from them by their flattening and widening at the base, besides by the disposition of the serrations.

VERTEBRAE. — Among the theropod vertebrae, recognizable by the fact that the centrum is very excavated on the sides and ventrally, we distinguish a group that immediately draws attention by their large size.

The Porto de Barcas locality has furnished 8 large vertebrae of this type.

A — An anterior dorsal (Coll. Fac. Sc.); the opening of the neural canal has a diameter of 3 x 3 cm (page 26, fig. 6 a).

B — A very powerful posterior dorsal (Pl. XIII, fig. 31, 32, 33) whose face has a somewhat less triangular shape (Torres Vedras Museum).

C — A rather planar anterior caudal (page 26, fig. 6 b) (Coll. Fac. Sc.).

D and D' — Two large, already more elongated caudals (Pl. XIV, fig. 35 and Pl. XXX, fig. 122), having belonged to a very large individual (Coll. Geol. Serv.).

E — A vertebra broken in two but entirely of the same type, although slightly smaller (Pl. XXV, fig. 86), was recovered at São Gregório de Fanadia (Coll. Geol. Serv.).

F and F' — Two middle caudals, of which one is complete (Coll. Geol. Serv.).

An anterior dorsal from Torrinha (Batalha) is 90 mm long with diameters of the face 100 mm x 110 mm (Pl. XIII, fig. 29 and Pl. XVIII, fig. 50).

Dimensions of the vertebrae of MEGALOSAURUS POMBALI

	LENGTH	WIDTH	HEIGHT (in cm)	
Vertebra A	8.5	12	12	(Fig. 6 *a*)

Vertebra B	13	17	15	
Vertebra C	7.5	12	10	(Fig. 6 *b*)
Vertebrae D and D'	16	14	12	
Vertebra E	13	13	11	
Vertebra F	12	10	8.5	
Vertebra G	13	9	8	

Finally, an amphicoelous and elongated posterior caudal (Pl. XIII, fig. 30), very pinched ventrally, was recovered isolated at Albergaria. It shows the powerful tail that this large megalosaur must have had. Length 135 mm; posterior diameters 90 x 100 mm (height).

MEGALOSAURUS SUPERBUS SAUVAGE
APTIAN

The author of this species had in his hands a 32 mm long fragment of tooth (Pl. XII, fig. 7) from Boca do Chapim (Cape Espichel). The diameter at the base is 20 mm. The denticles of the anterior edge stop a little below the upper third. Another fragment of a smaller tooth from the same locality was only specifically indeterminable to him (18 mm).

Such are the only documents indicating the existence of carnivorous theropods in Portugal at the beginning of Cretaceous times.

MEGALOSAURUS cf. **PANNONIENSIS** SEELEY
MAASTRICHTIAN

TEETH. — The Upper Senonian of Viso has furnished three fragments of megalosaurid teeth. The largest (Pl. XII, fig. 4) was figured by SAUVAGE [1897, pl. VIII, fig. 16] as *Megalosaurus* sp. The tooth is remarkable for its narrow form. Its diameter at the base is 12 mm. The point is broken, but the complete tooth must have been a little more than 30 mm long.

Another is an alveolar tooth 26 mm long (Pl. XII, fig. 5).

A third is only represented by a fragment, but one that shows the well-preserved, fine serrations of the two trenchant edges and the flattened general form (Pl. XII, fig. 20).

CLAWS. — Three forelimb claws come also from Viso (Pl. XII, fig. 19, 23, 24). They measure 20, 15 and 11 mm long, respectively. But the point is broken on all of them, which should cause an adjustment in length of 1.5 to 2 mm. They are symmetrical, and the groove is well marked on each side. The largest and smallest are very flat; that of medium size is proportionally thicker.

SIMILARITIES AND DIFFERENCES. — The much smaller size of the teeth and the elongated form of the serrations distinguishes the Viso *Megalosaurus* from the American carnivore

Dryptosaurus. In Europe, the teeth of megalosaurids are only very rarely noted in the Upper Cretaceous. Only *Megalosaurus pannoniensis* SEELEY (= *M. hungaricus* NOPCSA) is known in the Senonian of Austria and the Danian of Transylvania and the south of France [LAPPARENT 1947]. The shape of the serrations and the aspect of the tooth are similar; but the size is smaller, especially for the claws, in the Viso animal.

THE CAP MONDEGO FOOTPRINTS

The Faculty of Sciences of Lisbon preserves eleven counter-prints of an enormous dinosaurian reptile. They were found in 1884 in the Cap Mondego cliff, 2 km north of Buarcos, in relief on the lower part of a marly and lignitic limestone slab. We have relocated the precise locality, alongside the lignite mine on the beach [LAPPARENT, ZBYSZEWSKI, MOITINHO DE ALMEIDA & VEIGA FERREIRA 1951]; we saw there still three sandstone casts, which present themselves in cross-section and are different prints left in place. The prints were summarily described in a manuscript by JACINTO PEDRO GOMES, published posthumously [1916]. The scheme of this author, which we reproduce in fig. 7, is invaluable for making known their arrangement in the locality; there were 14 of them in all. The lower slab that bore the direct, hollow prints of the animal was destroyed by the waves and was not recovered.

The hollow prints were deeply impressed, from 6 to 10 cm according to the case, in soft ground by several animals walking on the mud. After consolidation of the sediment, these traces were filled by a coarse sand, whose very irregularly sized quartz grains are bound by a clayey-limestone sediment. Then the entirety was covered again by the spreading of a bed of finer sediments, a limestone that was marly yet intersected by sandy veins. It is a rather rare chance that a coarse sediment has preserved such fleeting vestiges.

The eleven prints that we have examined at Lisbon all belong to the same type (Fig. 8). The variations of form and size are easily explained by the more or less accentuated slip of the pes of heavy animals on the soft mud. The discovery plan shows that there are undoubtedly 4 or 5 intersecting trackways. By their consistently lesser dimensions, nos. 6, 7, 10 and 11 suggest that a slightly smaller individual accompanied other larger ones.

Fossil footprints often give a somewhat less deformed image of the foot of the animal. Although possessing several, the best ones are chosen and an average is established. Here essentially are tridactyl prints, but bearing the trace of a very reduced fourth digit, held on the side and not supporting the weight of the body; it corresponds to digit I. The characteristics of print no. 5, which can be taken for the type, are the following:

counter-imprint of left pes; heavy and powerful tridactyl print; total length, 64 cm; diameter of the central part, 20 cm; length of digit III, 21 cm; length of digit I, 7 cm; length of trailing heel, 19 cm; divergence between digit III and digit IV, 35°; between digit III and digit II, 30°; between digit II and digit I, 60°. The stride between two feet seems to have been about 1.40 m.

Counter-prints in relief from Cap Mondego (Coll. Fac. of Sciences)

No. of counter-print	Total length	Maximum width	Length of digit III	Length of digit I	Length of trailing claw	Depth of print	IV-III divergence	III-II divergence	II-I divergence
1	50	35							
2	65.5	24.5	19	9	16		10°	40°	
3	66	27	21	9.5	14	9		32°	
4	63.5	31	31	7	15			20°	40°
5	64	20	21.5	7	19		35°	30°	60°
6	43.5	26	24						
7	51	22	20	6.5		6	35°	36°	42°
8	65	25			20				
9	67	21			18	10	34°		
10	54.5	26		6	15		32°		
11	43	21			21.5				

The table above gives the measurements for each specimen. The most remarkable fact is the existence of a sort of heel, sometimes extremely elongated, behind the sole of the pes, measuring 15 to 20 cm, which makes the true length of the pes between 45 and 50 cm. Must this trace, as constant on all the specimens as it is on no. 1 where a prime example is seen, be due to the fact that the tarsal bones partly supported it during progression? Or furthermore, rather that the animal walked dragging the weight-bearing part of the pes before placing it plainly on the ground? In effect, some analogous cases were described [LULL 1915a (1953), p. 194 and 196] with a still more elongated form, and which can only be due to a dragging in the mud. Moreover, some prints of human feet on beach sand sometimes show a comparable trace of a heel behind, ensuing from a dragging progression.

The counter-prints from Cap Mondego should be attributed to large carnivorous theropods. They can be confused neither with those of sauropods, with columnar limbs and five digits, nor with *Iguanodon*-type ornithopods, as has already been remarked on from Dollo to J. P. Gomes, nor with those that could have been left by stegosaurians. Two types of Jurassic theropods are known in Portugal from teeth and bones, as has been seen previously. There is every reason to think that the Cap Mondego tracks are attributable to *Megalosaurus pombali*, a very large species according to the vertebrae. Among the known prints, they only have a certain similarity with those from the Liassic of Demnat in Morocco [LAPPARENT 1945]. In both cases, they are gigantic carnivorous theropods, but not the same species. The counter-prints from Portugal have an average size greater than 10 cm; the lateral digits are consistently farther apart; the mark of digit I, exceptionally known in the Demnat traces, is more constant in Portugal.

The reconstructions of the skeletons of *Antrodemus* and *Ceratosaurus* from America [GILMORE 1920, pl. 13 and pl. 30] permit giving an account of the tridactyl form of these large carnivores and of conceiving how the very reduced and non-weight-bearing digit I could nonetheless leave its trace impressed on the ground during the course of progression.

Fifty meters higher in the Lusitanian series, and 50 m below the lumachelle marble with *Ostrea pulligera*, we discovered in 1951 on the Cap Mondego beach (Pedra da Nau) a black limestone slab covered with 50 dinosaur footprints, which are hollowed into a soil with desiccation cracks (Fig. 9).

Here the traces are of two types. Five of them recall well those that have been described above: 60 to 70 cm in size; habitual presence of a fourth digit placed to the side. Sometimes the heavy beasts impressed deeply, sliding in the mid and giving for example a deformed imprint of 92 cm.

All the others belong to a smaller and more svelte animal of a different type, which is not a juvenile of the preceding form but another species. They are characterized thus: tridactyl prints, in only a single case showing the trace of digit I; average size: 30 to 40 cm long; distance between the ends of the lateral digits, 25 to 30 cm; stride between two feet, 1.20 m to 1.44 m along the trackways.

The traces are visible on the surface of three superimposed limestone laminae, which evoke frequent muddy scatterings in an estuary uncovered at low tide and of which the Rio Mondego bay gives a recent striking image, not far from the locality.

The attribution of these two types of prints to theropod, among which are some animals of the large carnivore lineage (Carnosauria), is undoubted.

Although the Cap Mondego prints do not have an exact equivalent in the ichnological descriptions from the Connecticut Triassic [LULL 1915a], it is however notable that the smallest are not without analogy in the types *Anomoepus* and *Eubrontes*.

But we can go further. In effect, or studies have revealed the presence of two theropod species in the Malm of Portugal: *Megalosaurus insignis*, of moderate size; and *M. pombali*, a new species known especially from powerful vertebrae.

Without doubt, the teeth and bones characterizing these two species were found in beds a little more elevated stratigraphically and of Kimmeridgian age. But on the one hand, for example at Ourém, these pieces are found at the limit of the Lusitanian and Kimmeridgian; on the other hand, at Cap Mondego, the same large prints are found at two levels separated by 50 m of sediments, while the Kimmeridgian begins on the beach about 140 m above the slab bearing the 50 prints. Besides, it is known that the reptile fauna is not characteristic of a stage and is constant throughout the Malm.

Alongside the footprints, geologists generally do not find bones of the animals that produced them, and with good reason: they died farther away and later. It is the same in Portugal. And, however, here we have the chance to be able to refer with great probability the two types of prints from Cap Mondego to two species of theropods known hereafter in the Upper Jurassic of this country.

MEASUREMENTS OF SOME HOLLOW PRINTS ON
THE BLACK LIMESTONE SLAB FROM CAP MONDEGO, 1951 (cf. fig. 9)

No. of print	Total length	Length of digit I	Distance between the ends of the lateral digits	IV-III divergence	III-II divergence
Very large prints (*Megalosaurus pombali*):					
1	63		53		
3	71	14	54		
4	58		54	45°	40°
12c	92				
Moderate prints (*Megalosaurus insignis*):					
5	32		32	60°	35°
6	31		28		
7	25		20		
15a	32		24		
15b	40				
17	58 (a)		26		
22	27		26		
22a	61 (b)		30		
24	35		28		
24a	43		27		
26	32		26		
28	25		31		
29	41		30		
30	28		30		
31	36		28		
32	37		33		

2 — THE HERBIVOROUS SAUROPODS

Different from the more slender and agile carnivorous theropods, the herbivorous sauropods attract attention immediately by their bones of gigantic proportions. In the Jurassic of Portugal, there was the chance to find several discoveries of whole bodies, which had floated,

(a) With a heel.
(b) Pes having slipped.

and whose truly complete bones could be collected in the same locality to the exclusion of the bones of all other animals. It is in this same manner that *Apatosaurus* from Alenquer and *Brachiosaurus* from Atalaia are presented, as well as a dwarf form aside these giants, *Astrodon* from Casal da Pedreira. Extended well beyond this choice material, more fragmentary discoveries made in other localities are not disregarded, which fortunately complete the anatomical description of these sauropods.

APATOSAURUS ALENQUERENSIS nov. sp.
LUSITANIAN-KIMMERIDGIAN

VERTEBRAE. — The Alenquer locality has furnished more than 26 enormous vertebrae belonging to the floated body of a single individual. Although very fragile, many could be reconstructed, at least with regard to the centrum.

4 anterior cervical vertebrae can be recognized, characterized by their very reduced size and very accentuated proportional elongation. The least broken measures 25 cm long and 15 cm wide. One cervical is already of much more considerable size; it is strongly opisthocoelous and measures 50 cm long; moreover this number is a little strong due to the flattening that it sustained.

The total number of dorsal vertebrae can subsequently be reconstructed as 11 (Pl. XVII, fig. 45). They are very strongly convex anteriorly (Pl. XV, fig. 41) and very concave posteriorly; several are found still deeply and solidly fit into one other. They are striking at first by their extraordinarily powerful aspect, compensated moreover by the deep excavations hollowing and thus notably lightening the centrum. The measurements taken on the least deformed give the following averages: length 30 cm; width 30; height of centrum 25. The three last dorsals are still strongly convex anteriorly and concave posteriorly; their average measurements are: length 30 cm; width 30; height 35. The lateral opening in the centrum is small and situated higher, which distances them from those of *Bothryospondylus*[*].

The dorsals are followed by five fused vertebral centra that represent the sacral vertebrae; they are much of the type of *Brontosaurus* [MARSH 1896, pl. XXIII].

Two enormous anterior caudals were found very nearby; they are flat posteriorly and slightly concave anteriorly; their face is circular and measures 30 cm in diameter; the neural canal is not a proportionally very large opening: 3.5 cm (Pl. XXI, fig. 69; Pl. XXVII, fig. 99; Pl. XXXV, fig. 149). There are also fragments of three other anterior caudals.

The neurapophyses of two vertebrae can be reconstructed, probably those of the last sacral and the first caudal. Above all note the curvature and thickness of the neural spine, which gives them a remarkable thickness for muscle attachment; but the spine is not extremely long. The neural canal has a 4 cm opening. The table below gives their measurements.

Total height	Greatest width of the neural spine	Smallest width of the lamina	Greatest thickness of the top of the spine

[*] *sic*: *Bothriospondylus* [MTC].

Spine A	38	15	5	13
Spine B	36	13	5	12.5

RIBS. — The Alenquer locality has furnished two cervical ribs, remarkable for their form and very large size. The most massive (A) belongs to the left side. The other, from the right side, must be situated more anteriorly; its shape is more slender, and the two rami are farther from one another, forming nearly a right angle. Here are their dimensions:

	Largest diameter	Width of the head	Width of the tubercle
Rib A	51	14	24
Rib B	46	12	12

The very great development of the cervical ribs is one of the characters of the genus *Brontosaurus*.

Portions of approximately 22 thoracic ribs belonging to the same animal have been reconstructed. They are large and of the classic sauropod type. The largest are flat ribs from the middle of the back that measure 11 cm wide at the maximum. Others, rounded and shorter, are anterior thoracic ribs; one, measuring 8 cm wide, was reconstructed as 122 cm long but is incomplete.

In all probability, 3 thoracic ribs found in the locality near Ribamar can be referred to *Apatosaurus alenquerensis*. The most complete is 160 cm long and 5 cm wide in its flat part; the end tapers into a very thin lamina. Another is 8 cm wide. A third is still wider and its end is inflated to a diameter of 12 cm.

PECTORAL GIRDLE. — Two scapulae with associated coracoids have been recovered (Fig. 10). The length of the scapula is 167 cm; the width of its distal end is 52 cm. The thickness of the bone bordering the glenoid cavity reaches 24 cm. This scapula is remarkable by the development of its upper part and the widening of its distal end.

The coracoid is massive but elongated transversely as in *Apatosaurus* [MARSH 1896, pl. XIX]; its largest diameter measures 53 cm; the edge of the glenoid cavity is 23 cm tall. The coracoid foramen is clearly visible and plunges obliquely as a canal.

FORELIMB. — The well-preserved long bones of the right limb were found still in position and undeformed.

The humerus [Pl. XX, fig. 58] measures 150 cm long; the transverse dimensions are: 60 cm for the proximal part, 43 for the distal part, 18.5 for the narrowest part of the shaft. This bone is remarkable for the slenderness of the shaft relative to the width of the two ends, and by the position of the deltoid process situated entirely on the edge.

The ulna is 106 cm long. The 101 cm long radius was found still enclosed in the furrow of the proximal part of the ulna (Pl. XX, fig. 61).

These three forelimb bones are of massive, heavy form; they must have furnished veritable “columnar” limbs.

The bones of the left carpus were determined relative to the figure given by OSBORN [1904] of the sauropod “manus”. The largest (15 cm long) probably represents the fusion of the three bones $c^1 + c^2 + c^3$, and must have rested on

metacarpals I, II and partially III. The second (10 cm) must represent carpal bones c^4 + c^5 and rested on metacarpals IV and V.

In the same lot is the proximal part of metacarpal III and above all a phalanx from digit II from the left manus, remarkable for its strong asymmetry.

PELVIS. — The pelvis of the Alenquer animal is known from three complete bones. The left ilium is remarkable for its great size (125 x 85 cm) and the powerful mass that forms the pubic peduncle; this articular surface with the pubis measures 28 cm in diameter.

The two ischia (Pl. XIX, fig. 51, 52) are 111 cm at their greatest length; the distal end, in a progressively wide lamina, is similar to that of *Haplocanthosaurus*.

The pubes are astonishingly massive (Fig. 12), of the *Brontosaurus* type figured by MARSH [1896, pl. XXXVI, fig. 2]. This may be judged from the following measurements: total length 110 cm; diameter of the articular surface with the femur 30. The distal end is very wide and massive, with a thickly triangular form, and ornamented with strong rugosities; its greatest diameter is 26 cm. The rugose articular surface with the ischium is 30 cm long. The foramen is an oblique opening, rounded as in *Brontosaurus*, and situated in the proximal part near the pubo-ischial symphysis.

HIND LIMB. — The bones of the left hind limb were found in articulation. The femur (Pl. XVIII, fig. 47) was by chance neither deformed at all nor flattened, so that the following measurements are very exact:

total length…….……..	174 cm
width of the proximal part…….	60 “
width of the distal part……...	53 “
minimum width of the medial part……..	30 “
projection of the endocondylar tuberosity of the distal part…….	17 “

The ends are ornamented with very strong rugosities.

The tibia (Pl. XX, fig. 56, 57) is 110 cm long with a minimum shaft width of 19 cm; the largest diameter of the upper surface, which received the weight of the femur, is 50 cm.

The fibula (Pl. XIX, fig. 54, 55) measures 116 cm long; its three diameters, from top to bottom, are 21, 11 and 19 cm respectively.

The left astragalus is a massive bone that is articulated with the preceding tibia and fibula. The two diameters are 36 and 23 cm; the height is 17.5 cm. Its dimensions are thus exceptionally strong and its remarkable transverse elongation must be noted.

The calcaneum is partly preserved still in place, stuck under the external part of the tibia; this is a square bone with rounded edges, with a diameter of 13 cm.

The right femur was recovered, but incomplete in its distal part.

TAIL FROM S. BERNARDINO. — The floated body at Alenquer must have accidentally lost its tail, of which no element was recovered apart from all of the first caudal vertebrae. But the S. Bernardino locality has furnished a series of 15 caudal vertebrae similar to the *Brontosaurus* type (Pl. XVI, fig. 43), as we have noted by comparison with the caudals figured by OSBORN [1904, p. 190, fig. 6].

First there is a 19 cm thick anterior caudal vertebra. The powerful vertebral face measures 29 x 23 cm, but these figures are partly inaccurate because of deformation sustained in the locality. This is perhaps the 6th or 7th anterior caudal, so that little is lacking to connect the S. Bernardino tail to the sacral vertebrae of the Alenquer animal.

After a gap of probably two vertebrae comes an uninterrupted series of connected vertebrae, nearly all reduced to the centrum. The five last anterior caudals have a massive, elevated form. The measurements ahead of the last (Pl. XXIX, fig. 116) are: length 17 cm, width 24, height 21.

The nine subsequent middle caudals (Pl. XXXV, fig. 153) tend to be elongated, but they still remain rather tall, as the measurements taken on the 7th indicate: length 15 cm, width 14.5, height 12.5. The first of these middle caudals partly preserves its neurapophysis.

OTHER LOCALITIES. — Some fragmentary remains, attributable to the same species as the Alenquer animal, were found in several other localities.

A 42 cm long sauropod cervical vertebra, slightly flattened but bearing its prezygapophyses, accompanied the remains of *Omosaurus armatus* at Baleal. There were still three other cervical vertebrae, but very battered.

Some caudal vertebrae of the *Brontosaurus* type were recovered isolated in a certain number of Kimmeridgian localities. They can be placed fairly exactly by reference to the S. Bernardino tail.

First there is an enormous anterior caudal, found at Areia Branca (Coll. Fac. Sc.). It is entirely similar to those from Alenquer, and its diameter (31.5 cm) likewise indicates a smaller animal. Its length is 15 cm. It is flat posteriorly and rather hollow (5.5 cm) anteriorly; the width of the neural canal is 6 cm.

We note the following:

A 6th middle caudal from Porto das Barcas.

A 7th middle caudal from Porto das Barcas (Pl. XVIII, fig. 49). Length 130 mm; posterior diameters 135 mm x 110 mm.

A 9th caudal from Salir de Matos (Caldas da Rainha). Length 130 mm; posterior diameters 135 mm x 120 mm (Pl. XXI, fig. 70 and Pl. XXIX, fig. 117).

An 11th caudal from Porto das Barcas (Pl. XIII, fig. 31, 32, 33), belonging to the Torres Vedras Museum.

A 12th caudal from Alcobaça (Pl. XV, fig. 39). Length 120 mm; posterior diameters 106 mm x 110 mm.

A 13th caudal from Praia de Santa Cruz (Pl. XXI, fig. 68). Length 120 mm; posterior diameters 115 mm x 90 mm.

The collections of the Superior Technical Institute of Lisbon include a small posterior caudal from the Chiqueda de Cima locality, near Alcobaça. It measures: length 8.5 cm, width 6, height 5.5, and it seems to us to belong to the end of the tail of an *Apatosaurus*.

Two humeri, a right and a left, we recovered from Praia dos Frades and Foz do Arelho, respectively. They are of entirely the same type as that of the Alenquer animal,

particularly in the narrowness of the shaft (minimum diameter 19 and 15.5 cm) and the position of the deltoid process at the exterior edge of the shaft; this process projects 12 cm on the first, 11 cm on the second. These humeri belong to animals of different sizes, both smaller than the Alenquer individual.

A left humerus is preserved at the Superior Technical Institute, only represented by the proximal part of the shaft but furnished with the deltoid process; it comes from São Mamede near Obidos. Its minimum diameter is 14 cm.

Another left humerus, of the same type but smaller, comes from an old collection at Ourém. The smallest midshaft diameter is 11 cm; the deltoid crest projects 7 cm.

Some large reddish bones, generally very worn, come from an unspecified point in the environs of Torres Vedras. Portions of two humeri and two femora can be recognized there, indicating columnar limbs of the *Apatosaurus* type, but from an animal a little smaller than that from Alenquer.

Finally a 22 cm long left Vth metatarsal from a sauropod, recovered isolated at Castanheira, may also be referred without doubt to *Apatosaurus* (Pl. XXV, fig. 89).

ISOLATED TEETH. — Sauvage attributed a tooth formerly recovered from the Jurassic of Ourém (Pl. XXVIII, fig. 105A) to a new species of *Morosaurus*. The enamel being destroyed, only the form of the object could be examined, which was slightly deformed besides. However, a tooth of typical sauropod type is recognized in its elongate spatular form. The root is cylindrical; the crown is asymmetrical, and "excavated in the shape of a spoon" [SAUVAGE, 1897098] on the internal face. An accentuated convexity leaning to the right of the midline ornaments the external face. Dimensions: length 43 mm; width 18 mm; thickness 13 mm.

Another slightly larger tooth, of entirely the same time, was preserved in the Upper Jurassic museum case at the Faculty of Sciences of Lisbon, but without indication of locality. Wear against the opposing tooth has deeply hollowed it on one side. The cross-section is oval. Broken at the neck, it has a length of 48 mm; its diameter is 17 mm near the base (Pl. XII, fig. 1).

The very extended attribution of isolated teeth is very hazardous. These two teeth incontestably resemble those of *Morosaurus* figured by Marsh. But on the one hand, it is known from the Damparis specimen [LAPPARENT 1943] that the form of sauropod teeth varies according to their position in the jaws; on the other hand, the rather poorly known teeth of sauropods seem very similar in different genera. As the two teeth in question also resemble those of *Brontosaurus* (MARSH 1896, pl. XX, fig. 1], and as in Portugal we have identified the bones of this genus and not those of *Morosaurus* (if it is truly distinct from *Brontosaurus*), it seems reasonable to us to attribute them instead to *Apatosaurus alenquerensis*.

SIMILARITIES AND DIFFERENCES. — A rather notable confusion still reigns on the subject of the distinction of sauropod genera and species. In a first period, paleontologists believed, both in America and in England, of numerous genera and species of the occasion of discoveries that were multiplied. At the current time, the number of species and also genera is restrained in considerable proportions.

Concerning the *Brontosaurus* group, the works of HOLLAND [1915b] and GILMORE [1936] have shown that *Brontosaurus* MARSH lies in synonymy with

Apatosaurus MARSH, a denomination with priority of date, in spite of the greater fortune of the term *Brontosaurus*, the "thunder lizard". Moreover, only two species are retained: *Apatosaurus excelsus* MARSH sp. and *Apatosaurus louisae* HOLLAND.

The specimen from Portugal shows all the characters of the genus *Apatosaurus* = *Brontosaurus*: strength of the cervical vertebrae; development of the cervical ribs; massive, elevated form of the middle caudal vertebrae; very short forelimb relative to the hind limb; large and very massive pubis. With regard to the species, the Alenquer animal seems to be distinguished rather clearly from the American forms, in particular from *A. louisae*, by the fact that its forelimb is shorter relative to the hind limb, as the following table shows:

	Humerus	Ulna	Radius	Femur	Tibia	Fibula
Apatosaurus louisae….	115	85	80	178	111	116
Alenquer animal….	150	106	101	174	110	116

Some other non-negligible differences are observed in the form and dimensions of the cervical ribs, the slightly more slender pelvis, and the elongation of the astragalus.

Thus we think that the Portuguese animal, the first representative of the genus *Apatosaurus* (= *Brontosaurus*) discovered in Europe, belongs to a new species, *Apatosaurus alenquerensis.*

BRACHIOSAURUS ATALAIENSIS nov. sp.
LUSITANIAN-KIMMERIDGIAN

Another gigantic sauropod, very different from the preceding one, seems to be very rare in the Kimmeridgian of Portugal. It is known above all by a single animal recovered at the top of the Atalaia cliffs.

VERTEBRAE. — The locality has furnished 28 vertebrae from one vertebral column (Pl. XVI, fig. 44). The following elements are recognized.

An anterior cervical, perhaps the 5th or 6th, very strongly convex anteriorly (Pl. XXV, fig. 85). The length of the centrum is 20 cm and its height is 12 cm. Another anterior cervical, probably close to the preceding, is very deformed.

Only a single dorsal can be recognized, from the middle of the back (Pl. XXII, fig. 71, 72). The centrum is 20 cm long and 24 tall. It is slightly excavated anteriorly and a little excavated posteriorly. The lateral cavity is large and situated lower than in *Diplodocus*. Two dorsal vertebral neurapophyses, whose height exceeds 50 cm above the centrum, were partially reassembled.

Two well-preserved anterior caudals are slightly amphicoelous, more concave anteriorly than posteriorly. The face of the vertebral centrum has a diameter of 26 cm on one, 24 on the other. The neurapophysis of the largest (Pl. XXIII, fig. 76, 77), probably the 2nd or 3rd anterior caudal, is rather well preserved. The neural canal has a diameter of 5 cm on this vertebra.

A more elongated anterior caudal has a diameter of 18.5 cm (Pl. XXIX, fig. 111). It still bears its neurapophyses and diapophyses; these extend nearly horizontally. The diameter of the neural canal is reduced to 4.5 cm

After a gap of three or four vertebrae, an uninterrupted series of 18 vertebrae begins, of which several have preserved various processes (Pl. XXIII, fig. 80 and Pl. XXII, fig. 74, 75). The first of the middle caudals measures 15 cm long and has a posterior diameter of 17.5 cm (Pl. XIX, fig. 53). But they do not delay to become elongated and simultaneously flattened dorsoventrally. Thus the 7th middle caudal measures 15.5 cm long and has a posterior diameter of 13.5 cm, while still being circular. Then the flattening becomes increasingly manifest, and the 17th middle caudal has a width of 10.5 cm for a height of 8 and a length of 12.5. The diameter of the neural canal is 3 cm on the 8th and 2 cm on the 17th.

The posterior caudals begin with the following vertebrae, whose dimensions diminish rapidly while their neurapophyses are reduced; length 11.5 cm; posterior diameters 9.5 cm and 7. The rest of the tail was not found; but according to the form of these caudals, the animal must have had a proportionally not very long tail.

The posterior caudal vertebrae are remarkable for the following characters.

Dorsoventrally flattened; narrowness of the central part of the vertebral centrum, which as a result puts the anterior and posterior vertebral faces into projection; prezygapophyses forming a rather acute angle (20°) at the start and diminishing rapidly, so that the anterior ends quickly become parallel to one another.

All this is in opposition to *Apatosaurus alenquerensis*, in which the posterior caudals are in contrast laterally compressed.

A good series of 12 caudal vertebral chevrons or haemapophyses come from this locality.

The dimensions of the four figured specimens are as follows:

Pl. XVII, fig. 46: length 315 mm; Pl. XXII, fig. 73: length 225 mm; Pl. XXIII, fig. 78L: length 120 mm; Pl. XXIII, fig. 79: length 255 mm; Pl. XXII, fig. 138: length 315 mm; width of the lamina 43 mm. The largest belong to anterior caudals and decrease in size from 40 to 30 cm long, according to their more or less anterior position. The width of the inferior lamina attains 6.5 mm in a 37 cm long specimen (Pl. XXIX, fig. 112). Some smaller chevrons, 20 to 15 cm long, must be attached to the last anterior caudal vertebrae. The chevrons of the first anterior caudals are closed by a bony bar; the subsequent ones are open, in the sense that their rami are free at their proximal part.

RIBS. — Several portions of sauropod ribs were recovered at Atalaia. Some are flat and 7.5 cm wide; others are round and have a diameter of 4 to 5 cm. Their total length is not known.

PECTORAL GIRDLE. — The distal end of a scapula is 52 cm wide; the rest of this bone was not found.

A fragment of flat bone 15 cm wide and ornamented on the two edges opposing the articular surfaces is referred to a right sternum Compared to the sternum of *Diplodocus*, it is of proportionally smaller dimensions.

FORELIMB. — The entire proximal portion of a right humerus, very large and remarkable for its slender form, is preserved undeformed for 101 cm. The maximum width of the superior part is only 55 cm. The middle of the deltoid crest is situated 72 cm from the head of the bone. Given the constant position of this crest on sauropod humeri, in all at a little more than one-third of the length of the bone, it can be calculated that this humerus was at least 205 cm long; this refers it immediately to the genus *Brachiosaurus*. The thick, rugose greater tuberosity is moreover located exactly as in *Brachiosaurus altithorax* [RIGGS 1903, fig. 1, p. 302]. We judge that the minimum width of the shaft is 23 cm and that the deltoid crest projects 10 cm.

The proximal part of the left humerus (Pl. XXIV, fig. 81, 82) could be reconstructed and shows the same characters. That of the right humerus is less complete.

We have the proximal part of the left ulna (Pl. XXV, fig. 88) preserved for 51 cm, and the distal part preserved for 44 cm (Pl. XXVIII, fig. 109); the central part of the shaft is broken. The proximal part is 40 cm wide; it is hollowed by a deep furrow where the radius lodges. The distal part ends in a powerfully rugose mass of broadly quadrangular shape; its largest diameter is 24 cm. The length of the bone can be evaluated at 115 cm.

The left radius is complete (Pl. XXVI, fig. 90; Pl. XXIX, fig. 115) and measures 113 cm long for a minimum midshaft diameter of 14 cm. This bone is astonishing for its remarkable length and gracility, compared to those of other sauropod families.

It seems to us that a very large bone, curious for its torsion, which intrigued us for a long time, must be attributed to the carpus of this animal (Pl. XXVII, fig. 97, 98). It is a right metacarpal II whose measurements are: length 37 cm; width of the proximal part 22, of the shaft 6.5, of the distal part 15. The articular surface for the phalanx has an oblique orientation. This arrangement, classic in sauropods, has the effect of separating the digits in order to more equally distribute the weight of the body on the base of the limb. The length and strength of this bone underlines the disproportional elongation of the forelimb that characterizes *Brachiosaurus*.

The size, width and torsion of this bone also inclined us to compare it to a sacral rib that had been detached accidentally from the sacrum. But its attribution to a metacarpal was plainly confirmed by Dr. Swinton, with whom we examined the question during a trip to London. The bone is intermediate between the right metacarpal II of *Brachiosaurus brancai*, whose length is extraordinary (63 cm) and of much more slender shape, and that of *Tornieria robustus*, 28 cm long and proportionally wider [JANENSCH 1922].

PELVIC GIRDLE. — An important 77 cm long fragment showing the superior edge of the ilium already indicates a pelvis that is proportionally much more slender than that of *Brachiosaurus.*

This impression is confirmed by the discovery of the rather slender left ischium (Pl. XXVIII, fig. 106); its largest diameter is 27 cm, instead of 35 in *Apatosaurus alenquerensis*; the height of the articular surface with the ilium is 15 cm. The shape of the distal end, accidentally broken, is unknown.

The left pubis is nearly complete (Pl. XXIV, fig. 84). The bone is rather flat and wide (26 cm at the minimum) but not very long (76 cm). The ends are without

comparison much less powerful than in *Apatosaurus*, as can still be seen on the distal end of the right pubis, preserved without deformation.

HIND LIMB. — A portion of an enormous left femur, preserved as 102 cm long and coming from the Praia de Areia Branca locality, must be referred to the same species, if not the same individual. Undoubtedly a little flattened, it measures 65 cm for the largest diameter of the proximal part and 41 for the smallest diameter of the shaft. Calculating the proportions on the part in our possession, the length of this bone can be evaluated at nearly 2 meters (Pl. XXI, fig. 64-65).

The left tibia was recovered at Atalaia in a perfect state of preservation (Pl. XXIV, fig. 83; Pl. XXVI, fig. 92); it is 112 cm long and the enormous articular surface with the femur measures 29 x 32 cm.

The proximal end of the left fibula has a maximum width of 30 cm and a shaft diameter of 15 cm; it is broken 51 cm from the end (Pl. XXVI, fig. 91).

A curious object, the left astragalus of this same animal (Pl. XXVII, fig. 103), which articulates perfectly with the corresponding tibia, is much stockier than the same bone from the Alenquer sauropod, its measurements being: 32 cm long; 22 wide, 17 tall. This observation underlines anew that, if the Atalaia sauropod had markedly longer limbs, they were also much more slender in aspect.

OTHER. LOCALITIES — Some *Brachiosaurus*-type vertebrae were recovered in several localities. They are grouped in the following table, with their dimensions, locality, and the museum where they are currently found.

Locality	Museum	Vertebra	Length	Width	Height
Areia Branca……	Fac. Sciences	anterior caudal	15	19	17.5
Porto Novo (Maceira) (Pl. XXVI, fig. 94)….	Geol. Serv.	anterior caudal (a)		18	19
Alcobaça……..	Sup. Tech. Inst.	4th middle caudal	13.5	14.5	13
Cambelas (Pl. XXVI, fig. 95) ……	Geol. Serv.	5th middle caudal	15	16	13
Praia das Almoinhas……	Geol. Serv.	posterior caudal	12 (b)	9.5	7

Smaller individuals are recognized at Porto Novo and Alcobaça, compared to those from Atalaia.

SIMILARITIES AND DIFFERENCES. — The Atalaia sauropod, whose description is given and to which are joined some elements from other localities, is remarkable for an entire group of traits that characterize it, which are summarized as follows.

"Unusual length of the forelimb bones: humerus, radius, ulna, and metacarpals. — The limbs are very long but relatively slender: humerus and femur measure at least 2 meters. — The forelimb is larger than the hind limb, which is known only in the genus *Brachiosaurus*:

humerus 205 cm femur 200

(a) One of the last anterior caudals.

ulna	115	tibia	112
	320		312

Pelvic girdle much more slender than in *Brontosaurus*. — Amphicoelous anterior caudal vertebrae furnished with very large chevrons. — Posterior caudal vertebrae dorsoventrally flattened; their vertebral centra are narrow in the central part; the prezygapophyses form a very acute angle."

The comparative measurements of the femur show, for this bone for example, a close resemblance between the American *Brachiosaurus* [after RIGGS 1903] and that from Portugal:

	Brachiosaurus altithorax	Atalaia *Brachiosaurus*
length……..	203	200 cm
width of head……..	59	65 (c)
width at 4th trochanter…….	43	40
distance from the head to the upper part of the 4th trochanter…….	78	70

Must it be referred to the same species for this reason?

In fact, *Brachiosaurus* is still poorly known. The American species is founded on a rather incomplete lot of bones; East Africa has furnished *Brachiosaurus brancai* on the one hand, *Tornieria* (= *Gigantosaurus* in part) on the other (JANENSCH 1922, 1937].

The differences with *B. brancai* are certain; it has cervical vertebrae reaching nearly a meter long and forelimbs still more gigantic than those from Portugal. It is perhaps a new genus among the Brachiosauridae; it is at least a new species, which we name *Brachiosaurus atalaiensis*.

PELOROSAURUS HUMEROCRISTATUS HULKE
LUSITANIAN-KIMMERIDGIAN

Two large sauropod teeth were recovered formerly in the Upper Jurassic (Lusitanian), one from Ourém and the other at Fervença near Alcobaça (Pl. XII, fig. 11). This type of very open spatulate tooth, pointed toward the top, with an accentuated convexity and widened on its external face, has been described several times from the Upper Jurassic of England and the Boulonnais, but under very diverse names: *Caulodon, Neosodon, Ornithopsis, Pelorosaurus*. SAUVAGE [1897] had well identified the two teeth from Ourém and Fervença, comparing them to those already known, and for which he finally adopted the genus name *Pelorosaurus* and gave the species name *P. humerocristatus*.

Above all, it can be asked whether these teeth necessarily indicate the presence of this rather poorly defined sauropod genus in Portugal, moreover belonging to the family Brachiosauridae. Or better whether they would not be referred rather to the gigantic *Brachiosaurus atalaiensis* whose bones were found in several Jurassic localities? The question can at least be posed.

(b) Calculated.
(c) A little flattened in the locality.

ASTRODON PUSILLUS nov. sp.
KIMMERIDGIAN

A lot of bones, presenting the same blackish aspect of fossilization and having belonged according to all probability to a single individual, were brought in from the Casal de Pedreira locality, near Lourinhã. At first, these bones are astonishing by their simple aspect and the small size of the dinosaur to which they belonged. One thinks immediately of the sauropod genus so remarkable for its reduced size, *Astrodon* (= *Pleurocoelus*). Moreover it is very poorly known to us, although its sparse remains, teeth and bones, were found in the Upper Jurassic and Lower Cretaceous of America and also noted in the Kimmeridgian and Wealden of Europe.

MARSH [1896] described several bones from the American Jurassic that he attributed to two species, *Astrodon montanus* and *A. nanus* (= *A. johnstoni*).

From Lourinhã, we have the following elements.

VERTEBRAE. — A very flat (length 3 cm) anterior caudal (Pl. XX, fig. 62; Pl. XXVI, fig. 93), whose face is 6.5 cm wide and 5 cm tall. It is slightly amphicoelous, a little more concave posteriorly than anteriorly. The trace of the neural canal is widened posteriorly with a very characteristic arrangement. It is very similar to that figured by MARSH [1896, p. 184, fig. 38-41] and slightly larger.

Another more elongate, platycoelous anterior caudal (Pl. XX, fig. 59-60) is remarkable for this form of the neural canal and its flattening: length 4.5 cm; 8 cm wide and 4 tall for the posterior face. It resembles the caudal vertebra figured by MARSH [1896, Pl. XI, fig. 8-9], without being identical.

Finally, an equally platycoelous posterior caudal (length 4 cm) is more massive: 5.5 cm wide and 4.4 cm tall.

LIMBS. — We have the proximal ends of four metacarpals (Pl. XXVIII, fig. 107 and Pl. XXIX, fig. 113, 114). The dimensions of the specimen in fig. 112 are 45 mm x 47 mm at the articulation. Those of figure 114 are 28 mm x 57 mm. They approach those of *Morosaurus* in their form, but are evidently much smaller [cf. MARSH 1896, Pl. XLI]; they indicate a proportionally very elongate metacarpal.

20 cm of the distal portion of a right femur is preserved (Pl. XXX, fig. 124 and Pl. XXXI, fig. 129). The maximum width of the head of this bone is 14 cm. The total length of the femur must be between 55 and 60 cm. The middle trochanter is strongly revealed; it stops abruptly toward the top, where an elongate depression is observed above it.

The distal end of a tibia has a diameter of 8 by 4.5 cm (Pl. XXXII, fig. 140).

The proximal fragment of a metatarsal is 6 cm wide [cf. MARSH, 1896, Pl. XLI, fig. 4].

A rounded ungual phalanx, 3.8 cm long and 3.5 cm wide, probably belonged to digit I (Pl. XXVIII, fig. 104). Another phalanx (from digit IV?) measures 4.5 cm by 3.5; it is flatter (Pl. XXI, fig. 66-67). We do not know, more than for the analogous objects figured by MARSH [1896, pl. XLI, fig. 5-7], whether it must belong to the fore- or hind limb.

The distal end of a scapula comes from the same locality, but not the same excavation. By its very simple contour and flattening, it is of the *Morosaurus* type, which well approaches *Astrodon*, in effect partly because of its size. It measures only 10 cm wide at its end.

Several bones found in other localities must still belong to this small sauropod: a very flat, slightly amphicoelous anterior caudal vertebra, recovered isolated at Areia Branca, measures 3.5 cm long, 7.5 wide and 5.5 tall (Pl. XX, fig. 63); then the proximal end of a metacarpal from Porto de Mós. The presence of *Astrodon* bones in at least three Portuguese Kimmeridgian localities indicates a certain abundance of these animals in the Jurassic fauna.

A little larger than *Astrodon nanus*, whose femur is only 39.5 cm long, the Portuguese species also presents specific characters, in particular in its caudal vertebrae and the form of its unguals. All this amply justifies a new denomination, and we propose to name it *Astrodon pusillus*, hoping that future discoveries make this small dinosaur, which lived alongside the previously described gigantic sauropods, better known.

We do not think that *Astrodon* is simply a juvenile of *Morosaurus* or *Brontosaurus*, although this hypothesis has been put forth. If the limb bones have an analogous form, in contrast the teeth and vertebrae seem very different.

ASTRODON VALDENSIS LYDEKKER
APTIAN

Under the name *Pleurocoelous valdensis*, SAUVAGE [1897] referred three teeth worn by mastication that were recovered at Boca do Chapim with reason to a small sauropod, although of the *Morosaurus* (= *Camarasaurus*) type. It has since been recognized that the name *Pleurocoelus* MARSH is synonymous with that of *Astrodon* COPE.

Two of these teeth measure 22 mm long (Pl. XII, fig. 2, 3). The internal face is hollowed into a spoon shape, whereas the external face is convex and asymmetrical. They are well of the type figured by MARSH [1896, pl. XL, fig. 2]. A third tooth, much narrower, is worn down to the root; it perhaps belongs to the anterior part of the jaw (Pl. XII, fig. 21).

It is interesting to note that in Portugal, as in America, the genus *Astrodon* is present in the Upper Jurassic and also passes into the Lower Cretaceous; in England it has been noted above all in the Wealden, and numerous teeth of *Pleurocoelus* (= *Astrodon*) from the Weald and the Isle of Wight are preserved in the British Museum collections. But the European species are different from those across the Atlantic, whereas that from the Portuguese Aptian seems to be the same as that from the Weald.

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* *

The carnivorous or herbivorous animals examined until now possessed a triradiate pelvis, of lizard-hipped type. We now arrive at an entirely different group of dinosaurian reptiles, the bird-hipped forms, whose tetraradiate pelvis recalls the structure of that in birds by simple and

rather distant convergence. Two groups are to be considered, the ornithopods and the stegosaurians.

3 — THE ORNITHOPODS

IGUANODON MANTELLI MEYER
APTIAN

The Boca do Chapim locality north of Cape Espichel has furnished diverse, various fragments of *Iguanodon*; until now it is the only one in the Portuguese Lower Cretaceous to have produced this reptile, although the fluviatile or lacustrine beds of this age present extended outcrops in Portugal.

TEETH. — Two large *Iguanodon* teeth, in a very good state of preservation (Coll. Fac. Sci.), formerly recovered at Boca do Chapim, were examined and figured by SAUVAGE [1897, pl. X, fig. 3-4]; the crown measures 50 mm long and 30 mm wide (Pl. XII, fig. 12, 15). A third tooth, preserved at the Geological Services in Lisbon, very altered and deformed but having the same proportions (50 x 33 mm), is referred to the same species. We add further a fragment of a small tooth, very worn but showing the characteristic marginal crests. During a common excursion to Boca do Chapim (5 October 1951), O. da Veiga Ferreira found there another large *Iguanodon* tooth whose point is worn by mastication. The ebony black enamel is perfectly preserved. The tooth measures 40 mm long and the crown is 22 mm wide at the worn summit (Pl. XII, fig. 13).

All these teeth are referred very exactly to *Iguanodon mantelli*, known in Europe during the entire Lower Cretaceous and also noted in the Aptian-Albian age sands of the extreme south of Tunisia [LAPPARENT 1951].

VERTEBRAL COLUMN. — Two platycoelous anterior caudal vertebrae come from the same locality. The first measures 11 cm long with a 14 x 14 posterior diameter (Pl. XXX, fig. 120); the second is a little smaller: 9 cm long and 13.5 x 13.5 (Pl. XXX, fig. 118). An amphicoelous posterior caudal is 12 cm long and 10 high (Pl. XXX, fig. 119). There is also a fragment of a slightly smaller posterior caudal.

A bone interpreted as “a fragment of dinosaurian occipital” by SAUVAGE [1897, pl. X, fig. 2] surely does not belong to an *Iguanodon* skull. It is instead an upper fragment of a vertebra, because a mixture of the marrow and two zygapophyses can be seen (Pl. XII, fig. 25-26).

LIMBS. — The22 cm wide distal end of a right femur (Pl. XXX, fig. 125) shows the very accentuated relief of the endocondyle posteriorly. Anteriorly, note the deep furrow characteristic of the femur of *Iguanodon*.

4 — THE STEGOSAURIANS

Some important remains of stegosaurians were found in the Jurassic of Portugal; they complete at a stroke the fragmentary knowledge that we have until now of these strange reptiles in Europe.

We note subsequently that at first one is found in the presence of a new genus that is very interesting for its ancient age, because it comes from the Middle Liassic, *Lusitanosaurus liasicus*; then the European form *Omosaurus*, representative of the American genus *Stegosaurus*; we have two species in Portugal, one larger, *Omosaurus armatus*, the other more slender and smaller, *Omosaurus lennieri*. These two species of *Omosaurus* come above all from the Kimmeridgian and Lusitanian stages.

LUSITANOSAURUS LIASICUS nov. gen., nov. sp.
LIAS (SINEMURIAN?)

The University of Lisbon collections include a block of hard, greenish, fine-grained limestone containing a portion of stegosaurian jaw. The imprecise label gives it as coming probably from the Liassic and a written indication bears the name *Scelidosaurus*. This piece seemed to us immediately to be of great interest, in spite of the regrettable imprecision of the provenance (Pl. XII, fig. 16).

DESCRIPTION. — Fragment of upper jaw, 10.5 cm long, 4.5 cm tall.

The 8 teeth have a well-marked neck and are of the stegosaurian type. But they are notably narrower than those of *Scelidosaurus* from the Liassic of England [OWEN 1861], at first by their much larger size, then by the absence of denticles between the points. The three points are unequal, the more anterior being the strongest and longest. The height of this point is around 14 mm above the neck.

The breakage of the limestone block permits seeing a replacement tooth still in its alveolus in the anterior part of each side.

In the posterior part, the replacement teeth for tooth 8 on the left and right are also distinguished. The succession of teeth is thus accomplished as in crocodiles.

The external face of the teeth is smooth, covered with a brilliant black enamel.

The prints of three mandibular teeth are recognized in the inferior part of the block. They show that the internal face was ornamented with fine, sharp, rather spaced crests.

All these teeth differ greatly from those of *Stegosaurus* from the Upper Jurassic, whose crown is shorter and ornamented with denticles that show the three primitive points nearly completely.

AGE. — This piece can only come from the Liassic or the Jurassic of Portugal. Besides, it was carefully ranged in the Liassic exhibit case with some fossils of this period. The rather special matrix was compared by one of us (G. Z.) with the various facies of these terrains in Portugal. The examination confirms the attribution to the Lias, and more precisely to the Sinemurian which presents rocks of comparable facies in the coastal region of São Pedro de Muel. Thus we think that this piece could be referred to the Middle Lias with a very strong probability.

SIMILARITIES AND DIFFERENCES. — The very special form of the teeth separates this piece from all known genera. The only contemporary is *Scelidosaurus harrisoni* Owen, from the Middle Liassic of Charmouth and Lyme Regis in England. But it is certainly from a different, new genus.

The Liassic bird-hipped forms are little known. Whence the interest of the piece from Portugal, whether it is imperfect. We give it a name: *Lusitanosaurus liasicus*, hoping that future discoveries will one day make better known this curious Liassic stegosaurian, recovered after 150 million years.

OMOSAURUS ARMATUS OWEN
LUSITANIAN-KIMMERIDGIAN

The Baleal locality has furnished important remains of a large stegosaurian already described previously by one of us [G. Z. 1946]. We summarize here the characteristics of the Baleal pieces.

VERTEBRAL COLUMN. — A single vertebra from the Baleal locality belongs in reality to *Omosaurus armatus*; it is a large, platycoelous anterior caudal; the anterior face is somewhat slightly convex (largest diameter 13 cm), the posterior face slightly concave (largest diameter 15 cm); the length of the centrum is 9.5 cm.

The sacrum is represented by the entire right side; it is entirely comparable to that of *O. armatus* described by OWEN [1874-1889] from the English Upper Jurassic. As judged from the reproductions of ZBYSZEWSKI [1946, pl. IV, fig. 6], the sacral ribs are powerful, a character that differentiates it well from *O. lennieri*.

RIBS. — A 41 cm long rib is preserved. At first it is formed by a thick shaft having 6 cm for its largest width. Then it is flattened toward its end into a 4.5 cm wide lamina.

PELVIS. — It includes 4 fused sacral vertebrae (Pl. XXXIV, fig. 147). The three bones of the right side are rather well preserved. The ilium is 73 cm long; the anterior point is broken. The maximum width of this ilium is 43 cm. The length of the acetabulum is 30 cm and its width is 20 cm. The left ischium is strongly mutilated.

The right ischium is nearly whole and has a length of 58 cm. There is also a notable fragment of the left ischium of the same individual.

Half of the right pubis is present, comprising the pseudo-pectineal process and the pectineal plateau; the postacetabular part of the bone is lacking. In comparing our specimen with the diagram given by NOPCSA [1910], one notes that it deviates from the pubis of *Stegosaurus priscus*, whose curvature is much more marked, but that in contrast it is similar to the form of the pubis of *Omosaurus*. The length of the pseudo-pectineal process is 38 cm; its minimum width is 7 cm and its maximum thickness is 3 cm. In its dimensions it is very similar to *Omosaurus armatus*.

HIND LIMB. — The right femur is complete and articulated with the described pelvis. It is a large bone, 110 cm long, of entirely characteristic aspect. Figures 12 and 13 of pl. IX and 14 and 15 of pl. X [ZBYSZEWSKI, 1946] give a good idea of it and highlight a very close resemblance with the femur of *Stegosaurus* and that of *Omosaurus armatus*.

Finally, a metatarsal, somewhat less complete at its ends, was recovered from the surface in the vicinity of the excavation. It measures 9.4 cm long.

Some other localities have also furnished various bones of this species, although rather rarely.

Six vertebrae of stegosaurian type, much larger and more massive, have been recovered at Foz do Arelho mixed with vertebrae of an *Omosaurus lennieri* (see below p. 51); we think that they belong to *Omosaurus armatus*. This lot includes two cervicals, an anterior caudal (Pl. XXXI, fig. 130 and Pl. XXXVI, fig. 155) and three subsequent middle caudals (Pl. XXIX, fig. 110 and Pl. XXXI, fig. 128). The table below gives the principal measurements:

	Length	Width	Height
anterior caudal…….	6.5	12	10 cm
middle caudal……..	8.5	1	8.5
other middle caudal…….	10	19.5	6.5

The strong base of a neural spine found at Vale de Portinheiro (Lourinhã) seems to be referable to *Omosaurus armatus* (Pl. XXXVI, fig. 156). Its diameters at the fracture are 120 mm and 72 mm. Another spine base was recovered by A. Romão Serralheiro in the Upper Jurassic of the Sesimbra beach. It is preserved in the museum of the Faculty of Sciences of Lisbon.

The collections of the Superior Technical Institute of Lisbon preserve a good right femur of a stegosaurian, recovered isolated at S. Bernardino. By its dimensions, it is exactly intermediate between *Omosaurus armatus* from Baleal and *Omosaurus lennieri* from Foz do Arelho (see table below). But just as this last individual seems to be of a large size for the species, if it is compared to that from Atalaia, we think that the S. Bernardino femur (Fig. 13) belongs instead to a moderately sized *Omosaurus armatus*. Moreover, this attribution is reinforced by the more massive form of this specimen than *O. lennieri*.

Measurements of *Omosaurus* femora from Portugal

Omosaurus armatus:	Length	Width of proximal part	Width of shaft	Width of distal part
Baleal, right femur……..	110	29	13.5	28
S. Bernardino, right femur……..	95	29	13.5	23
Omosaurus lennieri:				
Foz do Arelho……..……	88	22.5	11	20
Atalaia, right femur……..……..	75	22	9.5	20

OMOSAURUS LENNIERI NOPCSA
LUSITANIAN-KIMMERIDGIAN

An exceptional chance brought to light the grouped bones of four unique individuals in four localities. Our description will therefore gain by considering each of these animals successively.

First we examine a rather complete specimen recovered at Foz do Arelho.

VERTEBRAL COLUMN. — Two posterior cervical vertebrae are reduced to their centrum. They are slightly amphicoelous, although a little more hollow posteriorly. They differ greatly from the cervical vertebrae of saurischians, which always possess a strong convexity anteriorly. Stegosaurians have a very short and relatively less mobile neck (see Pl. XI, fig. 2). The best preserved has a length of 8 cm; the face is cylindrical and has an 8 cm diameter. The inferior part is pinched into the form of a crest, an arrangement somewhat similar to certain theropod vertebrae.

Three dorsal vertebrae are easily recognizable (Pl. XXVIII, fig. 100); the centrum is elevated but little elongate (7.5 cm). It is deeply excavated, a disposition that has the effect of sending the two articular faces, anterior and posterior, strongly into relief. This face is oval and measures 8.5 cm wide by 9.5 cm high. The opening of the canal is 3 cm, which is proportionally large for the size of the vertebrae. The neurapophysis is very elevated above the centrum. The spine is a lamina 10 cm high and 6 cm in anteroposterior diameter; it is only 1 cm wide at its base.

The sacrum is magnificently preserved (Pl. XXXIV, fig. 146) and shows the following characters. The last dorsal vertebra (presacral) is already fused by its posterior face. The aforementioned sacrals number 5 and their total length is 32 cm; they are solidly fused together. The half-width of the sacrum is 52 cm, measured from the vertebral axis up to the external edge of the ilium.

The 5 sacrals are intact on both sides. The very slender first rib is strongly curved and rests on both the last dorsal and first sacral. The second rib, already stronger and wider, is applied onto both the first and second sacrals. The third rib is articulated plainly with the corresponding vertebra. This arrangement is exactly that of *Omosaurus lennieri* [NOPCSA 1910, pl. IV][(1)].

The caudal vertebrae (Pl. XXXIII, fig. 141) have a circular form and moreover are ornamented with concentric raised lines, characteristic to the point of permitting identification of a simple fragment. The most anterior are large, very flat discs. The first has a length of 6.5 cm, the second 5.5, and the third 6.5 (Pl. XXXV, fig. 152). They are flat anteriorly and slightly depressed posteriorly. The posterior face measures 11.5 cm at its greatest width and 10 cm tall; this proportion is preserved almost constantly in the following vertebrae, giving them a characteristic aspect. The neural canal is deeply hollowed into the centrum; it measures 4 cm wide on the third anterior caudal; the cross-section of the neural canal of an isolated anterior caudal is oval and measures 31 cm wide and 37 mm tall.

Following these come 5 more anterior caudals that diminish in size little by little (Pl. XXXI, fig. 131; Pl. XXXV, fig. 154); then finally 3 middle caudals, after a gap of

[(1)] From Porto de Mós come two joined vertebrae in poor condition, which SAUVAGE [1897, p. 32, pl. VII, fig. 1] had determined as caudal vertebrae of *Iguanodon prestwichi*. It seems to us rather that these objects must be sacral vertebrae from a small *Omosaurus lennieri*.

six or seven vertebrae, a small posterior caudal, 6.5 cm wide and 5.5 tall; this approaches the end of the tail, which is not very long in stegosaurians.

RIBS. — Several rib fragments are preserved. Very different from those of sauropods, they begin with a twisted ramus of slightly triangular cross-section; subsequently, they curve inward rather rapidly and are flattened to form a 4 to 4.5 cm wide lamina. Here they are clearly more slender than in *Omosaurus armatus*, and indicate a moderately developed thorax.

PELVIC GIRDLE. — The two ilia are preserved fused to the pelvis (Pl. XXXIV, fig. 146). Note the form of the anterior ramus, very different from that of *Stegosaurus* [MARSH 1896, pl. XLVI, fig. 5] and in contrast identical to that of *Omosaurus lennieri*: the anterior ramus is wider than in *Stegosaurus*, splayed to the side, and not elongated anteriorly.

HIND LIMB. — A left femur was found alongside the preceding pelvis. It measures 88 cm long; its diameters are, from top to bottom: 22.5 cm, 11 cm and 20 cm. It has a form analogous to those of *Stegosaurus* and *Omosaurus armatus*; it is only of lesser proportions (Pl. XXXIII, fig. 143-144).

CAUDAL SPINES: see below p. 53.

OTHER. LOCALITIES — Some interesting complements to the knowledge of *Omosaurus lennieri* were furnished by a collection of bones previously recovered 1 km SE of Alfeizerão, very probably from a single individual. There are recognized (Pl. XXXI, fig. 126): 2 dorsal vertebrae, whose centra are 7.5 cm long and the faces are 9.5 cm in diameter; 6 caudal vertebrae (3 middle, Pl. XXXI, fig. 126 and 3 posterior, Pl. XXXI, fig. 127) similar to those described above; and several fragments of ribs. More important is the discovery of two humeri, right and left; they are represented by their very wide proximal part, preserved for 31 cm of length for the better one (Pl. XXXII, fig. 139 and Pl. XXXIII, fig. 145); their largest width is 31 cm; the total length of the bone must have been at most 65 cm.

The right tibia (Pl. XXXVI, fig. 158, 159) is 79 cm long; its articular surface with the femur is not planar as in sauropods, but rounded into the form of a condyle; it measures 22 cm for its largest diameter. A caudal spine was found with this bone.

A very rare thing, a reptile egg, broken in the middle, was recovered in 1908 at Alfeizerão with the same collection of bones and has since been deposited at the Geological Services of Lisbon (Pl. XXXVI, fig. 160). Its diameters are 13 x 19 cm. The interior is filled with a micaceous sandstone. The covering seems formed by a double shell, as has already been noted for a sauropod egg (LAPPARENT 1947, p. 25). The very worn external face of the shell does not allow the papillae to appear under a magnifying glass. A thin slab carried out of the marble shows a sandy limestone in which no structure is preserved. The general form of this object is altogether oval and bulging. It is more elongated than the *Hypselosaurus priscus* egg from Provence; but much less so than that of *Protoceratops* of Mongolia. If one tries to refer this egg to the various dinosaurs found in Portugal, above all one thinks of the stegosaurians due to its size. As this piece was recovered with the bones of a single individual at Alfeizerão,

there is every reason to think that it is an egg of *Omosaurus lennieri* and, as a result, that the bones in question are those of a female. We believe that this is the first time that the existence of a fossil egg from a stegosaurian has been noted.

A smaller individual was found at Atalaia. It is represented by a complete sacrum, smaller than that from Foz do Arelho: length of the five sacral vertebrae, 30 cm; width of a rib, 40 cm. By all its characters, it is very specifically referred to *Omosaurus lennieri*.

From this locality also come: several ribs; four caudal vertebrae; an anterior caudal vertebral neurapophysis, ending in a rounded club as in *Omosaurus armatus* but different from that of *Stegosaurus*; a 75 cm long right femur (Pl. XXXV, fig. 150, 151) with the following diameters, 22; 9.5 and 20 cm. It belongs to an individual clearly smaller than that from Foz do Arelho and agreeing well with the sacrum near which it was found. Finally there was a caudal spine (see below).

The dimensions of the caudal vertebrae figured are as follows:

Pl. XXVIII, fig. 101: length 40 mm; diameters 65 mm x 51 mm.

Pl. XXVIII, fig. 102: length 61 mm; posterior diameters 84 mm x 73 mm.

Pl. XXXVI, fig. 157: length 65 mm; posterior diameters 100 mm x 74 mm.

The remains of a fourth individual were found in 1951 near the Praia da Areia Branca. Beyond a small fragment of nuchal plate (Pl. XXVIII, fig. 108), they include six very typical caudal vertebrae that are distributed thus (Pl. XXXV, fig. 148): 2 anterior caudals, 3 middle caudals, and 4 posterior caudals. On these well-preserved specimens, the concentric costules diverging from the base of the neural canal, which ornament the anterior and posterior vertebral faces and are characteristic of *Omosaurus*, are noted better than on the preceding specimens.

Finally, we note that an isolated caudal vertebra similar to *O. lennieri* is found, without indication of provenance, in the Jurassic exhibit cases of the Faculty of Sciences of Lisbon.

ARMOR — After having described the bones of *Omosaurus lennieri* preserved in the Museum of Havre, NOPCSA [1910] judged that the animal must have been provided with bony armor; but he possessed not a single element. The localities of Portugal confirm Nopcsa's prediction: like all stegosaurians, *Omosaurus lennieri* had a tail ornamented with long bony spines, undoubtedly arranged symmetrically in pairs. By its asymmetry, the enlarged base permits recognizing those of the right side and those of the left.

Two large bony spines come from Foz do Arelho (Pl. XXXII, fig. 135 and Pl. XXXIII, fig. 142), one from Atalaia (Pl. XXXII, fig. 137), and one from Alfeizerão (Pl. XXXI, fig. 132, 133). They are of entirely the same type as the caudal spines of *Stegosaurus sulcatus* [GILMORE 1914, p. 95, fig. 60B] and also those of *Omosaurus armatus* figured by OWEN [1874-89]. Three are from the left side and two are from the right. The longest is preserved for 36 cm of length and could have been 50 cm long when it was complete (Pl. XXXIII, fig. 142). The cross-section of another (Pl. XXXI, fig. 134) measures 72 mm for its two diameters. This specimen comes from Porto Novo (Maceira). The cross-section of the fragment from Alfeizerão is slightly different

(Pl. XXXI, fig. 132, 133) and measures 70 x 46 mm. Finally, a last spine base (Pl. XXXII, fig. 136) comes from Pombal.

Beyond the caudal spines, we do not know if the animal was ornamented with extraordinary bony plates that were arranged in pairs as on the back of American stegosaurians. No trace has been found until now, either in Portugal or in Havre. However an isolated plate, comparable to those of *Stegosaurus*, comes from the Upper Jurassic of England (Collections of the British Museum) and has been attributed to *Omosaurus armatus*.

COMMENTS ON THE NEURAL CANAL — It is known that MARSH brought attention to the remarkable fact that, in stegosaurians, the spinal cavity is suddenly very inflated at its passage through the sacral vertebrae: this is the "sacral brain", much wider than the "cranial brain". It is supposed to have controlled the vegetative life of the reflexes, much more developed than a conscious life. But perhaps the widened cavity of the neural canal was largely occupied by connective tissue and not necessarily by nervous cells.

Whichever it is, it seems that the observations made on the specimens of *Omosaurus lennieri* from Portugal also show a tendency for exceptional development of the spinal cavity in the sacral region here. Without doubt, none of the sacra in our possession have preserved their neurapophyses, so that direct measurements cannot be made. But it can be remarked on the vertebrae immediately preceding or following the sacrals, that the neural canal enlarges notably and becomes wider and less tall than on other vertebrae.

Thus, at Alfeizerão a dorsal from the middle of the back has a canal 30 mm wide and 32 mm tall, whereas the penultimate (or ultimate) dorsal from the same animal shows an opening of 50 x 45 mm. In the tail, the size again becomes normal: an anterior caudal gives 30 x 36 mm and a middle caudal has 18 x 20 mm.

The material is less favorable at Foz do Arelho, but it gives the same impression. The neural canal of a dorsal measures 32 mm; it has 38 and 40 mm on the fourth and fifth anterior caudals, and 28 mm is found on the sixth middle caudal.

Finally, we note that the first (or second) anterior caudal of *Omosaurus armatus* from Baleal has a proportionally very wide canal, which measures 50 x 55 mm.

The opinion has been expressed that *Omosaurus* was not distinct from the genus *Stegosaurus*, and this indication figures at the British Museum on the large slab where the bones of *Omosaurus armatus* studied by OWEN [1874-89] are found. On the contrary, the discoveries from Portugal make us think that *Omosaurus* is the European representative of the American genus; it is distinguished rather clearly, in particular by the very different shape of the pelvis and form of the ilium.

CHAPTER III — STRATIGRAPHIC DISTRIBUTION, PALEOBIOLOGICAL RECOLLECTIONS

The study of a sufficiently abundant fossil terrestrial fauna must lead to the reconstruction of the biological environment and climate that conditioned it. In effect, the terrestrial vertebrates, as also the plants, are informers of their environment more than the marine animals.

It is thus that LULL [1915] worked to reconstruct the Triassic life in the Connecticut Valley very completely, and Mook [1915, 1916] strove to interpret the flora and fauna of the Upper Jurassic Morrison beds. Although disposed of less complete data, we attempt to put the list of dinosaurs from Portugal into a historical, biological, and ecological perspective, of which here is the distribution in time [(1)].

Upper Cretaceous (Maastrichtian): 60 million years ago
Megalosaurus pannoniensis

Lower Cretaceous (Aptian): 100 million years ago
Megalosaurus superbus
Astrodon valdensis
Iguanodon mantelli

Upper Jurassic (Portlandian-Kimmeridgian-Lusitanian): 120 million years ago
Megalosaurus insignis
Megalosaurus pombali
Apatosaurus alenquerensis
Brachiosaurus atalaiensis
Pelorosaurus humerocristatus
Astrodon pusillus
Omosaurus armatus
Omosaurus lennieri

Liassic (Sinemurian): 150 million years ago
Lusitanosaurus liasicus

LIASSIC

In Portugal, the Liassic is represented principally by marine beds, but often very littoral. *Lusitanosaurus*, which was produced from these beds, was a surely terrestrial animal and a herbivore like other stegosaurians. Its skull, which is all we possess, must therefore have been carried away by the waters and buried in the muddy sediments on the edge of a shore.

The firm land where it originated was probably found to the east. In this direction, it seems that the Liassic seas hardly extended past Coimbra, and the Paleozoic rocks of the Iberian Meseta formed a vast emergent terrain during this epoch. By this significant specimen, we know

[(1)] The figures below, evaluated according to the plumb method, are only indicative of an approximate order of magnitude; moreover they represent a minimum.

that stegosaurian reptiles with curious crenulated teeth and a body probably covered with bony armor lived there some 150 million years ago.

UPPER JURASSIC

Less distant from us, at the end of the Jurassic period the sea that reigned previously over a large part of Portugal began to retire: this was around 120 million years ago. The regression was slow and, in the clearly marine beds with cephalopods, succeeded brackish horizons of variable salinity, moreover with marine recurrences including oysters; all this evokes vast estuaries. Next come freshwater beds, well characterized by "lake-ball" type pisoliths indicating the existence of freshwater algae. The frequent reddish tint of the sediments could be attributed to lye-washing of clays by decalcification on the nearby emergent terrains.

Numerous plant fossil localities are known in the Lusitanian, Kimmeridgian, and Portlandian. Thus it is that in the Cap Mondego beds of Chão de Maçãs, Ourém, and Leira, *Equisitites lusitanicus* HEER, *Otozamites mundae* (MORRIS) TEIX., *Baiera viannai* TEIX. and *Elatides falciformis* TEIX. In a little less elevated bed is found *Cyparissidium micromerum* (HEER) TEIX. More to the south, around the Serra de Montejunto and in the vicinity of Dois Portos de Moita dos Ferreiros, Alfeizerão and Nazaré, the Upper Jurassic flora includes *Marchantites marchantiaeformis* (SAP.) TEIX., *Davallia delgadoi* (SAP.) TEIX., *Pecopteris browniana* DUNK., *Sphenolepis choffati* SAP., *Cyparissidium micromerum* (HEER) TEIX., *Scleropteris sinuata* SAP., etc. are recovered.

These non-marine beds, whose Lusitanian, Kimmeridgian, and Portlandian age was shown in the first chapter, have furnished a rich dinosaurian fauna.

The herbivores are represented by enormous beasts, *Apatosaurus, Brachiosaurus* and *Pelorosaurus*, comparable to the sauropods of the American Upper Jurassic which could be reconstructed so precisely. All converge to indicate that these heavy reptiles lived, the body half-supported in the water, in immense swamps comparable to modern "swamps" in Florida and Louisiana and were nourished there by aquatic plants.

A small herbivore, *Astrodon*, with a much more slender body but a weak dentition, must instead have lived in numerous herds on the low isles emerging from the swamps.

If the sauropods seem so connected to this swampy habitat, it is probably because they found there an efficacious refuge against the redoubtable serrated teeth of the carnivores. These more agile, more rapid forms with a very supple, tridactyl pes, in effect mostly haunted the firm ground. They ventured in a quest for prey on the uncovered areas of muddy estuaries, and the traces of their feet, so evocative, were found by the dozens at Cap Mondego. Two species of carnivorous theropods, one of large size, *Megalosaurus pombali*, the other of moderate size, *M. insignis*, must have abounded in Portugal at that time.

Finally, the two species of stegosaurians discovered in Portugal, the more agile *Omosaurus lennieri* and the more massive *O. armatus*, can be represented as frequenting the beaches on the edges of the swamps. These animals possessed two types of defense against predators: an immediate protection in the long spines that so strangely ornamented their body; a second in retreat to the heart of the swamps where they could swim and hide in the leaves of the abundant vegetation.

LOWER CRETACEOUS

The debut of Cretaceous times, 100 million years ago, sees living conditions very similar to those at the end of the Jurassic period continued in Portugal. The climate must have been analogous. The flora does not show marked changes, and it is still the reign of cycads with abundant *Weichselia*.

Plant localities are numerous in the Lower Cretaceous (Valanginian and Hauterivian). In the Caneças region north of Lisbon, Dr. Carlos Teixeira cited the presence of *Mattonidium geopperti* (ETT.) SCHENK, *Hausmannia lusitanica* TEIX., and *Sphenopteris* aff. *mantelli* BRONGN. The association of dipteridaceans and matoniaceans, which exist in Malaysia today, is noted. In the "Vale de Lobos sandstone", which belongs to the same geologic group, the flora includes *Sphenolepis plurinervia-gomesiana* HEER, *S. mantelli* BRONGN., *Pecopteris* aff. *dunkeri* SCHIMP., *Sph. sternbergiana* (DUNK.) SCHENK, *S. kurriana* (DUNK.) SCHENK, and *Brachyphyllum corallinum* HEER.

In the Torres Vedras region the "Torres sandstone" has produced *Sphenopteris subtillinervis* SAP., *S. mantelli* BRONGN., *S. sinuatilobula* (SAP.) TEIX., *Pecopteris browniana* DUNKER, *Weichselia reticulata* STOKES & WEBB., and *Otozamites laceratus* (SAP.) TEIX. The flora of the Almargem beds (Albian-Aptian) includes rather numerous species among which Dr. Carlos Teixeira cites the presence of *Sphenopteris valdensis* HEER, *Laccopteris pulchella* HEER, *Acrostichopteris nervosa* (HEER) TEIX., *Almargemia dentata* (HEER) FLORIN, *Brachyphyllum obesum* HEER, *Sphenolepis kurriana* (DUNKER) SCHENK, *Fenelopsis hohennegeri* (ETT.) SCHENK, and *Desmiophyllum latifolium* (HERR) FLORIN north of Lisbon.

The flora recovered in the "Torres sandstone" near Olhos Amarelos and Pousio da Galiota belong to the same geologic ensemble.

The flora of Cercal, probably of Aptian age, includes a large number of species among which are *Sphenopteris mantelli* BRONGN., *S. lobulifera* SAP., *S. plurinervia* HEER, *S. cercalensis* SAP., *Aneimidium lobulatum* SAP., *Acrostichopteris nervosa* (HEER) TEIX., *Isoetites choffati* SAP., *Choffatia francheti* SAP., *Brachyphyllum obesum* HEER, *Sphenolepis kurriana* (DUNKER) SCHENK, *Nymphaeites choffati* (SAP.) TEIX., *N. rhizostigma* (SAP.) TEIX., *Dichotilophyllum cerciforme* SAP., and *Hydrocotylephyllum lusitanicum* TEIX.

Above all, the Cercal flora is important for the existence of dicotyledons, represented by aquatic or humid locality forms, which seem to be a mixture of angiosperms and cryptogams. They are plants that populated shallower waters where small crustaceans and fishes lived.

The Nazaré flora corresponds to the Upper Aptian. *Isoetites choffati* SAP., *Frenelopsis lusitanica* ROMARIZ, *Laurus paleocretacica* SAP., *Proteophyllum daphnoides* SAP., *Carpites granulatus* SAP., etc. are found. A predominance of dicotyledons is observed.

The flora of the Alcanede beds that Choffat placed in the Upper Bellasian includes *Brachyphyllum obesum* HEER, *Sequoia matosi* TEIX., and *Eucalyptus geinitzi* HEER.

The sea had the same limits at the start. But soon it overtook the terrain, at least momentarily, so that after the Barremian the marine beds alternate with lacustrine and fluviatile sediments such as clays, sandstones, and gravels with floating wood.

As above all in Europe, the dinosaurian reptiles must have been present in Portugal at the beginning of the Lower Cretaceous, but nevertheless none have been noted at the base of the continental facies of Wealden type.

But the brackish beds included between the Barremian and Albian, and thus the Aptian, have furnished some interesting specimens at the Boca do Chapim locality, north of Cape Espichel. The recoveries are so poor that a small sauropod is recognized, *Astrodon valdensis*, reasonably frequent in the Wealden of England; a carnivorous theropod, *Megalosaurus superbus*,

moreover very similar to Jurassic megalosaurids; and finally *Iguanodon mantelli*, the ornithopod so characteristic of the Lower Cretaceous, of which typical teeth and various more or less eroded bones are possessed.

It is known that this last animal lived in numerous herds on firm ground, at the edge of humid and swampy zones; it was herbivorous and probably fed more on branches and leaves than on herbaceous plants.

UPPER CRETACEOUS

The Viso locality revealed continental beds belonging to the highest Cretaceous (Maastrichtian), at least 60 million years old. Fairly numerous remains of small reptiles have been recovered: crocodilian teeth and bones, turtle bones and plates, teeth and claws of the carnivorous theropod *Megalosaurus pannoniensis*, and several vertebrae of flying reptiles.

In effect, among the bone fragments recovered at km 20 of the of the Viso railway cut and preserved in the Geological Services of Lisbon, we have noted four small vertebrae with very elongated centra that can only belong to a pterosaurian. One could have thought equally of avian cervical vertebrae, but an attentive examination made us reject this hypothesis. It is very similar to the caudal vertebrae of a flying reptile. The greatest measures 25 mm long and 7 mm in diameter. Two others have a length of 18 mm and a diameter of 4 mm. The last is smaller, measuring 12 and 3 mm. On such weak indices, it can only be said that it is from a long-tailed pterosaurian, similar to *Dimorphodon* or *Rhamphorhynchus*, and not from the short-tailed pterodactyl *Pteranodon*. But the exclusively Jurassic long-tailed forms seem unknown until now in the Cretaceous. However, we note that pterosaurian vertebrae with Jurassic affinities have specifically been noted in the entirely Upper Cretaceous of Transylvania [NOPCSA 1923].

All this is still insufficient to form an idea of the biological conditions reigning then in Portugal. However, certain affinities make us think that this region formed the western extremity of a zone traversing Europe from east to west by Catalonia, the south of France, Austria, and Transylvania, which enjoyed very similar climatic and biological conditions [see NOPCSA 1923, LAPPARENT 1947, LAPPARENT & AGUIRRE 1956, LAPPARENT, QUINTERO & TRIGUEROS 1957].

These brief evocations based on the dinosaurian fauna already constitute a precious element in the reconstruction of the ecological history of Portugal, the final object of all stratigraphic and paleontological synthesis.

CHAPTER IV — COMPARISONS WITH EUROPE AND AMERICA

The position of Lusitania at the western end of Europe and facing the Atlantic along a thousand-kilometer coast, renders even more interesting the comparison of the vertebrate faunas of this country with those of Europe on the one hand, and North America on the other.

It has been remarked in the lecture of the preceding pages that the dinosaurs of Portugal are very similar to those described in other European countries.

Already in the Liassic, the stegosaurian *Lusitanosaurus*, so new and isolated, is similar above all to *Scelidosaurus* from the Liassic of England.

In the Upper Jurassic, one of the two carnivorous theropods, *Megalosaurus insignis*, is well known in France and England, and moreover the two stegosaurian species are similarly common with France and England. But the richness of the Portuguese localities lets us understand two new herbivorous sauropods rather completely; but their existence in Europe at the end of the Jurassic had only been indicated until now by fragmentary, hardly determinable, remains attributed to the genus *Pelorosaurus*.

In the Lower Cretaceous, the same narrow similarities exist between the Boca do Chapim fauna and the Wealden of Europe: the same carnivore, *Megalosaurus superbus*; the same small herbivore, *Astrodon valdensis*; the presence of *Iguanodon mantelli*, very particular to Europe where it is abundant.

Finally, in the Upper Cretaceous we attach the Viso fauna to that of southern Europe, from Spain to Transylvania. The same carnivorous theropod *Megalosaurus pannoniensis*, probably the same crocodile (*Crocodilus affuvelensis*) and the very rare presence of a pterosaurian in Portugal, as in Transylvania, show once more the narrow faunal similarities that attached Portugal to the rest of Europe during the entire extent of Mesozoic times.

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But the Upper Jurassic in Portugal reveals two sauropods that immediately recall the rich fauna of large dinosaurs exhumed from the Morrison beds of the United States. An *Apatosaurus* entirely similar to this very classic American genus is noted here for the first time on the Old Continent. Better still, the gigantic and very rare *Brachiosaurus* also appeared in Portugal, when until now this genus seemed localized in only two places of the world, North America and East Africa.

However, having looked there more closely, one realizes that the assertion of a direct connection between Portugal and North America which could come to mind, must have been very moderated and perhaps even isolated.

Apatosaurus is represented in Portugal by a unique species that seems to be distinguished from the two American species by several characters.

Regarding *Brachiosaurus*, the differences between the Portuguese animal and the American and African forms are much more considerable. Likewise it is very probable that it is a new genus within the family Brachiosauridae, although rather poorly defined.

Astrodon is a genus common to America and Europe; but the Portuguese and European species are different from those of America.

The theropods include several carnivores in Portugal and America; however the genera to which they belong differ on both sides of the Atlantic.

Finally, the stegosaurians with bony armor, all being of the same type on both sides of the ocean, are represented by two close but distinct genera, *Stegosaurus* in America and *Omosaurus* in Europe.

Thus, in spite of certain analogies with the American reptiles, the fauna of Portugal is clearly distinguished from it; with that of England, it constitutes a good fauna of typically European Jurassic dinosaurs.

*
* *

It must therefore be thought that the recent discoveries of dinosaurs in Portugal make us better understand the *common ground* of the reptile fauna that populated both Europe and America in the Jurassic and Lower Cretaceous. In the two regions, these reptiles include: carnivorous theropods with serrated, blade-shaped teeth; gigantic and heavy sauropods, whose species and genera are not always easy to distinguish; curious small herbivorous sauropods; and stegosaurians bearing a defensive dermal armor.

But the habitat in these distant regions had led to specific or generic differentiations, as the following table shows, where the representative forms may be noted.

NORTH AMERICA (Morrison Beds)	**EUROPE** (England, France, Portugal, etc.)
Theropods	
Ceratosaurus nasicornis	*?*
Antrodemus valens	*Megalosaurus pombali*
—— *fragilis*	
?	*Megalosaurus insignis*
	—— *dunkeri*
Dryptosaurus sp.	*Megalosaurus superbus*
Sauropods	
Apatosaurus excelsus	*Apatosaurus alenquerensis*
—— *louisae*	
Brachiosaurus altithorax	*Brachiosaurus atalaiensis*
?	*Pelorosaurus humerocristatus*
Astrodon montanus	*Astrodon pusillus*
—— *nanus*	—— *valdensis*
Stegosaurians	
Stegosaurus armatus	*Omosaurus armatus*
—— *ungulatus*	—— *lennieri*
—— *stenops*	
—— *sulcatus*	

Finally, we think that the dinosaurs of Portugal are clearly connected to the reptilian fauna of other European countries, with which easy terrestrial communications must have existed from the Iberian Meseta to the emergent terrains of the Ardennes and Scotland.

In contrast, it seems that an ocean separated Portugal and America in the Jurassic and Cretaceous just as today, to the point that the terrestrial reptilian faunas did not have possible similarities from one coast to another.

Our conclusion thus rejoins those of LULL [1915], with moderations due to the new Portuguese discoveries. Comparing the dinosaurs of the Morrison Beds with those of the European Jurassic, he believed he could affirm that these two faunas had nothing in common. However, and this is a new fact acquired for the knowledge of the past world of terrestrial vertebrates, we have specified *that there was a common ground, but diversified in species and genera unique to each of the two completely separated regions*.

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Fig. 149 — *Apatosaurus alenquerensis* nov. sp. Caudal vertebra. Kimmeridgian, Moinho do Carmo (Alenquer) — see p. 33.
Fig. 150-151 — *Omosaurus lennieri* NOPCSA. Right femur. Kimmeridgian, Atalaia (Lourinhã) — see p. 53.
Fig. 152 — *Omosaurus lennieri* NOPCSA. Third anterior caudal vertebra. Kimmeridgian, Murteiras (Foz do Arelho) — see p. 51.
Fig. 153 — *Apatosaurus alenquerensis* nov. sp. Middle caudal vertebra. Length: 155 mm; diameter of posterior disc: 15 x 14.5 mm. Kimmeridgian, Praia de S. Bernardino — see p. 37.

Fig. 154 — *Omosaurus lennieri* NOPCSA. Anterior caudal vertebra. Length: 78 mm; diameter of posterior disc: 107 x 101 mm. Kimmeridgian, Murteiras (Foz do Arelho) — see p. 52.

Note — The vertebrae of fig. 152 and 154 are represented upside down.

PLATE XXXVI

Fig. 155 — *Omosaurus armatus* OWEN. Anterior caudal vertebrae. Kimmeridgian, Murteiras (Foz do Arelho) — see p. 49.

Fig. 156 — *Omosaurus armatus* OWEN. Base of caudal spine. Kimmeridgian, Vale de Portinheiro (Lourinhã) — see p. 49.

Fig. 157 — *Omosaurus lennieri* NOPCSA. Middle caudal vertebra. Length: 65 mm; diameter of posterior disc: 100 x 74 mm. Kimmeridgian, Atalaia (Lourinhã) — see p. 53.

Fig. 158-159 — *Omosaurus lennieri* NOPCSA. Right tibia. Kimmeridgian, Alfeizerão — see p. 52.

Fig. 160 — *Omosaurus lennieri* NOPCSA. Part of an egg. Kimmeridgian, Alfeizerão — see p. 52.

FIGURE CAPTIONS

Fig. 1 — The distribution of dinosaur localities in Portugal.
The small crosses indicate Jurassic localities, the small stars Cretaceous localities.

Fig. 2 — The disposition of elements in the Alenquer locality.

Fig. 3 — Disposition of elements in the Atalaia locality.

Fig. 4 — *Megalosaurus insignis* DESL. — Caudal vertebrae from the Praia da Areia Branca locality (Coll. Fac. Sc. of Lisbon).

Fig. 5 — *Megalosaurus insignis* DESL. — Base of femur. Porto das Barcas (Coll. Fac. Sc. of Lisbon).

Fig. 6 — *Megalosaurus pombali* nov. sp. — Porto das Barcas (Coll. Fac. Sc.). — *a* — Anterior dorsal vertebra; *b* — anterior caudal vertebra.

Fig. 7 — Distribution of the first dinosaur footprints found at Cap Mondego, according to J. P. Gomes.

Fig. 8 — *Megalosaurus* — Footprint no. 5, Cap Mondego. (Coll. Fac. of Sc. of Lisbon).

Fig. 9 — Distribution of dinosaur footprints found in 1951 at Cap Mondego.
1 — Limits of the lower slab. — Limits of the middle slab. — Limits of the upper slab.

Fig. 10 — *Apatosaurus alenquerensis*: scapula and coracoid (Alenquer)

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