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THE
JURASSIC DINOSAURS
OF DAMPARIS (JURA)

BY

Albert F. DE LAPPARENT*

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THE JURASSIC DINOSAURS OF DAMPARIS (JURA)

INTRODUCTION

SITUATION OF THE DAMPARIS LOCALITY

In the environs of Dôle, the “zone of western plateaus” ends in a point between the Doube and Saône Rivers (fig. 1). It is still designated under the name “Dolian Jura” this “straight band of Jurassic terrains that advances between the Doube and Ognon amidst the Bressian sands¹.” The terrains are very weak as a result of the western recovering of the horst of the Serre Massif², where the crystalline base is affected by interesting breaks in the secondary covering.

Entirely at the southwest end of these plateaus, the Solvay Works and Company, established at Tavaux (Jura), exploits the compact Upper Jurassic limestones in a great quarry (pl. V, fig. 1) situated at Belvoye above the Damparis commune (Jura), 1.5 km south of this village. This is where was discovered in 1934 a locality of large dinosaur bones (pl. V, fig. 2).

HISTORY OF THE DISCOVERY

For a long time, one exploited in several quarries around Damparis, some fine-grained Marmorean limestones attributed to the Sequanian¹; these ancient exploitations are indicated in fig. 2.

In 1926, after a campaign of boring, the Solvay Company decided to open a quarry at Belvoye, where the Jurassic limestone furnished a material of very constant quality and composition. The limestone blocks, after having passed in a crushing-mill, are brought by aerial transport to the great works which was created, with its city around it, on the other side of the Rhône-Rhine canal; at the same time, the salt water retired from the Triassic (Keuper) of Poligny is led to the works by a subterranean canal forty kilometers long.

In the course of work of cutting in the Belvoye quarry, in April 1934, a quarryman presented to Mr. Koehret, employed at the works, a portion of a scapula that had been extracted from a pocket of red marls. Immediately alerted, the engineers Mr. Verhas and Mr. Chardin confirmed the bony nature of the piece in question and recognized the presence of other bones in the red marl. They advised then Mr. Haerens, director of the Tavaux Works. Thanks to his initiative, the methodical exploitation of the

¹ JOURDY. Orographie du Jura d'ômois, *Bull. Soc. Géol. Fr.*, (2), XXIX, 1872, p. 336. See also the geologic map of France at 1/80,000, no. 126, *Beaçon* page.

² J. F. G. DEPRAT. Le Massif de la Serre et son rôle tectonique, *Bull. Soc. Géol. Fr.*, (3), XXVIII, 1900, p. 84.

¹ A. DE LAPPARENT. *Traité de Géologie*, 5th ed., 1906, p. 1237.

locality was immediately decided and executed without delay; it was pursued in May and June 1934, according to the scientific directives of Mr. J. Piveteau who had gone on the spot in the company of Mr. R. Ciry. The complete exploitation of the marl lens was achieved on 22 June and Mr. Haerens, under the name of the Solvay Society, generously had all the pieces deposited in the Muséum National d'Histoire Naturelle in Paris. Mr. J. Piveteau then began the study of the bones, while Mr. Pansard was employed for a long time to remove and consolidate the pieces one by one. But, as a result, the work had to be interrupted.

The discovery was announced summarily by J. de Dorlodot, M. Dreyfuss², J. Viret³. The exploitation of the locality on the one hand was told in detail by Baron J. de Dorlodot⁴, who had followed all the phases, in an interesting publication accompanied by numerous photographic documents.

In 1939, under the impartial advice of Mr. J. Piveteau and with the benevolent authorization of M. C. Arambourg, I reprised the study of these fossils, so much more precious because one had known in France only the very fragmentary remains of dinosaurs.

Among the recovered remains, Mr. Piveteau had already discovered:

1) some teeth of a predatory theropod;

2) the bones and teeth of a herbivorous sauropod that could belong to the genus *Bothriospondylus*.

Here also, as has been noted for all the dinosaur localities in Belgium⁵, the predator accompanied the herbivore. One remarks that, at Damparis as well, the remains of the latter are more abundant than those of the former, of which one has often only teeth.

The mounting of large dinosaur bones is a long and difficult work. I must thank Mr. C. Arambourg who put freely at my disposition the personnel of his laboratory, in particular Mr. Wacquiez and Mr. Pansard, whose ability and patience have resulted, among other successes, in the complete removal of the magnificent cervical vertebra represented in pl. II, fig. 4.

The photographs of the elements were able to be taken under good conditions thanks to the talent of Mr. Cintract and Miss Cintract. Finally, Miss L. Christol brought her cooperation for the drawings in figures 4 and 5.

FIRST CHAPTER

STUDY OF THE LOCALITY

1. — STRATIGRAPHY

² M. DREYFUSS. Sur une roche à ossements de Dinosauriens, *Bull. Soc. Hist. Nat. du Doubs*, 1934, no. 44.

³ J. VIRET. *Rev. génér. des Sciences*, 30 April 1935, p. 237.

⁴ J. DE DORLODOT. L'exploration de gîte à Dinosauriens jurassiques de Damparis, *La Terre et la Vie*, October 1934.

⁵ L. DOLLO. Les Dinosauriens de la Belgique, *CR. Ac. Sc.*, 2 March 1903.

The great Solvay quarry, which is open at Belvoie on the border of the route from Damparis (fig. 2), cuts into the Jurassic limestones along 900 m of length toward the NE; it now attains a depth of thirty meters along all this distance (pl. V, fig. 1).

The *Sequanian** age of the exploited limestones is well established, this term being synonymous with *Astartian* employed by ancient authors, and corresponding to the J4 notation in the 1/80,000 map. South of Dôle, along the Doubs (fig. 2, near point 202), the same Damparis and Foucherans limestones become marly near the base and contain: *Rhynchonella pinguis* ROEM., *Terebratula zieteni* DE LOR., *T. subsella* LEYM., *T. pseudolahenalis* MOESCH; they support on the one hand, at Saint-Ylie, the Kimmeridgian (J5) limestones containing a marly layer rich in pteroceres and, in their upper part, a lumachella with *Exogyra virgula* DEFR. and *Pecten (Amussium) subtextorius* MÜNST. Thus, in the absence of characteristic ammonites, the age of the Damparis locality is clearly defined.

The detailed section of the Sequanian, revealed in the Solvay quarry, is as follows, from top to bottom (fig. 3):

8. Compact limestones with polyps, separated by lenses of greenish-yellow marls (e, f, g, h, i, j): thickness 8 to 10 m. A marly bank (h) thicker than the others along the whole length of the front of the cut, is enlarged in a point in a manner to form a lens of greenish, red and violet marls, much recalling the lens (c) that, in bed 7, constituted the dinosaur locality. The limestone roof of the bed (h) contains internal molds of fossils: *Astarte* sp., *Pecten (Amussium) vitreus* ROEM., *Panopaea* sp., *Nerinea* sp., *Natica* cf. *georgeana* D'ORB¹.
7. Thick banks of compact, fine-grained limestone (10 m). Between two of these banks, one sees running a thin bed (c) of red or "salmon" marls, sometimes yellow or violet, whose thickness is on the order of 2 cm, but which enlarges locally up to 50 cm, filling 9 m of length and 5 m of width on a shallow basin hollowed into a subjacent limestone bank (pl. V, fig. 2). All the dinosaur bones and teeth were found in the inferior part of the marl bed: the surface of the limestone wall was "smooth, the bones having no imprint of traces there, with the exception of an ulna whose extremity is deeply encased there²". The "salmon" marls have yielded small gastropods of the genus *Nerinella*³ and some recognizable specimens of ferns and cycads; the numerous "imprints with ornamentation of lizard skin" noted by J. de Dorlodot are nothing but traces of vegetation.
6. Bank of compact limestone (0.50 m) surrounding two lenses of red sands (a) and (b), very constant landmark at the top of the following oolitic layer.
5. Oolitic and gravel-bearing limestone with miliolacean and rotaliacean foraminiferans (2 to 3 m), much appreciated because of its great purity.
4. Lithographic limestone in compact banks (3 to 4 m).
3. Fine-grained limestone (4 m) becoming full toward the base with numerous organisms visible in section: *Terebratula* sp., *Diceras* sp. and trepostome bryozoans of the genus *Chaetetopsis*⁴.
2. Compact limestone recognized in the borings or search shafts (4 to 5 m).
1. Marly limestone (thickness not measured) belonging to the lower part of the Sequanian.

The limestone, analyzed at all levels from 2 to 7, contains a percentage of CaCO₃ always exceeding 98%. Beds 8 form the discovery of the quarry and are not utilized.

The banks are fairly regularly inclined toward the SSE, with a dip of 7°. They are cut into numerous vertical quarries, but from which the reject is ordinarily negligible.

* Sequanian = Upper Oxfordian — MTC.

¹ M. A. LANQUINE has been able to accept the determination of these Jurassic fossils.

² J. DE DORLODOT. *Loc. cit.*, p. 12.

³ Determination of Miss G. DELPEY.

⁴ Determination communicated amiably by Miss J. PFENDER.

In summary, the Sequanian of Damparis includes the principal facies following from top to bottom:

- IV. Compact limestones alternating with marly banks.
- III. Lithographic limestones with joints of red marls: one of these, expanded locally, furnished the dinosaur bones.
- II. Oolitic limestones and lithographic limestones.
- I. Marly limestones.

2. — PALEOGEOGRAPHY

The presence, in the heart of a collection of marine limestones, of plants and terrestrial vertebrates, poses a paleogeographic problem of which one word can be said: where was the firm land found? and how were these remains incorporated into the marine sediments?

One will remark at first that the Sequanian limestones, certainly formed at the heart of a tranquil sea, must not have been deposited under a great thickness of water: some constructing organisms such as polyps, accompanied by *Diceras* and the nerines, evoke a shallower sea where was established true reefs as for example at Fraisans to the NE of Dôle¹.

The existence of red beds alternating with limestone banks in an entirely marine series, without lacustrine or proper continental intercalation, can be explained by the lye-washing of the continental reliefs and the carrying away, into the sea, of the lateritic sands formed at their surface. To the limestone sedimentation was attached, in repeated periods corresponding to a slight sinking by fits and starts (phenomenon of subsidence), a more or less great proportion of sand ending in the deposition of red marls with calcareous nodules. Mr. Gignoux thinks in the same way as the siderolitic formations, carried away to the sea, could color the coastal marine deposits; he explains by this fact, in the Alps, the marine *red Argovian* and the Guillestre marbles, nodular limestones streaked with red and green².

The fact that one recovered in the red marls some *Nerinella*, sometimes marine gastropods, but indicating most often, according to G. Delpy, a brackish environment, could signify that one is found then, at Damparis, at the width of a vast delta. The local accumulation of a greater thickness of marls containing plant debris and terrestrial reptile bones, suggests the idea of a momentary fluvial flood carrying them to the sea³, as is seen in the Gulf of Mexico up to a fairly great distance from the mouth of the Mississippi. Among these remains, was found the entire cadaver of a large sauropod that was buried in the mud and slightly disarticulated, thanks to the absence of violent currents (cf. fig. 6, p. 17).

Nothing indicates, it seems to me, that it is necessary to retain the hypothesis according to which the red marl and the bones had been borrowed from an older

¹ Abbey BOURGEAT. Sur les changements de faciès que présente le Jurassique autour du Massif de la Serre, *Bull. Soc. Géol. Fr.*, (3), XXV, 1897, p. 695. See also GIRARDOT. Études géologiques sur la Franche-Comté septentrionale. Le Système oolithique, 1896.

² M. GIGNOUX. Géologie stratigraphique, 2nd ed., 1936, pp. 2 and 391.

³ This explanation had already been proposed as the most reasonable by J. DE DORLODOT in *La Terre et la Vie*, October 1934.

formation and buried just as they are in the Sequanian sediments. Without doubt, the stratigraphic significance of the great Mesozoic reptiles is far from being precise and the determination of the species can hardly provide information in this regard. But it is necessary for anyone to believe, according to the conditions of the locality, that the dinosaurs of Damparis lived in the Sequanian epoch on nearby emergent terrains.

It is not easy however to indicate where the dry land was found in the Sequanian.

The Serre Massif must not have existed in this epoch.

It was thought that Morvan could have been emergent, because of the band of reefs that are seen developed in the "Corallian" starting from Tonnerre and above all at Merry, Chatel-Censoir and Coulanges-sur-Yonne¹. But if the coral reefs are the sign of a shallower sea, they do not necessarily indicate the immediate proximity of an exposed land: it is known that the Great Barrier of Australia, along a length of 1,800 km, is usually found at 50 to 80 km from the shores, but can be extended to 150 km (Torres Strait) and up to 250 km (Capricorn Channel)².

Of the situation, emergent or not, of the Central Massif, we can say practically nothing, in the absence of sufficient indications of the littoral facies of the Jurassic in this direction.

According to the observations of L. Collot³, it is necessary rather to look to the north. "One enjoyed oneself, he said, to represent the coralline formations...as having bordered on one side a Vosgian relief and on the other that of Morvan, leaving in the middle a free passage (Morvano-Vosgian strait) where the muddy deposits would be produced." In opposition to this concept, Collot proved that the Vosges and the Black Forest were completely covered by the sea throughout the Jurassic. The coralline limestones formed a halo around the region uniformly submerged, extending to the Souabe Lorraine, where some currents were able to allow at certain moments the sandy deposits, of mica and clayey sand, imprints of a continent situated very far to the north (Ardenne-Eifel). The fact that at Damparis the red marls contain very small grains of clastic quartz, besides fairly numerous and fine spangles of white mica visible with a lens, do not necessarily indicate the proximity of a crystalline massif, these elements, practically unalterable, being able to be transported some considerable distances.

However, this continent of the north, which was found at 270 km from Bourgogne, is too distant to return account of all the continental influences observed in the Sequanian deposits: the presence of plants in the Tonnerre oolite; flora of Sampot near Auxey (Côte-d'Or), in the marine dolomites⁴; locality with plants and terrestrial vertebrates at Damparis. M. E. Chaput, consulted on this subject⁵, would think more

¹ See among others H. DOUVILLÉ. Note sur la partie moyenne du terrain jurassique dans le bassin de Paris et sur le terrain corallien en particulier, *Bull. Soc. Géol. Fr.*, (3), IX, 1881, p. 439; A. DE LAPPARENT. *Traité de Géologie*, 5th ed., p. 1234 and paleogeographic map, p. 1233.

² Distances evaluated according to the *Geologic map of Australia*, by T. W. Edgeworth DAVID, Sydney, 1931.

³ L. COLLOT. *Rapports de la Bourgogne avec les régions voisines ou Essai de coordination des faciès*, A. F. A. S., Dijon, 1911, p. 331.

⁴ See the legend of the Beaune sheet (no. 125) at 1/80,000. Specimens preserved at the Faculté des Sciences de Dijon and described by DE SAPORTA. *Plantes jurassiques*, IV, 1891, p. 240; Remarks, by A. CARPENTIER, *Bull. Soc. Géol. Fr.*, (5), IX, 1939, p. 113.

⁵ Oral communication. Also see E. CHAPUT. *Position stratigraphique de l'oolithe corallienne de la Côte-d'Or*, A. F. A. S., Dijon, 1924, p. 118.

readily of emergent limestone terrains, formed by the Bajocian and Bathonian bases in some regions abandoned by the waters at the time of the Callovo-Oxfordian instability and regression, and that the Rauracian* and Sequanian seas had not completely invaded. But in the present case, it does not seem possible to specify more where was found the emergent terrains on which the dinosaurs of Damparis prospered.

CHAPTER II

SUBORDER THEROPODA

Megalosaurus insignis DESLONGCHAMPS

Seven teeth of a carnivorous theropod were collected in the red marls of Damparis, one large and six small, which all seem to belong to the same species.

The largest is one good caniniform tooth¹, very compressed, trenchant, with a point recurved backward like the blade of a saber, with two serrated blades, one anterior and one posterior (pl. I, fig. 1). It belongs very exactly to *Megalosaurus insignis* DESLONGCHAMPS from the Portlandian of the Boulonnais according to a large tooth well figured by E. Sauvage². The size (110 mm) is the same. The serrations are visible along the entire posterior ridge; in contrast, *they occupy only two-third of the anterior ridge*; they attenuate progressively and stop exactly at the same point as in the Boulonnais specimen. According to E. Sauvage, "this particularity must be considered as characteristic of the species³." The serrations are more worn, and thus less marked, on the anterior ridge than on the posterior ridge. Finally, the aspect of the serrations is equally the same (cf. Sauvage, *loc. cit.*, fig. 1a); on the Damparis specimen, the serrations are a little wider and more serrated than in *Megalosaurus bradleyi* SMITH WOODWARD⁴ from the Bathonian.

Relationships and differences. — In all its characters, the large tooth from Damparis belongs to the group of Jurassic theropods, while it differs clearly from those of Cretaceous theropods such as *Megalosaurus superbus* SAUVAGE⁵ and *M. crenatissimus* DEPÉRET⁶ whose anterior ridge is furnished with serrations along its entire length, like that of *M. saharicus* DEPÉRET⁷ characterized by some oblique folds on the sides of the ridges. It is far however from the Middle Jurassic theropods such as *Megalosaurus bucklandi* MEYER whose serrations are limited to the upper third of the anterior ridge. It approaches well the forms of the Upper Jurassic like *Streptospondylus*

* Rauracian = Middle Oxfordian — MTC.

¹ One indicates thus in the megalosaurids one or several teeth much longer than the others, situated toward the middle of the tooth row, and playing the functional role of canines in an eminently predatory animal.

² *Mém. Soc. géol. Fr.*, (2), X, 1874, pl. V, fig. 1-2.

³ The same author, it is true, attributed to *M. insignis* another tooth (*Op. cit.*, pl. V, fig. 3) that is only serrated on its upper third, but which came from the anterior edge of the jaws (?).

⁴ *Quart. Journ.*, LXVI, 1910, pl. XIII, fig. 3b.

⁵ *Mém. Soc. géol. Fr.*, (3), II, 1882, pl. II, fig. 3-5.

⁶ *Bull. Soc. Géol. Fr.*, (3), XXIV, 1896, pl. VI, fig. 4-8; cf. THÉVENIN, *Ann. de Paléont.*, II, 1907, pl. I, fig. 17.

⁷ *Bull. Soc. Géol. Fr.*, (4), XXVII, 1927, pl. XII, fig. 1-2.

cuvieri OWEN⁸ from the Oxfordian and *Megalosaurus ingens* JANENSCH⁹ from Tendaguru but whose serrations are a little wider. It is more specifically identical to *Megalosaurus insignis*. This species is now known from the Sequanian in Portugal¹ and at Damparis; it becomes frequent in the Kimmeridgian (for example at Cap de la Hève) and the Portlandian (as in the Boulonnais).

Another tooth (pl. I, fig. 2), smaller, is an alveolar tooth²; it measures 22 mm, but is found a little truncated at the base. It shows the same characters as the preceding as to the general form and the shape and arrangement of the serrations. E. Sauvage³ has also referred to *M. insignis* a small tooth of 17 mm.

Two other teeth, measuring 10 and 11 mm, but slightly incomplete, are serrated in the same manner and seem to belong to the same species, in spite of a considerable difference in size.

Finally, in a last lot of three teeth, of still smaller size (pl. I, fig. 3), two are serrated while the third is not; in spite of this, all three must be referred to the preceding ones. It seems, in effect, according to the figures of the authors⁴, that the presence and arrangement of the serrations do not constitute absolutely constant characters for all the teeth in the same individual; these variations could correspond to the position in the jaw, which is evidently impossible to appreciate when one is disposed only of isolated teeth. Also, the phylogenetic analysis of megalosaurids tried by Depéret⁵ and based on this single character does not seem fully satisfactory.

CHAPTER III

SUBORDER SAUROPODA

Bothriospondylus madagascariensis LYDEKKER

HEAD

The skull is unknown.

But we have six teeth, of variable dimensions, corresponding without doubt to the position on the jaw. Their general characters are as follows.

Spatulate teeth, of large size. The enamel is strongly grained, but longitudinal striations are not observed. The external face is regularly convex; the internal face shows a median convexity and two lateral depressions. The cross-section is slightly biconvex. There is not the narrowing or neck well between the root and the crown.

⁸ Cf. J. PIVETEAU, *Ann. de Paléont.*, XII, 1923, pl. I, fig. 3.

⁹ *Palaeontographica*, suppl. VII, 1925, p. 91 and pl. IX, fig. 7-10.

¹ E. SAUVAGE. *Bull. Soc. Géol. Fr.*, (3), XXVI, 1898, p. 443.

² The alveolar teeth, much shorter than the caniniform ones, are teeth still incompletely disengaged from the alveolus.

³ *Op. cit.*, 1874, p. 11.

⁴ Compare E. SAUVAGE. *Op. cit.*, 1874, pl. V, fig. 1-2 and fig. 3 for *M. insignis*; OWEN, *Quart. Journ.*, 1883, pl. XI, fig. 3 and SMITH WOODWARD, *id.*, 1910, pl. XIII, fig. 3 for *M. bucklandi*.

⁵ *Bull. Soc. Géol. Fr.*, (4), XXVII, 1927, p. 260-264.

The largest (pl. I, fig. 4) is a little curved and slightly asymmetrical. Two other large teeth (pl. I, fig. 5 and 6) are recurved at their extremity and the crown is clearly asymmetrical; one of the edges is regularly convex, while the other extends nearly the entire height in a straight line, then curves in abruptly upon arriving at the top. This side is rather finely serrated, as is better observed on the two following teeth. The edges of these two large teeth are a little worn by mastication. Two others, smaller (pl. I, fig. 7 and 8), offer a still more marked asymmetry; one of them is strongly curved at its end. Finally, a last tooth, fractured at its two ends, allows seeing the compact ivory completely enclosed in a later of enamel 1.5 mm thick.

Relationships and differences. — These teeth belong to a dinosaur of the family Brachiosauridae, of which the general form in elongate spatula and the enamel with not very marked longitudinal striations seem constant characters of the dentition.

The fact that the teeth from Damparis are grained and not striated, and moreover present a slightly biconvex cross-section, draws them aside from those of *Pelorosaurus*¹, *Apatosaurus* (= *Brontosaurus*²), *Astrodon* (= *Pleurocoelus*³), all longitudinally striated, and those of *Helopus*⁴ offering a very particular concave cross-section. In contrast, they clearly resemble those of the genus *Camarasaurus* (= *Morosaurus*⁵), but still more the teeth from the Jurassic of Madagascar placed by Thévenin⁶ in the genus *Bothriospondylus*. This author having only one incomplete crown and being inspired by the tooth of *Camarasaurus* figured by Marsh, tried a restoration (*Op. cit.*, pl. I, fig. 2) where he figured a well-marked neck. According to the specimens from Damparis, the teeth of *Bothriospondylus* did not have the individualized neck.

From the broken specimen described by Thévenin, one was unaware of nearly all about the teeth up to now of the genus *Bothriospondylus*.

VERTEBRAL COLUMN

In sauropods, the vertebrae show distinctive characters very clear according to their position along the vertebral column: the cervical and dorsal vertebrae are opisthocoelous, that is concave posteriorly and convex anteriorly; the caudals are slightly concave anteriorly and flat posteriorly.

In addition to a good number of broken processes of large size, seven identifiable vertebrae and a good sacrum have been recovered at Damparis.

The best, of very large size, a little deformed but broken at its processes, is a cervical vertebra from the middle of the neck (pl. II, fig. 4). It is very deeply opisthocoelous (fig. 4b). It can be compared, by its position, to the 13th cervical of *Diplodocus*⁷. Its length is 45 cm and its height reaches 50 cm; it is above all remarkable

¹ SAUVAGE. *Bull. Soc. Géol. Fr.*, (3), IV, 1876, pl. XII, fig. 5 and XVI, 1888, pl. XII, fig. 1-4.

² MARSH. *Dinosaurs of North America, Sixteenth ann. Report of the U. S. Geol. Survey*, 1896, pl. XX, fig. 1.

³ *Id.*, pl. XL, fig. 2.

⁴ WIMAN. *Kreide Dinosaurier aus Shantung, Palaeont. Sinica*, 1929, pl. II, fig. 12-23.

⁵ MARSH. *Op. cit.*, pl. XXXI, fig. 1-2.

⁶ *Dinosauriens de Madagascar, Ann. de Paléont.*, 1907, fig. 2 and pl. I, fig. 1.

⁷ J. B. HATCHER. *Diplodocus* MARSH: Its osteology. *Mem. Carnegie Mus. Pittsburgh*, I, 1904, pl. III.

for its extraordinary slenderness, the body being hollowed by two long cavities separated from one another by a median lamina having only 5 to 6 mm in thickness.

We have still the anterior convex part of another cervical vertebra whose position cannot be specified.

A vertebra with a voluminous centrum, collected and powerful (pl. II, fig. 2), corresponds to the 3rd anterior dorsal¹. It is very strongly convex anteriorly. The centrum is hollowed by two vast, deep cavities, separated by a thin partition of 4 to 5 mm thickness. Length of the vertebra (slightly deformed): 25 cm. This element recalls rather closely the dorsal vertebra of *Morosaurus* figured by Marsh², but the hollow cavity in the centrum is still larger.

Another good vertebra (pl. III, fig. 4), moderately opisthocoelous and as a result from the middle of the back, corresponds to the 6th or 7th dorsal of *Diplodocus*³; but the lateral cavities are much wider and deeper than in *Diplodocus*. The median partition has 5 mm thickness. Length of the vertebra: 22 centimeters.

A dorsal vertebra coming to follow the preceding one (the 8th or 9th) is very deformed and reduced to the centrum (pl. II, fig. 3); but it shows well the two long cavities that hollow the centrum, and the median partition 4 mm thick. Length: 21 cm.

The sacrum, rather deformed by compression, constitutes however a magnificent piece (pl. III, fig. 1). It is composed of four coossified vertebrae. Lydekker⁴ indicated precisely this quantity in *Bothriospondylus madagascariensis* in spite of the poor state of the remains that he studied. The transverse processes, of which three on the left side and three on the right are preserved, have relatively thin stems, which are widened at their end in the form of strong bludgeons firmly sutured together. The openings between these processes and the centrum of the sacral vertebrae take a rather widened form. The length of the sacrum is 73 cm; its general shape recalls much that of *Camarasaurus* (= *Morosaurus*) *grandis* MARSH⁵ and the elongation of the sacral vertebrae seems very analogous in the two cases.

We possess still one of the first caudal vertebrae (pl. II, fig. 5), the 1st or 2nd, slightly concave anteriorly, slightly near planar posteriorly. The diameter of the centrum is 21 cm. Above the neural canal is developed strong, wide articular processes.

Finally, another anterior caudal vertebra, probably the 4th, shows the same characteristics (pl. II, fig. 1). Its diameter is 19 cm. On this specimen, one sees well in front, above the wide neural canal, the cavity or hypantrum in which comes to lodge the salient lamina or hyposphene of the preceding vertebra.

One will remark that the opening of the neural canal is here taller than wide, as in *Morosaurus*⁶. As much as one can judge in spite of the deformations undergone, this opening is also a little larger than in the dorsal vertebrae:

3rd dorsal.....40 X 40 mm
6th (or 7th) dorsal..... 32 X 32 mm

¹ HATCHER. *Op. cit.*, 1901, pl. VII.

² MARSH. *Dinosaurs of North America*, 1896, fig. 31-33, p. 181.

³ HATCHER. *Ibid.*

⁴ LYDEKKER. On bones of a Sauropodous Dinosaur from Madagascar. *Quart. Journ.*, LI, 1895, p. 33.

⁵ MARSH. *Dinosaurs of North America*, 1896, pl. XXXI, fig. 8.

⁶ MARSH. *Ibid.*, pl. XXXIV, fig. 4.

4th caudal.....50 X 40 mm

Contrarily to what usually arrives, the other caudal vertebrae have not been preserved.

RIBS

We possess numerous fragments of ribs. One of them (fig. 4) is the head of a right thoracic rib, the 7th according to Riggs¹. One complete rib measures 142 cm long with a midshaft width of 8 cm and a thickness of 2 cm; this would be the 3rd rib.

SCAPULAR GIRDLE

The left coracoid and two nearly complete omoplates (scapulae) have been collected. These are very long (137 cm), but do not show exceptional characters relative to those of already-described Jurassic sauropods.

FORELIMB

The forelimb bones are complete. We have the following pieces of which none are doubly employed.

A good right humerus, complete (pl. IV, fig. 1); its length is 133 cm. It is relatively slender in its median part. The deltoid process is very salient (8 cm) and rugose. The head is rounded, while the distal end is nearly flat.

The right (pl. IV, fig. 2) and left ulnae, both 90 cm long. The gutter, at the proximal part, is very deep; the cross-section of the bone is rather clearly triangular.

The right (pl. IV, fig. 3) and left radii, both 88 cm long.

A small carpal bone has been recovered (pl. IV, fig. 4), with rugose surface, probably representing $c^4 + c^5$ according to Osborn².

We have the three complete left metacarpals (pl. IV, fig. 5-7); they are very elongate, thus testifying the measurements:

metacarpal II	metacarpal III	metacarpal IV
38 cm	39 cm	36 cm

The right third metacarpal also measures 39 cm (pl. IV, fig. 8).

Finally, a lot of four phalangeal bones (pl. IV, fig. 9-12) and two large claws (pl. IV, fig. 13-14) each measuring 14 cm long, gives us some idea of the end of the manus, which is yet unknown in *Bothriospondylus*. One notes a first phalanx of the right pollex with its oblique direction (retroversion) to which Osborn (*Loc. cit., ibid.*) drew attention and which caused the first digit to be drawn aside: the weight of the body was thus more equally distributed on the five digits. The smallest of the phalanges discovered is attributable to the left fifth digit.

¹ E. S. RIGGS. Structure and relationships of opsithocoelian dinosaurs. I, *Apatosaurus* MARSH, *Field Columbian Mus. Chicago*, publ. 82, vol. II, no. 4, 1903, pl. XLVII.

² H. F. OSBORN. Manus, sacrum and fore limb of Sauropoda. *Bull. Amer. Mus.*, XX, 1904, p. 185, fig. 1.

PELVIS

Among the bones of the pelvis that are possessed, the right ilium does not show any very particular characters. The left pubis is incomplete. The right ilium, 73 cm long, is more characteristic: its distal end in a thin lamina, very elongate and *slightly widened* (fig. 5), is similar to that of *Camarasaurus* (= *Morosaurus*)¹ and still more to that of *Haplocanthosaurus*². The fragments from Madagascar described by Thévenin³ are much wider and one can ask whether it truly belongs to the genus *Bothriospondylus*?

HIND LIMB

The left femur is 146 cm long (pl. IV, fig. 15); it is complete but accidentally flattened. The proximal end is voluminous, rugose, incompletely ossified. The base of the femur shows anteriorly and above all posteriorly a marked depression that separates the ectocondyle and entocondyle; this last bears anteriorly a very salient tuberosity. This projection is however less developed in the quadrupedal sauropods than in the bipedal dinosaurs.

The right femur is only represented by its two ends, of which the proximal did not undergo crushing; its thickness is 11 cm at a distance of 40 cm from the top.

The left tibia (pl. III, fig. 2), very well preserved, has a length of 87 cm. It is slender in its middle, which indicates a rather gracile animal. The upper head is flat, wide, to give a solid base to the femur. The inferior head (pl. III, fig. 2c) shows on one side of the crest a cavity, on the other side a convexity, corresponding to an inverse position for the astragalus.

A left fibula is represented only by the proximal and distal ends. The stem, on this latter (pl. III, fig. 3), is more triangular and thinner than in *Diplodocus*.

A good left astragalus (pl. IV, fig. 16) is articulated perfectly with the corresponding tibia. This voluminous bone is 23 cm in its larger diameter; the tendinous insertions on the left posterior face are particularly deep. Apart from the points of articulation, the surface is rugose, above all at the right and left extremities.

The metatarsals are much shorter, more slender, and flatter than the metacarpals. The right 1st metatarsal (pl. IV, fig. 17), of good preservation, 17 cm long, is analogous to that of *Bothriospondylus madagascariensis* figured by Thévenin⁴; the author doubted whether it belonged to a sauropod, but the specimen from Damparis no longer leaves any hesitation on this point. The right 3rd metatarsal (pl. IV, fig. 18) is accidentally flattened at its proximal end; its length is 23 cm. The left 1st and 2nd metatarsals are broken and very deformed.

The relative lengths of the forelimb and hind limb furnish an important element for the classification of sauropods. Using only the principal bones, one obtains the following table:

¹ MARSH. *Dinosaurs of North America*, 1896, pl. XXXVI, fig. 1.

² HATCHER. *Osteology of Haplocanthosaurus*. *Mem. Carnegie Mus. Pittsburgh*, II, 1903, pl. IV.

³ THÉVENIN. *Dinosauriens de Madagascar*, 1907, p. 9, fig. 11.

⁴ THÉVENIN. *Dinosauriens de Madagascar*, 1907, pl. I, fig. 12.

humerus	133	femur	146
ulna	<u>90</u>	tibia	<u>87</u>
	223 cm		233 cm

The forelimb is thus nearly as long as the hind limb. This character is known only in the brachiosaurids, the type *Brachiosaurus* possessing a humerus a little larger than the femur.

If one includes the length of the podia, the size of the forelimb exactly equals that of the hind limb:

humerus	133	femur	146
ulna	90	tibia	87
carpal bone	4	astragalus	10
metacarpal III	<u>39</u>	metatarsal III	<u>23</u>
	266 cm		266 cm

The fore-part of the animal must be thus notably more elevated than the classic reconstructions of *Camarasaurus* and *Diplodocus*¹ indicate, but not as much as in *Brachiosaurus*².

SYSTEMATIC POSITION

One will note that the sauropod bones recovered at Damparis certainly belong to a single individual: the preceding description showed that no bones are repeated and that, on the contrary, the visible bones are put without loss in connection with one another. This result is in agreement with the plan drawn of the locality at the time of the discovery (fig. 6). One will remark, in effect, that the hind-part of the animal was found to the left (hind limbs, sacrum, caudal vertebrae and the fore-part to the right (forelimbs, scapulae, cervical and dorsal vertebrae). The head, lying without doubt in front and to the right, had to be broken before the methodical exploitation of the red marl was organized. The fact of being in the presence of a single individual is supremely important to permit appreciating the relative sizes among the various parts of the body.

Thévenin, in effect, comparing two limbs of *Bothriospondylus madagascariensis* such as they were restored and assembled in the Gallery of Paleontology in the Muséum¹, noted that the forelimb was 24 cm less than the hind limb. But in the same Gallery is preserved, from Madagascar, a good left humerus, also figured by Thévenin², of the same length (130 cm) as the preceding femur; von Huene³ wondered whether the comparison between these two latter bones did not have to be established, rather than between the preceding ones. For the bones from Madagascar discovered up to now, it is impossible if the humerus and femur belonged to the same animal. In contrast, the single individual

¹ W. E. SWINTON. The Dinosaurs, 1934, p. VIII and IX; O. ABEL. Die Rekonstruktion des *Diplodocus*. *Abhand. d. k. k. Zool.-Botan. Gesellschaft Wien*, Vol. V, No. 3, 1910.

² O. ABEL. Lehrbuch der Paläozoologie, 1924, fig. 610, p. 405.

¹ THÉVENIN. Dinosauriens de Madagascar, 1907, fig. 15, p. 11.

² *Ibid*, pl. II, fig. 1.

³ F. VON HUENE. Die Fossile Reptil-Ordnung Saurischia, *Monog. Geol. u. Palaeont.*, Berlin, 1932, p. 281.

from Damparis shows that the humerus of *Bothriospondylus* was slightly shorter than the femur (by 10 to 12 cm if one takes into account the accidental lengthening of the femur, rather flattened, while that of the humerus is intact).

By the form and structure of its teeth, by its very elongate cervical vertebrae, by the wide and deep cavities that give an extraordinary lightness to the vertebrae of the neck and back, by the slender shape of its limbs, finally by the size of the forelimb a little less than that of the hind limb, the Damparis sauropod belongs to the family Brachiosauridae (subfamily Brachiosaurinae of von Huene). It should be referred to the genus *Bothriospondylus* OWEN 1875⁴ and more precisely to the better-known species *B. madagascariensis* LYDEKKER 1895⁵. The individual from the Jura was somewhat larger in size than that from Madagascar⁶. But no significant character makes it possible to make a distinct species of it.

What precise place can be attributed to *Bothriospondylus madagascariensis* in the classification?

All the authors felt the extreme difficulty there was in classifying in a satisfactory manner these gigantic quadrupeds that formed, altogether, a rather homogenous group in the suborder Sauropoda. Among these recent attempts, two of preference will be retained.

F. von Huene⁷ distinguished two large families:

a) CETIOSAURIDAE, with four subfamilies:

1. Cetiosaurines: *Cetiosaurus*, *Haplocanthosaurus*, *Rhoetosaurus*.
2. Titanosaurines: *Tornieria*, *Titanosaurus*, *Aepisaurus*, *Laplataosaurus*, *Magyarosaurus*, *Hypselosaurus*.
3. Diplodocines: *Diplodocus*, *Barosaurus*.
4. Dicraeosaurines: *Dicraeosaurus*.

b) BRACHIOSAURIDAE, also including four subfamilies;

1. Brachiosaurines: *Brachiosaurus*, *Bothriospondylus*, *Pelorosaurus* (= *Ornithopsis*).
2. Camarasaurines: *Camarasaurus* (= *Morosaurus*), *Apatosaurus* (= *Brontosaurus*), *Uintasaurus*.
3. Astrodontines: *Astrodon* (= *Pleurocoelus*).
4. Helopodines: *Helopus*.

He recognized however that this double division is not absolute, at such point that in the Dogger “*Bothriospondylus* and *Cetiosaurus* are still so close one to the other, that they show a narrow relationship inside the same restricted group, and that they are distinguished only by some different adaptations” (*Op. cit.*, p. 248).

Also, Smith Woodward¹, following after Swinton², preferred simply to distinguish six families of sauropods, without trying to group them further:

⁴ R. OWEN. A monograph on the fossil Reptilia of the mesozoic formations. *Palaeontograph. Society*, 1875, p. 21.

⁵ The two other species, *B. robustus* OW. and *B. suffosus* OW., are established only on some vertebrae from the Jurassic of England.

⁶ Cf. A. THÉVENIN. Dinosauriens de Madagascar, 1907. — The hind limbs of *Diplodocus* from America and *Cetiosaurus* from England exceeded still by 20 to 25 cm the length of those of *Bothriospondylus* from the Jura.

⁷ F. VON HUENE. Die Fossile Reptil-Ordnung Saurischia, 1932, p. 248.

¹ In ZITTEL. Text-Book of Palaeontology, 1932, vol. II.

² W. E. SWINTON. The Dinosaurs, 1934, p. 87.

1. CETIOSAURIDAE: *Cetiosaurus*, *Haplocanthosaurus*.
2. BRACHIOSAURIDAE: *Brachiosaurus*, *Bothriospondylus*, *Pelorosaurus* (= *Ornithopsis*), *Rhoetosaurus*.
3. CAMARASAURIDAE (= MOROSAURIDAE): *Camarasaurus* (= *Morosaurus*), *Tornieria*, *Dicraeosaurus*, *Helopus*.
4. ATLANTOSAURIDAE: *Apatosaurus* (= *Brontosaurus*), *Atlantosaurus*, *Uintasaurus*.
5. DIPLODOCIDAE: *Diplodocus*.
6. TITANOSAURIDAE: *Titanosaurus*, *Hypselosaurus*.

All the authors are besides in agreement in recognizing that, in the two classifications, the brachiosaurids are distinguished from the cetiosaurids by the following characters: 1) the cervical and dorsal vertebrae are hollowed by vast and deep cavities separated by a very thin lamina: the cross-section of the centrum thus takes the form of a characteristic anchor³; 2) the forelimb is as long as, or longer than, the hind limb.

In summary, the study of the Damparis fossil has shown yet again the great homogeneity of sauropods. By its great size and the general shape of the bones, *Bothriospondylus* recalls rather close to *Cetiosaurus*; by the form of the ischium, it is similar to *Haplocanthosaurus*⁴ which belongs to the family Cetiosauridae; on the other hand, by its teeth, its sacrum and its caudal vertebrae, it is very close to *Camarasaurus* (= *Morosaurus*). However, this representative of the Brachiosauridae is sufficiently distinguished from the two near families, Cetiosauridae and Camarasauridae, by its very cavernous vertebrae and the length of the forelimb.

CONCLUSION

It is known that the dinosaurs prospered on the entire surface of the globe, exclusively in the Mesozoic Era. The first appeared in the Middle Triassic (Muschelkalk) and the more recent are still numerous in the last stage of the Cretaceous (Danian), after which they totally disappeared.

One finds, in France, the remains of dinosaurs during this entire period, from the Triassic to the Upper Cretaceous, with a maximum frequency during the Malm. The discovery of Damparis enriches our understanding of the French dinosaurs from a double point of view.

In the Upper Jurassic, only three stages have delivered some bones: the Oxfordian: *Megalosaurus cuvieri* from Villers-sur-Mer and *M. nicaeensis* from La Turbie (Alpes-Maritimes); the Kimmeridgian: *Cetiosaurus* (?), *Pelorosaurus*, *Megalosaurus* (?) from Boulogne and *Omosaurus lennieri* from Havre; the Portlandian: *Megalosaurus insignis* from Boulogne. From now on, we know moreover a theropod (*Megalosaurus insignis*) and a sauropod (*Bothriospondylus madagascariensis*) in the Sequanian of Jura.

Besides, the Damparis locality has furnished a more complete skeleton than has been recovered until now in France, where too often the citations of dinosaurs rest only on a tooth or long bone. The single individual of *Bothriospondylus madagascariensis* of

³ Cf. SWINTON, *Op. cit.*, 1934, fig. 14, p. 89.

⁴ Cf. HATCHER. Osteology of *Haplocanthosaurus*, 1903, p. 51.

which we have described six teeth, seven vertebrae, the sacrum, the two scapulae, notable portions of the pelvis, the forelimb and hind limb, brings much more precise knowledge on this genus, now known in the Jurassic of England, Madagascar, and the Jura. The bones, when they can be assembled in the Gallery of Paleontology of the Muséum, will give some idea of the gigantic reptiles that lived on the emergent terrains of Bourgogne and Franche-Comté, on the edge of the Jurassic seas.

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MEMOIR No. 47

PLATE I

Teeth of Jurassic dinosaurs of Damparis (Jura).

Megalosaurus insignis DESLONGCHAMPS
(carnivorous theropod)

FIG. 1. — Large caniniform tooth (110 mm).

FIG. 2. — Alveolar tooth (22 mm).

FIG. 3. — Other alveolar tooth (8 mm).

Bothriospondylus madagascariensis LYDEKKER
(herbivorous sauropod)

FIG. 4-8. — Five spatulate teeth. *a)* Internal face.
 b) External face.
 c) Lateral view.

All the teeth are represented at natural size.

These pieces, like those figured on the following plates, are part of the collections of the Laboratory of Paleontology of the Muséum.

MEMOIR No. 47

PLATE II

Bothriospondylus madagascariensis LYDEKKER

FIG. 1. — Caudal vertebra (fourth? caudal). Anterior face.

FIG. 2. — Anterior dorsal vertebra (third dorsal).

FIG. 3. — Dorsal vertebra (eighth or ninth dorsal).

View above showing the long cavities that hollow the centrum and the thin median partition.

FIG. 4. — Cervical vertebra (from the middle of the neck).
a) Lateral view; *b)* posterior face.

FIG. 5. — Caudal vertebra (first or second caudal). Posterior face.

Reduction: 1/4.

MEMOIR No. 47

PLATE III

Bothriospondylus madagascariensis LYDEKKER

FIG. 1. — Sacrum, composed of four coossified vertebrae.

a) Superior face; *b)* inferior face.

Reduction: 1/6.

FIG. 2. — Left tibia. *a)* External side; *b)* internal side; *c)* inferior head.

Reduction: 1/10.

FIG. 3. — Distal end of the left fibula. Internal face.

Reduction: 1/10.

FIG. 4. — Vertebra from the middle of the back (sixth or seventh dorsal).

Reduction: 1/4.

MEMOIR No. 47

PLATE IV

Bothriospondylus madagascariensis LYDEKKER

- FIG. 1. — Right humerus. Anterior face. 1/10.
FIG. 2. — Right ulna. 1/10.
FIG. 3. — Right radius. 1/10.
FIG. 4. — Small carpal bone. 1/6.
FIG. 5. — Left second metacarpal. Posterior face. 1/6.
FIG. 6. — Left third metacarpal. Anterior face. 1/6.
FIG. 7. — Left fourth metacarpal. Anterior face. 1/6.
FIG. 8. — Right third metacarpal. Anterior face. 1/6.
FIG. 9-12. — Four phalangeal bones. 1/6.
FIG. 13-14. — Two claws (ungual phalanges). 1/6.
FIG. 15. — Left femur. Anterior face. 1/10.
FIG. 16. — Left astragalus. Superior face. 1/6.
FIG. 17. — Right first metatarsal. Anterior face. 1/6.
FIG. 18. — Right third metatarsal. Posterior face. 1/6.

MEMOIR No. 47

PLATE V

FIG. 1. — The Solvay quarry, at Belvoye near Damparis (Jura).

The supporting wall, indicated by the arrow, currently closes the excavation from where the bones were extracted. The numbers correspond to those in fig. 3, p. 8.

FIG. 2. — The lens of red marls between two limestone banks, at the moment of discovery. The arrows at left indicate two bones in place; those at right show the spaces left by removal of portions of the scapula.

Solvay Stereotypes.

FIGURE CAPTIONS

FIG. 1. — Overall map of the western part of the Dolian Jura.
1. Crystalline, Permian, Triassic; 2, Jurassic; 3, Pliocene and Quaternary alluvium.

FIG. 2. — Geologic map of the environs of Damparis (Jura).
After the 1/80,000 map, Besançon page and personal observations.
J² Oxfordian: marls; J³ Rauracian: marly limestones; J⁴ Sequanian: fine-grained limestones; J⁵
Kimmeridgian: compact limestones; p Pliocene: gravel; a Quaternary: alluvium.

FIG. 3. — Section of the Sequanian in the Damparis quarry.
Scale: around 1/1,000.

FIG. 4. — Right thoracic rib. Head of the seventh (?) rib. 1/10/

FIG. 5. — Right ischium. 1/10.

FIG. 6. — Plan of the locality indicating the placement of the principal bones (after J. de Dorlodot).