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Paleontology

A new theropod dinosaur skull fragment from the Jurassic of the Vaches Noires (Normandy, France): remarks on the diversity of Jurassic theropods of Europe*

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Abstract *– The frontal bones of a theropod dinosaur from the Jurassic (upper Callovian or Oxfordian) of the Vaches Noires cliffs (Calvados, France) are described. The indicate a different animal from the already-reported contemporaneous species Piveteausaurus divesensis and Eustreptospondylus oxoniensis, which confirms the diversity of the still poorly known large theropods of the European Jurassic.*

Remains of theropod dinosaurs were reported as early as the 19th century from the Jurassic (Callovian and Oxfordian) of the Vaches Noires cliffs, on the Calvados coast between Villers-sur-Mer and Houlgate [1]. Among these fossils was hitherto a single braincase remnant, described by Piveteau [2] under the name *Streptospondylus cuvieri*, later names *Eustreptospondylus divesensis* by Walker [3], and finally referred to a new genus, *Piveteausaurus*, by Taquet and Welles [4] (the exact geographic provenance of this specimen is moreover slightly uncertain: Piveteau clearly indicated that it was found in the Vaches Noires "near Dives", whereas Taquet and Welles said it came from Dives, some kilometers to the west). In 1989, one of us (J.E.) found a new theropod braincase element in the Vaches Noires, which is described here.

The specimen, reocvered from the pebbles at the foot of the "false terrace", about 200 m east of Houlgate, is a water-worn bone whose exact origin within the cliff is uncertain, all the more so because no matrix still adheres to it. Its age is thus difficult to specify: it could come from either the Callovian Marnes de Dives which are visible at the foot of the cliffs and have produced many vertebrate remains, or from the overlying Oxfordian beds. Like the other dinosaur remains found in the Vaches Noires, it is presumably part of a carcass that floated out to sea some time before dropping to the bottom. The specimen suffered a significant abrasion on the left side, but the right side is well preserved.

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The specimen in question (Enos collection, cast kept at the Laboratoire de Paléontologie, Université Paris-VII) consists of the fused frontals of a very large theropod (fig.). There is little material from Europe with which it can be compared; comparisons were made principally with the braincase of *Piveteausaurus divesensis*, from the Callovian of the Vaches Noires, and with the frontals of *Eustreptospondylus oxoniensis*, known from a nearly complete skeleton from the Middle Oxford Clay (upper Callovian) near Oxford. The specimen was also compared with *Allosaurus fragilis*, from the Upper Jurassic of the United States, described in detail by Madsen [5].

One of the striking features of our specimen is the very advanced fusion of the frontals. The median suture line is barely visible, and even totally obliterated in the posterior part. In this regard, the specimen differs from those of Allosaurus fragilis described by Madsen, in which the medial suture is clearly visible. This suture is also easily observable on the type of *Piveteausaurus divesensis*. On that of *Eustreptospondylus oxoniensis*, the frontals show no sign of fusion and can easily be separated from each other along the medial suture.

Our specimen, subpentagonal in shape, is massive, thick (maximum median thickness: 23 mm), and relatively short (length: 110 mm) relative to its width (nearly 140 mm when the specimen was intact). Its dorsal surface is concave anteroposteriorly and transversely, the lateral borders were clearly upturned at the level of the contacts with the prefrontals, unlike the situation in *Piveteausaurus divesensis* and *Eustreptospondylus oxoniensis.* The rounded anterior edge corresponds to a sutural zone with the nasals; a slight rise, easily visible on the right side, marks the posterior limit of the part that was overlapped by these bones. This overlap area is proportionally much smaller than in *Eustreptospondylus oxoniensis*, in which the frontals form a longer anterior wedge that inserts under the nasals. In the posterior part, the edge of the supratemporal fossa is nearly flat, without the fairly distinct ridge seen in *Piveteausaurus divesensis*. The anterior part of the supratemporal fossa is much less elongated in our specimen than in *Piveteausaurus divesensis* and *Eustreptospondylus oxoniensis*. In *Allosaurus fragilis*, this part of the fossa is much wider. The median region between the fossa is wide and slopes sharply forward and downward, unlike the condition in *Piveteausaurus divesensis* and *Eustreptospondylus oxoniensis*. In lateral view, there is a deeply concave, dorsoventrally flattened contact area for the postfrontal, which is reminiscent of the same region in both of the aforementioned forms. Anterior to this cavity, the region corresponding to the dorsal edge of the orbit is much longer than in *Piveteausaurus divesensis* and *Eustreptospondylus oxoniensis*. Still more anteriorly, there is a cavity for the contact with the prefrontal, which is much higher and deeper than in these two species.

In ventral view, our specimen shows very pronounced reliefs, delimiting several paired concavities. The most posterior of them, corresponding to the roof of the orbit, is limited posteriorly by a broad ridge that reaches to the contact area for the laterosphenoid medially, and anteriorly by a ridge directed towards the contact for the prefrontal. The latter ridge is very sharp anterior to the cavity for the prefrontal and forms the posterior limit of another concavity. Medially, the roof of the olfactory tract forms a deep groove in its posterior part. Anteriorly, a median heart-shaped depression may correspond to the roof of the olfactory bulbs. Reliefs with an apparently similar disposition were described by Madsen in *Allosaurus fragilis.* In *Piveteausaurus divesensis* and *Eustreptospondylus oxoniensis*, the observed reliefs are much less marked than in our specimen.

There are thus many morphological differences between our specimen and the frontals of *Allosaurus fragilis*, *Eustreptospondylus oxoniensis* and *Piveteausaurus divesensis*. These differences are particularly interesting in the case of the latter two species, which are close to our fossil both geographically and stratigraphically. They do not seem to be explainable by differences in individual age. Although it is one-third smaller than the type of *Piveteausaurus divesensis*, our specimen shows a very advanced obliteration of the median suture between the frontals that suggests that it cannot be a juvenile. Judging from the state of its sutures (notably on the vertebrae), the type of *Eustreptospondylus oxoniensis* is a juvenile, but its frontals are of roughly the same length as those of our specimen, and therefore it is clear that they do not belong to the same form. Even though there are some resemblances between the frontals of *Eustreptospondylus oxoniensis* and *Piveteausaurus divesensis*, many differences in braincase anatomy have been noted by Walker [3] and Taquet and Welles [4] that do not seem to be of an ontogenetic nature, and separation at the specific [3] or generic [4] level seems justified.

Our specimen therefore can be referred neither to *Piveteausaurus divesensis* nor to *Eustreptospondylus oxoniensis*. It must be considered as indicating a third form of theropod. However, the available material is not sufficient for the erection of a new taxon, and no new name is proposed for this new theropod.

It results from the preceding remarks that three different types of frontal, corresponding to as many distinct theropods, are now known from the Callovian-Oxfordian of western Europe. Among these three forms, one (*Eustreptospondylus oxoniensis*) is known by a nearly complete skeleton, another (*Piveteausaurus divesensis*) by a braincase, and the third only by the frontals described here. Despite the incomplete nature of the available material, the discovery of this third form confirms the diversity of

these large theropods of the European Jurassic, whose phylogenetic positions remain imperfectly understood ([6], [7]). It also poses the question of the possible occurrence of the genus *Megalosaurus* (whose type species, *M. bucklandi*, is from the Bathonian of England) in the Callovian-Oxfordian of Europe. Jaw remains from the Vaches Noires are strongly reminiscent [7] of *Megalosaurus* specimens from the Bathonian and Bajocian of England [8]. Under these conditions, it cannot be excluded that some of the braincase remains – whether the type of *Piveteausaurus divesensis* or our specimen – from the Vaches Noires may in fact be referrable to the genus *Megalosaurus*. No decision can be made at the moment, because the braincase of *Megalosaurus* is not known with certainty (the specimen from the Bathonian of England described as such by Huene [9] in fact belongs in all likelihood to a sauropod, as pointed out by Woodward [10]). Only the discovery of more complete skull material, with associated braincase and jaws, may allow the problem to be resolved.

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