

PALEONTOLOGY. — *Biostratigraphic zonation and new vertebrate remains in the “Sables de Glos” (upper Oxfordian, Normandy)*. Note from **Eric Buffetaut, Max Bülow, Emmanuel Gheerbrant, Jean-Jacques Jaeger, Michel Martin, Jean-Michel Mazin, Christophe Milsent and Michel Rioult**, presented by Yves Coppens.*

The upper Sables de Glos fills a channel cut into the lower Sables de Glos, deposited in a regressive sequence, within a deltaic environment, in the neighborhood of an emerging terrain. The detrital beds of the channel base contain an assemblage of teeth and bones of fishes and aquatic, terrestrial, and flying reptiles, whose abundance and variety were unsuspected up to now. The upper Sables de Glos and their vertebrate fauna are dated to the upper Oxfordian (Regulare zone).

At the beginning of the upper Oxfordian, an abrupt return of erosion interrupted the carbonate sedimentation on the northeast Armorican platform. With the balance of the Pays d’Auge, after gulying of the Calcaire de Blangy (middle Oxfordian), a large sandy body was deposited and spread out very far toward the east, wide of the emergent Armorican terrains, passing laterally to more clayey or calcareous sediments. The “Sables de Glos” constitute this detrital formation well-known for having produced, within the classic localities situated southeast of Lisieux (Calvados), a fauna of Oxfordian mollusks as well preserved as those of the Cenozoic sandstones in the environs of Paris [1]. On the other hand, few vertebrate remains have been noted there up to now, aside from several teeth or bones of fishes and crocodylians [2].

Some stratigraphic researches in the Lisieux region (M. R. [3]) and the collections of two of us (C. M., M. B.), then sifting around 200 kg of sand by the team from Université Paris-VI (E. B., E. G., J. J. J., M. M., J. M. M.) led to specifying the depositional conditions and age of these Sables de Glos, and to notably completing our knowledge of their vertebrate fauna.

I. STRATIGRAPHY AND PALEOGEOGRAPHY OF THE SABLES DE GLOS. — The Sables de Glos Formation is divided at the outcrop into two depositional sequences. The lower Sables de Glos corresponds to a large terrigenous, detrital accumulation prograding toward the ENE while overflowing the Armorican platform toward the center of the Paris Basin. This first regressive sequence evolves until emergence, confirmed by a paleosol: after reworking the subjacent Calcaire de Blangy, these fluvio-marine sands contain in their lower part a mixture of shallow-water marine fossils (mollusks, calcareous algae) and fragments of continental vegetation, then some shelly lenses with often euryhaline bivalves, and is terminated by the Violet Bed [4] representing from 4 to 6 m an emerging horizon, having undergone a pedologic alteration and a gulying. The upper Sables de Glos fill a large channel cut into the lower Sables de Glos. The depth of this WSW-ENE-oriented channel, irregularly eroded, supports initially thick sandy beds containing blocks

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torn off the Violet Bed, of sandy slabs, ferruginous nodules, fragments of continental lignites or marine mollusks, then of sandstones or sands, clays, or limestones, with frequent indications of emergence, including beach ripples associated with tracks or burrows of crustaceans and reptile feet of small size, desiccation cracks, migrating ripple structures associated with lenses of plant debris. Some lenses of fossiliferous sandstone or shelly marine sand, with shallow-water bivalves and gastropods, are intercalated there. The top of this second regressive sequence is often marked by microconglomeratic passages, revealing an elevation of hydrodynamic energy on the bottoms. An erosive surface limits these upper Sables de Glos beneath the Aptian ferruginous sandstones. This second unit cut into the first reveals an initial, localized phase, predominately fluvial, of dismantling of the subjacent spreading sands by channel cutting and filling with reworked materials, as shown by the traces of heavy minerals ([5], [6]). Toward the north, these sandstones pass to sandy limestones and more or less sandy clays, toward the south to more confined clayey-carbonate slime.

At their base, the lower Sables de Glos are dated to the upper Oxfordian by the holotype of *Amoeboceras glosense* (Bigot and Brasil), an index of the Glosian zone and upper subzone (sub-boreal province). Regarding the upper Sables de Glos, which contain the vertebrate fauna noted below, they have produced *Aspidoceras (Euaspidoceras) striatocostatum* P. Dorn, from the basal Hypselum subzone, within the Bimammatum zone (sub-Mediterranean province), offering an invaluable marker between provinces within the Paris Basin, and corresponding to the upper subzone (Regulare) of the Serratium zone, sub-boreal [7]. In addition, some climatic variations are confirmed by the sedimentology and paleontology.

II. PALEONTOLOGY: NEW VERTEBRATE REMAINS FROM THE SABLES DE GLOS. — The vertebrate remains were obtained on the ground and by sifting the sands taken from the channel base. The morphoscopic and morphometric study of the quartz reveals the existence of two stocks of grains linked to two energy levels. One, elevated, is indicated by rounded grains, strong indices of sphericity-rounding (0.7–0.7), indicating a mature to super-mature arenite. To this stock of very worn quartz grains correspond very fragmentary and rounded vertebrate fossils (unidentifiable pieces of bone and enamel). The quartz grains of the second stock are angular, with weak indices (0.3–0.3), characterizing a sub-mature arenite, and coming from fresher continental terrigenous contributions. The vertebrate remains that can be referred back to it are more complete and better preserved, less transported.

In the sifted bed, the micro-remains of vertebrates are relatively abundant, because some 200 kg of sand furnished for example 170 crushing teeth of *Lepidotes* and 90 pycnodont teeth.

The list of vertebrate remains from the Sables de Glos, such as can be established today (8), is the following (the general already noted by Bigot and Brasil [2] are indicated by an asterisk):

- Class Chondrichthyes
 - Subclass Elasmobranchii
 - Order Selachii
 - Family Hybodontidae

*Hybodus** Agassiz: cephalic and dorsal spines, teeth, certain of which are attributable to the species *H. basanus* Egerton.

Polyacrodus Jaekel: teeth.

Indeterminate selachians: teeth.

Order Batoidea

Family Dasyatidae?: teeth.

Subclass Holocephali

Order Chimaeriformes: fragments of dental plates and characteristic ornamentation bone.

Class Osteichthyes

Subclass Actinopterygii

Order Semionotiformes

Family Semionotidae

*Lepidotes** Agassiz: fragments of marginal dentition, styliform marginal teeth, crushing teeth, scales of different types; a marginal tooth is attributable to *L. macrocheirus* Egerton.

Family Pycnodontidae

Microdon Agassiz: fragments of splenial dentition and isolated teeth.

Order Amiiiformes

Family Caturidae

Caturus Agassiz: small sharp and keeled teeth; a fragment of marginal dentition recalls *C. drieri* Thiollière.

Order Tetraodontiformes

Family Trigonodontidae

Stephanodus Zittel: hook-shaped pharyngeal teeth.

Indeterminate actinopterygians: lepidotrichia.

Class Reptilia

Subclass Anapsida

Order Testudines: incomplete dermal plates.

Subclass Lepidosauria

Order Rhynchocephalia

Family Sphenodontidae?: a well-preserved left palatine bearing six rectangular teeth. Comparison with known rhynchocephalians in the Upper Jurassic lithographic limestones of Europe is difficult because of differences in the mode of fossilization.

Order Squamata

Family indet.

Durotrigia Hoffstetter: small incomplete left dentary bearing five pleurodont teeth; the best preserved show an axial cuspid flanked by two enamel reinforcements. This specimen strongly recalls *D. triconidens*, from the Purbeckian of England [9].

Subclass Archosauria

Order Crocodylia

Family Teleosauridae

*Machimosaurus** von Meyer: several teeth whose enamel is ornamented with flexuous ribs disaggregating into granules toward the obtuse apex are referred without doubt to the species *M. hugii* von Meyer.

*Steneosaurus** Geoffroy Saint-Hilaire: very slender, pointed teeth, ornamented with fine longitudinal ribs, and presenting a double curvature. This morphology corresponds well to that described by Selenka [10] in *S. jugleri* (von Meyer).

Order Pterosauria: incomplete, fragile, hollow and elongate bones, certain of which are probably fragments of phalanges from the fourth digit (which supports the wing membrane). Added to this are several teeth, pointed at the crown, compressed, and with enamel reduced to an apical cap, and with anterior and posterior edges.

These remains indicate pterosaurs of rather large size.

Order Saurischia

Suborder Theropoda

Family Megalosauridae: laterally compressed, slightly recurved teeth with serrated carinae, evoking the genus *Megalosaurus* Buckland, a classic dinosaurian carnivore of the Jurassic of Europe.

Suborder Sauropodomorpha

Family Camarasauridae?: small spatulate tooth, with slightly concave lingual surface, without marked contraction at the neck. The weak differences between the teeth of various sauropod genera do not permit a generic identification.

Subclass Euryapsida

Order Sauropterygia: teeth and vertebrae attributable to a plesiosaur.

The vertebrate fauna of the Sables de Glos is thus revealed as much richer and more varied than had been supposed up to now. Among the fishes, the dominance of forms with crushing teeth (*Lepidotes*, pycnodonts), probably molluscivores, corresponds well to a littoral or deltaic setting favorable to mollusks. The reptiles are diversified, represented by aquatic animals, without doubt principally marine, such as Teleosauridae and plesiosaurs, but also by terrestrial groups, such as theropods, sauropods, squamates, and Sphenodontidae, or even flying forms (pterosaurs). The presence of terrestrial animals underlines the strong continental influences that reigned during the deposition of the Sables de Glos. The carcasses of these animals probably underwent only rather little transport before being buried in these sands. These facts are in agreement with the sedimentological and paleoecological data: settings in very shallow water and very close to shore, frequent emergences, high rate of sedimentation, probable risings.

Besides, the discovery of continental reptiles of very small size (rhynchocephalians, squamates) within the Sables de Glos suggests that the methodical exploitation of this formation could ameliorate our knowledge of the microvertebrate faunas of the European Jurassic. In effect, although several important assemblages (including mammals, among others) are already described in Great Britain and Portugal, nearly nothing comparable is yet known in France.

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