Notice

On the

Fossil Reptiles

Of the Cretaceous fluvio-lacustrine deposits
Of the Fuveau lignite basin

By

Mr. Philippe Matheron*

President of the Imperial Academy of Sciences, Letters and Arts of Marseille

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It is admitted in paleontology that the first appearance of crocodiles proper happened towards the start of the tertiary period and that these animals were preceded by the gavials, of which we find, effectively, remains in the upper stages of the Cretaceous terrain[2].

This opinion cannot continue to exist in science. The fossil remains of several species of crocodiles that are encountered in some of the beds of the Fuveau lignite basin prove that these animals are far older, since they had their place in the Cretaceous fauna of southeast France.

Crocodiles are also not the only vertebrates present in that fauna. They effectively were contemporaneous, as we will see, with some chelonians and several gigantic new saurians that are most closely analogous to the dinosaurians of the Wealdian beds of Tilgate Forest.

The special goal of this notice, given the restricted limits in which I must keep it, oblige me to exclude all purely stratigraphic discussion. I will not repeat here what I've already exposed[3] to demonstrate that the fluvio-lacustrine deposits of the Fuveau lignite basin were not Tertiary and to indicate how the logic of the facts force us to see, in the stages they present, the respective equivalents of diverse groups of marine beds subordinate to the upper stages of the Cretaceous terrain.

All the same, to be intelligible in what I have to say on the relative position of the beds holding the reptiles of which I speak, it is indispensable that I repeat before everything the results which one obtains when one studies the stratigraphic question of the Fuveai basin from different points of view.

These are the results:

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[1] This Notice was read on April 1st 1869 in a special session of the Academy.

[2] *Gavialis macrorhynchus*, Blainville.

[3] *Bulletin of the Geological Society of France*, 2nd series, 1864, vol. XXI, p. 532 and following; 1866, vol. XXIV, p. 48; 1868, vol. XXV, p. 762.

The Cretaceous series of marine origin stops, in Lower Provence, at beds that are very close to the age of the so-called Villedieu chalk and that is encountered not only on almost all the circumference of the Fuveau basin, but also on diverse points in Europe, notably at Gosau, at Aix-la-Chapelle and at Moulin de Tiffau, on the banks of the Salz, on the outskirts of Bains-de-Renne. There are no more of the marine beds in the Middle and Upper Senonian chalk, as Alcide d'Orbigny understood it, than there are in the surrounding countryside, that is to say the marine beds belonging to the Campanian and Dordonian of Mr. Coquand,

These facts denote an interruption in the marine deposits and prove that at a given moment the Cretaceous sea retreated from the land. The Fuveau lignite basin dates from that epoch, and, consequently, so do the first foundations of that powerful series of fluvio-lacustrine beds that are apparently unique to the Southeast of France.

This large series is extremely complex. It is divided into two parts of which one is Cretaceous and the other is Tertiary. But, as we find in the Tertiary part the manifest equivalents of all that we also know of in the Eocene and Lower Miocene and that its last foundations are covered by marine deposits of the Falunian period, it is easy to conclude that the numberless beds that constitute it were successively deposited during the immense stretch of time separating the epoch during which the land was abandoned by the Cretaceous ocean from that where the Falunian sea came to bath a part of the Rhone valley.

The Cretaceous part of this series is subdivided into four groups of beds or in four stages that correspond to as many periods.

For the duration of the first of these periods, almost all the Fuveau basin was bathed by brackish water. Accidentally and at several occasions, saltwater of varying salinity and sheets of freshwater covered some parts of its extent.

This variation in the nature of the waters allows us to consider this basin as a large depression that communicated then with the Cretaceous sea and which served as the mouth of one or several large streams.

Under such an environment, the population of mollusks developing in that basin could only be very variable. We can see, in fact, by examining the numberless fossils that constitute the fauna of the time, by the mode by which these organic remains were deposited in the beds and by the stratigraphic relations between them, that during this period, there simultaneously existed in this basin, here, marine bivalves such as oysters, cockles, and clams; there, there, estuarine shells, such as large freshwater clams, ceriths, melanias and melanopsids and other similar species, salt-marsh snails, unios and other freshwater gastropods whose remains are associated with land shells similar to those living today in warmer lands.

Towards the end of that first period, new modifications appearing in the relief of a part of Europe resulted in increasingly subjecting the Fuveau basin to the action or influence of seawater, and, contrariwise, throwing these waters on the brackish beds deposited in Gosau. Subsequently, the deposition of brackish beds was interrupted at the same time at Fuveau and in the Tyrolian Alps, and, by that fact, the two localities are found in a respective position such that the beds deposited later should certainly be lacustrine in the first and marine in the second.

Thus the Fuveau basin became the theater of lacustrine or fluvio-lacustrine phenomena, while at Gosau, and elsewhere in Europe, were made, within the sea, those great deposits of white chalk characterized well by *Belemnitella mucronata* and *Inoceramus Cripsi*.

The beds deposited in the Fuveau basin, during the second period, constitute a very large stage towards the base of which are several groups of lignite beds, known to the local miners as *Mène*. The oldest of these groups, which is also the most notable and as such is given the name of *Great Mène*, holds the bones of crocodiles and chelonian remains.

In another group, situated higher in the same stage and known as *Four-wall Mène*, is found the fragment of crocodile femur which was described and figured by Civier, and on whose characters Gray established his *Crocodilus Blavieri*.

The circumstances to which the Fuveau basin owes its new constitution naturally exercise a large influence on the animals peopling its waters and living on its banks. Only a few species of the preceding period survived the changes that occurred and competed thus, weakly, with the birth of a new fauna which included, besides the already mentioned crocodiles, estuarine turtles and myriad acephalous and gastropod mollusks, such as brackish clams, unios, melanias, melanopsids, salt-marsh snails, and bladder snails.

The situation in the Fuveau basin did not remain the same at the start of the second period, far from it. On the contrary, there happened incessant changes in the water regime under the influence of diverse circumstances. After that came considerable changes in the organic nature. New faunas succeeded each other in the basin; but what should not be forgotten is that, despite recognizing that faunas are inseparable, as they pass smoothly from one to the other, we must nevertheless recognize this remarkable fact that the animals living towards the end of this period had nothing in common with those living at the beginning when they started.

These endless modifications, which doubtless brought notable changes in the configuration of the basin, nevertheless did not increase the average area much; but, at one moment, under the influence of more general and especially more intense forces, large masses of freshwater, carrying with them an enormous quantity of sedimentary materials, invaded not only this basin, but also numerous depressions of the ground whose walls had emerged over the centuries. A phenomenon of this nature brought with it drastic changes in the aspect of the land. Henceforth, freshwater was no longer imprisoned in the relatively restrained limits of the Fuveau basin; they now occupied considerable surfaces, in the Midi of France as well as in the North of Spain. What is especially remarkable, and which proves that this freshwater invasion stemmed from general and uniformly-effecting causes, is that wherever those waters penetrated, they formed sedimentary layers identical both in petrographic composition and paleontological characteristics.

The foundations of the great Rognac stage, whose deposition corresponds to the third of the aforementioned periods, date from this time of troubles and flooding.

The phenomena manifesting their effects at the start of this third period were too incompatible with the laws of life to allow the development of a large lacustrine or fluvial population. But, despite being poor in genera and species, the Provencal

fauna of this epoch is nonetheless worthy of attention, for it records the existence of a large, probably aquatic chelonian, and the unexpected presence of a monstrous saurian, which bears the particular interest of having no apparent precursor in the country.

And yet calm settled little by little in this freshwater body. Beds of marly limestone and compact limestone successively covered the beds of purely detritic elements. Under this new state of things and the influence of a temperature dountlessly lower than that at the Fuveau lignite epoch but very probably equal to that of the intertropical regions of the modern world, numerous terrestrial and aquatic animals could develop. It was then that we find in our country, in the Fuveau basin as well as in the Alpines region, and at Segura, in Spain, those prototypes of snails which I have named Lychnus, and this multitude of other terrestrial mollusks that bring to mind the bulimulids and cyclostomes that live today under the warmer latitudes of India, America, and Polynesia.

Thus there also lived in our countries diverse reptiles whose numbers include a new crocodile and a dinosaurian cousin to the iguanodons, whose presence in the beds of the Rognac stage proves that the chain of dinosaurians was not interrupted since the lower stages of the Cretaceous.

Everything leads us to believe that the Rognac stage is the fluvio-lacustrine equivalent of the marine Hemipneustes beds of Maastricht, of Ausseing and Gensac and by extension the great saurians, which I just mentioned, are roughly contemporary with the famous *Mosasaurus Camperi*.

It is also probable that the sandstone forming the base of the Alet group of Mr. d'Archiac date from the same epoch.

The fluvio-lacustrine deposits of the Cretaceous do not end with the last foundations of the Rognac stage. The phenomena that put an end to those foundations were due to general causes that deeply modified the relief of Europe, the basin and shore of the Cretaceous sea, the configuration of the lakes and the biological conditions. The Cretaceous sea retired further on many points in the midi of France. However, the freshwater took a considerable extension, stretching over recently emerged surfaces. Under new climatic and biological conditions, a new fauna took the place of the extinct fauna of Rognac.

It was in the freshwater, which extended then in a nappe from the Var to the Haute-Garonne, that during the fourth and last of the aforementioned periods, were deposited those beds of rutilant marl, those breccias, those sandstones and those limestones which gave the Garumnian terrain, which they constitute, this particular physiognomy which is also seen in the Var, in the mountain of Cengle, near Aix, and in the valley of Valmagne, near Montpellier, as well as on the southern slopes of the Black Mountain, on the flanks of the Alaric Mounts and in the environs of the Baths of Alet.

The petrographic and paleontological characteristics of this Garumnian terrain are modified in Ariège and in Haute-Garonne. Little by little, the lacustrine beds pass laterally to beds of brackish water, then to deltaic deposits, and finally to true marine beds. It is reasonable to believe, based on that fact, that the contemporaneous sea of these great nappes of freshwater was not too far away from the territory occupied today by the Haute-Garonne department.

This bright red stage, which Mr. Leymerie considers as the equivalent of the pisolithic terrain of Northern France, is, in any case, a kind of intermediary between incontestably Cretaceous beds and the first foundations of the Tertiary deposits. It constitutes, in the Midi of France, an excellent geognostic horizon fixing the starting date of a new era in the history of the Earth.

The causes that determined that state in which was found the surface of our globe at the start of the Tertiary naturally exercised their influence on the Midi in France; everything changed: ground relief, ocean basin, water regime, climatic and biological conditions. The aforementioned great masses of freshwater ceased to exist or were displaced, and the sea, in which was deposited thosed mighty nummulitic beds that can be traced from Biarritz to the outskirts of Saint-Chinian, settled over surfaces of which some were once covered by freshwater.

And yet this sea, whose traces we also find in the extreme Southeast of France, in meridional Europe, in Egypt and in India, did not penetrate in the valley of the Rhone proper. The Fuveau basin, which had emerged little by little, ceased then to exist, and the Aix basin, that followed it, became in its turn the theater of purely fluvio-lacustrine phenomena. These phenomena resulted in the deposition of new beds of freshwater on the last foundations of the Garumnian terrain. Elsewhere, these same foundations were instead covered by marine beds subordinate to the nummulitic terrain.

The superposition of nummulitic terrain over the Garumnian terrain is a fact that dominates the stratigraphic question of the Fuveau basin. It peremptorily demonstrates, in effect, that the series of fluvio-lacustrine beds that we observe in this basin is more ancient than the nummulitic terrain; from which it follows that it was erroneous to consider the entire series, or some of the groups of observable beds, as the synchronic equivalents of certain paleontological horizons still situated elsewhere overwhere the nummulitic terrain.

That said, it is indispensable to determine the relationships that exist between this nummulitic terrain and the diverse known tertiary stages, and for that we must take into account the events that occurred after the retreat of the nummulitic sea.

When the sea abandoned the land, it created in southern France three principal regional subdivisions: 1st one in the West, in which were formed different marine deposits alternating sometimes with freshwater beds; 2nd one in the center, which was forever after removed from the action of the tertiary seas and in which only lacustrine and fluvial beds were afterwards deposited; 3rd a third one in the East, including the basins of the Rhone and Hérault, as well as a part of the Aude basin, and in which freshwater reigned at first, but which was then invaded later by the Falunian sea.

If we study in a comparative manner the geognostic constitution of these regions, we soon notice, in each one of them, the existence of the most characteristic horizons of the Tertiary, including the Lophiodon beds up to the *Dinotherium giganteum* group; we find starfish-bearing limestone in the great group of Tongrian beds, the manifest equivalent of the Fontainebleau sandstone and the marine beds of Faudou, near Gap, and the Diablerets, from which it follows that the upper nummulitic terrain of Messrs. Hébert and Renevier has nothing in common with the

nummulitic terrain proper, if not an unfortunate similarity of naming; we finally realize that there exist in the first of these regions, in Blaye itself, marine beds that belong to the horizon of *nummulites laevigata* of the Nantes and Paris basins, which demonstrates that the nummulitic terrain of southern France is more ancient than the massive Paris limestone.

However, as the fauna characterizing the marine beds of the Garumnian stage has no analogies with the faunas of the tertiary stages situated below the massive limestone and that it has, on the contrary, an incontestable Cretaceous physiognomy, it must be admitted that the nummulitic terrain of the French Midi is at least as ancient as the great group of beds which constitute, in the Paris basin, the sands of Bracheux, the limestones and the lacustrine marls of Rilly, the sands of Aizy and the *Nummulites planulata* beds, and consequently the Garumnian stage, and, even more so, the beds below it, that is the Rognac and Fuveau stages, cannot find a place in the Tertiary series.

By recapitulating what has been said and taking into account the many facts which I have mentioned elsewhere[4], we can see that the great series of fluvio-lacustrine beds of the south-east of France is intercalated between two marine deposits, the lower of which belongs to the inferior part of the Senonian terrain, and the upper belongs to the Tertiary period of the shelly deposits. We can see also that it is subdivided into two parts, of which one is Cretaceous and the other is Tertiary, and there exists at the base of those beds that appear to represent all or part of the nummulitic terrain. Finally, we see that the different groups of beds, which compose this series, are laid out as follows:

Falunian marine deposits.		
Great fluvio-lacustrine series of SE France.	Tertiary part.	Limestones parallel to the Beauce limestones.
		Marly limestones, sands and gypsums contemporary with the Fontainebleau sandstone.
		Marly limestones, with *Cyrena semistriata*.
		Aix gypsums with fish and insects.
		Mormoiron gypsums, lignites from around Apt with Paleotheriums.
		Limestones at Limnées d'Aix and Apt corresponding to the limestones of Saint-Ouen.
		Strong beds of sandstone and red marls with intercalated marly limestones.
		Various limestones and marls from the limestone age of Provins, of Saint-Parres and Bouxwillers, with Lophiodons.
		Montaiguet and Cannette limestones.
		Lacustrine limestones replacing all or part of the nummulitic terrain.
	Cretaceous part.	Rutilant Garumnian stage.
		Rognac stage.
		Fuveau stages.
		Basal beds of brackish water. Many shells. Reptiles.

[4] See the articles cited at the start of this Notice and, furthermore, the *Recherches comparatives sur les depots fluvio-lacustres tertiares des environs de Montpellier, de l'Aude et de la Provence,* in-8° Marseille, 1862.

The titular reptiles of this notice belong to five distinct horizons, to be exact:

5th In the Upper part of the Rognac stage: Chelonians, crocodiles, dinosaurians and large saurians.

4th In the detritic beds of the base of the same stage: Chelonian, large saurian.

3th In the lignite of the Four-wall Mène: *Crocodilus Blavieri*, Gray.

2nd In the lignite of the Great Mène: Chelonians. Crocodiles.

1st In the brackish-water stage of the base: Chelonians.

Vertebrates have been discovered in the Garumnian beds of the Ariège department; but the rutilant beds of the Fuveau basin does not have the slightest trace of them.

It is very remarkable that the Cretaceous beds of this basin never showed any traces of mammals and of fish, and that the vertebrates are only represented by reptiles.

With the exception of crocodiles, these reptiles belong to extinct genera which do not appear to have crossed a part of the Tertiary period, and whose analogues must be found in the Purbeck beds or the Wealdian deposits. This is a new fact whose importance will not escape paleontologists, and which supports the relative antiquity which the logic of stratigraphic facts assigns to the fluvio-lacustrine beds of the Fuveau basin.

The class of reptiles is only represented in this basin by chelonians, crocodilians, and saurians, which I shall summarily review in the order of their deposition.

1 – Reptiles of the basal brackish-water stage.

CHELONIANS. Of this stage, I only know absolutely indeterminable fragments of chelonians.

2 – Reptiles of the Great Mène lignite.

CHELONIANS. The animals of this order are represented by fragments which all appear to have beonged to the same species, of a type very close to Owen's pleurosternon. The animal was of medium size and very flattened. The external surface of the carapace bones offers only traces of very small, almost nonexistent longitudinal rugosities, being neither granular nor vermiculate, as in some river chelonians. Among the fragments I possess is a portion of the anterior and unpaired piece of the carapace, whose anterior side, slightly convex altogether and lightly sinuous in the middle, is the only one that is not fractured. The interior surface of this fragment is smooth and concave in the middle, in the longitudinal sense, that is, in the part corresponding to the neck of the animal. It is raised a bit towards its posterior extremity, towards the point where the first dorsal vertebra should be. The upper surface is barely convex. It is marked with three radiating grooves laid out between them as are those that exist above the *nuchal plates* marked *ch* in the figures of *Pleurosternon concinnum* and *Pleurosternon ovatum* given by Mr. Owen, in his monograph of the reptiles of Purbeck and the Wealdian[5]. The first of these grooves, which is median and longitudinal and occupies the anterior part of the

[5] Owen, *Monograph on the fossil reptilia, etc.*, part I, 1853, plates 2 and 7.

surface, indicates the separation of the two anterior paired scales. The two others, which are oblique, in concave curves on the anterior side and which reunite forming a prominent angle, on the top of which the aforementioned median groove, corresponding to the separation of the two paired anterior scales from the first ventral scale.

I possess another fragment from one of the lateral edges of the animal. It is entirely very flattened. It is made of a part of the carapace, which is slightly convex and sloping on its edge, and a corresponding part of the plastron, which is flat and slightly raised laterally. Above, about two centimeters from the edge, we can see a sort of irregular suture, by which two marginal pieces are separated from the extremity of dilated bone from one of its ribs. These two pieces are separated from each other by a lightly curved furrow, which passes below, after having crossed the rounded border of the specimen. This short furrow then runs transversely and a bit irregularly on the plastron, to reach, after a length of 44 millimeters, the jutting summit of an angle with a longitudinal furrow by which the underside of the aforementioned two marginal pieces is separated from a plastral piece.

This disposition results in the two marginal pieces being much larger below than above.

We can see by studying this specimen that the ribs of the animal do not end in a point, as in the trionyx, and that the carapace was not united to the plastron with simple cartilages, as is the case in fluvial turtles.

It is then probable that the two specimens that I have just described are the remains of a marsh turtle; and as the furrows on it that I have talked about are laid out exactly as may be observed in the corresponding piece of pleurosternon, I have reason to believe that they may both be assigned to this genus of chelonian. While waiting for ulterior observations to disprove or confirm the opinion I give on this regard, I shall name the animal they belonged to *Pleurosternon? provinciale*, taking care to leave doubt on its generic name.

This animal, which I have sometimes erroneously compared to the genus trionyx, was larger than Owen's *Pleurosternon concinnum* and *ovatum*; it was more than 40 centimeters in axial length.

CROCODILIANS. The crocodilian of the coal-bearing layers of the *Great Mène* did not have teeth equal to those of gavials. This animal had fifteen teeth on each side in the lower jaw. It was thus a true crocodile.

This will be my *Crocodilus affuvelensis*.

I know of this specimen several fragments, which have belonged to subjects of differing ages, namely:

1˚ Debris of a head presenting juxtaposed fragments of a left upper maxillary and the lower maxillary of the same side, with three posterior teeth in the upper bone and two in the lower bone. We notice as well two prints of teeth in the first of these bones and one in the second. These teeth have the well-known shape of the posterior teeth of crocodiles and caimans. They are very obtuse, slightly compressed; their crown is separated from their root by a constriction and show little, radiating rugosities, which flatten out with proximity to the summit. Towards the base, slightly above the aforementioned constriction, this crown is circumscribed by a slight horizontal depression. The teeth and tooth prints are at

their respective place; their axis-to-axis distance is about 11 millimeters, which allows us to suppose that they belonged to an animal whose total length was about two meters. The lower teeth interlock with those of the upper maxillary and are covered by it.

2° A lower left maxillary fractured near the coronoid apophysis and embedded in coal a little before the symphysis.

This magnificent specimen is deposited in a growing collection thanks to the enlightened initiative of Mr. Biver, principal agent of the concessionary company of the Gréasque and Fuveau mines.

It adheres to a piece of very compact coal on which we notice, as well, a large quantity of bone fragments; it shows the external surface of the maxillary with its characteristic rugosities.

There are no traces of the three first teeth; but the fourth, that is the largest, is in place; the fifth, sixth, and seventh are missing; the others from the eighth to the last, that is till the fifteenth, are in place.

3° Diverse isolated anterior and medium-sized teeth, all in a slightly curved cone shape and slightly compressed, with some large enough to have belonged to specimens over three meters in length. The summit of each of these teeth is more or less obtuse and has faint radiating rugosities.

4° A twenty-second vertebra, or third lumbar, whose articular apophyses and spinous apophysis are more or less fractured, but whose body and a portion of the annular part are perfectly preserved.

5° A twenty-third vertebra, or fourth lumbar, in which the annular part has been broken on both sides.

These two vertebrae belonged to the same animal which must have been about two meters long. The convexity of their posterior face is extremely pronounced.

6° A fragment of the annular part of the preceding vertebra with the left posterior articular apophysis and a part of the spinous apophysis.

7° A right coracoid, fractured a little above the neck and in which is consequently lacking the plane and enlarged part which unites with the sternum. We distinguish in this piece the facet on which the scapula pressed on; we also distinguish the apophysis whose external face formed one of the sides of the fossa which received the humeral head.

This coracoid probably belonged to a three-meter long animal.

8° A fragment of the upper part of a left femur broken a little above the tuberosity which stands in for a trochanter. The upper head of this bone must have been less compressed, in the lateral sense, and more extended, anteroposteriorly, than in modern crocodiles. The protuberance forming the trochanter is less extended and less conspicuous than in the femur of *Crocodilus Blavieri*, which we talk about below. We notice, a little above the base of this protrusion, a rather marked depression whose surface is slightly rugose. The entire bone must have been 20 to 22 centimeters long. By consequence, it belonged to an animal measuring about 3 meters in total length.

9° A fragment of the upper part of a femur, straight, absolutely symmetrical to the preceding, but having belonged to a subject that was only two meters long.

3. Reptiles of the Four-Wall Mène.

Of this coal-bearing deposits of the Fuveau basin, we only know the upper half of the right crocodile femur that was found, over 40 years ago, near the village of Mimet, and which Mr. Blavier, then engineer in chief of the mines, had sent to Cuvier. The knowledgeable anatomist recognized that these fragments belonged to the crocodile genus; he assigned the characters and he judged, based on those characters, that the coal bed of Mimet surely held the bones of a particular species of this kind of reptile.

Cuvier, who had not studied the region, adopted the opinion held then by the geologists on the geognostic position of the Fuveau or Mimet lignites. He believed that those lignites were Tertiary and that they were in the same relative position as the plastic clay and the lignites of Soissonnais, and as he had the occasion of noting in the Auteuil lignites, which are the same age as those of Soissonnais, the presence of a very small tooth, and a portion of the upper head of a humerus of a small crocodile, he was led to state that the species of Mimet could well be the same as that of Auteuil[6].

It is probable that Cuvier would not have hazarded that opinion, if he had known that the position of the coal-bearing bed of Mimet had absolutely nothing in common with that of the plastic clay of the Paris basin. In both cases, it is difficult to admit that we might identify two animal of which one is known only from half a femur, and the other, by a very minimal portion of humerus and an almost microscopic tooth.

Nevertheless, Mr. Gray, probably influenced, as had been Cuvier, by the assumed synchronism of the Mimet or Fuveau lignites with the Soissonnais lignites, thought that the crocodile of Provence, which he labeled with the denomination of *Crocodilus Blavieri*, was probably the same species as that of Auteuil[7].

Still, despite this remark, Mr. Gray also imposed a name on the animal of Auteuil and marked it down in his synopsis under the name of *Crocodilus Bequereli* (*sic*).

Later, in 1845, Mr. Pictet wrote that the lignites of Provence held remains of crocodiles of a very closely related species and which could be identical to that of Auteuil[8].

In 1847, Mr. Giebel, who probably did not know that synopsis of Mr. Gray, also had the idea of giving a name to the Mimet crocodile as well as to that of Auteuil; he imposed on the first the name of *Crocodilus provencialis* (*sic*) and on the second that of *Crocodilus indeterminatus*, noting that one could not yet recognize whether or not that last animal was distinguishable from the Provence specimen. Mr. Giebel also adopted, as did Mr. Gray, Cuvier's opinion on the contemporaneity of the Mimet lignites with the lignites and plastic clay of Auteuil[9].

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[6] See Cuvier, *Fossil Bones*, 2nd Edition 1821-1825, vol. V, p. 164, and 4th Edition 1836, vol. IX, p. 326, pl. 234, f. 17.

[7] John-Edward Gray, *Synopsis reptilium, etc.*, London 1831, p. 61

[8] Pictet, *Traité de Paléontologie élementaire*, t. II, p. 38.

[9] Giebel, *Fauna der Vorwelt mit steter, etc.* 1846, t. 11, p. 121

Mr. Gervais, on the other hand, dedicated a few lines to the animal of Mimet and referred this time to a crocodile tooth in the possession of the Aix museum, and which came from the Fuveau lignites[10].

Mr. Gervais did not categorically state an opinion on the relative position of those lignites; but what he says on this subject proves that he considers them more as Proicene than as Eocene proper; from which follows that according to the knowledgeable professor, the Mimet crocodile is probably part of the paleotherian fauna, rather than the fauna of the rough limestones and that in any case it would be more ancient than the animals of the Soissonnais lignites.

I have reason to believe that Mr. Gervais no longer holds this opinion. In any case, what I have said on several occasions about the stratigraphic question of the Fuveau basin demonstrates that there is little proof for the slightest connection between the Proicene stage and the coal-bearing beds exploited in this basin; and that *Crocodilus Blavieri* was no more contemporaneous of the paleotheriums of the Proicene or the Eocene lophiodons, than he was of the corryphodons [sic] of the Orthrocene. This animal was part of a Cretaceous fauna, less ancient than that to which belonged the chenolians [*sic*] and the crocodile of the coal beds of the Great Mène, but more ancient than that which once held the great chelonian, the crocodile, the dinosaurians and the gigantic saurians that characterized the Cretaceous stage of Rognac. This stage, as we know, occupies in the fluvio-lacustrine series of the Fuveau basin a position superior to the lignites, which can only be contested with stratigraphic facts with the preconceived notion of denying the evidence.

I do not have on hand the femur fragment described by Cuvier, but judging by the figure which was given in the research on the fossil bones, the femur of *Crocodilus Blavieri* differed from the femora of other crocodile species by a larger process and a larger prolongation of the tuberosity or trochanterian eminence. It is this character that differentiates it from the *Crocodilus affuvelensis* of the Great Mène.

Whatever it is, it is certain, in any case, that the *Crocodilus provincialis* of Giebel is none other than the *Crocodilus Blavieri* of Gray. As we only know the femoral fragment of this animal described and figured by Cuvier, and we ignore by consequence if its teeth were unequal or if they were roughly equal, it remains to be known whether it was a crocodile or a gavial. Ulterior observations will probably give an answer to this problem someday.

Reptiles of the Rognac Stage.

The unexpected presence of the vestiges of gigantic saurians and dinosaurians related to the iguanodon, in some of the beds of the Rognac stage, naturally brings up the interesting and difficult question of the successive appearance of different organic types and fixes the attention on the multiple causes which allowed some of those types to persist up to our time, while so many others have successively gone extinct, after having existed for one or several geological periods. Up to a certain point, it is easy enough to understand how, over time, various species could have modified themselves or gone extinct; but we must agree that the causes under which new types have directly manifested themselves for the

[10] Paul Gervais, *Zoologie et Paléontologie francaises*, 2nd edition, 1859, p. 441

first time have escaped to this day from our methods of investigation, and that the visible changes, in the scene of the world, and the successive creations which have been imagined to explain the appearance of those beings, have taught us absolutely nothing.

But, if we are completely ignorant concerning this matter, observation has at least made use recognize that the development of all these types across the various ages of the paleontological world does not appear to have happened intermittently, that is to say that everything leads us to believe that extinct species never reappeared, and, by consequence, the solutions of continuity, which sometimes seem to exist, will be filled up little by little as studies and paleontological observations are multiplied.

If this is the case, we may justifiably ask, up till what point can we say that the chain of large crocodilians and that of dinosaurians had been interrupted at the start of the Cretaceous period to start over in the Rognac stage? We may ask, in other terms, if the continuity we notice here is in fact apparent instead of real, and if it may be caused not so much by insufficient observations as by the rarity of animal debris forming the link between the large reptiles of the two epochs.

Whatever the case may be, what is certain is that the beds of the great Fuveau Stage, that is the beds which are older than those of Rognac, have not offered to this day any vestiges of animals that may be precursors to the great Cretaceous reptiles that once lived in our region. No less certain is that the presence of remains of those gigantic animals, in beds incontestably above the Fuveau lignites, give those beds, and, more notably, the lignites, a character of paleontological antiquity whose nature would make all doubts about the Cretaceous origin of those fluvio-lacustrine deposits vanish.

As I have already said, the large animals whose remains we find in the beds which constitute the Rognac Stage were not the only reptiles of the time: with them existed, in fact, chelonians and a crocodile. I will review the different remains of those animals that I have had a chance to observe.

4. Reptiles of the detritic beds of the base of the Rognac Stage.

CHELONIAN. The chelonian whose fossil remains have been found in the clayey sandstone of Rognac does not appear to be confidently assignable to a known genus. It was an animal lacking scales, similar to the trionyx, by its exoskeleton covered with large rugosities, and the emydids, with its plastron and marginal pieces, which served as a union between the plastron and the carapace.

It is probable, based on this, that this animal was related to the chelonians which served as the type for the genus Aplolidemys created by Mr. Pomel[11].

But as I only know this genus through what Mr. Pomel has said in the cited work, and as I only possess a small number of pieces from the Rognac specimen, all of which are more or less fractured, I must adjourn any generic determination until further evidence shows up. Thus, I will doubtfully designate this chelonian by the denomination of *Aplolidemys Gaudryi*[12].

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[11] *Archives de la bibliothèque universelle de Genève*. Vol. IV, p. 328.

[12] I dedicate this species to my learned friend Mr. Gaudry, whose knowledge I often had to refer to, and who wished to make bibliographic studies for me.

Among the fragments which I possess are found a part of the left shoulder bone. This bone is fractured several centimeters above the articular facet of the humerus. This facet is about 5 centimeters long at its long axis. We can distinguish perfectly the suture between the scapula and the coracoid. We can also see the base of the acromion.

This chelonian must have been about 80 centimeters long. Its carapace, which was rather thick, had elongated rugosities running down its length, irregular and protuberant. The plastron is much less rugose.

GREAT SAURIAN. At the same time as the chelonian which I have just mentioned, there lived in our land a monstrous saurian whose unexpected presence in the Rognac beds is well worthy of attention.

This animal brings to mind those gigantic reptiles that belong to the two groups of crocodilians with biconcave and convexo-concave vertebrae; that is, they are close to the genera *Steneosaurus*, *Streptospondylus*, *Cetiosaurus*, *Pelorosaurus*, etc.; I know of it the following pieces:

1° Fragments of a long bone that reaches a total length over 80 centimeters. This bone, which appears to be a left femur, has both of its heads almost entirely mutilated. It is slightly sinuous, depressed in the transverse sense, especially towards the middle where its section, a slightly quadrilateral oval, is 17 centimeters long and only 7 centimeters wide. It has no medullary canal, which allows us to assign it to an aquatic rather than a terrestrial animal. The central part is spongy, with rather loose tissue, but less loose than that of the heads.

2° A fragment which appears to belong to the lower part of a left tibia, between the lower third and the start of the dilation leading to the lower head. This bone is not cylindrical; its section, on the upper fracture, is in an oval slightly depressed from one side, 11 centimeters long and 5 and ½ centimeters wide. Compared to those of the corresponding parts of a crocodile tibia, these dimensions allow us to suppose that the entire bone must have been about 80 centimeters long.

This bone fragment lacks a medullary canal. The central spongy substance, almost absent in the upper section, is, on the contrary, largely developed in the opposite section.

3° A large portion of a very elongate bone, fractured on one side and ending in the other by an attenuated, highly pronounced dilation, of which one of the faces is convex, while the other is concave. This is probably a fragment of the fibula. Its length is 55 centimeters. This length coordinates rather well with that of the aforementioned femur and tibia.

The transverse section, not far from the fracture point, is shaped like an equilateral triangle with rounded angles; the sides of this triangle are about 7 centimeters long; the dilated and curved tile-shaped part is, towards its extremity, 18 centimeters long.

4° Two caudal vertebrae whose large dimensions and shape of their centra are as remarkable as the singularity of their apophyses.

These two vertebrae are consecutive, and as they differ very little from each other in their form and their dimensions, we may suppose that they come from a rather elongated tail, in which must have existed many vertebrae.

What distinguishes these vertebrae most of all is that their centra, instead of being compressed laterally, as in crocodiles, is, on the contrary, compressed dorsoventrally, and their articular faces are not circular but oval, in the transverse sense. These faces are 11 centimeters wide and 7 centimeters high; one is concave, the other is convex. This concavity and convexity are relatively less pronounced than in crocodile vertebrae.

The centrum is about 12 centimeters long. With the exception of the upper part, which is almost horizontal, it is excavated in a curve, such that towards its middle, it is only 8 centimeters wide and 5 and half centimeters high. The neural canal is small; along with the annular part, it only covers about half of the length of the vertebra, on the side where it is concave. This annular part rises over 6 centimeters above the upper face of the body of the vertebra and ends, on top, by a sort of blunt summit in which the spinous apophysis resumes. This peak is prolonged on one side in a cone that acts as an articular apophysis and whose obtuse summit does not exactly reach the plane of the convex face of the vertebra. From the opposite face, two symmetrical articular apophyses detach themselves from the annular part and advance in the direction of the side of the concave face of the vertebra, which they overtake by 4 centimeters. These two divergent apophyses are situated a little lower than the cone of the opposite side, where it follows, that in the articulation of two consecutive vertebrae, the cone of one is found symmetrically situated above and in the middle of the two apophyses divergent from each other.

On the edges of its convex face, we notice, under the vertebra, two very obtuse projections separated by a longitudinal depression and analogous to those that exist in the corresponding parts of the caudal vertebrae of crocodiles. It is permissible to think, based on that, that these vertebrae had a haemapophysis, that they were concavo-convex and that, in their articulation, the anterior apophyses were exterior and inferior, as in crocodiles.

These singular vertebrae have a few relations with that which is represented in Pl. V fig. 3 and 4 of supplement number 2 in the monograph of reptiles of the Wealdian and of Purbeck, and which Mr. Owen assigns with doubt to Pelorosaurus.

It is to be noticed, however, that there exists in this vertebra a haemapophysis adherent by ankylosis and that the articular apophyses, anterior and posterior, are less elevated and less protuberant than in the Rognac vertebrae.

It is probable that these two vertebrae belong, as is that which is figured by Mr. Owen, to the posterior part of the tail. We may judge, then, what could be the length of that part of the animal! This great dimension is coordinated as well with the dimensions of the bones which accompanied these vertebrae. At any rate we end up with a truly gigantic animal.

I cannot see the possibility of entering the vestiges of this reptile in one of the known genera. Setting aside error on my part, we must give way to the creation of a new genus to which, by reason of the great size which this animal probably had, I propose to give the name of *Hypselosaurus*. The Rognac species will be *Hypselosaurus priscus*.

The hypselosaur was probably an aquatic animal much like known large crocodilians. Its tail was not compressed laterally as in crocodiles. Its dentary

system is unknown. The absence of a medullary canal in the long bones does not allow us to suppose that it was terrestrial as was the iguanodon.

With the bony remains that I have just talked about are found two large and very enigmatic fragments of spheres or ellipsoids, which have tried the patience of several paleontologists. All things considered, it appears that they are fragments of eggshells. These eggs were even bigger than those of the great bird that Geoffroy Saint-Hilaire has named Aepiornis. Do the two fragments represent the vestiges of two eggs of a gigantic bird, or are they the remains of two hypselosaur eggs? Such is the question that remains to be solved.

I will give, in another circumstance, a detailed description of those two samples with drawings for support.

5. Reptiles of the Upper Part of the Rognac Stage.

The reptiles that remain for me to talk about are all from diverse lacustrine marly beds, which have been excavated by the Nerthe tunnel, by which the railroad from Paris to Lyon and to the Mediterranean enters the Marseille basin. These beds hang on the littoral of the Fuveau basin, and are situated on the geognostic and paleontological horizon of the upper beds of the Rognac stage.

The bones were extremely numerous in these marls; but almost all those that were collected, at the time of railway construction, are more or less fractured.

This, in its entirety, is the result of the study that I have made on the various reptile vestiges.

CHELONIANS. Indeterminable fragments of two species. One had a carapace textured by strong granulations, and the other, of which I possess a few vestiges of the vertebral column with a few portions of costal pieces, had a non-textured carapace, which was probably covered with scales.

CROCODILES. There were in the beds debris of a new species of crocodile, to which I give the name of *Crocodilus vetustus* and of which I possess the following pieces:

A. – Several teeth belonging to various parts of maxillaries. The posterior teeth have an obtuse crown that is separated from the root by a constriction, and on the tip of which we observe light radiating rugosities. These teeth, as well as the conical teeth, differ sensibly from those of *Crocodilus affuvelensis* and are slightly smaller than them.

B. – The lower half of a left femur whose condyles, especially the internal condyle, are in part fractured. The entire bone must have been 23 centimeters long, which suggests an animal three meters long.

C. – The upper portion of a left femur, smaller than the preceding, broken a little above the upper head. By its trochanterian process, this bone differs from the femur of *Crocodilus Blavieri* as much as from *Crocodilus affuvelensis*.

GREAT SAURIANS. There were with the remains of the chelonians and with those of the aforementioned crocodile, numerous fragments of saurian which I have not yet been able to determine. Those are portions of various bones and of convexo-concave vertebrae, or perhaps concavo-convex. I mention them here only as a reminder, while waiting for them to have been subject to an ulterior study.

DINOSAURIANS. But what will be of most interest is that there were, among the bony debris buried in the lacustrine marls of the Nerthe, the remains of a large

new terrestrial reptile which was most closely related to the iguanodon and to which, due to its fluted teeth, I propose to give the generic name of *Rabdodon*.

The Rabdodon had a pleurodont dentary system analogous to that of the iguanodon. The teeth were not lodged in distinct alveoli. They were all situated in a common alveolar pit and adhered, by one of the sides of their root, to the internal face of the jaw. They were compressed, festooned on their upper border, regularly channeled, in the vertical sense, on their lateral faces, and irregularly undulated, transversely, in their lower part, when they have fully developed.

I possess of this animal a certain number of pieces whose description would exceed by far the limits of this notice. I will thus only speak here of the principals, to the number of which are added, first of all, diverse fragments of the lower maxillary.

A. – *Lower maxillaries*.

Judging by the two fragments which belong to the posterior part of the jaw, one on the right, one on the left, the lower maxillary of the Rabdodon, like that of the iguanodon, was remarkable by the parallelism of its upper and lower borders and by the presence of teeth up to the point where the bone rises sharply enough to form the coronoid apophysis. I do not know if, as in the iguanodon, the anterior part of the maxilla was toothless and if it was cut obliquely. By analogy, we can suppose that it was so as well.

The anterior surface, unlike that of the iguanodon, which is vertically slightly concave upwards, is convex or subangular altogether, divided in two almost flat parts that form between them an obtuse angle with a rounded peak.

We notice on this exterior surface holes analogous to those that exist on the lower maxillary of the iguanodon, with the difference being that, in iguanodon those holes are all near the dentary border, while in the Rabdodon they are a little bit over the middle of the bone, that is, a bit above the obtuse angle that separates into two parts the external surface of the bone. Up to a point, those holes are closer to each other in the Nerthe animal than in the iguanodon. The external surface of the bone is smooth to the touch.

The alveolar pit rests on a protrusion of the dentary bone. It is formed at the base, by a sort of groove that exists above that protrusion; on one side, by the upper half of the dentary bone, and on the other by an opercular that rises up to the top of the upper border of the maxillary. It follows from there that the teeth are only apparent from their crown and that we can only observe them after having removed the opercular.

We see, below the protrusion supporting the alveolar pit, the mandibular canal which is exposed and whose depth increase the closer it is to the posterior part of the maxillary.

The teeth were numerous and contiguous. We can see all sizes, which allows us to suppose that their growth and replacement happened in the same way as in the iguanodon. The largest of the teeth I had the chance to observe was about 2 centimeters long from the front to the back.

The vertical height of the jaw I have before me is exactly half of that of the jaw of the iguanodon. However, as the other bony pieces in question are proportionally larger, since they are 2/3 the dimensions of the corresponding pieces of the iguanodons, we must conclude that either the jaws I possess belonged to

young individuals, or that, up to a point, the head of Rabdodon was relatively smaller than that of the iguanodon. It is probable that this last hypothesis is more likely than the former.

B. – A fractured and deformed lumbar vertebra. It is lightly bi-concave. The vertebral hole is large. We notice a part of the spinous apophysis, a portion of one of the transverse apophyses, vestiges of one of the posterior articular apophyses and the two anterior articular apophyses, one of which, the left one, is very well-preserved.

The articulation of the two consecutive vertebrae was done as in crocodiles, that is to say, the anterior articular apophyses of a vertebra were exterior and inferior with respect to the posterior apophyses of the preceding vertebra.

The articular face of the body of the vertebra is slightly elliptical in the vertical sense; its width is six centimeters.

This vertebra has dimensions equal to 2/3 of the analogous vertebrae in the iguanodon. There are no traces to be seen of an inferior apophysis.

C. – A fragment of sacrum in which we see two vertebrae with their annular part, accompanied by articular apophyses, and a fragment of a third vertebra. All those pieces are adherent to each other by ankylosis. The length of the vertebrae is 5 centimeters, that is to say, two thirds of the length of the iguanodon's sacral vertebrae.

This sample demonstrates by itself that the Rabdodon was a dinosaurian.

D. – A posterior caudal vertebra. This vertebra is slightly bi-concave. It is hollowed out in the middle and slightly depressed transversely. The small size of its vertebral hole proves it belongs to the last half of the tail. We can see above a few trace of apophyses. It is 8 centimeters long.

E. – A fragment of caudal vertebra from the middle of the tail, with traces of a long spiny apophysis.

F. A right humerus, whose upper head is fractured and which should be about twenty-nine centimeters in length. It is very similar to the humerus of the iguanodon.

G. – The upper half of a right femur, which is also very similar to the femur of the iguanodon. We see on one of the sides of its head a trochanter crest that separates from the bone and follows its curvature. Another trochanter exists on one of the sides of the bone, towards the middle of its length, to the point where it shows a depressed facet that forms, in a way, a flat surface.

The entire bone was probably fifty centimeters long. The length of the iguanodon femur is about eighty-four centimeters.

H. – The lower part of a right tibia. The lower head of this bone is proportionately larger than that of the megalosaurus tibia, but it is much less enlarged than that of the hylaeosaurus. The entire bone must have been 50 centimeters long.

Such are the principal remains of the reptile to which I apply the denomination of *Rabdodon priscum*. This was probably a herbivorous animal with terrestrial habits. Judging by a comparison with the iguanodon, its total length must have been about 6 meters. It had some kinship with the *acanthopholis horridus*,

Huxley[13]; but its teeth were not lancehead-shaped and were not swollen towards their base. We have not found, mixed with its remains, the least vestiges of dermal plates comparable to those that covered the body of the reptile described by Mr. Huxley. The *acanthopholis horridus* preceded the Rabdodon; it belongs to the lower Cenomanian horizon.

Resuming what I have just rapidly exposed in this notice, we see that the fluvio-lacustrine beds of the Fuveau lignite basin are characterized by remains of chelonians, crocodilians, great saurians related to crocodiles, and dinosaurians.

The order of chelonians is represented by indeterminable fragments which we encounter in the beds of brackish water at the base; by the *Pleurosternon? provinciale*, which characterizes the lignites of the *Great Mène*; by the *Aplolidemys Gaudryi*, of the base of the Rognac stage, and by two indeterminable species whose few vestiges we find towards the superior part of the Rognac stage.

The order of crocodilians is represented by the *Crocodilus affuvelensis*, which we find in the lignite of the *Great Mène*; by the *Crocodilus Blavieri*, of the *Four-Wall Mène*; finally, by the *Crocodilus vetustus*, which belongs to the horizon of the upper beds of Rognac.

The great saurians related to crocodiles are represented by the *Hypselosaurus priscus*, which belongs to the base of the Rognac stage, and by one or several other animals of which I only know a few fragments belonging to the horizon of upper beds of the Rognac stage.

Finally, the dinosaurians are represented by the *Rabdodon priscum*, which belongs to this horizon of upper beds of the Rognac stage.

I add to this notice five plates. The first is devoted to the crocodile of the *Great Mène*; the second represents the vestiges of the Hypselosaur; the three others are relative to the *Rabdodon*.

Pl. I. – **Crocodilus affuvelensis**. – Natural size.

Fig. 1. Fragment of right femur.
a posterior face. b anterior face. c internal face.
Fig. 2. Coracoid.
a posterior face. b anterior face. c internal face. d external face.
Fig. 3. A fragment of the twenty-second vertebra.
a seen from the left side. b seen from above.
Fig. 4. Fragment of the upper and posterior part of the twenty-third vertebra.
a seen from above. b seen from below.
Fig. 5. Lower part of the same twenty-third vertebra.
a seen from above. b seen from the left side. c seen from the posterior side.
Fig. 6. Various anterior and medium-sized teeth.
Fig. 7. Fragment of head with debris of two lower and upper maxillaries, each armed with a few posterior teeth.
Fig. 8. Portion of left lower maxillary.

[13] *Geological Magazine*, 1867, vol. IV, p. 65, pl. V. fig. 1-4

Pl. II - **Hypselosaurus priscus**. – 1/5 natural size.

Fig. 1. Large bone which appears to be a left femur.
a external side, with trausverse [sic] section. b fragment of the upper head, seen from the posterior side. c same fragment, seen from the internal side.
Fig. 2. Left tibia?
a seen from the internal face. b upper section. c lower section
Fig. 3. Large bone which appears to be a fibula.
a tibial face. b opposite face, with three transverse sections. c profile view. d Upper head, seen from above.
Fig. 4. Posterior caudal vertebra.
a seen from the left. b seen from the anterior side. c seen from above.
Fig. 5. Two consecutive caudal vertebrae, seen from the left side.

Pl. III. – **Rabdodon priscum**. – Natural size.

Fig. 1. Portion of left lower maxillary.
a external face. b internal face. c seen from above. d section following A B showing the section of a tooth. e section following C D also showing the section of a tooth.
Fig. 2. Portion of right lower maxillary.
a internal face with fragments of teeth in the parts where the opercular has been removed. b section of the posterior extremity of this portion of the maxillary.
Fig. 3. Fragment of left lower maxillary with fragments of teeth.

Pl. IV. – **Rabdodon priscum**. – ½ Natural size.

Fig. 1. Portion of the sacrum.
a seen from the left side. b seen from the posterior side.
Fig. 2. Right tibia.
a posterior side. b anterior side. c lower head seen from below.
Fig. 3. Lumbar vertebra.
a seen from the anterior side. b seen obliquely from the left side.
Fig. 4. Posterior caudal vertebra.
a seen from the left side. b anterior face. c seen from above.
Fig. 5. Vertebra of the middle of the tail with fragments of the spinous apophysis.

Pl. V. – **Rabdodon priscum**. – ½ Natural size.

Fig. 1. Upper part of the right femur.
a anterior face. b internal face. c external face. d upper head, seen from above.
Fig. 2. Left ulna.
a anterior face. b radial face.
Fig. 3. Right humerus.
a posterior side. b anterior side. c external face.

ERRATA

Read: Rhabdodon *instead of:* Rabdodon.
Page 5, line 30, *instead of*: were deposited those beds of rutilant marl, those breccias, those sandstones and those limestones which gave the Garumnian terrain, which they constitute, *read*: were deposited those beds of rutilant marl, of breccias, of sandstones and of limestones which gave the Garumnian terrain, which they constitute…
Page 6, line 5, *instead of*: climatic, *read*: climateric.
Page 17, line 20, *instead of*: anterior surface, *read*: exterior surface.
[numbers adjusted for this translation]