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THE DINOSAURS OF THE "CONTINENTAL INTERCALAIRE" OF THE CENTRAL SAHARA

BY

A. F. DE LAPPARENT

STUDY OF SOME VERTEBRATES FROM THE MUSCHELKALK OF DJEBBEL REHACH (SOUTHERN TUNISIA)

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THE DINOSAURS OF THE “CONTINENTAL INTERCALAIRE” OF THE CENTRAL SAHARA*

FIRST CHAPTER

RESEARCHES AND DISCOVERIES

The existence of remains of great fossil reptiles in the Saharan continental series was discovered and noted by several of the first explorers. Indeed, more than fifty years ago F. Foureau [1904] and E. Haug [1904] made known that there were remains of fishes and crocodilians and a fragment of dinosaur vertebra, recovered in 1893 in the Djoua during F. Foureau’s memorable missions. Then R. Chudeau [1907] noted the presence of reptile bone remains in the Marandet cliff, Niger in the course of his immense journeys.

A more outstanding discovery is that announced by Depéret and Savornin [1925, 1927], describing two megalosaurid teeth recovered by Captain Burté at Timimoun. Thereafter, Bourcart and Keller [1929; cf. Augiéras, 1931] noted in passing some large dinosaur bones at Tilemsi, while V. Pérébaskine [1933] discovered a sauropod vertebra in the Ibelrane cliff, Soudan.

However, neither C. Kilian nor N. Menchikoff had occasion to find vertebrate fossils during their bold explorations. Only the rich Baharija locality, in the Egyptian desert, revealed rich spoils to the missions of the Munich museum, which E. Stromer and his collaborators published little by little from 1914 to 1938.

It was in 1946, as soon as beginning some remote missions in Africa again after the war could be thought of, that Mr. N. Menchikoff proposed for me to go and prospect the Gourara and Touat. On his advice, some indications gave hope that the sandstones of Timimoun could reveal dinosaurs, because A. Meyendorff, having tragically disappeared in 1942, had recovered reptile bones at several places in the Continental Intercalaire of the Gourara [Meyendorff, 1938]. Thus nine missions were made into the Great Desert between 1946 and 1959. The memory of the first excursions evoked the Sahara of former times, where one walked with the regular step of the camels, going during the weeks from “pasture to pasture” in perfect solitude. In contrast, the last trips benefited from better-equipped missions, where all-terrain vehicles—Jeep, Land Rover, and Power Wagon—permitted astonishing excursions across the Sahara of today.

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Two voyages allowed me to explore initially the long band of Continental Intercalaire that girdles the Hammadas of the Tademait and Tinrhert (fig. 1): from

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November 1946 to January 1947, for the Gourara, Touat and Tidikelt; from November 1947 to January 1948, for the Djoua from Fort Flatters to Ohanet, then from this point up to Edjelé Tan In Azaoua, which no geologist had yet reached [Lapparent, 1949b].

Alerted by a passage of Pervinquière signaling fish remains in extreme southern Tunisia, and thanks to facilities that Mr. G. Castany—then director of the Geological Service of Tunisia—procured for me, I was able to realize two consecutive missions (January 1951 and February-March 1952) all along the Dahar cliff and up to Tripolitania, discovering at several points some dinosaurs of great interest.

Subsequently, thanks to the friendliness of the officers of Tamanrasset, I made a fruitful journey to Tamesna, far south of the Hoggar, in February 1953.

Then, from December 1953 to February 1954, I visited the Niger series in some detail, with the assistance of geologists J. Greigert and F. Joulia; some important dinosaur localities were discovered and studied in these regions. In contrast, I did not find reptile remains in the vast spaces of the Tibesti, Borkou, and Erdis, which I traversed with the geologists of the Borkou-Ennedi-Tibesti mission from the A. E. F. Geological Service from December 1954 to February 1955.

Finally, I returned in February 1958 to the region between Ohanet and Edjelé, profiting from the great facilities that the petroleum bases of the Company for Research and Exploration of Petroleum in the Sahara (C. R. E. P. S.) currently offered in this region, formerly so difficult to access.

This memoir has already been presented during the meeting of the Geological Society of France, when Mr. André Cornet of the Hydraulic Service of Algeria invited me to a rapid but full-interest tour in February-March 1959. Thanks to this occasion, I was able to visit the In Tedreft locality with A. Cornet and G. Busson, at the beginning of In Guezzam. Subsequently, we traversed south of the Tanezrouft under the guidance of Mr. Bourgeois; then the northern part of Tilemsi that extends northwest of Tessalit. Before the manuscript does not leave an impression, I was able to hold account of these new observations and important discoveries made at In Tedreft [Lapparent, 1959].

*

* *

Always accommodated well in the Sahara, I have no lack of interest in the research of the vertebrate fossils by several people who then sent me interesting elements.

Mr. J. Hugot, teacher at Aoulef, and Mr. Orengo, resident at Timimoun, recovered with patience in these two localities some elements that they addressed to me spontaneously. To Captain Archier we owe the discovery of the Tamesna localities and the organization of my 1953 mission. I also acquired several dinosaur bones, recovered on the one hand at In Abangarit by adjutant Pouillet, on the other south of Agadès by Captain M. Mareschal.

R. Karpoff announced his observations to me regarding the large dinosaur bones from Tilemsi. Ph. Renault accompanied me for several weeks at Tamesna, and G. Busson in the regions of Alrar and Zarzaïtine, then at In Tedreft and Tilemsi. F. Gautier sent me elements from In Tedreft and then wanted very much to lead me to the locality. Geologists Ph. Lefranc and H. Faure recovered with sagacity the remains of fossil reptiles in new or difficult to access regions. Finally, the petroleum geologists who traversed the vast zones of the Sahara in all directions naturally encountered new localities: Cl. Sallé, Ph. Deffrene, R. Nyssen, J.-C. Chavand, M. Gillmann, above all F. Nougarède and P. Claracq, thus gave me bones and teeth of real interest.

On his side, Abbey R. Lavocat traversed the Hammadas of southern Morocco from 1947 to 1950, and discovered some important and varied remains of dinosaurs in the Kem Kem region which he studied, and which will have to be compared with our own finds. He also made a mission to Tilemsi in 1953.

In spite of the fragmentary state of the objects thus amassed during twelve years, I have judged that the moment has come to publish that which concerns the dinosaurs of the Continental Intercalaire of the central Sahara. But it can be hoped that more forceful prospecting in the Great Desert will lead to the future discovery of new remains of fossil reptiles, which will complete the non-negligible knowledge that we have at the current time.

*
* *

Paleontological missions to the Sahara could not be undertaken without multiple assistances, ensuring financing on the one hand, progression and protection in the desert on the other.

My recognition initially goes to Mr. N. Menchikoff, who incited me to undertake my first voyage to the Sahara and then encouraged me effectively each time to specify a new project.

Numerous official organizations ensured me the necessary subsidies on several occasions, and I thank them for it: the Center for Saharan Research of the National Center for Scientific Research (Mr. N. Menchikoff), the Institute for Saharan Research of the University of Algiers (Mr. R. Capot-Rey), the Geological Mapping Service of Algeria (Mr. G. Bétier), the Hydraulic and Rural Equipment Service of Algeria (Messrs. Drouhin and Cornet), the Geological Service of Tunisia (Mr. G. Castany), the Federal Director of Mines and Geology of A. O. F. (Mr. L. Marvier), and the Geological Service of A. E. F. (Mr. J. Nicault and also Mr. M. Nicklès). Finally, the services of the C. R. E. P. S. facilitated with good grace the 1958 mission starting from the Maison Rouge base established near Edjelé, and those of the Company for the Exploration of Petroleum (C. E. P.) accommodated me in their sector of the Tinrhert.

Not being able to cite all those who offered me their traditional hospitality, I want to at least address my most particular memory to Mgr. G. Mercier, bishop of the Sahara, to the White Fathers of Adrar, El Goléa, and the I. B. L. A. at Tunis, to Mgr. Quillard, apostolic vicar of Niger, and to the Fathers of the Zinder mission.

In citing several names among the soldiers and administrators who facilitated my attempt and often were interested in it, I would like to associate all the others who aided me in diverse degrees: General Quénard, as Commander of the territory of Aïn Sefra; Colonel Thiriet (†1956), then Commander of the territory of Oasis; Colonel Vigourous, at Ouargla; Commander P. Le Liepvre, at In Salah and then Rhat; Commander J. Lecointre, at Aoulef and subsequently at Tamanrasset; Captain L. Archier, at Tamanrasset; Lieutenant G. Mercadier, who received me at Timimoun; Lieutenant C. Allibert at In Salah; the officers of Tatahouine and Rémada; Mr. Périé, Circle Commander at Agadès; Commander Ladurelli and Mr. Mora, at Largeau; Captain Decamp, at Fada; G. Touron, faithful companion at Tamesna; finally Dr. Amlot, Lieutenant-Doctor at Rhat in 1947-1948, who devoted himself to me during many days after a dramatic accident.

This incomplete enumeration at least underlines the close solidarity of the desert, in the good as well as the bad moments.

Naturally my memory also goes to all the faithful guides—Arab, Touareg, and Toubou—who always ensured good conditions on demanding routes and sometimes contributed to the discovery of fossils.

Let me add that such fossils, simultaneously fragile and heavy like the careful illustration of a memoir of this type, required diverse help. I must note all the help that was brought to me for these realizations, as much Mr. Solignac, molder, as Messrs. Leriche, Mémin, and M. Potiquet, photographers.

CHAPTER II

THE LOCALITIES

The Sahara or Great Desert is an arid zone nearly 2,000 km wide, saddled on the Tropic of Cancer, that traverses Africa from west to east, from the Atlantic coast to the Red Sea (fig. 2). We will agree to delimit the *central Sahara*, to which the present study refers, as the quadrilateral comprised between Colomb-Béchar, Tripoli, Gao, and Lake Chad, for a surface of some 2,500,000 km^2 (fig. 2 and 3). But the dinosaur terrains only naturally cover part of this extent (fig. 3).

To the north, the limit between the Sahara and Barbary is well marked topographically and geologically by the "Saharan flexure", from Agadir to Biskra. From this locality, we keep the Biskra-Gabès line as the limit of the Sahara; it leaves a "Tunisian province" to the north that recent studies have shown to be distinct from the Barbary proper.[1]

To the south the Sahara does not have as clear a limit [Capot-Rey, 1953, p. 16-35]. It is generally a little near the level of the 16th parallel where the desert proper passes into the savanna over several dozen kilometers, although, according to the abundance of the rains, the Savannah and desert can encroach alternatively on one another in a sometimes considerable manner.

I. Distribution and nomenclature of the localities.

A glance thrown on the maps (fig. 2 and 3) shows the distribution of thirty dinosaur localities that are currently known in the central Sahara. They are grouped, not randomly, but in two zones, situated on either side of the Tropic of Cancer and corresponding to large outcrops of the "Continental Intercalaire".

The northern zone includes the 5 localities of the Dahar cliff in Tunisia and Tripolitania on the one hand; the 11 localities ringing the Tademaït and Tinrhert on the other.

The southern zone includes 17 localities, of which 13 are found distributed in the cliff or plain of the Soudanese and Nigerien Sahara. They are enclosed by one locality on the eastern border and one on the western border of the Aïr, and by two on the western border of the Adrar des Iforas.

Moreover, figure 2 emphasizes the fact that, for the moment, apart from the central Sahara, only two dinosaur localities are known all in all, rather rich it is true: Baharija in the eastern Sahara and Kem Kem in the western Sahara (see the summary table, p. 45).

[1] The diverse zones of the Barbary, in the geological sense, indeed inflect frankly toward the northeast, and the limit of the Barbary follows the Biskra-Bizerte line. The "Tunisian province" is open to the east and includes some Mesozoic and Tertiary sedimentary series resting on a broken African base. Cf. G. CASTANY (1954), Les grands traits structuraux de la Tunisie. *B. S. G. F.*, (6), IV, p. 151; J. BOLZE (1954), Les rapports de la Berbérie et de l'Afrique en Tunisie. *C. R. Ac. Sc.*, vol. 238, p. 2177.

Besides, the word *locality* must be extended here in a slightly special manner. In the absence of precise toponymy, which often happens in the case of immense uninhabited and flat expanses, several fossiliferous points could be united under a single name. Thus the In Abangarit localities are distributed in a zone 20 km wide and more than 30 km long. Similarly, the zone of the El Rhaz localities, found by H. Faure in Niger, extends over 120 km. And in southern Morocco, by "dinosaur localities of Kem Kem" R. Lavocat [1952a] means a 250 km band along which a few fossil bones are found everywhere. But each time that a more varied topography favored a more abundant toponymy, I have specified the name of the fossiliferous place as much as possible. Here is the alphabetical list and enumeration of the localities, corresponding to the map in fig. 3:

No. 1. Agadès: 35 km south
2. Agadès: 16 km southeast
3. Alrar
4. Aoulef Cheurfa
5. Chebbi: Aïn Cheikh
6. Chebbi: Oulad Yahia gour*
7. Chenini
8. Déhibat
9. Djoua: Tab-Tab
10. Djoua: 120 km east of Fort Flatters
11. Ebrechko
12. El Rhaz
13. Giado
14. Guermessa
15. Ibelrane
16. Ifayen Ignère
17. Iguallala
18. In Abangarit
19. In Akhamil
20. In Gall
21. In Salah
22. In Tedreft
23. Rémada: Kanboute
24. Tébéhic: Soureya
25. Téfidet
26. Tiguidi: Marandet
27. Tiguidi: Zinder piste*
28. Tiguidi: Irayen
29. Tilemsi 1
30. Tilemsi 2: Tikarkas
31. Timimoun
32. Zarzaïtine: east of ZR.2
33. Zarzaïtine: Maison Rouge cliff

II. Description of the localities.

A) *LOCALITIES OF THE DAHAR CLIFF (EXTREME SOUTHERN TUNISIA AND TRIPOLITANIA).* — The map (fig. 4) indicates the position of five places along the Dahar cliff that have revealed dinosaurs. When we undertook its exploration in 1951, dinosaurs had not yet been noted there, rather only some fish scales ([Pervinquière, 1912]; in fact, the remains of fishes, and also crocodiles and turtles, are much more abundant than those of dinosaurs.

This 500 km long cliff, with slopes often covered again by rockslides that paste the slopes under the already desert climate, is not so favorable to paleontological researches. For a first reconnaissance, we proceeded in the following fashion. Leaving the principal pistes, we examined the slope of the cliff with binoculars; thus we chose the ravines skirting the falls or, better still, some small promontories or some gour detached

* *gour* = tabular hill, usually an erosional outlier (synonymous with *gara*) [MTC].
* *piste* = desert road, unpaved but usually worn to a hard and stable surface [MTC].

in front, on which the clays and sandstones are more widely exposed. We next went up to the foot of the cliff in the Land Rover; then we climbed the slope on foot, attentive to the gravel horizons or conglomerates, which are generally, but not always, revealed to be the richest. We thus methodically "probed" the cliff at numerous chosen points, and proceeded where it was revealed as fruitful; but it is natural that a first prospecting must let some localities escape that are yet to be found.

GUERMESSA (no. 14). — The case of this locality precisely illustrates what I have said. The isolated gara[*] that is encountered east of the village shows well some bone remains, but the rockslides there are too developed. Next we went a little more to the south (Djebel el Haddada on the 200,000 scale map of Tunisia, Foum Tatahouïne sheet), where some dismantled gour provide better exposures. There, a conglomerate revealed rather numerous remains of theropod and sauropod dinosaurs, along with silicified wood and crocodilian teeth.

CHENINI (no. 7). — Good exposures are present in this sector, in the gour that precedes the village of Douiret: a sandy zone at mid-height contains numerous trunks of silicified wood, and a conglomeratic level shows bones and teeth of fishes and reptiles. A theropod tooth and the remains of a large turtle were found in the gypsum beds of the cliff between Douiret and Chenini. But the richest locality is a bone bed, localized as a torrential delta in the clays, situated at Er Roua on the piste from Tatahouïne to Chenini.

RÉMADA: Kanboute (no. 23). — We went from the military post of Rémada to examine the exposures of Gara Kanboute, which attracts attention by its isolation 7 km to the southwest (Pl. I, fig. 3). Entirely at the top of the continental series, only several meters under the marine Cenomanian, we found a sandstone very rich in vertebrates; an *Iguanodon* tooth was recovered there, to my surprise.

Pervinquière noted the Segdel region, 10 km south of Rémada, as concealing some vertebrate remains. We found there a similar section to that of Gara Kanboute, with some remains of fishes and crocodilians at the same level, but no dinosaurs. In the Krechem el Hanana promontory, halfway between Rémada and Déhibat, we found only several crocodilian teeth.

DÉHIBAT (no. 8). — The environs of Déhibat are notched with deep ravines that are very favorable for prospecting; at several levels, silicified or ferruginous wood, remains of abundant fishes, teeth of crocodiles, and poorly determinable dinosaur bones are recovered, especially on the slopes of the Touil Déhibat and Garet er Rehi. The interest in this locality is to permit restoring—more easily than elsewhere—a complete section of the continental series comprised between the marine Upper Jurassic and the marine upper Cenomanian (fig. 5, section A). However one realizes that the same vertebrate fauna is encountered at different levels, sometimes at the summit (Kanboute and Déhibat), sometimes in the middle (Chenini), and sometimes toward the base (Déhibat) of the continental series. This is precious for fixing the Lower Cretaceous age of this fauna; but at the same time this shows that it was illusory to want to distinguish the stratigraphic sections in this series with the aid of vertebrates.

[*] *gara* = tabular hill, usually an erosional outlier (synonymous with *gour*) [MTC].

GIADO (no. 13). — A very similar section is observed in the cliff passed in Tripolitania, and we have recovered some vertebrates, notably fish scales, already noted by the Italian authors, at Nalut, Giado, Iefren, and Garian. Alone, toward the middle the Giado cliff has furnished us some dinosaurs in the form of a tooth and a theropod bone. However, it seems that the Tripolitanian zone is less rich in vertebrates than extreme southern Tunisia.

B) *LOCALITIES OF THE GOURARA, TOUAT, TIDIKELT, DJOUA, AND THE OHANET-BOURARHET REGION.* — All the geological maps of the Sahara reveal a continuous band of clayey-sandy terrains that form the slope and foot of the cliff girdling the Tademaït and Tinrehrt. The Gourara, Touat, Tidikelt, and Djoua are depressed zones dug principally into the Continental Intercalaire series. Between Ohanet and Bourarhet are extended vast sandy plateaus where one begins to foresee a more complete stratigraphy than in the preceding regions. The dinosaur localities are relatively numerous throughout this central Sahara zone, and we describe them summarily from west to east (fig. 6).

TIMIMOUN (no. 31). — The topographic disposition and the succession of terrains are a little different here than those of the Dahar cliff (fig. 5, section B). The Cenomanian-Turonian border of the Tademaït plateau is found moved back due to erosion to 50 km east of Timimoun (Moungar in Zouz); and the upper part of the Continental Intercalaire is essentially clayey: these are the El Goléa clays [J. de Lapparent, 1937] that never contain vertebrates. It is only the base of the continental series that will be fossiliferous here [Lapparent, 1947]. The vertebrate remains were found nearly exclusively in the spoils of the wells of the Amerhaïr foggara*, either by the first works by Captain Burté in 1924, by ourselves in 1946, or afterward by Mr. Orengo. The periodic re-digging of the foggara canal indeed starts with a conglomeratic level with yellow quartz pebbles, some quartzite pebbles, rounded silicified wood, and rather abundant vertebrate remains: fishes, crocodiles, turtles, and sauropod and theropod dinosaurs. The other foggaras, so numerous around Timimoun, provided nearly nothing except a large fragment of dinosaur bone near Oulad Noun. The Amerhaïr foggara is the most productive in fossils (fig. 7), not only because of its prominence (it is 7 km long, with numerous wells spaced every 10 m), but above all because it goes up beyond the first sandy cliff and thus re-covers the principal fossiliferous level, which most of the others do not reach.

The Adrar region has only furnished some small fragments of insignificant bones; we found the largest there in the spoils of the Reggan foggaras. But the best come from the CHEBBI region: Aïn Cheikh (no. 5) and the Oulas Yahi gours (no. 6); it is a large sauropod bone found in place in the sandstone immediately discordant on the Precambrian or Paleozoic.

AOULEF (no. 4). — Thus one arrives at the Aoulef Cheurfa foggara, which delivered reptile bones in abundance. Above all these are the remains of an enormous crocodile, a new species that will be described additionally under the name Aoulef

* *foggara* = a subterranean irrigation system [MTC].

crocodile; but there are also theropod and sauropod bones. The spoils of the Akabli foggara also gave us fragments of reptile bones.

At IN SALAH (no. 21), we observed bone fragments in the sandstones of several buttes to the north, on the El Goléa piste. But we did not have anything determinable at this locality, until the day when Captain Mourret agreed to give us, via Mr. Capot-Rey as intermediary, various bones of a large sauropod discovered in 1957-1958. Recently, Lieutenant C. Allibert found sauropod vertebrae (Pl. XI, fig. 3) in this locality, situated in the clayey-sandy cliff 17 km north-northeast of In Salah.

DJOUA (nos. 9 and 10). — The Djoua valley is relatively rich in vertebrate remains east of Fort Flatters. Dinosaurs were recovered at two points: at Tab-Tab (no. 9) (Pl. I, fig. 1) by F. Foureau himself, and 120 km east of Fort Flatters by F. Nougarède.

IN AKHAMIL (no. 19). — In the gour situated south of In Akhamil, since 1947 we have discovered a fossiliferous band in the greenish sandy clays: numerous fish teeth, crocodile bones, and a large sauropod femur.

ALRAR (no. 3). — The same band is very fossiliferous toward Alrar for a distance of 90 km. But beyond, according to geologist J. Ph. Lefranc, hardly any vertebrate localities are encountered east of the frontier, in the Fezzan territory; however, J. Ph. Lefranc and J. M. Freulon noted bone fragments in the red sandstones around Sabha.

In contrast, descending south of Alrar, dinosaurs are found at several levels in the great continental series, so difficult to date, that is developed between Ohanet and Bourarhet (fig. 8). We note these significant benchmarks.

Below the quartzitic flagstone that crowns the Taouratine series, G. Busson showed us some fragments of sauropod bone in the red sandstones, 10 km south of the In Akhamil locality.

But above all, in the region of the ZARZAÏTINE plateaus (Pl. I, fig. 2), 11 km east-northeast of petroleum wells ZR.2 (no. 32), the C. R. E. P. S. geologists discovered some bones belonging to a very large sauropod and probably a single individual: sacrum, tibia, metacarpals, and phalanges. The locality belongs to the Taouratine series.

Finally, Mr. P. Claracq recently recovered two teeth of *Teratosaurus* associated with some stegocephalian bones at the summit of the sandy ZARZAÏTINE cliff, above the Maison Rouge (no. 33); it is a lower stratigraphic level than all the preceding ones and one that had not yet furnished fossils.

C) *LOCALITIES OF SOUDAN AND NIGER*. — South of the Tropic of Cancer, the same geological structure present to the north is found with an astonishing symmetry. Thus inversely, from north to south, the following succession is observed corresponding with as many natural regions (fig. 3):

— the Precambrian base of the Hoggar, with its two large processes, the Adrar des Iforas and Aïr;

— a zone of sandy Paleozoic plateaus, the southern Tassilis;

— vast regs[*] covering depressed regions, established sometimes on the upper Paleozoic, most often on the clays and sandstones of the Continental Intercalaire [Lambert, 1932-1933];

[*] *reg* = stony or pebbly plain [MTC].

— a cliff with multiple steps crowned by the marine Upper Cretaceous[1] [Furon, 1935].

It is thus in this cliff and the plains which extend to its foot that the seventeen localities are found which remain for us to enumerate (fig. 9).

TILEMSI 1 and 2 (nos. 29 and 30). — At the western border of the Adrar des Iforas, the Continental Intercalaire goes directly to contact the Precambrian[*] without interposition of Paleozoic sediments. The great north-south Tilemsi depression is principally clear in the clays and sandstones that break through the sproutings of the base. In this region the post-Cretaceous tectonic movements are observed to be particularly emphasized, which locally have raised the Continental Intercalaire and marine Cretaceous to the vertical [Cornet, 1948].

Some large sauropod bones, discovered during the Augiéras-Draper mission halfway between Tessalit and Gao (locality no. 29), were noted by J. Bourcart and A. Keller [1929]. But the widest outcrops of the Continental Intercalaire are developed northwest of Tessalit, where. R Karpoff found bones in 1948, 115 km northwest of this locality. R. Lavocat and S. Rouaix found the place named Tikarkas (locality no. 30): it furnished some sauropod long bones and vertebrae. Moreover, they observed large sauropod bones 35 km further west, near the point marked Enaouallen-ouallen.

With A. Cornet and G. Busson, we returned to the Tikarkas locality in 1959, which appeared to us exhausted. But in a sandy relief 4 km south, we found long bones and a large sacrum of a sauropod, with a crocodile and an entire turtle.

Notable sandstone outcrops of the Continental Intercalaire are known south of Tanezrouft, recently studied by Mr. Bourgeois. Fishes (*Ceratodus*, *Platyspondylus foureaui*) have been recovered in the Ilaferh region. On the other hand, some calcareous sandstones outcropping on the reg at 28 and 32 km northeast of Guernène have furnished several bones of indeterminate dinosaurs, a rather abundant crocodile, and calcified wood. The interest of these recent works (1958 and 1959) is to show the extent of the reptiles of the Continental Intercalaire up to the western border of the Hoggar.

IBELRANE (no. 15). — The Cretaceous cliff north of Menake was described by V. Pérébaskine in his thesis [1933, p. 115]. He noted there in passing a 14 cm long sauropod vertebra, collected south of Ibelrane. We have not visited this locality; but there was without doubt interest in further prospecting the entire Continental Intercalaire zone east of Gao.

In contrast, we have brought our attention to the territory of Niger, where fourteen interesting localities are now known, whereas a single one was noted there prior to 1953.

IN ABANGARIT (no. 18). — The best fossil reptile localities of the central Sahara are those of the In Abangarit region, found by Captain L. Archier. We studied them in

[1] It has often been affirmed that on the border of the Adrar des Iforas the transgression began only in the Maastrichtian. If this marine transgression with *Libyoceras* is indeed the clearest, it seems however that one can also identify the Cenomanian-Turonian transgression. Above the red sandstones and clays of the Continental Intercalaire proper, indeed come two superimposed gypsum series; because they are separated from one another by limestone banks with oysters and diverse gastropods, clear indications of the arrival of the sea. In our opinion, this transgression, timid but real, appears well to correspond to that which is recorded everywhere else in the Sahara during the Cenomanian-Turonian.

[*] literally "Crystalline" ("Cristallin") [MTC].

1953, through a series of camel trips organized at the outset from a most primitive Touareg encampment [Lapparent, 1953c]. Bones and teeth are abundant in certain zones that seem to correspond to fluviatile deltas. The dinosaurs there are more varied than everywhere else in the central Sahara; the frequency of large carnivorous theropod teeth are noted. Stratigraphically, the In Abangarit series is situated in the upper part of the Continental Intercalaire, a little below the Cenomanian-Turonian.

IGUALLALA (no. 17). — At the same stratigraphic level is found the interesting locality of Mount Iguallala, where J. Greigert led us and which revealed three species of sauropods; the exigencies of a tour in these far countries did not allow us to explore this abundant locality sufficiently: it merits being revisited. Several bones were also found on the reg around Mount Kassot, 80 km north-northwest of Mount Iguallala.

IN TEDREFT (no. 22). — The In Tedreft locality is situated lower in the Continental Intercalaire. It was discovered by accident in 1958 during a petroleum reconnaissance mission by geologists Kieken, Nyssen, and F. Gautier. This last agreed to lead us to this rather difficult to find point [Lapparent, 1959]. The best way to go there is to follow the Agadès piste for 73 km on the Tamesna reg starting from In Guezzam; at the "Agadès 417 km" sign, take a right-angle turn northeast for 28 km. Clayey-sandy buttes covered with bone fragments are found on the eastern side of the Oued Timmersoï, approximately 15 km west of the In Tedreft well. There we recovered theropods, in particular elements of the genus *Elaphrosaurus*, and some very abundant sauropod bones.

Moreover the region comprises other fossiliferous points. We recovered crocodile and dinosaur bones in a small elongate relief 15 km from the "Agadès 417 km" sign. On the reg 8 km from this sign, numerous dispersed dinosaur bones are noted, and even the entire braincase of a sauropod, unfortunately extremely dislocated.

IN GALL (no. 20). — 1 km north of In Gall, at the foot of the clayey-sandy buttes, we discovered with J. Greigert, and then exploited with F. Joulia, a good locality where the bones of large sauropods are numerous (Pl. II, fig. 1), in particular the foot bones. There it resembles a cemetery of dinosaurs, which perhaps mired themselves in marshes, because they are found in the red clays and not in the sandstones. These "Irazer clays" belong to the lower part of the Continental Intercalaire.

In this same horizon, we encountered dinosaurs at other points located further east, where moreover some individualized sandy lenses are seen. We cite principally: AGADÈS: 35 km south (no. 1); AGADÈS: 16 km southeast (no. 2); IFAYEN IGNÈRE (no. 16) (fig. 10).

The localities of the TIGUIDI cliff are situated a little higher stratigraphically: Marandet (no. 26); Zinder piste (no. 27) (Pl. I, fig. 4); Irayen (no. 28). It is the same in the EBRECHKO promontory (no. 11), which furnished more especially numerous theropod teeth; and also the Soureya buttes north of the TÉBÉHIC well (no. 24), which contain rather numerous sauropod remains.

Moreover, this Tiguidi cliff should not be confused with the Cenomanian-Turonian cliff situated further south and forming the Damergou plateau, so remarkable for its development into a 250 km long circular arc. It is in reality determined by the "Tégama sandstone", with which we parallel the In Abangarit series (fig. 5, section C).

The most eastern localities of Niger, situated in a hardly explored region, were discovered by Hughes Faure.

The EL RHAZ region (no. 12), a well whose name does not figure on official maps, is found some 150 km east-southeast of Agadès and around 25 km east of 9° longitude (fig. 9). It includes small sandy reliefs that are extended for 120 km from north-northeast to south-southwest; they belong to the "Tégama sandstone" *sensu lato* and show rather abundant vertebrate remains throughout their outcrop zone (distributions given by H. Faure).

Moreover, 110 km southeast of El Rhaz, the same geologist discovered in 1957 some varied bones and a large theropod tooth in an analogous horizon southwest of Egaro; the near-total absence of toponymy on the maps lead to grouping this locality with those of El Rhaz.

Another important fossiliferous region, discovered by H. Faure, is found on the eastern border of the Aïr, some 200 km northeast of Agadès and immediately south of the Takolokouzet massif. Some remains of the large Aoulef crocodile and some theropod vertebrae were found at three points (Tamat Tadent, Tagrezou, and Oued Baouet) in the Continental Intercalaire of the "Tefidet ditch" (locality no. 25). The sandy series with silicified wood is found here directly on the Precambrian of the Aïr [according to H. Faure, 1956; cf. M. Raulais, 1951]. Finally, in the course of his last voyage, H. Faure recovered a sauropod caudal vertebra in the full Ténéré.

According to M. Dalloni [1948, p. 31], some reptile bones were encountered at Toummo, in the north of the Djado. But the geologists who have passed there since (Lefranc and Freulon, B. R. P. mission) found nothing (cf. Bureau of Petroleum Research [1959]).

It could have been thought *a priori* that vertebrate remains could also be found in the great extents of the Continental Intercalaire that girdle the Tibesti. Having participated in the first Borkou-Ennedi-Tibesti mission of the A. E. F. Geological Service in 1954-1955, we were naturally attentive to the eventuality of such paleontological documents, more especially in the regions of Ounianga and the Erdis, where the Continental Intercalaire is widely exposed (fig. 1). But neither this mission, nor those of P. Vincent in the following years, found fossil fishes or reptiles there, the same in the zones where silicified wood of the *Weichselia* and *Dadoxylon* types are very abundant and confirm its parallel with the classic Continental Intercalaire [Wacrenier, 1958]. No bone having been noted in the Koufra region either, it would follow that the eastern Sahara seems rather poor in vertebrate localities, at least for the moment. Indeed the single locality of Baharija is cited there(fig. 2), which was very productive [Stromer, 1915-1934], but now seems exhausted according to J. Cuvillier (oral communication).[1]

III. Age of the Continental Intercalaire.

In a penetrating note, Conrad Kilian [1931] posed the fundamental scheme of the succession of the continental series of the Sahara. He distinguished two great continental

[1] Cf. CUVILLIER, J. (1934): Du Caire à l'oasis de Farafra, via Baharia. *Bull. Soc. roy. Géogr. Égypte*, vol. 18, p. 257.

complexes there, surrounded by fossiliferous marine series: the "Continental Intercalaire", generally included between the last Paleozoic marine beds and the first transgressive Upper Cretaceous marine level; the "Terminal Continental" succeeds the marine Cretaceous and corresponds to the Tertiary period. Moreover, he introduced and later specified [Kilian and Langlois, 1938] the notion of a "Continental Post-Tassilian", representing the upper part of the Paleozoic beneath a non-marine facies.

However, the age of the Continental Intercalaire was not well specified. "Albian sandstones", as authors such as J. Savornin [1934, 1947] called it? Or a comprehensive series encompassing a continuous group from the Permian to the Cenomanian, as C. Kilian himself was inclined to think? We attempted a synthesis of this question on the occasion of the XIXth International Geological Congress [Lapparent, 1952], taking account of the observations acquired to that date. But these things can be still better specified now, thanks to all the recent paleontological discoveries.

It is certain that continental complexes of Carboniferous age exist, which conclude the Paleozoic beds of the Sahara. Their age can be specified, which is variable according to the place: Namurian at Tindouf; lower or middle Westphalian at Chebbi, Berga, and Edjelé; Stephanian at Colomb-Béchar. Corresponding to Kilian's Continental Post-Tassilian, these series are however less developed than had been thought: they are found localized in certain determined regions.

The Continental Intercalaire proper, which is now easily distinguished from the Continental Post-Tassilian[1], appears in two different ways in the central Sahara. In the first and most frequent case, the clayey-sandy series rests in clear discordance on the Paleozoic or Precambrian, and up to the heart of the old massifs as at Sérouénout [Nordet, 1954]. At the base and diverse levels, it contains a fauna and flora that are a little delicate to interpret, but all the same rather clearly indicate the Lower Cretaceous. In this case, the Continental Intercalaire is an enlarged equivalent of the Wealden of Europe, in other words a fluvio-lacustrine facies covering all or part of the Lower Cretaceous and within which it is illusory to distinguish stages. In the central Sahara, in the opinion of all it also encompasses the lower Cenomanian, because the transgression which surmounts it begins everywhere, in the north as in the south, with the upper Cenomanian with *Neolobites vibreyani*, a characteristic ammonite.

In the second case, the Carboniferous seems to be followed by a strong clayey-sandy series whose upper part only contains the vertebrates and silicified wood of the Continental Intercalaire, indicating the Cretaceous. It is particularly thus in the Ohanet-Bourarhet region. However, the very detailed researches of the C. R. E. P. S. geologists brought a solution whose elements we did not have in 1952. Thanks to aerial photos and bold explorations that were able to penetrate the Issouane Erg, these geologists discovered a cartographic discordance in the Zarzaïtine series on various ends of the Carboniferous [C. R. E. P. S., 1957, 1960]. Moreover, at the base of this Zarzaïtine series Messrs. Claracq and Chavand discovered remarkable vertebrate remains, determined by Mr. Lehman [1957] as belonging to capitosaurid stegocephalians, exclusively Triassic animals. Furthermore, Mr. Claracq recovered in 1958 two teratosaurid teeth, again with stegocephalians, in the sandstones at the summit of the Zarzaïtine cliff north of Maison Rouge; such an association indicates the Keuper. Therefore the Ohanet-Bourarhet

[1] Some doubtful attributions can persist, as is the case for the Tan Elak sandstones south of Fort Flatters, of which we know only that they are post-Tournaisian [Lapparent, 1948a; C. R. E. P. S., 1960].

section, noted for the first time in 1948 [Lapparent and Lelubre, 1948], can now be interpreted in the following manner.

The Carboniferous sea must have retreated little by little during the Moscovian; some continental clays and sandstones (our Tiguentourine series) represent the end of this stage.[1] After a gap in sedimentation, during which the Hercynian foldings were produced, the sandstones and clays of the Zarzaïtine series were deposited in slight discordance on the Paleozoic: without doubt they would be Middle Triassic for the lower part and Upper Triassic for their higher part (presence of capitosaurids and teratosaurids). The successive clayey-dolomitic group, or upper Zarzaïtine series, has been shown to be sterile up to now: by its position, it perhaps corresponds to the Liassic and Middle Jurassic.[2]

The Taouratine series, containing the large sauropod *Brachiosaurus* [Lapparent, Claracq, and Nougarède, 1958] and a flora of clearly Jurassic character [Boureau and Caillon, 1958], belongs without doubt to the Upper Jurassic. It is surmounted by the clayey-sandy beds of the In Akhamil series with fishes, crocodiles, dinosaurs, and plants, which acknowledge some marine lappings coming from the north, with Lower Cretaceous molluscs (Chavan *in* Lapparent and Lelubre [1948]). Along with the gypsum clays of the Djoua, the group encompass the Lower Cretaceous and lower Cenomanian.

But the Zarzaïtine and Taouratine series are folded and faulted in the region between Alrar and Edjelé. Because of this, before the recent vertebrate discoveries we were led to attach them to the Continental Post-Tassilian, in which we were followed by other authors [Freulon, 1955; Rumeau, Deffrenne and Decremps, 1956]. We recognize that our argument was not solid, and that once more only paleontology, even that of vertebrates, permits fixing the age of the terrain. Therefore from now on it is necessary to admit the notable reworkings and true post-Cretaceous foldings in this region, in addition to the Hercynian foldings, which agrees with more recent data on Saharan geology.

In our 1952 journey in the Nubian sandstones, we also mentioned Messak's section. Having studied it for his thesis, J. Freulon now thinks that its lower portion could be equivalent to the Zarzaïtine series. It is undoubtedly not excluded that in some other points of the Sahara the base of the Continental Intercalaire can comprise, at least under a reduced thickness, beds that would be Jurassic or Triassic [Boureau and Freulon, 1959].

Moreover, in the eastern Sahara, geologists such as H. Faure, J. Freulon, and J. Ph. Lefranc think that the Continental Intercalaire sandstones encompass a continental equivalent of the Upper Cretaceous *toward the top*; but these elevated levels have furnished neither vertebrates nor invertebrates.

In conclusion of this analysis, we accept that the dinosaur fauna which I will describe belongs essentially to the Lower Cretaceous; it reaches into the Albian and perhaps up to the lower Cenomanian. This is well confirmed by the existence of this same fauna in extreme southern Tunisia, at diverse levels in the Dahar cliff, surrounded

[1] Following recent surveys, certain petroleum geologists had a different opinion: they would see a stratigraphic section *below* the Tiguentourine series and then bring those back to the Lower Triassic. But this concept does not yet seem demonstrated.
[2] J. Ph. Lefranc [1958, 1959], utilizing new observations in Libya and data from more recent forays, thinks he is able to propose still more precise correlations; they must be confirmed by paleontological arguments.

by the marine Upper Jurassic below and the marine upper Cenomanian above [Lapparent, 1953a; Basse, 1953]. The dinosaurs of Baharija in the Egyptian desert and those of Kem Kem in southern Morocco are contemporaneous with more elevated levels, their localities being situated immediately below the marine Cenomanian or being intercalated with the oyster beds.

There will be only two exceptions in the paleontological descriptions to follow, one for the carnosaur teeth at the summit of the Zarzaïtine cliff, attributed to the Upper Triassic, the other for the gigantic bones of *Brachiosaurus* from ZR.2, which would have an Upper Jurassic age.

CHAPTER III

PALEONTOLOGICAL STUDY

Introduction

The paleontological study follows the classification of dinosaurs generally adopted by specialists (cf. Piveteau [1955, p. 785-962]). To facilitate the reading of this chapter, I indicate the place where the dinosaurs of the Sahara belong in this classification.

Everyone admits that the term dinosaur, consecrated by usage, artificially groups two very different phyletic series whose origins were distinct. On the one hand there are the *saurischians*, with a typically saurian pelvis bearing three bony branches; on the other the *ornithischians*, with a characteristic pelvis bearing four branches, the fourth being called the postpubis.

The following table of the systematic arrangement of the dinosaurs of the Sahara is then obtained.

Order ***Saurischia***
(triradiate pelvis)

1. Suborder *THEROPODA*, essentially carnivorous.
    - — Superfamily CARNOSAURIA, powerful predators.
        - — Family Teratosauridae: *Teratosaurus* sp.
        - — Family Megalosauridae: *Baharijasaurus ingens* STROMER,
          Inosaurus tedreftensis, nov. gen. nov. sp.
        - — Family Tyrannosauridae: *Carcharodontosaurus saharicus* (DEPÉRET).
    - — Superfamily COELUROSAURIA, gracile animals with slender, hollow bones.
        - — Family Coelurosauridae: *Elaphrosaurus iguidiensis, nov. sp.,*
          Elaphrosaurus gautieri, nov. sp.

2. Suborder *SAUROPODA*, heavy herbivores with four columnar limbs.
    - — Family Camarasauridae (?): *Rebbachisaurus tamesnensis, nov. sp.*
    - — Family Astrodontidae: *Astrodon* sp.
    - — Family Titanosauridae: *Aegyptosaurus baharijensis* STROMER.
    - — Family Brachiosauridae: *Brachiosaurus nougaredi, nov. sp.*

Order ***Ornithischia***
(tetraradiate pelvis)

Suborder *ORTHOPODA*.
- — Superfamily ORNITHOPODA, herbivores and bipeds.
    - — Family Iguanodontidae: *Iguanodon mantelli* MEYER.

— Superfamily STEGOSAURIA, bearing bony armor.
— Family Acanthopholidae: genus indeterminate.

The fossil elements studied and described in the following pages number more than five hundred. They include either bones examined at the locality and which for various reasons had to be left in place after measurements, sketches, and photographs, or above all samples brought back to Paris. All of these were initially pooled at the geology laboratory of the Catholic Institute, where most of this work was accomplished. Naturally, comparisons were often made with the collections of the Museum in Paris, and we have also profited by those of the British Museum (Natural History) in London. But it was not possible to directly compare the heavy sauropod bones with the skeletons mounted in the American or German museums, and we had to content ourselves with figures in books or certain molds.

The study ended, we made a gift all the material brought from the central Sahara to the National Museum of Natural History. We thank Mr. J. P. Lehman for his always benevolent reception, and for agreeing to take care of this new collection, which will be well placed among the rich African paleontological collections in this national establishment.

*
* *

Remarks on fossilization. — The dinosaur bones from the Sahara are easily recognizable on the terrain thanks to their habitual whitish color. Red colors are added to it due to iron oxides often filling the Haversian canals, and rather frequently bluish tints due to the presence of phosphates. Certain bones from In Gall, In Tedreft, and Marandet are very dark, nearly black, with a bluish tint on the surface.

Rarely the fossil bone became spongy. Usually it is heavy, mineralized by chalk phosphates. In these exceptional cases, bones are encountered alongside fossil wood that are calcified together: we noted this fact in the south of the Tanezrouft and in the Tilemsi.

The microstructure of the bone is frequently well preserved. Recall that in 1938, Meyendorff sent some bone fragments recovered by him in Gourara to Dr. Camp at Berkeley (California). By examining the thin sections, C. L. Camp recognized there the reptilian bone structure of the archosaur group, and in fact of dinosaurs (unpublished document).

We made the same observation on some well-preserved bones, in particular on a fragment of a *Rebbachisaurus tamesnensis* femur from Chebbi (Aïn Cheikh), a bone from In Tedreft, and a sauropod long bone from Tébéhic (Niger). The structure is identical in these three cases. In Pl. IX, fig. 6-7 I figure some microphotographs of the last. The detail of the Haversian canals surrounded by bone cells is seen there in transverse section, in the internal layer of the bone. A typical example of secondary ossification is developed there, in a circular arrangement around the Haversian canals; it is known that it is very preponderant in sauropod bones. The other thin section shows remains of fibrous primary ossification coming from the periosteum, widely invaded by secondary ossification. The appearance of the preparations entirely matches what is known of the microstructure of dinosaur bones.

Note that the sauropod metacarpal bones recovered at In Tedreft show under magnification a fine interlaced structure that makes the elements, on which rest the columnar limbs of an enormous animal, more solid.

ORDER SAURISCHIA

1. *SUBORDER THEROPODA*

It is thanks to the discovery of two large carnivorous dinosaur teeth at Timimoun that the existence of theropods was made known for the first time [Depéret and Savornin, 1925] in the pre-Cenomanian continental sandstones of the central Sahara. Since then, our researches have greatly increased perspectives on the knowledge, diversity, and distribution of carnivorous dinosaurs. Not only are the remains of a large carnosaur revealed to be abundant, but other carnivores have been discovered along with the always rare traces of fragile coelurosaurs, for a total of six theropod species.

In order to more easily recognize the samples described later, I have designated the theropod remains by the letter T, adding the letters A, B, C, D, E, and F for each of the species studied, and these indications are reported on the labels of the elements in the collection. The equivalences are then as follows:

T_A = *Teratosaurus* sp.
T_B = *Baharijasaurus ingens*
T_C = *Inosaurus tedreftensis*
T_D = *Carcharodontosaurus saharicus*
T_E = *Elaphrosaurus iguidiensis*
T_F = *Elaphrosaurus gautieri*

Superfamily ***Carnosauria***

Family **Teratosauridae**

Teratosaurus sp. [theropod A].

Pl. IV, fig. 5 and 6.

Following the paleontological order, I describe next two theropod teeth that must be put aside from the rest of the fauna studied in the subsequent part of the present work. These specimens, in good condition, come from the top of the Zarzaïtine cliff, which is a stratigraphic level clearly prior to those that furnished the other dinosaur remains; they were found by P. Claracq 2 km northeast of Maison Rouge, the C. R. E. P. S. base of Edjelé [Lapparent, Claracq and Nougarède, 1958].

The largest tooth measures 43 mm long and 16 mm wide at the base. It is slightly asymmetrical and must have occupied a rather anterior position in the jaw. The serrations ornamenting the trenchant edges are of the classic megalosaurid type; they are extended along the posterior edge and also the anterior edge. The smaller has the same characters; it measures 22 mm long and 9 wide at the base, where the trace of a rather well-marked neck is seen [Pl. IV, fig. 5-6].

Similarities and differences. — These two teeth are very similar to those of *Megalosaurus* found rather often in the Jurassic, and at first sight it is tempting to refer them to the family Megalosauridae. But a stratigraphical argument must invite prudence in affirming this. Indeed, the discoverer of these fossils brought back some stegocephalian bones, jaws, and teeth that he had recovered in the same locality. This discovery is necessarily referred to the Upper Triassic, or at most Rhaetian, summit of the Zarzaïtine cliff. I then consulted Mr. Fr. von Huene of the University of Tübingen, a specialist in Triassic dinosaurs. He remarked that our specimens are equally similar to the teeth of teratosaurids, carnosaurs from the Keuper and Rhaetian that are not very rare in southern Germany [von Huene, 1907-1908]. In his opinion, the Zarzaïtine teeth are referred as well to *Teratosaurus* or *Pachysaurus* as to *Gresslyosaurus*. Note that very close, if not identical, forms are known under the name *Orinosaurus* in the higher Triassic of South Africa. I underline that the discovery of teratosaurids in the central Sahara is a very new fact of great importance.

Family **Megalosauridae**

Baharijasaurus ingens STROMER [theropod B].

Pl. V, fig. 4, 16, and 17; VI, fig. 7.

At Mount Iguallala and In Abangarit, we found a dinosaur with compact vertebrae that seems very distinct from the other theropod described below. It is represented by six caudal vertebrae, of which here is the description.

One anterior caudal vertebra is amphicoelous, more hollowed anteriorly than posteriorly; it measures 6.5 cm long (Pl. VI, fig. 7). A very deep neural canal excavation will be noted.

Two middle caudal vertebrae, entirely of the same type, are 6 cm and 5.5 cm long (Pl. V, fig. 16-17). The articular surfaces for the chevrons are very prominent on the ventral posterior part.

Three other middle caudals measure 6, 5.5, and 5 cm long respectively (Pl. V, fig. 4).

We refer these vertebrae with probability to the Egyptian theropod *Baharijasaurus ingens* STROMER [1934], moreover rather poorly known. But the resemblance between these rather massive vertebrae and those figured by Gilmore [1920, fig. 66, p. 117 and pl. 42] equally recall the American genus *Dryptosaurus*, also from the Lower Cretaceous. It is evidently very desirable that new discoveries can permit a better understanding of this carnivore, whose presence in the fauna of the Continental Intercalaire is certain, but still in the state of indications.

Inosaurus tedreftensis, *nov. gen.*, *nov. sp.* [theropod C].

Pl. VII, fig. 1; XI, fig. 1.

While sorting the elements recovered in the course of our various missions, I noted four vertebrae from In Abangarit that did not appear to be attributable to a known form of dinosaur. They are all equally remarkable by their weak elongation.

First there is a last sacral vertebra, still fused to a portion of the preceding one; the centrum is only 4.4 cm long and the disc measures 3 x 3.5 cm.

A 4 cm long anterior caudal vertebra has the same characters (Pl. VII, fig. 1). The diameters of the anterior disc are 4.5 x 4.5 cm, so that it offers a nearly square aspect. The attachment points of the chevrons are situated very low, which has the effect of elongating the posterior disc from top to bottom; it measures 3 x 4 cm. The vertebra is narrow in is central part, which separates it from vertebra of *Astrodon* and makes it resemble a theropod.

A third, deteriorated and smaller (length = 3 cm), presents some rather close characters. The fourth is only 1.2 cm long and the keel is very sharp; it must belong to the end of the tail.

Stromer [1934, pl. II, fig. 20, 22, 23] figured three indeterminate caudal vertebrae from Baharija in Egypt that seem close to those I have described. They suggest that there was a new carnivorous dinosaur in the Continental Intercalaire of the Sahara, which later discoveries could make better known.

But precisely, in 1959 we recovered an entire series of elements of the same type at In Tedreft; they were found grouped together in the locality and perhaps belonged to a single individual. It comprises a lot of 18 vertebrae and a tibial fragment. The vertebrae are distributed in the following manner:

Two dorso-lumbar vertebrae have a very compact form; their length is 3.3 cm; the disc measures 4 x 4 cm. Two others are smaller (length = 3 cm). The ventral surface of the vertebral centrum shows a sharp keel between two deep depressions.

Two vertebrae fused together belong to the sacrum.

Five middle or perhaps posterior caudal vertebrae are 5 cm long (Pl. XI, fig. 1); the ventral surface is narrow and bears two keels. The first has preserved a good part of its neurapophysis; the total height of the vertebra must be 10 cm. The marrow mold, preserved on another, is flattened and measures 2 cm wide on the front of the vertebra. To these will be added seven fragments of caudal vertebrae.

The left tibia is represented by its proximal portion. It is entirely of the theropod tibia type, but its size is small: the greatest width of the superior surface is 6.5 cm.

As a result of these discoveries, we now propose for convenience to distinguish this theropod that appears in three Saharan localities by a new designation, *Inosaurus tedreftensis, nov. gen., nov. sp.* It seems to be related to the family Megalosauridae. Here are its characters:

Small theropod, incompletely known by twenty-five vertebrae and a portion of the tibia. The dorso-lumbar vertebrae are remarkable by their massive and nearly square appearance; the middle caudals bear two keels and are twice as tall as long.

Family **Tyrannosauridae**

Carcharodontosaurus saharicus (DEPÉRET) [theropod D].

Pl IV, fig. 1 to 4, 7, 9, and 10; V, fig. 1 to 6, 10 to 13; VII, fig. 6; VIII, fig. 5; IX, fig. 1.

Some teeth and bones from a large carnivore are relatively frequent in the dinosaur localities of the Sahara. Here is the description of the pieces gathered one by one and grouped for study.

SKULL. — The head is represented by two joined fragments recovered by Captain L. Archier at In Abangarit in 1952.

An internal mold of this piece, made under the care of Mr. J. P. Lehman, gave part of the endocranium. Comparisons were tried with the previously figured brains of tyrannosaurids, either *Tyrannosaurus* [Osborn 1912] or *Carcharodontosaurus* itself [Stromer, 1931]. But, in spite of a very visible symmetry, the interpretation—as much for the bony elements as for the partial endocranial mold—proved very arduous because the considered elements are very incomplete.

TEETH. — The teeth of this carnivore are numerous, although they are found in only four localities: 12 come from Timimoun, 5 from Guermessa, 137 from In Abangarit, and 2 from El Rhaz. If the 2 described originally by Depéret and 6 incomplete fragments are added, there is at a total of 164. This is a minimum figure, because such or such person collected them at In Abangarit and kept them as a precious Saharan souvenir; thus some were found in the collections of the French Institute of Black Africa at Dakar.

Those from Timimoun, recovered by us and Mr. Orengo, are referred very precisely to the specimens described by Depéret [1927] from the same locality, by the size, the form, the oblique folds on the two faces, and the arrangement of denticles along the entire length of both edges. Our largest measures 42 mm wide at the base (Pl. IV, fig. 9). The length of the largest must be between 12 and 14 cm.

Those from Guermessa are smaller, generally rather worn, but with the characteristic thickness and form.

The In Abangarit region has furnished the most important lot (Pl. IV, fig. 1-4 and 7; V, fig. 1-3). It includes the largest, and here are the measurements of several teeth:

length…………….	125 mm	7 mm	105 mm	90 mm	87 mm
width at the base…	47	45	40	37	36

There are also interesting varieties to note. Indeed, if more than 100 are wide and similar to those from Timimoun, with oblique folds on both faces, 20 others are narrower and present variably shown characteristic torsion. These last teeth very probably correspond to a more anterior position in the maxillae, as kinds of canine teeth placed at the turning of the jaw (Pl. IV, fig. 7; V, fig. 3). These more specialized teeth were only rarely noted and have never been well studied; however they are known from Tendaguru, Portugal, southern Morocco, and in the jaws of *Tyrannosaurus* precisely at this location. Here are the measurements of some of these canine teeth:

length……………..	80 mm	77 mm	62 mm	64 mm	54 mm
width at the base…	33	31	28	27	26

A good canine tooth 70 mm long was recovered by H. Faure 34 km southwest of EL Rhaz. A tooth fragment, analogous to the specimens from Timimoun and clearly showing the oblique folds, comes from 100 km southeast of El Rhaz.

VERTEBRAL COLUMN. — Thirty vertebrae of this large carnivore are reported.

Cervical vertebrae. A portion of a cervical vertebra was recovered at In Tedreft; it is strongly convex anteriorly. The neural canal is narrow and very deep, and this significant character will be found on the following ones.

Dorsal vertebrae. A very powerful vertebral centrum from Aoulef (Pl. VI, fig. 1) presents the following measurements: length = 7.5 cm; posterior diameter = 12 x 12 cm. The vertebra is concave anteriorly and flat posteriorly. It is slightly larger than the corresponding vertebrae of *Allosaurus valens* [Gilmore, 1920, p. 43]; but a little less than those of *Gorgosaurus* [Lambe, 1917, p. 24], and indicates a large theropod 6 to 7 m long.

Two strong dorsal vertebrae come from In Tedreft; the largest is 12 cm long and shows a deep, narrow neural canal.

Sacrum. A 28 cm long portion of a sacrum was found at In Tedreft, formed by two strong and solidly coossified vertebrae. The marrow cavity has a diameter of 3 cm. Without doubt these are only the last two sacral vertebrae, which could be modified caudals. They are larger than those of *Allosaurus* from America [Gilmore, 1920, p. 45 and pl. 8-10], which is in agreement with the very large size of our Saharan carnivore.

Caudal vertebrae. From the Aoulef locality, with the same color and fossilization characteristics as the dorsal vertebra above, comes an anterior caudal vertebral centrum (Pl. VI, fig. 3) that could be from the same animal. It is concave anteriorly and flat posteriorly. Its length is 10.5 cm; its minimum width 5.5; the disc diameters are 11 cm tall by 9 cm wide.

A vertebra from In Abangarit is an anterior caudal (Pl. VII, fig. 6); it is amphicoelous and measures 12 cm long. The total height of the vertebra bearing its neural spine is 23 cm. This process is notably flattened posteriorly and this differentiates our animal from *Gorgosaurus*; on the other hand it is much less elongated than the process on the anterior caudal vertebrae of *Allosaurus*. A middle caudal from In Tedreft measuring 11.5 cm long belongs to a large individual.

Two rather massive caudal vertebrae were brought by H. Faure from Oued Baouet (Pl. VI, fig. 2-3), east of the Aïr (Téfidet locality). They are two middle caudals typical of a theropod, but by their slenderness and development in height (perhaps exaggerated by a flattening during the course of fossilization) they seem to be of a different type than the two preceding vertebrae. They measure 8.5 cm long. Another of the same type from 100 km southeast of El Rhaz is slightly larger. We have hesitated to attribute them to *Carcharodontosaurus*, because they rather resemble some caudal vertebrae of *Ceratosaurus* (?) or an indeterminate theropod from Tendaguru [Janensch, 1925]. However, they seem to be of the same type as the vertebrae from the *Carcharodontosaurus* skeleton from Baharija described by Stromer [1931, pl. I, fig. 10], and we have no reason to distinguish them from it. One seizes on this occasion the fragility of theropod determinations that rest exclusively on caudal vertebra of banal type.

Five other middle caudal vertebrae were found at Timimoun (Pl. VI, fig. 6) and Aoulef; their lengths vary from 10 to 7 cm. A very deep neural canal is noted there, and, on one of them, a furrow for the passage of vasculature on each side anteriorly. An 8 cm long vertebra from Aoulef, which must be a caudal from this theropod, was showed to us by Mr. Augiéras in his personal collection from "Buffalo Bordj" at El Goléa. Three caudal vertebrae from In Tedreft measure 12, 11, and 10 cm long respectively; two chevrons from posterior caudal vertebrae come from this same locality. A 6 cm long vertebra from Alrar shows a well-marked flat part above the point of departure of the zygapophyses. Finally, I note a rather damaged vertebral centrum from In Abangarit, remarkable for its narrowness (2.5 cm) and the single, well-defined keel; it is a posterior caudal.

FORELIMB. — We have a portion of a humerus, recognizable by its characteristic torsion; the diameter of the median part is 4 cm. If this bone does belong to this large theropod, it underlines the forelimb reduction classic in this group. The same character of reduction is noted for a bone from El Rhaz that we interpret as a radius (calculated length: 11 cm).

A second phalanx from digit II of the left manus is perfectly preserved (Pl. VIII, fig. 5). It is 6 cm long; the width of the distal trochlea is 2.4 cm; the minimum diameter of the shaft: 1.8 cm. We also have the distal end of another phalanx, a little stronger than the preceding; the width of the distal trochlea is 2.8 cm.

A good manual ungual phalanx or claw is 8.5 cm long (Pl. VI, fig. 11). It is strongly recurved, with two deeply marked lateral furrows. Note that the lower process for muscular attachment is 2 cm long, which provided great force for depression of the claw into the flesh of the prey. Another, of the same length but more massive, is strongly arched and slightly asymmetrical (Pl. VI, fig. 13); it comes from El Rhaz.

HIND LIMB. — Different from those of the forelimb, the bones of the pes are long and strong. We have the distal portion of a metatarsal indicating a bone more than 30 cm long (Pl. IX, fig. 1). The shaft is hollow. The articulation with the first phalanx is a deep pulley, which must have permitted great flexibility of the pes. A large phalanx from El Rhaz is 8.5 cm long (Pl. IV, fig. 10).

A strong claw, probably from digit III, comes from Alrar (Pl. VI, fig. 12). Its length was at least 10 cm; its width on the side of the articular surface is 4 x 4 cm. The ventral surface is flattened, indicating that it belongs to a pes destined for walking and not a manus for grasping prey. Another, less massive claw, 9 cm long and a little asymmetrical, is perhaps from digit II (Pl. VI, fig. 10); it is rather worn.

Similarities and differences. — The bones and teeth described from the central Sahara bring interesting elements to our understanding of this carnivorous dinosaur. Recall that it was noted for the first time under the name *Megalosaurus saharicus* by Depéret and Savornin [1927], who figured two teeth from Timimoun. Some analogous teeth, a portion of skull, and various bones were recovered from Baharija in 1911 by the Munich Museum expedition. When he described them, Stromer [1931] separated this form from the genus *Megalosaurus* by creating a new genus, *Carcharodontosaurus*. We confirm the utility of this name (if not its elegance) for this Cretaceous carnivore, which could have arisen from Jurassic megalosaurids by an increase in size and more forceful development; it belongs to the family Tyrannosauridae, which is developed in the Cretaceous. R. Lavocat [1952] found numerous teeth of this animal in southern Morocco.

By its large, trenchant, and serrated teeth, and according to its vertebrae, *Carcharodontosaurus saharicus* (DEPÉRET) must be intermediate in size between Jurassic carnivores and Cretaceous giants such as *Gorgosaurus* [Lambe, 1917], *Tyrannosaurus* [cf. Osborn, 1916], or *Tarbosaurus* [Maleev, 1955].

The teeth of *Carcharodontosaurus*, very well described by Depéret [1927], seem a little less slender than those of the Tendaguru theropod [Janensch, 1925]; but it must be acknowledged that a distinction of the two forms based solely on teeth is rather subtle.

The forelimb is extremely reduced relative to the hind limb. The recurved, sharp manus claws, animated by solidly implanted muscles, made it a redoubtable predatory organ.

Known in Egypt and in southern Morocco, present in southern Tunisia at Hourara, as in the east and west of Niger, this large predator was an important element in the Saharan vertebrate fauna during Cretaceous times.

Superfamily ***Coelurosauria***

Family **Coeluridae**

Some very slender theropods, with hollow and fragile bones, have left significant remains full of interest among the varied bones that we have recovered in the Sahara. They seems to be distributed in two different types, which are each new species; but we have very few comparative terms to study them.

Elaphrosaurus iguidiensis, *nov. sp.* [theropod E].

Pl IV, fig. 8; V, fig. 7 to 11; XI, fig. 9.

TEETH. — Forty-nine theropod teeth, smaller, more elongate, clearly more curved, and thinner than the large teeth of *Carcharodontosaurus*, probably come from a coelurosaur. I say probably because certain specimens could be alveolar teeth from a carnosaur; the difficulty in correctly attributing isolated teeth of carnivorous dinosaurs is well known.

The Ebrechko (Niger) locality furnished thirty-one of them alone, recovered over several square meters (Pl. V, fig. 8-12); it is the manifestation of a torrential delta. The other tooth localities are distributed principally in two regions: extreme southern Tunisia (Pl. IV, fig. 8; V, fig. 13) and Niger. But one very typical tooth was recovered isolated south of Alrar (Pl. V; fig. 14), which indicates a vast geographic distribution in total.

VERTEBRAL COLUMN. — We have eight very elongated caudal vertebrae of very characteristic aspect; the vertebral centrum is hollow. They come from three localities: In Abangarit, Ifayen Ignère, and Timimoun, and this arrangement of rare and fragile elements is significant for the presence of this coelurid across the central Sahara. The most complete is 8 cm long for only 2.5 cm in height of the posterior disc (Pl. XI, fig. 9). Another smaller, incomplete one must measure 6.5 cm long for 2 cm in height of the posterior disc. The same proportions (5.5 cm long for 1.5 cm in height for the disc) exist for the one from Ifayen Ignère. The two smallest are only 4 cm long.

FORELIMB. — A small, 3 cm long claw comes from El Rhaz; two narrow and deep gouges, serving to lodge the retractor muscles, are situated very high and have a very different shape from those of large theropods.

HIND LIMB. — We have the damaged distal end of a small right femur. A more complete element is a 35 cm long tibia; the bone is hollow; the ends were partially destroyed.

Similarities and differences. — The characters of the bones described above indicate the family Coeluridae. The largest caudal vertebra (Pl. XI, fig. 9) is of the same type as that from the Upper Jurassic of Boulogne-sur-Mer figured by Sauvage [1897, pl. VII, fig. 7-8]. Similarities are to be sought alongside *Elaphrosaurus bambergi* JANENSCH from Tendaguru; but it seems that a constantly lesser size and some accentuated differences make it another species.

Elaphrosaurus gautieri, nov. sp. [theropod F].

Pl. V, fig. 5 and 6; X, fig. 2, 4 to 8, 10, and 11.

The In Tedreft locality has furnished important coelurid remains that seem to be larger and clearly different from the preceding one. Here is a description of the elements.

VERTEBRAL COLUMN. — Initially there is a lot of sixteen vertebrae distributed in the following manner.

One *cervical vertebra* is well preserved (Pl. XI, fig. 5). It measures 8 cm long; it is convex anteriorly and very hollow posteriorly, and this accentuated arrangement suggests a very mobile neck. The insertion points for the cervical ribs are noted anteriorly. The neurapophysis is largely preserved. The diameter of the marrow at the posterior exit of the neural canal is 18 mm.

Two *dorsal vertebrae*, 7 and 8 cm long, are characterized by extremely deep neural canals (Pl. X, fig. 5; XI, fig. 2). The ventral surface of the vertebral centrum is very excavated, which has the effect of placing the two articular surfaces into strong relief. Four other vertebral fragments belong to dorsals.

A massive and compact vertebra, 5 cm long, with wide and short zygapophyses, seems to be the *dorso-lumbar vertebra*. Indeed, its posterior face is widened and inclined obliquely (Pl. V, fig. 6).

Sacral vertebrae. Three bony pieces are revealed as half-vertebrae fused together; they are square in their median parts. They are evidently sacral vertebrae.

Caudal vertebrae. Three well-preserved caudal vertebrae are 8.5 to 8 cm long (Pl. V, fig. 5; XI, fig. 4). They are procoelous; the centrum is hollowed by lateral cavities which lighten it. The keel bears a single strong carina. Two other fragments are from caudal vertebrae of the same type, square in the middle.

FORELIMB. — I consider a short (20 cm long), wide (10 cm for the proximal part and 8.5 cm for the distal part) bone as a left humerus from this dinosaur (Pl. XI, fig. 10). It seems quite different from the very slender humerus of *Ornitholestes* [Osborn, 1903, 1916] but the same as that of *Elaphrosaurus bambergi* [Janensch, 1925]; by its robustness it indicates a strongly grasping forelimb.

A 30 cm long bone was recovered isolated; it seems that it must be an ulna from this theropod.

PELVIS. — The distal end of a right pubis shows the considerable widening of this bone so characteristic of theropods. The articular surface with the other pubis is oval, measuring 10.5 x 5.5 cm (Pl. XI, fig. 6).

HIND LIMB. — We have several pieces that testify to a hind limb adapted to running and much more developed than the forelimb. First there is the distal end of a femur. Then a right tibia, a good hollow bone of which we have the two well-preserved ends. The proximal end is strong and triangular, measuring 12.5 x 8.5 cm; the distal end is 8.5 x 5.5 cm. I also cite a fibula represented by its two ends, proximal and distal. The four metatarsal ends that we have recovered indicate extremely long, hollow, and very slender bones. The same character is manifest in a half-phalanx.

Finally, I think that a hollow bone, flat below, presenting an excavated and well-preserved articular surface can well be allotted to the proximal part of a metatarsal from this species; the element was recovered at In Abangarit.

Single individual. — At In Tedreft, we have also recovered bones from this same theropod; but they were found grouped together and belonged to a single individual; from whence came the interest to examine this lot of rare elements separately.

VERTEBRAL COLUMN. — Besides an isolated neural arch from a cervical vertebra, two dorsal vertebrae and one damaged caudal, one very interesting element is a 14 cm long sacrum. It is formed by two vertebrae fused solidly together (Pl. XI, fig. 7-8). The vertebral centra are widened considerably in the zone where they are united. The neural canal is wide (2 cm) and deep. The vertebrae are convex anteriorly and excavated posteriorly.

Does the sacrum really only include two vertebrae fused and thus reinforced by this unaccustomed widening? This can be asked; but in the absence of comparative elements, only the fact can be noted. In any case, the exact same type of widening of fused vertebrae is found in one of the elements described on the preceding page.

FORELIMB. — We have three small claws, lengths 4, 4.5, and 6 cm respectively; this last, with a more elongate form, is very asymmetrical at the base.

HIND LIMB. — A good tibia was complete in the locality and measures 70 cm; the bone is hollow. There is also a right tibia (Pl. XI, fig. 11), nearly exactly the same size as that described above.

We also have the distal end of a fibula, the proximal portion of a metatarsal, and four fragments of phalanges. These bones are extremely elongate and their form shows a great flexibility of articulation.

Similarities and differences. — Thus there are enough indications in recent finds made at In Tedreft to think that a second coelurid species lived in the Sahara in Cretaceous times. The consistently greater size of all the bony elements and the form of the vertebrae seem to us to justify the creation of a species distinct from *Elaphrosaurus iguidiensis*, which was recognized first. I name it *E. gautieri* as a sign of the recognition that owed to Mr. Francis Gautier, because he agreed to spend two days on the immense Tamesna reg seeking the In Tedreft locality, which he discovered the preceding year and subsequently led us to himself. It can be asked whether this species had not already been noted twice in other sectors of the Sahara: a tibia from Baharija [Stromer, 1934, pl. III, fig. 1-2] and a tibia recovered by R. Lavocat [1952] in southern Morocco; the length of the latter (64 cm) is in rather good agreement with ours.

According to the dimensions of the bones, and referring to the attempted reconstruction of *Elaphrosaurus bambergi* [Janensch, 1925, pl. I], *E. gautieri* can be thought of as a slightly larger animal, being around 6 m long.

2. *SUBORDER SAUROPODA*

The examination of a first lot of fifty similar vertebrae from the Sahara initially resulted in distinguishing two rather different types of sauropods, above all among the bones from Mount Iguallala in Niger. The first, also the most frequent, was a large animal whose caudal vertebrae had the tendency to be greatly elongated. The other was notably smaller, and its caudal vertebrae, with compact centra, immediately recalled the family Titanosauridae. In the following, the number of vertebrae examined is notably increased, which permits completing my first remarks. Thus I describe this large sauropod and this titanosaurid, but also a third, very rare genus of sauropod, *Astrodon*, which is presently revealed at In Gall, and a fourth, gigantic and very interesting, *Brachiosaurus*, from a slightly older stratigraphic level.

As for the description of the theropods, I designate each species by a letter reproduced on the elements in the collection, S indicating Sauropoda:

S_A = *Rebbachisaurus tamesnensis*	S_C = *Aegyptosaurus baharijensis*
S_B = *Astrodon* sp.	S_D = *Brachiosaurus nougaredi*

Family Camarasauridae (?)

Rebbachisaurus tamesnensis, nov. sp. [sauropod A].

Pl. II, fig. 1 and 2; III, fig. 1 and 2; V, fig. 18 to 20; VII, fig. 2 to 5, 7 to 9; VIII, fig. 1 to 4, 9, and 10; IX, fig. 2 to 5; X, fig. 1 and 2; XI, fig. 3, and text-fig. 12.

HEAD. — The skull, small and very fragile in sauropods, was not found; this is not surprising in this type of detrital locality, where these bones could hardly resist.

In contrast, we found a small number of teeth in the Niger localities: one at Tiguidi, two at Ebrechko, and one at In Gall. It is only the second time that sauropod teeth have been noted in Africa, the first discovery having been made in the Upper Jurassic of Tendaguru.

Two of the teeth from Niger have a wide spatulate shape with an accentuated convexity on the external face, whereas the internal or labial face is slightly concave and shovel-shaped (Pl. V, fig. 18). Thus the cross-section is not biconvex, which distinguishes them from those of *Bothriospondylus*. One tooth is symmetrical relative to the medial convexity of the external face; the other is strongly asymmetrical. The height of the crown is 25 to 27 mm, and the width is 21 mm. The neck is very marked, and the root is narrower than the crown. The enamel is elegantly chagrined.

A third (Pl. V, fig. 19), worn on the bias at the apex by mastication, is very narrow and elongate (length = 30 mm; width = 17 mm), and the neck is less accentuated; but the lingual face is concave as in the preceding ones. It is known that the form of the teeth in sauropods varies according to their position in the jaws.

The fourth comes from In Gall. It is the point of a sauropod tooth, 13 mm long and just as wide on the preserved part. Its chagrined enamel is intact and unused; it presents slight denticles on one of the edges.

Regarding the chagrined enamel, the widened shovel shape, and the concave cross-section, the teeth from Niger are more similar to those of *Camarasaurus* than to those of all other sauropod genera [Marsh, 1896, pl. XXXI, fig. 1-2; Osborn and Mook, 1921, pl. LX].

An anterior fragment of mandible with three teeth in place and the imprint of a fourth also comes from In Gall. It can be seen on this piece that the teeth alternate in two rows. It also seems that the spatulate shape is less accentuated for the anterior teeth than for the lateral teeth; and also that they are only nail-shaped far anteriorly, as is the case in *Dicraeosaurus*.

VERTEBRAL COLUMN. — I attribute more than 100 vertebrae examined by us to this sauropod, of which 60 were brought to Paris.

Dorsal vertebrae. A good, large dorsal (Pl. VII, fig. 3) bearing its neurapophysis was recovered in the eastern part of the Djoua by F. Nougarède. It is concave posteriorly but flat anteriorly, and as a result could correspond to the 8^{th} or 9^{th} dorsal of *Diplodocus* [Hatcher, 1901, pl. III-IV]. The length of the vertebral centrum is only 15 cm for a height of 20 cm. The neurapophysis is wide and strong; it is preserved for 23 cm, but must have attained at least double this. The diameters of the posterior disc are 18 cm wide by 16.5 cm tall.

The total height of the vertebra must reach 70 cm; it is remarkable at once by its great development in height and by the weak length of the vertebral centrum.

At Tamesna, in the In Ontololog region, we had to leave three large dorsal vertebrae from the same sauropod in place; one of these measures 1 m tall and struck us by its narrow character. Likewise at In Gall, we found a dorsal vertebra with a disc 21 cm wide; the neurapophysis was very dislocated by erosion, but according to the position of the fragments, we estimated that the height of the complete vertebra must slightly exceed 1 m.

A very complete sauropod dorsal vertebra was exposed at In Salah through the care of Lieutenant Allibert, who brought us some photos (Pl. XI, fig. 3). The element is presented by its posterior part, and numerous details of the bony laminae are visible. The neural spine seems relatively less elongate in height, whereas the two zygapophyses have a large lateral extension: the length reaches 52 cm, measured from one end to the other. Rather than thinking of referring it to another species of sauropod, it can be thought more simply that it is an anterior dorsal vertebra of *Rebbachisaurus tamesnensis*: the great development of the neural spine would occur only on the posterior dorsals, according to the arrangement known in sauropods.

Some neural spine fragments from dorsal vertebrae were recovered at Guermessa, In Gall, and Timimoun. The pieces from the latter localities are portions of the neurapophyseal shaft, characterized by their cross-section, and entirely analogous to the vertebra from the Djoua in the form and size of the neurapophysis.

Finally, six large fragments of dorsal vertebral neurapophyses and two of the transverse processes have been brought back In Tedreft. Several of these pieces, with a very complex architecture, should permit detailed comparisons with the vertebrae of large American sauropods; but such a study could only be made by direct comparison with the bony elements, their illustrations in books being insufficient.

Sacrum. A large sacrum (80 x 80 cm) was recognized at Tikarkas (locality no. 30) by its fused vertebrae and its bludgeon-shaped processes; but erosion had damaged it too much to allow its recovery.

A large vertebra from In Tedreft is 18 cm long. It is remarkable for the enormous and curiously curved posterior articular surface, widened up to 19 cm for 18 cm in height. This is probably the last dorsal, which is articulated with the sacrum.

Caudal vertebrae. The caudal vertebrae, with more massive centra, are naturally more frequent than the dorsals in fluviatile formations such as those of the Sahara, where elements underwent notable transport.

From Aoulef, we brought back one of the first caudals, in the form of a circular disc. Its diameters are 13 x 13.5 cm for a thickness of only 6 cm. Another of the same type was left at Iguallala.

A first (or second) caudal comes from In Tedreft, in the form of a flattened disc; it indicates a large animal, the disc measuring 19 x 19 cm for a vertebral centrum thickness of 10 cm. From the same locality, a third or fourth caudal is 11 cm long for a circular disc of 16 cm.

The anterior and middle caudals no longer have the form of discs; they have a massive, hardly elongate centrum; they are amphicoelous, but more hollowed anteriorly than posteriorly. A large vertebra of this sort was recovered at In Tedreft; it measures 13 cm long, and the disc has a diameter of 10 cm. Three others come from localities as distant as Aoulef, In Abangarit, and Iguallala; their lengths are 10, 10, and 9.5 cm respectively; the diameter of the disc on the last two is 9.5 cm. I also note the neural process from a middle caudal vertebra, widened in range (width of the distal end = 7.5 cm). One from In Gall, belonging to an individual of exceptionally large size, has a length of 18 cm and a disc 12 cm in diameter (Pl. VII, fig. 2).

For this type of vertebrae, the following should be noted from the In Tedreft localities: three middle caudals; twelve caudals left in place that belonged to the same tail; and two others that by their already more pronounced elongation mark the transition to the posterior caudals.

The posterior caudals are greatly elongated, and we have fourteen from the most diverse localities, to which are added five not brought back from Iguallala. Two from In Gall measure 12 cm, with a disc of 9 cm (Pl. VII, fig. 9); a good vertebra found at Guermessa is 14 cm long, with a disc of 8.5 cm; finally, a well-preserved one from Iguallala has a length of 10.5 cm and a disc of 7.5 cm.

Nine posterior caudal vertebrae from In Tedreft have lengths varying between 14 and 15 cm.

Northeast of El Rhaz, H. Faure photographed a portion of tail with thirteen consecutive vertebrae (Pl. III, fig. 1) measuring from 11 to 13 cm long; note that one of 13 cm is followed immediately by two of 16 cm; such irregularity of elongation of the caudal vertebrae has been noted in sauropods. The same geologist recently found a 14 cm long caudal in the Ténéré of Niger.

Near the end of the tail, the vertebrae are again elongated and the neural arch diminishes greatly in importance; this observation applies to thirteen specimens. In this lot I note: a 17 cm long vertebra from In Abangarit; one 18 cm long with a disc whose diameters are 5 x 6 cm, from In Tedreft; another from Aoulef, 12.5 cm long with a deep and rather narrow neural canal (Pl. VII, fig. 8); finally two, identical in form and size (12 cm), come from Guermessa (Tunisia) and Tébéhic (Niger), that is from localities 1,800 km distant.

From the end of the long tail of such a sauropod come (Iguallala and In Gall) six very elongate vertebrae in which the centrum narrows between the two anterior and posterior discs, which have become prominent. One of them (Pl. VII, fig. 5) is 10 cm long and only 3 cm in centrum diameter, for a disc measuring 3.5 cm tall and 5 cm wide. I add two very elongate vertebrae from In Tedreft, of which the best is still 14 cm long (Pl. IX, fig. 4).

I know of six chevrons or haemal arches from caudal vertebrae; the largest, from In Salah (Pl. VII, fig. 4), must be at least 30 cm long; the rising branches measure 11 cm long and 6 cm wide. These chevrons belong to a very large sauropod, but their fragmentary state does not permit saying more.

Two inferior portions of neural arch make it possible to evaluate the opening of neural canal of the caudals from the first part of the tail at approximately 35 mm, which appears a normal average in large sauropods.

RIBS. — Portions of wide and flat ribs are not rare; they indicate a large sauropod. The width of the fragments is often between 5.5 and 7.5 cm; two are larger, measuring 9 and 10 cm for a weak thickness of 1.5 cm. A distal end has a 4.5 cm wide inflation. Several examples are more interesting and more complete. I cite two portions of cervical ribs from In Abangarit, of which the largest has a width of 10 cm for the curvature between the two branches, and a fragment of cervical rib from In Tedreft; then one complete thoracic rib from Ifayen Ignère, measuring 90 cm long with 28 cm spacing between the two heads (Pl. X, fig. 1).

We found a curious, small 7 cm bone at Ifayen Ignère; on one side it has an asymmetrical articular surface and ends on the other by a 2.5 cm spatula; it seems that it could be interpreted as the lateral process of an anterior caudal vertebra (Pl. V, fig. 20).

PECTORAL GIRDLE. — We had to leave a very fragile left scapula in place 16 km south-southeast of Agadès; it was exposed and preserved for 110 cm and must have measured around 125 cm in total. It is rather remarkable for the form of the distal part, narrow at the beginning, then rounded in a racquet-shape. R. Lavocat [1952] founded the genus *Rebbachisaurus* on this rather exceptional sauropod character. However, in our specimen the racquet is proportionally more elongate and measures only 34 cm wide.

A complete, very damaged scapula was found at In Gall, besides a fragment of coracoid. Some more or less fragmentary portions of sauropod scapula were also brought back from the Oulad Yahia gour near Chebbi, from El Rhaz, from a point 20 km southwest of Alrar, and from In Tedreft.

FORELIMB. — The In Gall locality offers two humeri, a right and a left, both 1.50 m long and from the same animal. The measurements of the better-preserved left humerus (Pl. II, fig. 2) give: total length = 123 cm; width of each of the ends = 40 cm; width of the shaft at its narrowest median part = 17 cm. The deltoid process is a narrow, elongate crest situated in the upper third of the bone. This humerus is more massive than that of *Bothriospondylus*, but less so than that of *Camarasaurus*; it differs from that of *Diplodocus*.

16 km south-southeast of Agadès, we found the median portion of humerus with analogous dimensions, whose cross-section measures 18 x 9 cm. From Timimoun comes a humeral fragment with a well-preserved, 9.5 cm long deltoid process.

Three humeri were found in the In Tedreft localities. The best measures around 1 m long, a little incomplete at its distal end; the width of its proximal portion is 31 cm and the shaft diameter is 13 cm. The distal part of another was brought back; it is 23 cm wide. Thus this bone was smaller than those from In Gall.

The left ulna and radius, articulated but in poor condition, were seen at In Gall in immediate proximity to the distal end of the left humerus described above. The distal ends of another ulna and radius were found at In Gall, also in articulation; it is noted how the distal end of the radius is flattened and rugose. The distal end of an ulna was found at Tikarkas, and two portions of an ulna at In Tedreft.

A 90 cm long radius and near it a portion of an ulna were located 35 km south of Agadès. At Mount Iguallala, the distal end of a radius has a rugose surface 10.5 cm wide; the width of the shaft is 5.5

cm at 12 cm from the end. The distal end of a radius of the same proportions (length of the end = 11 cm; width of the shaft at the same distance = 5 cm) was also found at Ebrechko; another comes from El Rhaz, and two fragments were recognized at In Tedreft.

Some portions of a large ulna and radius come from Aoulef; these bones are in the same state of fossilization and must come from the same individual; in both cases the length of the bone is 9 cm.

Two carpal bones were found at In Gall. The larger, discoidal in shape, has a greatest diameter of 11.5 cm and a thickness of 5 cm. The smaller, more irregular, measures 6.5 x 5 cm with a thickness of 4.5 cm. The first represents carpal elements 1-2 or 1-3, and the second corresponds to carpal bones 4-5, according to Osborn's observations [1904] on *Morosaurus*.

The metacarpals are strongly elongate bones, but often broken in their middle due to the narrow shaft; also we found only the proximal or distal ends at the rich In Gall locality. Their number is considerable: sixty-eight recovered in a half-day over some dozens of square meters. As about half of the pieces can be referred to the proximal part and the other half to the distal part, this makes a total of thirty-four metacarpals. It is concluded that sixteen or seventeen sauropod feet accumulated in this place, which represent eight or nine animals, of which we have moreover fifteen phalanges and a dozen claws. In other words, there is a veritable cemetery of sauropod feet. All these bones seem to indicate the same species, our large sauropod *Rebbachisaurus tamesnensis*, but represented by individuals of variable size. This is already suggested by examination of the vertebrae from In Gall; and is well understood for reptiles whose growth is not limited at a determined age. The articular surfaces of the proximal parts are rugose, sometimes even with deeply dug, meandering furrows: probably there was a cartilaginous portion.

We were able to make several attributions in this abundant lot of metacarpals. From the right side, one II, two IV, and one V; from the left side, one III, one IV, and three V.

Another remarkable locality for metacarpals is that of In Tedreft. We recovered twenty metacarpal fragments on the slopes of one of the small fossiliferous buttes. They are all broken near the middle of the shaft, and some are proximal ends, others distal ends. This group thus represents a total of six metacarpals, and the locality must correspond to two feet dislocated in place. Several of these metacarpals are large: the ends of two of them measure 10 cm wide, and the proximal portion of another is 11.5 cm. Note, more curiously, the proximal portion of a left second metacarpal whose articular surface is very wide, and whose shaft is affected by a characteristic torsion.

We add that some other localities have furnished metacarpals, moreover not very many. We cite: a distal end of III from In Abangarit; the proximal end of a large right I (width = 12 cm) from Marandet; the proximal end of a right II from El Rhaz, remarkable for the triangular shape of the articular face measuring 9 x 7.5 cm; and two shaft portions from Guermessa.

Concerning the phalanges, the lot from In Gall includes several fragments of them, but some preserved well (Pl. VII, fig. 7; IX, fig. 3). A strongly asymmetrical one is probably from a right digit I (Pl. IX, fig. 5); it is of good size, measuring 8 x 6.5 cm.

It can be thought necessary to attribute the more elongate ungual phalanges or claws to the forelimb, but doubts remain as to their position when these elements are not found in articulation. The reconstructions of classic sauropods do not give any guarantees of objectivity, to such a point that it may truly be wondered [Osborn, 1903] whether *Diplodocus* bore bony claws on all the digits, or only on certain digits. Moreover, this hypothesis hardly appears plausible to us, and it is preferable to evoke the loss of certain claws during fossilization.

At In Gall, we have two enormous, complete claws, one from the right digit I (Pl. VIII, fig. 10) measuring 24 cm, and one from the right digit II (Pl. VIII, fig. 9) measuring 17 cm. They are notably larger and more elongate than those of *Diplodocus*.

The others, eight in number, are smaller and incomplete. Their asymmetry at the base is more or less accentuated; all bear a well marked groove on the right and left that is probably the place for a retractor muscle. We also note a 14 cm long claw from In Tedreft, whose strong asymmetry indicates that it belongs to the right foot.

PELVIS. — A flat bone from Mount Iguallala is probably an ilium, preserved for 80 cm. But above all we were able to bring back a complete left ischium (Pl. V, fig. 2) from 35 km south of Agadès. Here are its measurements: total length = 85 cm; length of the acetabular surface = 18.5 cm; maximum width from the pubic border = 26.5 cm; minimum width of the shaft = 10 cm; width of the distal end = 16.5 cm. Note the development of this distal end, with its two well-marked tubercles and its more massive shape than that of *Camarasaurus*.

In the lot of sauropod bones from the El Rhaz locality, we recognized a fragment of flat bone as coming from the proximal portion of an ischium of the same type, although slightly smaller.

HIND LIMB. — Two femora from the same animal whose humerus we described were also found at In Gall (Pl. II, fig. 1; III, fig. 2). The better specimen measures 150 cm long; the width of the shaft is 27 cm and that of the distal part 34 cm.

A complete right femur, only 90 cm long, comes from El Rhaz; the width of the shaft is 14 cm and that of the distal part 25 cm. The proportions are the same as for the preceding specimens: at El Rhaz it is a medium-sized animal. The other femur is only represented in this locality by a portion of the shaft preserved for 30 cm.

Still other localities have shown us large sauropod femora: a femur more than 10 m long at Ifayen Ignère; a left femur preserved for 110 cm but which must have been around 150 cm in total, with a width of the distal part of 35 cm, at In Akhamil; the median portion of a 22 x 10 cm shaft at Marandet; some fragments of a large femur and the proximal portion of the same bone at Guermessa; two fragments of a large femur at Chebbi; and R. Lavocat and S. Rouaix recovered a large sauropod femur at Tilemsi. Six more or less complete femora were found in the In Tedreft localities. Their lengths vary between 90 cm and 1.30 m, and this fact confirms the great variability in the size of sauropod limb bones according to the individual.

Some "columnar" bone fragments come from Guermessa, attributed to a tibia. A bone of the same type was found at Aoulef, and another at El Rhaz.

Two proximal ends come from In Tedreft, one from a right tibia and the other from a left tibia. These elements are not very large, the diameters of the articular surfaces being 13 x 20 cm and 11 x 15 cm respectively. Note that the expansion receiving the superior part of the fibula is hardly developed on this type of tibia.

A long bone, lacking its ends and preserved for 75 cm, with a minimum width of 11 cm, was photographed by us at Mount Iguallala; it is very probably a fibula. The upper portion of a left fibula from El Rhaz is preserved for 24 cm.

A calcaneum was found at Aoulef; this rugose bone is 7 cm tall; the upper face—the articulation with the fibula—measures 11.5 x 9.5 cm. This bone was unknown in *Diplodocus*; however, compared to the mold of the skeleton of *Diplodocus* in the museum in Paris, it corresponds very well to the place for this bone by the size and similarities with the fibula and astragalus.

Twelve metatarsals are known to us; they are short and solid bones whose attribution to the right or left side is often difficult.

One first metatarsal, in good condition, measures 10.5 cm long and 8 cm wide at its distal end (Pl. VIII, fig. 1). It presents, very accentuated, the characteristic torsion of this bone, which corresponds to a separated position or retroversion of the pollex, having the effect of assuring a wide support surface for the limb. The medial surface of the shaft is pierced by a foramen. One first metatarsal from In Abangarit is nearly the same size (respectively, 11 and 9 cm), and three other specimens were recognized at In Tedreft. A very strong first metatarsal (Pl. VIII, fig. 2), whose widths are 13 cm for the proximal end and 11 cm for the distal end, has a length of 14.5 cm; it is notably stronger than the corresponding bone of *Diplodocus*.

Two specimens of second metatarsals measure 15 and 14.5 cm long, 9 and 10 cm wide. On one, two foramina are seen for the passage of vessels on the medial surface (Pl. VIII, fig. 3).

We also note two rather slender third metatarsals measuring 17 (Pl. IX, fig. 2) and 15 cm long, and two others rather deformed. A last, 13 cm long, seems to be a fifth metatarsal of this large sauropod.

Among the fifteen phalanges from the In Gall locality, three could be attributed to the hind limb. First there is an enormous, 9 cm long phalanx from digit II whose proximal articular surface measures 9.5 x 7.5 cm. Two others can be referred, one to the left digit III, the other to the right digit IV.

Two ungual phalanges from In Gall must belong to the hind limb. A small one is probably from digit V; it measures 5 x 3.5 cm. One of moderate size is 6 cm long and 8 cm wide. Finally, a large phalanx of very curious shape is laterally compressed (Pl. VIII, fig. 4). This could be a phalanx from digit I; but no element of this type has yet been described in dinosaurs.

Similarities and differences. — As several of the studied elements indicate, this sauropod takes its place among the largest terrestrial animals of the Mesozoic. The length of the forelimb compared to the hind limb provides a classificatory element for sauropods. In taking the animal from In Gall as the type, we have:

humerus	femur	difference
123 cm	150 cm	27 cm

This ratio removes our animal from the brachiosaurids, whose humerus is as long as or longer than the femur, and makes it resemble other sauropod families. If the length of the feet are intervened, excluding the ungual phalanges, the size of the forelimb equals that of the hind limb:

forelimb		*hind limb*	
humerus	123	femur	150
radius	90	fibula	90[1]
carpus	5	tarsus	7
metacarpals	35	metatarsals	15
phalanx	8	phalanx	9
	261		261

Thus the fore-part of the animal must have been more elevated than in *Diplodocus*, however less so than in *Cetiosaurus*.

If one tries to compare it to the six families admitted within the sauropod group, our animal is clearly removed from cetiosaurids, brachiosaurids, and Jurassic diplodocids, just as from Cretaceous titanosaurids. It is less massive than *Brontosaurus* (= *Apatosaurus*). It shows certain resemblances with camarasaurids: the same type of spatulate teeth, and a rather comparable ischium and femur; but it is distinguished from them by important characters: the forms of the scapula, dorsal and caudal vertebrae, and foot bones; so that for the moment it cannot be classified it with certainty within one of the families enumerated above.

Based on the comparative elements that we could have for the foot bones, I noted how many metacarpals, metatarsals, and claws of the large Saharan sauropod were truly different from those of *Cetiosaurus* and *Diplodocus*, just as from those of *Brontosaurus* and *Camarasaurus*. There one is evidently in the presence of a new genus or even a new family, and anatomical comparisons prove to be delicate before the fragmentary elements. The Baharija locality has only provided rather poor sauropod remains, and it can only be thought that there also existed in Egypt what is so frequently shown in the central Sahara.

In contrast, the genus *Rebbachisaurus* was established by R. Lavocat [1952b] based on a scapula with rather characteristic form and a large dorsal vertebra found in southern Morocco. The bones from the central Sahara that I describe are very probably referred to this genus, since the same characters of the scapula and dorsal vertebrae are found. It can thus be characterized more completely from now on in the following manner:

[1] Calculated length.

Very large sauropod (probably 20 m long) with very elevated back; widened spatulate teeth; dorsal vertebrae from the middle and posterior back very developed in height, whereas the centrum is relatively small; long tail, whose posterior caudal vertebrae are very elongate; racquet-shaped scapula; equality of the fore- and hind limbs; metacarpals more than twice as long as the metatarsals; enormous foot claws; very strong metatarsals and phalanges.

However, I do not think that the same species is found in the central Sahara as that from Morocco, named *Rebbachisaurus garasbae* LAVOCAT. Indeed, the shape of the scapula is not exactly the same, and the dorsal vertebrae do not attain the exceptional dimensions of those from Morocco, with a height of 1.30 m. Rather, I think that we have a different species, *Rebbachisaurus tamesnensis, nov. sp.*

In the preceding description, I have referred some bones from very distant places to the same species; as a result, it is very evident that doubt often hovers over this attribution. However, the constancy of the characters that are noticed by handling and comparing the elements makes the attribution probable, and our determinations concern a number of already important bones: 4 teeth, 100 vertebrae, 12 ribs, 5 scapulae, 1 ilium, 2 ischia; and for the limbs:

7 humeri	13 femora
6 ulnae	5 tibiae
8 radii	3 fibulae
2 carpal bones	1 calcaneum
44 metacarpals	12 metatarsals
16 phalanges	15 phalanges
11 claws	2 ungual phalanges

Besides, one cannot proceed otherwise in a first work on the group. The eventual discovery of more complete skeletons, still to be made, would evidently permit a much more valuable description.

Family **Astrodontidae**

Astrodon sp. [sauropod B].

Pl. VI, fig. 14 and 15.

At In Gall, mingled with the bones of large sauropods, we recovered two very characteristic vertebrae, which entirely evoked in our memory the vertebrae of *Astrodon* (= *Pleurocoelus*) figured by Marsh [1896, p. 184 and pl. XI] and Lull [1911, pl. XI-XX].

The largest is a 7 cm long anterior dorsal, strongly convex anteriorly and slightly excavated posteriorly. The disc is almost circular, measuring 6.5 cm in diameter. The neural canal is remarkably narrow and deep. The neural arch is reduced by elongate, radiating cavities.

The other is a caudal from the beginning of the tail (Pl. VI, fig. 14-15). Of robust form, it is slightly amphicoelous, a little more hollow posteriorly than anteriorly. Its length is 5 cm; the disc measures 6 cm wide and 5 cm tall. The trace of the neural canal is widened anteriorly and still more posteriorly, following a characteristic drawing also figured by Marsh. In the middle of the upper plateau of the vertebral centrum, a bony bulge is noted on each side that is destined to ensure more solidity to the support of the neural arch. This is reduced by cavities at its base.

These two objects, coming from a single locality, are however so characteristic that they permit indicating the presence of this rare sauropod in the Sahara, noted in the Upper Jurassic of America and Portugal, and also in the Wealden of England.

I add that two proximal ends of metatarsals, also found at In Gall, also seem to belong to *Astrodon*, by the fact of their small size and their resemblance to that figured by Marsh [1896, pl. XLI, fig. 1-2].

Family **Titanosauridae**

Aegyptosaurus baharijensis STROMER [sauropod C].

Pl. V, fig. 15; VI, fig. 8 and 9; VIII, fig. 8.

Some caudal vertebrae recovered in one locality, at Mount Iguallala, are clearly distinguished from the preceding by a short, compact vertebral centrum that is flattened laterally and not dorsoventrally; they are strongly procoelous. These characters indicate the family Titanosauridae; the animal was smaller than *Rebbachisaurus*.

VERTEBRAL COLUMN. — *Anterior caudal vertebrae*. Some rather flat vertebrae come from immediately posterior to the sacrum. The largest (Pl. VIII, fig. 8) has a circular disc 12 cm in diameter; the length of the centrum is 10.5 cm. The opening of the neural canal can be measured on this as 20 mm, indicating a smaller sauropod than the giants of the *Bothriospondylus*, *Diplodocus*, *Camarasaurus*, etc. group in which it is necessary to measure an average of 40 to 50 mm.

Middle caudal vertebrae. Three merit mention from among the seven middle caudals. The largest, procoelous and very strongly convex posteriorly (Pl. VI, fig. 8), has a length of 12 cm for a disc 8 cm in diameter. The two others, still clearly procoelous (Pl. VI, fig. 9), are respectively 8 and 6.5 cm long, with 7 and 5 cm disc diameters. A neural arch with part of its processes also comes from Iguallala; its canal, measured at 15 mm, is thus also small.

Posterior caudal vertebrae. A small vertebra measures 3.4 cm long (Pl. V, fig. 15). Another very small one, from the end of the tail, is 2.7 cm long with a disc diameter of 1.7 cm. Both are clearly distinguished from the elongate vertebrae of sauropod A described previously.

I refer several vertebrae found in other localities to the same sauropod. An anterior caudal was recovered at In Gall, procoelous and convex posteriorly. Two 7 cm long middle caudals, not convex posteriorly, come from In Abangarit.

RIBS. — The distal end of a thoracic rib, whose expansion is only 3 cm wide, probably belongs to this species.

HIND LIMB. — Two proximal portions of metatarsals with rather slender form and modest size, of which one is a left III, were found at Mount Iguallala. I attribute them to this sauropod.

Similarities and differences. — The existence of a titanosaurid, characterized by its compact and laterally flattened vertebrae, was recognized at the Baharija locality. Although the elements were hardly numerous, Stromer [1932] created a genus and species, *Aegyptosaurus baharijensis*. I do not have much to add to the very incomplete knowledge of this animal. But the existence at Mount Iguallala of very typical vertebrae, very distinct from those of *Rebbachisaurus tamesnensis*, leads me to refer these elements to *Aegyptosaurus baharijensis*. The family Titanosauridae will be noted as characterizing the Cretaceous.

Family **Brachiosauridae**.

Brachiosaurus nougaredi, nov. sp. [sauropod D].
Pl. II, fig. 3 and 4; III, fig. 3 and 4; VIII, fig. 6 and 7; X, fig. 3 and 4.

In the Taouratine horizon, at a point located 11 km east-northeast of petroleum well ZR.2, the bones of a very large sauropod are found scattered over about 1 km. First, here is the objective description of the elements; I will interpret them subsequently.

VERTEBRAL COLUMN. — A large sacrum initially drew attention, lying flat on the reg (Pl. II, fig. 3-4). This beautiful element must have been complete during its burial in the sediment, not far from large trunks of silicified trees. The dorsal part was exposed by the erosion that delivered the piece today, and several transverse processes were altered. Such as could be removed and reconstructed, this sauropod sacrum presents an exceptional size: total length = 130 cm; diameter = 80 cm. The sacral vertebrae number four, fused together. The first offers an enormous anterior disc, 23 cm wide and 22 cm tall. The third sacral is 28 cm long and has a disc diameter of 20 cm; the keel is very marked on the ventral part, and the diameter of the centrum in the middle is only 10 cm. The zygapophyses have wide and strongly twisted stalks; they are extended up to 40 cm to the right and left of the neural canal; at their end, they are widened in the shape of a powerful club and are solidly fused together there. In spite of its weight, we were able to bring this element back to Paris.

FORELIMB. — Several hundred meters east of the sacrum lay the bones of the left forelimb (Pl. III, fig. 3), which were collected with care by Mr. Gillmann; they were accompanied by rather abundant fossil wood.

In the locality, the distal ends of the large ulna and radius were observed, and a carpal bone; these very fragile elements could not be recovered. In contrast, part of the metacarpals could be expedited to Paris. The foot showed its posterior surface in the locality, in other words it was inverted, and the phalanx of the third digit was pivoted 90°.

We have the proximal and distal parts of left metacarpal I, found a short distance from the other bones.

Metacarpal II was complete in the locality regarding its rather wide proximal part, and applied against metacarpal III.

Metacarpal III is a magnificent bone (Pl. VIII, fig. 6; X, fig. 3) that is striking in its dimensions: length = 43 cm; width of the distal part = 16.5 cm; minimum width of the shaft in the median part = 7.5 cm.

Metacarpal IV is a bone of comparable size to the preceding one. Its calculated length gives 42 cm; the proximal part has a width of 13 cm; the minimum shaft diameter is 6.3 cm.

A phalanx from digit III (Pl. VIII, fig. 7; X, fig. 4), lay near the end of metacarpal III, moreover displaced (Pl. III, fig. 3). Very well preserved, it is of a truly exceptional size if it is compared to other sauropod phalanges, as the following table shows:

	sauropod from ZR.2	*Diplodocus* from America	sauropod from In Gall (Niger)
length……………………………………	11.5 cm	5.5 cm	7 cm
width of proximal part…………………...	16.5	8	8
width of distal part………………………	13.5	8.5	7

HIND LIMB. — A complete right tibia was found 800 m west of the sacrum, visible in place by its posterior part (Pl. III, fig. 4). It is 85 cm long, 30 cm wide at its proximal end, and 21 cm at its distal end. It is of the sauropod type but not very large. If, as can be thought, it belongs to the same animal as the metacarpals that have been described, it reveals an accentuated disproportion between the immense forelimb and the shorter hind limb: a ratio that characterizes *Brachiosaurus*.

Between the points where the sacrum and tibia lay, we again found some bones in poor condition that seem to be portions of the metatarsals.

Similarities and differences. — The sauropod bones found east of ZR.2 appear to be very different from those that we have described in the rest of the Saharan Continental Intercalaire. The great size of the sacrum and the extreme elongation of the metacarpals immediately recall the genus *Brachiosaurus*, remarkable for the disproportionate size of the forelimb (fig. 11). But our documentation concerning this genus is still very fragmentary.

The sacrum presents analogies with that of the American *Brachiosaurus*, the type of the genus described by Riggs [1904, pl. LXXIII]; however, the author insisted on the fact that the width of the sacrum slightly exceeded its length; but according to his figures, the element seems to have suffered crushing and notable deformation. The size of ours is clearly greater, as it well shows, not only in its total length (table below), but also, for a precise detail, in the lengths of the sacral vertebral centra: they range from 25 to 28 cm in our specimen, versus only 18 to 22 cm in *B. altithorax*.

Janensch [1950a] made known two sacra from East Africa attributed to *Brachiosaurus brancai*. One, with five vertebrae, measures 1 m long, but it is very damaged. The other comprises four fused vertebrae and measures 66 cm long and 60 cm wide; it is rather similar in aspect to that from ZR.2 regarding the vertebrae, but its processes have a proportionally greater width. Note the exceptional size of the sacrum from ZR.2, which notably exceeds those of other sauropods by 40 to 50 cm, as the following comparisons emphasize:

	Brachiosaurus nougaredi	*Brachio. altithorax*	*Brachio. brancai*	*Bothriospondylus madagascariensis*	*Camarasaurus supremus*	*Brontosaurus excelsus*	*Diplodocus carnegi*
length…….	130 cm	95[1]	66	73	80	88	68
width………	80	98[2]	60	66	57	62 (?)	62 (?)

The metacarpals from ZR.2 are very similar to those of *Brachiosaurus brancai* from East Africa [Janensch, 1922, fig. 5 and 6] by their unaccustomed length and their general shape, while being a little less gigantic. They differ notably from those of *Diplodocus*, much more slender, since in this animal the left metacarpal III measures 30 cm long and only 9 cm in the diameter of its distal end. Of the tibia, of banal type for a sauropod, note that the hindquarters were proportionally more slender than in other sauropods, which was also recognized in *Brachiosaurus atalaiensis* from Portugal [Lapparent and Zbysewski, 1957, p. 40-41].

The genus *Brachiosaurus* is only known up to now from the Upper Jurassic (Lusitanian-Kimmeridgian-Portlandian). However, it is to this level that the layers where it was found should undoubtedly be referred: they are stratigraphically older than the In Akhamil series attributed to the Lower Cretaceous, and they have revealed a Jurassic flora [Boureau and Gaillon, 1958].

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[1] Quantity measuring 5 vertebrae, instead of 4 in *B. nougaredi*.
[2] Quantity probably exaggerated due to the notable deformation of the element.

Considering the rather particular characters of this animal, less gigantic than *Brachiosaurus brancai*, rather different from *Br. altithorax* and *Br. atalaiensis*, I am led to consider it as a new species, *Br. nougaredi*, dedicated to the geologist who brought back to us wisely collected elements from the Sahara more than once.

ORDER ORNITHISCHIA

Ornithischians are much rarer in the Sahara than the carnivorous and herbivorous saurischians described above. Just the same, they are signaled by several elements belonging to two very different groups from the suborder Orthopoda. By the single fact of these precise indications, it can be hoped that later attentive researches will make them better known.

SUBORDER ORTHOPODA

Superfamily ***Ornithopoda***

Family **Iguanodontidae**

Iguanodon mantelli MEYER [orthopod A].
Pl. V, fig. 23.

The presence of an *Iguanodon* in Africa is a new and unique fact. It is however very certain, because our Chambaa guide collected under my eyes on 15 January 1951, in the bone level of the Kanboute gara near Rémada (extreme southern Tunisia), a tooth that I immediately recognized as belonging to the genus *Iguanodon*. Advised by Mr. W. E. Swinton, I compared it with the tooth specimens of *Iguanodon* from the English Wealden preserved in the collections of the British Museum.

It is revealed to be entirely similar to the teeth of *Iguanodon mantelli* MEYER in its form, size, and arrangement of the marginal denticles; it can be specified as an upper right maxillary tooth (Pl. V, fig. 23). The greatest width of the crown is 2 cm, the height being 3.3 cm. It is broken at the neck, and the root is lacking. The external face is ornamented with a furrow and a marked fold; but neither are in the plane of symmetry of the crown.

Iguanodon mantelli was an animal 5 to 6 m long with a height of around 4 m, smaller than *I. bernissartensis*.

One *Iguanodon* tooth is so characteristic that the discovery of this unique specimen permits affirming for the first time the existence in the Lower Cretaceous of Africa of these large reptiles, whose complete skeletons are shown in the museums of London and Brussels.

Superfamily ***Stegosauria***

Family **Acanthopholidae**

Genus indeterminate [orthopod B].
Pl. V, fig. 21 and 22.

I believe that I can indicate the existence of armored dinosaurs in two localities in Niger, but their remains are very rare in the Sahara.

Above all there is a bony dermal plate from In Abangarit. It is 3.2 cm tall; the flat and elongate base is 4.5 cm long and 1.7 cm wide in the middle (Pl. V, fig. 22). The well-marked asymmetry indicates a plate situated on the flank of the animal. The bone is rather deeply hollowed by triangular furrows, as in *Struthiosaurus*. It is probable that it is a new genus from the family Acanthopholidae, more or less close to *Acanthopholis*.

On the other hand I refer a conical bone found at Irayen, in the Tiguidi cliff (Pl. V, fig. 21) to a stegosaurian dermal spine. It is 5 cm long and asymmetrical at its base; this measures 3 x 2.1 cm. It is surely not from a stegosaurid with large and long spines, such as *Stegosaurus*, *Omosaurus*, or *Kentrurosaurus*, but rather an acanthopholid whose genus cannot evidently be specified.

Conclusion and summary tables.

Although very fragmentary, the paleontological study of the dinosaur remains collected in a first prospecting of the central Sahara thus reveal an interesting variety of these reptiles, distributed among eleven different genera and twelve species. Here is the enumeration:

THEROPODS:		SAUROPODS:	
Teratosaurus sp.	T_A[1]	*Rebbachisaurus tamesnensis, nov. sp.*	S_A
Baharijasaurus ingens STROMER	T_B	*Astrodon* sp.	S_B
Inosaurus tedreftensis, nov. gen., nov. sp.	T_C	*Aegyptosaurus baharijensis* STROMER	S_C
Carcharodontosaurus saharicus	T_D	*Brachiosaurus nougaredi, nov. sp.*	S_D
(DEPÉRET)	T_E	ORTHOPODS:	
Elaphrosaurus iguidiensis, nov. sp.	T_F	*Iguanodon mantelli* MEYER	O_A
Elaphrosaurus gautieri, nov. sp.		indeterminate stegosaurian	O_B

In most of these cases, the elements are dispersed from animal cadavers that were greatly dislocated during transport and burial. It is therefore interesting to note here the rare times where we found a number of relatively ordered bones almost surely belonging to a single individual, by the fact of their grouping and relative positions in the locality. Minimally, they number six:

Inosaurus tedreftensis at In Tedreft;
Elaphrosaurus gautieri at In Tedreft;

[1] Designation of elements in collection.

Rebbachisaurus tamesnensis at In Gall (Pl. II, fig. 1-2), El Rhaz, and In Tedreft (fig. 12);

Brachiosaurus nougaredi at Zarzaïtine.

SUMMARY TABLE OF SAHARAN DINOSAURS GROUPED BY LOCALITIES

LOCALITIES	DINOSAURS	DISCOVERERS
CENTRAL SAHARA.		
No. 1 Agadès: 35 km south	*Rebbachisaurus tamesnensis*	Lapparent and Joulia
2 Agadès: 16 km southeast	*Rebbachisaurus tamesnensis*	Lapparent and Joulia
3 Alrar	*Carcharodontosaurus saharicus* *Elaphrosaurus iguidiensis* *Rebbachisaurus tamesnensis*	Lefranc; Lapparent
4 Aoulef Cheurfa	*Carcharodontosaurus saharicus* *Rebbachisaurus tamesnensis*	Lapparent; Hugot
5 Chebbi: Aïn Cheikh	*Rebbachisaurus tamesnensis*	Lapparent
6 Chebbi: Oulad Yahia gour	*Rebbachisaurus tamesnensis*	Lapparent
7 Chenini	*Elaphrosaurus iguidiensis*	Lapparent
8 Dehibat	indeterminate bones	Lapparent
9 Djoua: Tab-Tab	indeterminate vertebra	Foureau
10 Djoua: 120 km east of Fort Flatters	*Carcharodontosaurus saharicus* *Rebbachisaurus tamesnensis*	Nougarède
11 Ebrechko	*Elaphrosaurus iguidiensis* *Rebbachisaurus tamesnensis*	Lapparent and Joulia
12 El Rhaz	*Carcharodontosaurus saharicus* *Elaphrosaurus iguidiensis* *Rebbachisaurus tamesnensis*	Faure
13 Giado	*Elaphrosaurus iguidiensis*	Lapparent
14 Guermessa	*Elaphrosaurus iguidiensis* *Rebbachisaurus tamesnensis*	Lapparent
15 Ibelrane	indeterminate sauropod	Pérébaskine
16 Ifayen Ignère	*Elaphrosaurus iguidiensis* *Rebbachisaurus tamesnensis*	Lapparent and Joulia; Mareschal
17 Iguallala	*Baharijasaurus ingens* *Rebbachisaurus tamesnensis* *Aegyptosaurus baharijensis*	Lapparent and Greigert

18 In Abangarit	*Baharijasaurus ingens* *Carcharodontosaurus saharicus* *Elaphrosaurus iguidiensis* *Elaphrosaurus gautieri* *Inosaurus tedreftensis* *Rebbachisaurus tamesnensis* *Aegyptosaurus baharijensis* indeterminate stegosaurian	Archier; Lapparent; Pouillet
19 In Akhamil	*Rebbachisaurus tamesnensis*	Lapparent
20 In Gall	*Rebbachisaurus tamesnensis* *Astrodon* sp.	Lapparent, Greigert and Joulia
21 In Salah	*Rebbachisaurus tamesnensis*	Mourret and Allibert
22 In Tedreft	*Carcharodontosaurus saharicus* *Elaphrosaurus iguidiensis* *Elaphrosaurus gautieri* *Inosaurus tedreftensis* *Rebbachisaurus tamesnensis*	Kieken, Nyssen and Gautier; Lapparent, Cornet and Busson
23 Rémada: Kanboute	*Elaphrosaurus iguidiensis* *Iguanodon mantelli*	Lapparent
24 Tébéhic: Soureya	indeterminate sauropod	Lapparent and Joulia
25 Téfidet	*Carcharodontosaurus saharicus*	Faure
26 Tiguidi: Marandet	*Rebbachisaurus tamesnensis*	Chudeau; Lapparent and Joulia
27 Tiguidi: Zinder piste	*Elaphrosaurus iguidiensis* *Rebbachisaurus tamesnensis*	Lapparent and Joulia
28 Tiguidi: Irayen	indeterminate stegosaurian	Lapparent
29 Tilemsi no. 1	indeterminate sauropod	Bourcart
30 Tilemsi no. 2: Tikarkas	indeterminate sauropod	Karpoff, Lavocat and Rouaix; Lapparent
31 Timimoun	*Carcharodontosaurus saharicus* *Elaphrosaurus iguidiensis* *Rebbachisaurus tamesnensis*	Burté; Meyendorff; Lapparent; Orengo
32 Zarzaïtine: east of ZR.2	*Brachiosaurus nougaredi*	Nougarède and Claracq; Lapparent and Busson; Gillmann
33 Zarzaïtine: Maison Rouge cliff	*Teratosaurus* sp.	Claracq

EASTERN SAHARA.

Baharija	*Baharijasaurus ingens* *Carcharodontosaurus saharicus* *Spinosaurus aegyptiacus*	Stromer

	Elaphrosaurus sp.	
	Aegyptosaurus baharijensis	
WESTERN SAHARA		
Kem Kem	*Carcharodontosaurus saharicus*	Lavocat
	Elaphrosaurus sp.	
	Rebbachisaurus garasbae	

CHAPTER IV

PALEOBIOLOGICAL EVOCATIONS AND COMPARISONS

When we left for the first explorations, we nourished the hope of one day finding a locality in the immense Sahara where the presence of very complete bones would have engaged us to return there to carry out methodical excavations. In fact, above all we found sparse teeth and bones, most often mingled with the remains of crocodiles, turtles, and fishes, as if all these fossil remains had been dragged by running water and sediments pell-mell into types of deltas. It is much as the localities of In Abangarit are presented in particular, and it is however they which furnished us with the most numerous and varied dinosaurs, but always very dispersed “in detached pieces”. The Timimoun conglomerate with yellow quartz pebbles is also a largely detrital formation, where the pieces are dissociated and often fragmented, though of hardly rounded aspect.

However, there are localities in the clays or the sandy lenses that evoke lakes where the cadavers floated: Mount Iguallala and above all In Gall are presented thus. Perhaps there are some rather complete animals there; but we were only able to prospect at these two localities fairly rapidly, and it is necessary to return there.

In fact, all that has been recovered up to now is too fragmentary to permit drawing conclusions regarding the evolution of dinosaurs. But the elements studied are numerous and, as much by their abundance and variety as by the number and diversity of places where they were found, they express what the living world of the great vertebrates of the Lower Cretaceous could have been several hundred million years ago in this part of the African continent. Thus I will attempt some brief paleobiological evocations.

1. Paleobiological evocations.

The carnivorous theropods had hind limbs admirably adapted to rapid running, whereas their strong skull and large cutting and serrated teeth permitted savagely tearing the flesh of their prey. Surely they lived on emergent terrains, but they must have often approached humid places frequented by massive herbivores. However, the geology makes me suppose that in the Lower Cretaceous, emergent massifs formed from Precambrian or Paleozoic terrains must have existed where the Sahara now extends; the detrital formations of the Continental Intercalaire are deposited in low zones between these reliefs. One can certainly imagine a “central massif” corresponding more or less to the Hoggar, populated with bands of large predators or slender coelurids. Their bones and teeth, dragged by flowing water, are found rather abundantly in the southern Hoggar and the Aïr, in the localities of Niger (In Abangarit, In Tedreft, Ebrechko, Téfidet, etc.).

The localities of the northern zone that have furnished theropods, such as Timimoun, Alrar, and extreme southern Tunisia, seem well separated from the Hoggar. But one can think of other massifs emergent at that time: for Timimoun, the region of the Saoura and the Eglab; for the others, perhaps the Djebel Fezzan discovered by Freulon and Lefranc [1952], or a massif currently hidden but emergent during the Cretaceous, such as that which de Berriane recently discovered by deep excavations.

Some vast marshy zones, of which recent Chad can give some idea, although very residual compared to its previous extent, were haunted by herbivorous sauropods. In these complex places where land and water mix, and where an abundant vegetation prospers, are found at the time both the enormous quantity of nutrient vegetation which they needed, and without doubt an efficacious retreat against the pursuit of carnivores.

Moreover the so-called “lacustrine” setting was varied, as consideration of the fauna accompanying the dinosaurs suggests. Vast freshwater lakes, with red clay sedimentation in a tropical climate, where paladines, unios, and *Desertella* [Lefranc, 1950] lived numerous in the mud. Temporary lakes that are drained at certain periods, populated by *Estheria* and also *Ceratodus* with double respiration. Fluviatile spreading zones are intermingled with the lacustrine levels, where detrital formations predominate over clays: several species of unionids lived there with large gastropods similar to recent *Ampullaria* of African rivers [Mongin, 1954; Lapparent and Mongin, 1959]. Finally marshes themselves, which are the preferred habitat of large reptiles, crocodiles, and turtles, if the descriptions of the Mississippi and Amazon deltas are referred to, or the Florida “swamps”.

Regarding the orthopods, surely present but hardly signaled by a few remains, they must have frequented the edge of the marshes. *Iguanodon* in particular must have inhabited the humid forest zones, because it is thought to have been equipped to feed on branches and leaves rather than herbs. Moreover these forests are not lacking: *Wechselia*, rather similar to arborescent osmunds, and araucarians with trunks reaching 20 m, constituted very vast forested regions, if the innumerable specimens of silicified wood that are recognized in the Sahara are brought to mind [Boureau, 1958].

The climate that reigned during the Lower Cretaceous in the Saharan regions was indeed far from being desert. Thanks to the invertebrates [Mongin, 1954], vertebrates, and above all plants [Boureau, *passim*], it must be thought that a humid tropical climate reigned in the low zones, while the forested zones, with predominately araucarians, must have covered a large part of the emergent massifs.

2. Comparisons.

If I wish to attempt some comparisons at the end of my study, it is first necessary to put aside both Zarzaïtine localities, which due to their respective ages are exceptions in the Saharan Continental Intercalaire series. Subsequently I have a free field to study the faunas of Cretaceous age.

A) The summit of the Zarzaïtine cliff thus furnished two teratosaurid teeth, mixed with the remains of stegocephalians; by this fact, I have referred this locality to the Upper Triassic. It constitutes a precious milestone, the only one for the moment[1], between the relatively well known theropod faunas from the Triassic of Germany [Huene, 1907-1908], and those of the Karoo in South Africa, where some already significant discoveries have made news. Between two regions so separated, this intermediary

[1] Some elements of the same vertebrate fauna were noted in the Triassic of the Grand Atlas in Morocco: ARAMBOURG, C. and DUFFAUD, F. (1960): *C. R. somm. S. G. F.*, p. 118. (Note added during printing.)

located in the heart of the Sahara will undoubtedly be a precious indication for the study of similarities between the Karoo-type sandstones of Belgian Congo, the sandy series of Oubangui, and the Saharan Continental Intercalaire.

B) The discovery of *Brachiosaurus* in the Taouratine beds, which it seems must well be attributed to the Jurassic, evokes the dinosaur discoveries made at Tendaguru in the Upper Jurassic. Unfortunately, for the moment we do not have other elements from the Taouratine series to make comparisons.

Coming now to the dinosaurs found in the thirty-one localities of the central Sahara, entirely naturally I compare them with the faunas already described, either from the rest of the Sahara, from other regions of Africa, or still with the contemporaneous faunas from the Lower Cretaceous of Europe.

1. EASTERN AND WESTERN SAHARA. — By all evidence, the resemblances between the dinosaurs in all regions of the Sahara are very narrow.

The rich Baharija locality has furnished theropods and sauropods that I immediately brought closer to our first lucky finds: the localities of Niger then came to complete these generic resemblances, which similarly probably continue to the identity of species. For the theropods, *Baharijasaurus ingens*, an indeterminate form, and *Carcharodontosaurus saharicus* are common to both regions; and the coelurid *Elaphrosaurus iguidiensis* is perhaps not very different from *Elaphrosaurus* sp. noted by Stromer.

The sauropods are rather poorly represented at Baharija; that which was described there, *Aegyptosaurus baharijensis*, was found in Niger.

Spinosaurus aegyptiacus, this extraordinary theropod with immense dorsal vertebrae found uniquely at Baharija, is lacking in the central Sahara. In contrast, ornithischians have not been noted at Baharija.

R. Lavocat discovered some varied dinosaur remains in the western Sahara, to which the forms from the central Sahara are very close. The same *Carcharodontosaurus saharicus* left a great number of characteristic teeth there; a coelurid of the genus *Elaphrosaurus* is also noted there; finally, I referred most of the large sauropod remains found so often in the north and south of the Hoggar to the genus *Rebbachisaurus* LAVOCAT, but perhaps to a new species.

In summary, in the still fragmentary state of our understanding, the same dinosaur fauna seems to be present in the Continental Intercalaire throughout the Sahara, from east to west and from north to south.

2. AFRICAN CONTINENT. — The other regions known with dinosaurs in Africa are still not very numerous (cf. Furon [1960]). It is useful to compare them with the dinosaurs of the Continental Intercalaire of the Sahara.

a) The Cenomanian of *Amoura*, in the Saharan Atlas, is celebrated for numerous theropod footprints [Bellair and Lapparent, 1948]. The relatively modest size of these traces must exclude their attribution to a large carnosaur such as *Carcharodontosaurus saharicus*. Rather they would be attributed to a coelurosaurian, but it is impossible to specify the genus.

b) In East Africa, some magnificent discoveries were made at Tendaguru [Fraas, 1908; Janensch, 1922 to 1950]. The age of the dinosaur beds is essentially Upper

Jurassic. The dinosaurs from the Continental Intercalaire of the Sahara seem different from those of Tendaguru, with which the idea immediately came to compare them. If a large theropod with serrated teeth, a coelurid of the genus *Elaphrosaurus*, and sauropods can be cited in both cases, the species are not the same. On the other hand, the genus *Dicraeosaurus* and the enormous *Brachiosaurus* have not been found in the Saharan Lower Cretaceous; *Brachiosaurus* exists only in the Taouratine series, which is older stratigraphically.

c) Completely in the south of the African continent, some dinosaur beds were noted in the *Uitenhage* district (Cape Province) [Schwartz, 1913]. Their age is Lower Cretaceous, and they occur prior to the marine Barremian. But the remains described are too broken to permit a serious attempt at comparison.

3. INDIA AND MADAGASCAR. — *Madagascar* is celebrated for its dinosaurs, known at two levels, the Middle Jurassic on the one hand, the Upper Cretaceous on the other. But the Lower Cretaceous is marine; and on the large island there are no continental beds with dinosaurs that are contemporaneous with the Saharan Continental Intercalaire.

Neither can points of comparison be found in *India*, where the dinosaur beds (Lameta Beds) belong to the highest Cretaceous (upper Senonian or Danian), and where the forms are indeed very different [Lapparent, 1957].

4. EUROPE. — The Lower and Middle Cretaceous of Europe has furnished, in *England* above all, a rich dinosaur fauna to which it is evidently appropriate to compare that of the Continental Intercalaire. It is above all in the cliffs of the Isle of Wight [Swinton, 1936] and in the Wealden that the Lower Cretaceous species are known; several elements from the glauconitic Cenomanian of Cambridge [Swinton, 1934] must be added there. Thus what are the similarities with the Saharan fauna?

From a general point of view, the same faunistic ensemble is noted: carnivorous and herbivorous saurischians in similar proportions in the Sahara and England; rarer ornithischians in both cases, except for *Iguanodon* which lived in numerous herds in western Europe. But such remarks could undoubtedly be applied to every dinosaur fauna in a region where these animals are sufficiently known; they only reveal a reptilian fauna in biological equilibrium and do not necessarily imply narrow similarities.

In a more precise manner, not much can be made from the theropods, whose remains are very fragmentary in the Isle of Wight, although the presence of a carnosaur and one or several coelurids has been established there at the time. I note only that these two groups of carnivores, heavy forms and slender forms, are also found in the Lower Cretaceous of the Sahara.

In contrast, the sauropods show some clearer similarities due to the presence in both regions of the very particular genus *Astrodon* and titanosaurid vertebrae, a family very characteristic of the Cretaceous.

I also note that if *Iguanodon* seems habitually excluded from the African fauna, I have just the same noted its presence in extreme southern Tunisia, with the same species as in England, *I. mantelli*.

Rather loose similarities in total, due to the distance and the probable geographic separation; but rather clear indications that the fauna of the Saharan Continental

Intercalaire was contemporaneous with that of the Lower and middle Cretaceous of Great Britain.

GENERAL CONCLUSION

At the end of this first description of dinosaurs from the central Sahara, it is good to underline that it only constitutes a stage in the understanding of African fossil reptiles.

If the variety of dinosaurs and the abundance of bones are considered, seven localities can be retained as truly rich for the central Sahara ensemble (fig. 3),. Here they are, classed in order of importance:

In Abangarit (Niger)	Timimoun (Gourara)
Iguallala (Niger)	El Rhaz (Niger)
In Gall (Niger)	Alrar (extension of Djoua)
In Tedreft (Niger)	

Can it reasonably be hoped that deeper researches and excavations made in some of these localities could furnish a more complete and valuable paleontological material?

Yes, it seems, for the four regions or "localities" of In Abangarit, Iguallala, In Gall, and El Rhaz; perhaps also for In Tedreft. Regarding the others, it can be hoped that the essential has been recovered by the explorations already realized, at least regarding that which outcrops on the surface. I draw this conclusion as a fact of experience, noted in a certain number of cases: some repeated researches, at several recoveries in the same perimeter, finish at the end of a certain time by no longer producing anything new.

Naturally, it remains that chance could always bring forth an important discovery where it was least expected. Moreover, it should not be forgotten that many unexplored sectors still exist in the Sahara from the paleontological point of view.

We could be perhaps reproached as remaining at the stage of "fossil hunters of the 19th century, who recovered only the elements at the surface"[1], while at the same time powerful paleontological missions, making great excavations are shown in western Canada or Mongolia, for example.

The circumstances, it is true, have often allowed us to send out only camels or light vehicles. But we thought that with a little audacity these missions would be worth the pain. Sometimes besides, and especially at Tibesti, we profited from a well-equipped scientific mission. Indeed, these journeys have already brought very numerous data on the vertebrate localities of the Sahara with promising paleontological results.

My study of the dinosaurs is thus at the same time a *development* closing off the period of the first explorations, and a *point of departure* for the future.

Detailed researches will be possible from now on, in the new era that has been opened for the Sahara, so frequented now by geologists. The lucky finds that will follow will make much more fully known the living world that populated the Great Desert during geological periods. The paleontological study that I outlined could be completed; and also certain bony elements cited here will be restudied with more precision, because the absence of comparative terms has often shortened and limited my descriptions of new forms.

The present work was above all a first evocation of the dinosaur fauna of the central Sahara; I wish that it might also be a guide for later researches.

[1] ROJDESTVENSKI, A. (1960): Chasse aux Dinosaures dans le désert de Gobi, p. 18.

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See original text.

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Legend for Pl. I. — LANDSCAPES OF THE “CONTINENTAL INTERCALAIRE” OF THE CENTRAL SAHARA

FIG. 1. — Djoua. Effects of eolian erosion in the Djoua clays, between Fort Flatters and Tab-Tab.

FIG. 2. — Between Ohanet and Bourarhet. Effect of deflation in the pebble sandstones of the Zarzaïtine series.

FIG. 3. — Extreme southern Tunisia. At the first flat, clays and red sandstones of Segdel. Farther, the Kanboute, near Rémada, a detached gara in front of the Dahar cliff: they are crowned by the Turonian limestones; Cenomanian slope, then the Lower Cretaceous with rich vertebrate locality.

FIG. 4. — Niger. Tiguidi cliff, on the piste from Agadès to Zinder: Tégama sandstone, with cross-bedded stratification, dominating the Irazer plain toward the north (at left). Note the rocky mushroom due to eolian erosion.

PLATE II

DINOSAUR LOCALITIES OF THE CENTRAL SAHARA

FIG. 1. — In Gall (Niger): right humerus (at left), ribs, left femur (top right) of *Rebbachisaurus tamesnensis*.

FIG. 2. — In Gall (Niger): left humerus of *Rebbachisaurus tamesnensis* (length: 123 cm) belonging to the same individual as the bones in fig. 1.

FIG. 3. — Zarzaïtine (Libyan frontier): large sacrum of *Brachiosaurus*, having disarticulated. Lateral view, the posterior part being found on the left (length: 130 cm). The locality is 11 km east-northeast of drilling ZR.2.

FIG. 4. — Same locality and same element. View of anterior side.

PLATE III

DINOSAUR LOCALITIES OF THE CENTRAL SAHARA

FIG. 1. — El Rhaz (Niger): series of caudal vertebrae attributed to *Rebbachisaurus tamesnensis*. The handle of the hammer (32 cm) gives the scale. The locality is found 8 km east of El Rhaz (photo H. Faure).

FIG. 2. — In Gall (Niger): right femur of *Rebbachisaurus tamesnensis*; proximal portion, posterior surface. According to the other more complete femur of the same animal, found nearby, it must have measured 150 cm long.

FIG. 3. — Zarzaïtine (Libyan frontier): portion of the left forelimb of *Brachiosaurus*: ulna and radius (distal ends), carpal bones, metacarpals III and IV, and a large phalanx (photo M. Gillmann).

FIG. 4. — Zarzaïtine (Libyan frontier): right tibia of a sauropod (*Brachiosaurus*?) (length: 85 cm), posterior surface. The element sits 800 m west of the sacrum figured in Pl. II, fig. 3-4.

PLATE IV[1]

FIG. 1. — *Carcharodontosaurus saharicus* (DEPÉRET). Tooth. x 1. In Abangarit.

FIG. 2. — *Id.* Tooth. x 1. In Abangarit.

FIG. 3. — *Id.* Tooth. x 1. In Abangarit.

FIG. 4. — *Id.* Tooth. x 1. In Abangarit.

FIG. 5. — *Teratosaurus* sp. Small tooth. x 1. Zarzaïtine.

FIG. 6. — *Id.* Tooth. x 1. Zarzaïtine.

FIG. 7. — *Carcharodontosaurus saharicus* (DEPÉRET). Canine tooth. x 1. In Abangarit.

FIG. 8. — *Elaphrosaurus iguidiensis, nov. sp.* Tooth. x 1. Rémada: Kanboute.

FIG. 9. — *Carcharodontosaurus saharicus* (DEPÉRET). Tooth fragment. x 1. Timimoun.

FIG. 10. — *Id.* Phalanx from the hind foot. x 1/2. El Rhaz.

[1] In principle, the teeth were represented at natural size (x 1), the vertebrae and small bones reduced by half (x 1/2). The long bones had to be reduced further and figured at 1/3, 1/4, or 1/5. As it was impossible to group the same reductions on the same plate, attention will be paid to the indicated reduction.

PLATE V

FIG. 1. — *Carcharodontosaurus saharicus* (DEPÉRET). Tooth. x 1. In Abangarit.

FIG. 2. — *Id.* Tooth. x 1. In Abangarit.

FIG. 3. — *Id.* Canine tooth. x 1. In Abangarit.

FIG. 4. — *Baharijasaurus ingens* STROMER. Middle caudal vertebra. x 1/2. In Abangarit.

FIG. 5. — *Elaphrosaurus gautieri, nov. sp.* Caudal vertebra. x 1/2. In Abangarit.

FIG. 6. — *Id.* Dorso-lumbar vertebra. x 1/2. In Tedreft.

FIG. 7. — *Elaphrosaurus iguidiensis, nov. sp.* Posterior caudal vertebra. x 1/2. Timimoun.

FIG. 8-12. — *Id.* Teeth. x 1. Ebrechko.

FIG. 13. — *Id.* Tooth. x 1. Guermessa.

FIG. 14. — *Id.* Tooth. x 1. Alrar.

FIG. 15. — *Id.* Tooth. x 1. In Abangarit.

FIG. 16. — *Id.* Canine tooth. x 1. In Abangarit.

FIG. 17. — *Baharijasaurus ingens* STROMER. Middle caudal vertebra. x 1/2. In Abangarit.

FIG. 18. — *Rebbachisaurus tamesnensis, nov. sp.* Tooth. x 1. Tiguidi: Zinder piste.

FIG. 19. — *Id.* Tooth. x 1. Ebrechko.

FIG. 20. — *Id.* Transverse process of an anterior caudal vertebra. x 1/2. Ifayen Ignère.

FIG. 21. — Indeterminate stegosaurian. Dermal spine. x 1. Tiguidi: Irayen.

FIG. 22. — *Id.* Dermal plate. x 1. In Abangarit.

FIG. 23. — *Iguanodon mantelli* MEYER. Right upper maxillary tooth. x 1. Rémada: Kanboute.

PLATE VI

FIG. 1. — *Carcharodontosaurus saharicus* (DEPÉRET). Dorsal vertebral centrum. x 1/2. Aoulef.

FIG. 2-3. — *Id.* Consecutive caudal vertebrae. x 1/2. Téfidet (Oued Baouet).

FIG. 4. — *Id.* Anterior caudal vertebra. x 1/2. Iguallala.

FIG. 5. — *Id.* Anterior caudal vertebral centrum. x 1/2. Aoulef.

FIG. 6. — *Id.* Middle caudal vertebra. x 1/2. Timimoun.

FIG. 7. — *Baharijasaurus ingens* STROMER. Anterior caudal vertebra. x 1/2. Iguallala.

FIG. 8. — *Aegyptosaurus baharijensis* STROMER. Middle caudal vertebra. x 1/2. Iguallala.

FIG. 9. — *Id.* Caudal vertebra. x 1/2. Iguallala.

FIG. 10. — *Carcharodontosaurus saharicus* (DEPÉRET). Forelimb claw. x 1/2. In Abangarit.

FIG. 11. — *Id.* Forelimb claw. x 1/2. Djoua: 120 km east of Fort Flatters.

FIG. 12. — *Id.* Forelimb claw. x 1/2. Alrar.

FIG. 13. — *Id.* Forelimb claw. x 1/2. El Rhaz.

FIG. 14. — *Astrodon* sp. Anterior caudal vertebra, lateral view. x 1/2. In Gall.

FIG. 15. — *Id.* Same vertebra, viewed from above. x 1/2. In Gall.

PLATE VII

FIG. 1. — *Inosaurus tedreftensis, nov. gen., nov. sp*. Anterior caudal vertebra. x 1/2. In Abangarit.

FIG. 2. — *Rebbachisaurus tamesnensis, nov. sp.* Caudal vertebra. x 1/2. In Gall.

FIG. 3. — *Id.* Dorsal vertebra. x 1/2. Djoua: 120 km east of Fort Flatters.

FIG. 4. — *Id.* Caudal vertebral chevron. x 1/2. In Salah.

FIG. 5. — *Id.* Vertebra from the start of the tail. x 1/2. Iguallala.

FIG. 6. — *Carcharodontosaurus saharicus* (DEPÉRET). Anterior caudal vertebra. x 1/2. In Abangarit.

FIG. 7. — *Rebbachisaurus tamesnensis, nov. sp.* Forelimb phalanx. x 1/2. In Gall.

FIG. 8. — *Id.* Posterior caudal vertebra. x 1/2. Aoulef.

FIG. 9. — *Id.* Posterior caudal vertebra. x 1/2. In Gall.

PLATE VIII

FIG. 1. — *Rebbachisaurus tamesnensis, nov. sp.* Right first metatarsal. x 1/2. Iguallala.

FIG. 2. — *Id.* Left first metatarsal (large specimen). x 1/2. In Gall.

FIG. 3. — *Id.* Second metatarsal. x 1/2. In Abangarit.

FIG. 4. — *Id.* Hind limb phalanx (digit I?). x 1/2. In Gall.

FIG. 5. — *Carcharodontosaurus saharicus* (DEPÉRET). Second phalanx of digit II, left forelimb. x 1/2. In Abangarit.

FIG. 6. — *Brachiosaurus nougaredi, nov. sp.* Distal end of the left third metacarpal, showing strong rugosities. x 1/2. Zarzaïtine.

FIG. 7. — *Id.* Phalanx from digit III. x 1/2. Zarzaïtine.

FIG. 8. — *Aegyptosaurus baharijensis* STROMER. Anterior caudal vertebra. x 1/2. Iguallala.

FIG. 9. — *Rebbachisaurus tamesnensis, nov. sp.* Left forelimb claw (digit II?). x 1/2. In Gall.

FIG. 10. — *Id.* Right forelimb claw. x 1/2. In Gall.

PLATE IX

FIG. 1. — *Carcharodontosaurus saharicus* (DEPÉRET). Metatarsal, distal portion. x 1/3. Alrar.

FIG. 2. — *Rebbachisaurus tamesnensis, nov. sp.* Left third (?) metatarsal. x 1/2. Iguallala: Mount Kassot.

FIG. 3. — *Id.* Forelimb phalanx. x 1/2. In Gall.

FIG. 4. — *Id.* Posterior caudal vertebra. x 1/2. In Tedreft.

FIG. 5. — *Id.* Right forelimb phalanx (digit I?). x 1/2. In Gall.

FIG. 6. — Thin-section from a sauropod long bone. Tébéhic: Soureya (Niger). Section in polarized light, manifesting the chalk phosphate mineralization. x 50.

FIG. 7. — Same section in natural light. Haversian canals cut transversely and osteoblasts of secondary ossification. x 50.

PLATE X

FIG. 1. — *Rebbachisaurus tamesnensis, nov. sp.* Thoracic rib. x 1/5. Ifayen Ignère.

FIG. 2. — *Id.* Left ischium. x 1/5. Agadès: 35 km south.

FIG. 3. — *Brachiosaurus nougaredi, nov. sp.* Left third metacarpal. x 1/3. Zarzaïtine.

FIG. 4. — *Id.* Phalanx from digit III, forelimb. x 1/3. Zarzaïtine.

FIG. 5. — *Elaphrosaurus gautieri, nov. sp.* Dorsal vertebra. x 1/2. In Tedreft.

PLATE XI

FIG. 1. — *Inosaurus tedreftensis, gen. nov., sp. nov.* Middle caudal vertebra. x 1/2. In Tedreft.

FIG. 2. — *Elaphrosaurus gautieri, nov. sp.* Dorsal vertebra (figured in Pl. X, fig. 5) viewed from the posterior face; note the depth of the neural canal. x 1/2. In Tedreft.

FIG. 3. — *Rebbachisaurus tamesnensis, nov. sp.* Anterior dorsal vertebra viewed in the locality from behind. In Salah (photo C. Allibert).

FIG. 4. — *Elaphrosaurus gautieri, nov. sp.* Caudal vertebra. x 1/2. In Tedreft.

FIG. 5. — *Id.* Cervical vertebra, viewed from the left side. x 1/2. In Tedreft.

FIG. 6. — *Id.* Distal end of a right pubis. x 1/2. In Tedreft.

FIG. 7. — *Id.* Sacrum showing two fused vertebrae. Viewed dorsally. x 1/2. In Tedreft.

FIG. 8. — *Id.* Same element, viewed ventrally. x 1/2. In Tedreft.

FIG. 9. — *Elaphrosaurus iguidiensis, nov. sp.* Caudal vertebra. x 1/2. In Abangarit.

FIG. 10. — *Elaphrosaurus gautieri, nov. sp.* Left humerus. x 1/4. In Tedreft.

FIG. 11. — *Id.* Right tibia. x 1/4. In Tedreft.

FIGURE CAPTIONS

FIG. 1. — Itineraries of the paleontological missions to the Sahara.

1: 1946-1947 mission (Colomb-Béchar-Adrar-In Salah-Ghardaïa) — 2: 1947-1948 mission (Ouargia-Fort Flatters-Edjélé-Rhat) — 3: 1951 mission (Tunis-Gabès-Tatahouine-Remada) — 4: 1952 mission (Tunis-Tatahouine-Tripoli-Nalut) — 5: 1953 mission (Tamanrasset-In Abangarit) — 6: 1953-1954 mission (Tahoua-Agadès-Zinder) — 7: 1954-1955 mission (Borkou-Ennedi-Tibesti-Erdis, starting from Largeau) — 8: 1958 mission (Edjélé-Alrar) — 9: 1959 mission (In Tedreft-Bidon V-Tessalit, starting from Tamanrasset).

A; Agadès; Ab: In Abangarit; Ad: Adrar; Bi: Bidon V; CB: Colomb-Béchar; Ed: Edjélé; EG: El Goléa; FF: Fort Flatters; Ga: Gabès; Gh: Ghardaïa; Is: In Salah; L: Largeau (Faya); Ou: Ouargla: Re: Reggan; Rt: Rhat; Tah: Tahoua; Tam: Tamanrasset; Te: Tessalit; Ti: Timimoun; Tri: Tripoli.

FIG. 2. — General map of the Sahara, indicating the regions with dinosaurs.

1: Extreme southern Tunisia and Tripolitania — 2: Gouara, Taouat, and Tidikelt — 3: Djoua and Ohanet-Bourarhet region — 4: Soudan — 5: Niger.

FIG. 3. — Geological scheme of the central Sahara (after R. FURON [1956]) and distribution of dinosaur localities.

1: Precambrian — 2: Paleozoic — 3: Continental Intercalaire — 4: Upper Cretaceous — 5: Quaternary terrains and dunes. Numbers 1 to 33 on the map correspond to the alphabetical list of localities on p. 10.

FIG. 4. — Map of dinosaur localities in extreme southern Tunisia and Tripolitania.

1: Jeffara plain — 2: Lower Cretaceous and continental Cenomanian — 3: Upper Cretaceous plateaus.

FIG. 5. — Stratigraphic sections of the Continental Intercalaire of the central Sahara.

Section A: Dahar cliff, extreme southern Tunisia; thickness: 250 to 280 m. — *Js*: marine and brackish Upper Jurassic — 1: clays and sandstones with ferruginous wood (Neocomian) — 2: clays and sandstones (Barremian-Aptian?) — 3: rather constant quartzite flagstone — 4: sandy sandstone with quartz pebbles and silicified wood, gypsum clays (Albian and lower Cenomanian) — *Ce*: Cenomanian — *Tu*: Turonian — ¥^{1} and ¥^{2}: fish localities at Déhibat — ¥^{3}: fishes, crocodiles, and dinosaurs at Guermessa, Douiret, Déhibat — ¥^{4}: fishes, crocodiles, and theropods at Chenini — ¥^{5}: crocodiles, theropods, *Iguanodon* at Kanboute and Touil Déhibat — ¥^{6}: fishes at Rhomerassen.

Section B: Timimoun (Gourara); thickness: 200 m. — *Pal*: Paleozoic (Dinantian) — 1: brick-red clay — 2: red, rose, or white sandstone and bright-red clay — 3: quartzite flagstone (which does not have continuity of depth, according to A. Cornet) — 4: sandstone with quartz pebbles — 5: sandstone with kerbour and clays — 6: variegated El Goléa clays — *Ce-Tu*: Cenomanian-Turonian dolomitic limestone.

Section C: Agadès-Tamout (Niger); thickness: 200 to 250 m. — *Pc*: Precambrian gneiss — 1: Agadès sandstone and Irazer clays — 2: Tiguidi cliff sandstones (cf. Pl. I, fig. 4) — 3: Tégama sandstones and clays — ¥^{1}: level of the In Gall, Agadès, Ifayen Ignère, and Tébéhic localities — ¥^{2}: level of the Marandet, Tiguidi, and Ebrechko localities.

FIG. 6. — Map of dinosaur localities of the Touat in Fezzan.

1: Ancient terrains — 2: Continental Intercalaire — 3: Upper Cretaceous — 4: covering terrains (Tertiary, Quaternary, dunes).

FIG. 7. — Detailed map of the Amerhaïer foggara at Timimoun (according to a sketch in place and an aerial photo). A, B, C, D, E: five watch-towers — H: ruined house — *cgl*: small conglomerate with yellow quartz pebbles, rounded pebbles, wood, and bones, outcropping under the quartzite flagstone.

Detail of the fossiliferous points visited in 1946. ¥^{1}: some bone debris — ¥^{2}: more abundant bone debris — ¥^{3}: a large crocodile tooth — ¥^{4}: numerous bone pieces, fragments of long bone — ¥^{5}: a vertebra — ¥^{6}: numerous bones and teeth (richer place, in the earth of 3 or 4 consecutive wells) — ¥^{7}: vertebrate and fragments of skull bones — ¥^{8}: numerous crocodile bones and teeth, in a yellow quartz conglomerate. East of house H is a sterile zone of white sandstone.

FIG. 8. — Stratigraphic section of the continental series between Ohanet and Bourarhet; thickness: 700 m.

Tig: Tiguentourine series (Upper Carboniferous?) — *Zr.i.*: lower Zarzaïtine series, clayey-sandy (Middle and Upper Triassic) — *Zr.s.*: upper Zarzaïtine series, clayey-dolomitic (Liassic-Dogger?) — *Ta*: Taouratine series (Upper Jurassic) — *Ak*: Akhamil series (Lower Cretaceous and lower Cenomanian) — *Ce*: marine Cenomanian — *Tu*: Turonian — †1: Middle or Upper Triassic stegocephalians and reptiles — †2: Upper Triassic stegocephalians and dinosaurs (*Teratosaurus*) — †3: Jurassic flora (after E. Boureau) — †4: Upper Jurassic sauropod dinosaur (*Brachiosaurus*) — †5: Lower Cretaceous flora, fishes, crocodiles, theropod and sauropod dinosaurs.

FIG. 9. — Map of the groups of dinosaur localities of Soudan and Niger.

1: Ancient terrains (Precambrian and Paleozoic) — 2: Continental Intercalaire — 3: Upper Cretaceous and Tertiary.

FIG. 10. — Map of dinosaur localities of the Agadès region (Niger).

1: Aïr Precambrian — 2: Agadès sandstone and Irazer clays = lower part of the Continental Intercalaire — 3: Tégama sandstone = upper part of the Continental Intercalaire.

Numbers of localities (corresponding to the list on p. 10): 1: Agadès, 35 km south — 2: Agadès, 16 km southeast — 11: Ebrechko — 16: Ifayen Ignère — 20: In Gall — 24: Tébéhic, Soureya — 26: Tiguidi, Marandet — 27: Tiguidi, Zinder piste — 28: Tiguidi, Irayène.

FIG. 11. — *Brachiosaurus*. Reconstruction (after Abel). 1/130.

FIG. 12. — Plan of the bones of a single indivudual of *Rebbachisaurus tamesnensis*.
In Tedreft, locality 10 km northeast of the “Agadès 417 km” sign (after a sketch made in place).

Ba: pelvic bones — *Fe*: femur, distal portion — *Is*: ischium — *Pe*: fibula — *Ti*: tibia (length of the preserved portion = 90 cm) — *Ti*: other tibia, distal portion — V^{1}: caudal vertebra, viewed by the posterior disc measuring 17 x 19 cm — V^{2}: anterior caudal vertebra, disc diameter: 22 cm — $V^{3\text{-}12}$: series of 10 middle caudal vertebrae — $V^{13\text{-}17}$: group of 5 posterior caudal vertebrae — V^{18}: isolated caudal vertebra.