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CONTRIBUTION TO THE STUDY OF SEDIMENTARY BASINS. THE "COASTAL" BASIN OR GULF OF THE MENABE (MADAGASCAR). ENDEMIC CHARACTER OF ITS FAUNA.*

BY

Maurice COLLIGNON

SUMMARY

Here it is desired to show the appearance, in a calm-water gulf, of an original fauna with a characteristic endemism, its evolution, in particular that concerning the rare genus *Pseudoschloenbachia*, which provided me 8,000 specimens, whereas its other representatives in the rest of the world do not exceed a few tens of specimens.

Some very numerous other genera of ammonites, all speciose, lived only on the shores of this gulf during a very limited time. It seems, moreover, that the genus *Pseudoschloenbachia*, despite its astonishing proliferation, provided successive "trials" on the spot, without succeeding in giving them a force of sufficient propagation apart from the narrow limits of its family.

The other ammonites probably came from abroad, brought by currents which pushed them onto the shores of the gulf (20% versus 80% nearby). Some other endemic local forms are very abundant (inoceramids, crustaceans).

It is remarkable to note that, still now, endemism is a characteristic of the Malagasy fauna and flora.

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All along the west coast of Madagascar, between the 17th and 22nd parallels, the sedimentary deposits form a more or less wide border, occasionally interrupted or very reduced because of the existence of eruptive formations covering vast surfaces (region of the Renobe and Manambao Rivers) or still, sometimes, more or less partially recovered by the sandy covering that masks the outcrops from Cretaceous to Eocene (region of Morondava–Maharivo).

The result is that the sediments, in particular Cretaceous, are discontinuous, and that they cannot be followed everywhere, principally to the west of the Jurassic Bemaraha plateau.

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However, a fairly vast region is partially exposed of these coverings: this is the Menabe limited to the east by the faulted Bemaraha cliff, to the north by the very vast basaltic outpourings north of Antsalova, to the south by the approximate course of the Morondava. A relatively deep surface between the Manambolo and Tsiribihina Rivers permits direct observation at a great number of points.

Perhaps this Menabe could be called, or more exactly the portion of the Menabe between Manambolo and Tsiribihana a "coastal" basin like those that are so easily delimited on the west coast of Africa (Gabon-Tarfaya)? Yes, above all if one considers this region from the paleontological point of view, because, within their limits, the fossil faunas, often extremely abundant, present particular characters of endemism that clearly put aside as well in Madagascar (the same in considering the other fossil faunas discovered as much in the north up to Diégo Suarez as in the south up to Tuléar and Betioky) as in the rest of the world, and this character of endemism is entirely remarkable.

The detailed 1/100,000 map (Behamorta F. 48 and Ampolipoly G.48 page) shows moreover, thanks to the incurving of the Cretaceous sediments to the northwest (in particular those of the Turonian and Santonian than of the Campanian that one discovers up to the south and west edges of the Tsiazohena swamp, Andimaka region), that the Menabe was in the Cretaceous a sort of gulf narrowed to the north, more open to the south.

The Menabe was traversed for the first time, at the beginning of the century, by the officers of the Marine Infantry who had a reconnaissance mission of study and pacification. Thus Lieutenant BÜHRER and Captain CONDAMY, then after them, Captain COLCANAP, traversed the country from Lake Hima up to Antsalova and made the first recoveries of fossils there (1). These, sent to Marcellin BOULE, Professor of Paleontology at the Muséum National d'Histoire Naturelle de Paris, were entrusted to me by him, and the first publication on the Menabe came in 1932 (2). Meanwhile and most recently, the region was studied by H. BESAIRIE, then mapped by V. HOURCQ; and this latter published a remarkable thesis in 1930 that was the origin of all the later studies of the Menabe (3).

H. BESAIRIE and V. HOURCQ made some very good collections. V. HOURCQ established long lists of Jurassic and Cretaceous fossils; then he allowed me to study the important groups whose results were published in the *Annales Géologiques* of the Service of Mines of Madagascar from 1948 (4).

Since 1952, free of my military obligations, I was called to Madagascar by H. BESAIRIE who gave me the honor of the revision and study of the sedimentary terrains of the entire west coast. Thus in 1953, 1954 and 1957, I traversed through several months the Menabe and made very abundant fossil collections there, whose study has not besides been completely achieved. However, following the instructions of H. BESAIRIE, then director of the Geological Service of Madagascar, then his successors Messrs. ZAFIMAHOVA and RAZAFINIPARANY, I dedicated twelve years to the drafting of an *Atlas des Fossiles caractéristiques de Madagascar* [*Atlas of Characteristic Fossils of Madagascar*] (ammonites) that appeared from 1958 to 1971 and that included no fewer than 17 volumes totaling 563 plates with the description and illustration of 2,423 species (5). This already considerable work will be completed by an index, and the continuation will be dedicated to other molluscs (gastropods and lamellibranchs) and to echinoids.

Naturally the faunas of the Menabe occupy a very great place in my descriptions, above all in that concerning the Cretaceous; and I was able to define a stratigraphy that, concerning the Menabe, was pushed in detail. Its exposure, with tables, was presented at the time of the "Geological Seminars of Antananarivo" from 1966 to 1970 (6) (22).

V. HOURCQ defined and specified the lithology of the Menabe. Most recently, I benefited from the researches made by the "Copetma" Society that charged me with studying the fossils of a new cut of the Menabe recovering the mines, previously, and I then had a 1/500 log (September 1969 by Messrs. MAGNIER and RAZAFIMBELO) giving me since the Turonian the lithological succession of various strata (marls, limestones, sands, etc.) much better and with more precision than I had made myself (*a*).

I have already commented, according to V. HOURCQ, on how the terrain is presented (6): approximately, while walking along the pistes, one encounters a succession of beds very isolated from one another and whose dip is extremely weak. The weakness of the dip permits examining diverse beds on a certain height and breadth, and these dimensions correspond approximately to the distances measured on a succession of closer points whose intervals were given to me by the kilometric counter of the car that I used. All along the traverse I had numbered all a series of localities following and superimposing in ascending order. I was then able to compare my results with those of Messrs. MAGNIER and RAZAFIMBELO and verify their exact agreement.

LOWER CRETACEOUS (BELEMNITE MARLS)

From the great Bemaraha fault (Maintirano no. 6 page of the geological map of 1956 at 1/500,000 by H. BESAIRIE) is extended, in talus, the belemnite marls whose more characteristic elements are, according to the studies of Mr. COMBEMOREL (*b*):

Hibolites pistilliformis BLAINY.
Hibolites subfusiformis RASP.
Hibolites joleaudi BESR.
Belemnopsis africanus TATE.
Belemnopsis madagascariensis BESR.
Duvalia cf. *dilatata* BLAINY.
Duvalia cf. *sakalava* BESR.
Duvalia lata BLAINY var. *guillantoniana* BESR.
Duvalia cf. *grasiana* DUV. JOUVE.

It is thoroughly interesting to note that most of these species are already found in the Tithonian and upper Kimmeridgian. They are often shown in the Hauterivian. In reality these *Duvalia marls* form a fairly coherent group where the subdivisions are subtle or impossible. It must be noted that one recovers them in most of the "Neocomian" deposits of Madagascar.

Above the *Duvalia marls* the Barremian and Aptian are not known with certainty.

(*a*) I have to thank here Messrs. MAGNIER and RAZAFIMBELO whose studies allowed me to complete the mines. Unfortunately I was not able to obtain communication of the determinations of the foraminiferans made by their care. And I am RESTE about the already very old and preliminary studies made by my friend J. SICAL.

(*b*) Assistant-master to the Faculty of Sciences of the Université de Lyon who prepared a thesis applied on the Malagasy material that I sent him.

ALBIAN

The Albian furnishes nothing in particular. Moreover, in the south on the Ampolipoly page at 1/100,000 (1958, by A. de VENDEGIES and M. COLLIGNON) I recovered a fragmentary example of *Lyelliceras pseudo-lyelli* PAR. and BON. (Locality 760. East bank of Lake Hima, 4 kilometers from Ankaboka (8)). This discovery specifies the existence of the Albian at least in this place.

CENOMANIAN

The Cenomanian is represented partially by some continental deposits because I have observed in several places to the west of Andranomena (south on the Ampolipoly page) some large broken bones of dinosaurs and some vertebrae. The conditions of the moment did not permit me to recover them.

More to the north, near Ampolipoly, the marine Cenomanian furnished some good localities of ammonites discovered by V. HOURCQ, at Andranovoritelo and Ankilimanarivo (which I saw again in 1954) and which I studied in 1939. This is the first original ammonite fauna in the Menabe: it includes *Hourcqiceras* COLL. 1939. This genus has not been found elsewhere, at least to my knowledge (9).

TURONIAN

It is with the Turonian that the Menabe faunas acquire a partially endemic, but already exceptional, character.

The upper zone (*Coilopoceras requieni* and *Romaniceras deveriai* Zone) furnished at Masiaposa the two new very particular genera *Masiaposites* COLL. 1965 and *Hourcquia* COLL. 1965 (10). Both are represented by numerous specimens sometimes of considerable size. Paleontologically it must be seen there the first Barroisiceratinae from which results in particular the genus *Barroisiceras* GROSS. Only *Hourcquia* was recovered recently in Japan by MATSUMOTO (11).

This Turonian fauna (Atlas Vol. XII) includes, moreover, from Masiaposa and Antsarona:

a. Species unique to the Menabe:

Phylloceras masiaponense COLL. (Pl. CCCLXXVI, Fig. 1634);
Mespuziosa beloensis COLL. (Pl. CCCLXXVII, Fig. 1638);
Lewesiceras masiaponense COLL. (Pl. CCCLXXX, Fig. 1644);
Lewesiceras donovani COLL. (Pl. CCCLXXX, Fig. 1645);
Kamerunoceras antsaronense COLL. (Pl. CCCLXXXVII, Fig. 1661);
Neoptychites subxetriformis COLL. (Pl. CCCXCIX, Fig. 1682);
Subprionocyclus casterasi COLL. (Pl. CDV, Fig. 1693-1695);
Mammites menabensis COLL. (9). p. 24. Fig. ?? Pl. VI. Fig. 2*a*-*b*;
Mammites hourcqi COLL. (9). p. 26. Fig. ?? Pl. VII. Fig. 1*a*-*b*, 2, 2*a*.

b. Some species common with India:

Gaudryceras varagurense KOSSM. (Pl. CCCXXVI, Fig. 1635);
Kossmaticeras recurrens KOSSM. (Pl. CCCLXX?, Fig. 1642);
Fagesia superstes KOSSM. var. *sphaeroidai* PERV. (here as in Algeria).

(Pl. CCCXC, Fig. 1677)
Fagesia rudra STOL. (Pl. CCCXCI-CCCXCV, Fig. 1678*a-b*).

c. Some species common with Japan:
Mesopuzosia yubarensis JIMBO (Pl. CCCLXVII, Fig. 1637);
Jimboiceras planulatiforme JIMBO (var. *madagascariensis* COLL.)
(Pl. CCCLXXX, Fig. 1647);
Yubariceras yubarense MATS (Pl. CCCLXXX, Fig. 1657).

d. One species common with Nigeria:
Glebosoceras glebasum REYMENT (Pl. CDX, Fig. 1686-1687).

e. Some rare species known elsewhere in the rest of the world:
Pachydesmoceras linderi GROSS. (Pl. CCCLXXIX, Fig. 1640);
Placenticeras memoriae-schloenbachi LAU. (var. *ambilobensis* COLL.)
(Pl. CCCLXXX, Fig. 1646-1648);
Romaniceras deveriai d'ORB. (Pl. CCCLXXXI, Fig. 1655);
Romaiceras uchauxiense COLL. (Pl. CCCXXXIV, Fig. 1656);
Coilopoceras requieni d'ORB (var. *alte-sella* COLL.) (Pl. CDIII-CDV,
Fig. 1688-1689, 1690*a-b*);
Kamerunoceras salmuriense COURT. (Pl. CCCLXXXVI, Fig. 1659-1660);
Subprionocyclus neptuni GEIN. (Pl. CDVI, Fig. 1691-1692).

Nevertheless, by the considerable numbers of individuals of the genera *Masiaposites* and *Hourcquia*, the original character of the fauna is already clearly established.

In contrast, the other genera such as *Pseudaspidoceras* HYATT, *Schindewolfites* WISDM., *Ampakabites* COLL., *Watinoceras* WARREN, *Vascoceras* CHOFF., *Thomasites* PERV., *Betiokytes* COLL., do not exist in the south of Madagascar (*Pseudaspidoceras conoliatum* Zone, not known until now in the Menabe).

CONIACIAN

In the Coniacian, there are only two new genera: *Neokanabiceras* COLL., extremely close to a Californian genus from the Cenomanian-Turonian (12), and *Ankinatsites* COLL., which recalls the Japanese forms (13). All the other genera, very abundant in species and individuals, already exist either in Madagascar, Europe, India, or Japan. These are:

Bostrychoceras HYATT. (numerous specimens of this genus are identical to a Japanese species, *B. indopacificum* MATS. 1967 (25)).
Barroisiceras GROSS;
Kossmaticeras GROSS;
Damesites MATS;
Lewesiceras SPATH;
Proplacenticeras SPATH;
Gauthiericeras GROSS;
Peroniceras GROSS;

Yabeiceras TOK. and SHIM;

Pseudoxybeloceras WEIGHT and MATS.

This, in this stage, the Menabe fauna offers a still exceptional character, but eminently cosmopolitan.

SANTONIAN

With the Santonian we attend the appearance of genera unique to the Menabe or very rare in other regions of the world. Their "explosion" will not delay and will be spectacular as of the upper part, and likewise the middle, of the stage.

A. Lower Santonian

(*Texanites oliveti* Zone)

The lower Santonian appears under the sandy carapace (red sands) 4,600 km west of Ampolipoly, and is extended over about 3,500 km. It is composed of an extremely monotonous alternation of variously colored, poorly fossiliferous marls. Fortunately, the rarity of the fossils is compensated for by the existence, on the northern margin of the Menabe (several kilometers north of Manambolo), of the localities of Tsianalako (14) and Mitraiky (15), which enclose an important fauna though of hardly original character.

But it is here that, in the Menabe, appear nearly at the same time the new genera *Praemuniericeras* COLL., 1966 and *Pseudoschloenbachia* SPATH, 1924.

It is at kilometer 6,900 (locality 268) that the first *Pseudoschloenbachia* appears. The appearance of this genus is extremely important because of its extraordinary proliferation in the Santonian and lower Campanian. It must be noted that this genus was discovered previously in the Pondoland by HOEPEN ("*Schloenbachia*") in some beds that are poorly stratigraphically defined and that I attribute to the highest part of the Santonian and the base of the Campanian (because of the ammonites that accompany it, in particular *Eulophoceras*) (16). A little beyond, at kilometer 7,100 of my cut, there is *Praemuniericeras* COLL., which produced the first species, *P. primum* COLL.

To note in the lower Santonian the existence of *Neocrioceras* (*Schlüterella*) WIEDM., and numerous Baculitidae already known, in particular from the Pondoland (*B. capensis* WOODS and var.), the first *Protexanites* MATS. (*P. planatus* LASSW. Pl. CDLXI, Fig. 1,888), already known from Texas and unique *Inoceramus* (*I. arthriticus* SORNAY).

B. Middle Santonian

(*Texanites hourcqi* Zone)

The succession of beds (marly limestones and marls) always also uniform delivered many Texanitinae (*T. oliveti* BLANCK., *T. soutoni* BAILY, *T. stangeri* BAILY, *T. hourcqi* COLL., pp. 68-78, pl. CDLXXXII to CDLXXXVII, Fig. 1955-1961 and 1964-1965. Atlas Vol. XIV) D'OU S'ECARTE *Parabevahites* COLL., 1948 (pp. 76-82, Pl. CDLXXXVI and CDLXXXVIII, Fig. 1962-1963 and 1966-1970), some Baculitidae (*B. capensis* WOODS), and the new genus: *Pachydiscoides* SPATH (16), abundant in the

Menabe (Tsarahotana) and very rare in the rest of the world. And an isolated ramus of this genus, *Tuberodiscoides* COLL., 1966 from a unique locality (XIV, p. 31, Pl. CDLXVIII, Fig. 1910-1912). The heteromorphs are represented by *Hyphantoceras* HYATT of which the complete or more often broken specimens, sometimes very large, abound a little everywhere; and above all *Madagascarites* COLL., 1966 (XIV, p. 26, Pl. CDLXV, Fig. 1897-1898) with disordered unfolding recalling that of *Nipponites* YABE, recovered, like *Hourcquia*, from Japan by MATSUMOTO (17).

Then *Pseudoschloenbachia* (p. 58, Pl. CDLXXVIII, Fig. 1945-1949) and *Praemuniericeras* (pp. 41-48, Pl. CDLXXII-CDLXXIV, Fig. 1919-1930) become more and more abundant and characterize successive levels: a new species of *Pseudoschloenbachia* (*Ps. praeumbulaxi* COLL., p-é, Pl. CDLXIX, Fig. 1950) will lead to *Pseudoschloenbachia* (*Pseudoschloenbachia*) *umbulazi* BAILY characteristic of the upper part of the stage. However, a lateral branch issued from *Pseudoschloenbachia*, *Lehmaniceras* COLL., 1966 (Atlas XIV, p. 13, Pl. CDLX, Fig. 1881-1882) occupies a level not very thick, but continuous, with several species which permit connecting between them the same levels of other cuts (localities 758 and 279), but it does not appear to have descended from it. And *Protexanites* MATS. gives two new species (pp. 64-66, Pl. CDLXXX-CDLXXXI, Fig. 1952-1954).

C. Upper Santonian

(*Pseudoschloenbachia umbulazi* Zone)

It is immediately, from the very start, the disappearance of *Lehmaniceras* (280) and the decline of *Praemuniericeras* that takes place definitively with true *Muniericeras* GROSS. (18), a very rare genus in the world, but very abundant then in the Menabe where it is limited within the time: *Muniericeras* develops in the last beds of the Santonian and disappears almost at once (p. 91, Pl. CDXCIII to CVIII, Fig. 1981-1995).

But the mass of ammonites, with numerous Texanitinae (*Parabevahites* COLL.) and Pachydiscidae, is represented by *Pseudoschloenbachia* of which locality 280 already permits distinguishing several lineages. The principal is that of *Pseudoschloenbachia* (*Pseudoschloenbachia*) which furnishes numerous species at several successive levels (*Ps. umbulazi* BAILY, *Ps. griesbachi* VAN HOEPEN, *Ps. hoepeni* COLL., *Ps. youngi* COLL., *Ps. drouchitzi* COLL., *Ps. coarctata* COLL., *Ps. segregata* COLL., pp. 103-116, Pl. CDXCIX-DV, Fig. 1996-2014); then by *Fournierella* COLL., 1966, a new subgenus that already appeared sporadically in the middle Santonian (p. 117, Pl. DVI, Fig. 2015-2018).

Texanites sensu str. are still numerous at the moment before disappearing (pp. 121-132, Pl. DVII-DXII, Fig. 2019-2025).

And a new genus appears at the top of the subzone: it is *Neoselwynoceras* COLL., 1966 (p. 133, Pl. DXIII, Fig. 2027) issued from *Selwynoceras turoniens.* One then arrives at the summit of the Santonian: here *Muniericeras* are completely disappeared, *Pseudoschloenbachia* (*Pseudoschloenbachia*) become rare, and already numerous subgenera appear to which they have given birth: *Pseudoschloenbachia sensu lato*.

And it is the bed of the base of the Campanian where the first *Bevahites*, *Eulophoceras* and *Amapachydiscus* appear.

In recapitulating the data acquired on the Santonian, it must be noted that *Pseudoschloenbachia* spread out in the upper Santonian in Pondoland, Texas, very rarely

France, and Madagascar in the Mikoboka (Ambararata, BASSE, 1934), and near Diégo-Suarez, but that it disappears everywhere (except perhaps in Texas), whereas, in the Menabe, in this same moment, with the start of the lower Campanian, it gives forth new and numerous very well characterized subgenera (or genera), spread in profusion and *each occupying one or several stratigraphic levels*, and totally unknown up to here in the rest of the world. It is truly an endemic genus giving the fauna its essential character.

LOWER CAMPANIAN

At the base, the lower bed, called *Neogauthiericeras zafimahovai* "base" (COLL., 1966), presents immediately an exceptional interest, because this ammonite was found in all the cuts, in rare specimens it is true, but constant, and precious, because they permit a perfect parallelism.

With it appear:

— Some very numerous *Elophoceras* HYATT, studied by V. HOURCQ (19), a relatively cosmopolitan genus, but also never as abundant as in the Menabe where the recovered specimens surpass by their number all those which could have been found besides;

— *Hauericeras* GROSS., appeared in the Campanian (*H. antiguum* COLL.) which proliferated to a point such that, because of its stratigraphic distribution, I considered the principal species *Hauericeras* (*Gardeniceras*) *gardeni* BAILY as characteristic of the lower Campanian;

— Some very numerous Pachydiscidae (*Anapachydiscus* YABE and SHIM., *Pachydiscus* ZITT. — *Eupachydiscus* SPATH) that abound and, remarkable fact, of which most of the species are found in India (from which the Texanitinae are excluded…);

— Some very numerous Texanitinae: the genus *Texanites sensu stricto* becomes rare and disappears; it is replaced by *Bevahites* COLL. 1948, very abundant in the first part of the stage, and sometimes in very great specimens;

— But the bottom of the fauna is constituted by *Pseudoschloenbachia* which "explodes" and henceforth fills all the levels from 80% and even more. Certain localities contain only this unique ammonite. Their abundance led me to distinguish a whole series of subgenera (or genera) within the subfamily Pseudoschloenbachiinae (COLL. 1969).

I have already indicated (Atlas XIV, p. 73) how I have established these subgenera in honor of the geologists and paleontologists of Madagascar. And I added: "it is entirely remarkable to note that these different subgenera coexist, are succeeded, take turns in a relatively short space of time, affecting only several successive levels, whose thickness must not exceed 200 meters: thus the relationships between these different cuts raised on the terrain by my care could be established with certainty. It is all also remarkable to note that the genus *Pseudoschloenbachia sensu lato* extends definitively to the summit of the lower Campanian, after having extraordinarily proliferated *in the entire Menabe*, while the most abundant ammonites, and which proceed from them, Texanitinae, Pachydiscidae and Baculitidae, are still very abundant in the middle Campanian, and these two last families reach the summit of the Cretaceous.

And I note today: I thought, during my studies, still not achieved, that in this genus, the subgenera could pass from one to the other, in progressive evolution. I believe also that certain among them are in reality only some "trials", some "tentative" remains without success, coming out early to their disappearance without posterity. This

hypothesis will be studied in detail in the next part of my "Neo-Cretaceous Ammonites of the Menabe" (in progress). Paleontologically, this series of "non-successes", or "failures" is extremely interesting for its repetition.

In the lower Campanian of the Menabe with essentially sandy sedimentation, I have distinguished three successive zones (local stratigraphy):

— *Anapachydiscus wittekindi* and *Eulophoceras jacobi* Zone;

— *Karapadites karapadensis* Zone;

— *Menabites boulei* and *Anapachydiscus arrialoorensis* Zone.

I must remark that I intentionally chose ammonites already well known elsewhere than in Madagascar, in order to correspond as much as possible this lower Campanian with those of the rest of the world, whereas, in choosing the subgenera of *Pseudoschloenbachia* I established a much finer stratigraphy, which I wanted to avoid. But this inconvenience is no longer the same one with regard to the subzones: and they are now, or most often, the same *Pseudoschloenbachia* that serve to designate them, because, remarkably, their sequence and succession allows such an application.

A. *Anapachydiscus wittekindi* and *Eulophoceras jacobi* Zone

This zone includes two subzones:

— *Besairiella besairiei* Subzone;

— *Hourcquiella hourcqi* Subzone.

The two genera of ammonites that designate them are strictly limited; they follow one another and take turns while overlapping only by very rare specimens at the limit of the two subzones. And, although succeeding one another, it is not possible that the second is derived from the first.

Besairiella has its first representative in the *Neogauthiericeras zafimahovai* "base" level and is distributed throughout all the levels and localities of its subzone without presenting up to now a maximum in a particular locality.

Hourcquiella which comes above is probably the most abundant of all the *Pseudoschloenbachia* because I recovered 800 specimens there, and it is the most strictly delimited because certain localities produce only this one genus. The first specimens coexist with the last *Besairiella*; but the genus does not extend past the summit of the *Anapachydiscus wittekindi* and *Eulophoceras jacobi* Zone, at the summit of which it disappears definitively.

Alongside these two genera exist still rare representatives of *Pseudoschloenbachia* (*Pseudoschloenbachia*), unequally distributed in the two subzones which they do not exceed, which disappear equally toward the summit of the zone. And also a new subgenus *Vandegiesiella* that, appearing with *Besairiella*, disappears in the *Hourcquiella* subzone. It could characterize the group of the two subzones.

With these *Pseudoschloenbachia* there are still very numerous *Eulophoceras* (I found 225 there) that I recovered in all the levels of the zone, and in all the localities,

— numerous *Bevahites*;

— some *Bostrychoceras*: *B. elongatum* WHITEAVES, known previously only from Canada, is strictly limited to specimens with jointed turns at the junction of both subzones, before reappearing at the summit of the *Rabiella orthogonia* zone as specimens with jointed turns, and some other species;

— the new genus *Neoglyptoxoceras* at a remarkably limited and constant level with very numerous specimens;

— numerous hamitidas (*Diplomoceras*);

— numerous *Pseudophyllites* in very large specimens;

— some nautilids (*Eutrephoceras*) and, especially, among them the appearance of *Hercoglossa* CONRAD, sometimes in very beautiful specimens, moreover rare, but absolutely characteristic. It seems that it is in the lower Campanian of the Menabe (*Neogauthiericeras* base level) that this reputedly Maastrichtian-Danian genus has made its appearance. I collected only 27 specimens of *Hercoglossa milleri* COLL. not yet published; but I hardly have any more from the Maastrichtian of Mikoboka.

— some abundant inoceramids in unique species described by J. SORNAY (20). The most abundant among them, *Inoceramus* (*Cordiceramus*) *paraheberti* SORNAY goes up into the middle Campanian;

— some crustaceans (S. SECRETAN 1966) of already known genera; but the species are particular to the Menabe;

— the gastropods, echinoids, serpulids, etc., very abundant in certain hardly thick beds, are still not described;

Thus the *Anapachydiscus wittekindi* and *Eulophoceras jacobi* Zone is above all remarkable because of the enormous proportion of ammonites of the genus *Pseudoschloenbachia* whereas, alongside, the other genera of ammonites play only a relatively reduced role; and all these *Pseudoschloenbachia* are original and exist only in the "Gulf of Menabe".

B. *Karapadites karapadensis* Zone

This is the median zone and the thinnest of the lower Campanian (about 20 meters approximately but it shows already a remarkable renewal of *Pseudoschloenbachia*). Because, with rare exceptions, the genera signaled above have definitively disappeared and are replaced by others. This zone was divided into two subzones:

— *Maorites aemilii* Subzone;

— *Scaphites reesidei* Subzone.

This subdivision holds account, like for the zones, of the existence of ammonite genera found in the rest of the world.

The lower zone, with *Maorites aemilii*, is characterized by the abundance of some Kossmaticeratidae of the genus *Karapadites*, well known before, but above all by the appearance as sudden as ephemeral of the genus *Maorites* (relatively rare: New Zealand, Antarctic lands, Australia, New Caledonia).

The upper zone is characterized by the proliferation of the scaphites that, with only two species, *Scaphites reesidei* COLL. (Atlas XIV, p. 51, Pl. DXXXII, Fig. 2098-2099) and *Scaphites aquisgranensiformis* COLL. (Atlas XIV, p. 53, Pl. DXXXII, Fig. 2100-2103), literally encumber certain banks with hundreds of specimens. Then *Scaphites* dies out and disappears nearly completely, because, above, one does not find any more but very rare specimens, sometimes only one in a well defined level. This it is sufficiently delimited and characterizes this *Scaphites reesidei* Zone.

At the same time the *Pseudoschloenbachia* change completely or nearly completely. Two new subgenera appear together at the same time as *Maorites* at the base of the subzone with this name: these are *Condamyella* and *Bühreriella* and they develop

there intensely. But, while *Condamyella* does not pass beyond the lower levels of the following *Rabeiella orthogonia* subzone, in contrast *Bührеriella* crosses and exceeds it, then arrives nearly at the summit of the lower Campanian. Both are represented by very numerous specimens. I have studied 120 and 200 of them respectively, and many others remain unstudied.

It is necessary moreover to indicate:

— that *Bevahites* disappears at the same time as *Maorites*; it is then relayed by other texanitids, *Menabites* COLL. 1948, *Submortoniceras* SPATH 1921, and *Bererella* COLL. 1948, appearing nearly simultaneously. There is thus radical changing of most of the elements of the fauna in spite of this, but the Desmoceratidae continue to proliferate (Hauericeratinae) and also the Pachydiscidae;

— that there is the sporadic and very limited appearance of a heteromorph, *Paeasolenoceras* COLL. 1969 (*P. splendens* COLL., p. 44, Pl. DXXX, Fig. 2087) and a sphenodiscid that I have named *Praemanambolites* COLL., 1969 (p. 213, Pl. DCV, Fig. 2262).

— that the inoceramids noted above continue to proliferate the same as the crustaceans.

C. *Menabites boulei* and *Anapachydiscus arrialoorensis* Zone

This zone is marked:

— by the total disappearance of the Kossmaticeratidae;

— by the rarefaction of the Scaphitidae, which one no longer finds but in unique specimens;

— by the abundance of the Hauericeratinae which, in certain localities, are represented by hundreds of specimens, and with a level limited to *Hauericeras* (*Gardeniceras*) *madagascariensis* COLL.;

— by the diversity of *Menabites*, while the other Texanitinae, *Submortoniceras* and *Bererella*, are relatively rare;

— by the existence of privileged levels with the very rare *Christophoceras* COLL. 1969 (p. 47, Pl. DXXXI, Fig. 2093), numerous *Epiglyptoxoceras* COLL. 1969 (p. 40-42, Pl. DXXXVIII-DXXXIX, Fig. 2081-2083) and a remarkable *Bostrychoceras*, *B. protractum* COLL. (p. 32, Pl. DXXIV, Fig. 2069-2070).

But above all one witnesses a new blooming of *Pseudoschloenbachia* in the two distinguished subzones:

— *Rabeiella orthogonia* Subzone;

— *Termiericeras lenticulare* Subzone.

Rabeiella characterized the subzone of this name (100 specimens studied) and does not exceed it.

In contrast, *Rabenjanahariella*, appearing a little after the preceding species, and probably deriving from it, is shown in the *Termiericeras lenticulare* subzone, and is represented by very numerous specimens, it reduces besides to several species only (320 specimens studied), but often of very large size and often also enclosed in spherical sometimes enormous nodules, and which let appear only the external part of these remarkable ammonites.

At the same time *Bührеriella* arrives near to the summit of the zone.

And the *Termiericeras lenticulare* zone ends the series: already here the ammonites are rare (only 60 specimens of *Termiericeras*); and, alongside the very rare genus *Hirtziella* gives some beautiful specimens from the top to the bottom of this last zone.

Then one arrives at the summit of the cuts made in the lower Campanian: this is its end. *Pseudoschloenbachia* disappears totally and suddenly. However the inoceramids proliferate more than ever and paper certain localities (*Inoceramus* (*Cordiceramus*) *paraheberti* SORNAY has furnished hundreds of specimens). The crustaceans, always very abundant, pass into the middle Campanian.

Thus it appears that *Pseudoschloenbachia* was affected at the top of the lower Campanian by a veritable crisis bringing its destruction: this circumstance, whereas the other ammonite families subsisted, then makes the ammonite fauna of the Menabe lose, at least partially, this curious character of endemism that I have tried to bring to light.

MIDDLE CAMPANIAN

There is no longer any trace of *Pseudoschloenbachia*: to tell the truth the genus exists perhaps still in Pondoland and Texas, but certainly very rare and perhaps not in the same levels as those of the Menabe. I think that they do not exceed the base of the lower Campanian and that this stage here is comparatively reduced.

The character of endemism of the fauna subsists however, but it is attenuated:

The Desmoceratidae decline. Only *Hauericeras* still furnishes fairly numerous specimens; but all the specimens undergo an astonishing reduction of size. Among them the genus *Grandidiericeras* COLL. 1961 is represented by very rare specimens.

The Pachydiscidae are represented by very numerous specimens of *Eupachidiscus* and *Pachydiscus* up to the summit of the stage. They extend into the Maastrichtian (in particular apart from the Menabe, in the Mikoboka). *Patagiosites* SPATH 1924 and *Hoepenites* COLL. 1952 are very rare.

There are then the Texanitinae that furnish the most interesting elements of the fauna. *Submortoniceras* and *Menabites* survive without being very abundant, and include some curious species with a massive lateral lobe that, after deep study, must receive a special subgeneric name. But, in number, at the summit of this stage there are the previously created subgenera of *Menabites* which dominate: *Delawarella* COLL. 1948 and *Australiella* COLL. 1948, recovered in abundance in Texas (K. YOUNG (14)), and a new, fairly remarkable subgenus is added to it, *Ankilizatella* COLL., 1969 from a particularly limited level.

And it is the family Baculitidae that by the profusion of its representatives dominates all the levels. Also I was brought, after division in:

— Zone with *Pachydiscus grossouvrei* at the base;

— Zone with *Delawarella subdelawarensis* and *Australiella australis* at the summit, to distinguish the subzones (with *Eupachydiscus lamberti* and *Pachydiscus bassae*) within which I defined the principal levels by the *Baculites* (3-XVI).

To signal still several heteromorphs and, at the summit, terminate the series of fossiliferous beds of the Menabe, the genus *Manambolites* HOURCQ 1932 (19), only representative of the family Sphenodiscidae (after *Praemanambolites*) characterizing a strictly limited terminal level. The genus, very rare besides, was found in Angola and Texas with a species unique to each region.

The inoceramids of the lower Campanian abound in all the localities. The crustaceans are still widely represented.

UPPER CAMPANIAN

In the Menabe itself, within the limits defined here, the upper Campanian is masked by the sandy covering.

To find it one must go near the north margin of the Menabe where H. BESAIRIE collected meager faunas characterized by the presence of fairly varied *Hoplitoplacenticeras*, but without originality (3-XVI).

MAASTRICHTIAN

In the Menabe the Maastrichtian appears only much more to the west with a fauna very poor where the heteromorphs with American affinities play the principal role; and more to the south, south of the Tsiribihina, where the region of Antsoha furnished me beautiful faunas unfortunately still not completely studied.

Here Menabe widens and loses the character of a gulf or coastal basin recognized between Manambolo and Tsiribihina.

The faunas discovered are cosmopolitan besides (Pachydiscidae known principally in Europe) and are connected to those of the Mikoboka, much more meridional (3-XVII).

CONCLUSIONS

The coastal basin of the Menabe appears as a veritable gulf where millions of organisms lived and evolved in place (in particular *Pseudoschloenbachia* and the inoceramids) by receiving only rare external contributions. And the number of new genera, without posterity, without flourishing apart from the gulf, is impressive (with rare exceptions). The nature of the sedimentation indicates a continuation of the successive shores encasing one in another where the ammonites came to carefully fail from abroad, while the great mass lived in place in the calm waters, which fairly well proves the proliferation of innumerable inoceramids always bearing their two valves, sometimes as enormous specimens, that the abundance, above all in the Campanian, of heteromorphs (*Bostrychoceras*) and others, to forms sometimes complex (*Madagascarites*, *Anaklinoceras*) and some *Baculites*, all organisms that lived probably partially enclosed in the sand at a weak depth, by the abundance of large nodules often enclosing the ammonites, by the mode of preservation of the crustaceans “which often preserved their appendages in connection with the carapace” (see H. and G. TERMIER, 23 p. 159-160).

It is not astonishing that in a “universe” so tranquil, numerous organisms lived without the currents coming to disturb them, except the contributions from abroad, besides relatively low numbers (less than 20% of the fauna whereas, for example, the single genus *Pseudoschloenbachia* forms 80% of the ammonite ensemble in about 10,000 collected specimens) and smothered by those that proliferated in place and that are, in reality, the true endemic fauna of the Menabe.

A word must be added on the problem of the correlations that remain, for the moment, in suspense: I think, after so many researches on these remarkable faunae, on

their succession, their sequence, to have arrived at a stratigraphy, unfortunately still too local. The most interesting correlation exists with Texas (Gulf Coast fauna described by K. YOUNG, 1963, p. 18-34); unfortunately the abundance of the Menabe ammonites is not equivalent to Texas where, according to K. YOUNG, they are relatively rare; and I then, for the moment, accept only temporarily the stratigraphy of the American paleontologist, since I established that the table on page 108 of my memoir on the Texanitinae (1948) was not any more exact after my studies on the place during three years. I established, for example, that in the Menabe, *Delawarella* and *Australiella* characterize the upper part of the middle Campanian and were strictly limited there.

Another curious problem will be studied later: how was it that India did not have the Texanitinae whereas the Pachydiscidae of the Menabe existed there nearly all? How was it that the only region where some of the rarest elements of the Menabe faunas were found was Japan?

But I have already remarked that, in the circum-Pacific and Indian grouping, the Japanese and Malagasy faunas had many analogous points. But perhaps also it is because they are, up to now, the most complete and most abundant described.