



## **Litho and Bio-Stratigraphy of Albian of Ambatolafia - Mahajanga Basin-Madagasikara**

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### **ABSTRACT**

The lithology and the fossils of Ambatolafia formation provide more details of knowledge about the early Albian lithological successive in Mahajanga Basin. These "diggings" along the outcrop are the source of the fossils labelled Ambatolafia in dealers lists. The description of the section is taken largely from the field work in situ in the wells. The wells show the layers succession in details. The fossils faunas listed are as quoted by the original authors, together with addition from the biostratigraphy and paleontology laboratory Antananarivo including the author's collection. It marks not only a major diminution in the thickness of the equivalent age sediments at Belohasifaka, but the absence here of the Collignon's Lemuroceras Zone. Neither here, nor further west is there any indication of a "Pseudosonneratia sakalava" Zone intervening between the Late Aptian hiatus and the earliest sediments of the Paraceloniceras besairiei Zone as indicated in Besairie (1971). The sections at Ambatolafia and Belohasifaka are on the geological excursion guide.

**Keywords:** Lithology - fossils -Alban -Ambatolafia - Mahajanga basin - Madagasikara

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### **1. Introduction**

The knowledge of the Albian lithological succession in Madagasikara is due in the French era, largely to the work of Henri Besairie and colleagues of the Service Geologiques et des Mines, Madagasikara (culminating in Besairie 1953, 1971, Besairie and Collignon 1956,) and to Maurice Collignon (1949, 1950, 1952). A comprehensive bibliography of the earlier work on the Albian of Madagasikara is provided in Besairie (1953, 1971) including the survey map sheet memoirs. Numerous sites of early Albian and contained ammonites fauna of Mahajanga Basin are described by the work of the great french paleontologist and biostratigrapher Collignon (1949, 1963, 1965 b, 1978) However, there were some albian sites well known as Ambatolafia locality but the litho and bio-stratigraphy study were not done. So there are problem relating to his interpretation of the early Albian succession. Current diggings in the outcrop in Ambatolafia show that the un-weathered sediments become grey-light buff-brown in colour and the original nacreous aragonitic shells of the fauna are well preserved. In more recent years, this attracted the interest of dealers in fossil jewellery and as a result became a source of income for the local village populations. The object of this paper is to rectify the part of problem of early albian succession in Madagasikara, provided by the determination of Albian of Ambatolafia litho and bio-stratigraphy.

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### **2. Geological setting**

The northern side of Mahajanga and Sitampiky cirques is flanked by an escarpment capped by the late Cretaceous flood basalts. Below are Cenomanian terrestrial grits overlying unconformably, Early Albian sediments of the Ambarimaninga Formation resting in turn unconformably on glauconitic sandstones of Late Aptian age. The outcrop is obscured in places by land-slipping. The thickness and degree of representation of these Albian sediments varies according to the degree of down-cutting of the Cenomanian (Fig.1). To the west (Soalala) area of the outcrop, the succession is thick and contains later Albian deposits. The succession thins eastward into Bekipay (Sitampiky Cirque) and by the area of the river Mahavavy Sud is solely Early Albian in date. The succession thins markedly at the junction between the Sitampiky and Mahajanga Cirques and is more incomplete in the area of Ambatolafia. The thickness increases rapidly eastward in the Mahajanga Cirque (Madirovalo subdistrict) in the Ambato-Boeni District. In the Berambo area east of the Betsiboka River, Middle and Late Albian sediments are preserved and this increase in thickness continues northward toward the Analalalava district (Sofia region) (Besairie 1971).

The current view of a general depositional Mahajanga Basin area in north-west Madagasikara is not supported by the field evidence for the Albian. The Ambatolafia area with its reduced Early Albian succession, marks a tectonic structure between the Soalala – Mahavavy Sud basin in the west and the Mahajanga – Berambo - Sofia Basin to the east and north. The evidence suggests post Late Albian - pre-Cenomanian block faulting or, possibly, anticlinal folding followed by early Cenomanian erosion and the deposition of terrestrial deposits.

### 3. Materials and methods

The study area Ambatolafia is located 30 km North North Est of the Sitampiky village, 100km south of the Mahajanga city and 60 km South west of Ambato Boeny It belongs in the Commune of Bekipay (Fig1) limited the geographical coodonates between south latitude and Est longitude as a map is showig as a folow.

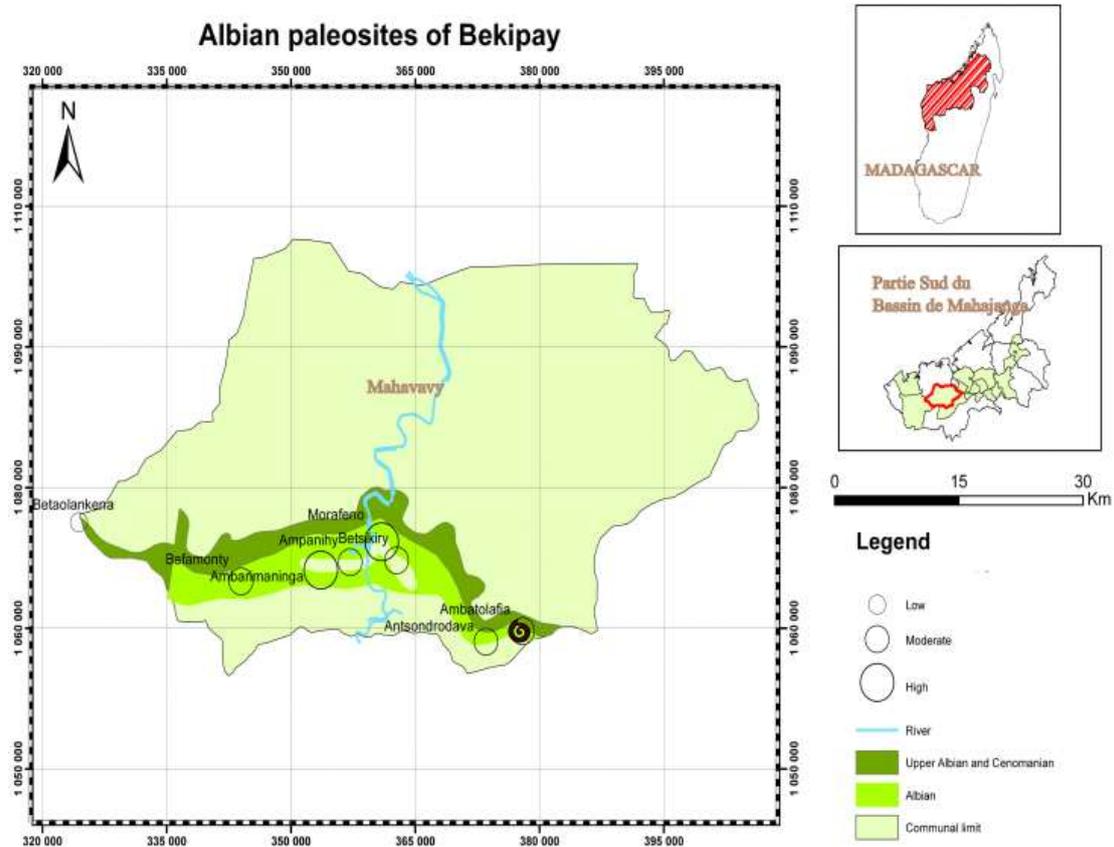


Figure 1: Location of the study site (source: BD 500 Foibentaontsarini Madagascar)

Three series of expeditions had ever been carried off in situ in 2004, 2014 and 2021. The current Ambatolafia site is situated 3 km WNW of Ambatolafia extending westward for approximately 10 km along the outcrop to Antsondrodava. These "diggings" along the outcrop are the source of the fossils labelled Ambatolafia in dealers lists. It encompasses now the sites Ambatolafia I and II of Collignon (1963). The description of the section have been realized in the well, a hole that is dug into the ground in order by the ammonites digger. The fossils faunas listed are as quoted by the original authors, together with addition from the biostratigraphy and paleontology laboratory Antananarivo including the author's collection.

### 4. Results

#### 4.1 Lithology

The description of the section is taken largely from the field work in situ in the wells. The wells show the layers succession detail. In Ambatolafia site, the lithological section description account is as a follow

Bed 7: Cenomanian terrestrial sediment 0,8m

Major discontinuity

Bed 6: Unfossiliferous, ferruginous "marls weathering yellow, 0,9m,

Bed 5: Yellow ferruginous "marls" with a discontinuous marly limestone at top, 1,6m

Bed 4: Yellow "ferruginous marls" with a discontinuous cement-stone calcareous layer about middle and sandy lenses at top, 2,6m

Bed3: Ferruginous siltstone; grey weathering yellowish. Fossils preserved, 1,6m

Bed 3: Fine-grained siltstone without fossils, 1,5m

Bed 1: Mid-grey fine-grained ferruginous siltstone, weathering brown. Weathered fossils casts brown; un-weathered material with original nacreous shell. Kiel's Ammonite Bed, 3,3m.

Discontinuity major

Bed 0: glauconitic sandstone 0,9m, Aptian

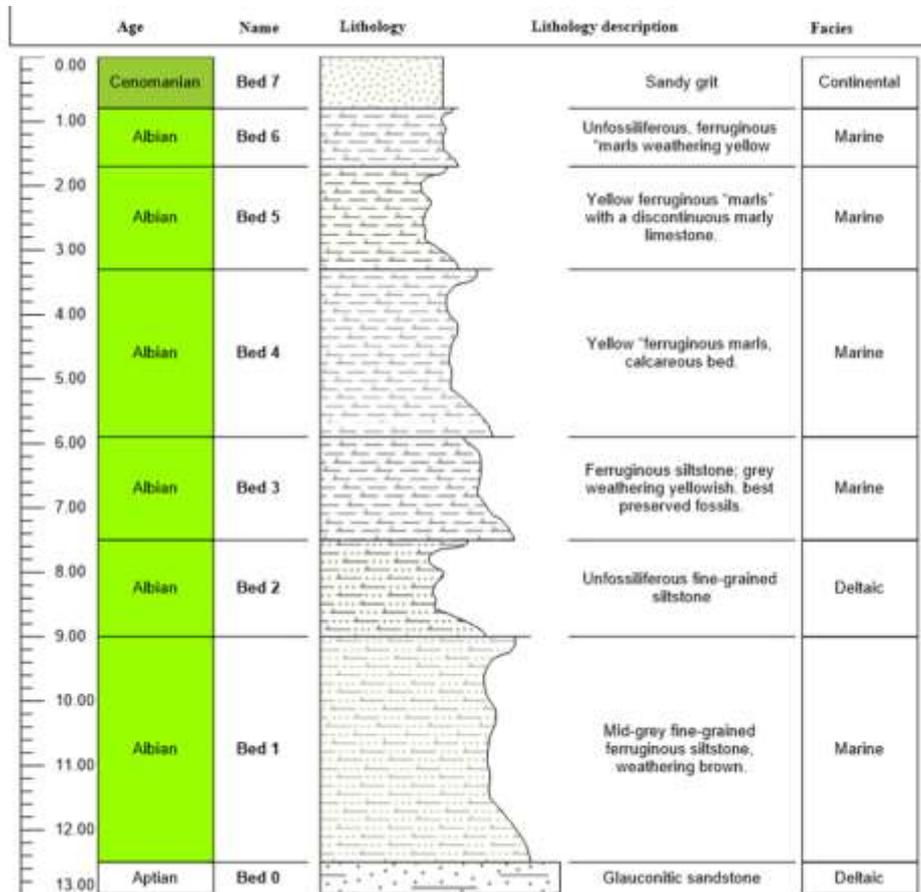


Figure 2: Lithological section of Ambatolafia by Rakotonimanana (2006)

#### 4.2 Paleontology

Fossils recorded from its bed is as follows (generic assignments modified herein) plus additional specimens from the author's collection.

Bed 1.

*Phylloceras vellidae* Michelin; *Gaudryceras varagurense* Kossmat; *Eogaudryceras umbilicostriatus* Collignon; *Desmoceras latidorsatum* Michelin; *Neosilesites maximus* Collignon; *Neosilesites nepos* Douville; *Neosilesites ambatolafiensis* Collignon; *Beudanticeras revoili* (Pervinquiere); *Beudanticeras arduennense* Breistroffer; *Paracleoniceras besairiei* Collignon; *Paracleoniceras tenuicostulatum* Collignon; *Paracleoniceras cleoniforme* Collignon; *Paracleoniceras crassefalcatum* Collignon; *Paracleoniceras inaequale* Collignon; *Paracleoniceras ambiguum* Collignon; '*Cleonicer*' *Madagasikaraiense* Collignon; '*Cleonicer*' *quercifolium* Collignon non d'Orbigny; *Douvilleiceas leightonense pringlei* Casey; *Douvilleiceas scabrosum* Casey, Belemnites, Bivalves, Brachiopods and Gasteropods.

Bed 3

*Desmoceras latidorsatum* Michelin; *Beudanticeras caseyi* Collignon; *Beudanticeras arduennense* Collignon non Breistroffer); *Paracleoniceras besairiei* Collignon; *Paracleoniceras morganiforme* Collignon; *Paracleoniceras inaequale* Collignon; *Paracleoniceras pychitiforme* Cellignon; *Paracleoniceras ambiguum* Collignon; *Moretella subquadrata* Collignon; *Anacleoniceras Madagasikaraiense* Collignon; *Moretella pinguis* Collignon [ex *Uhligella*]; *Moretella aff. subquadrata* Collignon; *Moretella ihopensis* Collignon; *Moretella balmensiformis* Collignon; *Cymatoceras sakalavum* Collignon

Bed 4

*Desmoceras latidorsatum* (Michelin); *Beudanticeras revoili* Pervinquier; *Paracleoniceras besairiei* Collignon; '*Cleoniceras*' *Madagasikaraiense* Collignon; '*Cleoniceras*' *quercifolium* Collignon non d'Orbigny; *Paracleoniceras pychitiforme* Collignon; *Douvilleiceras mammillatum* Schlotheim Spath; *Douvilleiceas monile* Sowerby early form; *Douvilleiceras alternans* Casey; *Douvilleiceras leightonense* Casey;

Bed 5

*Desmoceras latidorsatum* Michelin; *Paracleoniceras besairiei* Collignon.

## 5. Discussion

Bed 1 The basal part of Bed 1 shows a preponderance of transitions between "*Beudanticeras*" and *Paracleoniceras*, particularly *P. tenuicostulatum* with associated small examples of *Desmoceras latidorsatum*, fore-runners of *Douvilleiceras leightonense* Casey and *D. pringlei* Casey with *Eodouvilleiceras* transitional characteristics, together with rare heteromorphs. Where the shell is retained, they show a powdery pale dusting over a nacreous test. Specimens prepared for sale or study have this pale coating removed and a bluish iridescence revealed. Higher in this bed, the additional taxa listed by Rakotonimanana become more apparent, together with small individuals showing umbilical lateral tubercles throughout and thus taxonomically separate from *Paracleoniceras* with its beudanticeratid inner whorls. These are the forms of *Anacleoniceras* somewhat foreshadowing *Moretella* but showing earlier features than the forms figured by Collignon from Ambarimaninga and found in the blocks from Bed 3 at Ambatolafia. No examples of these early *Moretella* have been seen in the blocks from the basal part of Bed 1.

Bed 2 suggests the same interval described by Kiel without macrofossils but with foraminifera.

Bed 3. The molluscan fauna is different when Beds 1 and 3 are compared and this difference is borne out by the ammonite evidence. *Moretella* is common and includes *M. balmensisiformis*, *M. subquadrata*, *M. ihopensis*, *M. pinguis* together with the common occurrence of the nautiloid *Cymatoceras*. *Douvilleiceras* appears to be uncommon in this bed and more akin to the earlier form seen in Bed 1. Noteworthy is the occurrence of the form "*Beudanticeras dupini* d'Orb. variety *percostata* Collignon (1963, 1163) which has umbilical-lateral tubercles in the juvenile and is an *Anacleoniceras*. This "variety" may be conspecific with *Anacleoniceras Madagasikaraiensis* (Collignon) which occurs also in Bed 3. This assemblage is significant in relation to the succession seen in the lower part of Besairie's Bed 2 at Ambarimaninga quoted in Collignon (1949) and the sections at Ampanihy; see below. Kiel's opinion that his Ammonite Bed (Bed 1) gastropod fauna was older than Bed 2 (lower) at Ambarimaninga is borne out by the fauna in blocks from Bed 3 at Ambatolafia and this was recognised in Besairie (1971).

Bed 4. Blocks from this bed contain large *Douvilleiceras* identified as *D. mammillatum* and *Paracleoniceras* together with rather more Tethyan forms. Bed 5 appears to have the same fauna, but no specimens of *Lemuroceras* have been seen or recorded.

The outcrop in the region of Ambatolafia has been known for some time. Collignon (1963) separates an Ambatolafia I and II, localities (gisements – technically deposits or surface scrapes) Survey Localities 60 and 68 respectively, in the Marovoay district as it was at that date; both situated 3 km W. of Ambatolafia. His sections in the province were weathered outcrops and this is evident from some of the imperfectly preserved specimens figured by Collignon (1963) collected during the original geological surveys. He did not describe the sections in 1963, but lists ammonites from his two localities given below. The ammonites listed by Collignon (1963) are referring to his figured specimens. Also, Collignon's (1963) generic names are as quoted here. Ammonites have been figured also by, Rakotonimanana (2006), Rakotonimanana and Randrianaly (2018) and Zhakarov et al (2016) from this site; the latter refigured in Di Cencio et al. (2017). However, with the exception of Rakotonimanana (2006) the ammonite specimens do not have a precise stratigraphic context within the measured section.

Ambatolafia I 60 (*Cleoniceras besairiei* Zone Collignon)

*Gaudryceras* sp. indet, aff. *vagurense* Kossmat 1062; *Beudanticeras* sp, aff. *revoili* Perv, 1164; *Cleoniceras quercifolium* d'Orbigny 1184; *Cleoniceras* (*Paracleoniceras*) *inaequale* Collignon 1185 Holotype; *Cleoniceras* (*Paracleoniceras*) *besairiei* Collignon 1187; *Cleoniceras* (*Paracleoniceras*) *cleoniforme* Collignon 1190 Holotype, 1191; *Cleoniceras* (*Paracleoniceras*) *tenuicostulatum* Collignon 1193 Holotype; *Cleoniceras* (*Paracleoniceras*) *crassifalcatum* Collignon 1195 Holotype; *Neosilesites maximus* Collignon 1235 Holotype; *Douvilleiceras* sp. indet. 1240; *Douvilleiceras mammillatum* Schlotheim Spath 1241.

Ambatolafia II 68-1, 68-2 (*Cleoniceras besairiei* Zone Collignon)

*Eotetragonites umbilicostriatus* Collignon 1060; *Ephamulina trituberculata* Collignon 1078 [68-2] 1081 [68-2]; *Beudanticeras arduennense* Breistroffer 1166; *Beudanticeras revoili* Perv. 1167; *Desmoceras latidorsatum* Michelin 1180; *Cleoniceras Madagasikaraiense* Collignon 1181; *Cleoniceras* (*Paracleoniceras*) *besairiei* Collignon 1189; *Cleoniceras* (*Paracleoniceras*) *tenuicostulatum* Collignon 1194; *Cleoniceras* (*Paracleoniceras*) *ambiguum* Collignon 1196 Holotype; *Neosilesites* (*Neoposiella*) *nepos* Douville 1233; *Neosilesites ambatolafiensis* Collignon 1237 Holotype.

Unfortunately, there is no detailed stratigraphy associated with the material, but from the current indication of the superposition of the faunas, it appears that Ambatolafia II is slightly older than Ambatolafia I.

With regard to Collignon's data from surface "scrapes" and the modern work of Rakotonimanana (2006) in which a section is provided, the whole succession, with the possible exception of Rakotonimanana's Bed 5, is within the *Paracleoniceras besairiei* Zone.

## 6. Conclusion

The lithology and the fossils of the wells in Ambatolafia formation determine that it marks not only a major diminution in the thickness of the equivalent age sediments at Nord Belohasifaka, but the absence here of the Collignon's *Lemuroceras* Zone. Neither here, nor further west is there any indication of a "*Pseudosonmeratia sakalava*" Zone intervening between the Late Aptian hiatus and the earliest sediments of the *Paracleoniceras besairiei* Zone as indicated in Besairie (1971). The correlation of the sections at Ambatolafia with those of Belohasifaka, Manosobohitra and Ambarimanga areas is deduced and shown in this study. It should be emphasised that, except for the sections near Ambatolafia and to a lesser extent at Ambarimanga and Nord Belohasifaka, no section is measured in detail in the literature and as shown above, even at Ambatolafia there is Kael (2006) another conflicting versions, albeit that this section given by this paper is the more accurate. The sections at Belohasifaka and Ambatolafia are on the geological excursion guide.

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