

Bivalves (Mollusca) from the Coniacian-Santonian Anguille Formation from Cap Esterias, Northern Gabon, with notes on paleoecology and paleobiogeography

Benjamin MUSAVU MOUSSAVOU

Université des Sciences et Techniques de Masuku et URESTE,
Faculté des Sciences, Département de Géologie,
boîte postale 943, Franceville (Gabon)
musavu@yahoo.fr

Published on 25 September 2015

urn:lsid:zoobank.org:pub:C2610B58-9855-48AC-8833-7209F091957F

Musavu Moussavou B. 2015. — Bivalves (Mollusca) from the Coniacian-Santonian Anguille Formation from Cap Esterias, Northern Gabon, with notes on paleoecology and paleobiogeography. *Geodiversitas* 37 (3): 315-324. <http://dx.doi.org/10.5252/g2015n3a2>

ABSTRACT

The Anguille Formation (Coniacian-Santonian) of North of Gabonese coastal basin has been analysed from the 'Cap Esterias' section. Palaeoecologic and paleogeographic aspects of the bivalves were taken into account. Twelve bivalve species representing 9 genera have been identified from 'Cap Esterias' section. Among these *Acanthocardia* cf. *denticula* (Baily, 1855), *Aphrodina dutrugei* (Coquand, 1862) and *Protocardia* cf. *pauli* (Coquand, 1862) are found for the first time in the 'Cap Esterias' region. A large part (66.67%) of the identified bivalve species occur over a wide geographical area: from Brazil to Central Africa, eastern Mediterranean region, Madagascar, Nigeria, northwestern Africa, South Africa, southern India and southern Europe. The fauna is composed only of suspension-feeders indicating that food resources were dominantly in suspension. The assemblage of bivalves is dominated by shallow burrowing infaunal bivalves and indicates the existence of an unstable and soft substrate. This assemblage can be regarded as parautochthonous.

RÉSUMÉ

Les Bivalves (Mollusques) du Coniacien-Santonien de la Formation de l'Anguille du Cap Estérias, nord du Bassin Gabonais; notes sur la paléoécologie et paléogéographie.

Les aspects paléoécologiques et paléogéographiques des bivalves de la Formation de l'Anguille (Coniacien-Santonien), au nord du bassin côtier gabonais, ont été analysés à partir de la coupe du « Cap Estérias ». Douze espèces de bivalves représentant neuf genres ont été identifiées au niveau de cette coupe. Parmi elles, *Acanthocardia* cf. *denticula* (Baily, 1855), *Aphrodina dutrugei* (Coquand, 1862) et *Protocardia* cf. *pauli* (Coquand, 1862) sont signalés pour la première fois dans la région du « Cap Estérias ». Une grande partie (66,67 %) des espèces identifiées ont une large distribution géographique. Elles sont connues au Brésil, en Afrique centrale, à l'Est de la région méditerranéenne, à Madagascar, au Nigéria, au Nord-Ouest de l'Afrique, en Afrique du Sud, au sud de l'Inde et au sud de l'Europe. La faune est composée seulement des suspensivores. Ceci est l'indice de l'abondance de la nourriture en suspension. L'assemblage des bivalves est dominé par les épibiontes enfouis, ce qui indique un substratum instable et meuble. L'assemblage peut être regardé comme para autochtone.

KEY WORDS

Palaeoecology,
paleogeography,
Gabonese coastal basin,
bivalves,
Cap Esterias.

MOTS CLÉS

Paléoécologie,
Paléogéographie,
Bassin côtier gabonais,
bivalves,
Cap Estérias.

INTRODUCTION

The history of the Gabonese coastal basin (Fig. 1) is connected to opening of the South Atlantic Ocean (Klasz 1965; Reyre 1989; Teisserenc & Villemain 1990). The tectonic and sedimentary evolution (Mbina Mounquengui 1998; Mbina Mounquengui *et al.* 2002; Mbina Mounquengui & Lang 2003) permit three phases to be distinguished: prerift phase (Precambrian-Jurassic), rift phase (Neocomian-Barremian) and postrift phase (Aptian-present). Prerift and rift phases are characterized mainly by continental, lacustrine and fluvial sediments whereas postrift phase is characterized by marine sediments.

The postrift phase contains several formations. Among these, there is the Anguille Formation which occurs in the Cap Esterias region. The stratigraphical framework, together with the palaeontological value of the Anguille Formation has been discussed by several authors (Hourcq & Hausknecht 1954; Darteville & Brébion 1956; Darteville & Freneix 1957; Gérard 1958; Klasz 1965; Hudeley & Belmonte 1970; Vidal *et al.* 1975; Moussodou 1984; Reyre 1989; Teisserenc & Villemain 1990; Dupont 1996; Volat *et al.* 1996; Chevalier *et al.* 2002; Mbina Mounquengui *et al.* 2008). Unfortunately, references to the marine bivalves exist in the form of species list, without taxonomic descriptions or illustrations. Only Darteville & Freneix (1957) provide information on taxonomy and paleogeography. There are no known works on the paleoecology of the Anguille Formation. Therefore the marine bivalve fauna and its ecology in the Anguille Formation are still unknown, despite the abundance and often dominance of bivalve fossils in the deposits.

This paper is an attempt to improve this situation based on bivalve mollusks collected from the so-called 'Cap Esterias' section, North subbasin of Gabonese coastal basin.

GEOLOGICAL SETTING

The Anguille Formation was deposited on the continental shelf and shows two sedimentary cycles (Klasz 1965; Vidal *et al.* 1975; Logar 1983; Moussodou 1984; Reyre 1989; Teisserenc & Villemain 1990; Dupont 1996; Volat *et al.* 1996; Chevalier *et al.* 2002). The base of the first cycle is composed of silty clays with chert layers. The rest of the first cycle is silty. The second cycle is more sandy. The first and second cycle are assigned respectively to Coniacian and Santonian by microfossils and ammonites (Hudeley & Belmonte 1970; Klasz & Michelot 1971). In the western part of the basin, the Anguille formation has clay at the base, overlain by thick turbiditic sand deposits.

The Anguille Formation overlies the Azilé Formation (Turonian) and is overlain by the Pointe Clairette Formation (Campanian) (Fig. 2). Total thickness of the Anguille Formation is about 650 to 800 m (Teisserenc & Villemain 1990).

Fossils of the Anguille Formation include foraminifera, ostracods, gastropods, ammonites, pollen and bivalves (Darteville & Brébion 1956; Darteville & Freneix 1957; Hudeley & Belmonte 1970; Klasz & Micholet 1971; Boltenhagen 1975a, b; Klasz 1965; Dupont 1996; Volat *et al.* 1996).

The measured section (Fig. 1C) is located at 'Cap Esterias' region in North of Libreville within North subbasin at GPS coordinates 0°36'50.3"N, 9°19'07.0"E (Fig. 1). It consists of clay, sandstone, silt to argillaceous sandstone and silty clay. The section was subdivided into five units, based on lithology. From the bottom to the top, these units are: Unit 1 is composed of 1.8 m thick of dark clay with medium bioturbation. Unit 2 made of 1.2 m of bioclastic, indurated, medium to coarse sandstone. This unit is highly bioturbated towards the top and contains bivalves, rare ammonites and rare gastropods. Some articulated bivalves specimens were found in live position. The upper 3.10 m represents Unit 3 which is consisting of silt to argillaceous sandstone with low bioturbation. Above there is 50 cm (Unit 4) of Breccia. Higher up in the section is Unit 5 composed of 90 cm of highly bioturbated silty clay.

MATERIAL

The study was conducted based on 86 specimens from Cap Esterias section. All specimens are collected only within Unit 2. From the collected specimens, 54 are disarticulated and 32 are articulated. Most of the specimens are preserved as internal or external mould like *Agelasina plenodonta* Riedel, 1932 and *Aphrodina gabonensis* Darteville & Freneix, 1957. Some specimens have shell preserved as *Granocardium productum* (Sowerby, 1832) and *Granocardium* sp.

The material is deposited at the collection of the Geology Department, Faculty of Sciences Masuku University of Franceville (Gabon), under collection number MDG/CEs/Lm.

BIVALVE FAUNA

Identification of material has relied on various sources, inclusive of Sowerby (1832), Sharpe (1850), Baily (1855), Coquand (1862), Stoliczka (1871), Woods (1906), Pervinquier (1912), Barber (1958), Riedel (1932), Darteville & Freneix (1957), Dhondt & Dieni (1993), Abdel-Gawad *et al.* (2004), El Qot (2006), Ayoub-Hannaa (2011), Benyoucef *et al.* (2012). In the descriptions, the terms small, medium and large are defined by the following size ranges: small, up to 10.0 mm long; medium, 10.1 mm to 30 mm; large 30.1 mm and over.

Family ARCTICIDAE Newton, 1891

1. *Agelasina plenodonta* Riedel, 1932
(Fig. 4F, H, L, P)

DESCRIPTION

Shell large, equivalve, inequilateral subtrigonal to subtrapezoidal in outline; umbo prosogyrate; valves inflated; outer surface with or without fine concentric growth line; anterior and ventral margins well rounded; posterior margin evenly rounded; carina in both valves.

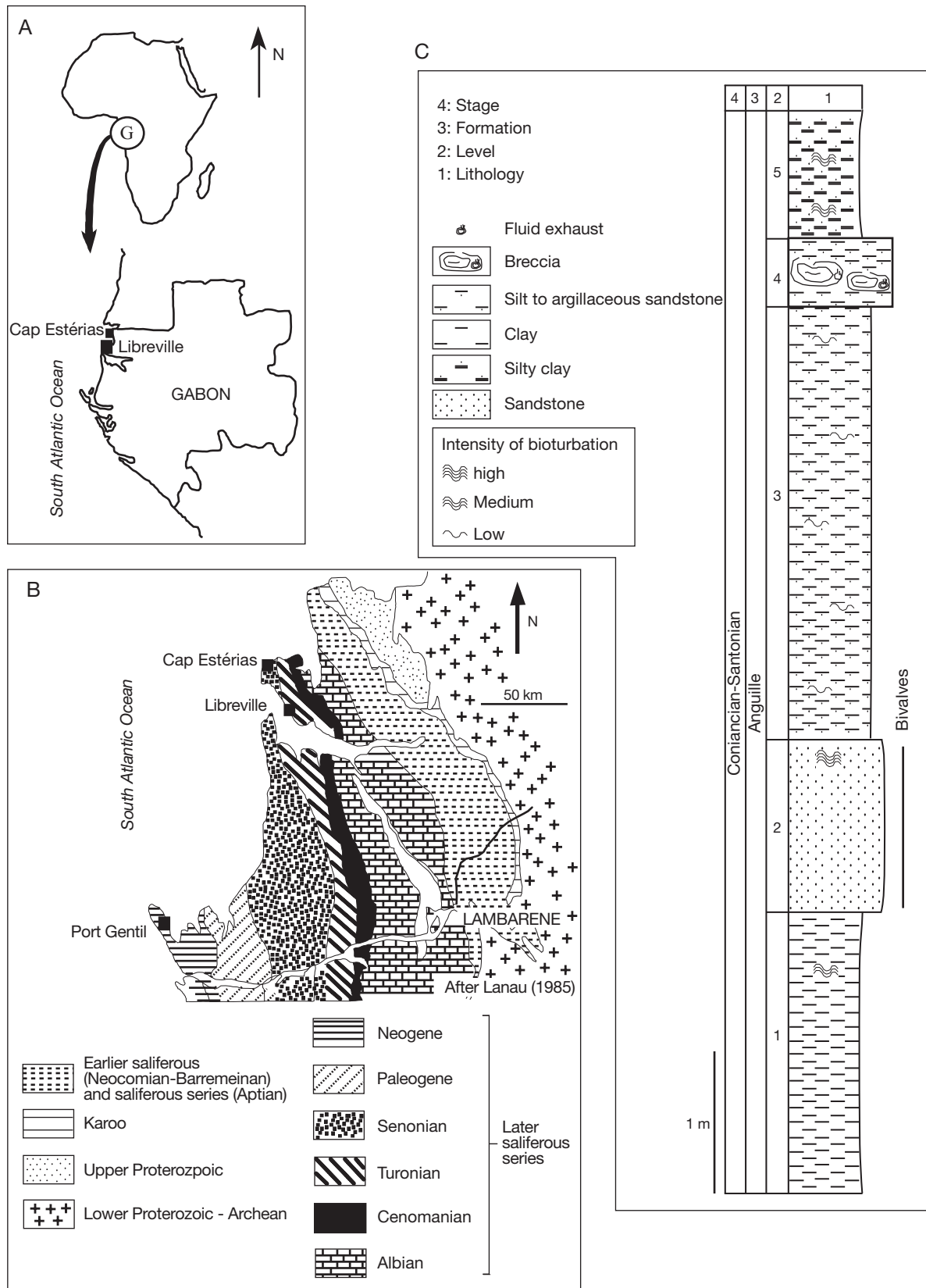


FIG. 1. — **A**, Location map of Gabon and Cap Estérias; **B**, geological map of north Gabonese coastal basin; **C**, lithostratigraphy of the 'Cap Estérias' section. Geological map after Lanau (1985).

TECTONIC ASSEMBLAGE	SALIFEROUS PHASE	BIOZONATION Ostracods, spores and pollens, foraminifers					FORMATIONS	EQUIVALENCE	
Post-Rift	Post saliferous phase	EW	M6	C16		Ewongue	MAASTRICHTIAN	SENONIAN	
		PC	M5		2	Pointe Clairette	CAMPANIAN		
		AG	M4	C15	1		Anguille		SANTONIAN
				C14	2	CONIACIAN			
		AZ				Azile	TURONIAN		
		LO				Cap-Lopez	CENOMNIAN		
		MD				Madiela	ALBIAN		
Syn-Rift	Pre saliferous phase	AP				Ezanga	APTIAN		
						Como			
		BA				Série des Shistes	BARREMIAN		
		NE					HAUTERIVIAN		
Pre-Rift						Grès de N'dombo			

Fig. 2. — Cretaceous stratigraphic nomenclature of the Gabonese sedimentary basin and place of the Coniacian-Santonian (after Mbina Mounguengui & Lang, 2003, modified).

Family CARDIIDAE Lamarck, 1809

2. *Acanthocardia* cf. *denticulata* (Baily, 1855) (Fig. 4B)

DESCRIPTION

Shell medium, triangular in outline; umbo prosogyrate; valves weakly inflated; outer surface with radial ribs; anterior and posterior margins straight, ventral margin weakly rounded.

3. *Granocardium productum* (Sowerby, 1832) (Fig. 4C)

DESCRIPTION

Shell large, equivalve, subequilateral, subtrigonal to suborbicular in outline; umbo prominent; valves inflated; outer surface with radial ribs; anterior margin slightly rostrate, rounded in outline; posterior margin straight, rounded into ventral margin.

4. *Granocardium* sp. 1 (Fig. 4D)

DESCRIPTION

Shell large, equivalve, inequilateral, subtrigonal to elongate in outline; umbo prosogyrate, valve inflated; outer surface with radial ribs which have pearls; anterior margin rostrate, rounded in outline; posterior margin rounded.

5. *Granocardium*? sp. 2 (Fig. 4A, Q?)

DESCRIPTION

Shell large, inequilateral subtrigonal to elongate in outline; umbo breacked, valve slightly inflated, outer surface with

big radial ribs. Anterior margin rounded; posterior margin straight, rounded into ventral margin.

6. *Protocardia* cf. *pauli* (Coquand, 1862)
(Fig. 4G, J)

DESCRIPTION

Shell large, equivalve, inequilateral, elongate in outline; umbo prosogyrate, valves inflated, anterior margin straight, subrounded into ventral margin; posterior margin cruved; no ornament preserved.

7. *Protocardia*? sp.
(Fig. 4E)

DESCRIPTION

Shell medium, equal, inequilateral, diamond-shaped in outline; umbo prosogyrate, valves inflated; anterior margin more rostrate than posterior margin; no ornament preserved.

Family LIMIDAE Rafinesque, 1815

8. *Plagiostoma pseudohoernesii* (Riedel, 1932)
(Fig. 4N)

DESCRIPTION

Shell large, subequivalve, suborbicular in outline; umbo prominent; valves slightly inflated; outer surface with ten ribs (five in each part) anterior and posterior margins straight, rounded into ventral margin.



FIG. 3. — Palaeobiogeographical distribution of bivalves fauna of 'Cap Estérias' in the Late Cretaceous. Geological map modified after Vrielynck & Bouysse (2003).

Family VENERIDAE Rafinesque, 1815

9. *Anofia?* sp. (Fig. 4M)

DESCRIPTION

Shell large, suborbicular in outline; umbo prosogyrate; outer surface with fine concentric line toward ventral margin; anterior and posterior margins straight, rounded into ventral margin.

10. *Aphrodina dutrugei* (Coquand, 1862) (Fig. 4I)

DESCRIPTION

Shell medium to large, equivalve, inequilateral, subtrigonal in outline; umbo prosogyrate; valve inflated; anterior margin slightly rostrate, rounded in outline; posterior margin evenly rounded, passing smoothly into the weakly convex ventral margin, no ornament preserved.

11. *Aphrodina gabonensis* Darteville & Freneix, 1957
(Fig. 4O)

DESCRIPTION

Shell large, equivalve, inequilateral, subtrigonal in outline; umbo prosogyrate; valves slightly inflated; outer surface with

concentric fine line; anterior margin slightly rounded; posterior margin curved.

Family PINNIDAE Leach, 1819

12. *Atrina laticostata* (Stoliczka, 1871)
(Fig. 4K)

DESCRIPTION

Shell large, equivalve, inequilateral, elongate triangular in outline; umbo beak; outer line with radial ribs; anterior and posterior margins straight; ventral margin straight to slightly round.

DESCRIPTION OF BIVALVE ASSEMBLAGE

The fossil bivalve assemblages from the unit 2 of the 'Cap Estérias' section consist of 12 species belonging to 9 genera. These species are *Acanthocardia* cf. *denticulata*, *Agelasina plenodonta*, *Anofia?* sp., *Aphrodina dutrugei*, *Aphrodina gabonensis*, *Atrina laticostata*, *Granocardium productum*, *Granocardium* sp. 1, *Granocardium?* sp. 2, *Plagiostoma pseudohoernesii* (Riedel, 1932), *Protocardia* cf. *pauli*, *Protocardia?* sp.

The bivalve assemblage from 'Cap Esterias' section is dominated by genera *Aphrodina* Conrad, 1869 (22 specimens)

TABLE 1. — Summary of life-habit and trophic groups of the bivalves identified in this study.

Families	Species	Life-Habit							Trophic-Groups	
		free and mobile	cemented	byssate	semi-infaunal-byssate	shallow-burrower	deep-burrower	mobile	Suspensions-feeders	deposit-feeders
		Epifaunal				Infaunal				
Arctiidae	<i>Agelasina plenodonta</i> Riedel, 1932					x			x	
Cardiidae	<i>Acanthocardia</i> cf. <i>denticulata</i> (Baily, 1855)					x			x	
	<i>Granocardium productum</i> Sowerby, 1832					x			x	
	<i>Granocardium</i> sp. 1					x			x	
	<i>Granocardium</i> ? sp. 2					x			x	
	<i>Protocardia</i> cf. <i>pauli</i> (Coquand, 1862)					x			x	
	<i>Protocardia</i> ?					x			x	
Limidae	<i>Plagiostoma pseudohoernesii</i> (Riedel, 1932)			x					x	
Veneridae	<i>Anofia</i> ? sp.					x			x	
	<i>Aphrodina dutruegi</i> (Coquand, 1862)					x			x	
	<i>Aphrodina gabonensis</i> Darteville & Freneix, 1957					x			x	
Pinnidae	<i>Atrina laticostata</i> (Stoliczka, 1871)				x				x	

and *Agelasina* Riedel, 1932 (24 specimens). At the family level, it is dominated by the family Cardiidae with six species (Table 1). The others families are represented by one or three species (Table 1).

With respect to life habits (Table 1), the bivalve assemblage from 'Cap Esterias' is dominated by shallow infaunal burrowers (96.82%). These are *Agelasina plenodonta* (40.68%), *Aphrodina gabonensis* (22.22%) and *Aphrodina dutruegi* (11.11%). *Plagiostoma pseudohoernesii* and *Atrina laticostata* are the only representatives respectively of epifaunal byssate (1.59%) and semi-infaunal-byssate (1.59%) bivalves. The assemblage is characterized by the absence of deep-burrower and mobile infaunal elements one one hand and by absence of free, mobile and cemented epifaunal on the other.

According to their trophic-group (Fig. 4), all bivalves are suspension-feeders. The representatives of *Aphrodina* and *Agelasina*, together comprising 74.01% of the fauna, are suspension-feeders bivalve that dominate the assemblage. They others bivalves are represented by 2.33% such *Granocardium* and *Protocardia* or 1.59% such as *Acanthocardia* Gray, 1851, *Anofia* Reymont, 1955, *Atrina* Gray, 1842 and *Plagiostoma* Sowerby, 1814. No deposit feeders were found in the assemblage.

DISCUSSION

PALEOBIOGEOGRAPHY

Of the nine identified species, eight (88.89%) occur over a broad geographical area, ranging from Brazil to Central Africa (Angola, Cameroon, Congo, Gabon, RDC) (Riedel 1932; Darteville & Freneix 1957; Ricardo Lopes De Simone & Mezzalana 1994; Musavu Moussavou *et al.* 2013, 2014), eastern Mediterranean region (Jordan, Palestine) (Berndt 2002; Ahmad 2005), Madagascar (Basse 1933), Nigeria (Barber

1958), northwestern Africa (Egypt, Tunisia, Algeria, Morocco) (Pervinquier 1912; Abbass 1962; Fawzi 1963; Abdel-Gawad *et al.* 2004; El Qot 2006; Benyoucef *et al.* 2012), South Africa (Baily 1855; Woods 1906), southern India (Stoliczka 1871), and southern Europe (Italy, Portugal) (Sharpe 1850; Dhondt & Dieni 1993) (Fig. 3). Species with such broad distributions include: *Acanthocardia* cf. *denticulata* (Fig. 4B), *Agelasina plenodonta* (Fig. 4F, H, L), *Aphrodina dutruegi* (Fig. 4I), *Atrina laticostata* (Fig. 4K), *Granocardium productum* (Fig. 4C), *Plagiostoma pseudohoernesii* (Fig. 4N) and *Protocardia* cf. *pauli* (Fig. 4G, J), *Protocardia*? sp. (Fig. 4E). Among taxa identified, *Aphrodina gabonensis* (Fig. 4O) (8.33%) represents the only endemic species to the gabonese coastal basin during Coniacian-Santonian interval. This means that open marine connections were established between north of Gabon, the mediterranean province, Central Africa, South Africa, southern India and southern Europe in Coniacian-Santonian.

PALAEOECOLOGY

The palaeoautecology of bivalves is summarised in Table 1. It is based on information by Yonge (1953), Duff (1978), Pugaczewska (1986), Berndt (2002), Delvene (2003), Ayoub-Hannaa (2011), Ayoub-Hannaa & Fürsich (2012). Most of the bivalve taxa encountered have been previously recorded from 'Cap Estéris' region (Darteville & Freneix 1957) excepted for *Acanthocardia* cf. *denticulata*, *Aphrodina dutruegi* and *Protocardia* cf. *pauli* which are recorded here for the first time.

Many studies have treated the distribution patterns of marine macroinvertebrates (e.g., Fürsich 1984, 1994; Berndt 2002; Delvene 2003; Fürsich *et al.* 2004; Harzhauser & Mandic 2004; Zuschin *et al.* 2004a, b; Fürsich & Thomsen 2005; Schneider *et al.* 2009; Ayoub-Hannaa 2011; Ayoub-Hannaa & Fürsich 2012; Bengtson *et al.* 2014). The parameters controlling faunal distribution are substrate, water energy, salinity, temperature, nutrient supply and oxygen availability.



FIG. 4. — **A, Q**, *Granocardium*? sp. 2; **B**, *Acanthocardia* cf. *denticulata* (Baily, 1855); **C**, *Granocardium productum* (Sowerby, 1832); **D**, *Granocardium* sp. 1; **E**, *Protocardia*? sp.; **F, H, L, P**, *Agelasina plenodonta* Riedel, 1932; **G, J**, *Protocardia* cf. *pauli* (Coquand, 1862); **I**, *Aphrodina dutrugei* (Coquand, 1862); **K**, *Atrina laticostata* (Stoliczka, 1871); **M**, *Anofia*? sp.; **N**, *Plagiostoma pseudochoernesii* (Riedel, 1932); **O**, *Aphrodina gabonensis* Darteville & Freneix, 1957. Scale bar: 2 cm.

The bivalve assemblage of 'Cap Estérias' section is dominated by shallow burrower infaunal bivalve. This indicates the existence of soft substrate (Delvene 2003; Fürsich & Tomsen 2005; Ayoub-Hannaa 2011; Ayoub-Hannaa & Fürsich 2012; Bengtson *et al.* 2014). Deep-burrower infaunal bivalves are absent. This may be related to the dissolution of aragonitic shell during early diagenesis and/or to low oxygen condition in deeper layers of the substrate.

All bivalves are suspension-feeders. This means that the water energy level was sufficiently high to keep organic matter in suspension (Berndt 2002; Delvene 2003; Fürsich & Tomsen 2005; Ayoub-Hannaa 2011; Ayoub-Hannaa & Fürsich 2012). The absence of deposit feeders suggests probably a very small amount of organic matter in the sediment or organics in the water column (Ayoub-Hannaa & Fürsich 2012). This, suggest also an environment at least intermittently influenced by waves and/or currents (Fürsich & Heinberg 1983).

According to Boucot *et al.* (1958), the degree of disarticulation is a reliable means of determining the relative amount of taphonomic reworking. In 'Cap Estérias' section, 54 disarticulated and 32 articulated specimens are collected. Moreover abrasion and breakage of shells are low. Large-sized *Agelasina* shells are common (10 articulated specimens versus 13 disarticulated specimens). This suggests that bivalve community from 'Cap Estérias' section is transported under high-energy conditions, but of short duration and a short distance after death (Boucot *et al.* 1958; Seeling & Bengtson 1999). Therefore the assemblage of bivalves can be regarded as parautochthonous.

Acknowledgements

I am grateful to Drs J. A. Grant-Mackie, S. Schneider and A. Oleinik, and to the Journal editorial board, for their constructive comments which greatly improved the manuscript.

REFERENCES

- ABBAS H. L. 1962. — A monograph of the Egyptian Cretaceous pelecypods. *Geological Survey and Mineral Research Department UAR, Palaeontological Series*, 1, 224 p.
- ABDEL-GAWAD G. I., ORABI O. H. & AYOUB W. S. 2004. — Macrofauna and biostratigraphy of the Cretaceous section of Gebel El-Fallig area, northwest Sinai, Egypt. *Egyptian Journal of Paleontology* 4: 305-333.
- AHMAD F. 2005. — The heterodont bivalve *Aphrodina dutrugei* (Coquand, 1862) from The Cenomanian of Jordan. *Rivista Italiana di Paleontologia e Stratigrafia* 111: 191-195.
- AYOUB-HANNAA W. S. 2011. — Taxonomy and palaeoecology of the Cenomanian-Turonian macro-invertebrates from eastern Sinai, Egypt. *Thèse de Bayerischen Julius-Maximilians-Universität Würzburg*, 386 p.
- AYOUB-HANNAA W. S. & FÜRSICH F. T. 2012. — Palaeoecology and environmental significance of benthic associations from the Cenomanian-Turonian of eastern Sinai, Egypt. *Beringeria* 42: 93-138.
- BAILY W. H. 1855. — Description of some cretaceous fossils from South Africa, collected by Captain Garden. *Quaternary Journal of the Geological Society of London* 11: 454-465.
- BARBER W. 1958. — Upper Cretaceous Mollusca from north-eastern Nigeria. *Records of the Geological Survey of Nigeria Bulletin* (for 1956): 14-46.
- BASSE E. 1933. — Paléontologie de Madagascar. XVIII. Faune malacologique du Crétacé supérieur du S.O. de Madagascar. *Annales de Paléontologie* 22: 1-37.
- BENGTSON P., AYOUB-HANNAA W. S. & FÜRSICH F. T. 2014. — Taxonomy and palaeoecology of Pinna (P) cretacea (Scholtheim, 1813) from the Upper Cretaceous of the sergipe basin, Brazil. *Revista Brasileira de Paleontologia* 17 (3): 289-306.
- BENYOUCEF M., MEISTER C., BENSALAH M. & ZOHRA MALTI, F. 2012. — La plateforme pré-africaine (Cénomanien supérieur-Turonien inférieur) dans la région de Béchar (Algérie) : stratigraphie, paléoenvironnement et signification paléobiogéographique. *Revue de Paléobiologie* 31: 205-218.
- BERNDT R. 2002. — Palaeoecology and taxonomy of the macrobenthic fauna from the upper Cretaceous Ajlun Group, southern Jordan. *Unpublished PhD Thesis Würzburg University Germany*, 222 p.
- BOLTENHAGEN E. 1975a. — Quelques spores du Crétacé supérieur du Gabon. *Revue de Micropaléontologie* 18 (2): 69-90.
- BOLTENHAGEN E. 1975b. — La microflore sénonienne du Gabon. *Revue de Micropaléontologie* 18 (4): 191-199.
- BOUCOT A. J., BRACE W. & DEMAR R. 1958. — Distribution of brachiopod and pelecypod shells by currents. *Journal of Sedimentary Petrology* 28: 321-332.
- CHEVALIER L., MAKANGA J. F. & THOMAS R. J. 2002. — *Carte géologique de la République gabonaise au 1/1 000 000*. Notice explicative. Council for geoscience, 195 p.
- CONRAD T. A. 1869 — Notes on recent and fossil shells, with descriptions of new genera. *American Journal of Conchology* 4: 246-249.
- COQUAND M. H. 1862. — Géologie et Paléontologie de la région sud de la Province de Constantine. *Mémoires de la Société d'Émulation de la Provence* 2: 1-341.
- DARTEVELLE E. & BRÉBION PH. 1956. — Mollusques fossiles du Crétacé de la côte occidentale d'Afrique du Cameroun à l'Angola. I. Gastéropodes. *Annales du Musée royal du Congo belge, Série 8, Sciences géologiques* 15, 128 p.
- DARTEVELLE E. & FRENEIX S. 1957. — Mollusques fossiles du Crétacé de la côte occidentale d'Afrique du Cameroun à l'Angola. II. Lamellibranches. *Annales du Musée royal du Congo belge, Série 8, Sciences géologiques* 20, 271 p.
- DELVENE G. 2003. — Middle and Upper Jurassic bivalve associations from the Iberian Range (Spain). *Geobios* 36: 519-531.
- DHONDT A. V. & DIENI I. 1993. — Non-rudist bivalves from Late Cretaceous rudist limestones of NE Italy (Col dei Schiosi and Lago di S. Croce areas). *Memorie Scienze Geologiche* 45: 165-241.
- DUFF K. L. 1978. — *Bivalvia from the English Lower Oxford Clay (Middle Jurassic)*. The Palaeontographical Society, Monographs, London, 137 p.
- DUPONT G. 1996. — Principaux foraminifères planctiques du Crétacé gabonais (Aptien à Campanien inférieur), in JARDINÉ S., KLASZ I. DE & DEBENAY J.-P. (eds), *Géologie de l'Afrique et de l'Atlantique Sud*. Actes Colloques Angers 1994: 83-121.
- EL QOT G. M. 2006. — Late Cretaceous macrofossils from Sinai, Egypt. *Beringeria* 36: 3-163.
- FAWZI M. A. 1963. — La faune Cénomanienne d'Égypte. *Geological Survey of Egypt, Monograph* 2: 1-133.
- FÜRSICH F. T. 1984. — Palaeoecology of boreal invertebrate faunas from the Upper Jurassic of central Greenland. *Palaeogeography, Palaeoclimatology, Palaeoecology* 48: 309-346.
- FÜRSICH F. T. 1994. — Palaeoecology and evolution of Mesozoic salinity-controlled benthic macroinvertebrate associations. *Lethaia* 26: 327-346.
- FÜRSICH F. T. & HEINBERG C. 1983. — Sedimentology, biostratigraphy, and palaeoecology of an Upper Jurassic offshore sand bar complex. *Bulletin of the Geological Society of Denmark* 32: 67-95.
- FÜRSICH F. T. & THOMSEN E. 2005. — Jurassic biota and biofacies in erratics from the Sortland area, Vesterålen, northern Norway.

- Norges geologiske undersøkelse Bulletin 443: 37-53.
- FÜRSICH F. T., ÖSCHMANN W., PANDEY D. K., JAITLEY A. K., SINGH I. B. & LIU C. 2004. — Palaeoecology of middle to lower Upper Jurassic macrofaunas of the Kachchh Basin, western India: an overview. *Journal of the Palaeontological Society of India* 49: 1-26.
- GÉRARD G. 1958. — *Carte géologique de l'Afrique équatoriale française au 1/2 000 000. Notice explicative*. Gouvernement Général de l'Afrique Équatoriale Française, Direction des Mines et de la Géologie, 198 p.
- GRAY J. E. 1842 — Molluscs, in *Synopsis of the Contents of the British Museum*. 44th edition. G. Woodfall & Son, London: 48-92.
- GRAY J. E. 1851 — Mollusca acephala and brachiopoda, in GRAY J. E., GRAY G. R., WHITE A., STEPHENS J. F., SMITH F., DENNY H., STANTON H. T. & SHEPHERD E. (eds), *List of the Specimen of the British Animals in the Collection of the British Museum*. British Museum (Natural History). Part VII, 1845-1855. Department of zoology, printed by order of the trustees, London, 17 volumes by various authors: Iv + 167 p.
- HARZHAUSER M. & MANDIC O. 2004. — The muddy bottom of Lake Pannon a challenge for dreissenid settlement (Late Miocene; Bivalvia). *Palaeogeography, Palaeoclimatology, Palaeoecology* 204: 331-352.
- HOUCQ V. & HAUSKNECHT J.-J. 1954. — *Notice explicative sur la faille Libreville-Ouest et carte géologique de reconnaissance au 1/500 000*. Gouvernement Général de l'Afrique Équatoriale Française, Paris, 25 p.
- HUDELEY H. & BELMONTE Y. 1970. — *Carte géologique de la République gabonaise au 1/100 0000. Notice explicative*. BRGM, Mémoire 72, 191 p.
- KLASZ I. DE 1965. — Biostratigraphie du bassin. Colloque international de Micropaléontologie, Dakar, 1963. *Bureau de Recherches géologiques et minières*, Mémoire n°32: 277-303.
- KLASZ I. DE & MICHOLET J. 1971. — *Éléments nouveaux concernant la biostratigraphie du bassin gabonais*. Acte du IV^e Colloque africain de Micropaléontologie, Abidjan, 1970.
- LAMARCK J. B. P. DE M. 1809. — *Philosophie zoologique, ou exposition des considérations relative à l'histoire naturelle des animaux; à la diversité de leur organisation et des facultés qu'ils en obtiennent; aux causes physiques qui maintiennent en eux la vie et donnent lieu aux mouvements qu'ils exécutent; enfin, à celles qui produisent, les unes le sentiment, et les autres l'intelligence de ceux qui en sont doués*. Chez dentu et l'auteur, Paris, vol 1, 422 p ; vol. 2, 466 p.
- LANAU M. 1985. — Sédimentation et diagenèse d'une série hyper-siliceuse: le groupe d'Ozouri, Paléocène supérieur-Éocène inférieur du bassin côtier gabonais. *Thèse de l'Université de Poitiers*, 258 p.
- LEACH W. E. 1819. — Descriptions des nouvelles espèces d'animaux découvertes par le vaisseau Isabelle dans un voyage au pôle boréal. *Journal de Physique, de Chimie, d'Histoire naturelle et des Arts* 88 (6) : 462-467.
- LOGAR J. F. 1983. — *Well Evaluation Conference, Afrique de l'Ouest*. Document Schlumberger, 1-1 à I-69.
- MBINA MOUNGUENGUI M. 1998. — *Dynamique sédimentaire et fluctuations eustatiques au cours du Cénomanién et du Turonien basal dans le Nord du bassin côtier gabonais*. Thèse de l'Université de Bourgogne, 376 p.
- MBINA MOUNGUENGUI M., LANG J., GUIRAUD M. & JOCKTANE O. 2002. — Sedimentary dynamics and structural geology of pre-rift deposits of interior basin of Gabon. *Journal of African Earth Sciences* 35: 315-329.
- MBINA MOUNGUENGUI M. & LANG J. 2003. — Évolution de la dynamique sédimentaire au cours du Cénomanién et du Turonien dans le Nord du bassin côtier gabonais. *Africa Geoscience Review* 10 (1, 2): 85-102.
- MBINA MOUNGUENGUI M., BAUDIN F. & GUIRAUD M. 2008. — Caractérisation et paléoenvironnements des dépôts riches en matière organique de la série de l'Anguille d'âge coniacien-santonien dans le bassin sédimentaire côtier gabonais. *Africa Geoscience Review*, Special Publication 2008/01c 89-97.
- MOUSSODOU L. 1984. — Étude sédimentologique et géodynamique de forages sénoniens p.p. entre plate-forme et talus dans la région de Port-Gentil (Gabon). Formations Pointe-Clairette et Anguille. Thèse 3^{ème} cycle, Université de Dijon, 168 p.
- MUSAVU MOUSSAVOU B., NDONG ONDO S. M., MAKAYA M'VOUBOU. 2013. — Turonian bivalves from the Coastal Basin of Gabon, South of Libreville. *Bulletin de l'Institut scientifique, Rabat, section Sciences de la Terre* 35: 1-8.
- MUSAVU MOUSSAVOU B., MAKAYA M'VOUBOU, NDONG ONDO S. M. 2014. — Turonian bivalves from Gabonese coastal basin: Belle vue 3 section, South of Libreville region. *Bulletin de la Société Géologique de France* 185 (1): 43-50.
- NEWTON R. B. 1891. — *Systematic List of the Frederick E. Edwards Collection of British Oligocene and Eocene Mollusca in the British Museum (Natural History) with References to the Type Specimens from Similar Horizons Contained in Other Collections Belonging to the Geological Department of the Museum*. Printed by order of the Trustees, Longmans and Co, London, xxviii + 365 p.
- PERVINQUIÈRE L. 1912. — Étude de la paléontologie tunisienne, II, gastéropodes et lamellibranches des terrains crétacés. *Carte géologique de la Tunisie*. J. Lamarre et Cie, Paris, 352 p.
- PUGACZEWSKA H. 1986. — Bivalvia of the Polish Middle Jurassic and remarks on their paleoecology. *Acta Palaeontologica Polonica* 31 (1-2): 27-83.
- RAFINESQUE C. 1815. — *Analyse de la nature*. Palermo, 225 p.
- REYMENT R. A. 1955. — Upper cretaceous Mollusca Lamellibranchia and Gastropoda from Nigeria. *Colonial Geology and Mineral Resources* 5 (2): 127-155.
- REYRE D. 1989. — Évolution géologique et caractères pétroliers d'une marge passive: cas du bassin Bas Congo-Gabon, in *Dynamique et méthodes d'étude des bassins sédimentaires*. Association des Sédimentologues français: 227-247.
- RICARDO LOPES DE SIMONE L. & MEZZALIRA, S. 1994. — Fossil molluscs of Brazil. *Governo do Estado de Sao Paulo, Secretaria do Meioambiente, Coordenadoria de informações técnicas, documentação e pesquisa ambiental instituto geológico*, Boletim 11, 202 p.
- RIEDEL L. 1932. — Die Oberkreide vom Mungofluss in Kamerun und ihre Fauna. *Beiträge zur Erforschung der deutschen Schutzgebiete* 16: 1-154.
- SEELING J. & BENGTON P. 1999. — Cenomanian oyster from the Sergipe basin, Brazil. *Cretaceous Research* 20: 747-765.
- SCHNEIDER S., BERNING B., BITNER M. A., CARRIOL R.-P., JÄGER M., KRIWET J., KROH A. & WERNER W. 2009. — A parautochthonous shallow marine fauna from the Late Burdigalian (early Oligocene) of Gurlarn (Lower Bavaria, SE Germany): Macrofaunal inventory and paleoecology. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 254: 63-103.
- SHARPE D. 1850. — On the secondary district of Portugal which lies on the north of the Tagus. *Quaternary Journal of Geological Society* 6: 135-195.
- SOWERBY J. & SOWERBY J. DE C. 1812-1846. — *The Mineral Conchology of Great Britain or Coloured Figures of those Remains of Testaceous Animals or Shells which have been Preserved at Various Times and Depths in the Earth*. 7 vols, 803 p.
- STOLICZKA F. 1870-71. — Cretaceous fauna of southern India: The Pelecypoda, with a review of all known genera of this class, fossil and recent. *Palaeontologia Indica* 6 (3): 1-557.
- TEISSERENC P. & VILLEMIN J. 1990. — Sedimentary Basin of Gabon – Geology and Oils Systems, in EDWARDS J. D. & SANTOGROSSI P. A. (eds), Divergent/Passive margin basins. *Bulletin American Association Petroleum Geologists, memoir* 48: 117-199.
- VIDAL J., JOYES R. & VAN VEEN J. 1975. — L'exploration pétrolière au Gabon et au Congo. *Proceeding 9th World Petroleum congress (Tokyo)* 3: 149-165.
- VOLAT J.-L., HUGO B. & BIGNOUMBA-ILOGUE J. 1996. — Foraminifères arénacés du Crétacé supérieur du Gabon. *Bulletin des Centres de Recherches Exploration-Production Elf Aquitaine* 20 (1): 229-275.

- VRIELYNCK B. & BOUYSSÉ P. 2003. — *Le visage changeant de la Terre*. Commission de la carte géologique du monde, Éditions UNESCO, 32 p.
- WOODS H. 1906. — The cretaceous fauna of Pondoland. *Annals of South African Museum* 4 (12): 275-350.
- YONGE C. M. 1953. — Form and habit in *Pinna carnea* GME-LIN. *Philosophical Transactions of the Royal Society of London* B237: 335-374.
- ZUSCHIN M., HARZHAUSER M. & MANDIC O. 2004a. — Spatial variability within a single parautochthonous Paratethyan tidal flat deposit (Karpatian, Lower Miocene-Kleinebersdorf, Lower Austria). *Courier Forschungsinstitut Senckenberg* 246: 153-168.
- ZUSCHIN M., HARZHAUSER M. & MANDIC O. 2004b. — Taphonomy and Palaeoecology of the Lower Badenian (Middle Miocene) molluscan assemblages at Grund (Lower Austria). *Geologica Carpathica* 55: 117-128.

*Submitted on 2nd April 2014;
accepted on 12 May 2015;
published on 25 September 2015.*