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Lower Maastrichtian inoceramids from Nigeria

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(With 7 Textfigures, 5 Plates, and 3 Tables)

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Abstract

Three taxa of Lower Maastrichtian inoceramids from Calabar (Cross River State, Nigeria) are described: *Trochoceramus ianjonaensis* (SORNAY, 1973), ? *Endocostea coxi* (REYMENT, 1955), and *Cataceramus balticus* (BÖHM, 1907). Their palaeogeographical distribution shows the first two to be typical Tethyan taxa, but *Trochoceramus ianjonaensis* extends into the southern part of the Temperate realm as is also the case for some other bivalve taxa of that age.

Zusammenfassung

Aus dem Unter-Maastricht von Cross River State, Nigerien werden drei Inoceramen-Arten beschrieben: *Trochoceramus ianjonaensis* (SORNAY, 1973), ? *Endocostea coxi* (REYMENT, 1955), *Cataceramus balticus* (BÖHM, 1907).

Die paläogeographische Verbreitung zeigt dass die beiden ersteren Taxa eine typische Tethys Verbreitung haben, wobei aber *Trochoceramus ianjonaensis* in den südlichen Teil des "Temperate Realm" reicht, worauf auch einige andere Bivalven dieses Alter hinweisen.

Introduction

During fieldwork in Lower Maastrichtian strata near Calabar, Cross River State, Nigeria, a large inoceramid sample was collected by H. Lobitzer in 1977. See below for the geological and geographical location of the outcrops.

These inoceramids belong to three species: *Trochoceramus ianjonaensis* (SORNAY, 1973), ? *Endocostea coxi* (REYMENT, 1955), and *Cataceramus balticus* (BÖHM, 1907). *Trochoceramus ianjonaensis* is mainly a Tethys species but its most northern occurrence is in the "Craie à *Baculites*" (Cotentin, France).

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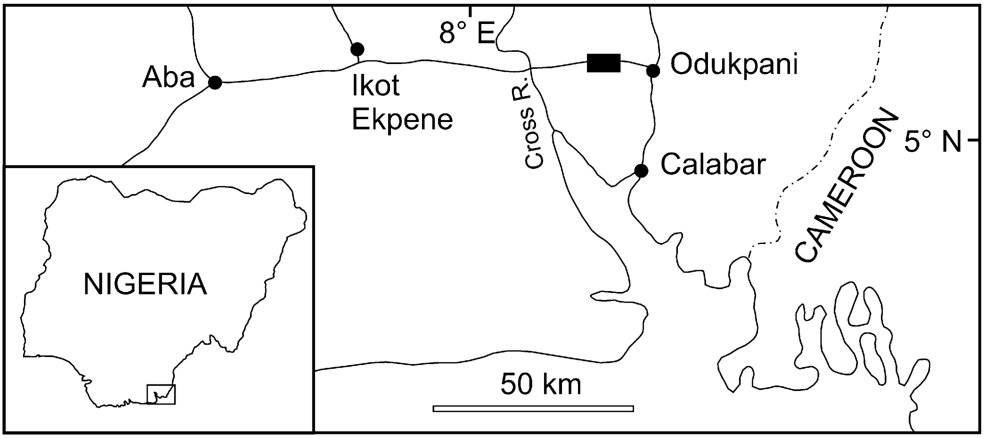


Fig. 1: Map showing the location of the outcrops.

Geological and geographical setting

(H. LOBITZER)

Previous research on the Nkporo Shales of Calabar Flank

For over 30 years palaeontological research of the Cretaceous of SE Nigeria was closely connected with R.A. REYMENT (1951 ff.). He included the locally abundant findings of inoceramids from Turonian to Maastrichtian sequences in his research. In REYMENT (1951) he mentioned *Inoceramus (Boehmiceramus) bantu* (HEINZ) from the Coniacian at Anofia and two large specimens from Awgu which he thought to be similar to *I bantu* and "may well constitute a new species". A brief discussion of *I. bantu* sensu REYMENT (1951, 1955b) is given below (p. 242). REYMENT (1955) made an attempt at establishing the biostratigraphy, based on ammonites, in this highly fossiliferous region of Cross River State, Nigeria. At that time REYMENT could only confirm a Maastrichtian age for the Nkporo Shales and did not find any evidence for the presence of Campanian strata. In his later papers (e.g. REYMENT 1959, REYMENT & DINGLE 1987) he dealt with faunal correlations of the Mid- to Upper Cretaceous of the West African coastal basins, the history of the opening of the South Atlantic Ocean, the Trans-Atlantic correlation of the Brazilian and West African coastal basins, and last but not least, the timing of the establishment of the Trans-Saharan Seaway between the South Atlantic and the Tethys Ocean. The basic papers on the regional geology of Cross River State, Nigeria were published by SHORT & STÄUBLE (1967) and MURAT (1972). These papers summarize the extensive fieldwork data, the airborne data, and in particular the studies of drill holes by SHELL/BP Nigeria.

The exposures visited by us in 1976 and 1977, respectively their surroundings, were later revisited and sampled again. FÖRSTER (1978) and FÖRSTER & SCHOLZ (1979) mostly dealt with the beginning of the opening of the South Atlantic. Based on our own and on FÖRSTER's collections, they also reported the first data on the Maastrichtian fauna of our Nkporo Shales outcrops. Most probably the sample points of ZABORSKI (1982) are identical or at least situated nearby our localities.

Geological setting

The Cretaceous of "Calabar Flank" in Cross River State, Nigeria, where our fossil specimens came from, is famous for its rich and well-preserved marine Albian-Maastrichtian fauna.

However, due to the tropical vegetation most fossils come either from quarries or from other temporary exposures, for instance during road construction. According to SHORT & STÄUBLE (1967) the Calabar Flank is part of an X-shaped, fault-controlled depression formed in the crystalline metamorphic basement complex of the African craton .

One spur of this basement complex, which protrudes from the Cameroons in western direction is called the Oban Hills or Oban Massif. During the early opening of the South Atlantic Ocean in the mid-Cretaceous, the southern and south-western gentle-dipping slope of the Oban Massif (i.e. the Calabar Flank) acted as a shoreline during several marine transgressions from the Albian to the Maastrichtian. The sequence of this Calabar Flank was studied repeatedly by several authors in respect of the earliest opening of the seaway between the North and South Atlantic Ocean and in respect of Trans-Atlantic and Trans-Saharan faunal exchanges.

Numerous drill holes, field exposures and the limestone quarry in Mfamosing show that the Albian sequence of the Calabar Flank is represented by dolomites (only in drill holes), overlain by yellowish-white, and in part very fossiliferous limestones (Mfamosing Formation of internal reports of Calabar Cement Co.). The top of the Mfamosing limestone is represented by a mineralised hardground showing a condensed fauna of ammonites and other molluscs of Albian/Cenomanian age (see also FÖRSTER & SCHOLZ 1979). Above this hardground dark grey marls of Cenomanian age with the foraminifer *Thomasinella punica* SCHLUMBERGER (det. W. Fuchs) are exposed. Further to the north, e.g. along the "Odukpani-Itu-road", the Turonian marls (Eze Aku Shales) are exposed, intercalated by nodular limestone beds, which display a relatively rich, but often poorly preserved mollusc assemblage, including ammonites, gastropods and inoceramid bivalves. The Coniacian/Santonian Awgu Shales could not be traced with certainty in the exposures investigated. The samples investigated in this paper come from the highly fossiliferous clay/marl exposures of the Nkporo Shale Group, which show Late Campanian/Maastrichtian age. The Nkporo Shales are well known for their rich and often well-preserved fauna, including numerous inoceramids and oysters.

Material

The previously undescribed inoceramid specimens from Cross River State, Nigeria consist of: *Cataceramus balticus* (one specimen), ? *Endocostea coxi* (26 specimens) and *Trochoceramus ianjonaensis* (72 specimens).

In 1976, a new road heading north of Odukpani village, to the west of Calabar river, was constructed towards the town of Itu. Excellent fresh roadside outcrops temporarily exposed a stratigraphically incomplete, but highly fossiliferous Cenomanian to Maastrichtian sequence. Lithologically the sequence of the "Odukpani-Itu road" consists predominantly of marls and clays, intercalated by limestone and/or sandstone beds. The macrofossils mentioned below were identified by R. Förster (+), Munich (see also FÖRSTER, 1978). In 1976 and 1977 H. Lobitzer collected the following samples:

Sample point 77/39: road-construction-km 18,00-18,05 on the northern slope of the road.

Baculites sp.

Sample point 77/44: road-construction-km 18,00-18,1 on the southern slope of the road.

The outcrop resembles sample point 77/39. Maastrichtian. *Sphenodiscus* cf. *lobatus* (TUOMEY) and the crab *Costacopluma concava* COLLINS & MORRIS. In addition *Calianassa* and Ranidae indet., bivalves, gastropods, vertebrate bones indet., dinosaurian vertebrae, *Onchopristis*-teeth, ostracods, foraminifera.

Sample point 77/46: road-construction-km 12,8 on the southern slope of the road. *Libycoceras* cf. *ismaeli* Zittel, Lower Maastrichtian. *Afrobolivina* indet.

Taxonomy

(G. LÓPEZ, A.V. DHONDT & K.A. TRÖGER)

The terminology used herein comes from SORNAY (1966), MOORE (1969) and HARRIES et al. (1996).

Abbreviations and definitions:

α: angle between anterior margin and hinge line (anterior hinge angle)
β: angle between anterior and posterior portions of the beak area (apical angle)
H: height of the valve
W: width of the valve
S: length of the hinge line
HA: length measured along the growth axis
NA: length taken perpendicularly to HA
C.C.: position of geniculation measured from the umbo to the first geniculation, along the growth axis
WA: angle between hinge line and growth axis
B: maximum convexity of a valve, i.e. maximum distance perpendicular from the plane of commissure to the top of the valve (equivalent of W in HARRIES et al., 1996 – translation of "Breite")

Repository:

The specimens from Cross River State, Nigeria are housed in the Geologische Bundesanstalt, Vienna.

The type of *Trochoceramus garridoi* (BATALLER) is housed in the Museo Geominero of the Instituto Geológico y Minero de España (IGME) in Madrid.

Bivalvia LINNÉ,1758

Pteriomorpha BEURLEN, 1944

Pterioida NEWELL, 1965

Pterioidea GRAY, 1847

Inoceramidae ZITTEL, 1881 (ICZN 473)

Trochoceramus HEINZ, 1932

Type species: *Inoceramus helveticus* HEINZ, 1932

Trochoceramus ianjonaensis (SORNAY, 1973)
Tab. 1; Figs. 2, 3; Pl. 1, figs. 1-2; Pl. 2, figs. 1-5; Pl. 3, figs.1-4, Pl. 5, fig. 2

(1934) *Inoceramus (Helicoceramus)* aff. *occidens* Heinz (sic) – BASSE: 116 (*fide* SORNAY, 1973: 88).
v?.1947 *Pseudomonotis ? Garridoi* Almela – ALMELA in BATALLER: 179-181, n° 446.
v?.1966 *Didymotis garridoi* (Almela) – QUINTERO & REVILLA: 37, pl. 4, fig. 8.
v.*1973 *Inoceramus (Trochoceramus) ianjonaensis* n. sp. – SORNAY: 85-88, pls 1, 2, pl. 3, fig. 5, pl. 4, fig. 1; text-figs. 2, 3.
v.1973 *Inoceramus* (*Trochoceramus*) *morgani* n.sp. – SORNAY: 91-93, pl. 3, figs. 3-4, pl. 4, figs. 2, 3, fig-text 5.
v.1980 *Inoceramus (Trochoceramus) ianjonaensis* Sornay – TRÖGER & RÖHLICH: 93-103, pl. 1, figs. 1-8, text-figs. 1-6.
pp 1991 *Inoceramus* (*Trochoceramus*) *ianjonaensis* Sornay – TRÖGER & RÖHLICH: 1376, pl. 5, figs 1, 2, 3, text-fig. 16 (non pl. 5, fig. 4).
.? 1996 *Inoceramus (Trochoceramus) ianjonaensis* Sornay – SEIBERTZ: 331-332, fig.20a-b (only).
v ? 2000 *Trochoceramus ianjonaensis* (Sornay) – ROBASZYNSKI et al.: 416, fig. 46.
non 1969 *Inoceramus zitteli sensu* ANTUNES & SORNAY: 89.
non 1978 *Inoceramus* (*Trachoceramus* –sic) sp. aff. *ianjoanensis* Sornay – NODA & KANIE : 68, pl. 6, figs 1A, 1B.

H o l o t y p e : specimen R 61341 (ex. 13-10) from Mandembata, SW Madagascar, Laboratoire de Paléontologie, Département d'Histoire de la Terre, Muséum national d'Histoire naturelle, Paris, France.

Type material of *Trochoceramus garridoi* : ALMELA in BATALLER (1947: 179-181, n° 446) created the species *Pseudomonotis ? Garridoi* on the basis of a single specimen. The same specimen was figured again and described by QUINTERO & REVILLA (1966: 37, pl. 4, fig. 8) as *Didymotis garridoi* (ALMELA). The specimen is presently housed at the Museo Geominero (IGME), Madrid, Spain, with number 1180C (Pl. 1, fig. 3) (from the Lower to middle Maastrichtian of the Sierra del Coscollet [Colladita en el origen del Barranco del Tozal de Colomina, al S. del río Sallent y a 1.400 metros al S.O. de la Ermita de San Miguel. Coll de Nargó (Lérida)], Spain (fide sheet Oliana 291 of the IGME Geological map of Spain – in print).

Type of *Trochoceramus morgani*: specimen R 61283 from Picauville, Port Fiollet (Manche, NW France), ? Lower Maastrichtian; Laboratoire de Paléontologie, Département d'Histoire de la Terre, Muséum national d'Histoire naturelle, Paris.

U n p u b l i s h e d m a t e r i a l: 72 valves from near Calabar (Cross River State, Nigeria).

L o c u s t y p i c u s and s t r a t u m t y p i c u m: Mandembata, SW Madagascar, Lower Maastrichtian.

D i a g n o s i s: Small to medium, occasionally large, *Trochoceramus* species with thin shell and strongly developed radial and commarginal ornamentation. On average, near the umbo, the commarginal rugae are more strongly developed than radial plicae. Growth lines intersect rugae obliquely.

Geniculations strongly developed. At the geniculation the ornamentation often changes abruptly. Also the obliquity changes resulting in a more oblique stage. Occasionally a short and broad endocostean sulcus is present on the adult stage.

D e s c r i p t i o n of the Nigerian specimens: Most specimens show a flattish juvenile stage and at least one strong geniculation separating the juvenile from the adult stage (Table 1). The geniculation angle between the juvenile stage and the adult stage can vary from about 90° to about 150°.

Tab. 1: General measurements of selected specimens of *Trochoceramus ianjonaensis* (Sornay, 1973)

Specimen	α	β	H	L	HA	NA	S	C.C./HA
A-24	148°	104°	43,00	42,50	47,20	34,40	123,00	26,80
A-25	148°	104°	40,50	42,50	42,00	42,00	10,50	31,00
A-37	141°	120°	66,80	72,00	68,40	67,00	——	——
A-46	163°	103°	38,00	56,00	44,60	56,50	39,50	——
A-48	150°	121°	78,30	74,50	83,00	75,50	48,10	64,50
A-50	150°	105°	44,10	58,90	47,20	55,50	29,10	51,20
A-56	170°	101°	40,90	66,40	55,50	52,50	16,50	28,50
A-58	162°	112°	58,90	77,50	62,00	70,00	23,00	——
A-59	157°	115°	68,50	61,20	60,50	73,20	12,90	——
B-5	155°	109°	48,50	51,90	62,00	48,00	20,50	——
B-15a	162 °	101°	40,53	74,70	75,00	60,54	42,80	——
B-15b	154°	125°	41,00	60,10	52,00	57,70	31,10	32,00
B-16a	146°	104°	51,50	54,00	61,00	48,00	12,00	——
B-19	150°	115°	44,10	58,90	47,20	55,50	29,10	33,20
B-23	145°	119°	32,00	55,50	39,50	55,00	39,00	27,50

The flattish to slightly convex juvenile stage is covered with closely spaced, often narrow, commarginal rugae and with radial, often narrow plicae. Near the umbo the commarginal rugae are often strongly developed, but at about 10 to 15 mm from the umbo the radial plicae are often more pronounced than the commarginal rugae. The size of this juvenile stage varies greatly: the length varies from 77.5 mm to 142 mm. The older parts of juvenile stages of 3 left and 4 right valves show at 6.2 to 25.5 from the umbo on the growth axis the beginning of a well developed endocostean sulcus that almost always continues unto the adult stage ranging in width from 1.4 to 7 mm. There are no important differences in the growth pattern between right and left valves (Figs. 2, 3), the main ones are observed in the NA%HA graphs.

The post-geniculation adult stage is present on most specimens but not on all: some, even largish specimens did not always develop a very clear geniculation and look only slightly convex or even flattish; on those that have a geniculation it occurs usually between 20 to 35 mm from the umbo along the growth axis, and the ornamentation on the adult stage mainly consists of narrow to wide commarginal and more rarely narrow radial irregular folds. At the intersection between the two they sometimes form small

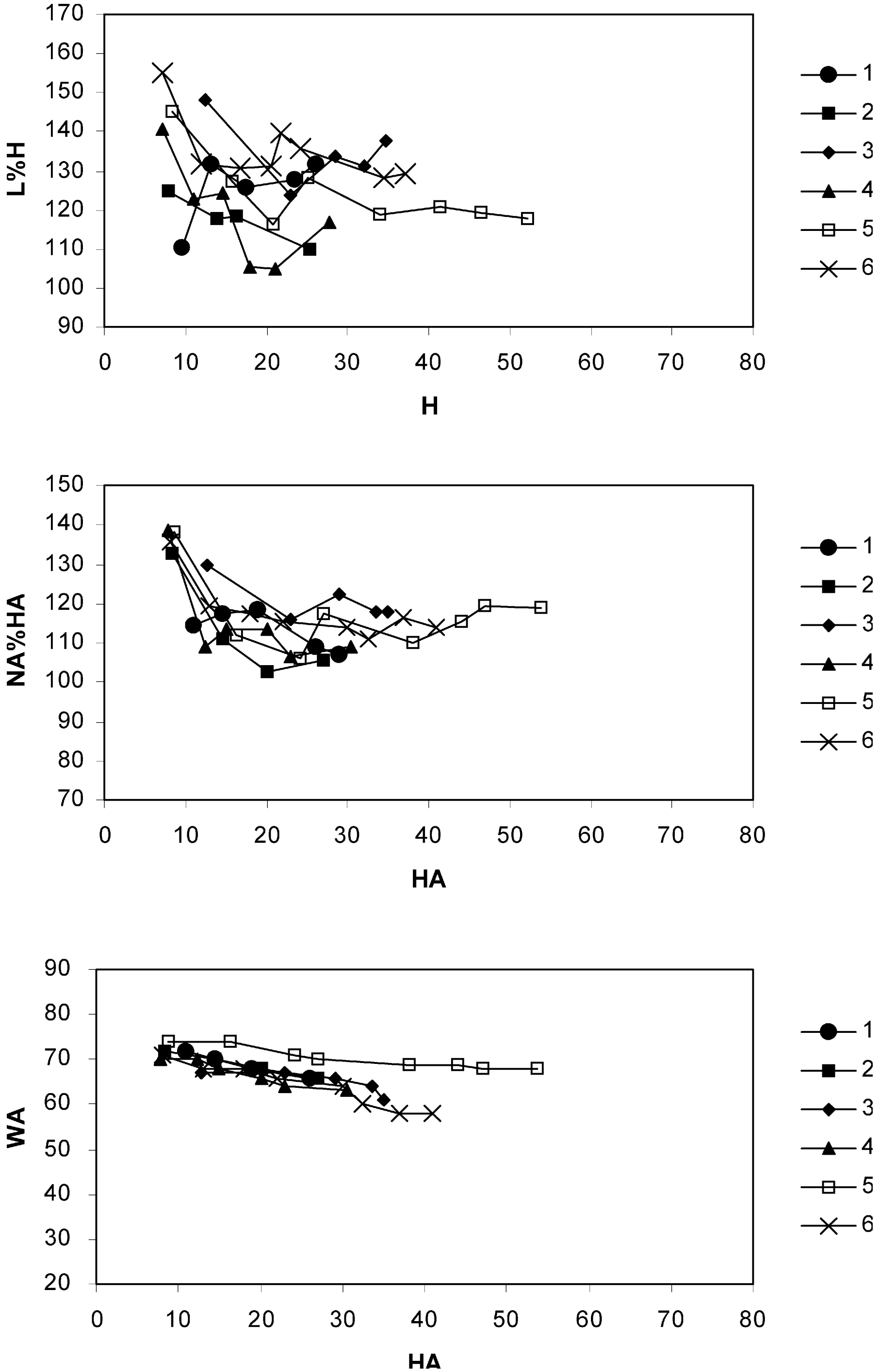


Fig. 2: Ontogenic measurements of right valves of selected specimens of *Trochoceramus ianjonaensis* (SORNAY, 1973). Specimens plotted: 1) A24, 2) A25, 3) A37, 4) A46, 5) A48, 6) B15b.

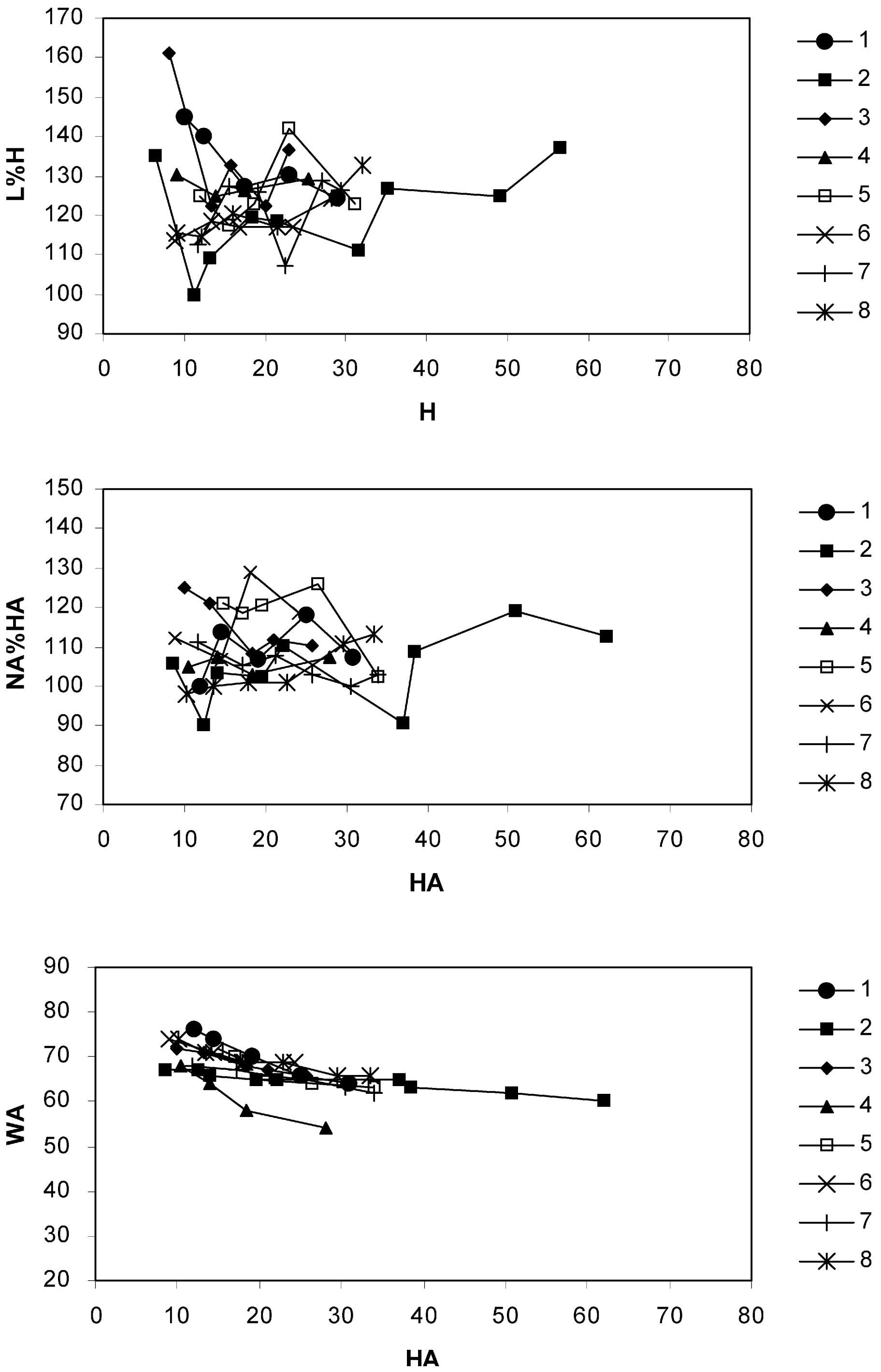


Fig. 3: Ontogenic measurements of left valves of selected specimens of *Trochoceramus ianjonaensis* (SORNAY, 1973). Specimens plotted: 1) A56, 2) A58, 3) A59, 4) B5, 5) B15a, 6) B16a, 7) B19, 8) B23.

tubercles. The large adult stages are not complete on any of the Nigerian specimens but it is obvious that some specimens were quite large with a height of easily as much as 150-180 mm. On double-valved specimens endocostean sulci are not necessarily present on both valves.

D i s c u s s i o n: The Nigerian specimens of *Trochoceramus ianjonaensis* are of a somewhat different preservation than those from Madagascar – this certainly explains the minor differences between the two populations.

Variability of the Nigerian specimens: amongst the 72 valves from near Calabar (Cross River State, Nigeria) (samples 77/39 and 77/44) are 42 left valves and 30 right valves.

The general shape of the specimens varies greatly

a) in as far that the position of the umbo can be almost central and then the rugae are more or less circular; on other specimens the umbo is situated more towards the posterior side - thus giving an almost *balticus*-like aspect to the specimens.

b) the size of the juvenile stage is sometimes very small and sometimes quite large; when the juvenile state is very small and slightly convex the specimens have a *balticus* –like look except for the fact that the commarginal rugae are much wider apart than in a normal *Endocostea baltica* specimen.

The Spanish specimen figured in BATALLER (1947: 180, n° 446) is interpreted as a possible large juvenile stage of the species, but more specimens are needed to check their variation. Similar juvenile stages are found on specimens A35 to A58 and B 20, B 23 from near Calabar (Cross River State, Nigeria) (Pl. 1, figs. 1, 2; pl. 2, figs. 2, 3, 4, 5; pl. 3, fig. 1).

Variability of the Madagascan specimens of *Trochoceramus ianjonaensis*: The specimens described and figured by SORNAY (1973) are not different on average from those from near Calabar (Cross River State, Nigeria) but the photographs in SORNAY, especially of the adult stages, do not very clearly show the radial ornamentation.

Variability of the Libyan specimens of *Trochoceramus ianjonaensis*: TRÖGER & RÖHLICH (1980: 93-103) described and figured a group of specimens from the Lower Maastrichtian Lower Tar Fm., collected to the East of Ghadames, NW Libya. They also discussed the variability of the taxon and especially of its geniculation between the juvenile and adult stages. They drew attention to the presence of the endocostean sulcus already mentioned by SORNAY (1973: 87) as a rare occurrence on the Madagascan fauna. The preservation of the illustrated Libyan specimens appears to be better than that of the Madagascan or Nigerian specimens and their general shape is undoubtedly more regular. Of course, this could be the result of the selection of the photographed Libyan specimens, or of a somewhat different ecological environment in Libya from that in Nigeria and Madagascar. TRÖGER & RÖHLICH (1980: fig. 3) showed more varied shapes for the taxon than the photographed specimens on pl. 1 lead one to assume.

S y n o n y m y: - The unique Spanish specimen of *T. garridoi* (BATALLER ,1947) is considered as a large juvenile specimen, similar in ornamentation and shape to some ungeniculated specimens of *T. ianjonaensis* described herein from Calabar. If more Spanish material were available the synonymy of *T. garridoi* with *T. ianjonaensis* could probably be demonstrated. In recently described faunas trochoceramid species are well known from other Spanish areas, as the Alicante Province (GALLEMI et al. 1995, 1996), but no other specimens of *T. garridoi were* reported .

- *Trochoceramus morgani* (SORNAY, 1973) from the "Craie à *Baculites*" in the Cotentin (France) was considered as a species close to *T. ianjonaensis* by SORNAY (ibid.), but characterised by a less circular shape of the commarginal rugae on the juvenile part. SORNAY (1973: 92) also insisted on a different development of the radial costulation on the specimens from the "Craie à *Baculites*".

When comparing the original specimens of *T. morgani* from the Cotentin with some of the smaller specimens in the *T. ianjonaensis* sample from Nigeria, the French specimens seem to fall easily within the variability of the Nigerian sample. WALASZCZYK et al. (2002: 290) already stated that *T. morgani* (SORNAY) does not represent a separate species from *T ianjonaensis,* but that *T morgani sensu* WALASZCZYK et al., 1996 belongs to another species [= *T. costaecus* (KHALAFOVA, 1966)].

- *Inoceramus (Trochoceramus) ianjonaensis* SORNAY, 1973 is figured by SEIBERTZ (1996) on the basis of mainly incomplete and poorly preserved Maastrichtian specimens from NE Egypt that do not convincingly show the typical characteristics of the SORNAY species, except possibly for the specimen illustrated on fig. 20a, b.
- From Kalaat Senan (Tunisia) ROBASZYNSKI et al. 2000 listed, briefly described and illustrated mainly a.o. Lower Maastrichtian inoceramids. Among the *Trochoceramus* species are *T. nahorianensis* (KOCIUBYNSKIJ, 1968), *T. radiosus* (QUAAS, 1902), and also *T. ianjonaensis* (SORNAY, 1973), but the specimen illustrated by ROBASZYNSKI et al. (2000: 416, fig. 46) is not totally convincing.

Trochoceramus specimens from many other African and European uppermost Campanian and Lower Maastrichtian localities differ from *T. ianjonaensis* in being generally not as strongly geniculated, and in not showing strongly differentiated growth stages. The pronounced geniculations seen on *T. ianjonaensis* are a character occurring quite frequently in different groups of inoceramids. However, TRÖGER (1981) and TRÖGER & RÖHLICH (1991) suggested that geniculations are basically due to environmental/ecological factors and have no taxonomic value. Further research is probably necessary to decide on the exact value of this characteristic.

ANTUNES & SORNAY (1969) suggested the assignment of *Pseudomonotis* (?) *garridoi* ALMELA in BATALLER to the genus *Trochoceramus*. They synonimized it with *Inoceramus zitteli* KOCIUBYNSKIJ (1958) non PETRASCHECK (1906), in 1968 already renamed *I. nahorianensis* by KOCIUBYNSKIJ.

The specimen from Angola described in ANTUNES & SORNAY (1969) as *I. zitteli* is undoubtedly a trochoceramid but its rugae are more circular and regular than on the original of *Trochoceramus ianjonaensis,* and it seems quite flat and has no geniculations.

R e l a t e d t a x a: In strata of Late Campanian and Early Maastrichtian age *Trochoceramus* ssp. are not uncommon (see in SEITZ 1970, DHONDT 1993, WALASZCZYK et al. 1996, ROBASZYNSKI et al. 2000, TRÖGER et al. 2001, WALASZCZYK et al. 2001 and 2002).

D i s t r i b u t i o n: *Trochoceramus ianjonaensis* is widely distributed in Lower Maastrichtian Tethyan regions of Africa and Europe, and in the Southern part of the European Temperate Realm.

Endocostea WHITFIELD, 1877

Type species: *Endocostea typica* WHITFIELD, 1880

? ***Endocostea coxi*** (REYMENT, 1955)

Tab. 2 ; Figs. 4, 5; Pl. 4, figs. 1-7

v*. 1955 b *Inoceramus coxi* n.sp. – REYMENT: 140 , pl. 3, fig. 4a, 4b.
? 1995 *Endocostea (Endocostea) coxi* (Reyment) – MORRIS: 258, pl. 1, figs. 2-4.
. 2001 *Endocostea coxi* (Reyment) – WALASZCZYK, COBBAN & HARRIES: 182, pl. 40, fig. 6.

H o l o t y p e: Specimen B.M. L 82963, Department of Palaeontology, The Natural History Museum, London, UK.

L o c u s t y p i c u s and s t r a t u m t y p i c u m: Auchi, Edo State, Nigeria, Maastrichtian.

M a t e r i a l: 26 specimens, 11 left valves 15 right valves from near Calabar (Cross River State, Nigeria).

D e s c r i p t i o n: Small to average (Tab. 2), subquadrate, very globose inoceramid with strongly developed regular commarginal rugae. The ontogenetic growth shows differences between right and left valves (Figs. 4, 5). The number of rugae varies:

- on some specimens they are wider and more widely separated,
- on others they lie closely together and are narrower.

Tab. 2: General measurements of selected specimens of ? *Endocostea coxi* (REYMENT, 1955)

Specimen	α	β	H	L	HA	NA	S	B
A-14	162 °	101°	30,50	52,00	53,80	43,50	47,00	——
A-17	——	75°	47,20	61,00	63,20	48,50	0,00	22,40
A-18l	153°	82°	55,20	93,40	83,20	62,00	40,20	18,50
A-18r	154°	87°	29,00	45,00	36,50	38,00	20,00	18,50
B-7	121°	89°	33,50	34,50	37,50	34,00	25,60	17,10
B-9	——	82°	29,00	32,80	37,50	32,20	25,20	14,20
B-28d	170°	101°	40,90	66,40	55,50	52,50	16,50	——

The umbo is recurved towards the hinge line. When the endocostean sulcus is present it is relatively deep and long - it is generally present on those specimens that have coarser ribs. The hinge line on well-preserved specimens is longish and straight, but on the anterior side of the umbo no auricle seems to be developed.

The main variability seen in *Endocostea coxi* is the number of commarginal rugae in the middle part of the valves: on some specimens 3 strong rugae per cm growth axis are observed, on others the rugae are much less pronounced and narrower ranging up 6-7 to per cm growth axis. Also visible is that rugae of the Nigerian *E. coxi* are not continuous from one side of valve to the other.

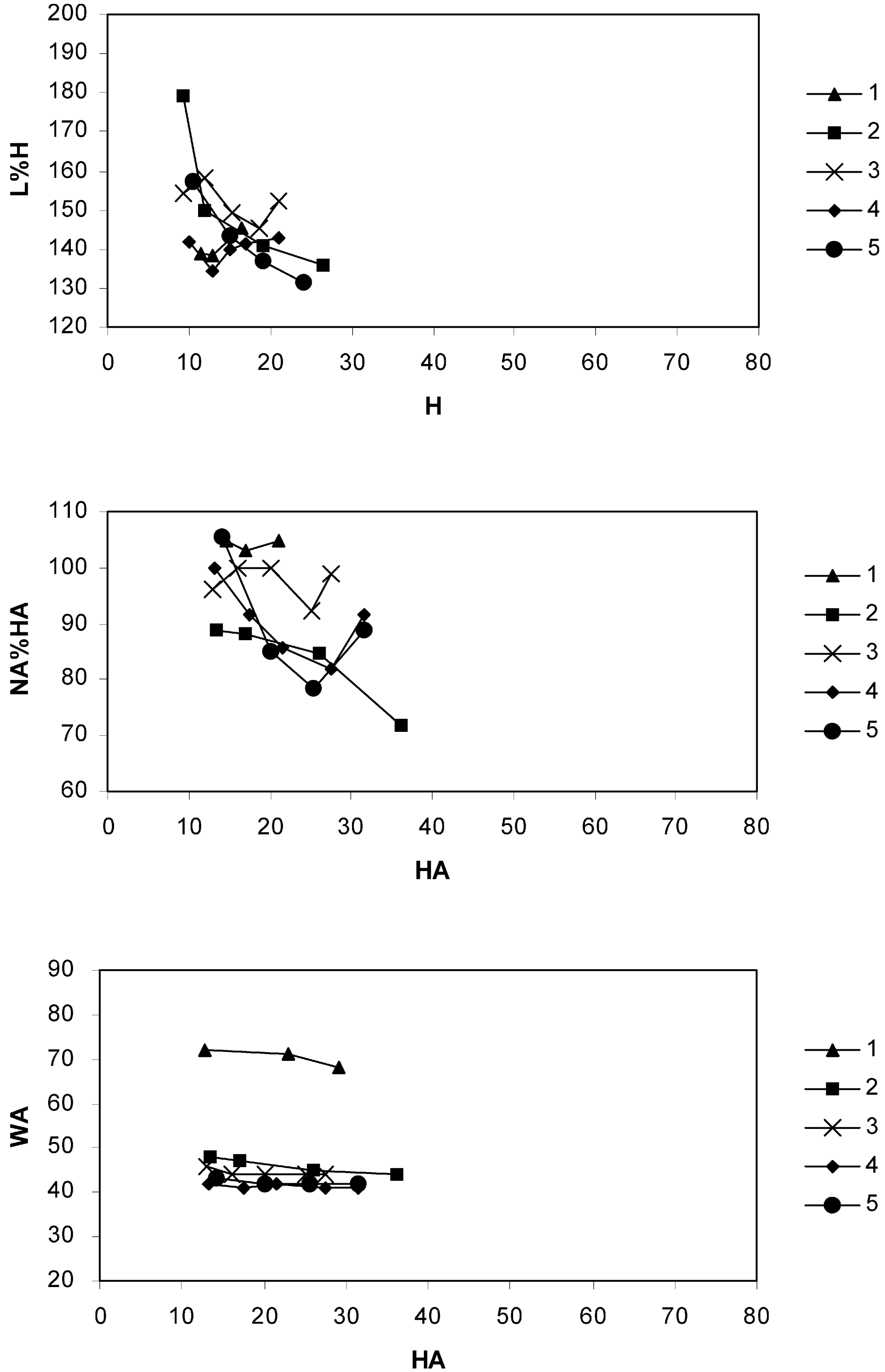


Fig. 4: Ontogenic measurements of right valves of selected specimens of ? *Endocostea coxi* (REYMENT, 1955). Specimens plotted: 1) A17, 2) A18, 3) B7, 4) B9, 5) B28d.

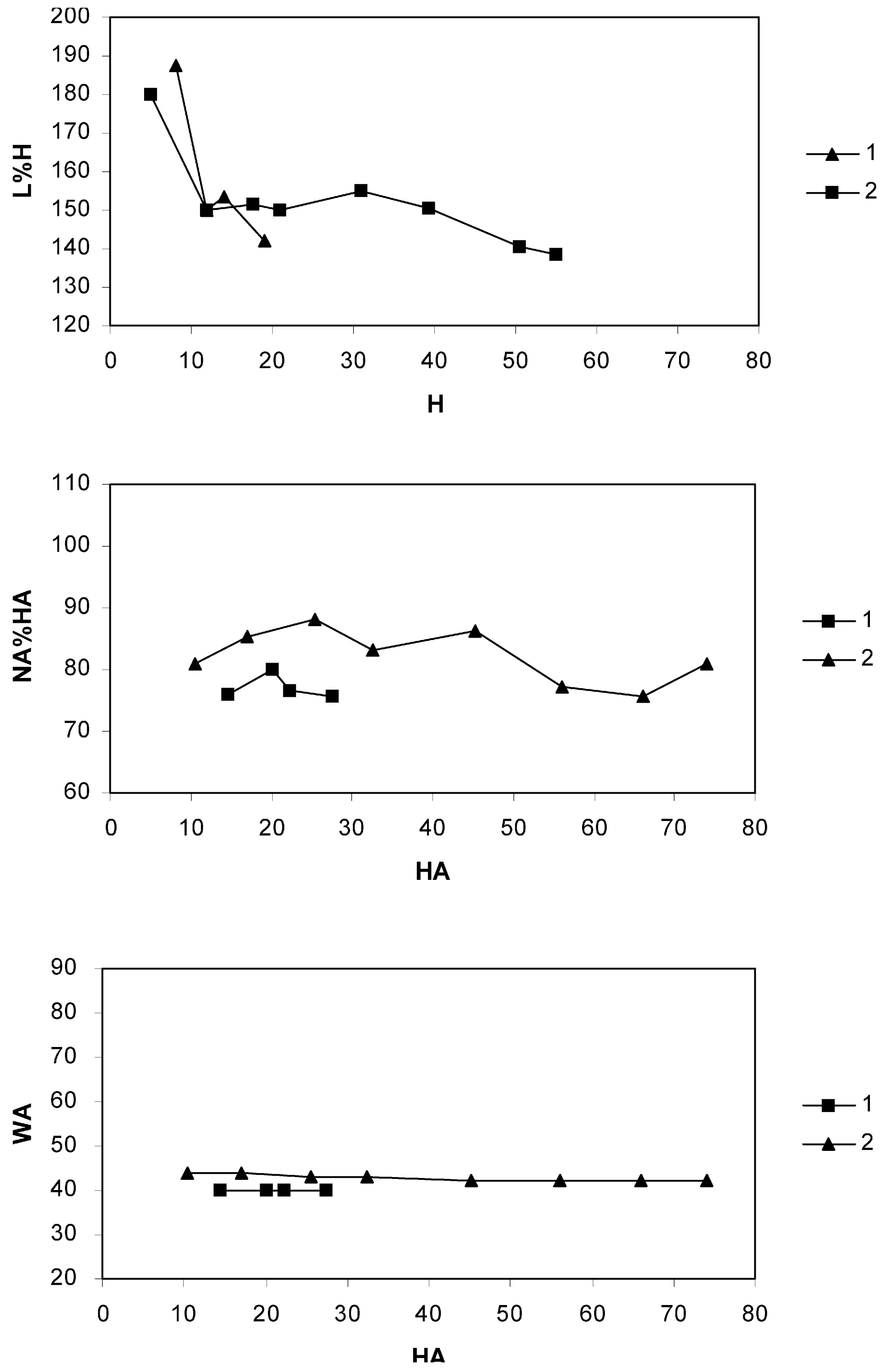


Fig. 5: Ontogenic measurements of left valves of selected specimens of ? *Endocostea coxi* (REYMENT, 1955). Specimens plotted: 1) A14, 2) A18.

V a r i a b i l i t y: the commarginal rugae are not always equally wide:

- on those specimens where they are wide the number of such rugae in the first 2 cm starting from the umbo varies between 10 and 12 (A13 = 10, B4 = 11, B9 = 11, B11 = 11, B28 = 12).
- when the sulcus is not developed and the rugae are more developed and the ribs are fine we can get as many as 19 in the first two cm starting from the umbo.

S y n o n y m y: REYMENT (1955b: 140) in the original description of *Inoceramus coxi* mentioned the presence of radial riblets. We consider that those "riblets" are part of the interior shell structure and not of the external shell ornamentation.

The American specimens from the Nacatoch Sands in Arkansas of *Endocostea coxi* discussed and illustrated by WALASZCZYK et al. (2001) are not very well preserved and the differences between these specimens and *E. typica* (WHITFIELD, 1880) are not very obvious. In the synonymy of WALASZCZYK et al. 2001 it is suggested that the taxon occurs in Libya. The figures in TRÖGER & RÖHLICH (1991) do not show this convincingly. On the Nigerian specimens of *E. coxi* studied by us radial lines are present (as mentioned by WALASZCZYK et al. 2001 for American specimens) occasionally but as stated above it is a structure inside the valve and not on the outside layers.

C o m m e n t s: Unlike what MORRIS (1995) stated, the publication year of *Inoceramus coxi* is 1955 (and not 1958). Furthermore REYMENT (1955b: pl. 3, figs. 3, 5, 6) does not illustrate inoceramids. MORRIS (1995: pl. 1, fig. 4) shows a small incomplete specimen that is not really specifically identifiable.

D i s t r i b u t i o n: *Endocostea coxi* is a taxon only found in a few Tethyan Maastrichtian localities - in Nigeria, (in Auchi and near Calabar) and possibly in the Arabian Peninsula, and the USA.(?)

Cataceramus HEINZ, 1932

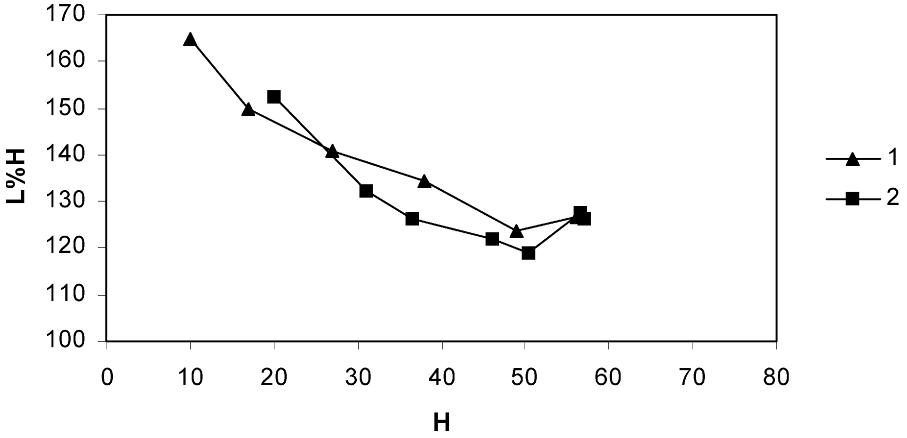
Type species: *Inoceramus balticus* BÖHM, 1907

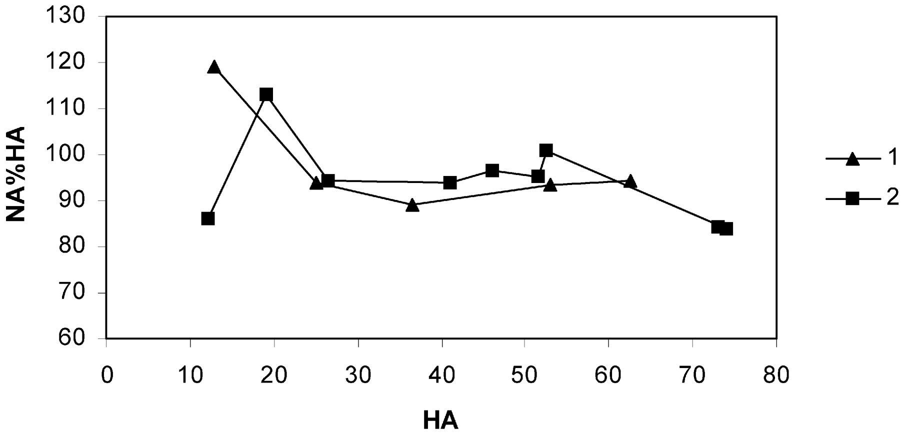
Cataceramus balticus (BÖHM, 1907)

Tab. 3 ; Fig. 6; Pl. 5, fig. 1

v. 1835	*Inoceramus Crippsi* MANT. – GOLDFUSS: 110, pl. 112, fig. 4b (non pl. 112, fig. 4a, c-d).
* 1907	*Inoceramus balticus* – J. BÖHM: 114.
p.p.1909	*Inoceramus balticus* nov. sp. – J. BÖHM : 47, pl. 11, figs. 2, 2a (non pl. 12, fig. 1 = *C. baltica marcki* GIERS, 1964)
.1964	*Inoceramus balticus balticus* J. Böhm – GIERS: 238, pl. 1, figs. 2-4.
.1967	*Inoceramus (Endocostea) balticus* J. Böhm – SEITZ : 67, pl. 6, figs. 1, 2; pl. 7, figs. 1, 2; pl. 8, figs. 1, 2; pl. 10, fig. 1; pl. 12, figs. 1, 2.
?1986	*Inoceramus (Endocostea) balticus* cf. *balticus* – LOPEZ: 237, pl. 1, fig. 19.
. 1997	*Cataceramus balticus* (Böhm, 1907) – WALASZCZYK :18, pl. 12, figs.1, 2, 4, ? 5.

L e c t o t y p e: Specimen designated by GIERS (1964: 238) and figured by BÖHM 1909 (pl. 11, fig. 2) and previously figured by GOLDFUSS (1835: pl. 112, fig. 4b) as *Inoceramus Cripsii*. The original is housed in the Goldfuss Museum, Paläontologisches Institut, Rheinische Friedrich Wilhelms Universität, Bonn, Germany.





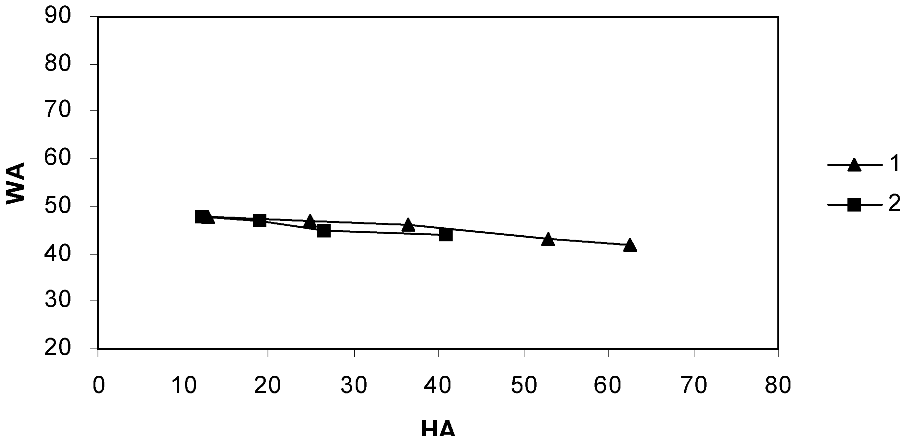


Fig. 6: Ontogenic measurements of the studied specimen, number D-1, of *Cataceramus balticus* (BÖHM, 1907). Legend: 1) right valve of D1, 2) left valve of D1.

Locus typicus and stratum typicum: Dülmen, Westfalen, Upper Santonian (fide GIERS 1964: 240); in SEITZ (1965, 1967), KAPLAN et al. (1996) and WALASZCZYK (1997) the age of these strata is considered as Campanian.

Material: one specimen from locality 77/46 near Calabar (Cross River State, Nigeria).

Description: The unique specimen does not warrant a detailed description. The single specimen is a typical *Cataceramus balticus* as illustrated by the lectotype of the species. It is of medium size (Table 3) and its ontogenetic growth (Fig. 6) shows the typical pattern of the species. The commarginal rugae are ovate. The older parts of the juvenile stages show at 41.0 mm in the right and at 32.5 mm in the left valve from the umbo along the growth axis, the beginning of a well developed endocostean sulcus that almost always continues unto the adult stage ranging in width from 5.0 to 8.2 mm. The width of the interrugae spaces ranges up to 7.2 mm in the adult stages.

Tab. 3: General measurements of studied specimen of *Cataceramus balticus* (BÖHM, 1907)

Specimen	α	β	H	L	HA	NA	S
D-1L	112°	92°	63,00	115,50	104,00	79,90	93,00
D-1R	112°	92°	63,00	111,50	109,90	97,00	93,00

Discussion: Specimen BM L82966 from the Maastrichtian of the Afikpo district (Nigeria), figured in REYMENT (1955b: pl. 2, fig. 5) as "*Inoceramus bantu* (RIEDEL) ex HEINZ", resembles C*ataceramus balticus* and our specimen D1, though it must be noted that the incompleteness of REYMENT's specimen gives the impression that it is much more elongated than it actually was.

The "Coniacian" specimens of *I. bantu* REYMENT (ibid.) mentioned are undoubtedly something totally different (see also SORNAY 1957).

Occurrence: *Cataceramus balticus* is very widely distributed in Campanian strata (see also WALASZCZYK, 1997).

Palaeogeography

(A.V. DHONDT & G. LÓPEZ)

Trochoceramus ianjonaensis (SORNAY, 1973) is mainly known from African Lower Maastrichtian outcrops – Madagascar, E. Nigeria, Libya, Tunisia, France (Cotentin) and possibly from Spain (N. Spain – Pyrenees) (Fig. 7).

Similar, if not identical distributions are found in some other Maastrichtian bivalves: such as the pectinids *Merklinia palassoui* (LEYMERIE, 1851) [= *M. catalaunica* (VIDAL, 1921) = *M. perornata* (COTTREAU, 1922)] which occurs from Cuba to the Arabian peninsula, and Madagascar, North and South of the Pyrenees, Algeria and Egypt (DHONDT 1992) and also *Dhondtichlamys acuteplicata* (ALTH, 1850) which occurs from Egypt, Israel, the Crimea, Mangyshlak (?), Poland, W.Ukraine to Maastricht (DHONDT 1992).

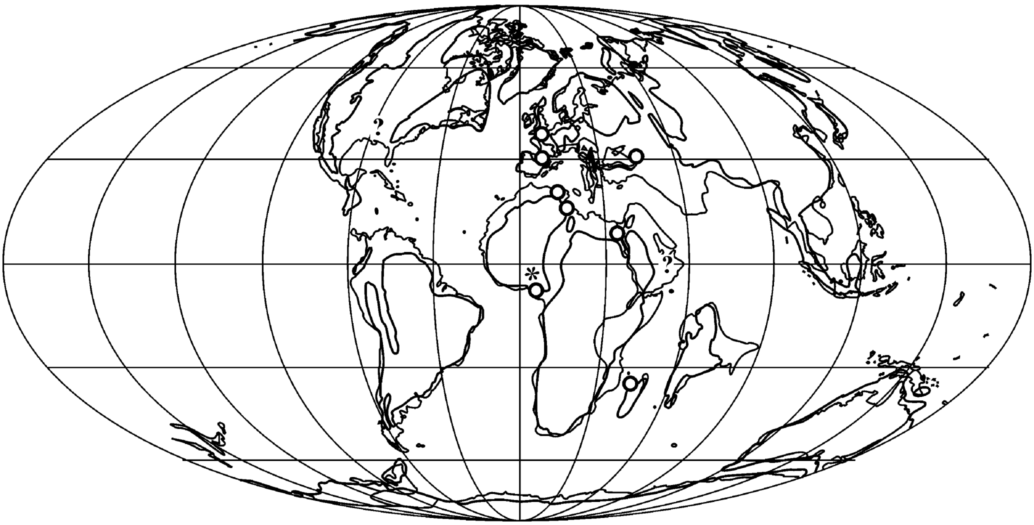


Fig. 7: Geographical distribution of *Trochoceramus ianjonaensis* and ? *Endocostea coxi* on a palaeogeographical reconstruction of the world 70 Ma ago (SMITH et al. 1995). circle: marks *Trochoceramus ianjonaensis* occurrences; asterisk: marks certain occurrence of ? *Endocostea coxi*; question mark: marks occurrences of ? *Endocostea coxi* in literature that do not totally convince the authors.

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Plate 1

Trochoceramus ianjonaensis **(SORNAY, 1973)**

Fig. 1: Left valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/1 (nºA58).

Fig. 2: Right valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/2 (nºA50).

Trochoceramus garridoi **(BATALLER, 1947)**

Fig. 3: Holotype, right valve. – middle Maastrichtian of the Sierra del Coscollet [Colladita en el origen del Barranco del Tozal de Colomina, al S. del río Sallent y a 1.400 metros al S.O. de la Ermita de San Miguel. Coll de Nargó (Lérida)], Spain (sheet Oliana 291). – Museo Geominero (IGME), Madrid, nº 1180C.

The scale bars on the plates represent 1 cm.

All specimens, except plate 1, fig. 3, are deposited in the Geologische Bundesanstalt, Vienna, Austria (GBA). All specimens from Nigeria were collected by H. Lobitzer in 1976-77.

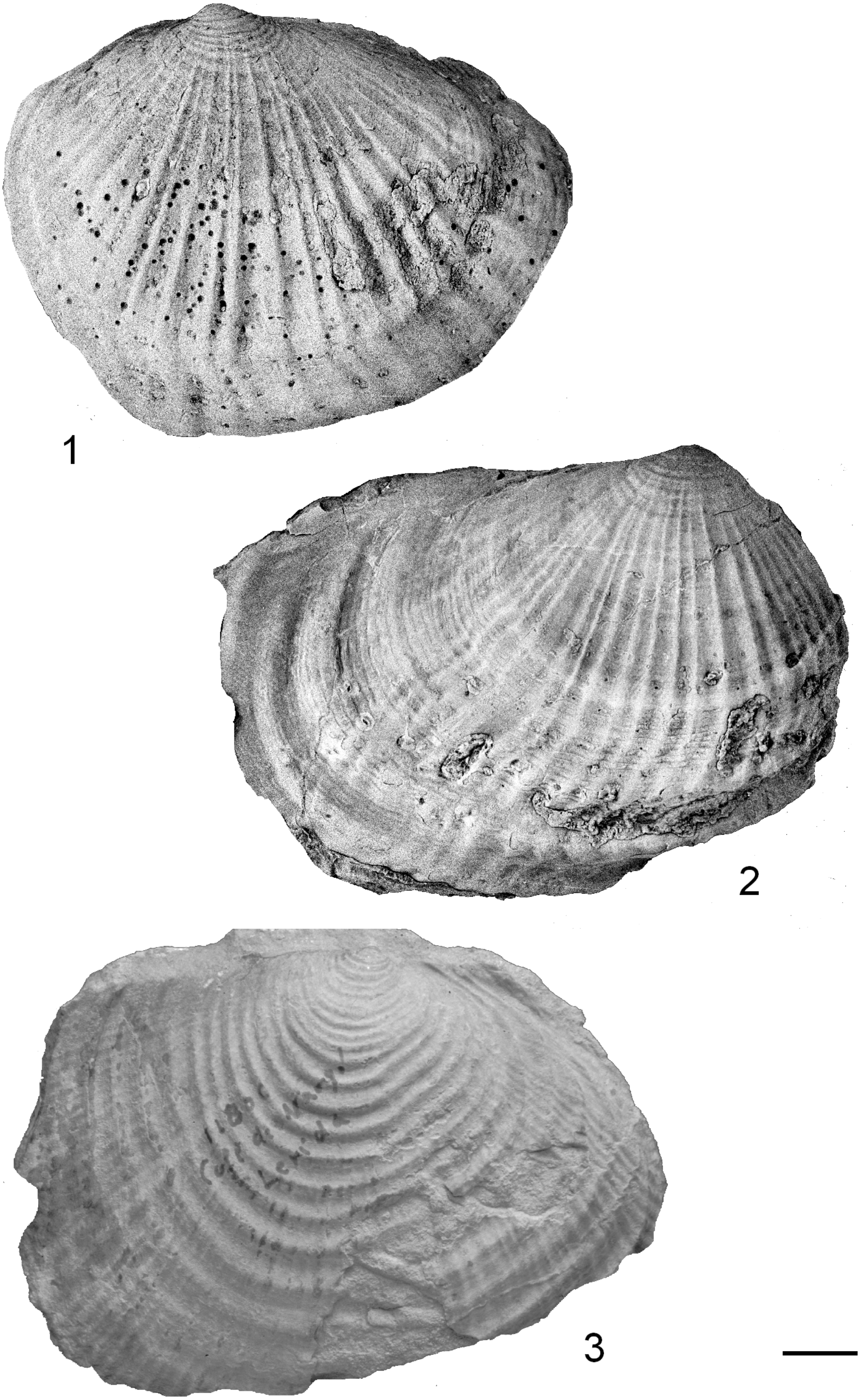
1
2
3

Plate 2

Trochoceramus ianjonaensis **(SORNAY, 1973)**

Fig. 1: ? Left valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/3 (nº A59).

Fig. 2: Right valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/4 (nº B20).

Fig. 3: Left valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/5 (nº A48).

Fig. 4: Right valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/6 (nº A24).

Fig. 5: Left valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/7 (nº B23).

The scale bars on the plates represent 1 cm.

All specimens are deposited in the Geologische Bundesanstalt, Vienna, Austria (GBA). All specimens from Nigeria were collected by H. Lobitzer in 1976-77.

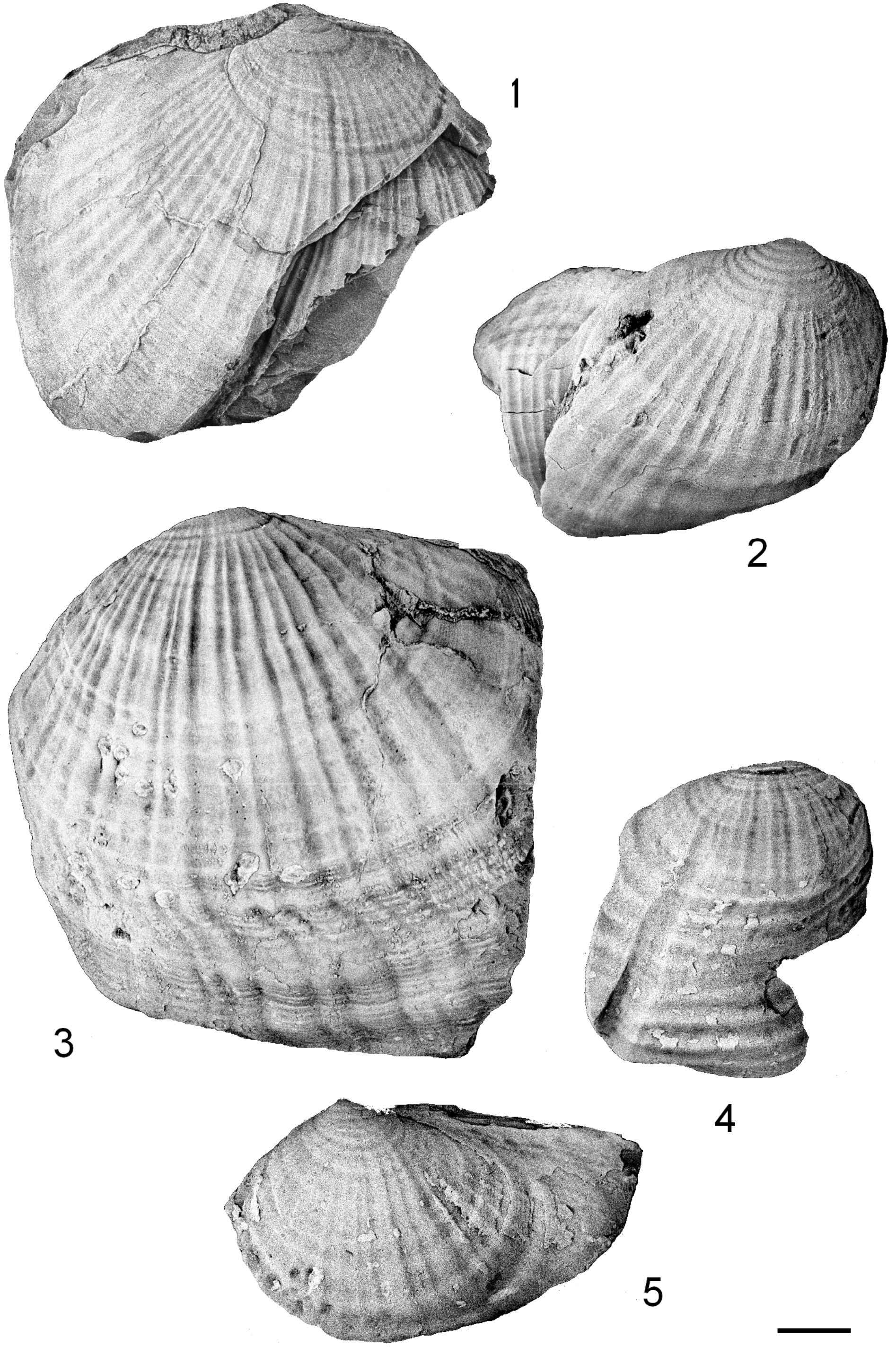
1
2
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Plate 3

Trochoceramus ianjonaensis **(SORNAY, 1973)**

Fig. 1: Left valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/8 (nº A35).

Fig. 2: Right valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/9 (nº B8).

Fig. 3: Left valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/10 (nº A51).

Fig. 4: Right valve. – Lower Maastrichtian, from Odukpani near, Cross River State, Nigeria. – GBA 2004/22/11 (nº A46b).

The scale bars on the plates represent 1 cm.

All specimens are deposited in the Geologische Bundesanstalt, Vienna, Austria (GBA). All specimens from Nigeria were collected by H. Lobitzer in 1976-77.

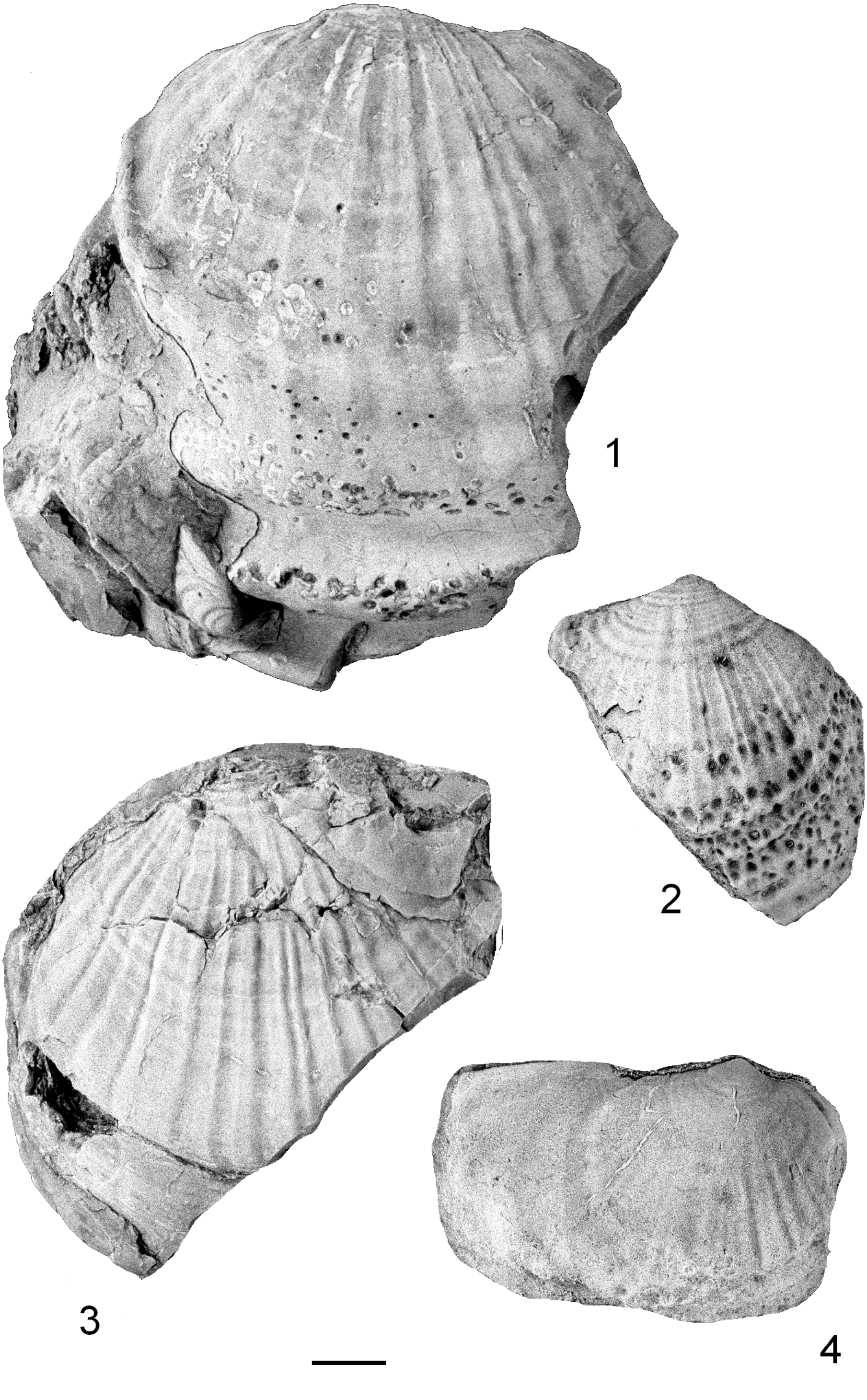
1
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Plate 4

***? Endocostea coxi* (Reyment, 1955)**

Fig. 1: Right valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/12 (nº A17).

Fig. 2: Right valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/13 (nº B 9).

Fig. 3: Left valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/14 (nº A 14).

Fig. 4: Left valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/15 (nº A 19).

Fig. 5: Left valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/16 (nº B 11).

Fig. 6: Left valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/17 (nº B 10).

Fig. 7: Right valve. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/18 (nºA12).

The scale bars on the plates represent 1 cm.

All specimens are deposited in the Geologische Bundesanstalt, Vienna, Austria (GBA).

All specimens from Nigeria were collected by H. Lobitzer in 1976-77.

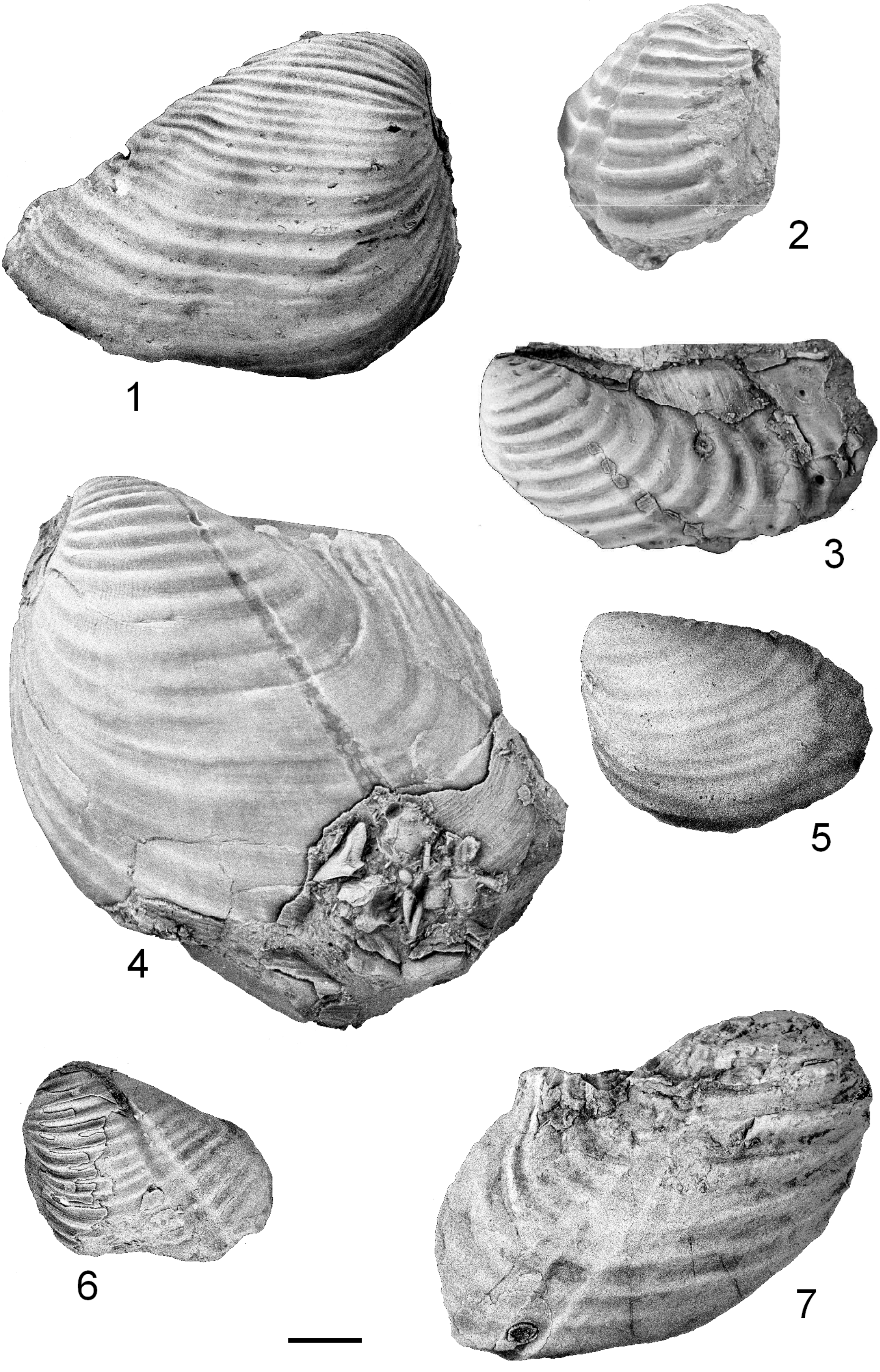
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Plate 5

Fig. 1: ***Cataceramus balticus* (BÖHM, 1907)**, bivalved specimen. – From Odukpani, Cross River State, Nigeria. – GBA 2004/22/19 (nº D1).

Fig. 2: ***Trochoceramus ianjonaensis* (SORNAY, 1973)**, fragment showing growth lines obliquely intersecting rugae. – Lower Maastrichtian, from Odukpani, Cross River State, Nigeria. – GBA 2004/22/20 (nºA28).

The scale bars on the plates represent 1 cm.

All specimens are deposited in the Geologische Bundesanstalt, Vienna, Austria (GBA). All specimens from Nigeria were collected by H. Lobitzer in 1976-77.