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Middle Cenomanian ammonites from the Odukpani Formation, Calabar Flank, Cross River State, southeastern Nigeria

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10 Text-Figures, 1 Table, 13 Plates

Ammonites
Cenomanian
Odukpani Formation
Calabar Flank
Cross River State
Nigeria

Contents

Abstract

The Middle Cenomanian part of the Odukpani Formation in exposures between Odukpani and Itu, Calabar Flank, Cross River State, Nigeria, yielded abundant ammonites. The faunas can be correlated with the *Turrilites costatus* and *Turrilites acutus* subzones of the widely recognized *Acanthoceras rhotomagense* Zone, and are dominated by species of *Cunningtoniceras*. The taxa that are present, in additional to the index *Turrilites*, are: *Damesites africanus* sp. nov., *Forbesiceras obtectum* (SHARPE, 1855), *Forbesiceras* sp., *Cunningtoniceras meridionale* (STOLICZKA, 1864), *C. alatum* (ZABORSKI, 1985), and *Calycoceras* (*Gentoniceras*) group of *gentoni* (BRONGNIART, 1822).

Eine Ammonitenfauna des mittleren Cenomaniums der Odukpani-Formation, Calabar Flank, Cross River State, Südostnigeria

Zusammenfassung

Eine individuenreiche Ammonitenfauna des mittleren Cenomaniums wird von Aufschlüssen der 1976 und 1977 im Bau befindlichen Straße zwischen Odukpani und Itu, Calabar Flank, Cross River State, Nigeria, beschrieben. Die von *Cunningtoniceras* div. sp. dominierte Fauna kann mit der *Turrilites costatus*- und der *Turrilites acutus*-Subzone der weithin anerkannten *Acanthoceras rhotomagense*-Zone korreliert werden. Zusätzlich zu den erwähnten *Turrilites* sp. konnten folgende Taxa nachgewiesen werden: *Damesites africanus* sp. nov., *Forbesiceras obtectum* (SHARPE, 1855), *Forbesiceras* sp., *Cunningtoniceras meridionale* (STOLICZKA, 1864), *C. alatum* (ZABORSKI, 1985) und *Calycoceras* (*Gentoniceras*) ex gr. *gentoni* (BRONGNIART, 1822).

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Introduction

In 1976 and 1977 Harald Lobitzer, working in close cooperation with the geologists of Calabar Cement Company (Calcemco), carried out extensive fieldwork on the "Calabar Flank" (MURAT, 1972) in the wider environs of the Mfamosing limestone quarry. The goal of these investigations was prospecting for raw material commodities suitable for cement production. Special focus was put not only on limestone, but also on supplementary materials such as sand, clay, marl, shale, bauxite and lateritic soils. They supply the bulk of the silica, alumina and ferric oxide for blending the desired cement-clinker composition, which in practice is determined by the locally available raw materials making up the bulk of the cement raw meal. Haulage costs are also a significant factor in view of the large quantities of materials used in cement production.

At the time of the stay of Harald Lobitzer with Calcemco, a new road with excellent fossiliferous roadcuts was in construction. This A4-1 road branches off from the A4 highway about 25 km North of Calabar, respectively north of New Netim village (about 7 km north of Odukpani) to Itu and Ikot Ekpene in western direction (Text-Fig. 1). The distances to the fossiliferous exposures on the A4-1 in direction to the A342 highway were measured from this junction.

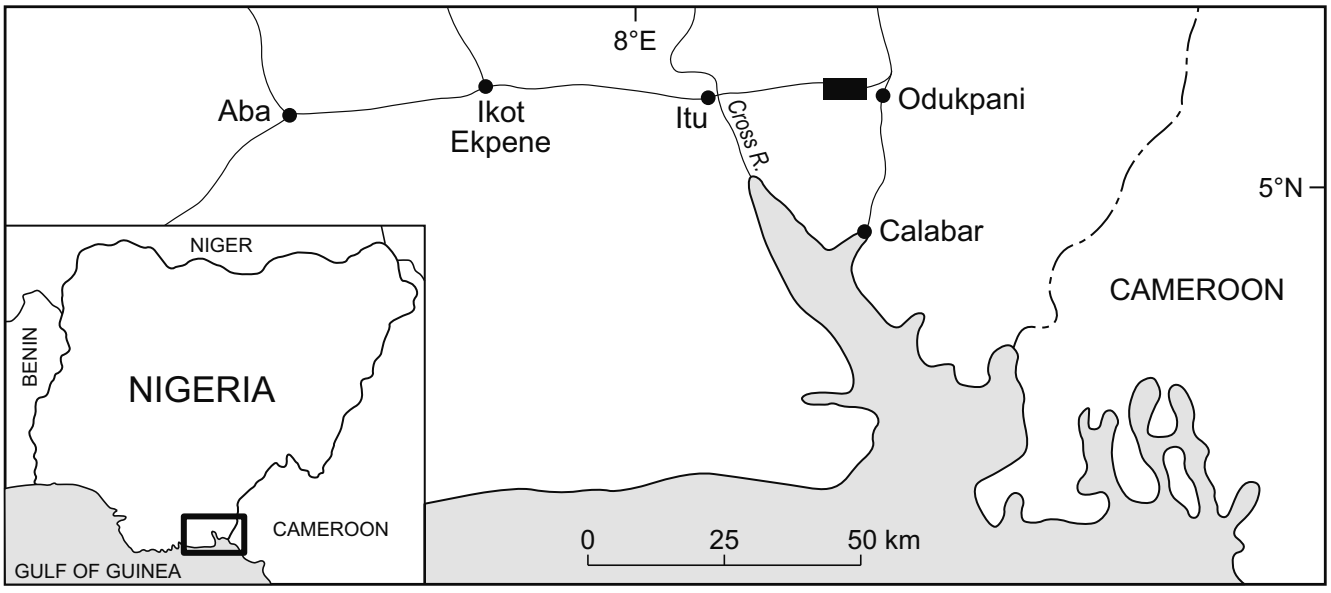
During construction the A4-1 road was informally designated as the "Odukpani-Itu road" or "RCC-road" the latter named after the "Reynolds Construction Company". For several kilometers along the route, a highly fossiliferous, but stratigraphically incomplete sequence was well exposed in the embankments on both sides of the road (Text-Fig. 2). Up to about road-km 5,5 the exposures yielded Cenomanian macrofaunas of the Odukpani Formation. Further to the West, progressively younger exposures in the Nkporo Formation yielded rich Campanian–Maastrichtian faunas (ZABORSKI, 1982, 1983, 1985; LÓPEZ et al., 2004). Macro- and microfossil samples were obtained during sampling for technological investigations in connection with appraisal of the sequence as a potential source of raw materials for the production of cement.

The Odukpani Formation

The term "Odukpani Formation" was coined by REYMENT (1955a). In this and several following papers (e.g. REYMENT, 1955b, 1965), he recorded Cenomanian and Turonian ammonites from the formation. Subsequently several papers dealt with the micropalaeontology of the Odukpani Formation, and a type section was described by DESSAUVAGIE (1972). It consists predominantly of grey shales and (sandy) marls, with numerous thin limestone and/or (arkosic) sandstone intercalations. Besides molluscs, vertebrate bones (? mosasaurids) occur in some outcrops; they have not been collected. REYMENT (1965) considers the sediments of the Odukpani Formation as typical nearshore deposits, KOGBE (1989a, b) follows his opinion, while FAYOSE & DESSAUVAGIE (1976) wrote about a "*shallow water open marine depositional environment*".

As in the Eze-Aku Shales from the surroundings of the Mfamosing quarry, all our samples of the Odukpani Formation were barren of calcareous nannofossils (HERBERT STRADNER, Geologische Bundesanstalt, Vienna). However, as in the coarse grain residues of our washed samples from the Eze-Aku Shales from the surroundings of the Mfamosing quarry, the characteristic foraminifer *Thomasinella punica* is also omnipresent in the Odukpani Formation.

In a previous contribution (KENNEDY & LOBITZER, 2019), we demonstrated that the hardground at the top of the Mfamosing Limestone yielded an ammonite fauna indicative of the lower Lower Cenomanian *Neostlingoceras carcitanense* Subzone fauna of the widely recognised *Mantelliceras mantelli* Zone. ZABORSKI (1985) had previously demonstrated the presence of Lower Cenomanian to Lower Turonian ammonite faunas in the Odukpani Formation in cuttings on the Calabar-Ikot Ekpene road. The Middle Cenomanian faunas he described have elements in common with what is described below, but 30 years on from his account, the material before us provides additional information on species present, including new records that reflect the progress made on Cenomanian stratigraphy and ammonite fau-



Text-Fig. 1.
Locality map, after LÓPEZ et al. (2004). Black rectangle indicates area of examined road outcrops.

Text-Fig. 2.
Outcrop on Odukpani-Itu-Road, km 4.

nas in the intervening years. The material, from cuttings on the Odukpani-Itu road (Text-Fig. 1–3), becomes progressively younger from east to west, and can be correlated with the standard zonation recognized in Western Europe and across the north side of the Tethys (Tab. 1). The faunas correspond to the lower Middle Cenomanian *Acanthoceras rhotomagense* Zone, the critical markers being the first occurrences of subzonal indices *Turrilites costatus* LAMARCK, 1801, and its successor, *Turrilites acutus* PASSY, 1832. The sequence of faunas and localities are dated in these terms below.

The faunas from km 3.8 (south side), km 3.8–4.2 (loose specimen), km 4 (north side), km 4 (south side), km 4.5 and km 6.1 correspond to faunas 3, 4, 5 and ?6 in ZABORSKI (1985: Fig. 2), and are as follows:

Km 2.8: *Damesites africanus* sp. nov: not dated.

Km 3.8: *Forbesiceras* sp. indet, group of *largilliertianum* (D'ORBIGNY, 1841), *D. africanus* sp. nov., *Cunningtoniceras meridionale* (STOLICZKA, 1864), *Turrilites costatus* LAMARCK, 1801. Middle Cenomanian, *costatus* Subzone.

Km 4.0: *D. africanus*, *Forbesiceras beaumontianum* (SHARPE, 1853), *Cunningtoniceras meridionale*, *Cunningtoniceras alatum* (ZABORSKI, 1985), *Turriites acutus*. Middle Cenomanian, *acutus* Subzone.

Km 4.5: *Cunningtoniceras alatum*, *Calycoceras* (*Gentoniceras*) sp., group of *gentoni* (BRONGNIART, 1822). Middle Cenomanian, *acutus* Subzone inferred.

Km 5.5: *Forbesiceras* sp., Middle or lower Upper Cenomanian.

Text-Fig. 3.
? Mosasaurid bones on Odukpani-Itu-Road, km 4.

SUBSTAGE	ZONE	SUBZONE
Middle Cenomanian	*Acanthoceras jukesbrownei*	
	Acanthoceras rhotomagense	*Turrilites acutus* *Turrilites costatus*
	Cunningtoniceras inerme	

Tab. 1.
Middle Cenomanian ammonite zones and subzones recognized in Western Europe.

Conventions

Dimensions are given in millimeters: D = diameter; Wb = whorl breadth; Wh = whorl height; U = umbilicus; c = costal dimension; ic = intercostal dimension. Figures in parentheses are dimensions as a percentage of the diameter. The suture terminology is that of KORN et al. (2003): E = external lobe; A = adventive lobe (= lateral lobe, L, of KULLMANN & WIEDMANN, 1970); U = umbilical lobe; I = internal lobe.

Repositories of specimens

BMNH: The Natural History Museum, London.

GBA: Geologische Bundesanstalt, Vienna.

MNHP: Laboratoire de Paléontologie of the Muséum Nationale d'Histoire Naturelle, Paris.

Systematic Palaeontology

Order Ammonoidea ZITTEL, 1884
Suborder Ammonitina HYATT, 1889
Superfamily Desmoceratoidea ZITTEL, 1895
Family Desmoceratidae ZITTEL, 1895
Subfamily Desmoceratinae ZITTEL, 1895
Genus *Damesites* MATSUMOTO, 1942

(ICZN name no. 1349)

Type species: *Desmoceras damesi* JIMBO, 1894: 172, Pl. 1, Figs. 2, 3: ICZN Opinion 555, 1959.

Damesites africanus sp. nov.

(Pl. 1, Figs. 1–15; Pl. 2, Figs. 1–4)

Types: The holotype is GBA 2016/004/0001, from the levelled surface at the top of the 4 km section (Pl. 2, Figs. 1–4). Paratypes GBA 2016/004/0002–0003 are from the 4 km, section; paratype GBA 2016/004/0004 is from the 4 km section, south side, all *acutus* Subzone; paratypes GBA 2016/004/0005–0007 are from the 2.8 km section, lower Middle Cenomanian.

Additional material: 2.8 km: 3 specimens, lower Middle Cenomanian. 4 km, north side, 9 specimens; 4 km, from the levelled surface at the top of the north side, 2 specimens; 4 km, south side, top of section, 3 specimens, all *acutus* Subzone.

Diagnosis: A large, slightly involute, compressed species of *Damesites*, with three constrictions per half whorl, the constrictions near-straight across the inner and middle flank, concave on the outer flank, and projected strongly forwards on the ventrolateral shoulders and venter, marking the outline of a long apertural ventral rostrum. Venter rounded to feebly fastigiate on internal mould of phragmocone, with a coarse ventral keel on the internal mould of the body chamber.

Dimensions:

	D	Wb	Wh	Wb:Wh	U
GBA 2016/004/0004	39.1 (100)	12.9 (33.0)	17.9 (45.8)	0.72	9.5 (24.3)
GBA 2016/004/0005	44.4 (100)	14.6 (32.9)	19.0 (42.8)	0.77	10.8 (24.3)
GBA 2016/004/0006	56.8 (100)	19.2 (33.8)	26.0 (45.8)	0.74	14.0 (24.6)
GBA 2016/004/0002	59.2 (100)	20.8 (35.1)	27.7 (46.8)	0.75	13.9 (23.5)
GBA 2016/004/0007	64.5 (100)	21.5 (33.3)	27.4 (42.5)	0.78	18.1 (28.0)
GBA 2016/004/0003	66.9 (100)	22.2 (33.2)	30.1 (44.9)	0.74	18.6 (27.9)

Description: All of the specimens described below are internal moulds. Phragmocones (Pl. 1, Figs. 1–15) are slightly involute, with over half of the previous whorl covered. The umbilicus is of moderate width, shallow, with a low, flattened wall, and quite narrowly rounded umbilical shoulder. The whorl section is compressed, the whorl breadth to height ratio varying between 0.72 and 0.78, the greatest breadth below mid-flank, the inner to middle flanks very feebly convex, and subparallel. The convex ventrolateral shoulders converge to an incipiently to feebly fastigiate venter. There are three narrow rectiradiate constrictions per half whorl. They are feebly concave on the umbilical wall and shoulder in some specimens (Pl. 1, Fig. 2), straight (Pl. 1, Fig. 13) to very slightly convex (Pl. 1, Fig. 8) on the inner to middle flank, convex on the outer flank and ventrolateral shoulder, and projected strongly forwards into a long, narrow, acute ventral chevron.

The holotype (Pl. 2, Figs. 1–4) consists of a phragmocone with a maximum preserved diameter of 78 mm, and a 120° sector of body chamber with a maximum preserved whorl height of 56 mm, corresponding to an estimated diameter of 120–130 mm when complete. The umbilical wall is flattened and outward-inclined, the umbilical shoulder narrowly rounded. The whorl section is compressed, with a whorl breadth to height ratio of 0.67, the greatest breadth below mid-flank. The flanks are very feebly convex and subparallel, the rounded ventrolateral shoulders converging to a coarse, strong siphonal keel. There are two constrictions on the body chamber fragment. They are rectiradiate, very feebly convex on the innermost flank, very feebly convex at mid-flank, and strongly concave on the outermost flank, projecting forwards to form a long, narrow, very acute chevron with the siphonal keel at the apex. The constrictions are markedly asymmetric in cross section, with a wide gently inclined adapical side and a narrow, subvertical adapertural side.

The suture is deeply and intricately subdivided, with narrow-stemmed, bifid E/A and A/U2, and trifid A.

Discussion: The species currently assigned to *Damesites* are comprehensively reviewed by NISHIMURA et al. (2010). The present species differs from all of these in its much wider umbilicus and fewer constrictions per whorl. In *Damesites damesi*, the umbilicus comprises 11 % or less of the diameter (MATSUMOTO, 1954: 268); in *Damesite sugata* (FORBES, 1846) the figure is 11.5 % or less (KENNEDY & HENDERSON 1991), compared to up to 28 % in *D. africanus*. The present species is the largest assigned to the genus; the maximum diameter for previously described species is 90–100 mm according to NISHIMURA et al. (2010). It is also one of, if not the earliest species of this typically Turonian to Maastrichtian genus. The only other Cenomanian species described to date is *Damesites laticarinatus* SAITO & MATSUMOTO, 1956 (192, Text-Fig. 1), from Japan (better figures of the holotype, a half whorl fragment, are provided by NISHIMURA et al., 2010: Text-Figs. 6e–g). This species has longitudinal striations, and lacks constrictions.

Occurrence: As for types.

Superfamily Acanthoceratoidea DE GROSSOUVRE, 1894

Family Forbesiceratidae WRIGHT, 1952

Genus *Forbesiceras* KOSSMAT, 1897

Type species: *Ammonites largilliertianus* D'ORBIGNY, 1841: 320, Pl. 95, by the subsequent designation of DIENER (1925: 180).

Forbesiceras obtectum (SHARPE, 1853)

(Pl. 3, Figs. 1–4)

1853 *Forbesiceras obtectum* SHARPE, 1853: 20, Pl. 7, Fig. 4.

1984 *Forbesiceras obtectum* (SHARPE, 1853); WRIGHT & KENNEDY: 94, Pl. 12, Fig. 4; Pl. 14, Figs. 1, 2; Pl. 15, Fig. 4; Text-Figs. 16g–j, 18 (with full synonymy).

1985 *Forbesiceras obtectum* (SHARPE, 1853); ZABORSKI: 22, Text-Figs. 22–25, 29.

2018 *Forbesiceras obtectum* (SHARPE, 1853); KLEIN: 256, 263 (with synonymy).

Type: The holotype, by monotypy, is the original of SHARPE (1853: Pl. 7, Fig. 4), from the 'chalk with siliceous grains' of Chardstock, Devon. It has not been traced.

Material: GBA 2016/004/0008, from the 4 km section, *acutus* Subzone.

Dimensions:

D	Wb	Wh	Wb:Wh	U
104.3 (100)	26.5 (25.5)	61.6 (59.2)	0.43	4.8 (4.6)
125.3 (100)	– (–)	62.1 (49.6)	–	11.9 (9.5)

Description: The specimen retains areas of replaced shell, and a short sector of body chamber. To a diameter of 110 mm approximately the coiling is very involute, the tiny, shallow umbilicus comprising less than 5 % of the diameter. The whorl section is very compressed, with a whorl breadth to height ratio of 0.43, the flanks very feebly convex, with the greatest breadth around mid-flank. The venter is narrow, with crenulated keels at the junction of flank and venter, and a blunt siphonal ridge. To this diameter, ornament consists of delicate crowded prorsiradiate riblets that arise on the umbilical shoulder and are straight and prorsiradiate on the inner to middle flank. They flex back around mid-flank, and may branch. They are at their greatest strength on the adapical part of the outer whorl, and form an obtuse angle with the inner to mid-flank part of the rib. On the outer part of the flank they are strongly rursiradiate, straight to feebly convex, convexity increasing on the outermost flank, where they sweep back and link to minute clavi on the ventral ridges. Delicate transverse riblets on the venter are more numerous than the clavi. The ribbing weakens on the succeeding 90° whorl sector, and on the final adapertural sector, there are widely spaced low riblets on the inner to mid-flank and numerous barely detectable rursirdiate ribs on the outer flank. The umbilical seam egresses markedly on the final sector, the umbilical diameter increasing to 9.5 %

Discussion: The change in strength of flank ornament and increase in umbilical diameter on the adapertural part of the outer whorl shown by this specimen suggests it is an incomplete adult, and by comparison with previously described *Forbesiceras obtectum* from the Odukpani Formation (the second group of ZABORSKI, 1985: 24) is a microconch. The specimen differs from the missing holotype (SHARPE, 1853: Pl. 7, Fig. 4) in lacking a mid-lateral tubercle at the point where rib direction changes; similar individuals, regarded as intraspecific variants of *obtectum*, are known from southern England (KENNEDY, 1971: Pl. 46, Fig. 1), central Tunisia (KENNEDY in KENNEDY & GALE, 2015: Pl. 1, Fig. 9) and elsewhere. Differences from other species are discussed by WRIGHT & KENNEDY (1984: 95).

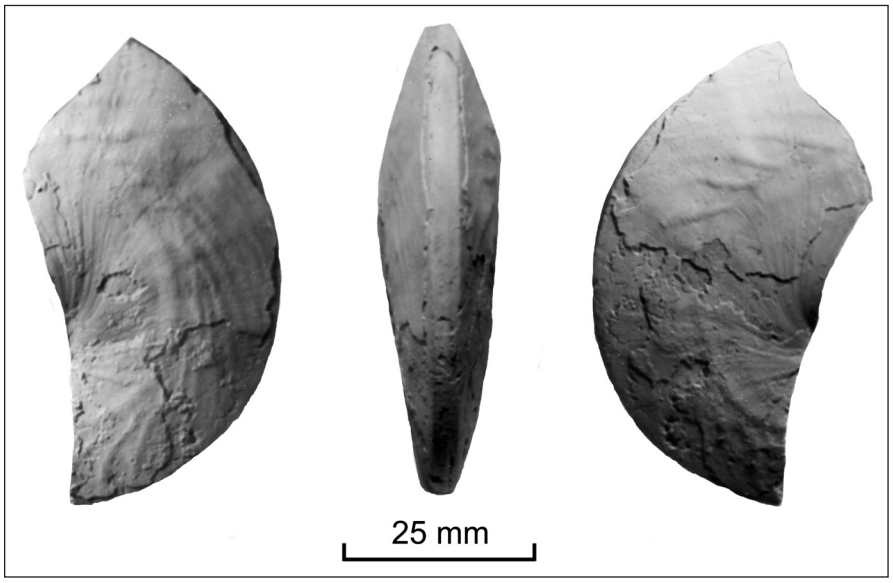
Occurrence: The species is lower Middle Cenomanian where well dated, but may appear already in the Lower Cenomanian. Specimens from central Tunisia referred to as *F.* cf. *obtectum* by KENNEDY in KENNEDY & GALE (2015: 262) may indicate an extension of range into the lower Upper Cenomanian. The geographic distribution extends from southern England to France, Turkmenistan, Algeria, Tunisia, Lebanon, Nigeria and Madagascar.

Forbesiceras sp.

(Text-Fig. 4)

Material: GBA 2016/004/0009, from the 5.5 km exposure, Odukpani Formation, Middle or lower Upper Cenomanian.

Description: The specimen is a well-preserved 180° whorl sector of phragmocone 67 mm in diameter, retaining recrystallized shell. Coiling is very involute, the umbilicus minute. The whorl section is very compressed, with a whorl breadth to height ratio of 0.42, the greatest breadth below mid-flank, the inner flanks very feebly convex, the outer flanks flattened and convergent, the venter narrow, the junction of flanks and venter marked by an incipiently crenulated ridge. There is a blunt siphonal ridge. The inner half of the flanks is ornamented by straight prorsiradiate growth lines only. A blunt spiral ridge separates this area



Text-Fig. 4.
Forbesiceras sp. GBA 2016/004/0009, km 5.4, from the Middle or lower Upper Cenomanian part of the Odukpani Formation between Odukpani and Itu, Cross River State, Nigeria.
All figures are natural size.

from the outer flank, which is ornamented by low, blunt, narrow ribs. At the adapical end of the fragment they are very strongly rursirsdiate and concave, becoming feebly convex and very strongly rursiradiate over the remainder. Some appear to bifurcate.

Discussion: Irregular ornament and the presence of a spiral ridge separating the markedly different inner and outer flank ornament are distinctive. There are some similarities to *Forbesiceras bicarinatum* Szász, (1976: 170, Pls. 1, 2, Pl. 3, Figs. 1, 2; Text-Figs. 1, 2) some specimens of which have a comparable spiral ridge (Wright & Kennedy, 1984: Pl. 14, Fig. 5). Alternatively, it may be no more than an aberrant *F. obtectum*. It is left in open nomenclature here.

Occurrence: As for material.

Family Acanthoceratidae De Grossouvre, 1894
Subfamily Acanthoceratinae De Grossouvre, 1894
Genus *Cunningtoniceras* Collignon, 1937

Type species: *Ammonites cunningtoni* Sharpe, 1855: 35, Pl. 15, Fig. 2, by the original designation of Collignon (1937: 64).

Discussion: This is the most abundant ammonite genus in the present material, with over 150 specimens, most of them fragments. They provide a basis for a development of the analysis of the genus put forward elsewhere (Kennedy in Kennedy & Gale, 2015: 284). Two groups were recognised within the genus: The group of *C. cunningtoni sensu stricto*, where there are fewer outer ventrolateral than siphonal tubercles, and the group of *C. meridionale* (Stoliczka, 1864) where there are equal numbers of outer ventrolateral and siphonal tubercles. This is a very different view from that of previous authors, as noted there: Kennedy (1971) regarded *meridionale* as a variety of *cunningtoni*; Cooper (1973) as a subspecies; Howarth (1985) as a variety; Wright & Kennedy (1987) as a synonym; Matsumoto et al. (1969) as a separate species.

In Western Europe, *Cunningtoniceras inerme* (Pervinquière, 1907) is the index species of the lowest zone of the Middle Cenomanian. Above this level, the *Cunningtoniceras* record is minimal. Wright & Kennedy (1990: 193) writing before the recognition that *Cunningtoniceras* preceded *Acanthoceras* in the record (Robaszynski et al., 1994; Gale, 1995) derived *Cunningtoniceras* from *Acanthoceras*; the reverse is the case (Kennedy in Kennedy & Gale, 2015: 284). Subsequent studies in North Africa (Central Tunisia; Kennedy & Gale, 2015; north-west Algeria: Kennedy & Gale, 2017; South India: Kennedy in Gale et al., 2019) demonstrated that *Cunningtoniceras* flourished in these areas after it had disappeared (temporarily at least) from the north side of the Tethys; the present material, with *Cunningtoniceras* abundant in association with the index species of the *costatus* and *acutus* Subzones of the *rhotomagense* Zone, confirm this.

Cunningtoniceras meridionale (Stoliczka, 1864)

(Pls. 4–7; Text-Figs. 5, 6)

1864 *Ammonites meridionalis* Stoliczka: 76, Pl. 41, Fig. 1.

1985 *Euomphaloceras cunningtoni meridionale* (Stoliczka); Zaborski: 43, Figs. 45, 46 (non Fig. 43 = *C. inerme*).

1985 *Euomphaloceras cunningtoni cunningtoni* (Sharpe); Zaborski: 45, Figs. 47–52.

2015 *Cunningtoniceras meridionale* (Stoliczka, 1864; Kennedy in Kennedy & Gale: 286, Pl. 15, Fig. 3; Pl. 16, Figs. 1, 5; Text-Fig. 22a (with additional synonymy).

Type: The lectotype, by the subsequent designation of Matsumoto et al. (1969: 272), is the original of Stoliczka (1864: 76, Pl. 41, Fig. 1, no. 175) in the collections of the Indian Geological Survey, Kolkata, from the Uttatur Group of Odium, South India.

Material: GBA 2016/004/0010–0012, 0014–0016, from the south side of the 3.8 km section, *costatus* Subzone GBA 2016/004/0013, from the top of the km 4 section, *acutus* Subzone.

Dimensions:

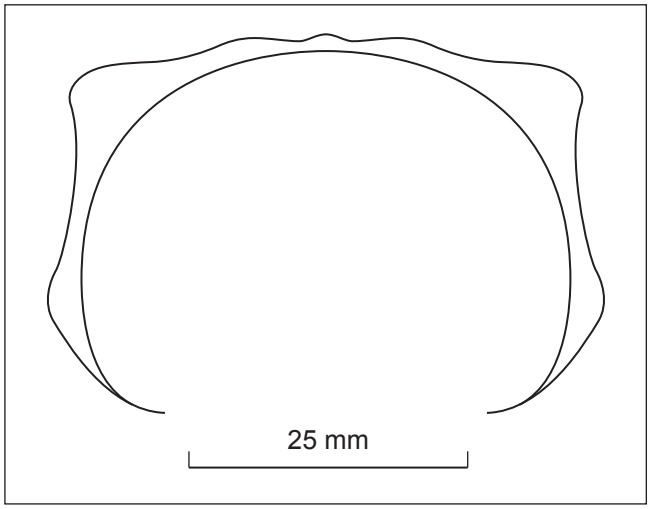
	D	Wb	Wh	Wb:Wh	U
GBA 2016/004/0010 (costal)	170 (100)	91.3 (53.7)	73.9 (43.5)	1.24	61.4 (36.1)

Description: GBA 2016/004/0010 (Pl. 4, Pl. 5, Figs. 1, 2) is an internal mould of a phragmocone 170 mm in diameter. Coiling is very evolute, the umbilical wall feebly notched to accommodate the inner ventrolateral spines of the preceding whorl. The umbilicus comprises 36.1 % of the diameter, and is of moderate depth, with a feebly convex wall and broadly rounded umbilical shoulder. At the greatest preserved diameter, the intercostal whorl section is depressed trapezoidal, with a whorl breadth to height ratio of 1.27, the greatest breadth just outside the umbilical shoulder. The flanks are flattened and convergent, the ventrolateral shoulders broadly rounded, the broad venter very feebly convex. The costal whorl section is trapezoidal-polygonal, with the greatest breadth at the umbilical tubercles, the whorl breadth to height ratio 1.24. There are fifteen primary ribs on the penultimate whorl. They arise at the umbilical seam, and strengthen across the umbilical wall and shoulder, where they develop into strong, narrow bullae. A broad, straight, prorsiradiate rib links to laterally compressed, outwards and upwards directed inner ventrolateral horns. There are 19–20 primary ribs on the outer whorl. They are initially of comparable development on the flank as on the penultimate whorl, with prominent inner ventrolateral horns, but as diameter increases, the horns are transformed into a strengthened angulation on the rib. At the beginning of the outer whorl, the inner ventrolateral horns are linked across the venter by two ribs. A strong transverse rib bears equal, rounded to very feebly clavate outer ventrolateral and siphonal tubercles (Pl. 5, Fig. 1). A second, adapertural rib projects forwards from the inner ventrolateral horn, and then flexes back into a transverse rib with outer ventrolateral and siphonal clavi. This pattern of ventral ornament extends to a diameter of 135 mm (Pl. 5, Fig. 2), beyond which only a single double rib of this type is developed, the pattern at this stage being of predominantly regularly alternating primary ribs and single short intercalated ventral ribs. The siphonal clavi decline progressively and are lost on the adapertural 60° sector of the outer whorl, and the outer ventrolateral tubercles are transformed into an angulation in the rib profile (Pl. 5, Fig. 2).

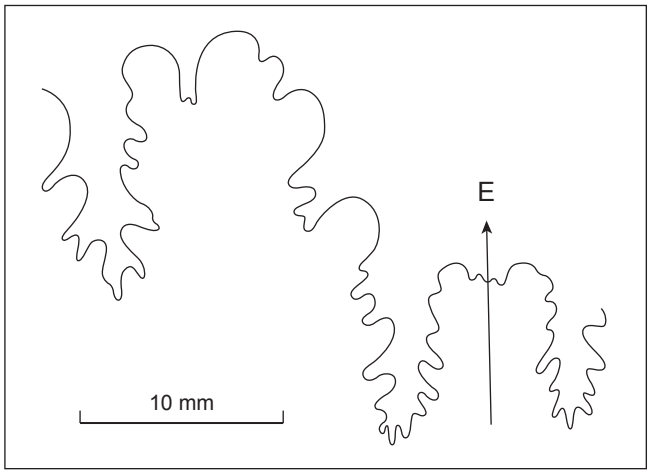
GBA 2016/004/0016 (Pl. 7, Figs. 3, 4) is a body chamber fragment with a maximum preserved whorl height of 69 mm, with comparable ornament to the later growth stages of the previous specimen.

GBA 2016/004/0015 (Pl. 7, Figs. 1, 2) has a maximum measurable whorl height of 60 mm, with stronger inner ventrolateral tuberculation than the previous specimens at the same size.

GBA 2016/004/0011 (Pl. 6) is a 60° whorl sector from the adapical end of an adult body chamber, with a maximum preserved whorl height of 86 mm, corresponding to an estimated diameter of over 200 mm. The convex umbilical wall is inclined outwards. There are four coarse, strong, widely separated primary ribs on the fragment. They are weak on the umbilical wall, but strengthen into feeble bullae, displaced out onto the inner flank. There are well-developed inner ventrolateral tubercles, but the outer ventrolaterals are weak, the venter concave in costal section.



Text-Fig. 5.
Cunningtoniceras meridionale (Stoliczka, 1864), whorl section of GBA 2016/004/0013.



Text-Fig. 6.
Cunningtoniceras meridionale (Stoliczka, 1864), external suture of GBA 2016/004/0013.

GBA 2016/004/0014 (not figured) is a fragment of venter in which the outer ventrolateral tubercles are lost, the ventral development of the ribs flat in costal profile. With an estimated whorl breadth of over 120 mm, the fragment suggests adults of the species may have reached over 220 mm in diameter. All of the above specimens are interpreted as macroconchs.

GBA 2016/004/0012 (Pl. 5 Fig. 3) is the adapical 120° sector of a body chamber. Whereas GBA 2016/004/0010 (Pl. 4) has prominent inner ventrolateral horns at the same whorl height, this specimen has much weaker tubercles in this position, as does phragmocone fragment GBA 2016/004/0013 (Pl. 5, Figs. 4, 5). This latter specimen also shows weakening ventral tuberculation. It is possible that these are fragments of microconchs, but firm evidence is lacking.

A composite partial suture taken from GBA 2016/004/0013 (Text-Fig. 6) shows moderate incision. E/A is very broad and asymmetrically bifid, A is small and bifid.

Discussion: As noted above, *C. meridionale* has equal numbers of outer ventrolateral and siphonal tubercles, whereas in *C. cunningtoni* there are fewer outer ventrolateral than siphonal tubercles. *Cunningtoniceras inerme* (PERVINQUIÈRE, 1907) (see revisions in WRIGHT & KENNEDY, 1987: 194, Pl. 52, Fig. 1; Pl. 53, Fig. 6; Text-Figs. 74, 75, 79; KENNEDY in KENNEDY & GALE, 2015: 284, Pl. 14, Fig. 4; Pl. 15, Fig. 4; Pl. 16, Fig. 7; Pl. 17, Fig. 1; Pl. 20, Fig. 1; KENNEDY in KENNEDY & GALE, 2017: 92, Pl. 6, Figs. 4–7; Pl. 7, Figs. 1–11; Pl. 8, Figs. 1, 2, 5, 6; Pl. 9, Figs. 1, 2, 5, 6) has a ribbed body chamber and does not develop ventrolateral horns. *Cunningtoniceras alatum* (ZABORSKI, 1985), described below, develops a distinctive adult ornament, with enormous compressed ventrolateral horns.

Occurrence: Lower Middle Cenomanian, south India, Hokkaido, Japan, Iran, Morocco, Central Tunisia, Nigeria, Angola, and Bathurst Island, northern Australia.

Cunningtoniceras cunningtoni (SHARPE, 1855)

(Pl. 9, Figs. 9, 10; Pl. 10, Figs. 3, 4)

1855 *Ammonites cunningtoni* SHARPE: 35, Pl. 15, Fig. 2.

non 1985 *Euomphaloceras cunningtoni cunningtoni* (SHARPE); ZABORSKI: 45, Figs. 47–52 (= *C. meridionale*).

2019 *Euomphaloceras cunningtoni* (SHARPE, 1855); KENNEDY in GALE et al.: 229, Pls. 25, 26; Pl. 27, Figs. 1–4; Pl. 37, Figs. 5, 6 (with full synonymy).

Type: The holotype, by monotypy, is BMNH 88704, the original of SHARPE (1855: 35, Pl. 15, Fig. 2), from the Lower Chalk of Upton Scudamore, Wiltshire. It was refigured by WRIGHT & KENNEDY (1987: Text-Figs. 76–77).

Material: GBA 2016/004/0017–0018, *ex situ*, from the Middle Cenomanian part of the Odukpani Formation between Odukpani and Itu.

Description: GBA 2016/004/0017 (Pl. 9, Figs. 9, 10) is 120° whorl sector of an internal mould of a phragmocone with a maximum preserved whorl height of 49 mm. Coiling is evolute, the umbilicus deep, the high umbilical wall very feebly convex, the umbilical shoulder very broadly rounded. The whorl section is depressed, rounded-rectangular in intercostal section, the whorl breadth to height ratio 1.19, with the greatest breadth around mid-flank. The flanks are feebly convex, the ventrolateral shoulders broadly rounded, the venter broad and very feebly convex. There are three primary ribs on the fragment. They arise at the umbilical seam, and are low and broad on the umbilical wall, strengthening progressively and linking to a large umbilicolateral bulla, from which a broad, weak, straight rectiradiate rib links to a massive dorsoventrally flattened inner ventrolateral horn. This is wedge-shaped in ventral view, and links to a weak, blunt, outer ventrolateral clavus. A pair of feeble to near-effaced transverse ribs link the clavi across the venter, and bear a siphonal clavus. Short ventral ribs intercalate between successive primary ribs, and bear feeble siphonal tubercles; there are thus more siphonal than outer ventrolateral tubercles. GBA 2016/004/0018 (Pl. 10, Figs. 3, 4) is a much larger fragment, of body chamber, with a maximum preserved whorl height of 51 mm and a whorl breadth to height ratio of 1.3, the greatest breadth at mid-flank. Two ribs are preserved on the fragment. They are very widely separated, and are broad and coarse, developing into large umbilicolateral bullae. These are linked by a broad, strong, feebly prorsiradiate rib to very large ventrolateral horns. These are directed outwards in a direction normal to the median plane of the body chamber, and have a distinct median groove. The venter is feebly concave between in costal section.

Discussion: Differences from *C. meridionale*, and *C. alatum* are noted above.

Occurrence: Lower Middle Cenomanian, southern England, France, Spain, Germany, Switzerland, Nigeria, Madagascar, Tamil Nadu in south India.

Cunningtoniceras alatum (ZABORSKI, 1985)

(Pl. 8, Figs. 1–28; Pl. 9, Figs. 1–8, 11; Pl. 10, Figs. 1, 2; Pl. 11, Figs. 1–9; Text-Figs. 7–9)

1985 *Euomphaloceras cunningtoni alatum* ZABORSKI, 49, Text-Figs. 53–56.

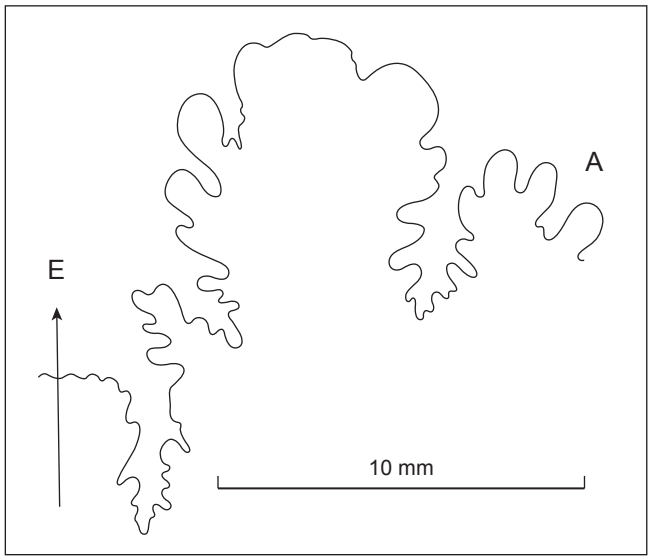
Type: The holotype, by original designation, is BMNH C83479, the original of ZABORSKI (1985: 49, Text-Figs. 53–56), from the Middle Cenomanian part of the Odukpani Formation 30.3 km from Calabar, Cross River State, Nigeria. There are 16 paratypes, BMNH C83108–12, C83480–5, and UIN 485.1–5 in the collections of the Department of Geology of Ilorin University, Nigeria.

Material: GBA 2016/004/0019, km 4; GBA 2016/004/0020, 0021, 0038, 0039, km 4, top of section; GBA 2016/004/0022, 0024–0028, 0030, 0033, km 4, north side; GBA 2016/004/0023, 0029, 0031, 0032, 0035, 0066; GBA 2016/004/0036, south side, top of section; GBA 2016/004/0037, 4.5 km; GBA 2016/004/0040–0041, collected *ex situ*, and numerous additional fragments, all *acutus* Subzone.

Dimensions:

	D	Wb	Wh	Wb:Wh	U
GBA 2016/004/0037 at c	37.7 (100)	22.7 (60.2)	15.8 (41.9)	1.43	12.2 (32.4)
GBA 2016/004/0034 ic	56.6 (100)	25.1 (44.3)	21.6 (38.1)	1.16	17.5 (30.9)
GBA 2016/004/0027 ic	63.8 (100)	30.3 (47.5)	25.8 (40.4)	1.17	22.3 (34.9)
GBA 2016/004/0041 ic	90.6 (100)	40.6 (44.8)	36.0 (39.7)	1.13	33.2 (36.6)
GBA 2016/004/0019 ic	102 (100)	36.1 (35.3)	31.1 (30.5)	1.16	41.8 (41.0)
GBA 2016/004/0019 c	106.5 (100)	51.5 (48.3)	37.4 (35.2)	1.37	41.8 (41.0)

Description: At the smallest diameters seen (34–46 mm: Pl. 8, Figs. 1–13, 16, 17), coiling is very evolute, the umbilicus comprising around 30 % of the diameter, of moderate depth, with a feebly convex, outward-incline wall and broadly rounded umbilical shoulder. The whorl section is slightly depressed in intercostal section, rectangular, with feebly convex flanks, broadly rounded ventrolateral shoulders and a broad, feebly convex venter. There are 6–8 primary ribs per half whorl. They arise at the umbilical seam,

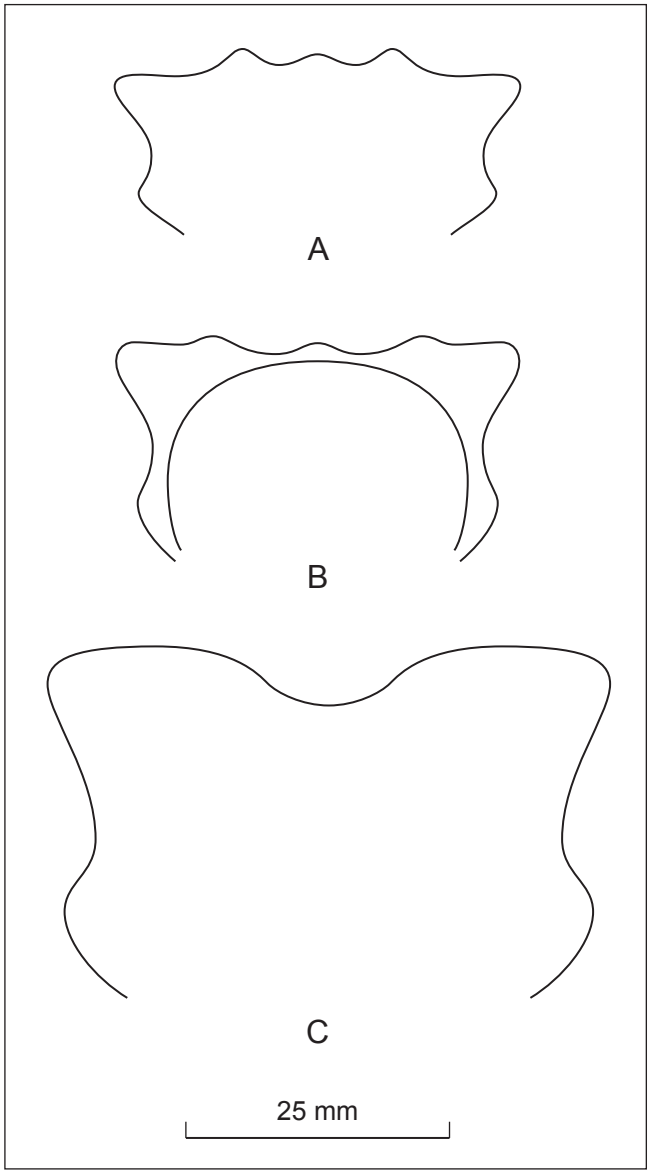


Text-Fig. 7.
Cunningtoniceras meridionale (Stoliczka, 1864), external suture of GBA 2016/004/0036.

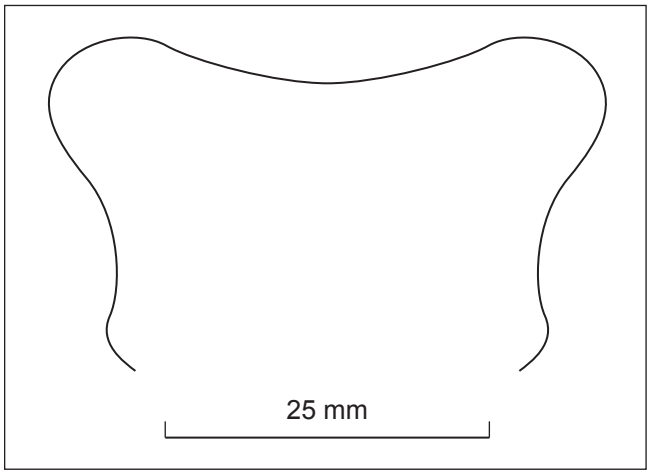
strengthen across the umbilical wall, and develop into strong umbilical bullae. These give rise to single straight, coarse, prorsiradiate ribs that link to strong conical inner ventrolateral tubercles. A strong, feebly prorsiradiate rib links to a strong conical to feebly clavate outer ventrolateral tubercle, the tubercles linked across the venter by a low, broad, transverse rib that bears a subequal feebly clavate siphonal tubercle. The primary ribs are separated by single intercalated ribs that arise on the outer flank, strengthen progressively, and link to outer ventrolateral tubercles with a development similar to that seen on the primary ribs. Larger specimens such as GBA 2016/004/0034 (Pl. 8, Figs. 21, 22), show the intercalated ribs confined to the ventrolateral shoulders and venter, and the beginning of a link developing between the outer ends of the intercalated ribs and the inner ventrolateral tubercles of the primary ribs. This arrangement appears irregularly, and at variable whorl heights, typically around 20 mm.

GBA 2016/004/0027 (Pl. 8, Figs. 25, 26), a phragmocone 64 mm in diameter, has 12 very coarse primary ribs on the outer whorl, the ribs becoming progressively more widely-space on the adapertural half of the outer whorl, the primary and secondary ribs looping across the venter from the inner ventrolateral tubercles. GBA 2016/004/0066 (Pl. 8. Figs. 27, 28) also shows the primary ribs becoming more widely spaced on the adapertural half of the outer whorl, the inner ventrolateral tubercle becoming increasingly prominent. They point outwards, normal to the median section of the shell, a feature well-seen in GBA 2016/004/0038 (Pl. 8, Fig. 14; Text-Fig. 9A) and GBA 2016/004/0039 (Pl. 8, Figs. 18, 19), on most of the outer whorl, but on the adapertural two ribs, they strengthen, and their orientation changes to pointing outwards and upwards (Pl. 8, Fig. 28).

GBA 2016/004/0021 (Pl. 11, Figs. 3, 6) is the adapical 120° sector of an adult body chamber with a whorl height of 25 mm at the adapical end. Three primary ribs are very widely separated, intercalated ribs and siphonal tubercles weaken and efface, leaving primary ribs only on the adapertutral part of the fragment, separated by feeble flank ribs. The primaries have much weaker to effaced umbilical bullae compared to the phragmocone, and the profile of their ventrolateral development changes to a wide, compressed flange, with a deep ventral concavity in the rib profile (Text-Fig. 8C), that is lost on the final rib on the fragment. GBA 2016/004/0036 (Pl. 11, Figs. 5, 9) is a complete adult, 98 mm in diameter, with a 120° sector of body chamber. Intercalated ribs are effaced and lost, and the form of the ventrolateral tubercles is as in the previous specimens on two of the ribs. The final three ribs have progressively weakening and effacing umbilical bullae, and lack ventrolateral tubercles, indicating the specimen to be complete, and a microconch. GBA 2016/004/0019 (Pl. 11, Figs. 1, 7, 8) is a larger specimen, the body chamber 105 mm in diameter. There are six primary ribs on the adapertural half of the penultimate whorl, becoming increasingly wider spaced. On the body chamber, intercalated ribs, present at the adapical end, are lost, and the distinctive ventral ornament develops, as in in GBA 2016/004/0040 (Pl. 10, Figs. 1, 2). These specimens may be incomplete macroconchs. The largest fragments in the present collection



Text-Fig. 8.
Cunningtoniceras alatum (Zaborski, 1985). Whorl sections of A: GBA 2016/004/0038; B: GBA 2016/004/0070; C: GBA 2016/004/0071.



Text-Fig. 9.
Cunningtoniceras alatum (ZABORSKI, 1985). Whorl section of GBA 2016/004/0072.

(GBA 2016/004/0068–0069) have whorl heights of up to 46 mm at the adapertural end, and differ in no significant respects from the holotype body chamber fragment (ZABORSKI, 1985: Text-Figs. 53a, b).

GBA 2016/004/0029 (Pl. 11, Fig. 4) is a fragment from the adapical end of a very small body chamber of a pathological individual, with markedly asymmetric ventral ornament, having suffered non-lethal damage to the mid-ventral region.

The suture (Text-Fig. 7) is moderately incised, with a massive, asymmetrically bifid E/A.

Genus and Subgenus *Calycoceras* HYATT, 1900

(ICZN Generic Name No. 1352)

Type species: By designation under the Plenary Powers (ICZN Opinion No. 557) *Ammonites navicularis* MANTELL, 1822: 198, Pl. 22, Fig. 5 (ICZN Specific Name No. 1633).

Subgenus *Calycoceras* (*Gentoniceras*) THOMEL, 1972

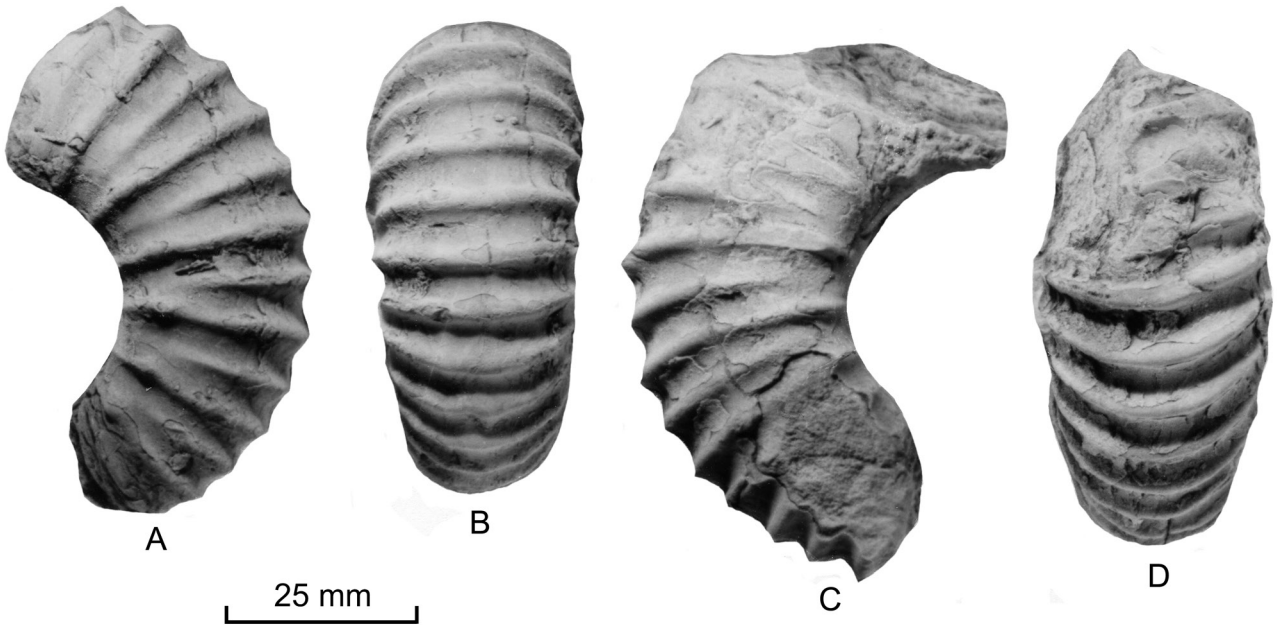
Type species: *Ammonites gentoni* BRONGNIART, 1822: 83, 392, Pl. 6, Fig. 6 from the lower Middle Cenomanian of Rouen, Seine-Maritime, France, by original designation by THOMEL (1972: 65).

Calycoceras (*Gentoniceras*) sp. group of *gentoni* (BRONGNIART, 1822)

(Text-Figs. 10A–D)

Material: GBA 2016/004/0042–0043, from km 4.5, *acutus* Subzone inferred.

Description: GBA 2016/004/0042 (Text-Figs. 10A, B) is a 120° fragment of body chamber with a maximum preserved costal whorl height of 28 mm. Coiling is moderately evolute, the umbilicus of moderated depth, with a feebly convex umbilical wall and broadly round umbilical shoulder. The costal and intercostal whorl sections are reniform, the costal whorl breadth to height ratio 1.1, the greatest breadth at the umbilicolateral bullae. On the outer whorl fragment, six ribs arise at the umbilical seam, strengthen across the umbilical wall and shoulder and strengthen further into a small umbilicolateral bulla. The primary ribs



Text-Fig. 10.
Calycoceras (*Gentoniceras*) sp., group of *gentoni* (BRONGNIART, 1822). A, B: GBA 2016/004/0042; C, D: GBA 2016/004/0043.
Both specimens are from the Odukpani Formation at km 4.5, between Odukpani and Itu, Cross River State, Nigeria.
All figures are natural size.

alternate with long intercalated ribs. The ribs are strong, narrow, straight and prorsiradiate, narrower than the interspaces, and pass straight across the venter without any indication of tubercles. The dorsum preserves an external mould of the venter of the preceding whorl; there are indications of possible inner and definite outer ventrolateral tubercles, but the siphonal area is obscured by matrix.

GBA 2016/004/0043 (Text-Figs. 10C, D) is a further 120° body chamber fragment, with a maximum preserved whorl height of 33 mm. Parts of 12 ribs are preserved, the ribbing differing from that of the previous specimen in being slightly rursiradiate.

Discussion: The ribbing style, lack of ventrolateral and siphonal tubercles on what are interpreted as adult body chambers indicate these specimens to be *Calycoceras* (*Gentoniceras*) of the *gentoni* group, revised by WRIGHT & KENNEDY (1987: 128; 1990: 219 et seq.). In that revision, *gentoni* of Brongniart and *subgentoni* of Spath were kept separate. Subsequent study indicates that the latter is no more than a variant of the former (KENNEDY & JUIGNET, 1994: 30, Text-Figs. 1a; 2d, e; 6d, e, j, k; 8a–e; 22a, b). The present slight material most closely resembles that from southern England (WRIGHT & KENNEDY, 1990: Pl. 59, Fig. 2).

Occurrence: The *gentoni* group range from lower Middle to lower Upper Cenomanian, *rhotomagense* to *guerangeri* Zones in Western Europe. The geographic distribution extends from southern England to France, Spain, Germany, Iran, Algeria, Tunisia, northern KwaZulu-Natal in South Africa, Madagascar, and Nigeria.

Suborder Ancyloceratina WIEDMANN, 1966
Superfamily Turrilitoidea GILL, 1871
Genus *Turrilites* LAMARCK, 1801

Type species: *Turrilites costatus* LAMARCK, 1801: 102, by original designation by LAMARCK (1801: 102).

Turrilites costatus LAMARCK, 1801

(Pl. 12, Figs. 1–12; Pl. 13, Fig. 11)

1801 *Turrilites costata* LAMARCK: 102 (*pars*).

1985 *Turrilites scheuchzerianus* BOSC, 1801; ZABORSKI: 10, Text-Figs. 7, 8.

1985 *Turrilites costatus* LAMARCK, 1801; ZABORSKI: 10 (pars), Fig. 10 only.

1996 *Turrilites costatus* LAMARCK, 1801; WRIGHT & KENNEDY: 354, Pl. 103, Figs. 1, 2, 5, Pl. 104, Figs. 1–4, 6, 8–10, Pl. 105, Figs. 1, 5, 6, 10, 12, 13, 16, 17, 19, Pl. 106, Figs. 1–6, 9, 10, Text-Figs. 137c, 139a–c, 142a, f, g, 143a–g, i–p (with full synonymy).

2015 *Turrilites costatus* LAMARCK, 1801; KLEIN: 176, 179 (with synonymy).

2019 *Turrilites costatus* LAMARCK, 1801; KENNEDY in GALE et al.:127, Pl. 58, Figs. 20, 22–25.

Type: The lectotype, by the subsequent designation of DOUVILLÉ (1904: fiche 54a, Fig. 1), is the specimen from Rouen, France, no. F. A25610 in the Lamarck collection, housed in the Muséum national d'Histoire naturelle in Paris that was figured by DOUVILLÉ (1904: fiche 54a, Fig. 1), of which a cast is figured here (Pl. 12, Fig. 2).

Material: GBA 2016/004/0046–0048, 0054, 0067, km 3.8, *costatus* Subzone; GBA 2016/004/0049–0053, 3.8–4.2 km, *ex situ*; GBA 2016/004/0055, km 4, top of section, *acutus* Subzone.

Description: The best-preserved specimen (Pl. 12, Fig. 4) has an apical angle of 20°. The earliest growth stage seen (Pl. 12, Fig. 6) has a minimum whorl height of 9 mm. The whorls are in tight contact, the inter-whorl suture deeply incised, the outer whorl face rounded in intercostal section. There are 19–20 ribs per whorl. They arise at the junction of upper and outer whorl faces, and are strong, straight, and feebly prorsiradiate, strengthening into a sharp, transversely elongated tubercle in the middle of the outer whorl face. The ribs weaken markedly below this, producing a distinctive impressed band that separates the upper row of tubercles from a second, smaller row of transversely elongated tubercles on the lower part of the outer whorl face. There is a much smaller, adaperturally displaced row at the junction of the outer and lower whorl faces. GBA 2016/004/0067 (Pl. 12, Fig. 4) consists of six whorls, in part body chamber, although the position of the final septum cannot be established. The maximum preserved whorl height at the beginning of the final whorl is 28 mm. There are 18–19 ribs on the smallest whorl. They are coarse and straight, and link to a strong, transversely elongated tubercle in the middle of the whorl face, separated by a zone of weakened ornament from a smaller conical tubercle, with a third tubercle partially concealed in the strongly crenulated inter-whorl suture. As size increases, the ribs lengthen, and the final part of the largest whorl elongates, suggesting it to be a near-complete adult.

A series of larger body chamber fragments (Pl. 12, Figs. 8, 9, 11, 12; Pl. 13, Fig. 11) have whorl heights of up to 28 mm. There are up to 25 ribs per whorl that extend across the upper half of the exposed whorl face, and strengthen into a feeble transversely elongated tubercle, much weaker than on the phragmocones, the succeeding zone of weakened ornament less pronounced, and sometimes lost, being replaced by an indentation in the rib, below which a weak transversely elongated tubercle develops. The third and lower row of tubercles is weak to efface in these specimens.

Discussion: GBA 2016/004/0051 (Pl. 12, Fig. 4) differs in no significant respects from the lectotype (Pl. 12, Fig. 2). The ornament of larger body chamber fragments with ribs longer than in the lectotype and the tubercles in the upper row weaker, so that the whorl profile is less angular, corresponds to that of both juvenile and adult specimens from South India figured by STOLICZKA (1866: Pl. 87, Figs. 9, 10), Germany (SCHLÜTER, 1876: Pl. 38, Figs. 1, 2) and Sarthe in France (KENNEDY & JUIGNET, 1983: Text-Figs. 25m–o, 27h, 28a). These variants have a superficial resemblance to *Turrilites scheuchzerianus* BOSC, 1801 (see revision in WRIGHT & KENNEDY, 1996: 349, Pl. 106, Figs. 7, 8, 11, 12, Pl. 107, Figs. 1–7, Text-Figs. 137g, j, 138c, d, f–i, n, 139d–l, 140a, d, e–i, 143h, 147a, b), but this species never develops tubercles, the ribs interrupted or weakened around mid-flank in the early growth stages, but entire thereafter. The upper

and lower whorl faces are smooth, and the inter-whorl suture entire, rather than crenulated. The *Turrilites scheuchzerianus* of Zaborski (1985: 10, Text-Figs. 7, 8) are *Turriites costatus* body chambers of this type. *Turrilites costatus* gives rise to *Turrilites acutus* Passy, 1832 (Atlas: 9, Pl. 16, Figs. 3, 4), described below. They differ in that *acutus* is trituberculate rather than ribbed and tuberculate, the whorl section lower in the lectotype and corresponding specimens. There are, however, transitions between the two.

Occurrence: *Turrilites costatus* is index of the widely recognized lower Subzone of the lower Middle Cenomanian *Acanthoceras rhotomagense* Zone, extending as a rarity into the upper Middle and lower Upper Cenomanian, although records from condensed basement beds in Western Europe may be remanié individuals. The geographic distribution extends to England, France, Germany, Switzerland, Poland, Spain, Portugal, Romania, Ukraine (Crimea), Russia, Kazakstan and Kopet Dag in Turkmenia, Iran, Algeria, Central Tunisia, the Middle East, Nigeria, Angola, KwaZulu-Natal in South Africa, Mozambique, Madagascar, South India, Tibet, northern Australia, Mexico, the U.S. Gulf Coast and California.

Turrilites acutus Passy, 1832

(Pl. 13, Figs. 1–10, 12, 13)

1832 *Turrilites acutus* Passy: Atlas, 9, Pl. 16, Figs. 3, 4.

1985 *Turrilites costatus* Lamarck, 1801; Zaborski: 10 (pars), Fig. 9 only.

1996 *Turrilites acutus* Passy, 1832; Wright & Kennedy: 358, Pl. 103, Fig. 3; Pl. 104, Figs. 5, 7, 11; Pl. 105, Fig. 21; Pl. 108, Figs. 1–4, 8, 11, 12; Text–Figs. 138m, 141a, 146n–o (with full synonymy).

2015 *Turrilites acutus* Passy, 1832; Kennedy in Kennedy & Gale: 318.

2015 *Turrilites acutus* Passy, 1832; Klein: 175, 177.

2017 *Turrilites acutus* Passy, 1832; Kennedy in Kennedy & Gale: 105, Pl. 17, Figs. 9, 11, 15, 17.

2019 *Turrilites acutus* Passy, 1832; Kennedy in Gale et al.: 128.

Type: The lectotype, by the subsequent designation of Juignet & Kennedy (1976: 65), is the original of Passy (1832: Pl. 16, Fig. 3, no. F. RO3993) in the collections of the Muséum national d'Histoire naturelle, Paris, and from Rouen, Seine-Maritime, France. It is figured here as Plate 13, Figures 3, 4.

Material: GBA 2016/004/0056–0061, km 4, north side; GBA 2016/004/0062, 0063, km 4, north side, top of section; GBA 2016/004/0064–0065, km 4, south side, all *acutus* Subzone.

Description: The apical angle of the most complete fragments is 25–27°. The inter-whorl suture is deeply impressed, and strongly crenulated. The outer whorl face has a convex profile in intercostal section and a markedly angular costal section. Eighteen short, coarse, very feebly prorsiradiate ribs arise at the junction of the upper and outer whorl faces and strengthen into strong conical tubercles in the middle of the outer whorl face. A weakened to effaced rib links to second row of weaker, adaperturally displaced conical tubercles on the lower part of the outer whorl face, with a third, much weaker row partially concealed in the crenulations in the inter-whorl suture. Ornament of this type occurs in fragments with whorl heights of up to 36 mm (Pl. 13, Fig. 9). The larger specimens (Pl. 13, Figs. 12, 13) have whorl heights of up to 41 mm, and are interpreted as adult body chambers. The ornament weakens, but the three rows of tubercles persist. The largest specimen (Pl. 13, Fig. 13) has 22 ribs on the final whorl; the lower two rows of tubercles are elongated and distinctly prorsiadiate.

Discussion: The smaller specimens differ in no significant respects from the lectotype (compare Pl. 13, Figs. 1, 2, 5 and Figs. 3 and 4). Differences from *Turrilites costatus* are described above. The *Turrilites costatus* from the Odukpani Formation of Zaborski (1985: 10, Fig. 9, non Fig. 10) are in part *Turrilites acutus*.

Occurrence: Middle Cenomanian, index of the upper subzone of the widely recognized *Acanthoceras rhotomagense* Zone to lower Upper Cenomanian *Calycoceras guerangeri* Zone. The geographic distribution extends from England to France, Germany, Poland, Spain, northern Russia, Kazakhstan, Turkmenia, Iran, Algeria, Central Tunisia, Nigeria, South India, Tibet, Texas, the U.S. Western Interior and California.

Acknowledgements

We are grateful to David Sansom (Oxford) and Marek Plosch (Warsaw) for their assistance in the preparation of the figures. Harald Lobitzer is grateful to the management of Calabar Cement Company (Calcemco) for providing him and his colleagues from Calcemco with a car with driver (including weekends), thus giving us the opportunity to learn more about the geology of the "Calabar Flank". Thanks also to the management of Reynolds Construction Company (RCC) for permission to carry out geological research during the construction of the Odukpani-Itu Highway.

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Plates

Plate 1

Damesites africanus **sp. nov.**

Figs. 1–3: paratype, GBA 2016/004/0004, km 4, south side.
Figs. 4–6: paratype, GBA 2016/004/0005, km 2.8.
Figs. 7–9: paratype, GBA 2016/004/0002, km 4.
Figs. 10, 11: paratype, GBA 2016/004/0006, km 2.8.
Figs. 12, 13: paratype, GBA 2016/004/0003, km 4.
Figs. 14, 15: paratype, GBA 2016/004/0007, km 2.8.

All specimens are from the Middle Cenomanian part of the Odukpani Formation between Odukpani and Itu, Cross River State, south-eastern Nigeria.

All figures are natural size.

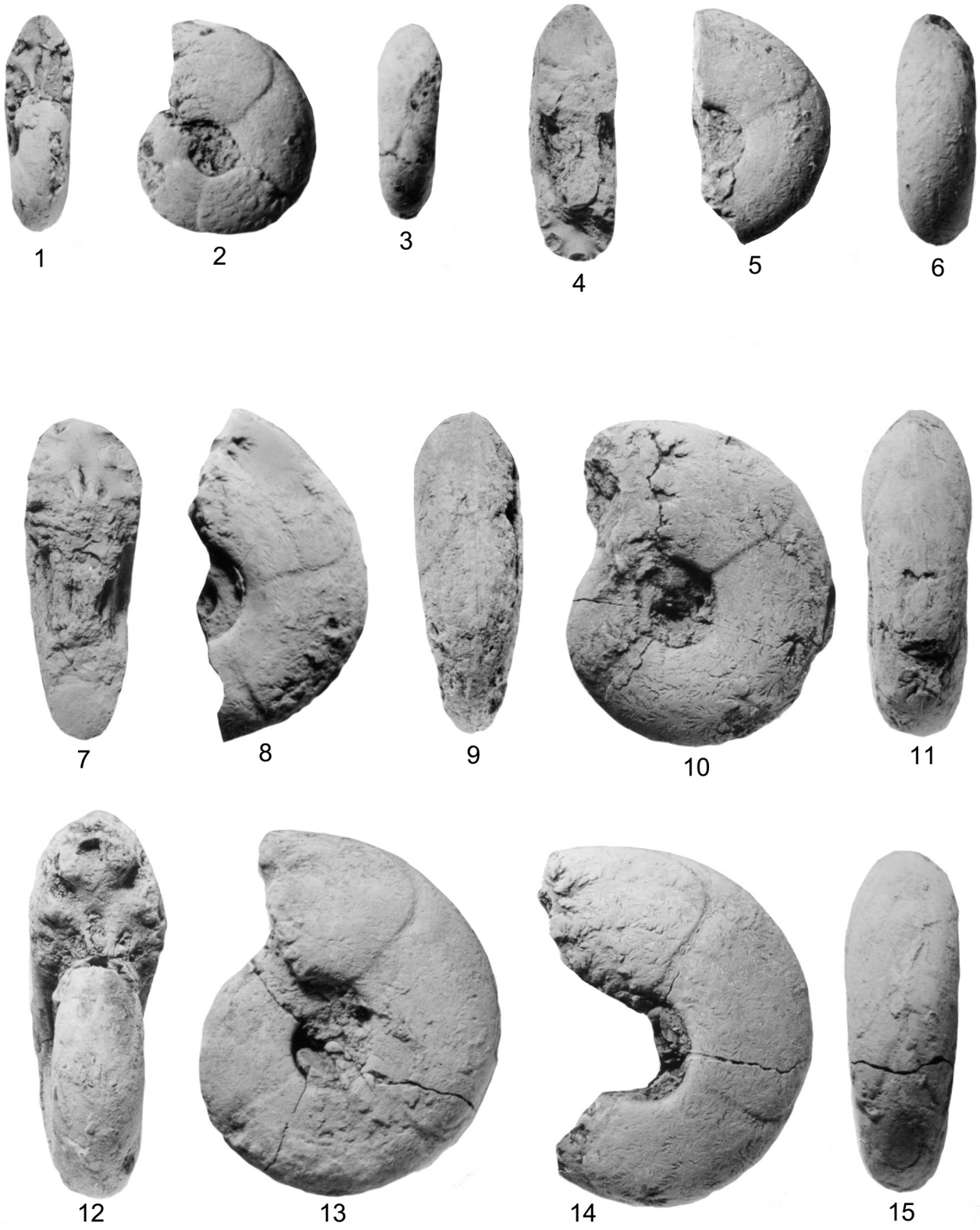
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Plate 2

Figs. 1–4: *Damesites africanus* sp. nov.

The holotype, GBA 2016/004/0001, km 4, upper part of section.

The specimen is from the Middle Cenomanian *acutus* Subzone part of the Odukpani Formation between Odukpani and Itu, Cross River State, southeastern Nigeria.

All figures are natural size.

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Plate 3

Figs. 1–4: *Forbesiceras obtectum* (SHARPE, 1853).

GBA 2016/004/0008, km 4, from the Middle Cenomanian *acutus* Subzone part of the Odukpani Formation between Odukpani and Itu, Cross River State, southeastern Nigeria.

All figures are natural size.

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Plate 4

***Cunningtoniceras meridionale* (Stoliczka, 1864).**

GBA 2016/004/0010, km 3.8, south side, from the Middle Cenomanian *costatus* Subzone part of the Odukpani Formation between Odukpani and Itu, Cross River State, southeastern Nigeria.

The figure is natural size.

Plate 5

Cunningtoniceras meridionale (Stoliczka, 1864).

Figs. 1, 2: GBA 2016/004/0010, km 3.8, south side, *costatus* Subzone.

Fig. 3: GBA 2016/004/0012, km 3.8–4.2, *ex situ*.

Figs. 4, 5: GBA 2016/004/0013 km 4, south side, top of section, *acutus* Subzone.

All specimens are from the Middle Cenomanian part of the Odukpani Formation between Odukpani and Itu, Cross River State, south-eastern Nigeria.

The figures are natural size.

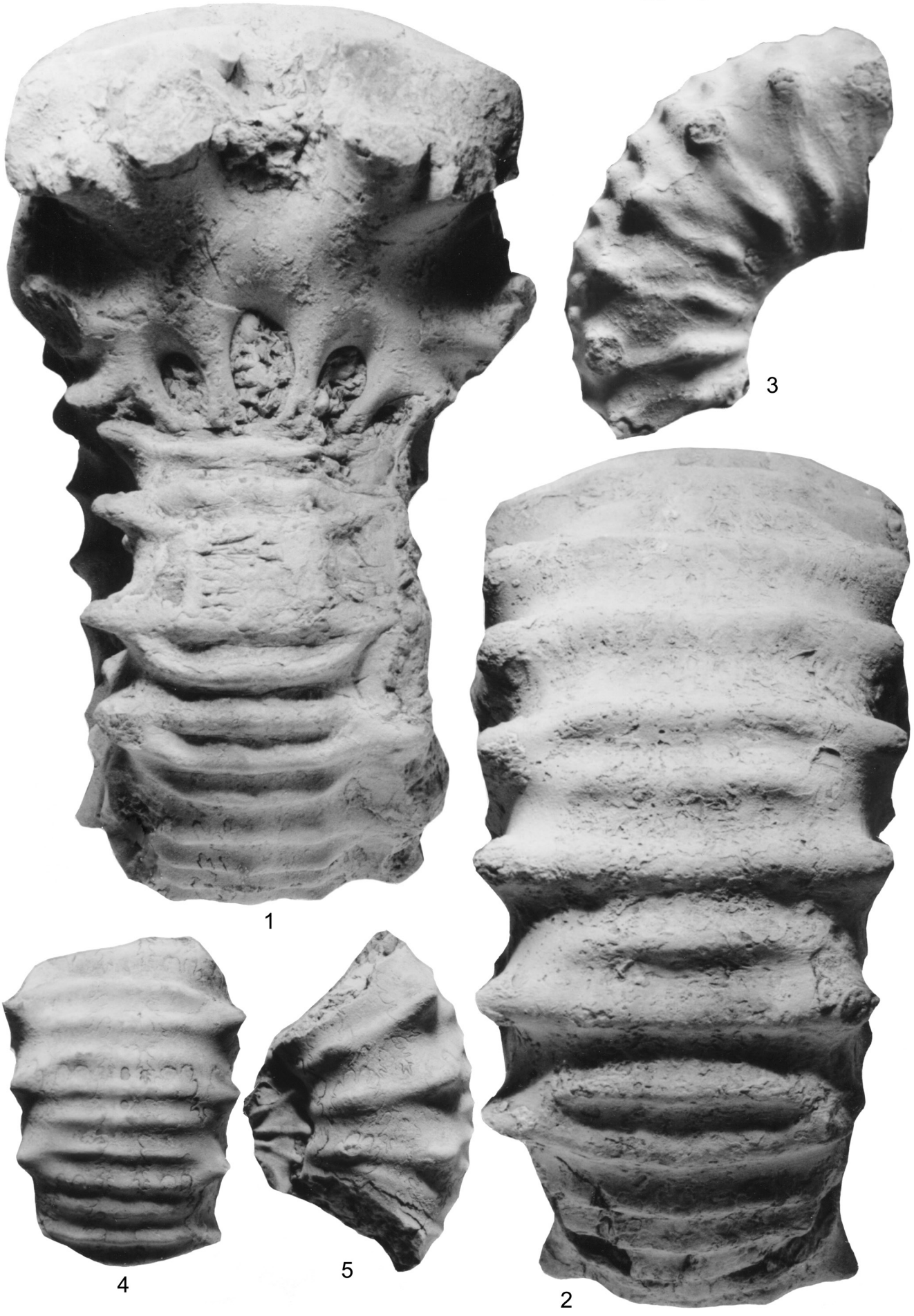
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Plate 6

***Cunningtoniceras meridionale* (Stoliczka, 1864).**

GBA 2016/004/0011, km 3.8, south side, from the Middle Cenomanian *costatus* Subzone part of the Odukpani Formation between Odukpani and Itu, Cross River State, southeastern Nigeria.

The figures are natural size.

Plate 7

Cunningtoniceras meridionale (Stoliczka, 1864).

Figs. 1, 2: GBA 2016/004/0015.
Figs. 3, 4: GBA 2016/004/0016.

Both specimens are from km 3.8, south side, the Middle Cenomanian *costatus* Subzone part of the Odukpani Formation between Odukpani and Itu, Cross River State, southeastern Nigeria.

The figures are natural size.

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Plate 8

Cunningtoniceras alatum Zaborski, 1985.

Figs. 1, 2: GBA 2016/004/0022, km 4, north side.
Figs. 3, 4: GBA 2016/004/0023, km 4, south side.
Figs. 5, 6: GBA 2016/004/0031, km 4, south side.
Figs. 7, 8: GBA 2016/004/0032, km 4, south side.
Figs. 9–11: GBA 2016/004/0037, km 4.5.
Figs. 12, 13: GBA 2016/004/0020, km 4, north side, upper part of section.
Fig. 14: GBA 2016/004/0038, km 4, upper part of section.
Figs. 15, 20: GBA 2016/004/0035, km 4, south side.
Figs. 16, 17: GBA 2016/004/0024, km 4, north side.
Figs. 18, 19: GBA 2016/004/0039, km 4, upper part of section.
Figs. 21, 22: GBA 2016/004/0034, km 4, south side.
Figs. 23, 24: GBA 2016/004/0026, km 4, north side.
Figs. 25, 26: GBA 2016/004/0027, km 4, north side.
Figs. 27, 28: GBA 2016/004/0066, km 4, south side.

All specimens are from the Middle Cenomanian *acutus* Subzone part of the Odukpani Formation between Odukpani and Itu, Cross River State, southeastern Nigeria.

The figures are natural size.

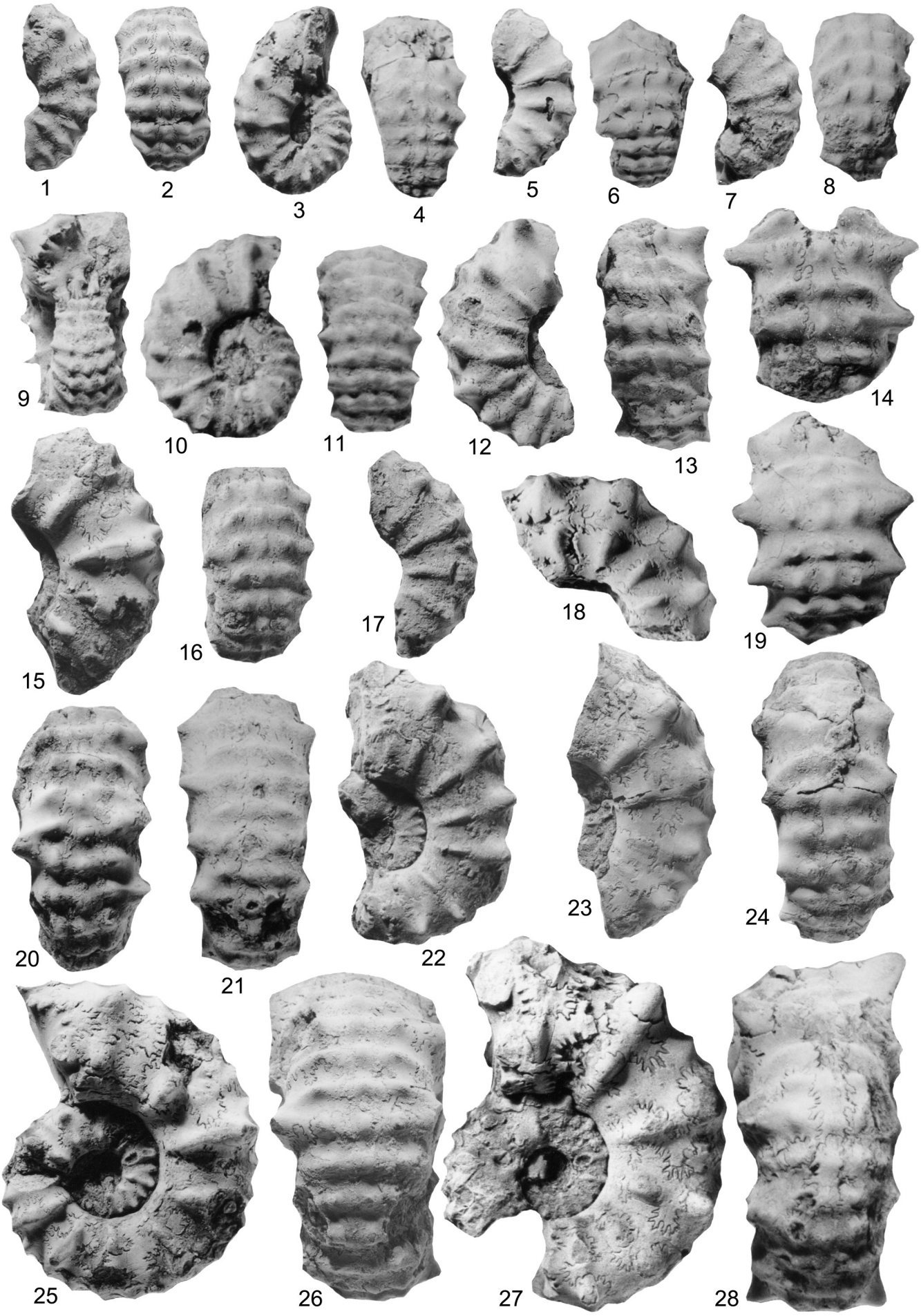
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Plate 9

Figs. 1–8, 11: ***Cunningtoniceras alatum*** **Zaborski, 1985.**

Figs. 1, 2: GBA 2016/004/0033, km 4, north side, *acutus* Subzone.

Figs. 3, 4: GBA 2016/004/0035, km 4, north side, *acutus* Subzone.

Figs. 5, 6: GBA 2016/004/0030, km 4, north side, *acutus* Subzone.

Figs. 7, 8, 11: GBA 2016/004/0041, *ex situ*.

Figs. 9, 10: ***Cunningtoniceras cunningtoni*** **(Sharpe, 1855)**, GBA 2016/004/0017, *ex situ*.

All specimens are from the Middle Cenomanian part of the Odukpani Formation between Odukpani and Itu, Cross River State, south-eastern Nigeria.

The figures are natural size.

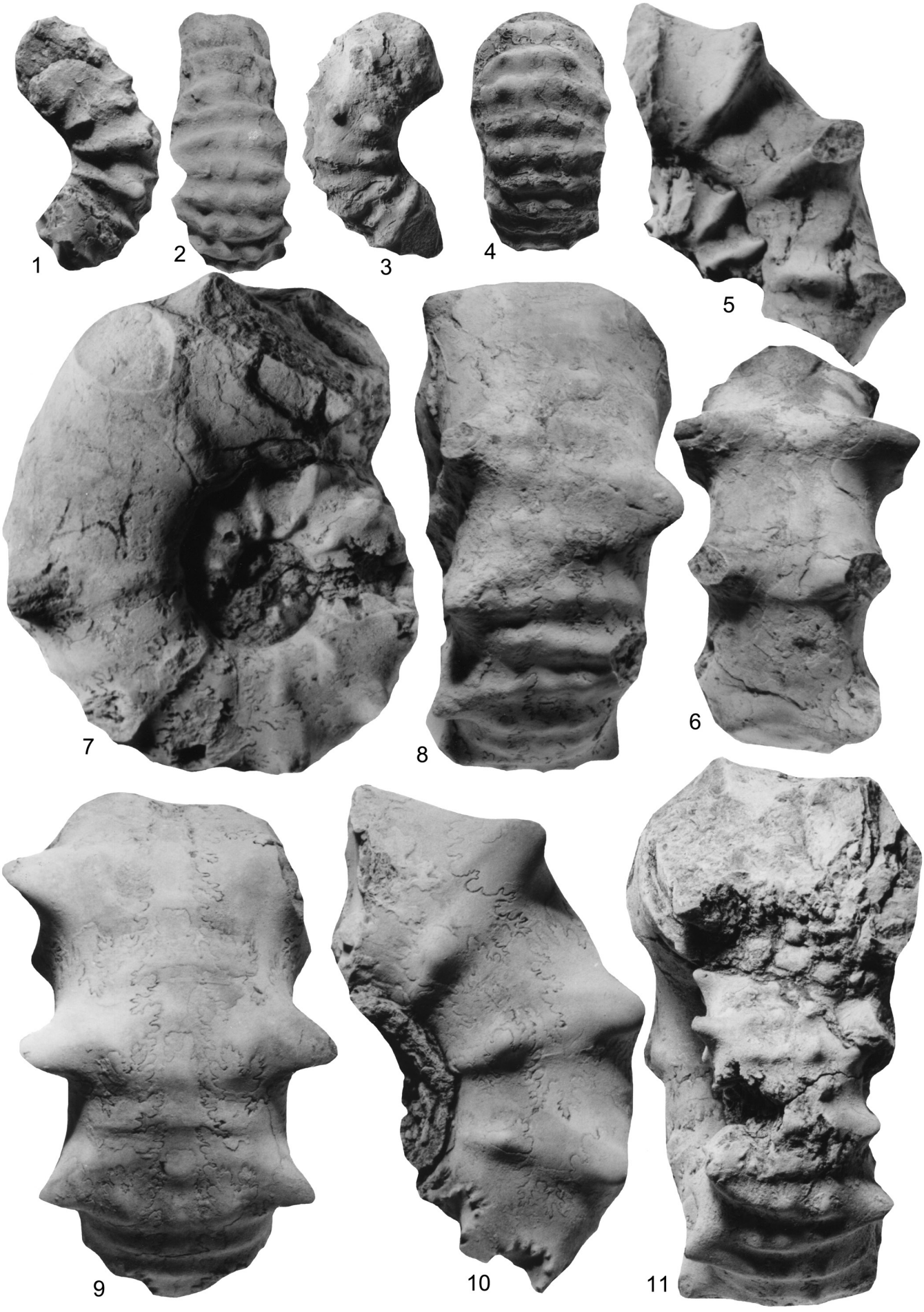
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Plate 10

Figs. 1, 2: ***Cunningtoniceras alatum* Zaborski, 1985**, GBA 2016/004/0040, *ex situ*.

Figs. 3, 4: ***Cunningtoniceras cunningtoni* (Sharpe, 1855)**, GBA 2016/004/0018, *ex situ*.

Both specimens are from the Middle Cenomanian part of the Odukpani Formation between Odukpani and Itu, Cross River State, south-eastern Nigeria.

The figures are natural size.

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Plate 11

Cunningtoniceras alatum Zaborski, 1985.

Figs. 1, 7, 8: GBA 2016/004/0019, km 4, *ex situ*.
Fig. 2: GBA 2016/004/0028, km 4, north side, *acutus* Subzone.
Figs. 3, 6: GBA 2016/004/0021, km 4, top of section, *acutus* Subzone.
Fig. 4: GBA 2016/004/0029, km 4, south side, *acutus* Subzone.
Figs. 5, 9: GBA 2016/004/0036, km 4, south side, top of section, *acutus* Subzone.

All specimens are from the Middle Cenomanian part of the Odukpani Formation between Odukpani and Itu, Cross River State, south-eastern Nigeria.

The figures are natural size.

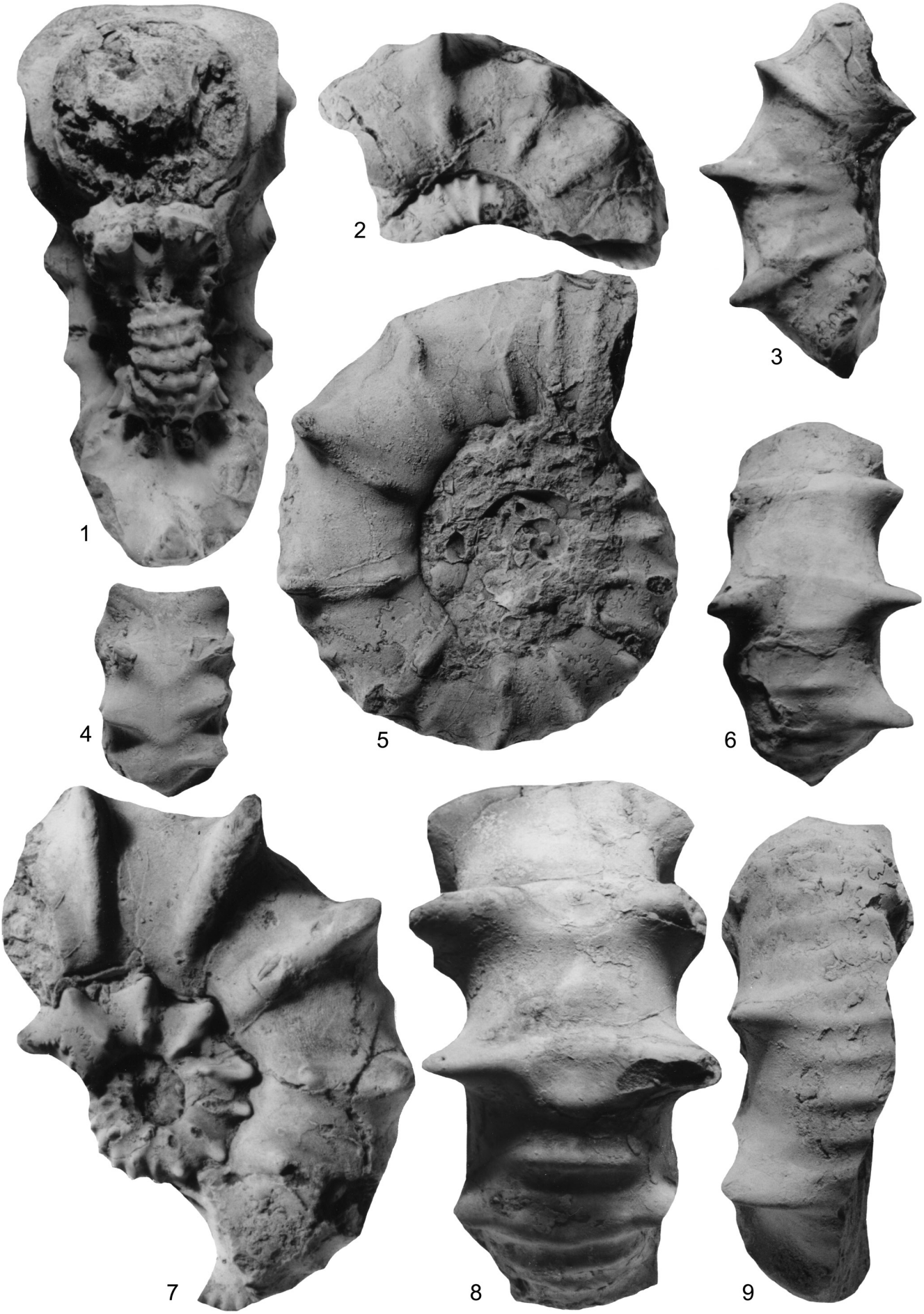
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Plate 12

Figs. 1–12: ***Turrilites costatus*** **LAMARCK, 1801.**

Fig. 1: GBA 2016/004/0046, km 3.8, south side, *costatus* Subzone.

Fig. 2: The lectotype, from Rouen, France, no. F. A25610 in the Lamarck collection, housed in the Muséum National d'Histoire Naturelle, Paris.

Fig. 3: GBA 2016/004/0049, km 3.8–4.2, *ex situ*.

Fig. 4: GBA 2016/004/0067, km 3.8, south side, *costatus* Subzone.

Fig. 5: GBA 2016/004/0051, km 3.8–4.2, *ex situ*.

Fig. 6: GBA 2016/004/0050, km 3.8–4.2, *ex situ*.

Fig. 7: GBA 2016/004/0047, km 3.8, south side, *ex situ*.

Fig. 8: GBA 2016/004/0054, km 4, *acutus* Subzone.

Fig. 9: GBA 2016/004/0054, km 4, *acutus* Subzone.

Fig. 10: GBA 2016/004/0048, km 3.8, south side, *costatus* Subzone.

Fig. 11: GBA 2016/004/0052, km 3.8–4.2, *ex situ*.

Fig. 12: GBA 2016/004/0053, km 3.8–4.2, *ex situ*.

Figures 1 and 3–12 are from the Middle Cenomanian part of the Odukpani Formation between Odukpani and Itu, Cross River State, southeastern Nigeria.

The figures are natural size.

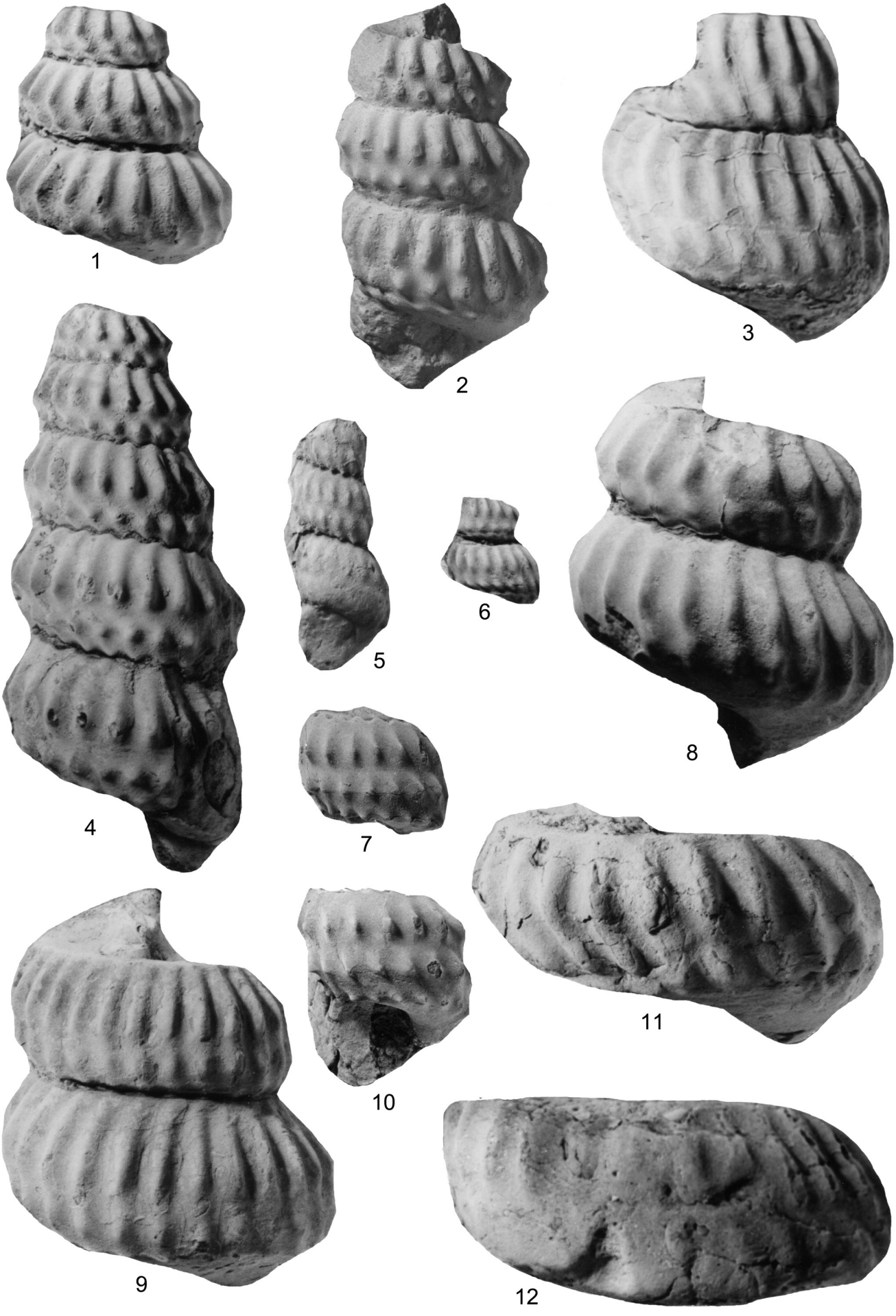
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Plate 13

Figs. 1–10, 12, 13: ***Turrilites acutus*** **Passy, 1832**

Fig. 1: GBA 2016/004/0056, km 4, north side.

Fig. 2: GBA 2016/004/0057, km 4, north side.

Fig. 3: a cast of the lectotype, the original of Passy (1832: Pl. 16, Fig. 3), no. F. RO3993 in the collections of the Muséum national d'Histoire naturelle, Paris, and from Rouen, Seine-Maritime, France.

Fig. 4: GBA 2016/004/0065, km 4, south side.

Fig. 5: GBA 2016/004/0058, km 4, north side.

Fig. 6: GBA 2016/004/0060, km 4, north side.

Fig. 7: GBA 2016/004/0063, km 4, south side, top of section.

Fig. 8: GBA 2016/004/0059, km 4, north side.

Fig. 9: GBA 2016/004/0064, km 4, south side.

Fig. 10: GBA 2016/004/0061, km 4, north side.

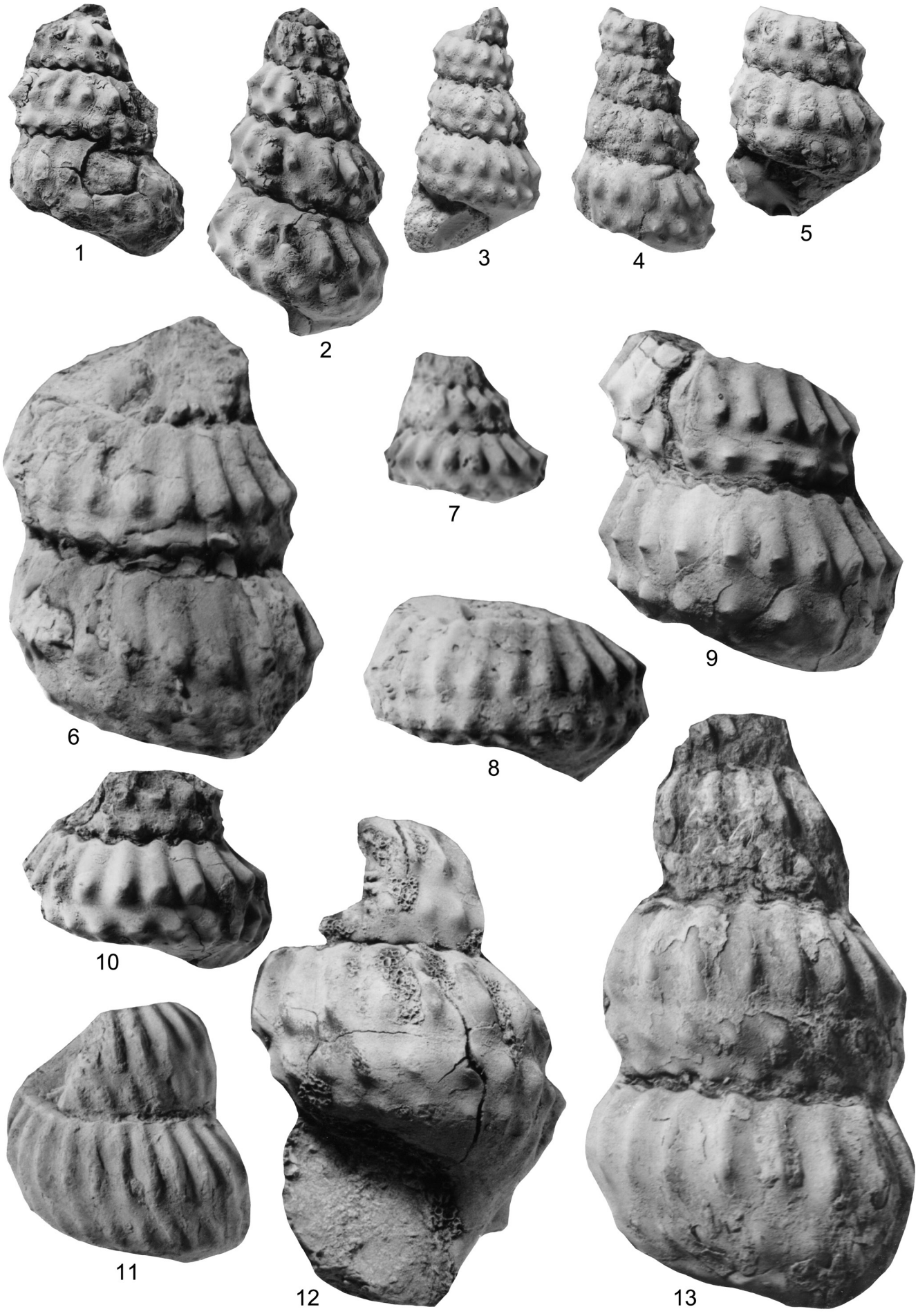
Fig. 12: GBA 2016/004/0065, km 4, south side.

Fig. 13: GBA 2016/004/0062, km 4, north side, top of section.

Fig. 11: ***Turrilites costatus*** Lamarck, 1801, GBA 2016/004/0055, km 4, south side, top of section.

Figures 1, 2 and 5–13 are from the Middle Cenomanian *acutus* Subzone part of the Odukpani Formation between Odukpani and Itu, Cross River State, southeastern Nigeria.

The figures are natural size.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