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Upper Albian, Cenomanian and Lower Turonian stratigraphy, ammonite and inoceramid bivalve faunas from the Cauvery Basin, Tamil Nadu, South India

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ABSTRACT:

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The lithostratigraphy, biostratigraphy, sequence stratigraphy, ammonite and inoceramid faunas of the Upper Albian, Cenomanian, and Lower Turonian Karai Formation, the highest unit of the Uttatur Group in the Pondicherry Sub-Basin of the Cauvery Basin in Tamil Nadu, south India, are documented. Detailed logs and descriptions of sections between Karai and Kulakkalnattam, Odiyam and Kunnam, and north-west of Garudamangalam are presented. They provide the evidence for an ammonite zonal scheme that can be correlated in detail with sequences developed in Europe, with successive Upper Albian zones of *Pervinquieria* (*Subschloenbachia*) *rostrata* and *P.* (*S.*) *perinflata* (the latter on slight evidence), Cenomanian zones of *Mantelliceras mantelli*, *Cunningtoniceras cunningtoni*, *Calycoceras* (*Newboldiceras*) *asiaticum*, *Pseudocalycoceras harpax*, *Euomphaloceras septemseriatum* and *Pseudspidoceras footeanum*. The Lower Turonian is represented by a *Neoptychites cephalotus–Mytiloides borkari* fauna. Over 120 ammonite species are described, of which *Puzosia* (*Bhimaites*) *falx*, *Protacanthoceras parva*, *Watinoceras elegans*, *Euomphaloceras varicostatum*, *Kamerunoceras multinodosum*, and *Carthaginites multituberculatus* are new. The new genus *Kunnamiceras*, with *Ammonites tropicus* Kossmat, 1865 as type species, is interpreted as a paedomorphic dwarf derivative of *Pseudocalycoceras harpax* (Stoliczka, 1864). Ammonite faunas from shales are dominated by feebly-ornamented taxa: leiostraca; those from sandstones by strongly ornamented taxa: trachyostraca, differences interpreted as reflecting the preferred habits of adults in life. 15 species of inoceramid bivalves, including a newly described species *Inoceramus chiplonkari*, are recognised, with a mixed East African–Euramerican–North Pacific affinity. On the basis of the stratigraphic framework developed, a sequence stratigraphic interpretation of the Karai Formation is proposed, and correlated with those recognised in Europe, Morocco, and the United States Gulf Coast and Western Interior.

Key words: Cretaceous; Ammonites; Inoceramid bivalves; Sequence stratigraphy; South India.

PREFACE: ON FERDINAND STOLICZKA (1838–1874)

All work on the fossil invertebrate faunas of south India is founded on the extraordinary contribution of Ferdinand Stoliczka, a summary of whose life and work is set out below. Stoliczka was born near Kroměříž in the Slin region of Moravia, in what is now the Czech Republic, on June 7th 1838. His father was a forester in the employ of the Archbishop of Olomouc. He studied geology in Prague and Vienna under Eduard Suess and Rudolf Hoernes, and graduated with a doctorate from the University of Tübingen in November 1861. He joined the Imperial Geological Institute of Austria and published on recent and fossil bryozoans, as well as the fauna of the Gosau Group. Stoliczka joined the Geological Survey of India in 1862, and was tasked with describing the Cretaceous faunas of south India, publishing monographs on the Cephalopoda, Gastropoda, Brachiopoda, Bivalvia, Echinodermata and other invertebrate and vertebrate groups in *Palaeontologica Indica* between 1870 and 1873. As his obituary notes, this extends to around 1500 pages, illustrated by 178 plates, an extraordinary contribution from a man in his twenties and early thirties. Palaeontology apart, there were also publications on Indian mammals, birds, reptiles, molluscs, bryozoans, arachnids, coleoptera, and corals, and there are bats, birds, butterflies, fish, lizards, mammals and snakes that bear his name. Added to this, he lent his name to Stoliczka Island, the northernmost island of the Franz Joseph Archipeligo (81°11' N, 58°16' E) in the Arkhangelsky Oblast of the Russian Federation. Stoliczka took part in a series of expeditions visiting Burma (Myanmar), Malaya, the Andaman and Nicobar Islands, Kutch, and the Ladakh Valley, on which he contributed numerous publications. His final expedition was to Turkestan, as part of the Second Yarkan Mission. He suffered severe headaches as the expedition crossed the Karakorum Pass (altitude 5580 m); on the 18th of June he set off to examine a sequence of dolomitic limestones and shales, in spite of deteriorating health. He died (of chronic mountain sickness) at Moorghi in Ladakh on June 19th 1874, ten days after his 36th birthday. There is a monument to his memory in the Moravian Mission Cemetery in Leh, in Jammu and Kashmir.

(An obituary, by W.T. Blanford, appeared in *Nature* on July 9 1874. This is reproduced in part in the Anniversary Address of the President of the Geological Society, John Evans, on pp. xlvii–xlix of the *Proceedings of the Geological Society of London* for 1874–1875, where the passing of John Phillips, Élie de Beaumont and D'Omalius D'Halloy are also noted. There is a more accessible account of Stoliczka's life to be found on Wikipedia under his name.)

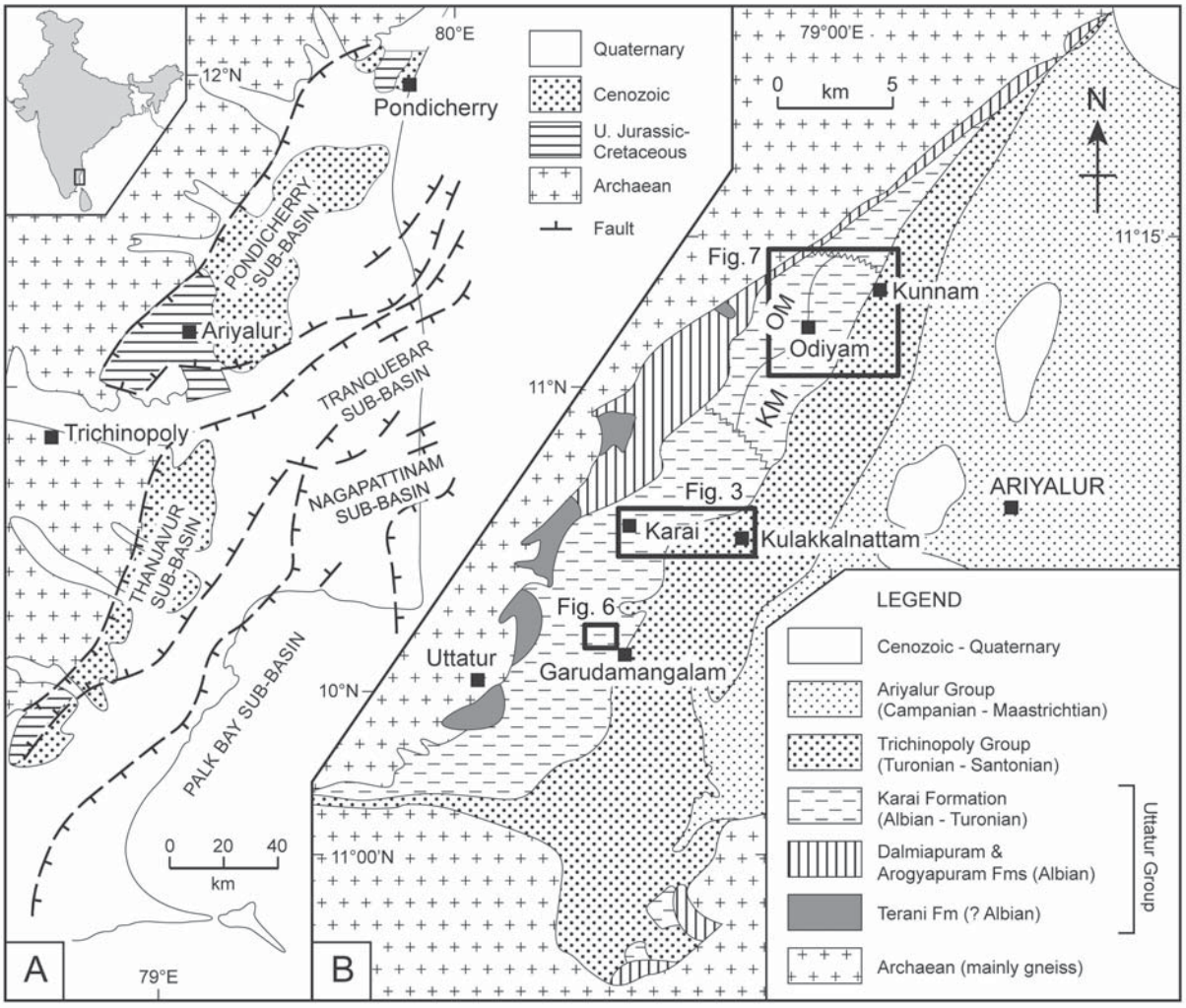
Ferdinand Stoliczka (1838–1874)

INTRODUCTION

Largely owing to their rich, diverse, fossil content, the Upper Cretaceous strata of the Cauvery Basin in south-east India have been the focus of considerable interest since the pioneering work of Blanford (1862), Stoliczka (1863–1866, 1870–71, 1872, 1872–1873) and Kossmat (1895–1898). Albian to Turonian macrofaunas have long been known from the regions to the west of Ariyalur, and ammonite zonal schemes have been proposed for this interval (e.g. Sastry *et al*. 1968; Ayyasami 1990). Planktonic foraminiferal stratigraphy has been based upon samples from a series of cored boreholes around Karai and Kunnam (Govindan *et al*. 1996). A nannofossil biostratigraphy has also been established for the region (Kale and Phansalkar 1992a, b). Gale *et al*. (2002) outlined a sequence stratigraphy for part of the Cenomanian, and recorded the presence of international zonal Cenomanian ammonite species, but did not provide further details. A useful review of the literature was provided by Govidan *et al*. (1996).

GEOLOGICAL SETTING

The Cauvery Basin (Text-fig. 1) is one of a number of passive-margin sedimentary basins along the coast of south-east India that formed during the break-up of eastern Gondwana in Early Cretaceous times (e.g.



Text-fig. 1. **A** – simplified geological map of the Cauvery Basin. **B** – simplified geological map of a part of the Pondicherry Sub-Basin, showing the position of the three study areas

Powell *et al.* 1988). Structurally, the basin is dominated by north-east–south-west trending en-echelon extensional faults which define a series of sub-basins and intervening horst blocks of Precambrian basement (Sastri *et al.* 1981; Prabhakar and Zutshi 1993). Albian, Cenomanian and Turonian strata are exposed only in the Ariyalur district of the Pondicherry Sub-Basin (Text-fig. 1B), where they constitute part of a 2.3-km-thick Cretaceous succession (Sundaram *et al.* 2001). The Cenomanian strata form part of the mudstone-dominated Karai Formation (Late Albian–mid Turonian; Sundaram and Rao 1986; Sundaram *et al.* 2001) of the Uttatur Group (Text-fig. 2). The Uttatur Group is thought to have been deposited in a partly enclosed north-north east-south-south west elongated

GROUP	FORMATION	MEMBER
UTTATUR	KARAI	KUNNAM
		ODIYAM
	DALMIAPURUM	
	AROGYAPURUM	
	TERANI	

Text-fig. 2. Lithostratigraphic divisions of the Uttatur Group (modified after Henderson *et al.* 2001)

embayment some 20–30 km across, connected to the open ocean in the north but separated from it to the south-east by an emergent (Sundaram and Rao 1986) or shallowly submerged (Sastri and Raiverman 1968) basement high. The locally developed, sandy Odiyam–Kunnam succession was deposited relatively close to the fault-controlled basin margin; Archaean high-grade metamorphic rocks are exposed c. 2 km north-east of the study area. The Karai Formation generally dips gently (5–10º) to the south-east, except in the vicinity of minor low-amplitude closures.

LITHOSTRATIGRAPHY

Previous work

Blanford (1862) gave the first detailed account of the Cretaceous succession to the NE of Trichinopoly. In more recent years, a number of lithostratigraphic schemes have been proposed (Sundaram and Rao 1986; Ramasamy and Banerji 1991; Tewari *et al.* 1996; Sundaram *et al.* 2001). Although there are differences between these classifications, the boundaries and status of the Karai Formation are essentially constant. Since Blanford's (1862) initial description ('Ootatoor beds'), lithofacies analysis of the formation has been limited. It was divided into lower, clay-dominated and upper, more sand-rich members by Sundaram and Rao (1986; members only differentiated in the Odiyam area) and Banerji (1973; also Ramasamy and Banerji 1991; whole formation divided). The locally developed Odiyam Sandstone Member of Tewari *et al*. (1996) appears to correspond to the upper, Kunnam Member of Sundaram and Rao (1986), which includes most of the Odiyam–Kunnam section described in this paper. In the absence of measured type sections the value of these subdivisions appears limited. Sundaram and Rao suggested deposition in 'moderately deep water' for the greater part of the Karai Formation, with the Kunnam Member representing a regressive phase. Based on foraminiferal assemblages, Banerji and Sastry (1979) suggested inner shelf deposition for Banerji's (1972) lower, argillaceous member, and a very shallow marine-fluvial setting for the upper, sandier member.

Sundaram *et al*. (2001), identified an Albian to Turonian Karai Formation, dominantly mudrock and marl deposited in an offshore environment. This is up to 410 m in thickness along the 50 km length of the north-east–south-west Cretaceous outcrop to the west of Ariyalur (Text-fig. 1), and is overlain unconformably by the Kulakkalnattam Formation of the Trichinopoly Group (for discussion see Sunduram *et al*. 2001). The Karai Formation passes laterally into a sandy, nearshore to marginal marine facies in the region of Odiyam and Kunnam (Text-fig. 1B), distinguished as the Odiyam and Kunnam Members (Sundaram *et al*. 2001; Text-fig. 2). No detailed lithostratigraphic logs of these sequences have been published to date.

Present observations

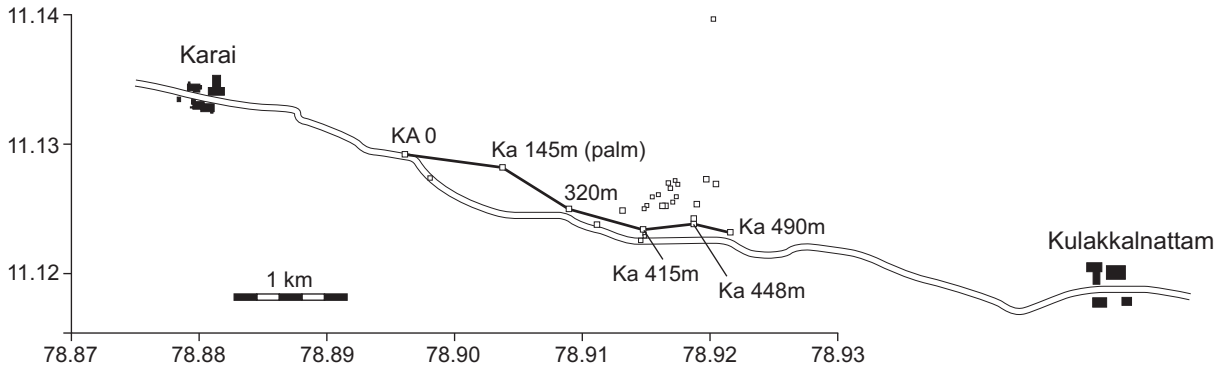
Sections were logged in three areas: between Karai and Kulakkalnattam, north-west of Garudamangalam, and between Odiyam and Kunnam (Text-fig. 1B). Detailed accounts are given below.

Karai Formation, Karai–Kulakkalnattam and Garudamangalam sections

The successions comprise marls and calcareous clays, weathering to brown and grey (black in subcrop, according to Sundaram *et al*. 2001), and variably glauconitic, with some levels containing a high percentage of glauconite. Thin, glauconitic, strongly bioturbated sandy beds, commonly <10 cm in thickness, are present, and possibly represent storm beds or turbidites. Thicker sandstones contain moulds of originally aragonitic fossils. Limonitized originally pyritic nodules, including steinkerns of molluscs, are abundant at certain levels, and calcareous, phosphatic and barytes concretions occur less frequently. Belemnites, oysters and serpulid worm tubes are the most common calcitic fossils.

Karai–Kulakkalnattam (Text-figs 3, 4): A 480 m section in sparsely vegetated badlands, north of and parallel with the road from Karai to Kulakkalnattam, was logged and sampled. Important markers include a highly glauconitic unit between 9 and 13.5 m, a series of five fine silty sandstones between 198 and 211 m, and a disconformable surface, overlain by a shell bed at 411 m, which passes laterally into a 15 m deep channel, the *asiaticum* channel (Text-fig. 5), the base of which locally contains a conglomerate made up of corals and thick-shelled bivalve fragments. A group of three metre-thick highly glauconitic beds, each capped by a thin sandstone are present between 436 m and 446 m. An outline log of this locality, and palaeoenvironmental interpretation based upon trace fossils, were provided by Paranjape *et al.* (2015).

West-north–west of Garudamangalam (Text-fig. 6): A succession nearly 200 m of Karai Formation, exposed in badlands 2 km WNW of the village of



Text-fig. 3. Locality map for the section in the Karai Formation between Karai and Kulakkalnattam. KA 0–490 refer to heights in meters above the base of the section

Garudamangalam, was logged and sampled in a series of four traverses (A–D). The succession comprises calcareous clays and marls, with infrequent red and yellow coloured, bioturbated sandstone beds, 10–50 cm in thickness. Pyritized molluscs are preserved at some levels. The lower part, up to 100 m, contains common to abundant belemnites; at 107 m, oysters become common, and persist up to 150 m. Important markers include three red sandstones, between 53 and 61 m, and a sandstone pair at 108–109 m.

Odiyam-Kunnam (Text-figs 7–11)

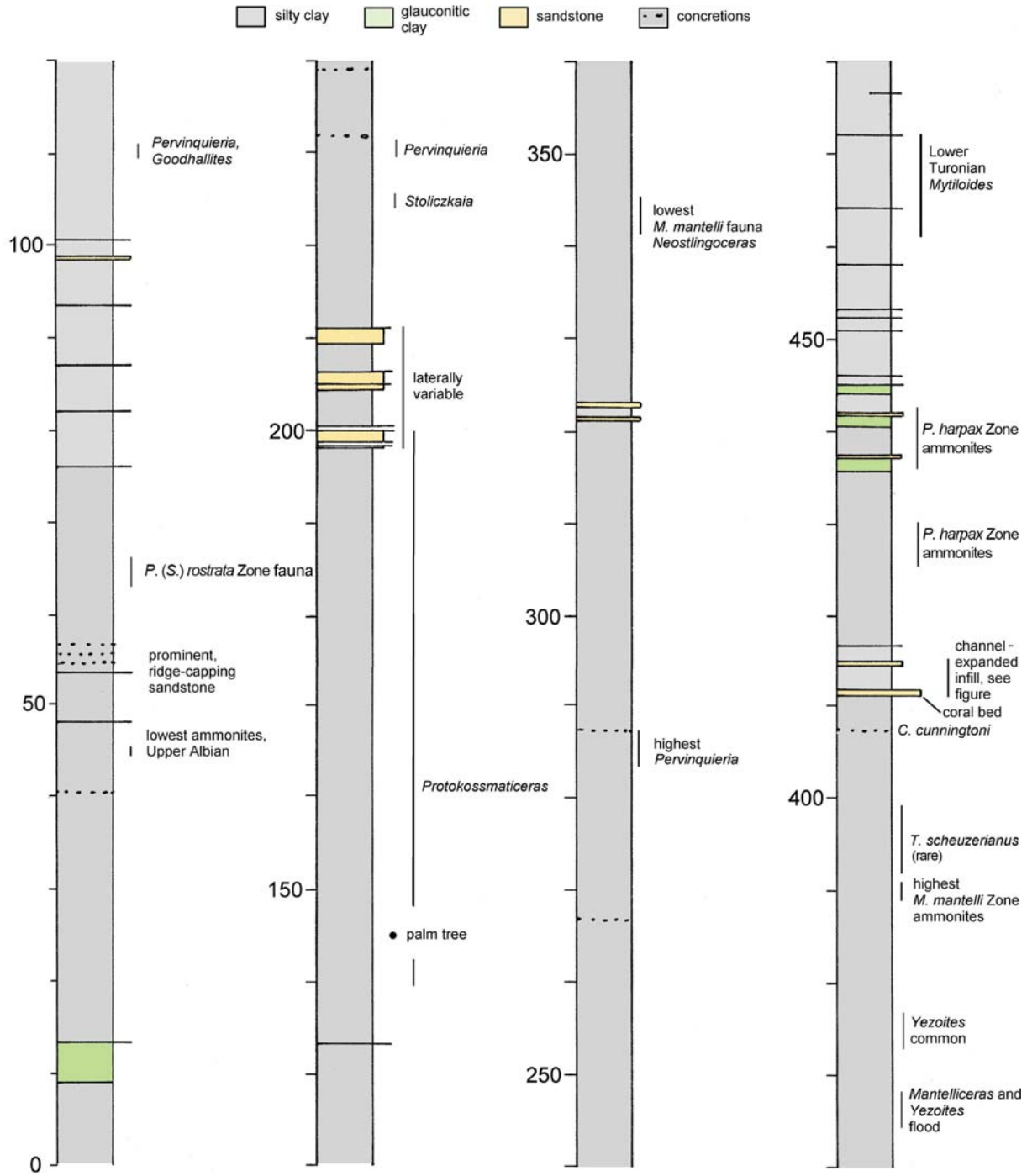
Although most of the Karai Formation consists of relatively deep-marine mudstones (Tewari *et al.* 1996), a sandy, marginal-marine facies is developed close to the villages of Kunnam and Odiyam, 60 km NNE of Trichinopoly (Text-fig. 7). The sequence has been assigned to the Odiyam and Kunnam Members of the Karai Formation (Sundaram *et al.* 2001; Text-fig. 2). Exposure is locally good, but generally consists of relatively short sections in stream courses or badlands broken by minor faults and areas of poor or no outcrop; typical exposures are shown in Text-fig. 8. Nevertheless, correlation of marker horizons allowed us to compile a composite section for the Upper Albian–Lower Turonian in the Odiyam–Kunnam area.

The sequence is sedimentologically complex and includes a number of discrete facies, briefly described below.

1. Intensely bioturbated, silty, fine to very fine sandstone (locally sandy siltstone: Text-fig. 8A, lower part; 8G). This is the dominant marine facies in the succession. Detrital silt content is variable (10–60%), but generally high. No primary sedimentary structures are preserved. Fe-cemented burrow fragments litter the yellow-brown weathered surfaces. Carbonate concretion horizons, typically with spacing in the range 0.8–1.5 m, are common. These include levels of isolated oblate-spheroidal "cannonballs" (commonly 20–30 cm thick, some septarian), and more continuous horizons of irregular, horizontally branched concretions (generally to 10 cm thick), which commonly preserve ?*Thalassinoides* burrow networks in their upper parts. There are also rare laterally continuous carbonate-cemented intervals up to 80 cm thick which contain abundant, but well dispersed inoceramids and ammonites. Elsewhere fossils are generally more sparse, although coiled serpulid tubes are abundant throughout.

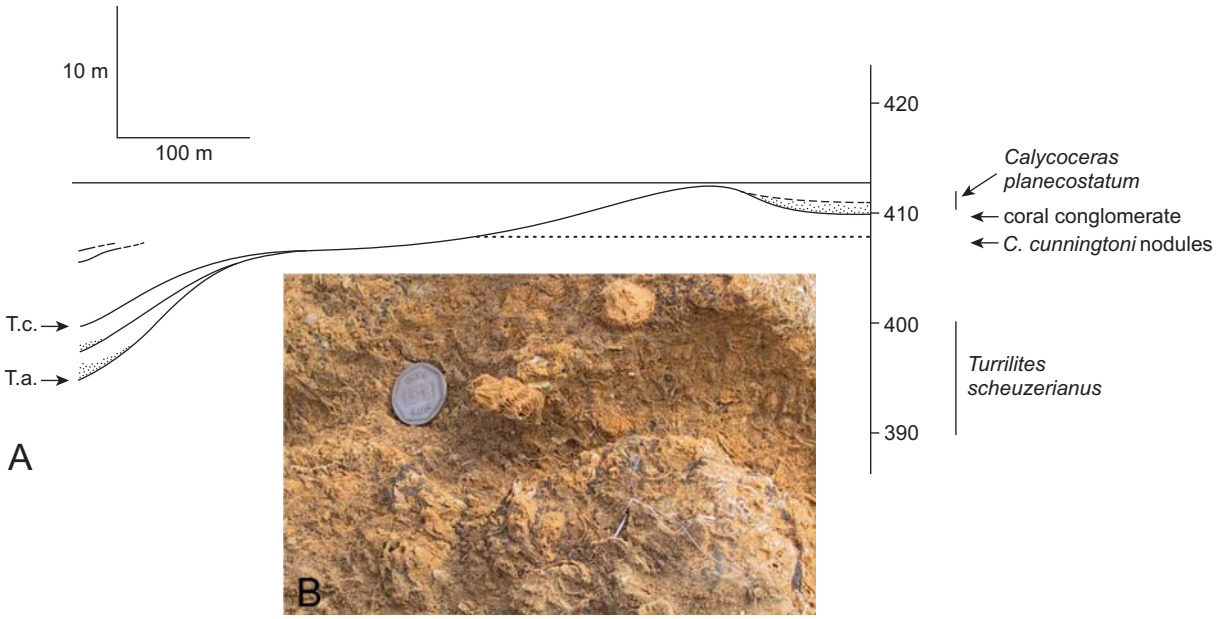
2. Thin-bedded fine sandstone (beds generally 3–10 cm thick, some < 3 cm: Text-fig. 8F). Typically occurs as isolated units, better cemented than enclosing Facies 1 silty sandstones. Invariably intensely bioturbated, and may in places be homogenized into Facies 1, but tend to be more continuous than horizons of rounded concretions. No primary sedimentary structures are preserved. Some beds are relatively rich in shell debris, and these may pass laterally to a thin lumachelle (oysters etc.).

3. Medium- to thick-bedded, fine-grained (rarely fine to medium grained), generally well-sorted, sandstone (Text-fig. 8F). A few beds are very thick (up to 1.6 m). Most units are intensely bioturbated and primary sedimentary structures are rare. However, some beds show horizontal or slightly undulating stratification (some in the lower part only). For instance, at the c. 206 m level in the main Odiyam section a 1-m-thick interval consists mainly of sharp-based, relatively parallel-sided 13–24 cm thick units. These have basal divisions of flat-stratified fine sandstone which locally contain abundant shell debris, and finer,



Text-fig. 4. The section in the Karai Formation between Karai and Kulakkalnattam

bioturbated silty sandstone tops. Beds are amalgamated, burrows in the upper parts of beds are commonly truncated by the sharp, erosional base of the overlying sandstone, and in places flame structures are developed. Elsewhere, an amalgamated, lenticular sandstone up to 80 cm thick has a basal division consisting of fine sandstone with shell-debris rich horizons defining 5–10 cm scale flat stratification.



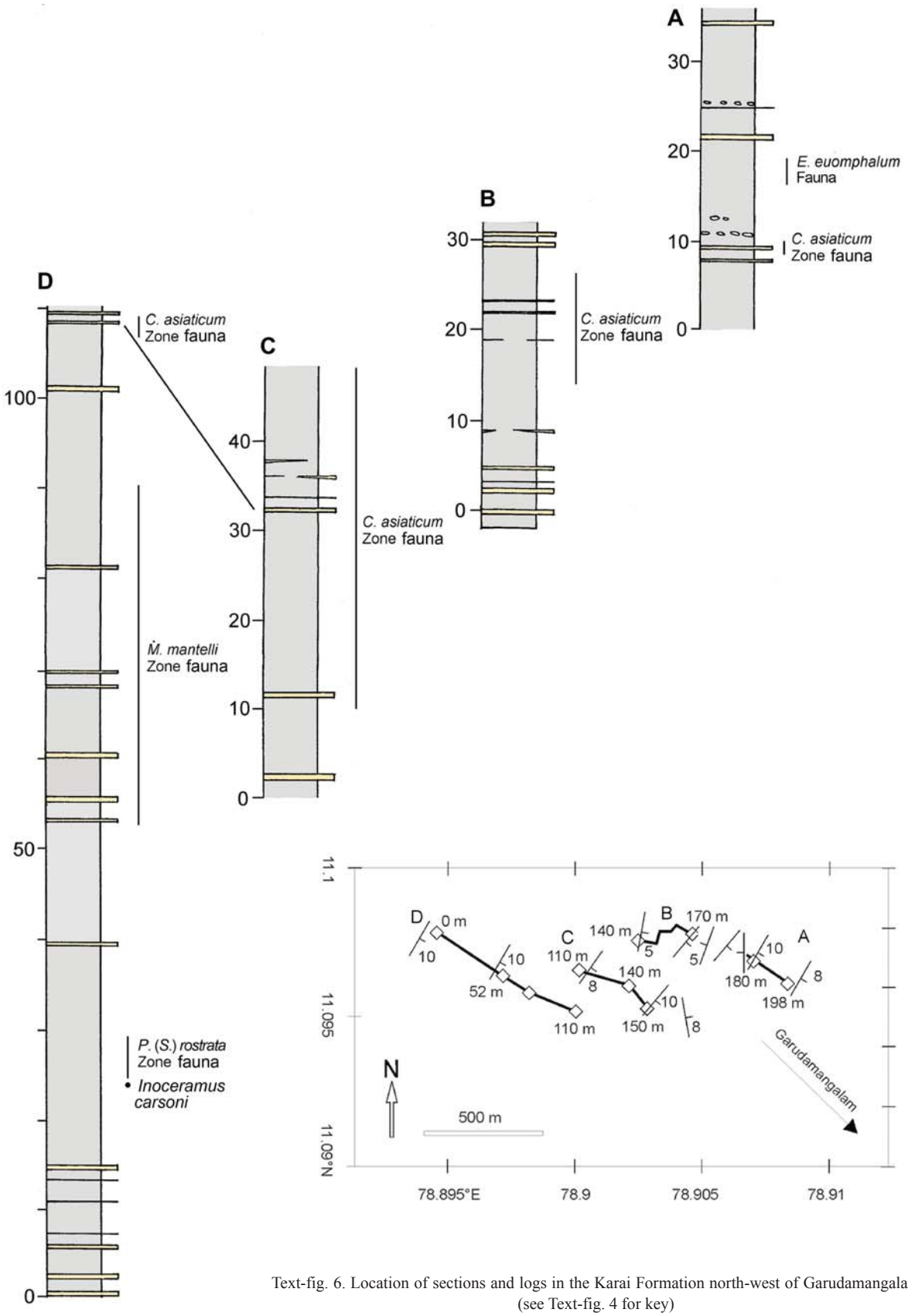
Text-fig. 5. **A** – Schematic section of the *asiaticum* Zone channel cut into lower and middle Cenomanian sediments at the 410 m level in the section between Karai and Kulakkalnattam (see Text-figs 3 and 4 for location). An erosional surface at 410 m cuts down to the north, and erodes through a line of concretions containing *Cunningtoniceras cunningtoni* (Sharpe, 1855), to rest on upper Lower Cenomanian sediments with rare limonitic early whorls of *Turrilites scheuchzerianus* Bosc, 1801. The channel has a maximum visible depth of about 15 m. The channel fill in the southern part comprises a conglomerate made up of worn pieces of scleractinian coral (**B**) and serpulids. To the north, the channel fill expands and is made up of several discrete fining-upwards packages of sediment. The lowest of these contains an indigenous specimen of *Turrilites acutus* Passy, 1832. A remanié, phosphatised *Turrilites costatus* Lamarck, 1801 is present 4–5 m above the base of the channel. In the south, the base of the channel fill yields *Calycoceras* (*Newboldiceras*) *planecostatum* (Kossmat, 1897) and *C.* (*N.*) *asiaticum* (Jimbo, 1894) between 410 and 412 m. The coin in B is 1.5 cm in diameter

Its upper part consists of hummocky cross-stratified? fine sandstone, with a sharp, erosional base (concave-upward scour) on the lower part. Trough cross-stratification was seen at a single location (Text-fig. 8F), where cross-sets up to 30 cm thick alternate with intervals rich in comminuted shell debris. One 1.3 m thick unit contains mud clasts with long axes up to 8cm long (mostly bedding parallel), and wood fragments and ammonites occur at the top of some beds. Some beds are continuous within outcrop limits (up to several hundred metres along strike), but many are seen to lens out, passing laterally into carbonate concretion horizons. Many beds appear to "pinch and swell" around large (to 4 m), oblate concretions with diffuse margins (these may enclose smaller, 10–30 cm, sharper edged, previously formed concretions).

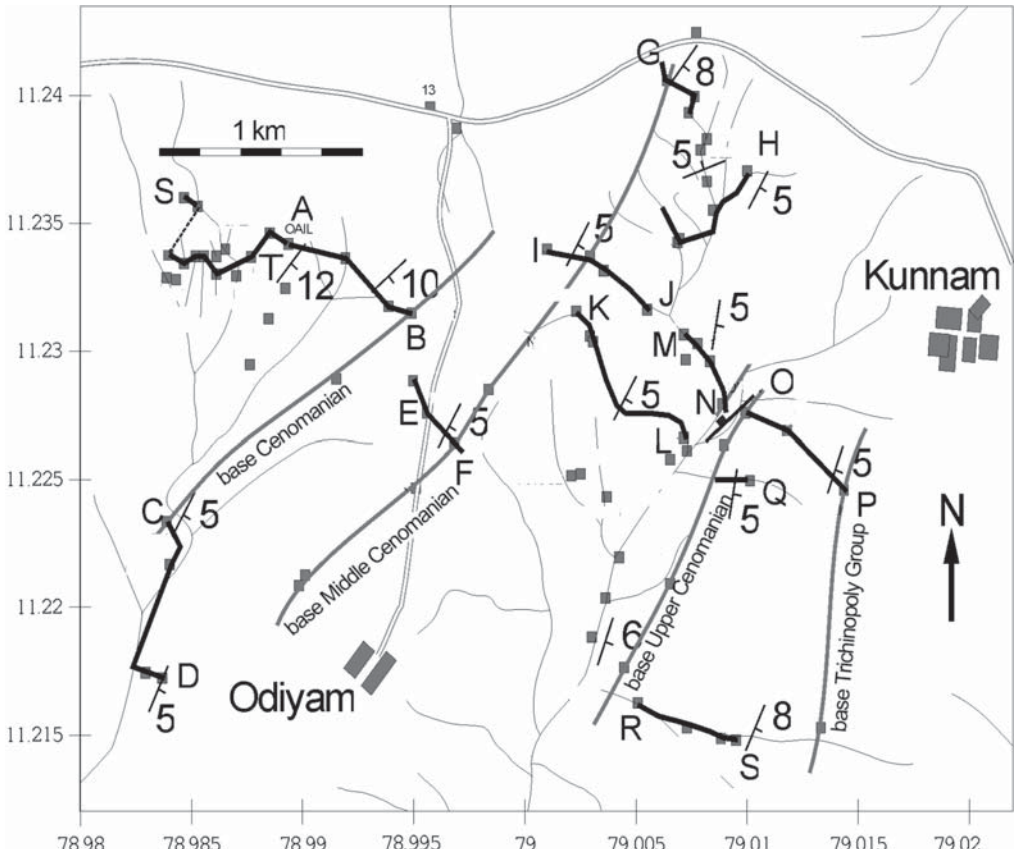
4. Coquina (Text-fig. 8H). This facies typically consists of clast-supported shell gravel with a well-sorted fine sandstone matrix. Although individual units are laterally variable, it is possible to distinguish two main types:

a. Erosionally based, commonly indurated shell beds, containing variably bored fossils (bivalves, gastropods, serpulids, coral), reworked carbonate-cemented concretions (locally abundant, rarely bored, with clavate *Gastrochaenolites*-type borings in some clasts) and well-rounded igneous/metamorphic pebbles (generally rare). These occur as single beds, or, more rarely, amalgamated packets of several beds, up to 1.5 m thick. Where outcrop permits, they are seen to be laterally impersistent, filling scours or channels ranging from 5 to 25 m across, which (where orientations can be measured) trend broadly east-west (range 80–120º). Sorting of the gravel-grade fraction ranges from good to poor. Some beds appear to be internally structureless, but most show either cross/inclined or apparently horizontal stratification.

b. Simple, generally relatively thin (up to 20 cm), shell beds without markedly erosional bases, commonly dominated by oysters (without borings) and lacking basement-derived pebbles or reworked concretions.



Text-fig. 6. Location of sections and logs in the Karai Formation north-west of Garudamangalam (see Text-fig. 4 for key)

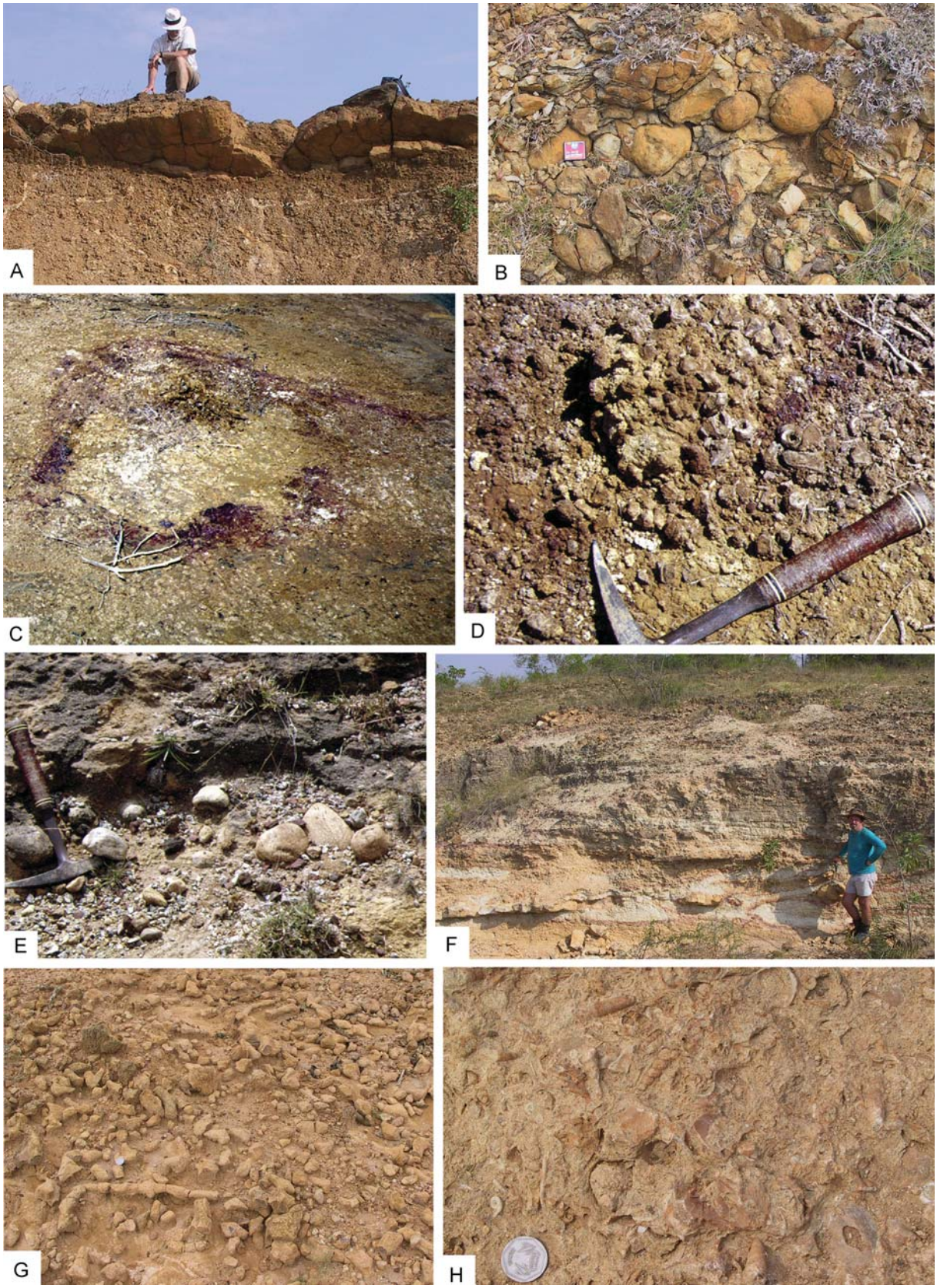


Text-fig. 7. Locality map for sections in the Karai Formation between Odiyam and Kunnam

5. Concretion conglomerate (Text-fig. 8B). Lenticular clast-supported beds up to 50 cm thick, consisting of irregularly shaped concretions (up to 30 cm across) in well-sorted fine sand matrix which may be abundantly fossiliferous. In places an erosional base on Facies 3 sandstone is exposed.

6. Basement-derived conglomerate. There are two lenses, one in the Albian part of the sequence, the other at the base of the *harpax* Zone coquina with *Eucalycoceras pentagonum* (Text-fig. 8E). The lenses consist of poorly sorted, clast-supported conglomerate made up of well-rounded, extraformational, metamorphic/igneous pebbles/cobbles up to 12 cm in diameter in a sandy matrix. The lens in the *harpax* Zone is up to 70 cm thick, extends 13m along strike, and has a finer, 20-cm-thick sandy top. The poorly exposed Albian lens is up to 40 cm thick. Both occur within thick multiple palaeosol successions.

7. Palaeosols (Text-fig. 8C, D). Pedogenically modified intervals range from erosionally truncated reddened horizons less than 10 cm thick to sequences of multiple palaeosols several tens of metres thick. Although some palaeosols are mottled red and pale grey, most have a striking horizontally banded structure, consisting of 20–50 cm thick pale blue-grey intervals with thin (typically 1–3 cm), brick-red upper and lower margins. These horizons may occur singly within thick yellow-brown marine successions or be vertically stacked to form compound soils separated by minimally weathered marine sediments, or be composite, lacking unmodified marine horizons (cf. Kraus 1999) profiles. Lower contacts with pedogenically unmodified sediment are typically sharp and relatively planar. Upper contacts tend to be similar, but may show erosional truncation or disruption by marine bioturbation (e.g. *Thalassinoides*). It appears that the parent material in all cases was marine silty sand (Facies 1 or 2). Marine carbonate concretion horizons occur within composite profiles and primary sedimentary structures (e.g. flat stratification in sandstones) are pre-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served in some palaeosols. However, colour banding appears to be developed independently of any stratification planes that record superposition of soil geochemistries. Apart from the colour banding and rare relict features, most palaeosols appear to be relatively structureless at outcrop. Visible root traces are rare, but at some levels calcareous rhizocretions (1–2 cm across) form 10–20-cm-diameter bundles surrounded by blue-grey, red-outlined halos within marine Facies 1 sandstones.

THE AMMONITE FAUNAS

Previous research

The first mid-Cretaceous ammonite to be described from south India is *Ammonoceratites lamarcki* Bowditch (1822 (February), p. 21 pl. 3, fig. 14), the same material (MNHN. F. A29217) being described as *Ammonoceras glossoidea* by Lamarck (1822 (August), p. 644) in volume seven of his *Histoire naturelle des animaux sans vertebrès* (see Casey 1960, p, 2, footnote 1). The provenance of the material is indicated by Chenu (1859, p. 90), who quotes Valenciennes as telling him that "Lamarck lui a souvent répété que ce fossile, dont il faisant grand cas, avait été rapport par le secrétaire de la colonie de Pondichéry, et donnant au fils de Buffon, qui lui en avant luimême fait cadeaux. M. Valenciennes ajoute que parmi les ammonites rapporteés."

It is generally agreed that *Ammonoceratites lamarcki* is a lytoceratid, and that it may well be what has been subsequently described as *Ammonites mahadeva* (Stoliczka, 1865) (p. 165, pl. 80, fig. 1), the type material of which comes from Moraviatoor, and is of Albian age (see Kennedy and Klinger 1978, p. 283 *et seq*; Hoffman in Klein *et al*. 2009, p. 296).

The first substantial account of ammonite faunas from Tamil Nadu is that of Edward Forbes (1846), based on material collected by Kaye and Cunliffe; in all 178 species, of which 165 are molluscs. Most of the species described were from the environs of Pondicherry. Forbes regarded the Pondicherry fauna as Lower Cretaceous, although subsequent workers placed them higher in the sequence; the Pondicherry ammonites were revised by Kennedy and Henderson (1992a, b) who concluded that they were from the Upper Maastrichtian. Forbes also described four species from Verdachellum (Vridachellum): *Ammonites Sugata* (type species of *Damesites* Matsumoto, 1942); *Ammonites Gaudama* (a *Mesopuzosia* Matsumoto, 1954), *Ammonites Sacya* and its synonym *Ammonites Buddah* (type species of *Anagaudryceras* Shimizu, 1934). The age and provenance of this material is in doubt, as discussed by Blanford (1862, p. 65) and Sastry *et al*. (1969). On the basis of occurrences elsewhere, *Damesites sugata* has a range from Coniacian to Campanian; the types are re-described by Kennedy and Henderson (1991a). *Mesopuzosia gaudama* has a range from Upper Turonian to Coniacian on the basis of records from Madagascar. The type is re-described by Kennedy and Henderson (1991b). *Anagaudryceras sacya* has a range from Middle Albian to Coniacian; the types of *sacya* and *buddah* are revised by Kennedy and Klinger (1979), who erroneously gave the name *buddah* priority. This is principally a Middle Albian and Cenomanian species, but may range higher, depending on the interpretation of the species (Kennedy and Klinger 1979, p. 152; Matsumoto 1995, p. 39).

The publication, fifteen years after Forbes, of the account of the Ammonitidae with revision of the Nautilidae by Ferdinand Stoliczka (1863–1866), in Blanford and Stoliczka's *The Fossil Cephalopoda of the Cretaceous rocks of southern India*, published in the *Memoirs of the Geological Survey of India, Palaeontologica Indica* (series 3), is the text upon which all subsequent accounts of the fauna depend. Stoliczka's work is illustrated by lithographs that depict his material with all of its imperfections. At the time he was writing, planispirally coiled ammonites were still referred to *Ammonites*, within which various grouping: Cristati, Clypeiformes, Laevigati, Pulchelli, Rotomagenses etc., were recognized, following the system comprehensively set out in Alcide d'Orbigny's thesis (1846, p. 31 *et seq.*). The next substantial work on the ammonite faunas of south India was that of Franz Kossmat (1871–1938), whose doctoral dissertation at the University of Vienna was the basis for his *Untersuchungen über die S*üd*indische*

← Text-fig. 8. Exposures of the Karai Formation in the vicinity of Odiyam and Kunnam. **A** – intraformational conglomerate (facies 5) resting on bioturbated very fine sand (facies 1), section G–H, at the 205 m level. **B** – detail of intraformational conglomerate (facies 5). Square object is 3 cm in long. **C**, **D** – palaeosols (facies 7); ring-shaped red mottle represents the position of a tree (**C**), in which tubular rhizocretions are developed (**D**): **E** – basement derived conglomerate of poorly sorted pebbles in sandy matrix (facies 6), section O–P at the 246 m level. **F** – cross-bedded fine sands, showing some fine planar lamination (facies 2) and beds of structureless sandstone (facies 3) section T–U at the 60–75 m level. **G** – bioturbated very fine sand (facies 1) containing horizontal *Thalassinoides* burrow systems. The coin is 1.5 cm in diameter. **H** – coquina in sandy matrix, containing abundant gastropods (*Turritella* sp.) and bivalves, shells replaced by calcite (facies 4)

Kreideformation, published in *Beiträge zur Paläontologie Österreich-Ungarns und des Orients* between 1895 and 1898, based on Stoliczka's material and that in the Warth Collection (housed in the collections of the Geological Survey of India). *Ammonites* had been superseded by a taxonomy that is generally in use today (for a tribute Kossmat see Summesberger and Govidan 2000).

Since the work of Kossmat, there have been only minor revisions of the mid-Cretaceous ammonite faunas of South India (the revisions of Forbes' 1846 work, noted above, excepted), most dealing with individual species and genera These include contributions by Ayyasami (1990), Chiplonkar *et al*. (1986), Chiplonkar and Phansalkar (1978a, b), Gautam *et al*. (2015), Matsumoto *et al*. (1966), Phansalkar (1977, 1983, 1994), and Vartak and Ghare (1987). Casts of a few of Stoliczka and Kossmat's specimens have been figured photographically in publications describing non-Indian faunas (for example Wright and Kennedy 1981, 1990; Delanoy and Latil 1988), but there is no comprehensive published photographic record.

The sequence of ammonite faunas

Figure 12 shows the ammonite zonal sequence proposed for the Upper Albian to Lower Turonian in the study area, and its correlation with the Western European standard sequence. The basis for this zonation, and its record in the three study areas is described below. Table 1 plots the zonal distribution of the species present.

Kossmat (1895, p. 102 (6); 1898 p. 126 (191) *et seq*.) produced detailed comparisons between the ammonite faunas from Tamil Nadu and elsewhere. He recognised the following divisions in the Uttatur Group:

"a) Schloenbachienschicten von Maravattur, Odium, Uttatur, mit *Schloenbachia inflata* Sow., *Turrilites Bergeri* Brong., *Hamites armatus* Sow etc." This corresponds to the Upper Albian *inflatum* and *perinflatum* zones of the present scheme.

"b) *Acanthocerassichichten* von Odium etc. mit zahlreichenen *Acanthoceras* aus der Gruppe des *Rhotomagense* Defr. und *Mantelli* Sow, *Turrilites costatus* Lam. etc." In his taxonomic section, species such as *Acanthoceras pentagonum* are assigned to the "Acanthocerashorizont" (1897, p. 15 (122)), and the *Acanthocerasschichten* clearly corresponds to the *mantelli*, *cunningtoni*, *asiaticum*, and *harpax* zones of the present scheme.

"c) Schichten von Cunum mit *Mammites conciliatus* Stoliczka, *Nautilis huxleyanus* Blanf. etc." We have not ourselves found *conciliatus*, but records in Madagascar (Besairie and Collignon 1971, p. 248), where it co-occurs with *Neoptychites cephalotus* suggest it is in part or in whole equivalent to the *Neoptychites cephalotus–Mytiloides borkari* association of the present scheme.

Sastry *et al.* (1968) proposed the following sequence:

3. *Mammites conciliatum* Zone
2. *Calycoceras newboldi* Zone
1. *Schloenbachia inflata* Zone

At first sight, this zonation appears to be basically that of Kossmat, with the Acanthocerasschichten renamed the *newboldi* Zone. However, their species lists for the *inflata* Zone include the exclusively Lower Cenomanian *Hypoturrilites tuberculatus*, and it is assigned by the authors to the Upper Albian and Lower Cenomanian. The *newboldi* Zone was assigned to the Lower and Middle Cenomanian, but problematically, "*Romaniceras medlicottianum* (Stol.)" is stated to be restricted to the zone, appearing about the middle of the zone (p. 14). This is problematic, as *medlicottianum* is a Turonian *Romaniceras* (*Romaniceras*) Spath, 1923, and a synonym of *R*. (*R*.) *deverianum* according to Kennedy *et al*. (1980, p. 338) and Upper Turonian (Robaszynski *et al*. 2014). The *conciliatum* Zone is regarded as Upper Cenomanian and Lower Turonian, but there is a problematic record of *Turrilites costatus*.

Ayyasami and Banerji (1984) proposed the following sequence across the Cenomanian–Turonian boundary:

Lower Turonian: *Pseudaspidoceras conciliatum* Zone
Upper Cenomanian *Eucalycoceras pentagonum* Zone
Middle Cenomanian *Calycoceras newboldi* Zone

The *newboldi* Zone corresponds to the *asiaticum* Zone of the present scheme ; the *pentagonum* Zone corresponds to the *harpax* Zone of the present scheme; the *conciliatum* Zone to the *footeanum* Zone and the *Neoptychites cephalotus–Mytiloides borkari* fauna, and spans the Cenomanian–Turonian boundary.

Ayyasami (1990) proposed the following heteromorph-based zonation of the Uttatur Group:

5. No characteristic heteromorph
4. *Scaphites kingeanus* Zone
3. *Turrilites costatus* Zone
2. *Scaphites obliquus* Zone
1. *Anisoceras perarmatum* Zone

On the basis of associated faunas (Ayyasami 1990, p. 113), the *perarmatum* Zone corresponds to the *rostrata* and *perinflata* zones of the present scheme,

ammonite taxa \ ammonite zones	Pr	Pp	Mm	Cc	Ca	Ph	Es	Pf	Nc
P. (H.) seresitense seresitense	*		*			*			
P. (H.) ellipticum					*				
P. (H.) velledae velledae			*						
P. whiteavesi	*		*		*				
T. subtimotheanus			*						
G. berakatense			*						
Eogaudryceras sp.	*								
G. mite									*
G. vertebratum					*				
Gaudryceras spp. juv.			*						
A. multiplexum	*			*	*				
A. utaturense		*			*				
K. marut	*		*						
P. (P.) compressa	*								
P. (P.) crebrisulcata					*		*		
P. (P.) insculpta					*				
P. (P.) odiensis					*				
P. (B.) bhima				*	*				
P. (B.) stoliczkai	*		*						
P. (B.) falx					*				
D. (D.) latidorsatum	*			*	*	*	*		
D. (D.) mahabobokaensis			*						
H. cf. *cliveanus*	*								
Holcodiscoides sp.	*		*						
Protokossmaticeras sp.	*								
M. papillatus	*								
P. (P.) stoliczkai	*								
P. (S.) rostrata	*								
P. (S.) gr. *perinflata*		*							
Cantabrigites sp.	*								
G. cf. *besaktrense*	*								
Goodhallites sp.	*								
A. (A.) besairiei			*						
S. (S.) clavigera	*		*						
S. (L.) crotaloides	*								
O. cf. *ojinagense*			*						
F. largilliertianum			*						
F. chevillei					*				
M. mantelli			*						
M. cantianum			*						
M. lymense			*						
M. saxbii			*						
M. cf. *picteti*			*						

ammonite taxa \ ammonite zones	Pr	Pp	Mm	Cc	Ca	Ph	Es	Pf	Nc
M. spp. juv.			*						
S. indicum			*						
S. florencae			*						
S. sp.			*						
U. vicinale			*						
A. renevieri			*						
C. cunningtoni				*					
C. sp.				*					
A. rhotomagense					*				
A. whitei					*				
Acanthoceras sp. juv.					*				
K. tropicum						*			
P. parva					*				
C. (*C.*) *bathyomphalum*					*				
C. (*C.*) *naviculare*						*			
C. (*C.*) cf. *barruei*						*			
C. (*G.*) *boehmi*					*				
C. (*P.*) *choffati*					*				
C. (*N.*) *asiaticum asiaticum*					*				
C. (*N.*) *asiaticum spinosum*					*				
C. (*N.*) *planecostatum*					*				
C. (*N.*) *tunetanum*					*				
P. harpax						*			
E. pentagonum						*			
E. gothicum					*				
E. cf. *jeanetti*								*	
T. (*S.*) *faustum*							*		
W. elegans							*		
E. euomphalum						*			
E. septemseriatum							*		
L. abberans						*			
H. coleroonense								*	
P. footeanum								*	
K. multinodosum									*
K. turoniense									*
V. diartianum							?		
F. rudra									*
N. cephalotus									*
A. saussureanum saussureanum	*								
A. angulatum	*								
A. perarmatum	*								
A. plicatile					*				
Anisoceras sp.					*				

ammonite taxa \ ammonite zones	Pr	Pp	Mm	Cc	Ca	Ph	Es	Pf	Nc
A. auberti			*						
Anisoceras? sp. juv.	*								
H. duplicatus			*						
H. cf. *subvirgulatus*	*								
H. simplex	?	*							
Hamites sp. A				*					
Hamites sp. B	*								
Hamites sp. C	*								
H. cf. *tropicum*		*							
O. (*O.*) *rorayense*			*						
O. (*O.*) sp.			*		?	?			
N. carcitanense			*						
N. sp.					*				
C. multituberculatus						*			
Carthaginites sp.									
M. (*M.*) *circumtaeniata*	*								
M. (*M.*) *lewesiensis*			*						
M. (*M.*) sp. juv.	*								
T. *scheuchzerianus*			*						
T. aff. *scheuchzerianus*				*					
T. costatus					*				
H. gravesianus			*						
H. tuberculatoplicatus				*					
H. wiedmanni			*						
L. (*L.*) *gaudini*	*								
S. cucullatum				*	*				
S. antinamangaensis			*	*	*				
S. cf. *gracile*							*		
Sciponoceras sp. (smooth)			*			*			
Worthoceras sp.						*			
Y. kingianus			*						
S. dailyi			*						
S. collignoni			*						
S. similaris					*				

Table 1. Zonal distribution of the species present in the Upper Albian to Lower Turonian of the study area. Abbreviations to index taxa of ammonite zones: Pr – *Pervinquieria* (*Subschoenbachia*) *rostrata*; PS – *Pervinquieria* (*Subschloenbachai*) *perinflata*; Mm – *Mantelliceras mantelli*; Cc – *Cunningtoniceras cunningtoni*; Ca – *Calycoceras* (*Newboldiceras*) *asiaticum*; Ph – *Pseudocalycoceras harpax*; Es – *Euomphaloceras septemseriatum*; Pf – *Pseudaspidoceras footeanum*; Nc – *Neoptychites ceaphlotus*. Compare Text-fig. 12

the *obliquus* Zone to the *mantelli* Zone, the *costatus* Zone to the *cunningtoni* and *asiaticum* zones, the *kingeanus* Zone to the *harpax* Zone. We have not found *Scaphites obliquus* in the sections studied.

Sections between Odiyam and Kunnam

Text-figs 9–11 show the location and logs of the 10 sections studied in this area.

Upper Albian

Section T–U (Text-fig. 9), *Pervinquieria* (*Subschloenbachia*) *rostrata* Zone:

10 m: *Puzosia* (*Bhimaites*) sp., *Marshallites papillatus* (Stoliczka, 1866), *Hamites* sp., indeterminate Baculitidae.

33 m: *Desmoceras* (*Desmoceras*) sp., *Pervinquieria* (*Subschloenbachia*) *rostrata*.

52 m: *Puzosia* (*Bhimaites*) *stoliczkai*, *Kossmatella* cf. *marut* (Stoliczka, 1865), *Goodhallites* cf. *besakatrense* Collignon, 1963, *Hamites* sp., *Scaphites* sp.

69 m: *Desmoceras* (*D.*) sp. juv., *Kossmatella marut* (Stoliczka, 1865), *Scaphites* sp. indet.

70–75 m: *Stoliczkaia clavigera* (Neumayr, 1875).

Section A–B (Text-fig. 9), Lower interval: *Pervinquieria* (*Subschloenbachia*) *rostrata* Zone:

9.5–10 m: *Tetragonite subtimotheanus*, *Holcodiscoides* sp., *Anisoceras saussurenum* (Pictet, 1847), *Lechites gaudini* (Pictet, 1847), *Mariella* (*M.*) *circumtaeniata*.

10 m: *Anisoceras perarmatum* Pictet and Campiche, 1861, *Holcodiscoides* cf. *cliveanus* (Stoliczka, 1865), *Inoceramus carsoni* M'Coy, 1865.

13 m: *Pervinquieria* (*Subschloenbachia*) *rostrata*.

17 m: *Desmoceras* (*D.*) *latidorsatum* (Michelin, 1838), *Puzosia* (*P.*) *compressa* Kossmat, 1898, *Pervinquieria* (*Pervinquieria*) *stoliczkai* Spath, 1921, *Mariella* (*Mariella*) *circumtaeniata*.

Section A–B (Text-fig. 9), Upper interval: *Pervinquieria* (*Subschloenbachia*) *rostrata* Zone:

0–2 m: *Phyllopachyceras whiteavesi* (Kossmat, 1897), *Anagaudryceras multiplexum* (Stoliczka, 1865), *Puzosia* (*P.*) *compressa*, *Desmoceras latidorsatum*, *Protokossmaticeras* sp., *Stoliczkaia* (*S.*) *clavigera* (Neumayr, 1875), *S.* (*Lamnayella*) *crotaloides* (Stoliczka, 1864), *Hamites* sp., *Anisoceras perarmatum*, *Mariella* (*M.*) *circumtaeniata*.

56 m: *Phylloceras* (*Hypophylloceras*) sp., *Tetragonites subtimotheanus*, *Desmoceras* (*D.*) *latidorsatum*, *Anisoceras perarmatum*, *A. angulatum* (Stoliczka, 1866), *Scaphites pervinquierei* Wiedmann, 1965.

61 m: *Phylloceras* (*Hypophylloceras*) sp., *Desmoceras* (*Desmoceras*) sp., *Puzosia* (*Puzosia*) sp.

Section C–D (Text-fig. 9), *Pervinquieria* (*Subschloenbachia*) *perinflata* Zone:

68 m: *Pervinquieria* (*Subschloenbachia*) sp., group of *perinflata*. Upper Albian, equivalent to the western European *perinflata* Zone.

Lower Cenomanian

The base of the Cenomanian, defined by the first occurrence of the planktonic foramniferan *Thalmanninella* [*Globotruncana*] *globotruncanoides* in the Mont Risou section (Kennedy *et al*. 2004) cannot be rcognised in ammonite terms. It is rather the first occurrence of *Neostlingoceras oberlini* (Dubourdieu, 1953) and *Mantellicera mantelli* (J. Sowerby, 1814) that indicate the base of the Cenomanian in ammonite terms, and these first appear 6 m above the boundary in the Global Stratotype Section, defining the base of the *Mantelliceras mantelli* Zone and the *Neostlingoceras carcitanense* Subzone of the Western European standard sequence. Both of these species occur in the Tamil Nadu sections; we have not ourselves found the former, but Stoliczka (1866, p. 187, pl. 87, figs 6–8) described and figured examples, as *Turrilites tuberculatus*, from the 'neighbourhood of Odium'. Accordingly, we recognise a *Mantelliceras mantelli* Zone as the lowest zone of the Cenomanian in the Tamil Nadu sections.

The key succession is seen in section C–D (Text-fig. 9), *Mantelliceras mantelli* Zone:

79 m: *Phylloceras* (*Hypophylloceras*) sp., *Tetragonites subtimotheanus*, *Puzosia* (*Puzosia*) sp., *Puzosia* (*Bhimaites*) *stoliczkai* (Kossmat, 1898), *Desmoceras* (*D.*) *latidorsatum*, *Stoliczkaia* (*S.*) *clavigera*, *Utaturiceras vicinale* (Stoliczka, 1864), *Acompsoceras renevieri* (Sharpe, 1857), *Ostlingoceras*? sp., *Mariella* (*M.*) *lewesiensis* (Spath, 1926b), *Scaphites* sp.

81 m: *Mariella* (*M.*) *lewesiensis*.

82–83 m: *Mantelliceras* sp., *Mariella* (*M.*) *lewesiensis*.

90 m: *Tetragonites* cf. *subtimotheanus*, *Acompsoceras renevieri*, *Sciponoceras* sp. juv.

92 m: *Desmoceras* (*Desmoceras*) sp. juv., *Puzosia* (*Puzosia*) sp. juv., *Ojinagiceras* sp. cf. *ojinagense* Cobban and Kennedy, 1989, *Mariella* (*M.*) *lewesiensis*.

97 m: *Tetragonites* sp. juv., *Sciponoceras* sp., *Ostlingoceras* (*O.*) *rorayensis* (Collignon, 1964): *Mariella* (*M.*) *lewesiensis*.

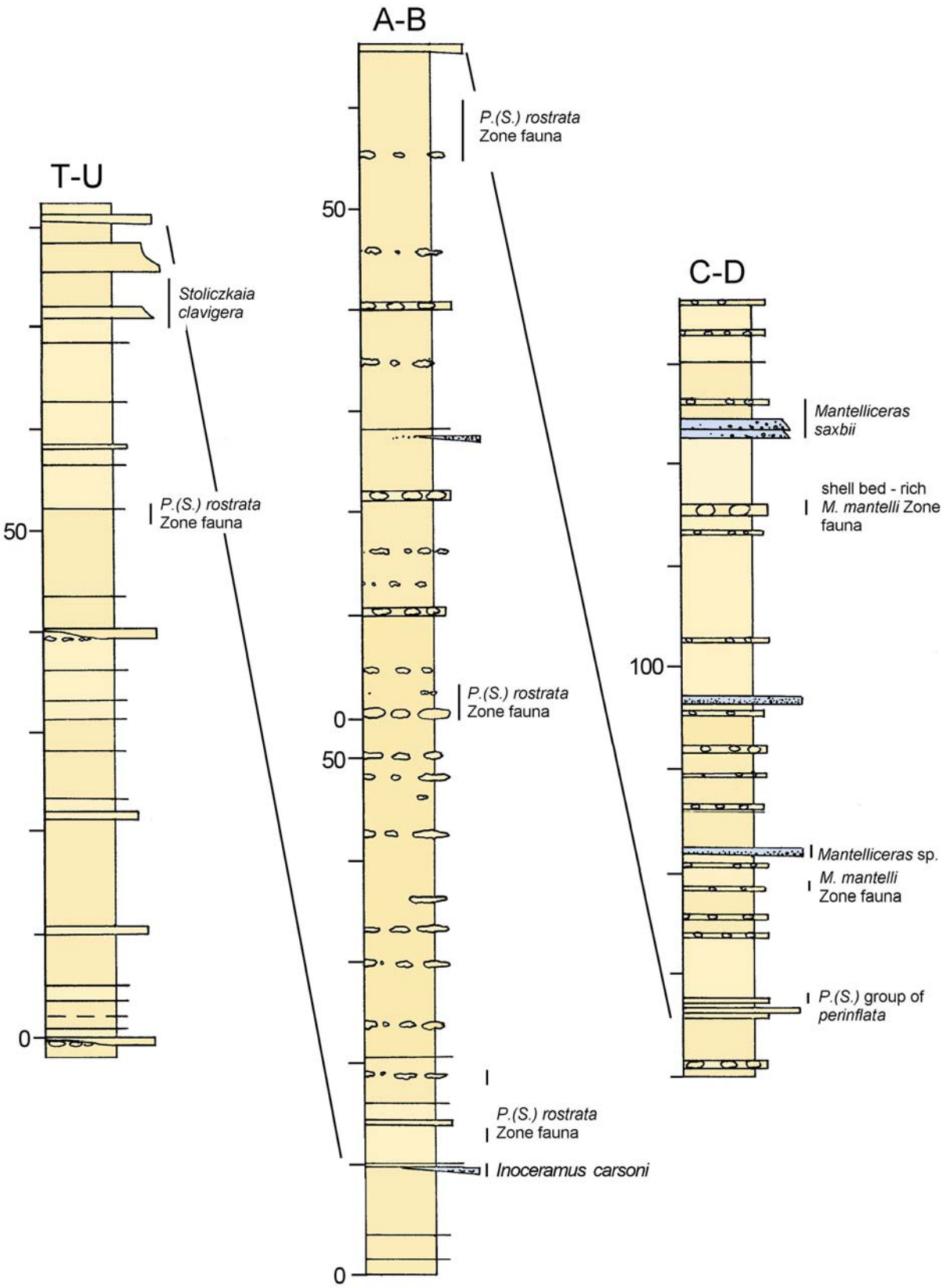
105 m: *Scaphites dailyi* Wright, 1953.

116 m: shell bed with abundant fauna of *Phylloceras* (*Hypophylloceras*) sp., *Phyllopachyceras* sp. juv., *Gaudryceras vertebratum* Kossmat, 1895, *Anagaudryceras utaturense* Shimizu, 1935, *Gabbioceras berekatense* (Collignon, 1964), *Tetragonites subtimotheanus*, *Puzosia* (*Bhimaites*) *stoliczkai*, *Desmoceras* (*D.*) sp., *Algericeras besairiei* (Collignon, 1964), *Forbesiceras largilliertianum*, *Mantelliceras mantelli* (J. Sowerby, 1814), *M. cantianum* (Spath, 1926a), *M. saxbii* (Sharpe, 1857), *M. lymense* (Spath, 1926b), *Hamites simplex* d'Orbigny, 1841, *Hamites duplicatus* Pictet and Campiche, 1861, *Anisoceras auberti* (Pervinquière, 1907), *Mariella* (*M.*) *lewesiensis*, *Sciponoceras* sp. (smooth), *Scaphites dailyi*.

123 m: *Hypoturrilites wiedmanni* (Collignon, 1964), *Yezoites kingianus* (Stoliczka, 1865).

127 m: *Mantelliceras saxbii*.

133 m: *Mantelliceras saxbii*, *Hypoturrilites gravesianus* (d'Orbigny, 1841).



Text-fig. 9. Logs of sections in the Karai Formation between Odiyam and Kunnam (see Text-fig. 4 for key)

These faunas indicate a horizon above the base of the Lower Cenomanian on the basis of the presence of *Acompsoceras renevieri*, which first appears in the upper, *Mantelliceras saxbii* Subzone of the *mantelli* Zone in Western Europe.

Faunas from section E–F (Text-fig. 10) can be referred to the *mantelli* Zone, and are as follows:

130 m: *Puzosia* (*Bhimaites*) *stoliczkai*, *Mantelliceras* cf. *mantelli*.

132.5 m: *M. saxbii*, *M. cantianum*.

135 m: *M.* cf. *mantelli*, *M.* cf. *cantianum*, *M.* cf. *saxbii*.

148 m: *Mantelliceras* sp. (pathological) cf. *picteti* Hyatt, 1903.

Similarly in section G–H (Text-fig. 10):

151 m: *Mantelliceras* sp.

155 m: *Mantelliceras* cf. *cantianum*.

155–160 m: *Mantelliceras* sp.

157 m: *Mantelliceras* sp., *Sharpeiceras* sp.

158 m: *Mantelliceras* sp.

159 m: *Mantelliceras*? sp., *Sciponoceras* cf. *antanimangaensis* (Collignon, 1964).

160 m: *Mantelliceras cantianum*, *Mantelliceras* sp. *Sharpeiceras* sp.

163 m: *Mantelliceras* sp.

165 m: *Mantelliceras cantianum*.

167 m: *Sciponoceras* sp.

The Lower–Middle Cenomanian boundary

We have seen no unequivocal evidence for the upper Lower Cenomanian *Mantelliceras dixoni* Zone in the present collections, or in the faunas described and illustrated by Stoliczka (1863–1866). The zonal index is known from Madagascar (*Mantelliceras pseudohyatti* Collignon, 1964, p. 73, pl. 341, fig. 1525, and *Mantelliceras lateretuberculatum* Collignon, 1964, p. 90, pl. 348, fig. 1548; pl. 349, fig. 1552, are synonyms of *dixoni*: *fide* Wright and Kennedy 1984, p. 124), which was adjacent to South India during the Cenomanian. More telling is the rarity of *Turriiltes scheuchzerianus* Bosc, 1801, which is common in the *dixoni* Zone elsewhere (Kennedy and Gale 2015, 2016, 2017, *in* Wright and Kennedy 2017).

The base of the Middle Cenomanian in ammonite terms is drawn at the first appearance of *Cunningtoniceras* (Tröger and Kennedy 1996; Kennedy and Gale 2016, 2017; *in* Wright and Kennedy 2017), In Western Europe this is at the base of a *Cunningtoniceras inerme* Zone, and the range of the index species corresponds to the upper part of the range of common *Turrilites scheuchzerianus*. *C. inerme* is not known from south India, but *Cunningtoniceras cunningtoni* (Sharpe, 1855) is a proxy, its first occurrence in the reference section at Southerham near Lewes in Sussex, U.K. (Kennedy and Gale 2017, text-fig. 9) corresponds to that of *C. inerme*. *Cunnigtoniceras inerme* and *C. cunningtoni* disappear immediately below the first occurrence of *Turrilites costatus* Lamarck 1801, in Western Europe. In contrast, *Cunningtoniceras inerme* extends higher, and overlaps with *Turrilites costatus* in North Africa (Kennedy and Gale 2006, 2017), as does *Cunningtoniceras cunningtoni* in South India. We recognise here a *Cunningtoniceras cunningtoni* Zone as the lowest zone of the Middle Cenomanian in Tamil Nadu, the species occurring with *Turrilites costatus*. There is thus no unequivocal record of the lower part of the range of *C. cunningtoni,* where it is associated with *Turrilites scheuchzerianus*. So far as the present sections are concerned, the presence of *Cunningtoniceras cunningtoni* and *Turrilites costus* are both markers for the lower Middle Cenomanian in south India, the presence of the latter correlating with the lower, *Turrilites costatus* Subzone of the *Acanthoceras rhotomagense* Zone of the Western European standard zonation. In conclusion, we have seen no unequivocal evidence for upper Lower, and lowermost Middle Cenomanian ammonite faunas, equivalent to those of the *dixoni* and *inerme* zones.

In section E–F (Text-fig. 10), there is a gap of 7 m between the highest Lower Cenomanian and the lowest Middle Cenomanian ammonites, with the following sequence:

155 m: *Desmoceras* sp. juv., *Forbesiceras* cf. *largilliertanum* (d'Orbigny, 1841), *Turrilites costatus*, *Sciponoceras* sp. (smooth).

157.5 m: *Turrilites costatus*.

163 m: *Turrilites costatus*.

There is a clearer record in section I–J (Text-fig. 10), *Cunningtoniceras cunningtoni* Zone:

13 m: *Anagaudryceras multiplexum*, *Cunningtoniceras cunningtoni*, *Cunningtoniceras* sp., *Hamites duplicatus*, *Hypoturrilites tuberculatoplicatus* (Seguenza, 1883), *Turrilites* sp.

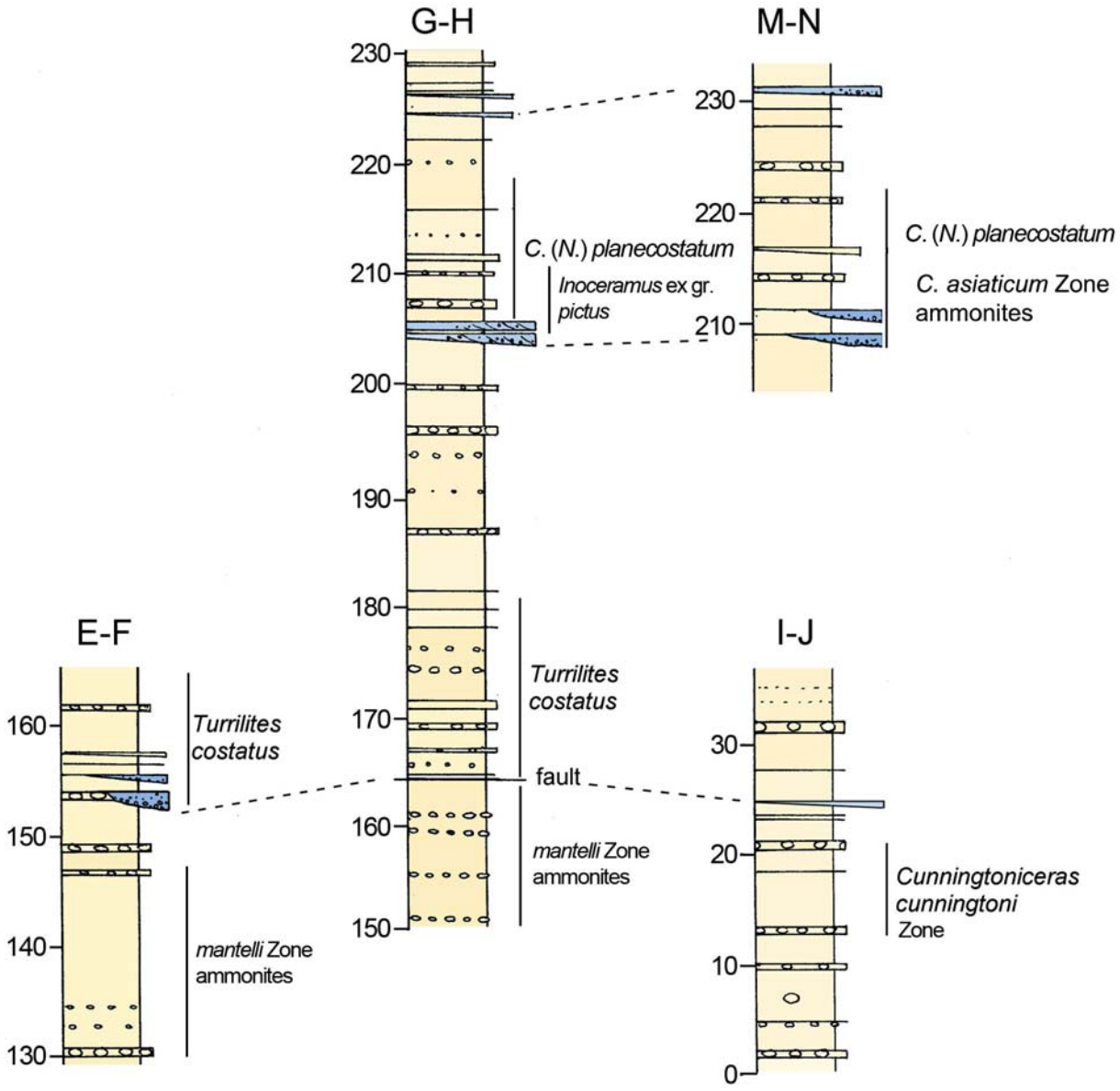
15.4 m: *Desmoceras* (*Desmoceras*) sp.

20 m: *Turrilites* aff. *scheuchzerianus*.

20.5 m: *Cunningtoniceras cunningtoni*, *Hypoturrilites tuberculatoplicatus*.

20–21 m: *Desmoceras* (*D.*) *latidorsatum*, *Hypoturrilites tuberculatoplicatus*.

The *cunningtoni* Zone is succeeded by a *Calycoceras* (*Newboldiceras*) *asiaticum* Zone that extends



Text-fig. 10. Logs of sections in the Karai Formation between Odiyam and Kunnam (see Text-fig. 4 for key)

from the last occurrence of *Cunningtoniceras cunningtoni* to the first occurrence of *Pseudocalycoceras harpax* (Stoliczka, 1864), taken as index of a lower Upper Cenomanian *harpax* Zone, into which *C.* (*N.*) *asiaticum asiaticum* (Kossmat, 18978) and *C.* (*N.*) *asiaticum spinosum* extend. A key marker in the *asiaticum* Zone is the first occurrence of *Calycoceras* (*Newboldiceras*) *planecostatum* (Kossmat, 1897), which first appears in the *Acanthoceras jukesbrownei* Zone of the Western European sequence. Details of *asiaticum* Zone sequences are as follows:

Section G–H (Text-fig. 10): *Calycoceras* (*Newboldiceras*) *asiaticum* Zone:

165–170 m: *Phyllopachyceras* sp. juv., *Desmoceras* (*D.*) *latidorsatum*, Acanthoceratinae indet.

168 m: *Puzosia* (*Puzosia*) sp., *Puzosia* (*Bhimaites*) sp., *Turrilites costatus.*

168–170 m: *Desmoceras* (*Desmoceras*) sp., *Puzosia* (*P.*) sp., *Turrilites costatus.*

168–173 m: *Puzosia* (*P.*) *odiensis* Kossmat, 1898, *Desmoceras* (*D.*) *latidorsatum*, *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894), *Anisoceras plicatile* (J. Sowerby, 1819), *Sciponoceras cucullatum* Collignon, 1964, *Turrilites costatus*.

169 m: *Forbesiceras chevillei* (Pictet and Renevier, 1866), *Cunningtoniceras* sp., *Acanthoceras* cf. *whitei* Matsumoto, 1959, *Calycoceras* (*Newboldiceras*) sp., *Turrilites costatus.*

170 m: *Phyllopachyceras* sp., *Puzosia* (*Puzosia*) *crebrisulcata* Kossmat, 1898, *Turrilites costatus.*

170–175 m: *Desmoceras* (*D*). *latidorsatum*, juvenile Gaudryceratinae, *Forbesiceras chevillei*, *Acanthoceras rhotomagense* (Brongniart, 1822), *A. whitei*, *Calycoceras* (*Newboldiceras*) sp., *Sciponoceras* sp., *Turrilites costatus*.

171 m: *Puzosia* (*P.*) *crebrisulcata*, *Calycoceras* (*Gentoniceras*) *boehmi* Spath, 1926b, *C*. (*Newboldiceras*) *asiaticum asiaticum*.

171.3 m: *Turrilites costatus*.

172 m: *Puzosia odiensis*, *Sciponoceras* cf. *cucullatum*.

172–175 m: *Desmoceras* (*D.*) *latidorsatum*, *Forbesiceras chevillei*, *Hypoturrilites tuberculatoplicatus*, *Anisoceras* sp. juv., *Sciponoceras antimanangaensis*, *Turrilites costatus.*

173–175 m: *Forbesiceras chevillei*, *Anisoceras* sp., *Sciponoceras* sp., *Turrilites costatus*.

174–175 m: *Hypoturrilites tuberculatoplicatus*.

175 m: *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*, *C*. (*N.*) *asiaticum spinosum* (Kossmat, 1897), *C*. (*N.*) sp., *Sciponoceras* sp.

176 m: *Calycoceras* (*G.*) *boehmi*.

177 m: *Acanthoceras rhotomagense*, *Calycoceras* (*G.*) *boehmi*.

177–180 m: *Puzosia* (*P.*) sp., *Turrilites costatus*.

177–181 m: *Phylloceras* (*Hypophylloceras*) sp., *Desmoceras* (*D.*) *latidorsatum*, *Puzosia* (*P.*) aff. *crebrisulcata*, *Acanthoceras rhotomagense*, *Calycoceras* (*G.*) *boehmi*, *C*. (*Newboldiceras*) sp.

180 m: *Puzosia* (*P.*) sp. juv., *Calycoceras* (*G.*) *boehmi*.

183 m: *Turrilites costatus*.

184 m: *C*. (*Newboldiceras*) sp.

187 m: *Calycoceras* (*Newboldiceras*) t*unetanum* (Pervinquière, 1907), *Turrilites* cf. *costatus.*

195–196 m: *Desmoceras* (*D.*) *inane* (Stoliczka, 1865), *Puzosia* (*P.*) *odiensis*, *P.* (*P.*) *insculpta* Kossmat, 1898, *Calycoceras* (*G.*) *boehmi*, *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*, *C*. (*N.*) *asiaticum spinosum*, *C*. (*N.*) *tunetanum*.

196–201 m: *Calycoceras* (*Gentoniceras*) *boehmi*, *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*.

203 m: *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*.

205 m: juvenile gaudryceratid, *Desmoceras* (*D.) latidorsatum*, *Puzosia* (*Puzosia*) sp., *Puzosia* (*Bhimaites*) *stoliczkai*, *Calycoceras* (*Newboldiceras*) *tunetanum*, *C*. (*N.*) sp.

205–215 m: *Calycoceras* (*Newboldiceras*) *planecostatum* (Kossmat, 1897).

209 m: *Anisoceras* sp.

209–210 m: *Tetragonites subtimotheanus*, *Puzosia* (*Puzosia*) sp., *Sciponoceras antanimangaensis*, *Calycoceras* (*Calycoceras*) *bathyomphalum* (Kossmat, 1895).

210 m: *Phylloceras* (*Hypophylloceras*) sp., *Phyllopachyceras whiteavesi*, *Desmoceras* (*Desmoceras*) sp.

210–212 m: *Tetragonites* cf. *subtimotheanus*, *Gaudryceras multiplexum* (Stoliczka, 1865), *Puzosia* (*P.*) *odiensis*, *P.* (*P.*) *crebrisulcata*, *Desmoceras* (*D.*) *latidorsatum*, *Calycoceras* (*C.*) *boehmi*, *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*, *C*. (*N.*) *asiaticum spinosum*, C. (*N.*) *planecostatum*, *C*. (*N.*) sp. *Sciponoceras* cf. *antanimangaensis*.

218 m: *Calycoceras* (*Newboldiceras*) *planecostatum*.

Section K–L (Text-fig. 11; only the upper part is shown); *Calycoceras* (*Newboldiceras*) *asiaticum* Zone:

50–60 m: *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*, *C*. (*N.*) *asiaticum spinosum*, C. (*N.*) sp.

Section M–N (Text-fig. 10); *Calycoceras* (*Newboldiceras*) *asiaticum* Zone:

205 m: *Turrilites costatus*.

210 m: *Puzosia* (*P.*) *odiensis*, *Calycoceras* (*Newboldiceras*) *planecostatum*, *C*. (*N.*) sp.

213–216 m: *Puzosia* (*P.*) *crebrisulcata*, *Desmoceras* (*D.*) sp., *Calycoceras* (*Newboldiceras*) *asiaticum hunteri* (Kossmat, 1897).

214 m: *Calycoceras* (*Newboldiceras*) sp.

214–216 m: *Desmoceras* (*D.*) *latidorsatum*, *Puzosia* (*P.*) *crebrisulcata*, *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*, *C*. (*N.*) *asiaticum spinosum*, *C*. (*N.*) *planecostatum* (common).

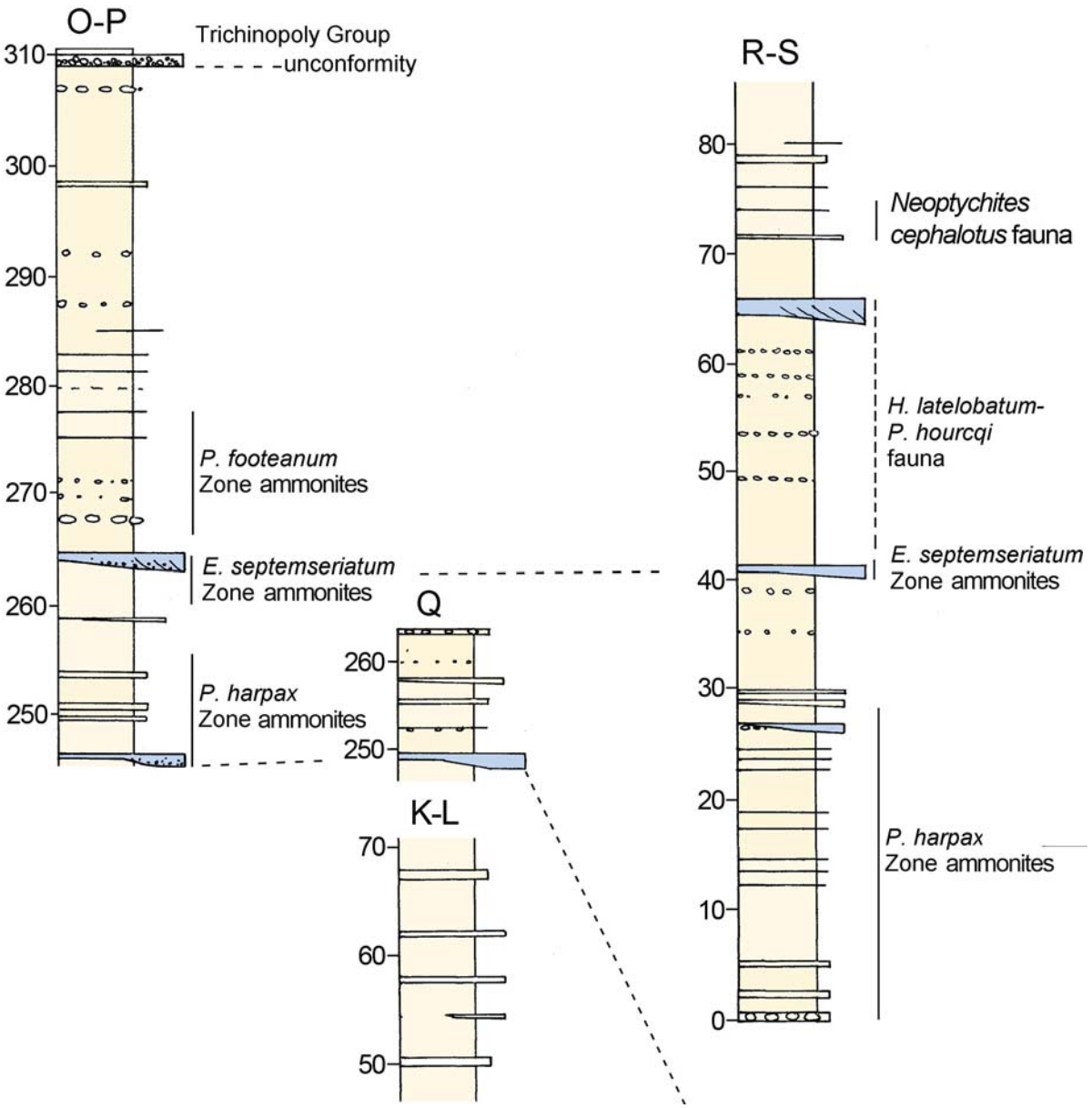
214–215 m: *Puzosia* (*P.*) *odiensis*, *Calycoceras* (*Newboldiceras*) *planecostatum* (several), *Sciponoceras* sp. (smooth).

215 m: *Calycoceras* (*Gentoniceras*) *boehmi*, *Calycoceras* (*Newboldiceras*) sp.

221 m: *Anagaudryceras utaturense* Shimizu, 1935, juvenile gaudryceratids, *Puzosia* (*Bhimaites*) *bhima* (Stoliczka, 1865), *P.* (*B.*) *falx* sp. nov., *Desmoceras* (*D.*) *latidorsatum*, *Protacanthoceras* sp., *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*, *C*. (*N.*) cf. *asiaticum spinosum*, *C*. (*N.*) *planecostatum* (common), *Hamites* sp., *Sciponoceras* sp., *Scaphites similaris* Stoliczka, 1866 (mass occurrence).

Upper Cenomanian

There is at present no consensus on the ammonite definition of the base of the Upper Cenomanian



Text-fig. 11. Logs of sections in the Karai Formation between Odiyam and Kunnam (see Text-fig. 4 for key)

substage. Hancock (1991) suggested the level of replacement of *Acanthoceras* by *Calycoceras*. Tröger and Kennedy (1996) noted five possible ammonite criteria, without reaching a firm conclusion. In the Western European standard sequence it is drawn at the top of an *Acanthoceras jukesbrownei* Zone. The index species does not occur in Tamil Nadu; indeed, its geographical distribution is limited to an area on the north side of the Tethys, from Northern Ireland to the Kopet Dag in Turkmenistan. There are, however, a number of species that have a first occurrence that is unequivocally post-*jukesbrownei* Zone in Western Europe, including *Eucalycoceras pentagonum* (Jukes-Browne, 1896), which first appears in association with *Pseudocalycoceras harpax* (Stoliczka, 1864) in the present faunas. The latter is common in the Tamil Nadu sections, and we select it as index of a *Pseudocalycoceras harpax* Zone. There is a good record in sections O–P and R–S. The *harpax* Zone faunas are succeeded, in section O–P by a slight fauna

that includes *Kanabiceras septemseriatum* (Cragin, 1893). This species has a wide geographic distribution (southern England, France, Nigeria, Angola (KwaZulu-Natal subsurface, Klinger personal communication) Japan, Texas, New Mexico, Arizona, Colorado, Montana, Kansas, Utah, and California in the United States). The stratigraphic range is precisely documented in the Global Stratotype Section for the base of the Turonian Stage at Pueblo, Colorado, where it ranges from beds 67–77 in the upper part of the *Sciponoceras gracile* Zone (Cobban 1985, Kennedy and Cobban 1991, Kennedy *et al*. 2000, 2005). It has a similar range in the upper part of the correlative *Metoicoceras geslinianum* Zone in southern England (Wright and Kennedy 1881; Gale *et al*. 2005), where it first occurs in bed 7. On this basis we recognise a *septemseriatum* Zone, slight as the Tamil Nadu assemblage is.

Higher still in section O–P is a fauna that includes an association of *Pseudaspidoceras footeanum* (Stoliczka, 1864) and *Hourcqiceras coleroonense* (Stoliczka, 1864) which defines a *footeanum* Zone. This is assigned to the Upper Cenomanian on rather thin ammonite evidence. This includes the presence of *Calycoceras* (*C*.) *naviculare*, otherwise known only from the Upper Cenomanian (Wright and Kennedy 1981, 1990). *Pseudaspidoceras* first occurs (as *P. pseudonodosoides* (Choffat, 1899)) in southwestern New Mexico in the Upper Cenomanian *Neocardioceras juddii* Zone (Cobban and Hook 1983, Cobban *et al*. 1989). Detailed records of the Upper Cenomanian sequences are as follows.

Section O–P (Text-fig. 11), *Pseudocalycoceras harpax* Zone:

246 m: *Pseudocalycoceras harpax* (common). *C*. (*N*.) *asiaticum spinosum*, *Kunnamiceras tropicum* (Stoliczka, 1864).

250 m: *Pseudocalycoceras harpax*, *Lotzeites aberrans* (Kossmat, 1895).

250–255 m: *Eucalycoceras pentagonum* (Jukes-Browne, 1896).

252 m: *Desmoceras* (*D*.) *latidorsatum*.

253 m: *Sciponoceras* sp.

254 m: *Eucalycoceras pentagonum*.

254–255 m: *Eucalycoceras pentagonum*.

255 m: *Pseudocalycoceras* sp., *Eucalycoceras* cf. *pentagonum*, *Sciponoceras* sp.

Section O–P (Text-fig. 11), *Euomphaloceras septemseriatum* Zone:

261 m: *Tetragonites subtimotheanus*, *Puzosia crebrisulcata*, *Desmoceras* (*D*.) *latidorsatum*, *Tarrantoceras* (*Sumitomoceras*) *faustum* Matsumoto, 1969, *T.* (*S*.) sp. juv., sp., *Euomphaloceras septemseriatum* , *Anisoceras* sp., *Sciponoceras* sp. (smooth).

Section O–P (Text-fig. 11), *Pseudaspidoceras footeanum* Zone:

265 m: *Watinoceras elegans* sp. nov., *Hourcqiceras coleroonense*.

267–269 m: *Puzosia* (*P.* sp.), *Calycoceras* cf. *naviculare*, *Eucalycoceras* cf. *jeanneti* (Collignon, 1939), *Euomphaloceras* sp. juv., *Pseudaspidoceras footeanum*, *Hourcqiceras coleroonense*.

268 m: *Pseudaspidoceras foooteanum*.

277 m: *Puzosia* (*P.*) cf. *insculpta*?

285–286 m: *Holcodiscoides elegans* sp. nov.

Section R–S (Text-fig. 11)

The *harpax* Zone is well-developed in section R–S, and is interpreted as extending to the 28 m level. 13 m higher, a single specimen of *Sciponoceras* cf. *gracile* (Shumard, 1860) provides slight evidence for the *septemseriatum* Zone. 24 m higher still, at the 65 m level, a more diverse fauna includes *Hourcqiceras latelobatum* Collignon, 1939, and *Pseudaspidoceras hourcqi* (Collignon, 1939). These species were originally described from Ankilimanarivo in the Menabe region of western Madagascar. The material was collected by M. V. Hourcq of the Service des Mines de Madagascar, where they occurred in association with abundant *Hourcqiceras hourcqi* (Collignon, 1939), and *Puzosia odiensis* (Kossmat, 1898). These do not allow a precise dating of the assemblage. However, Collignon (1939, p. 83) described, but did not figure, a specimen that he assigned to *Forbesiceras obtectum* (Sharpe, 1857) from a nearby locality, Andranovoritelo, in association with *Hourcqiceras hourcqi*. Where well-dated, *Forbesiceras obtectum* extends no higher than the Middle Cenomanian (Wright and Kennedy 1984, p. 95). It is possible that the Andranovoritelo specimen (which we have not seen) belongs to the not-dissimilar *Forbesiceras bicarinatum* Szász, 1976, which extends into the *Metoicoceras geslinianum* Zone, specifically bed 3 of the Plenus Marls at Eastbourne, Sussex, U.K. (the *Forbesiceras* cf. *bicarinatum* of Gale *et al*. 2005, p. 470), and co-occurs with other elements of the *geslinianum* Zone fauna in the Sables à *Catopygus obtusus* of Briollay, Maine-et-Loire, France (the *Forbesiceras* aff. *largilliertianum* of Kennedy *et al*. 1981, p. 39, text-fig. 10a). We conclude that the *Hourcqiceras latelobatum–Pseudaspidoceras hourcqi* fauna is equivalent to a part of the *Metoicoceras geslinianum* Zone, but cannot place it precisely in relation to the *Kanabiceras septemseriatum* Zone fauna noted above from section on faunal criteria alone.

The succession in section R–S (Text-fig. 11) is as follows:

Pseudocalycoceras harpax Zone:

0–1 m: *Calycoceras* (*Newboldiceras*) *asiaticum spinosum*, *Pseudocalycoceras harpax*.

4.5 m: *Desmoceras* (*D.*) *latidorsatum*, *Pseudocalycoceras harpax*.

8 m: *Desmoceras* (*D.*) *latidorsatum*, *Pseudocalycoceras harpax*, (common).

5–10 m: *Phylloceras* (*Hypophylloceras*) *seresitense* Pervinquière, 1907, *Desmoceras* (*Desmoceras*) sp., *Kunnamiceras tropicum*, *Calycoceras* (*Newboldiceras*) *asiaticum spinosum*, *Pseudocalycoceras harpax*, *Eucalycoceras pentagonum*, *Lotzeites aberrans*.

6–8 m: *Pseudocalycoceras harpax* (frequent).

19 m: *Desmoceras* (*Desmoceras*) sp., *Eucalycoceras pentagonum*, *Calycoceras* (*C.*) *naviculare*.

26 m: *Eucalycoceras* cf. *pentagonum*.

26.5 m: *Eucalycoceras* sp.

27 m: *Phylloceras* (*Hypophylloceras*) sp., *Calycoceras* (*C.*) *naviculare*, *Eucalycoceras* cf. *pentagonum*.

28 m: *Calycoceras* (*C.*) cf. *naviculare*, *Eucalycoceras pentagonum*, *Eucalycoceras* sp.

? *Euomphaloceras septemseriatum* Zone:

41 m: *Puzosia* (*Puzosia*) sp., *Sciponoceras* cf. *gracile*.

Hourcqiceras latelobatum–Pseudaspidoceras hourcqi fauna:

65 m: *Anaudryceras multiplexum*, *Gaudryceras* sp., *Desmoceras* (*Desmoceras*) sp., *Puzosia* (*P.*) *odiensis*, *Euomphaloceras varicostatum* sp. nov., *Pseudaspidoceras hourcqi*, *Hourcqiceras latelobatum*, *Hourcqiceras* sp., *Hamites* sp., *Sciponoceras* sp.

Lower Turonian

The base of the Turonian Stage is defined at the first occurrence of the ammonite *Watinoceras devonense* Wright and Kennedy, 1981, at the base of bed 86 of the Bridge Creek Member of the Greenhorn Limestone in the Global Boundary Stratotype Section in Rock Creek, west of Pueblo, Colorado (Kennedy *et al*. 2005; see also Cobban 1985; Kennedy and Cobban 1991; Kennedy *et al*. 2000). A key secondary marker is the first occurrence of *Mytiloides puebloensis* Walaszczyk and Cobban, 2000, in bed 86 of the section.

The Lower Turonian is represented by what is here termed the *Neoptychites cephalotus–Mytiloides borkari* fauna from between 70 and 74 m in section R–S, 5 m above the *Hourcqiceras latelobatum–Pseudaspidoceras hourcqi* fauna. *Neoptychites cephalotus* (Courtiller, 1860) is a long-ranging species. The lowest occurrence of which we are aware is in south-western New Mexico, where a lower, but not lowest Turonian *Vascoceras birchbyi* Zone, succeeding the lowest Turonian *Pseudaspidoceras flexuosum* Zone, yields the species (Cobban *et al*. 1989). It extends into the lower Middle Turonian *Romaniceras* (*R.*) *kallesi* Zone (the lower part of the *Collignoniceras woollgari* Zone of authors) in Western Europe (Amédro and Badillet 1978; Robaszynski *et al*. 1982).

Details are as follows:

70 m: *Puzosia* (*Puzosia*) sp., *Neoptychites cephalotus*, *Mytiloides mytiloides*, *Mytiloides borkari*.

72 m: *Puzosia* sp., *Mytiloides borkari*, *Rhyssomytiloides diversus*.

74 m: *Gaudryceras* sp., *Puzosia* (*Puzosia*), sp. *Kamerunoceras multinodosum* sp. nov., *Mytiloides borkari*.

A specimen of *Fagesia rudra* (Stoliczka, 1965), VP Kn 230 (Pl. 48, Figs 3–5) from the environs of Kunnam, and one of *Kamerunoceras turoniense* (d'Orbigny, 1850), VP Kn 101 (Pl. 47, Figs 5, 6), from Kunnam, both collected *ex-situ*, may be from this fauna, or from a higher level in the sequence, both species ranging into the lower middle Turonian elsewhere.

Sections north-west of Garudamangalam

The material is referred to four sections, A, B, C, and D (Text-fig. 6)

Section D, with limonitic faunas

Upper Albian, *Pervinquieria* (*Subschloenbachia*) *rostrata* Zone:

24 m: *Mariella* (*Mariella*) sp. juv.

25 m: juvenile gaudryceratid, *Tetragonites* sp. juv., *Desmoceras (Desmoceras*) sp. juv.

28 m: juvenile phylloceratid, juvenile gaudryceratid, *Kossmatella* sp., *Tetragonites* sp. juv, cf. *subtimotheanus*, *Desmoceras* (*Desmoceras*) sp., *Cantabrigites spinosum* (Pervinquière, 1907), *Hamites* sp., *Hemiptychoceras* sp., *Scaphites* sp. juv.

Lower Cenomanian, *Mantelliceras mantelli* Zone:

53–60 m: *Desmoceras* (*Desmoceras*) sp., *Sharpeiceras vohipalense* Collignon, 1964, *Sciponoceras* sp., *Mariella* (*M.*) *lewesiensis*, *Scaphites* sp.

53.5 m: *Utaturiceras* sp.

73 m: limonitic fauna, *Phyllopachyceras* sp. juv., *Tetragonites* sp. juv., *Mariella* (*Mariella*) sp.

78 m: *Mariella* (*Mariella*) *lewesiensis*.

90 m: limonitic fauna, *Phyllopachyceras whiteavesi*, *Tetragonites* cf. *subtimotheanus*, *Puzosia* (*Bhimaites*)? sp., *Scaphites* sp. juv. indet.

Middle Cenomanian, *Calycoceras* (*Newboldiceras) asiaticum* Zone

109 m: *Turrilites costatus*, *Newboldiceras* sp. Limonitic fauna, *Phylloceras* (*Hypophylloceras*) sp. juv., *Phyllopachyceras whiteavesi*, *Gaudryceras* cf. *vertebratum*, *Anagaudryceras* sp., *Tetragonites* sp., *Desmoceras* (*Desmoceras*) sp., *Acanthoceras* sp., *Calycoceras* (*Newboldiceras*) *planecostatum*, *Calycoceras* (*Newboldiceras*) sp., *Anisoceras* sp., *Sciponoceras* sp.

Section C

Middle Cenomanian, *Calycoceras* (*Newboldiceras*) *asiaticum* Zone:

10 m: limonitic fauna, '*Phylloceras*' sp., *Tetragonites subtimotheanus*, *Puzosia* (*Puzosia*) sp., *Desmoceras* (*Desmoceras*) sp., *Protacanthoceras* sp., *Calycoceras* (*Newboldiceras*) sp.

31 m: limonitic fauna, *Calycoceras* (*Newboldiceras*) sp. (phosphatised), *Calycoceras* (*Proeucalycoceras*) *choffati* (Kossmat, 1897).

35 m: *Calycoceras* (*Calycoceras*) *bathyomphalum* (Kossmat, 1897), *Calycoceras* (*Proeucalycoceras*) *choffati* (Kossmat, 1897).

42–43 m: limonitic fauna, *Phylloceras* (*Hypophylloceras*) sp., *Phyllopachyceras* sp. juv., *Gaudryceras vertebratum*, *Tetragonites subtimotheanus*, *Puzosia* (*Puzosia*) sp., *Desmoceras* (*Desmoceras*) sp., *Acanthoceras* sp. juv., *Protacanthoceras*? sp., *Calycoceras* (*Calycoceras*) *bathyomphalum*, *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*, *C.* (*N.*) *planecostatum*, *Eucalycoceras* sp., S*ciponoceras* sp.

47–48 m: limonitic fauna, *Phylloceras* (*Hypophylloceras*) sp., *Phyllopachyceras whiteavesi*, *Gaudryceras vertebratum*, *Tetragonites subtimotheanus*, *Desmoceras* (*D.*) *latidorsatum*, *Puzosia* (*Puzosia*)? sp., *Calycoceras* (*Newboldiceras*) *planecostatum*, *C.* (*N.*) sp., *Eucalycoceras* sp., *Sciponoceras* sp., *Scaphites* sp.

Section B

Middle Cenomanian, *Calycoceras* (*Newboldiceras*) *asiaticum* Zone:

14–16 m: limonitic fauna, *Phylloceras* (*Hypophylloceras*) sp., *Gaudryceras vertebratum*, *Desmoceras* (*D.*) *latidorsatum*, *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*, *C.* (*N.*) *planecostatum*, *Neostlingocera*s sp., *Sciponoceras* sp.

10–20 m: limonitic fauna, *Phylloceras* (*Hypophylloceras*) *ellipticum*, *P.* (*H.*) sp., *Phyllopachyceras whiteavesi*, *Gaudryceras* sp. juv., *Tetragonites subtimotheanus*, *Desmoceras* (*D.*) *latidorsatum* (common), *D.* (*D.*) *inane* (Stoliczka, 1865), *Protacanthoceras parva* sp. nov., *Protacanthoceras*? sp., *Gaudryceras* sp. juv., *Calycoceras* (*Newboldiceras*) *planecostatum* (common), *C.* (*N.*) sp., *Eucalycoceras gothicum* (Kossmat, 1895), *Sciponoceras* sp., *Carthaginites* sp., *Scaphites* sp.

24–26 m: limonitic fauna, *Tetragonites* sp., *Desmoceras* (*Desmoceras*) sp., *Eucalycoceras* cf. *gothicum*, *Eucalycoceras* sp., *Sciponoceras* sp.

Section A

Middle Cenomanian, *Calycoceras* (*Newboldiceras*) *asiaticum* Zone:

9 m: *Calycoceras* (*Newboldiceras*) sp.

9–10 m: limonitic fauna, *Phylloceras* (*Hypophylloceras*) *ellipticum*, *P.* (*H.*) sp., *Tetragonites subtimotheanus*, *Desmoceras* (*Desmoceras*) *latidorsatum*, *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*, *C.* (*N.*) *asiaticum spinosum*, *C.* (*N.*) *planecostatum*, *Sciponoceras* sp. (smooth).

Upper Cenomanian, *Pseudocalycoceras harpax* Zone:

Euomphaloceras euomphalum fauna: This fauna includes species such as *Euomphaloceras euomphalum* (Sharpe, 1855) and *Vascoceras diartianum* (d'Orbigny, 1850) that are absent from *Pseudocalycoceras harpax* Zone faunas elsewhere in the area. It is not clear if these differences are a result of collection failure, or if the fauna represents a different horizon. Of species present, the best-dated in expanded sections is *Vascoceras diartianum*, known from the *Metoicoceras mosbyense* Zone, that which precedes the *Sciponoceras gracile* Zone in south-western New Mexico (Cobban *et al*. 1989, p. 63), and the lower part of the *Metoicoceras geslinianum* Zone (bed 3 of the Plenus Marls) at Compton Bay, Isle of Wight U.K. (Wright and Kennedy 1981, pp. 86, 119; pl. 17, fig. 1). Accordingly, a *Euomphaloceras euomphalum* fauna is recognised that is probably equivalent to the upper part of the *harpax* Zone, although possibly extending higher.

16–18 m: limonitic fauna, *Gaudryceras vertebratum*, *Tetragonites subtimotheanus* (flood abundance), *Phylloceras* (*Hypophylloceras*) sp. juv., *Phyllopachyceras whiteavesi*, *Puzosia* (*Puzosia*) sp. juv., *Puzosia* (*Bhimaites*) sp. juv., *Desmoceras* (*Desmoceras*) *latidorsatum* (abundant) *Calycoceras* (*Calycoceras*) cf. *barruei* (Pervinquière, 1907), *Calycoceras* (*Calycoceras*) sp. juv., *Euomphaloceras euomphalum*, *Eucalycoceras* cf. *pentagonum*, *Vascoceras diartianum*, *Hemiptychoceras* sp. juv., *Sciponoceras* sp. (smooth) (abundant), *Carthaginites multituberculatus* sp. nov.

Section between Karai and Kulakkalnattam

This is plotted in Text-fig. 4. Belemnites dominate the cephalopod faunas of this predominantly shale sequence. Ammonites faunas are dominated by classic leiostraca: relatively feebly ornamented, long-ranging phylloceratids, gaudryceratids, and desmoceratids. In contrast, those from the silt- and sandstone intervals described above are dominated by short-rang-

SUBSTAGE	WESTERN EUROPE	TAMIL NADU
LOWER TURONIAN	*Mammites nodosoides*	*Neoptychites cephalotus* fauna
	Watinoceras devonense	–
UPPER CENOMANIAN	*Neocardioceras juddii*	*Pseudaspidoceras footeanum*
	Metoicoceras geslinianum	*Euomphaloceras septemseriatum*
		(? no record)
	Calycoceras (*P.*) *guerangeri*	(*Euomphaloceras euomphalum* fauna) *Pseudocalycoceras harpax*
MIDDLE CENOMANIAN	*Acanthoceras jukesbrownei*	*Calycoceras* (*Newboldiceras*) *asiaticum*
	Acanthoceras rhotomagense	
	Cunningtoniceras inerme	*Cunningtoniceras cunningtoni*
LOWER CENOMANIAN	*Mantelliceras dixoni*	*Mantelliceras mantelli*
	Mantelliceras mantelli	
UPPER ALBIAN (part)	*Pleurohoplites briacensis*	(no record)
	Pervinquiera (*S.*) *perinflata*	*Pervinquieria* (*S.*) *perinflata*
	Pervinquiera (*S.*) *rostrata*	*Pervinquieria* (*S.*) *rostrata*

Text-fig. 12. Assemblage zones and substages recognised in the upper Upper Albian, Cenomanian and Lower Turonian in the Pondicherry Sub-Basin of the Cauvery Basin and their correlation with the succession in Western Europe

ing trachyostraca: strongly ornamented species of Acanthoceratoidea and Turrilitoidea. This topic is returned to below. Only stratigraphically significant taxa are listed here.

Upper Albian

The 63 to 337–338 m interval is referred to the Upper Albian, the datable elements suggesting a correlation with the *Pervinquieria* (*Subschloenbachia*) *rostrata* Zone:

63–67.5 m: *Hamites* cf. *subvirgulatus* Spath, 1941.
80 m: *Hamites* cf. s*ubvirgulatus*, *Lechites* sp.
103.5–108 m: *Marshallites* cf. *papillatus* (Stoliczka, 1865)
110 m: *Marshallites papillatus*, *Pervinquieria* (*Pervinquieria*) cf. *stoliczkai*,*Goodhallites* sp. juv.
115 m: *Goodhallites* sp. juv.
140 m: *Protokossmaticeras* sp. juv.
170–175 m: *Protokossmaticeras* sp. juv.
175–180 m: *Protokossmaticeras* sp. juv.
180 m: *Cantabrigites* sp.
200 m: *Protokossmaticeras* sp. juv.
212 m: *Protokossmaticeras* sp. juv.
225 m: *Stoliczkaia* sp. juv. indet.
230 m: *Pervinquieria* (*Pervinquieria*) sp. juv.
240 m: *Mariella* (*Mariella*) sp. juv.
274–278.5 m: *Holcodiscoides* sp. juv.
275–280 m: *Mariella* (*Mariella*) sp. juv., juvenile Marshallitinae.
283–287.5 m: *Pervinquieria* sp. juv.

There is a 54 m undated interval between the highest Upper Albian *Pervinquieria* and the lowest Lower Cenomanian *Neostlingoceras.*

Lower Cenomanian

Mantelliceras mantelli Zone:

341.4–346 m: *Mariella* (*M.*) cf. *lewesiensis*, *Neostlingoceras carcitanense*, *Yezoites kingianus.*
345–350 m: *Holcodiscoides* sp. juv., *Mantelliceras* sp. juv.,

Utaturiceras sp. juv., *Mariella* (*M.*) *lewesiensis*, *Hypoturrilites* sp. juv., *Sciponoceras* sp., *Yezoites kingianum* (flood abundance).

346–350.5 m: *Mantelliceras cantianum*, *Mantelliceras* sp., *Hypoturrilites gravesianus*, *Sciponoceras* sp., *Yezoites* sp., flood of juvenile scaphitids.

348 m: *Ostlingoceras* sp., *Neostlingoceras carcitanense*, *Anisoceras* sp. juv., *Yezoites* cf. *kingianus*.

350 m: *Hemiptychoceras* sp., *Neostlingoceras carcitanense*, *Yezoites kingianus*.

350.5–355 m: *Holcodiscoides* sp. juv., '*Mantelliceras*' sp. juv., *Yezoites kingianus*.

352 m: *Mariella* (*M.*) cf. *lewesiensis*, *Yezoites kingianus*.

355–359.5 m: *Mantelliceras* sp., *Hypoturrilites* cf. *gravesianus*, *Sciponoceras* sp., *Yezoites* cf. *kingianus* (common).

359.5–364 m: *Mantelliceras* sp. indet., *Sciponoceras* sp., *Yezoites kingianus*.

364–368.5 m: *Mantelliceras* sp. juv. indet.

373–377.5 m: *Yezoites kingianus* (common).

377.5–382 m: *Ostlingoceras* sp. A, Mantelliceratinae sp. juv. indet., *Hypoturrilites* sp. juv. indet., *Yezoites kingianus*.

380–390 m: *Yezoites kingianus*.

Upper Lower or lower Middle Cenomanian

The zonal position of this sequence is uncertain; the occurrence of two specimens of *Turrilites scheuchzerianus*, rare in the present collections, is a species that is common in the upper Lower Cenomanian (*dixoni* Zone of the Western European sequence), but extends higher:

386.5–391 m: *Hypoturrilites tuberculatoplicatus*.

390–400 m: *Turrilites scheuchzerianus* Bosc, 1801 (two specimens).

400–404 m: *Ostlingoceras* sp.

405–410 m: *Ostlingoceras* sp., *Hypoturrilites* sp. juv.indet.

Middle Cenomanian

Cunningtoniceras cunningtoni Zone:

408 m: *Forbesiceras* cf. *largilliertianum*, *Cunningtoniceras cunningtoni* (barite infilled), *Cunningtoniceras* sp. (barite infilled) (OUM KY6031–6037).

Calycoceras (*Newboldiceras*) *asiaticum* Zone:

A coral-shell bed at the 410 m level marks the base of a major channel (the *asiaticum* Zone channel: Text-fig. 5). To the east of the Karai–Kulakkalnattam road, this yielded an upper Middle Cenomanian *asiaticum* Zone fauna at the 410–412 m level: *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum*, *C.* (*N.*) *asiaticum spinosum*, *C.* (*N.*) *planecostatum* (common). To the west of the road, the channel, which has a maximum observed depth of 15 m, cuts down into the Lower Cenomanian. The basal shell bed within the channel yielded indigenous unmineralised moulds (OUM KY6013–60330) of *Gaudryceras vertebratum*, *Puzosia* (*Puzosia*) *odiensis*, *P.* (*P.*) sp., *Hamites* sp., *Anisoceras* sp., *Sciponoceras* sp., and *Turrilites acutus* Passy, 1832. A phosphatised fragment of *Turrilites costatus* (OUM KY6030), was collected 4–5 m above base of channel.

415 m: *Calycoceras* (*Newboldiceras*) sp., *Sciponocereas antanimangaensis*, *Scaphites* sp. juv.

Upper Cenomanian

Pseudocalycoceras harpax Zone:

427–430 m: *Calycoceras* sp. indet., *Pseudocalycoceras harpax*.

430–433 m : *Protacanthoceras* sp.

436–439 m: *Sciponoceras* sp.

437 m: *Eucalycoceras pentagonum*.

437.5 m: *Eucalycoceras pentagonum*.

442 m: *Eucalycoceras pentagonum*.

(22 m undated interval)

Lower Turonian

463.9 m: *Mytiloides mytiloides*.

472 m: *Mytiloides* sp.

AMMONITE PRESERVATION

Sandstones and siltstones

Ammonites in sandstones, siltstones, and calcareous concretions developed in these lithologies occur as internal and external moulds lacking any trace of the original aragonite in most cases (Pl. 11, Figs 12–14). In others, the original aragonite has been replaced by calcite (Pl. 15), that survives over part or all of the internal mould. Pristine nacreous aragonite survives only in un-weathered concretions (Pl. 41, Figs 1–3, 6–8). In most cases, internal moulds are cemented sediment, but in some cases, phragmocone whorls may have infillings of sparry calcite.

Shales

Ammonites from shales sequences are either nuclei (Pl. 2), or adults of genuinely diminutive species (Pl. 60, Fig. 2). They are preserved as limonitic internal moulds (Pl. 4, Figs 19–24) or may retain traces of limonite films that replaced the original aragonitic

shell. Thick layers of limonite line camerae, and their inner surfaces are a mass of tiny cubic crystals of the original iron pyrites, now replaced by pseudomorphing limonite. In some cases, a later generation of sparry calcite has overgrown the now limonitised pyrites. Most specimens retain their original proportions, but in others, the limonitic internal moulds are crushed to varying degrees (Text-fig. 34), presumably because the pyrites lining was unable to support the increasing overburden pressure as the shales dewatered.

It is assumed that these nuclei are those of much larger individuals, rather than juveniles. The deeply weathered Karai shales have not preserved the composite moulds of the outer whorls. The assumption is supported by observations from comparable occurrences in mudrocks, the classic example being the Jurassic Oxford Clay (Oxfordian) in the now infilled brick pit at Woodham in Buckinghamshire in southern England. At this locality (Arkell 1939; Callomon 1968; Hudson and Palframan 1969; Horton *et al*. 1995, p. 30, pl. 6), Arkell recorded a section divided into a lower 11.7 m interval (the Spinosum clays of Hudson and Palframan) separated from an upper 8.8 m interval (the Mariae clays of Hudson and Palframan) by a 30 cm calcareous mudstone (the Lamberti Limestone of authors). The upper 6m is weathered, and yielded abundant limonitic ammonite nuclei and adults of genuinely diminutive species, together with crushed moulds of adults of large species (Palframan 1966, pl. 48, fig. 1). The Lamberti limestone was crowded with whole and fragmentary juvenile and adult ammonites up to tens of centimeters in diameter, the moulds coated in a pyritic film (Hudson and Palframan 1969, p. 405). In some cases, the nuclei of these large specimens have the early phragmocone whorls infilled by a lining of iron pyrites and a later infill of sparry calcite to a diameter corresponding to that of nuclei in the clays. The Spinosum clays yielded abundant pyritic nuclei, associated with composite moulds of the adult whorls.

The record at Woodham demonstrates unequivocally that most limonitic or pyritic nuclei found there are those of adults of larger individuals, and are not the inner whorls of juveniles. As in the Karai shales, there are also adults of genuinely diminutive species, as demonstrated by Palframan (1966, 1967), who recognised two dimorphic pairs, the microconchs preserved as limonitic/pyritic adults with body chamber, the macroconchs as limonitic/pyritic nuclei, the upper size limit of individual specimens being in the 2–3 cm range. As Palframan noted: "…there seems that there is a maximum size above which ammonites were not pyritised or limonitised" (1966, p. 290). This preservation is widespread (but not universal) in Mesozoic mudrocks; typical examples are the faunas from mid-Cretaceous sequences in Algeria and Tunisia (Pervinquière 1907, 1910; Dubourdieu 1953; Sornay 1955a) Madagascar (Collignon 1928–29, 1931, 1932, 1964), Tanzania (Kennedy and Morris 2018); Texas in the United States (Kennedy 2004; Kennedy *et al*. 2005), and the Northern Territory, Australia (Henderson 1990).

AMMONITE OCCURRENCES VERSUS FACIES

A striking feature of the ammonite assemblages upon which this study is based, is the marked difference between the faunas in the siltstone/sandstone facies and those in shale facies. In the former, assemblages consist of much smaller numbers than in the shales, numbering in tens of commonly adult specimens ranging from 13 mm (*Ojinagiceras* cf. *ojinagense*) up to 250 mm in diameter (*Pseudaspidoceras footeanum*), whereas some levels in the shales yielded hundreds of specimens, mostly limonitic nuclei less than 30 mm in diameter, as well as adults of diminutive species, in the same size range as the nuclei. Differences in size of collection is a reflection of the lower numbers of individual per unit of outcrop in sandstones/siltstones than shales. Differences in faunal composition are real, and not the result of differential preservation (as argued above), as many (but not all) species occur in both facies associations, albeit in different numbers. The associations in the sandstone/siltstone facies are dominated by species with well-developed ornament: the classic trachyostraca of authors, notably the Acanthoceratoidea, whereas assemblages in the shales are dominated by Tetragonitoidea and Desmoceratoidea, with Phylloceratoidea in lesser abundance. Amongst the heteromorphTurrilitoidea, there are horizons of flood abundance of *Yezoites* and *Sciponoceras* in the shales. Because of the discontinuous nature of fossil occurrences, it is not possible to identify synchronous assemblages in both siltstone/sandstone and shale facies. A comparison at zonal level is, however possible, and Upper Cenomanian associations from the *harpax* Zone demonstrate the most extreme case of facies-linked associations, even though there is an order of magnitude difference in the numbers of individuals.

The shale association comes from the Upper Cenomanian *harpax* Zone, *Euomphaloceras euomphalum* association in shales at the 16–18 m level in section A, north-west of Garudmangalam (OUM KY3913–3974; many are collective numbers); total number of specimens 732.

LEIOSTRACA 85.1%
Phylloceratoidea
Phylloceras (*Hypophylloceras*) 17 (2.3%)
Phyllopachyceras whiteavesi 1 (0.14%)
Tetragonitoidea
Tetragonites subtimotheanus 331 (45.2%)
Gaudryceras sp. 3 (0.41%)
Desmoceratoidea
Desmoceras (*D.*) *latidorsatum* 269 (36.7%)
Puzosia (*Puzosia*) sp. 3 (0.41%)
Puzosia (*Bhimaites*) sp. 3 (0.41%)
TRACHYOSTRACA 6%
Acanthoceratoidea
Calycoceras (*C.*) spp. 19 (2.6%)
Eucalycoceras cf. *pentagonum* 1 (0.14%)
Euomphaloceras euomphalum 21 (2.9%)
Vascoceras diartianum 3 (0.4%)
HETEROMORPHS 8.8%
Turrilitoidea
Hemiptychoceras sp. 6 (0.82%)
Sciponoceras sp. 55 (7.5%)
Carthaginites sp. 4 (0.56%)

The sandstone/siltstone fauna comes from the Upper Cenomanian *harpax* Zone of section O–P between 246 and 256 m, between Odiyam and Kunnam, 10 km to the sourth-south-west. The total number of individuals is 28:
LEIOSTRACA 3.6%
Desmoceratoidea
Desmoceras (*D.*) *latidorsatum* 1 (3.6%)
TRACHYOSTRACA 85.7%
Acanthoceratoidea
Calycoceras (*Newboldiceras*) *asiaticum spinosum* 1 (3.5%)
Pseudocalycoceras harpax 17 (60.7%)
Kunnamiceras tropicum 1 (3.6%)
Eucalycoceras pentagonum 4 (14.4%)
Lotzeites aberrans 1 (3.6%)
HETEROMORPHS 10.8%
Turrilitoidea
Sciponoceras sp. 3 (10.8%)

These results are summarized below.

	Sand- and siltstones%	Shales%
LEIOSTRACA	3.6	85.1
Phylloceratoidea	–	2.3
Tetragonitoidea	–	45.6
Desmoceratoidea	3.6	37.5
TRACHYOSTRACA	85.7	5.8
HETEROMORPHS	10.8	9.1
Turrilitoidea	10.8	9.1

Interpretation of these data rapidly enters into the realms of speculation. Many of the species present in the Tamil Nadu faunas, including those discussed above, had a wide, near-cosmopolitan distribution, and were clearly able to achieve wide dispersal, either passively, or actively. The first assumption made here is that the disparate distribution of taxa between sand- and siltstones and shales is a true record of original distribution, and not a result of, say selective dissolution of small individuals. The second assumption is that the nuclei in shales are the nuclei of much larger individuals, including adults on the basis of the preceding discussion. If these two assumptions are made, then present distributions may reflect those at the time of death of the animals. A second scenario is that these distributions reflect where species spent part or all of their lives, as a reflection of a preference for onshore versus offshore, higher versus lower energy, shallower versus deeper water, or high light intensities versus low light intensities. These speculations assume that the ammonites concerned were not dispersed by passive drifting of their shells in life or after death, as might be expected if the shell with its gas-filled chambers was a buoyant apparatus. Any hypothesis must reconcile the following:

Many of the species present, both leiostraca and trachyostraca had a cosmopolitan distribution.

In the Tamil Nadu faunas overall, many species occur in both sandstone and shale facies, but trachyostraca dominate in the fauna in the former, and leiostraca in the latter in sections that are around l0 km apart, even though many of the species present had distributions that extended across thousands of kilometres.

These observations can be reconciled if:

(1) Dispersal took place during the early, post-hatching period.

(2) At maturity, species segregation occurred, with trachyostraca favouring shallower, higher energy parts of the water column, and leiostraca favouring deeper, lower energy parts of the water column. The factors producing this segregation are elusive.

(3) There was no, or minimal *post-mortem* drift of shells.

Two recent publications provide some support for the second proposition. Henderson and Price (2012) determined oxygen and carbon isotope ratios on pristine aragonite in a Middle Cenomanian molluscan assemblage from the Moonekai Formation on the southern coast of Bathurst Island, northern Australia. Trachyostracan *Euomphaloceras* and *Acanthoceras* provided the highest temperatures, whilst *Sciponoceras* provided lower temperatures, suggesting adults of the former secreted their shells in shallower, warmer waters, the latter in deeper, cooler waters. Sessa *et al.*

(2015) carried out similar analyses on pristine aragonite in molluscs from the Maastrichtian Owl Creek Formation of north-eastern Mississippi in the United States, and found planispirally coiled *Sphenodiscus* to have secreted their shells in warmer waters (palaeotemperatures overlapping with those of planktonic foraminifera), while heteromorph Baculitidae and Scaphitidae secreted their shells in cooler waters, palaeotemperatures overlapping with those determined from benthic bivalves and gastropods, suggesting a shallower, warmer habitat for the former, and a deeper, cooler habitat for the latter.

REPOSITORIES OF SPECIMENS

BGS. GSM: British Geological Survey, Keyworth, Nottinghamshire; BMNH: The Natural History Museum, London; GSI: Geological Survey of India, Kolkata; MNHN: Laboratoire de Paléontologie of the Muséum Nationale d'Histoire Naturelle, Paris; OUM: Oxford University Museum of Natural History; WG: Faculty of Geology, University of Warsaw.

SYSTEMATIC PALAEONTOLOGY: AMMONOIDEA (W. J. KENNEDY)

Conventions

The suture terminology is that of Korn *et al.* (2003): E = external lobe; A = adventive lobe (= lateral lobe, L, of Kullmann and Wiedmann 1970); U = umbilical lobe; I = internal lobe.

The taxonomy of Wright (1996) is followed here. Many of the species described below have received detailed discussion in recent publications, and these are referred to rather than repeating them.

Order Ammonoidea Zittel, 1884
Suborder Phylloceratina Arkell, 1950
Superfamily Phylloceratoidea Zittel, 1884
Family Phylloceratidae Zittel, 1884
Subfamily Phylloceratinae Zittel, 1884
Genus *Phylloceras* Suess, 1866

TYPE SPECIES: *Ammonites heterophyllus* J. Sowerby, 1820, p. 119, pl. 226, by monotypy.

Subgenus *Hypophylloceras* Salfeld, 1924

TYPE SPECIES: *Phylloceras onoense* Stanton, 1895, p. 74, by monotypy.

Phylloceras (*Hypophylloceras*) *seresitense seresitense* Pervinquière, 1907
(Pl. 1, Figs 11–18; Pl. 2, Figs 13, 14, 21, 22; Text-fig. 13B)

1907. *Phylloceras velledae* var. *seresitensis* Pervinquière, p. 52.
2009. *Hyporbulites seresitensis seretisensis* (Pervinquière, 1907); Klein *et al*., pp. 90, 93 (with full synonymy).

TYPES: The variety *seresitensis* of Pervinquière was based on 20 syntypes from the 'Vraconniene' of Henchir oum d'Aboub (Roman Seresita) and other localities in Tunisia. I was unable to locate them in the collections of the Sorbonne, where Pervinquière's other Tunisian specimens were housed, nor do they appear in the database of the Muséum national d'Histoire naturelle in Paris, to which his other type material was subsequently transferred. Until these specimens are located described and figured, lectotype designation is not possible. Wiedmann's designation (1964, p. 222) of the original of Pervinquière 1910, pl. 10 (1), fig. 1 as lectotype is invalid, as it is not part of the original material mentioned by Pervinquière from Tunisian localities, being from Berrrouaghia in Algeria.

MATERIAL: OUM KY3474, from section R–S at the 10 m level, Upper Cenomanian, *harpax* Zone; OUM KY4756, from section T–U Upper Albian, *rostrata* Zone, between Odiyam and Kunnam. OUM KY5523, from the Karai–Kulakkalnattam section at the 180 m level, Upper Albian. OUM KY5571 (collective of 11 specimens), at the 346–350 m level, OUM KY6005 (collective of six specimens), OUM KY6006, all Lower Cenomanian *mantelli* Zone, and from the Karai–Kulakkalnattam section.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY6005a	27.0 (100)	8.5 (31.5)	16.3 (60.4)	0.52	– (–)
OUM KY6005b	27.3 (100)	8.75 (32.0)	16.6 (60.8)	0.53	– (–)
OUM KY3474	29.7 (100)	11.0 (37.00	17.9 (60.2)	0.61	– (–)
OUM KY6006	55.2 (100)	19.4 (35.1)	33.6 (60.9)	0.57	– (–)

DESCRIPTION: Limonitic nuclei (Pl. 2, Figs 13, 14, 21, 22) are up to 55 mm in diameter, the largest phragmocone seen, OUM KY4756 (Pl. 1, Fig. 18), is 70 mm in diameter. Coiling is very involute, the tiny umbilicus with a flattened wall and rounded shoulder. The whorl section is compressed,

with feebly convex flanks, broadly rounded ventrolateral shoulders and a feebly convex venter, with a whorl breadth to height ratio that ranges from 0.52 to 0.61, the greatest breadth around mid-flank. Where shell is preserved (OUM KY3474; Pl. 1, Figs 11–13) ornament consists of delicate prorsiradiate growth lines on the inner flank that flex back at mid-flank, strengthening into crowded rursiradiate lirae on the outermost flanks, ventrolateral shoulders and venter, which they pass straight across. The suture (Text-fig. 14B) is deeply incised, with narrow-stemmed bifid saddles.

DISCUSSION: In the absence of the syntypes, the species is interpreted in the widely accepted sense (Kennedy and Klinger 1977a, p. 364, pl. 4, fig. 6; pl. 6, fig. 4, pl. 7, fig. 4; pl. 9; Joly 1993, p. 64, pl. 4, fig. 2; pl. 5, fig. 13 pl. 12, fig. 1; pl. 13, figs 1, 2; pl. 15, fig. 2; Joly 2000, p. 164, pl. 39, figs 13, 14, 15; text-figs 389–394). These authors discuss the subtle differences between the various subspecies recognized.

OCCURRENCE: Upper Aptian (Balaerics) to Cenomanian. The geographic distribution extends from southern England to southern France, Switzerland, Hungary, Ukraine, northern Spain, Sardinia, Algeria, Tunisia, The Balaerics, Angola, KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, Sakhalin, Hokkaido, Alaska, and California.

Phylloceras (*Hypophylloceras*) *ellipticum* Kossmat, 1895
(Pl. 2, Figs 18–20; Text-fig. 13C)

1865. *Ammonites Sub-Alpinus* Stoliczka, p. 114, pl. 58, fig. 3.
1895. *Phylloceras ellipticum* Kossmat, p. 107 (11), pl. 15 (1), fig. 2; pl. 20 (6), fig. 1.
2009. *Phylloceras* (*Goretophylloceras*) *subalpinum* morph *ellipticum* Kossmat, 1895; Klein *et al*., p. 37 (with full synonymy).

TYPE: The holotype is the original of Kossmat (1895, p. 107 (11), pl. 15 (1), fig. 2; pl. 20 (6), fig. 1), previously figured by Stoliczka (1865, pl. 58, fig. 3), and from Penangoor.

MATERIAL: OUM KY4092, from section A, at the 9–10 m level, Middle Cenomanian*, asiaticum* Zone. OUM KY4125, from section B at the 10–20 m level, Middle Cenomanian*, asiaticum* Zone.

DESCRIPTION: OUM KY4125 (Pl. 2, Figs 18–20) is a phragmocone 26.4 mm in diameter. Coiling is very involute, the umbilicus comprising 7.5% of the diameter, with a convex wall and broadly rounded umbilical shoulder. The whorl section is compressed, with a whorl breadth to height ratio of 0.75, the greatest breadth well below mid-flank. The whorl section is compressed, rounded-trigonal, the inner flanks convex, the outer flanks converging to broadly rounded ventrolateral shoulders and venter. The surface of the internal mould is smooth, but for feeble constrictions, three per half whorl. OUM KY4092 is a larger phragmocone fragment, 33 mm in diameter, with well-developed constrictions, straight and prorsiradiate on the inner and middle flanks, flexing slightly forwards and feebly concave on the outermost flank and ventrolateral shoulder, and crossing the venter in a very feeble convexity. The suture (Text-fig. 13C) is deeply incised, with narrow-stemmed E/A and A/U2, A deep and trifid. There are numerous much smaller specimens, from the shales of the Karai–Kulakkalnattam section that may belong here.

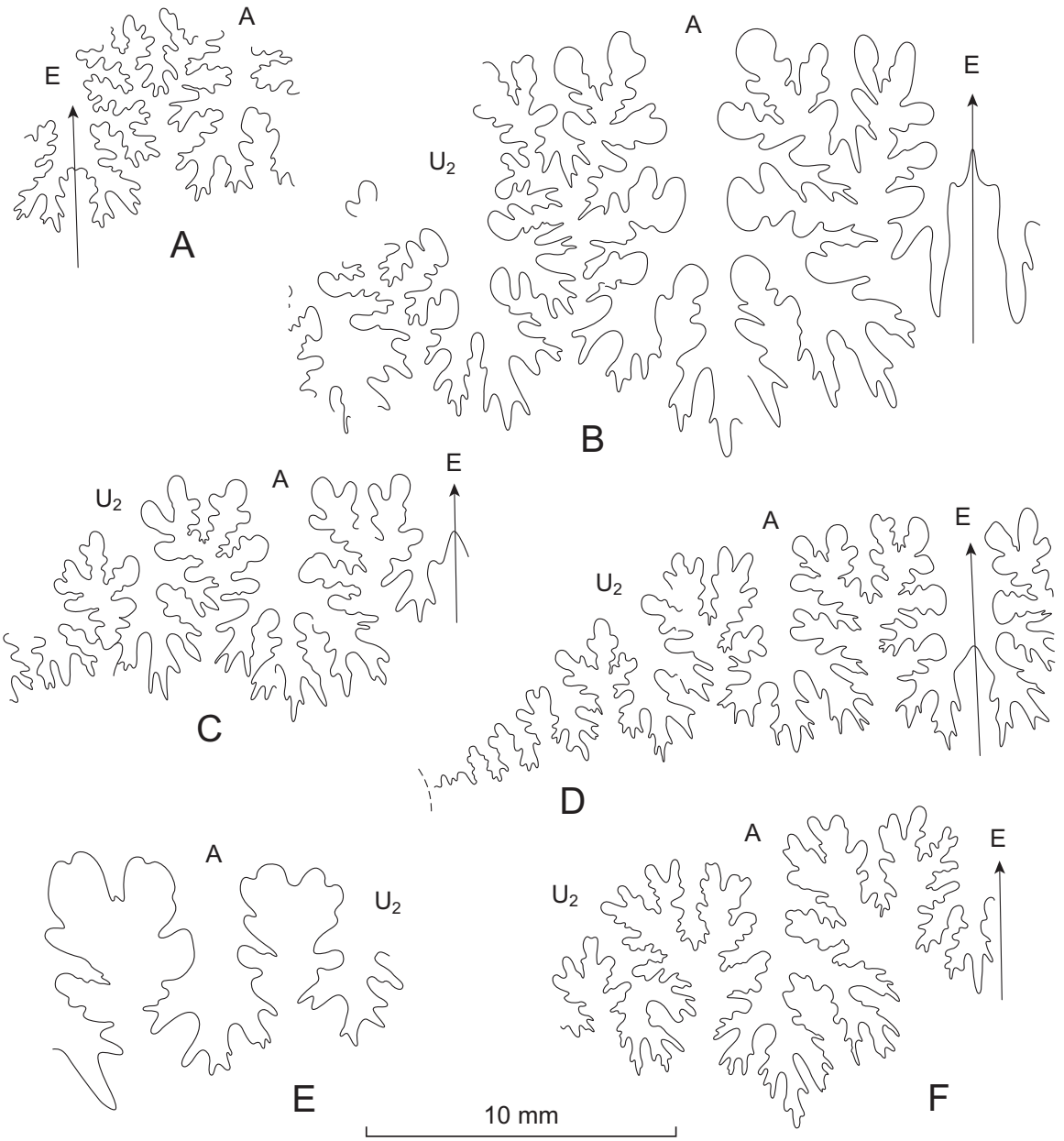
DISCUSSION: There is no agreement as to the status of *ellipticum*, which has been afforded specific status, regarded as a subspecies of *P.* (*H.*) *subalpinum* (d'Orbigny, 1850) (introduced as *nomen novum* for *Ammonites alpinus* d'Orbigny, 1841 p. 283, pl. 83, figs 1–3), or as a 'morph' of that species, as the synonymies in Klein *et al*. (2009, pp. 36, 37) record. Differences from other taxa are discussed by Kennedy and Klinger (1977a, p. 358).

OCCURRENCE: Lower Albian to Upper Cenomanian southern England, Hungary, Switzerland, Spain, Sardinia, The Baleaerics, Algeria, Tunisia, KwaZulu-Natal in South Africa, and Tamil Nadu.

Phylloceras (*Hypophylloceras*) *velledae velledae* (Michelin, 1834)
(Pl. 1, Figs 3–5)

1834. *Ammonites velledae* Michelin, p. 14, pl. 35.
2009. *Phylloceras* (*Hypophylloceras*) *velledae velledae* (Michelin, 1838); Klein *et al*., pp. 7, 27 (with full synonymy).
2017. *Phylloceras* (*Hypophylloceras*) *velledae velledae* (Michelin, 1838); Tajika *et al*. p. 46, text-fig. 11z, aa.

TYPE: The neotype, designated by Wiedmann 1964, p. 211, is MNHN F. R00476 (= LPMP R467 in Gauthier, p. 101), the original of d'Orbigny 1841, pl. 82, figs 1, 2, from the Albian of Epothémont



Text-fig. 13. Suture lines: **A** – *Anagaudryceras multiplexum* (Stoliczka, 1865), OUM KY2890/3. **B** – *Phylloceras* (*Hypophylloceras*) *seresitense seresitense* (Pervinquière, 1907), OUM KY3732. **C** – *Phylloceras* (*Hypophylloceras*) *ellipticum* Kossmat, 1895, OUM KY4092. **D** – *Phyllopachyceras whiteavesi* (Kossmat, 1897), OUM KY3666. **E** – *Algericeras* (*Algericeras*) *besairiei* (Collignon, 1964), OUM KY3666. **F** – *Puzosia* (*Puzosia*) *compressa* Kossmat, 1898, OUM KY2556

near Bar-sur-Aube, France. It was refigured by Wiedmann (1964, pl. 11) and Joly (in Gauthier 2006, pl. 39, fig. 1).

MATERIAL: OUM KY3664, from section C–D at the 64 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: The specimen is a phragmocone with an estimated maximum preserved diameter of 45 mm, retaining extensive areas of recrystallized shell. Coiling is very involute, the tiny, deep umbilicus comprising around 6% of the diameter. The whorl section is compressed, with a whorl breadth to

height ratio of 0.68, the greatest breadth around mid-flank, the umbilical wall feebly convex and outward-inclined, the flanks feebly convex and subparallel, the ventrolateral shoulders broadly rounded, the venter feebly convex. The surface of the recrystallized shell bears a dense ornament of lirae. They are very feeble, delicate, straight and prorsiradiate on the inner flanks, flexing back and feebly convex across the outer flanks, where they coarsen markedly, increasing by branching and intercalation. They pass near-straight across the venter. The sutures are not seen.

DISCUSSION: See Kennedy and Klinger (1977a, p. 359 *et seq*.), and Joly (1993, p. 36) for an alternative view.

OCCURRENCE: Lower Albian to Lower Cenomanian, France, Switzerland, Austria, Spain, Slovakia, Poland, Hungary (?), Bulgaria, Ukraine, Georgia, Egypt, KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, and California.

Genus *Phyllopachyceras* Spath, 1925a

TYPE SPECIES: *Ammonites infundibulum* d'Orbigny, 1841, p. 131, pl. 39, figs 4, 5, by the original designation of Spath 1925a, p. 101.

Phyllopachyceras whiteavesi (Kossmat, 1898)
(Pl. 1, Figs 1, 2, 6–10; Pl. 2, Figs 15–17)

1895. *Phylloceras forbesianum* d'Orbigny; Kossmat, p. 109 (13), pl. 15 (1), fig. 1.
1898. *Phylloceras whiteavesi* Kossmat, p. 189 (124).
2009. *Phyllopachyceras whiteavesi* (Kossmat, 1898); Klein *et al*. pp. 53, 70 (with full synonymy).

TYPE: The holotype is the original of *Phylloceras Forbesianum* d'Orb. sp. Kossmat 1895, p. 109 (13), pl. 15 (1), fig. 1, from the Uttatur Group of Odium, South India.

MATERIAL: OUM KY2511, from section A–B, upper interval, at the 0 m level, Upper Albian, *rostrata* Zone. OUM KY2891, 2892 (collective of five specimens), section G–H at the 210 m level, Middle Cenomanian, *asiaticum* Zone. OUM KY4126 (collective of six specimens), from section B at the 10–20 m level, *asiaticum* Zone. OUM KY5179–5181, from the Karai–Kulakkalnattam section at the 175–180 m level, Lower Cenomanian, *mantelli* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY5179a	20.6 (100)	12.2 (59.2)	12.7 (61.6)	0.96	–
OUM KY4126a	20.7 (100)	11.8 (57.0)	12.7 (61.4)	0.93	–
OUM KY3683	27.5 (100)	16.8 (61.0)	16.9 (61.4)	0.99	–
OUM KY2511	31.4 (100)	17.5 (55.7)	19.4 (61.8)	0.9	–

DESCRIPTION: Limonitic nuclei (Pl. 2, Figs 15–17) range from 11–27.5 mm in diameter. Coiling is very involute, the umbilicus near-occluded. The whorl section is barely compressed, the flanks feebly convex, ventrolateral shoulders broadly rounded, the venter feebly convex. The internal moulds are smooth.

OUM KY2891 (Pl. 1, Figs 6–8) is the largest specimen seen, 38 mm in diameter, and retaining a 120° sector of adult body chamber, the last few septa interfering. Proportions are as with the previous specimens. There are small surviving patches of shell material, ornamented by delicate lirae. At the adapertural end of the outer whorl, there are two widely spaced transverse ribs on the venter, with a third, preceded by a constriction, marking the adult aperture. The corroded suture of this specimen is deeply incised, with bifid E/A and A/U2.

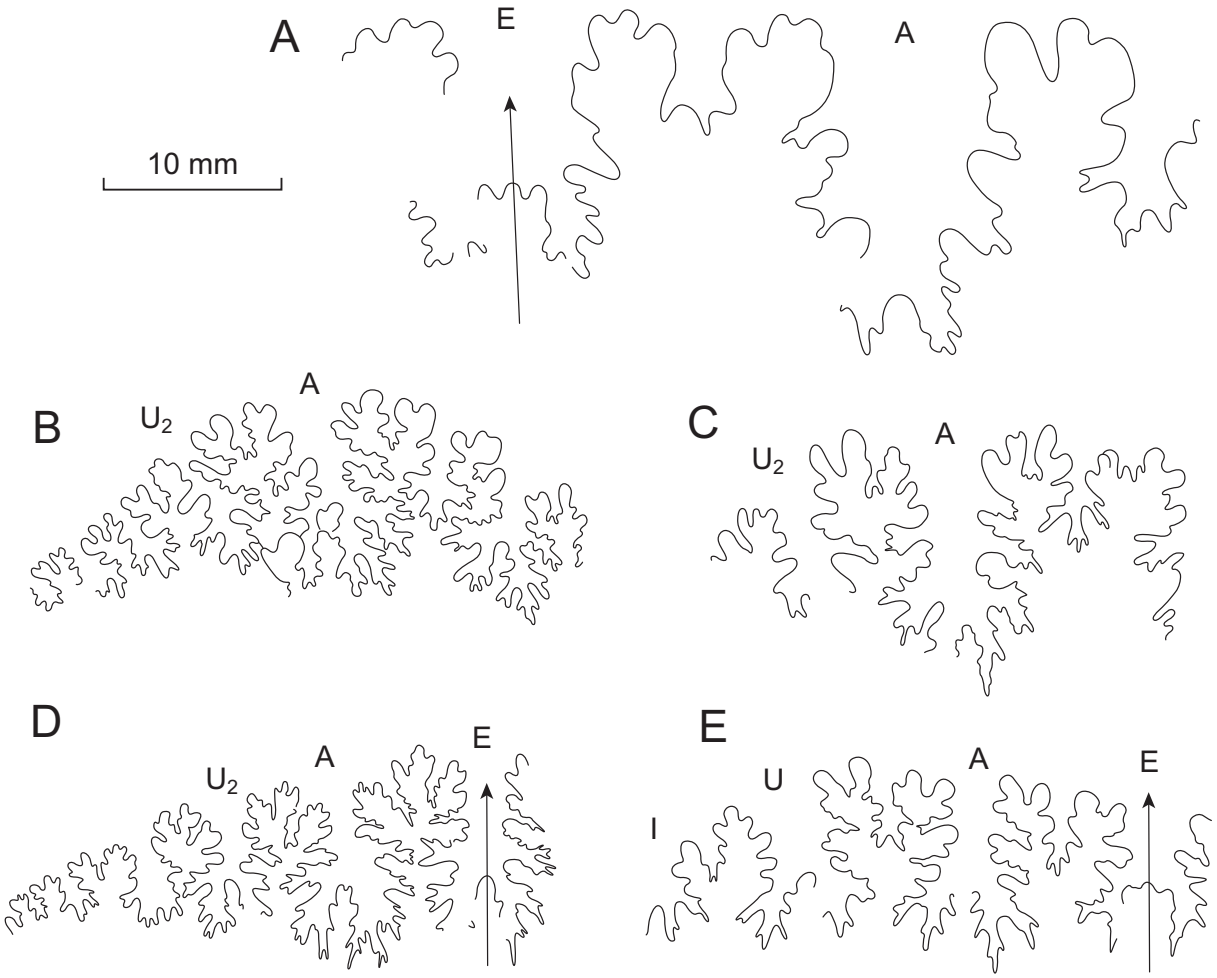
DISCUSSION: The barely compressed whorl section, near-occluded umbilicus and ribbon-like ribs in OUM KY2891 (Pl. 1, Fig. 8) distinguished *Phyllopachyceras ellipticum* from all other phylloceratids in the present fauna. See Joly (1993, p. 46) for further discussion.

OCCURRENCE: Upper Albian to lower Upper Cenomanian, southeastern France, Spain(?), The Canary Islands, KwaZulu-Natal in South Africa, Madagascar, and Tamil Nadu.

Suborder Lytoceratina Hyatt, 1889
Superfamily Tetragonitoidea Hyatt, 1900
Family Tetragonitidae Hyatt, 1900
Subfamily Tetragonitinae Hyatt, 1900
Genus *Tetragonites* Kossmat, 1895

TYPE SPECIES: *Ammonites timotheanus* Pictet, 1847, p. 295, pl. 2, fig. 6; pl. 3, figs 1, 2, by the original designation of Kossmat, 1895, p. 131 (35).

Tetragonites subtimotheanus Wiedmann, 1962
(Pl. 2, Figs 7–12; Pl. 3, Figs 1–6; Text-fig. 14D)



Text-fig. 14. Suture lines: **A** – *Stoliczkaia* (*Stoliczkaia*) *clavigera* (Neumayr, 1875), OUM KY3649. **B** – *Forbesiceras largilliertianum* (d'Orbigny, 1841), OUM KY3771. **C** – *Utaturiceras vicinale* (Stoliczka, 1864). **D** – *Tetragonites subtimotheanus* Wiedmann, 1962, OUM KY3766. **E** – *Anisoceras auberti* Pervinquière, 1907, OUM KY3788a

1865. *Ammonites timotheanus* Mayor; Stoliczka, p. 146, pl. 73, figs 3, 4, 6.
1895. *Lytoceras* (*Tetragonites*) *Timotheanum* Mayor sp.; Kossmat, p. 133 (37), pl. 17 (3), figs 11, 13.
1962. *Tetragonites subtimotheanus* Wiedmann, p. 131.
2009. *Tetragonites subtimotheanus maclearni* Wiedmann, 1962; Klein *et al*, pp. 230, 244 (with full synonymy).
2009. *Tetragonites subtimotheanus subtimotheanus* Wiedmann, 1962; Klein *et al*., pp. 230, 244 (with full synonymy).
2017. *Tetragonites* cf. *timotheanus* Wiedmann, 1962; Kennedy in Kennedy and Gale, p. 86.
2017. *Tetragonites subtimotheanus subtimotheanus* Wiedmann, 1962; Tajika *et al*., p. 45, text-fig. 11aj, 11ak.

TYPE: The holotype, by the original designation of Wiedmann, 1962, p. 131, is the original of Kossmat, 1895, p. 133 (37), pl. 17 (3), fig. 13, from the Upper Albian or Lower Cenomanian of Odiyam, Tamil Nadu, South India.

MATERIAL: OUM KY3355, from section O–P at the 261 m level, Upper Cenomanian, *harpax* Zone. OUM KY3661–3663, from section C–D at the 69 m level, Lower Cenomanian, *mantelli* Zone. OUM KY3765–3770, KY3794, from section C–D at the 116 m level, Lower Cenomanian, *mantelli* Zone. OUM KY3963 (collective of 78 specimens), KY3963 (collective of 78 specimens), KY3965 (collective of 119 spec-

imens) from the 16–18 m level of section A, Upper Cenomanian, *harpax* Zone, *euomphalum* fauna.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3965a	16.9 (100)	8.4 (49.7)	6.1 (36.1)	1.38	4.5 (26.6)
OUM KY3695b	17.4 (100)	8.9 (51.1)	7.5 (43.1)	1.19	4.9 (28.1)
OUM KY3965c	18.7 (100)	9.4 (50.3)	8.6 (46.0)	1.1	5.0 (26.7)
OUM KY3965d	19.2 (100)	9.9 (51.6)	8.5 (44.2)	1.16	5.1 (26.6)
OUM KY3767 at	29.8 (100)	17.0 (57.0)	12.6 (42.3)	1.35	6.8 (22.8)

DESCRIPTION: The species is represented by abundant limonitic nuclei (Pl. 2, Figs 7–12) from the Karai shales, and a few individuals (Pl. 3, Figs 1–6) from the Odiyam sandstones. In individuals less than 20 mm in diameter, coiling is involute, the umbilicus, of moderate depth, comprising around 27% of the diameter, the umbilical wall feebly convex, the umbilical shoulder quite narrowly rounded. The whorl section is slightly depressed, the flanks feebly convex, subparallel, the greatest breadth at mid-flank, the ventrolateral shoulders broadly rounded, the broad venter very feebly convex. There are five constrictions per whorl. They are deeply incised into the umbilical shoulder, straight and strongly prorsiradiate across the flanks, weakening and effacing across the ventrolateral shoulders. There is a feeble siphonal ridge in some individuals. As size increases, the constrictions strengthen, sweep forwards, are concave on the ventrolateral shoulders, and cross the venter in a shallow concavity, flanked by collar-ribs, well-developed on ventrolateral shoulders and venter.

Of the larger specimens, OUM KY3767 (Pl. 3, Figs 2–4) is a well-preserved internal mould with a maximum preserved diameter of 39.7 mm, retaining a 240° sector of body chamber. Coiling is involute, the umbilicus of moderate depth, with a feebly convex umbilical wall and broadly rounded umbilical shoulder. The whorl section is depressed, with the greatest breadth below mid-flank, the whorl breadth to height ratio 1.35, the flanks feebly convex, convergent, the umbilical shoulder broadly rounded, the venter broad and very feebly convex. There are six widely separated constrictions on the outer whorl. They are narrow, strongly prorsirsdiate on the umbilical wall, quite deeply incised into the umbilical shoulder, strongly prorsirsdiate, very feebly concave on the inner flank, straight and prorsiradiate on the outer flank, sweeping back across the ventrolateral shoulder, and very feebly concave on the venter. OUM KY3555 (Pl. 3, Figs 5, 6) is a deformed into an ellipse with a major diameter of 49.7 mm. Constrictions are well-developed on both internal mould and partially exfoliated shell, their course as in the previous specimen. The largest specimen seen is OUM KY3661 (Pl. 3, Fig. 1), an adult 85 mm in diameter, with a 240° sector of body chamber preserved. The adult aperture is marked by a flared margin preceded by a marked constriction, srongly prorsirsdiate on the flanks, convex on the ventrolateral shoulders, and feebly concave over the venter. The suture (Text-fig. l4D) is deeply incised with narrow-stemmed saddles and large bifid E/A.

DISCUSSION: The species is interpreted broadly here. Wiedmann (1973, p. 595, pl. 4, fig. 1; pl. 5, figs 1–3; text-fig. 3) separated his subspecies *maclearni* from the typical form on the basis of the development of an oval, rather than broadly rounded cross section in adults. For differences from other species, see Kennedy and Klinger (1977b, p. 161).

OCCURRENCE: The species ranges from Upper Albian to lower Upper Cenomanian, with records from Tamil Nadu, KwaZulu-Natal in South Africa, Madagascar, southern England, south-eastern France, Spain, Hungary, British Columbia and Alaska.

Subfamily Gabbioceratinae Breistroffer, 1953a
Genus *Gabbioceras* Hyatt, 1900

TYPE SPECIES: *Ammonites Batesi* Gabb, 1869, p. 132, pl. 21, fig. 10 (*non* Trask 1855, p. 40), by the original designation of Hyatt 1900, p. 570 = *Gabbioceras angulatum* Anderson 1902, p. 87.

Gabbioceras beraketense Collignon, 1964
(Pl. 2, Figs 1–6)

1964. *Jauberticeras beraketense* Collignon, p. 5, pl. 318, figs 1354, 1355.
1967. *Gabbioceras beraketense* (Collignon, 1964); Murphy, p. 604, pl. 64, figs 10, 15.
2009. *Gabbioceras beraketense* (Collignon, 1964); Klein *et al*., pp. 210, 211.

TYPE: The holotype, by original designation, is the original of Collignon 1964, p. 5, pl. 318, fig. 1354, in the Collignon Collection, housed in the Université de Bourgogne, Dijon. It was refigured by Murphy (1967, pl. 64, figs 10, 15), and is from the Lower Cenomanian

of Collignon's locality 478, 5 km west of Beraketa sur Sakondry (Manera), Madagascar.

MATERIAL: OUM KY3794a–b, from section C–D at the 116 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: OUM KY3794a is 11.4 mm in diameter; OUM KY3794b is 11.3 mm in diameter. Both specimens are phragmocones retaining traces of exfoliated shell. Coiling is involute, cadicone, the deep umbilicus conical, the umbilical wall flattened and outward-inclined, the umbilical shoulder quite broadly rounded, the whorl section very depressed with a whorl breadth to height ratio of 2. There are no flanks; the venter is broad and convex. What may be traces of ornament survive on areas of exfoliated shell on the venter of OUM KY3794a, and takes the form of feeble concave ridges.

DISCUSSION: The present species can be distinguished from most others assigned to the genus on the basis of the whorl section, as in clear from the sections shown in pl. 64 and text-fig. 1 in Murphy (1967). It most closely resembles the Middle Albian *Gabbioceras michelenianum* (d' Orbigny, 1850, p. 124) (Murphy 1967, p. 602, pl. 64, figs 6, 7, 12, 13, 17, 18), which, as Collignon noted (1964, p. 5), is even more depressed.

OCCURRENCE: Lower Cenomanian of Madagascar and Tamil Nadu.

Family Gaudryceratidae Spath, 1927
Subfamily Gaudryceratinae Spath, 1927
Genus and subgenus *Eogaudryceras* Spath, 1927

TYPE SPECIES: *Ammonites numidus* Coquand, 1880, p. 22, by the original designation of Spath 1927, p. 66.

Eogaudryceras (*Eogaudryceras*) sp.
(Pl. 5, Figs 19–21)

MATERIAL: OUM KY5141–5142, from the Upper Albian at the 171–175.5 m level on the north side of the Karai–Kulakkalnattam road.

DESCRIPTION: The specimens are limonitic internal molds, the larger (OUM KY5142) 30 mm in diameter. Coiling is moderately involute, the umbilicus of moderate depth, comprising 30% approximately of the diameter, with a feebly convex outward-inclined umbilical wall and broadly rounded umbilical shoulder. The whorl section is as wide as high, the flanks feebly convex, the ventrolateral shoulders broadly rounded, the venter feebly convex. There is neither ornament nor constrictions. The corroded sutures are gaudryceratine.

DISCUSSION: The material lacks sufficient characters for specific assignation. They are referred to *Eogaudryceras* (*Eogaudryceras*) on the basis of whorl section, lack of ornament and constrictions, and the gaudryceratine suture. The overall morphology is close to that of specimens referred to *Eogaudryceras numidum* (see synonymy in Klein *et al*. 2009, p. 153) as for example by Jacob (1908, pl. 11(1), fig. 6).

OCCURRENCE: As for material.

Genus *Gaudryceras* de Grossouvre, 1894

TYPE SPECIES: *Ammonites mitis* Hauer, 1866, p. 305, pl. 2, figs 3, 4, by the subsequent designation of Boule *et al*. 1906, p. 183 (11).

Gaudryceras (*Gaudryceras*) *mite* Hauer, 1866)
(Pl. 3, figs 7, 8)

1866. *Ammonites mitis* Hauer, p. 305, pl. 2, figs 3, 4.
2009. *Gaudryceras mite* (Hauer, 1866); Klein *et al*., pp. 173, 184 (with synonymy).
2017. *Gaudryceras mite* (Hauer, 1866); Summesberger *et al*., p. 15 (with additional synonymy).

TYPE: The holotype, by monotypy, is no. 1866/01/3 in the collections of Geological Survey of Austria the original of Hauer 1866, pl. 305, pl. 2, figs 3, 4, and probably from the Upper Turonian Gosau Group of Strobl/Weissenbach, Austria. It was refigured by Kennedy and Summesberger (1979, pl. 1, figs 1–4) and Summesberger and Zorn (2012, pl. 4, fig. 4).

MATERIAL: OUM KY3639, from section R–S at the 74 m level, Lower Turonian, *Neoptychites cephalotus–Mytiloides mytiloides* fauna.

DESCRIPTION: The specimen has a maximum preserved diameter of 150 mm, and retains exfoliated recrystallized shell. Coiling is moderately evolute, the umbilical wall convex, the umbilical shoulder broadly rounded. The whorl section is slightly depressed, with feebly convex converging flanks, broadly rounded ventrolateral shoulders and venter. Ornament is of dense crowded lirae that strengthen

across the flanks, ventrolateral shoulders and venter, and increase by branching and intercalation. They are strong, prorsiradiate and convex on the inner to middle flanks, very feebly concave on the outer flanks, and cross the venter near-straight. There are three strengthened, ribbon-like collar ribs on the fragment, the most conspicuous 90° from the adapical end.

DISCUSSION: See revisions in Kennedy and Summesberger (1979) and Summesberger and Kennedy (1996).

OCCURRENCE: The species ranges from Turonian to Lower Campanian. The geographic distribution extends from Austria to Poland, France, northern Spain, Romania, Eastern Cape Province and KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, Madagascar, Japan, Sakhalin, and California.

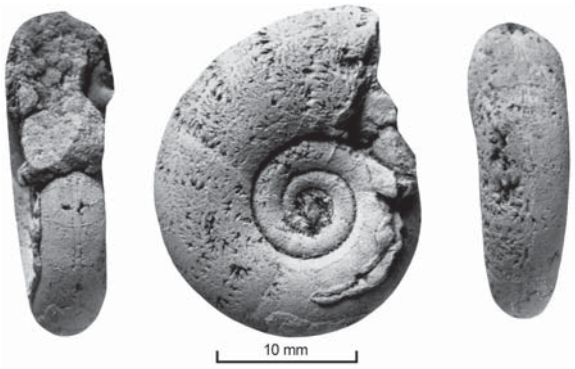
Gaudryceras (*Gaudryceras*) *vertebratum* (Kossmat, 1895)
(Pl. 6, Figs 14, 15)

1865. *Ammonites Kayei* Forbes; Stoliczka, p. 156 (*pars*), pl. 77, fig. 2 only.
1895. *Lytoceras* (*Gaudryceras*) *vertebratum* Kossmat, p. 126 (30), pl. 15 (1), figs 4, 5.
2009. *Gaudryceras vertebratum* (Kossmat, 1895); Klein *et al*., pp 174, 193 (with full synonymy).

TYPE: The lectotype, here designated, is the original of Kossmat 1895, pl. 15 (1), fig. 4, from Odiyam.

MATERIAL: OUM KY6013, from the basal shell bed of the Middle Cenomanian *asiaticum* Zone channel around the 400 m level on the north side of the road between Karai and Kulakkalnattam.

DESCRIPTION: OUM KY6013 (Pl. 6, Figs 14, 15) is a poorly preserved composite mould 68 mm approximately in diameter that closely resembles the lectotype. The maximum preserved whorl height is 33 mm. The original whorl proportions cannot be established due to crushing. The flanks are feebly convex, subparallel, the ventrolateral shoulders broadly rounded, the venter feebly convex. Ornament consists of coarse lirae that increase by branching and intercalation. They are prorsiradiate and very feebly convex on the inner flank, near-straight on the outer flank, and pass straight across the venter. Individual lirae are periodically strengthened, possibly marking the site of constrictions on the internal mould.



Text-fig. 15. Limonitic nucleus of *Gaudryceras* sp. C, OUM KY6008b, from the Karai Formation, Lower Cenomanian, *mantelli* Zone, between Karai and Kulakkalnattam

DISCUSSION: The even, coarse, crowded lirae of *vertebratum* contrast markedly with the coarser, markedly flexuous lirae of *Gaudryceras mite* of comparable size, as represented by specimens assigned to *Gaudryceras varagurense* (Kossmat, 1895) (p. 122 (26), pl. 17 (3), fig. 9; pl. 18 (4), fig. 2) by authors, but regarded as a synonym of *mite* herein (*fide* Kennedy and Summesberger 1979, p 75); see, for example Howarth (1965, pl. 4, fig. 5; pl. 5, figs 1, 2).

OCCURRENCE: Middle Cenomanian of Tamil Nadu, Madagascar, and Romania.

'*Gaudryceras*' spp. juv.
(Pl. 5, Figs 1–9; Text-fig. 15)

DISCUSSION: Limonitic gaudryceratid nuclei are abundant in the Karai Shale: we have more than 100 specimens, regarded as too small to assign to species known from larger individuals in the sandstone facies. At least three species are present.

'*Gaudryceras*' sp. A (Pl. 5, Figs 1, 2) is represented by very evolute serpenticone individuals up to 19 mm in diameter, with very fine prorsirsdiate lirae ; figured examples are OUM KY55160a–b, from the Lower Cenomanian *mantelli* Zone at the 345–350 m level on the north side of the Karai–Kulakkalnattam road.

'*Gaudryceras*' sp. B (Pl. 5, Fig. 3) is much more coarsely lirate; OUM KY5552a, from the Lower Cenomanian *mantelli* Zone at the 346–350 m level on the north side of the Karai–Kulakkalnattam road is typical.

'*Gaudryceras*' sp. C (Pl. 5, Figs 4–9; Text-fig. 15) lacks lirae, but has well-developed widely separated

constrictions. The whorl section is depressed, with a broad, feebly convex venter, as with the inner whorls of *Gaudryceras vertebratum* (Kossmat 1895) (pl. 15 (10), fig. 4). Typical examples are OUM KY6007a and 6008a, from the Lower Cenomanian *mantelli* Zone on the north side of the Karai–Kulakkalnattam road.

Subenus *Anagaudryceras* Shimizu, 1934

TYPE SPECIES: *Ammonites sacya* Forbes, 1846, p. 113, pl. 14, fig. 10, by the original designation of Shimizu 1934, p. 67.

Gaudryceras (*Anagaudryceras*) *multilplexum* (Stoliczka, 1865)
(Pl. 6, Figs 1–5, 16; Text-fig. 13A)

1865. *Ammonites Sacya* var. *multiplexus* Stoliczka, p. 155, pl. 76, fig. 1.
1865. *Ammonites Sacya* Forbes; Stoliczka, p. 154 pl. 76, fig. 2.
1895. *Lytoceras* (*Gaudryceras*) *multiplexum* Kossmat, p. 121 (25), pl. 15 (1), fig. 6.
2009. *Anagaudryceras multiplexum* (Stoliczka, 1865); Klein *et al*., pp. 157, 162 (with synonymy).

TYPES: Stoliczka (1865, p. 155) stated: '*A. Sacya*, var. *multiplexus* is a variety, which we have represented in the figures 2 and 3, pl. LXXVI'. In the explanation of the plate, figure 1 is clearly stated to be var. *multiplexus*. Figures 2 and 3 are not stated unambiguously as var. *multiplexus*, but the wording is such that they could be interpreted as such. Kossmat (1895, p. 121 (25), referred only fig. 1 to *multiplexus* in his synonymy. Collignon (1956, p. 69) pointed out that the inner whorls of Stoliczka's pl. 76, fig. 2 did not correspond to those of pl. 76, fig. 1, whereas Klein *et al*. (2009, 162) refer pl. 71 figs 1 and 2 to *multiplexum* in their synonymy. The original of Stoliczka's pl. 76, fig. 3 is the holotype, by original designation, of *Anagaudryceras utaturense* Shimizu, 1935 (p. 176). In order to stabilize the situation, the original of Stoliczka 1865, pl. 71, fig. 1 is here designated lectotype; it is from the neighborhood of Odiyam.

MATERIAL: OUM KY2521–2522, from section A–B at the 0–2 m level, Upper Albian, *rostrata* Zone. OUM KY2889 and 2890, from section G–H, at the 210–212 m level, Middle Cenomanian, *asiaticum* Zone. OUM KY3005, from section I–J at the 13 m level, Middle Cenomanian, *cunningtoni* Zone. OUM KY3548, from section R–S at the 65 m level, *hourcqi–latelobatum* fauna. Upper Cenomanian.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3005	54.5 (100)	22.6 (41.5)	20.9 (38.7)	1.1	24.2 (44.4)

DESCRIPTION: OUM KY2889 (Pl. 6, Fig. 16) consists of a nucleus 33 mm in diameter and fragments of a much larger whorl. Coiling is very evolute, the coiling of the nucleus serpenticone, with a very wide, shallow umbilicus that comprises 56% approximately of the diameter. The umbilical wall is convex and outward-inclined, the flanks feebly convex, the ventrolateral shoulders broadly rounded, the broad venter feebly convex. Where traces of shell survive on the nucleus, an ornament of strongly prorsiradiate flank lirae is present, as are widely separated prorsiradiate constrictions. The fragments of the outer whorl that retain recrystallized shell bear coarse lirae, feebly prorsiradiate on the outer flank, and near-transverse over the venter. There are two coarser ribs, separated by a deepened interspace that presumably marks the position of a constriction on the internal mould. OUM KY3548 (Pl. 6, Fig. 10), 20 mm in diameter and OUM KY3005 (Pl. 6, Figs 1, 2), 54.5 mm in diameter, are juveniles with replaced shell material. The lirae are strongly prorsiradiate across the umbilical wall, flexing back and feebly convex across the umbilical shoulder and innermost flank, straight and feebly rursiradiate across the outer flanks and transverse across the venter.

DISCUSSION: The distinctive feature of *Anagaudryceras multiplexum* is the change in ornament from finely lirate inner whorls to coarsely lirate outer whorls, as illustrated by Kossmat (1895, pl. 15 (1), fig. 6), the exact changes shown by the present material (Pl. 6, Fig. 16).

OCCURRENCE: Upper Albian to Upper Cenomanian in Tamil Nadu. Also recorded from Madagascar, Sakhalin, Serbia, Chile, and Antarctica.

Gaudryceras (*Anagaudryceras*) *utaturense* Shimizu, 1935
(Pl. 6, Figs 6–9, 11–13)

1865. *Ammonites Sacya* Stoliczka, p. 154 (*pars*), pl. 76, fig. 3 only.
1935. *Anagaudryceras utaturense* Shimizu, p. 176.
1953. *Anagaudryceras utaturense* Shimizu; Spath, p. 9.

1959. *Anagaudryceras utaturense* Shim.; Collignon , p. 44.
?1963. *Gaudryceras* (*Anagaudryceras*) aff. *utaturense* Shim.; Collignon, p. 17, pl. 248, fig. 1061.
1979. *Anagaudryceras utaturense* Shimizu, 1935; Kennedy and Klinger, p. 146.
2009. *Anagaudryceras utaturense* Shimizu, 1935; Klein *et al*., pp. 158, 169 (with synonymy).

TYPE: The holotype, by the original designation by Shimizu (1935, p. 176), is the original of *Ammonites sacya* Forbes of Stoliczka (1865, p. 154 (*pars*), pl. 76, fig. 3 only), from the neighbourhood of Odiyam.

MATERIAL: OUM KY3202–3203, from section M–N at the 221 m level, Middle Cenomanian *asiaticum* Zone. OUM KY3741 and 3744, from section C–D at the 116 m level, Lower Cenomanian, *mantelli* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3202	77.5 (100)	32.3 (41.7)	32.8 (42.3)	0.98	27.4 (35.4)

DESCRIPTION: OUM KY3202 (PL. 6, Figs 11–13) is an internal mould of a phragmocone with a maximum preserved diameter of 77.5 mm, with traces of recrystallised shell. Coiling is very evolute. The broad umbilicus is of moderate depth, and comprises 35.4% of the diameter. The umbilical wall is feebly convex, the umbilical shoulder broadly rounded. The whorl section is very slightly compressed, with a whorl breadth to height ratio of 0.98, the greatest breadth below mid-flank. The inner and middle flanks are feebly convex, the outer flanks converging to broadly rounded ventrolateral shoulders and venter. The surface of the internal mould is smooth. Where recrystallized shell is preserved, the surface is covered in very fine crowded lirae. OUM KY3203 (Pl. 6, Figs 6, 7) and 3744 (Pl. 6, Fig. 9) are fragments with whorl heights of up to 24 mm that have better-preserved ornament. The lirae are prorsiradiate on the umbilical wall and flanks, where they are feebly flexuous, straight on the inner flank, feebly convex at mid-flank, very feebly concave on the outer flank, and transverse across the venter. There are three strengthened, presumably collar ribs on the 120° fragment.

The suture of OUM KY3202 is deeply incised, with narrow-stemmed saddles.

DISCUSSION: The near-smooth internal mould and very fine lirae where shell is preserved distinguish *Anagaudryceras utaturense* from *A. multiplexum*, described above. *Anagaudryceras involvulum* (Stoliczka, 1865) (p. 150, pl. 75, fig. 1) and *A. utaturense* have been regarded as synonyms, the latter having priority (Howarth 1966, p. 220; Wright and Kennedy 1984, p. 51). In contrast, Matsumoto (1995, p. 45) who had examined the type material of Stoliczka, thought the holotype of *utaturense* could be a middle-aged example of *Ammonites madraspatanus* Stoliczka, 1865 (p. 151, pl. 75, fig. 2), which latter he referred to *Anagaudryceras*, although not including it in his synonymy of *A. madraspatunum*, and remarking that it might rather be an *Eogaudryceras* (1995, p. 46). The present material does nothing to resolve the problem, and as the best of the present specimens (Pl. 6, Figs 11–13) bears such a close resemblance to the holotype, the name is retained here. As Matsumoto notes, more and adult specimens are needed to resolve these issues. In contrast, *Anagaudryceras sacya* (Forbes, 1846) (p. 112, pl. 14, fig. 9) develop strong, band-like feebly flexuous ribs on the adult whorl at a size where *utaturense* remains ornamented by delicate lirae only. (see revision, under the name *Anagaudryceras buddha* in Kennedy and Klinger 1979, p. 146, pl. 8, figs 1–3; pl. 9, figs 1–3; pl. 10, figs 1–6; pl. 10, figs 1–6; pl. 11, figs 1, 2; text-fig. 2, and Matsumoto 1995, p. 37, text-fig. 18).

OCCURRENCE: As for material.

Genus *Kossmatella* Jacob, 1907

TYPE SPECIES: *Ammonites Agassizianus* Pictet 1847, p. 303, pl. 4, fig. 3, by the subsequent designation of Roman 1938, p. 43.

Kossmatella marut (Stoliczka, 1865)
(Pl. 5, Figs 10, 11)

1865. *Ammonites Marut* Stoliczka, p. 162, pl. 79, fig. 1.
1897. *Lytoceras* (*Gaudryceras*) *Marut* Stoliczka; Kossmat, p. 130 (34), pl. 17 (3), fig. 3.
2009. *Kossmatella marut* (Stoliczka, 1865); Klein *et al*., pp. 200, 203 (with full synonymy).

TYPE: The holotype, by monotypy, is the original of *Ammonites marut* Stoliczka, 1865, p. 162, pl. 79, fig. 1, from Odiyam.

MATERIAL: OUM KY5021, collective of 8 specimens, Karai–Kulakkalnattam section, 103.5–108 m level, Upper Albian; OUM KY5839–5841, 390–400 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: The material consists of poorly preserved limonitic nuclei up to 23 mm in diameter, many with gypsum overgrowths. Coiling is very evolute, the umbilicus shallow, the umbilical shoulder convex and inclined outwards, the umbilical shoulder broadly rounded. The expansion rate is low, the whorl section compressed, with feebly convex parallel flanks, broadly rounded ventrolateral shoulders, and a feebly convex venter. Ornament consists of low, broad, straight prorsiradiate ribs, ten per half whorl, that broaden and strengthen across the flanks, then decline and efface across the ventrolateral shoulders. The sutures are not seen.

DISCUSSION: Whorl section, coiling and ribbing correspond to that of specimens figured by Stoliczka and Kossmat, and the specimen from KwaZulu-Natal described by Kennedy and Klinger (1979, p. 166, pl. 14, fig. 8), who discuss differences from other species assigned to the genus.

OCCURRENCE: Upper Albian and Lower Cenomanian of Tamil Nadu; Upper Allbian of KwaZulu-Natal, South Africa.

Suborder Ammonitina Hyattt, 1889
Superfamily Desmoceratoidea Zittel, 1895
Family Desmoceratidae Zittel, 1895
Subfamily Puzosiinae Spath, 1922b
Genus and Subgenus *Puzosia* Bayle, 1878

TYPE SPECIES: *Ammonites planulatus* J. de C. Sowerby, 1827 (p. 134, pl. 570, fig.5), *non* Schlotheim, 1820 (p. 59) = *Ammonites mayorianus* d'Orbigny, 1841, p. 267, pl. 79, figs 1–3, by the subsequent designation of H. Douvillé (1879, p. 91).

DISCUSSION: See Wright and Kennedy 1984, p. 54.

Puzosia (*Puzosia*) *compressa* Kossmat, 1898
(Pl. 7, Figs 1–5, 8–11)

1865. *Ammonites durga* Stoliczka, p. 143, pl. 71, figs 6, 7.
1898. *Puzosia compressa* Kossmat, p. 184 (119), pl. 24 (18), fig. 4.
1906. *Desmoceras* (*Puzosia*) *compressum* Kossmat; Boule *et al*., p. 190 (18), pl. 17 (4), fig. 3; pl. 18 (5), figs 1, 2; text-figs 9, 10.
1961. *Puzosia compressa* Kossmat; Collignon, p. 28, pl. 2, fig. 1.
1964. *Puzosia compressa* Kossmat; Collignon, p. 40, pl. 326, fig. 1461.
1964. *Puzosia praecompressa* Collignon, p. 55, pl. 332, fig. 1493.
1986. *Puzosia compressa* Kossmat; Chiplonkar *et al*., p. 33, pl. 1, figs 7, 8.
1988. *Puzosia compressa* Kossmat, 1898; Matsumoto, p. 38.
2011. *Puzosia* (*Puzosia*) *compressa* Kossmat, 1898; Klein and Vašiček, pp. 65, 71 (with additional synonymy).
2011. *Puzosia* (*Puzosia*) *praecompressa* Collignon, 1964; Klein and Vašiček, pp. 67, 85.
2014. *Puzosia compressa* Kossmat, 1898; Kennedy and Klinger, p. 7, text-fig. 1d–f; 7a–d.

TYPE: The lectotype, by the subsequent designation of Matsumoto 1988, p. 38, is the original of *Ammonites durga* Stoliczka, 1865, p. 143, pl. 71, fig. 7, from Odiyam.

MATERIAL: OUM KY2508, from section A–B, upper interval, 0 m level; OUM KY2535–2542, 0–2 m level; OUM KY2551, 21 m level; OUM KY2563, 56 m level; all Upper Albian, *rostrata* Zone. OUM KY4757–4760, from section T–U, Upper Albian, *rostrata* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2551	46.8 (100)	10.8 (23.1)	16.7 (35.7)	0.65	17.3 (37.0)
OUM KY2536	69.6 (100)	16.2 (23.3)	23.8 (34.2)	0.68	28.4 (40.8)
OUM KY2540	100.6 (100)	24.1 (24.0)	38.5 (38.3)	0.62	40.2 (40.0)
OUM KY2535	112.1 (100)	21.8 (19.4)	40.9 (36.5)	0.53	39.6 (35.3)

DESCRIPTION: OUM KY2536 (Pl. 7, Figs 1–3) is an internal mould of a typical juvenile of the species. Coiling is very evolute, the broad shallow umbilicus comprising 40.8% of the diameter. The umbilical wall is low and convex, the umbilical shoulder narrowly rounded. The whorl section is very compressed, with a whorl breadth to height ratio of 0.68, the flanks barely convex, subparallel, the ventrolateral shoulders broadly rounded, the venter very feebly convex. There are five strong constrictions per whorl on the internal mould. They are deeply incised into the umbilical shoulder, straight and prorsiradiate across the flanks, flexing forwards and concave on the ventrolateral shoulder, projecting forwards to form a feeble obtuse ventral chevron. No ornament is present on the internal mould to a diameter of 57 mm. Beyond this, delicate crowded ribs appear; they are more prominent on fragments of the shell. The ribs are delicate and narrow, and are present on the

outermost flanks, ventrolateral shoulders and venter only, being concave on outer flanks and ventrolateral shoulders and feebly convex over the venter. OUM KY2535 (Pl. 7, Figs 4, 5, 11) is an internal mould of a half whorl of phragmocone with a maximum preserved diameter of 112 mm, and retains a short sector of body chamber. There are two constrictions on the fragment, deeply incised into the umbilical wall and shoulder, strong and feebly prorsiradiate across the inner flanks, feebly concave across the middle and outer flanks, and crossing the venter in an obtuse V-shaped chevron. There are traces of delicate ribs on the outer flanks, ventrolateral shoulders and venter of most of the outer whorl. OUM KY2540 (Pl. 7, Figs 8–10) is a phragmocone with a maximum preserved diameter of 100.6 mm, and four constrictions on the outer whorl.

DISCUSSION: *Puzosia* (*Puzosia*) *compressa* is readily distinguished from all other *Puzosia* in the present collection on the basis of the evolute coiling, very compressed whorl section, and shape of the ventral chevron. *Puzosia* (*P.*) *praecompressa* Collignon, 1964 (p. 55, pl. 332, fig. 1493) from the Lower Cenomanian Niveau à *Puzosia compressa* of the Col de Vohimaranitra (Betioky), Madagascar (refigured by Kennedy and Klinger 2014, text-fig. 7c, d), was distinguished on the basis of its broader whorl section (the whorl breadth to height ratio is 0.78 according to Collignon's figures), smaller umbilicus (25%), and coarser ornament. It was regarded as a synonym by Kennedy and Klinger 2014, p. 8).

OCCURRENCE: Upper Albian, *rostrata* Zone of Tamil Nadu. Lower Cenomanian of Madagascar.

Puzosia (*Puzosia*) *crebrisulcata* Kossmat, 1898
(Pl. 8, Figs 1–4, 8, 9)

1865. *Ammonites planulatus* Stoliczka, p. 134 (*pars*), pl. 67, fig. 2.
1898. *Puzosia* (*Puzosia*) *crebrisulcata* Kossmat, p. 181 (116), pl. 23 (17), fig. 4; pl. 24 (18), fig. 2.
non 1971. *Puzosia* (*Puzosia*) cf. *crebrisulcata* Kossmat; Kennedy, p. 36, pl. 14, figs 5, 7 (= *P.* (*P.*) *mayoriana* (d'Orbigny, 1841).
2011. *Puzosia* (*Puzosia*) *crebrisulcata* Kossmat, 1898; Klein and Vašiček, pp. 65, 71 (with full synonymy).

TYPES: Kossmat cited two specimens; the original of his pl. 23 (17), fig. 4, is here designated lectotype; it and the figured paralectotype are from Odiyam.

MATERIAL: From section G–H: OUM KY2755, from the 170 m level; KY2759, 171 m; KY2785, 177–181 m; KY2887, 210–212 m; KY3111, 213–216 m; KY3161, 214–216 m level, all Middle Cenomanian, *asiaticum* Zone. From section O–P, at the 261 m level: OUM KY3346–3350, all Upper Cenomanian, *septemseriatum* Zone. From section I–J: OUM KY4411, from the 25 m level, Middle Cenomanian, *asiaticum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2759	46.2 (100)	– (–)	18.7 (40.5)	–	15.8 (34.2)
OUM KY2755	77.1 (100)	– (–)	30 (38.9)	–	29.2 (37.9)
OUM KY3347	78.6 (100)	– (–)	32.3 (41.1)	–	26.4 (33.6)
OUM KY4411	83.7 (100)	24.9 (29.7)	32.0 (38.2)	0.78	30.8 (36.8)

DESCRIPTION: OUM KY4411 (Pl. 8, Figs 8, 9) is a well-preserved individual with a maximum preserved diameter of 83.7 mm, retaining recrystallized shell, and a 180° sector of body chamber. Coiling is evolute, the broad, shallow umbilicus comprising 36.8% of the diameter, with a low, flattened wall and quite narrowly rounded umbilical shoulder. The whorl section is compressed, with a whorl breadth to height ratio of 0.78, the greatest breadth below mid-flank, the inner to mid-flanks flattened and convergent, the ventrolateral shoulders broadly rounded, the venter feebly convex. There are seven strong constrictions on the outer whorl, deeply incised into the umbilical wall and shoulder, straight and feebly prorsiradiate to mid-flank, then projecting strongly forwards and markedly concave on the outermost flanks and ventrolateral shoulders, crossing the venter in an obtuse linguoid peak, the apex narrow at the beginning of the outer whorl, less so at the greatest preserved diameter. The constrictions are flanked by an adapical collar rib, best developed on outermost flanks, ventrolateral shoulders and venter. The exposed inner to middle flank region of the penultimate whorl is smooth, so far as it is visible. At the beginning of the outer whorl, the outer flanks, ventrolateral shoulders and venter are ornamented by delicate, barely perceptible riblets that parallel the constrictions. Following a damaged section, ornament is visible at a diameter of 70 mm, on the outer flanks, ventrolateral shoulders and venter, consisting of relatively coarse ribs, 8–10 between successive constrictions/collar ribs, which they parallel, strengthening progressively across the flanks and

ventrolateral shoulders. OUM KY2579 is a phragmocone 46.2 mm in diameter with seven strong constrictions on the outer whorl. Scraps of shell material are preserved, with indications of delicate ribs on the venter. OUM KY3346 (Pl. 8, Figs 3, 4) has the ventral chevron of the constrictions more acute than in the previous specimens, the penultimate whorl with barely detectable ornament on the ventrolateral shoulders and venter. On the outer whorl, the adapertural 180° sector is body chamber, with three constrictions and 10 relatively coarse ribs between successive constrictions/collar ribs. It is interpreted as a robustly ornamented variant of the species. OUM KY2755 (Pl. 8, Figs 1, 2), with a maximum preserved diameter of 77.8 mm, has seven constrictions on the outer whorl. OUM KY2785 (Pl. 8, Figs 5–7, 10) consists of a nucleus 51.4 mm in diameter with seven constrictions per whorl and no clear indication of ornament on the internal mould, plus an outer whorl septate to a diameter of 76 mm, retaining shell, with well-preserved ornament on outer flanks, ventrolateral shoulders and venter.

DISCUSSION: The distinctive features of *crebrisulcata* that separates the species from others in the present fauna are the relatively stout whorl section, late acquisition of ornament, and the strong feebly sinuous constrictions 7–8 per whorl, with strong collar-ribs.

OCCURRENCE: The species ranges throughout most of the Cenomanian. There are records from Tamil Nadu, Madagascar, Mozambque, Romania, and, possibly Texas.

Puzosia (*Puzosia*) *insculpta* Kossmat, 1898
(Pl. 7, Figs 6, 7)

1898. *Puzosia insculpta* Kossmat, p. 185 (120), pl. 24 (18), fig. 5.
1906. *Desmoceras* (*Puzosia*) *insculptum* Kossmat; Boule *et al*., p. 191 (19), pl. 16 (3), figs 2–4; pl. 17 (4), fig. 2; text-fig. 11.
2011. *Puzosia* (*Puzosia*) *insculpta* (Kossmat 1898); Klein and Vašiček, pp. 66, 75 (with full synonymy).

TYPE: The holotype, by monotypy, is the original of Kossmat 1898, p. 185 (120), pl. 24 (18), fig. 5, from Odiyam (?).

MATERIAL: OUM KY2805, from section G–H at the 195–196 m level, Middle Cenomanian, *asiaticum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2805	64.4 (100)	21.5 (33.4)	24.0 (37.3)	0.9	23.2 (35.7)

DESCRIPTION: The specimen is a well-preserved internal mould of a nucleus and a 180° sector of phragmocone, the greatest preserved diameter 64.4 mm. Coiling is moderately evolute, the shallow umbilicus comprising 35.7% of the diameter, the umbilical wall low and feebly convex, the umbilical shoulder narrowly rounded. The whorl section is slightly compressed, with a whorl breadth to height ratio of 0.9, the greatest breadth below mid-flank. The inner and middle flanks are flattened and convergent, the outer flanks converging to broadly rounded ventrolateral shoulders and venter. There are 3 constrictions on the adapertural 180° sector of the outer whorl. They are deeply incised into the umbilical wall and shoulder, straight and prorsiradiate on the inner flanks, projecting forwards and concave on the outer flanks, then projecting strongly forwards on the ventrolateral shoulders, and crossing the venter in a convex linguoid peak. The surface of the internal mould is smooth between the constrictions.

DISCUSSION: The distinctive features of the present species are the relatively small umbilicus, high whorls, lack of ornament on the internal mould, an ornament of growth lines only on the shell surface, and seven convex constrictions per whorl that cross the venter in a broad convexity. The present specimen, though smaller than the 112 mm diameter holotype, differs in no significant respects.

OCCURRENCE: Middle Cenomanian of Tamil Nadu; Lower Cenomanian of Madagascar.

Puzosia (*Puzosia*) *odiensis* Kossmat, 1898
(Pl. 9, Figs 1–8, 10, 11)

1898. *Puzosia planulata* var. *Odiensis* Kossmat, p. 177 (112), pl. 22 (16), figs 4; pl. 24 (18), fig. 4.
2011. *Puzosia* (*Puzosia*) *odiensis* (Kossmat, 1898); Klein and Vašiček, pp. 67, 84 (with full synonymy).

TYPE: The lectotype, by the subsequent designation of Wright and Kennedy 1981, p. 177, is the original of Kossmat 1898, p. 177 (112), pl. 16 (22), fig. 5, from Odiyam.

MATERIAL: From section G–H, OUM KY2738 and KY2739, at the 168–173 m level; KY2765,

172 m; KY2802, KY2804, 195–196 m; KY2885 and KY2886, 210–212 m level, all Middle Cenomanian, *asiaticum* Zone. From section M–N, OUM KY4532 and KY4533, from the 210 m, level; OUM KY3063, from the 214–215 m level; KY4538, from the 214–216 m, all Middle Cenomanian, *asiaticum* Zone. OUM KY3565–3573, section R–S at the 65 m level, Upper Cenomanian *hourcqi–latilobatum* fauna.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2804	36.9 (100)	13.9 (37.7)	14.5 (39.3)	0.96	11.9 (32.2)
OUM KY2739	50.4 (100)	– (–)	18.4 (36.5)	–	19.5 (38.7)
OUM KY3063	64.1 (100)	– (–)	24.4 (38.0)	–	19.6 (30.6)
OUM KY2781 at	71.8 (100)	24.1 (33.6)	28.3 (39.4)	0.85	26.8 (37.3)

DESCRIPTION: OUM KY2804 (Pl. 9, Figs 7, 8) is a well preserved nucleus with a maximum preserved diameter of 54 mm. Coiling is moderately evolute, the shallow umbilicus comprising 38.7% of the diameter, with a low, feebly convex wall and quite broadly rounded umbilical shoulder. The whorl section is slightly compressed, with a whorl breadth to height ratio of 0.96, the inner and middle flanks flattened and subparallel, the outer flanks converging to broadly rounded ventrolateral shoulders and a broad, feebly convex venter. There are six constrictions per whorl at a diameter of 34 mm. They are deeply incised into the umbilical wall and shoulder, prorsiradiate across the inner and middle flanks, then flexing forwards and markedly concave on the outer flanks and ventrolateral shoulders, crossing the venter in an obtuse linguoid peak, the apex narrowly rounded at a diameter of 30 mm, becoming more broadly rounded as size increases. The constrictions are preceded by a weak collar rib. The surface of the internal mould is smooth. Where recrystallized shell is preserved, the inner to mid-flank region is smooth. Delicate crowded ribs, an estimated 18 between successive constrictions/collar ribs, arise on the outer flanks, and strengthen progressively across outer flanks, ventrolateral shoulders and venter, which they cross in a convexity that is broader than that of the constrictions.

OUM KY2739 (Pl. 9, Figs 1, 2), an internal mould of a phragmocone 50 mm in diameter, has six constrictions on the outer whorl, and shows the same changes in the shape of the linguoid ventral peak from narrowly to broadly rounded as in the previous specimen. OUM KY3063 (Pl. 9, Figs 5, 6), 64 mm in diameter, retains recrystallized shell. There are six constrictions on the outer whorl, with a broadly rounded linguoid ventral peak and either an adapical or adapertural collar rib, strongly developed on ventrolateral shoulders and venter. There are19 ribs between successive constrictions. OUM KY2802 shows the same pattern of constrictions and ribs to a diameter of 98 mm, and is in part body chamber, although the position of the final septum cannot be established. The largest well-preserved specimen, OUM KY4412 (Pl. 9, Figs 3, 4), is a 120° whorl sector with a maximum preserved whorl height of 40 mm, the whorl breadth to height ratio 0.9, with two well-developed constrictions flanked by an adapical collar rib, best-developed on ventrolateral shoulders and venter. There are 14 ribs between successive constrictions/collar ribs. They arise at mid-flank where they are prorsiradiate, sweeping forwards and concave on outermost flanks and ventrolateral shoulders, and crossing the venter in a broad convexity.

Also referred to *P.* (*P.*) *odiensis* is Upper Cenomanian material (OUM KY3565–3573, from section R–S at the 65 m level), comprising two near-complete juveniles and a series of much larger fragments with whorl heights of up to 38 mm, with well-preserved nacreous shell. Coiling is evolute, the shallow umbilicus comprising 36.2% of the diameter in OUM KY3569 (Pl. 10, Figs 1, 2), a juvenile 55 mm in diameter, the umbilical wall low, and feebly convex, the umbilical shoulder broadly rounded. The whorl section is compressed, the whorl breadth to height ratio 0.69 in OUM KY3566, the flanks are feebly convex and subparallel, the ventrolateral shoulders broadly rounded, the venter feebly convex. There are seven widely separated strong constrictions per whorl. They are very feebly falcoid, straight and feebly prorsiradiate on the inner flank, concave on the outer flanks, sweeping forwards over the ventrolateral shoulder and crossing the venter in a convex linguoid peak. They are flanked by an adapical or adapertural collar rib, strengthened over ventrolateral shoulders and venter. There are up to 12 ribs between successive constrictions. They are well-developed on the outer flanks, ventrolateral shoulders and venter, and parallel the constrictions. On larger fragments, both ribs and collar ribs become very coarse, as in OUM KY3565 (Pl. 10, Fig. 4), 3567, and 3570, a feature not shown by individuals from lower horizons.

DISCUSSION: Amongst species in the present collection *P.* (*P.*) *odiensis* most closely resembles *P.* (*P.*) *crebrisulcata*, but that species is smooth at a stage where ornament is well-developed in *odiensis*, the

constrictions are stronger, forming a ventral peak with narrowly rounded apex, rather than broad, and coarser ribs when ornament appears.

OCCURRENCE: Middle and Upper Cenomanian. There are records from Tamil Nadu, Madagascar, and southern England.

Subgenus *Puzosia* (*Bhimaites*) Matsumoto, 1954

TYPE SPECIES: *Ammonites bhima* Stoliczka, 1865, p. 137, pl. 69, fig. 2, by the original designation of Matsumoto 1954, p. 113.

Puzosia (*Bhimaites*) *bhima* (Stoliczka, 1865)
(Pl. 10, Figs 8, 9; Pl. 12, Figs 14, 15; Text-fig. 16E)

1865. *Ammonites Bhima* Stoliczka, p. 137, pl. 69, figs 2, 3, ?non 1.
1898. *Puzosia bhima* Stol.; Kossmat, p. 184 (119).
2011. *Puzosia* (*Bhimaites*) *bhima* (Stoliczka, 1865); Klein and Vašíček, pp. 94, 95 (with synonymy).
2014. *Bhimaites bhima* (Stoliczka, 1865; Kennedy and Klinger p. 9, text-fig. 10.

TYPES: The lectotype, by the subsequent designation of Matsumoto (1988, p. 20) is the original of Stoliczka 1865, pl. 69, fig. 2, GSI 272, from the Upper Albian of Moraviatoor. Paralectotype GSI 271 is the original of Stoliczka 1865, pl. 69, fig. 1, and may belong to a different species (Matsumoto 1988, p. 21).

MATERIAL: OUM KY3205, from section M–N at the 221 m level, Middle Cenomanian, *asiaticum* Zone. OUM KY4404 from section I–J at the 20–21 m level, Middle Cenomanian, *cunningtoni* Zone.

DESCRIPTION: OUM KY3205 (Pl. 10, Figs 8, 9) has a maximum preserved diameter of 59 mm, and retains extensive areas of partially exfoliated shell material. It retains a 180° sector of body chamber. Coiling is involute, the umbilicus comprising 24% of the diameter, shallow, the umbilical wall feebly convex and outward-inclined. The umbilical shoulder is more narrowly rounded. The whorl section is compressed oval, the greatest breadth just outside the umbilical shoulder, with a whorl breadth to height ratio of 0.88. The surface of the exfoliated shell is smooth, but for constrictions, of which there are seven on half a whorl. They are weak on the umbilical wall, strengthening across the umbilical shoulder, very feely concave on the inner flank, straight on the outer flank, and very feebly convex on the venter.

OUM KY4404 (Pl. 12, Figs 14, 15), is a 180° sector of a juvenile with a maximum preserved diameter of 30 mm and five constrictions that become more closely spaced on the adapertural 60° sector.

DISCUSSION: As discussed by Kennedy and Klinger (2014, p. 9) *Puzosia pinguis* Crick, 1907 (p. 218) has been regarded as a synonym of the present species (Spath 1921, p. 274; Klein and Vašiček 2011, p. 95). They differ in that the constrictions of *pinguis* are markedly falcoid, and it develops ventral ribs in later growth and strong collar ribs (Kennedy and Klinger 2014, p. 10, text-figs 12–20). *Puzosia* (*Bhimaites*) *stoliczkai* Kossmat, 1898, described below, has a more compressed whorl section, the constrictions feebly falcoid, near-straight and prorsirsdiate across most of the flanks, and projected forwards and markedly concave on the ventrolateral shoulder.

OCCURRENCE: Middle Cenomanian of Tamil Nadu, Upper Albian of northern KwaZulu-Natal.

Puzosia (*Bhimaites*) *stoliczkai* Kossmat, 1898
(Pl. 5, Figs 12–18; Pl. 10, Figs 5–7, 10–14)

1865. *Ammonites Beaudanti* Brongniart; Stoliczka, p. 142, pl. 71, figs 1–4; pl. 72, figs 1, 2.
1868. *Ammonites Yama* Stoliczka, p. 35.
1898. *Puzosia stoliczkai* Kossmat, p. 184 (119), pl. 24 (18), fig. 6.
1988. *Bhimaites stoliczkai* (Kossmat, 1898); Matsumoto, p. 20.
2011. *Puzosia* (*Bhimaites*) *stoliczkai* Kossmat; Klein and Vašiček, pp. 94, 95 (with synonymy).
2014. *Bhimaites stoliczkai* (Kossmat, 1898); Kennedy and Klinger, p. 10, text-fig. 11a–c.

TYPE: The lectotype, by the subsequent designation of Kennedy and Klinger 2014, p. 10, is the original of Stoliczka 1865, pl. 71, fig. 3, from Odiyam.

MATERIAL: There are abundant limonitic nuclei from the shale facies of the section north of the Karai–Kulakkalnattam road. Larger individuals from the sandstone facies include OUM KY4576, from section T–U at the 52 m level, Upper Albian, *rostrata* Zone. OUM KY4363, from section C–D at the 79 m level, Lower Cenomanian, *mantelli* Zone. OUM KY3728–3730, from section C–D at the 116 m level, Lower Cenomanian, *mantelli* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY5982a	25.3 (100)	8.2 (32.4)	12.5 (49.4)	0.66	5.4 (21.3)
OUM KY5982b	27.6 (100)	10.0 (36.2)	14.3 (51.8)	0.7	6.0 (21.7)
OUM KY5982c	28.2 (1000	– (–)	14.1 (50.0)	–	5.5 (19.5)
OUM KY4576	48.5 (100)	14.7 (30.3)	23.8 (49.0)	0.62	10.4 (21.4)
OUM KY4363	59.2 (1000	19.2 (32.4)	28.9 (48.8)	0.66	14.0 (23.6)

DESCRIPTION: Two forms are recognized amongst the limonitic nucei from the shale facies, those lacking constrictions (Pl. 5, Figs 14–16), and those in which constrictions are present (Pl. 5, Figs 12, 13, 17, 18). Coiling is involute, the umbilicus comprising around 20% of the diameter, shallow, with a feebly convex wall and quite narrowly rounded umbilical shoulder. The whorl section is compressed, the whorl breadth to height ratio varying around 0.7, the greatest breadth just outside the umbilical shoulder, the inner flanks feebly convex, the outer flanks flattened and convergent, the ventrolateral shoulders broadly rounded, the venter very feebly convex. Internal moulds are smooth (Pl. 5, Figs 14–16).

The second group of nuclei, including OUM KY5512a-b, KY5102 (Pl. 5, Figs 12, 13), and KY5125 (Pl. 5, Figs 17, 18) have comparable proportions (when uncrushed), and develop weak constrictions that are straight and feebly prorsirsdiate on the inner flank, very feebly convex at mid-flank and concave on the outer flank, flexing forwards on the ventrolateral shoulder and crossing the venter in a linguoid peak.

OUM KY6011 is a larger fragment of phragmocone with a maximum preserved whorl height of 21 mm, and a whorl breadth to height ratio of 0.7. There are two well-developed constrictions on the fragment, deeply incised into the umbilical shoulder, straight and prorsiradiate on the inner and middle flank, flexing forwards, strengthening, and concave on the outer flank, then weakening on the ventrolateral shoulder and crossing the venter in a broad convexity. OUM KY4576 (Pl. 10, Figs 5–7) has a maximum preserved diameter of 48.5 mm and is an internal mould retaining a short section of body chamber. Coiling is involute, the small shallow umbilicus comprising 21.4% of the diameter, the umbilical wall feebly convex, the umbilical shoulder broadly rounded. The whorl section is compressed, with a whorl breadth to height ratio of 0.62, the flanks feebly convex, subparallel, the outer flanks converging to broadly rounded ventrolateral shoulders and a feebly convex venter. The surface of the mould is smooth, but for feeble constrictions on the ventrolateral shoulders and venter, preceded by a blunt adapical collar rib; there are three in a 90° sector of the adapical part of the outer whorl. OUM KY4363 (Pl. 10, Figs 10, 11), a slightly corroded internal mould of a180° sector of phragmocone with a maximum preserved diameter of 59.2 mm shows no indication of constrictions.The largest specimen in the present collection, OUM KY3729 (Pl. 10, Figs 12, 13), is a 120° sector of phragmocone with a maximum preserved whorl height of 42.6 mm and a whorl breadth to height ratio of 0.67, the greatest breadth below mid-flank. Coiling is moderately involute, the umbilicus shallow, with a feebly convex, outward-inclined wall and broadly rounded umbilical shoulder. The flanks are very feebly convex, converging to broadly rounded ventrolateral shoulders, the venter very feebly convex. There are two well-preserved relatively broad constrictions on the internal mould, separated by an arc of 35°. They are straight on the inner flank, concave on the outer flank and ventrolateral shoulder, weakening markedly and very feebly convex across the venter. The corroded suture is puzosiine, deeply and intricately incised.

OCCURRENCE: Upper Albian and Lower Cenomanian where well-dated. The geographic distribution extends from Tamil Nadu to Madagascar, KwaZulu-Natal in South Africa, Iran, Sardinia, Venezuela, and, possibly, north-western Spain.

Puzosia (*Bhimaites*) *falx* sp. nov.
(Pl. 12, Figs 7–10)

DERIVATION OF NAME: *Falx* (Latin): sickle; pertaining to the form of the constrictions.

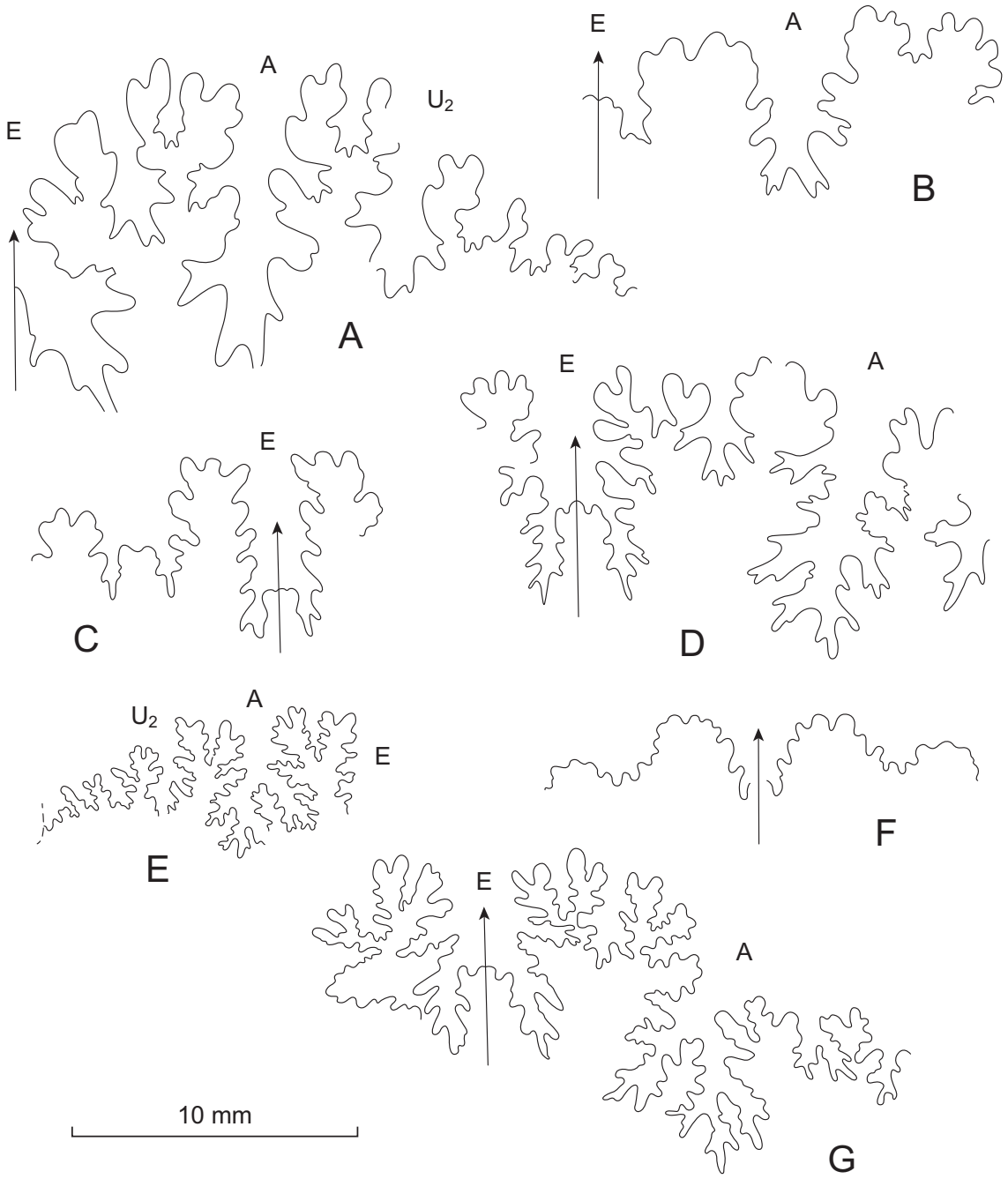
TYPE: The holotype is OUM KY3209, from section M–N at the 221 m level, Middle Cenomanian, *asiaticum* Zone.

DIAGNOSIS: A *Puzosia* (*Bhimaites*) with falcoid constrictions.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3209	45.2 (1000	18.6 (41.2)	21.7 (48.0)	0.86	11.4 (25.2)

DESCRIPTION: The holotype consists of a nucleus and a 200° sector of body chamber, the greatest pre-



Text-fig. 16. Suture lines: **A** – *Forbesiceras chevillei* (Pictet, 1847), OUM KY2719. **B** – *Stoliczkaia* (*Lamnayella*) *crotaloides* (Stoliczka, 1864), VP 50b. **C** – *Euomphaloceras euomphalum* (Sharpe, 1855), OUM KY3660. **D** – *Acompsoceras renevieri* (Sharpe, 1857), OUM KY3660. **E** – *Puzosia* (*Bhimaites*) *bhima* (Stoliczka, 1865), OUM KY3775. **F** – *Vascoceras diartianum* (d'Orbigny, 1850), OUM KY2918. **G** – *Hypoturrilites wiedmanni* Collignon, 1964, OUM KY3804

served diameter 45.2 mm. Coiling is moderately involute, the shallow umbilicus comprising 25.2% of the diameter, the umbilical wall flattened and outward-inclined, the ventrolateral shoulder broadly rounded. The whorl section is slightly compressed, with a whorl breadth to height ratio of 0.85, the flanks

feebly convex, converging to broadly rounded ventrolateral shoulders and a feebly convex venter. The specimen is an internal mould with traces of shell material; both lack ornament. Two constrictions are present on the internal mould of the outer whorl. They are falcoid, strongly prorsirsdiate on the inner flank, convex below mid-flank, markedly concave and strongly prorsirdiate on the outer flank. They project strongly forwards on the ventrolateral shoulders and venter and efface over the mid-ventral region.

DISCUSSION: The course of the constrictions distinguishes *falx* from all other *Bhimaites*.

OCCURRENCE: As for type.

Genus *Mesopuzosia* Matsumoto, 1954

TYPE SPECIES: *Mesopuzosia pacifica* Matsumoto, 1954, p. 82, pl. 14, fig. 1; pl. 15, figs 1, 2; pl. 16, figs 1–3; text-fig. 2, by the original designation of Matsumoto 1954, p. 79.

Mesopuzosia sp.
(Pl. 9, Figs 12, 13)

MATERIAL: OUM KY3572, from section R–S at the 65 m level, Upper Cenomanian, *hourcqi–latelobatum* fauna.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3572	58.1 (100)	– (–)	26.9 (46.3)	–	16.6 (28.6)

DESCRIPTION: The specimen is an internal mould of a phragmocone with a maximum preserved diameter of 58.1 mm. Coiling is moderately evolute, the shallow umbilicus comprising 28.6% of the diameter, with a feebly convex wall and quite narrowly rounded umbilical shoulder, the whorl section compressed with feebly convex convergent flanks, broadly rounded ventrolateral shoulders and a feebly convex venter. The whorl breadth to height ratio is 0.71, the greatest breadth well below mid-flank. They are five broad, shallow constrictions on the fragment. They are straight and feebly prorsiradiate, flexing slightly forwards and very feebly concave on outer flanks and ventrolateral shoulders, and cross the venter in a broad convexity. On the adapical part of the fragment, successive constrictions are separated by four ribs. They arise at the umbilical seam, and follow the course of the constrictions, strengthening on the ventrolateral shoulders and venter. The ribs between the succeeding constrictions are variable; some are collar ribs, others long or short, all strengthening over the ventrolateral shoulders and venter.

DISCUSSSION: The presence of strong primary ribs arising at the umbilical shoulder separate this fragment from all other Puzosiinae in the present collection. This style of ornament corresponds to that of the early whorls of *Mesopuzosia* illustrated in Matsumoto (1988), although none is a precise match.

OCCURRENCE: As for material.

Family Desmoceratidae Zittel, 1895
Subfamily Desmoceratinae Zittel, 1895
Genus and Subgenus *Desmoceras* Zittel, 1884

TYPE SPECIES: *Ammonites latidorsatus* Michelin, 1838, p. 101, pl. 12, fig. 9, by the subsequent designation of Böhm 1895, p. 364.

Desmoceras (*Desmoceras*) *latidorsatum* (Michelin, 1838)
(Pl. 4, Figs 19–25; Pl. 11, Figs 7–14)

1838. *Ammonites latidorsatus* Michelin, p.101, pl. 12, fig. 9.
2011. *Desmoceras* (*Desmoceras*) *latidorsatum* (Michelin, 1838); Klein and Vašíček, pp. 141, 144 (with full synonymy).
2013a. *Desmoceras* (*Desmoceras*) *latidorsatum* (Michelin, 1838); Kennedy and Klinger, p. 40, text-figs 1–5.
2014. *Desmoceras* (*Desmoceras*) *latidorsatum* (Michelin, 1838); Kennedy and Fatmi, p. 58, text-fig. 11a–h.
2017. *Desmoceras* (*Desmoceras*) *latidorsatum* (Michelin); Agirrezabala and Lopez-Horgue, p. 42, text-fig. 5e.
2018. *Desmoceras* (*Desmoceras*) *latidorsatum* (Michelin, 1838); Kennedy and Morris, p. 90, figs 5a–f, j–l, h–o, 6d.

TYPE: The holotype by monotypy, and now lost, is the original of Michelin 1838, p. 101, pl. 12, fig. 9, from the Albian Gault Clay of Aube, France. The neotype (Joly in Gauthier 2006, p. 97, pl. 33, fig. 1) is MNHN F. B846095, *ex* d'Orbigny Collection 5773-B1. It is from the condensed Albian of Escragnolles, Var, France.

MATERIAL: From section A–B, OUM KY2507, lower interval, 17 m; KY2510, upper interval, 0 m;

KY2545, 2546, 0–2 m; KY2549, 21 m; KY2556–2559, 56 m, all from the upper interval, all Upper Albian, *rostrata* Zone. From section G–H: OUM KY2651, 168 m. level; KY2685, 170–175 m; KY2701, 172–175 m; KY2744–2747, 168–173 m; KY2787, KY2788, 173–181 m; KY2810, 2811, 195–196 m; KY2817, 205 m; KY2582–2584, 210–212 m level; all Middle Cenomanian, *asiaticum* Zone From section I–J, OUM KY3024–3026, from the 20–21 m level, Middle Cenomanian, *cunningtoni* Zone. From section M–N, at the 214–216 m level, OUM KY3158–3160, KY4539, Middle Cenomanian, *asiaticum* Zone. From section O–P, OUM KY3317, 252 m level, Upper Cenomanian, *harpax* Zone; OUM KY3354, 261 m level, Upper Cenomanian, *septemseriatum* Zone. From section R–S, 8 m level, OUM KY3441, KY3442, Upper Cenomanian, *harpax* Zone. From section C–D, OUM KY3666, Lower Cenomanian, *mantelli* Zone. From section A, 9–10 m level, OUM KY4106 (collective of 7 specimens), KY4114, 16–18 m level; KY3966–3974, a series of collectives, in total 269 specimens, all Middle Cenomanian, *asiaticum* Zone. From section B, 10–20 m level, OUM KY4136 (collective of 22 specimens), KY4137, Middle Cenomanian, *asiaticum* Zone. From the Karai–Kulakkalnattam section: OUM KY4904, 58.5–63 m level; KY5184 (collective of five specimens, 175–180 m; KY5246, KY5247, 190 m; OUM KY5301, 225 m; OUM KY5354, KY5355, 256–260.5 m level, all Upper Albian, *rostrata* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3974a	23.3 (100)	11.8 (50.6)	12.7 (54.5)	0.93	3.5 (15.0)
OUM KY3974b	25.2 (100)	13.6 (54.0)	13.4 (53.2)	1.0	4.1 (16.3)
OUM KY3974c	26.5 (100)	– (–)	14.5 (54.7)	–	4.2 (15.8)
OUM KY2787 at	46.7 (100)	23.9 (51.2)	23.0 (49.3)	1.0	9.4 (20.1)
OUM KY2985	55.9 (100)	32.7 (58.4)	26.9 (48.1)	1.21	11.9 (21.2)
OUM KY3026	61.7 (100)	33.0 (53.5)	30.9 (50.1)	1.1	15.0 (24.3)
OUM KY2651	69.0 (100)	32.0 (46.4)	32.2 (46.7)	1.0	16.8 (43.3)

DESCRIPTION: Limonitic nuclei (Pl. 4, Figs 19–25) are very involute, the umbilicus comprising around 15% of the diameter, with a feebly convex wall and broadly rounded umbilical shoulder. The whorl section varies from as wide as high to slightly compressed, the flanks flattened and subparallel, the ventrolateral shoulders broadly rounded, the venter very feebly convex. Most specimens lack constrictions around diameters of up to 25 mm. Where present, they are prorsiradiate, very feebly sinuous across the flanks, sweeping forwards across the ventrolateral shoulders, and crossing the venter in a shallow convexity.

OUM KY2744 (Pl. 11, Figs 12–14) is the largest individual from the sandstone facies, an internal mould with a 180° sector of body chamber preserved. Coiling is very involute, the umbilicus deep, the umbilical wall convex, the umbilical shoulder broadly rounded. The whorl section is depressed reniform, the whorl breadth to height ratio 1.1. The flanks are feebly convex, the ventrolateral shoulders broadly rounded, the venter feebly convex. The surface of the mould is smooth, but for narrow, widely spaced constrictions, of which three are well-preserved on the body chamber. They are concave on the umbilical wall, near-straight and prorsirsdiate on the innermost flanks, feebly convex to mid-flank, flexing forwards and markedly concave on the outer flank, then sweeping forwards and crossing the venter in a broad convexity.

OUM KY2651 (Pl. 11, Figs 10, 11) is an internal mould of a less depressed individual 69 mm in diameter that retains a short sector of body chamber with a whorl breadth to height ratio of 1.0. Coiling is involute, the umbilicus of moderate depth, with a convex wall and broadly rounded umbilical shoulder. The flanks are feebly convex and subparallel, the outer flanks converging to broadly rounded ventrolateral shoulders and a broad, feebly convex venter. There are five weak constrictions per half whorl, feebly concave across the umbilical wall, straight and prorsiradiate across the inner flanks, then feebly convex before flexing strongly forwards across the outer flanks and ventrolateral shoulders, and crossing the venter in a broad convexity. There is a well-developed adapical collar rib on ventrolateral shoulders and venter.

The suture is deeply incised, with narrow-stemmed bifid saddles.

DISCUSSION: See Kennedy and Klinger 2013a, p. 40.

OCCURRENCE: Middle Albian to Upper Cenomanian, southern England, southern France, Italy, northern Spain, southern Germany, Switzerland, Hungary, Romania, Serbia, Poland, Sardinia, Ukraine, northern Algeria, Central Tunisia, Egypt, Nigeria, Angola, KwaZulu-Natal South Africa, Mozambique, Madagascar, Tamil Nadu, Pakistan, Japan New Zealand, Mexico and Venezuela.

Desmoceras (*Desmoceras*) *inane* (Stoliczka, 1865)
(Pl. 11, Figs 1–6)

1865. *Ammonites inanis* Stoliczka, p. 121, pl. 59, fig. 13, *non* 14 (= *D.* (*D.*) *latidorsatum*).
1898. *Desmoceras inane* Stoliczka; Kossmat, p. 172 (107), pl. 25 (19) figs 6, 7.
2011. *Desmoceras* (*Desmoceras*) *inane* (Stoliczka, 1865); Klein and Vašíček, pp. 141, 143 (with full synonymy).

TYPE: The lectotype, by the subsequent designation of Kossmat (1898, p. 173 (108)) ('als neuer Typus...') is the original of Stoliczka 1865, pl. 59, fig. 13, from Odiyam.

MATERIAL: OUM KY2810, from section G–H, at the 195–196 m level, Middle Cenomanian, *asiaticum* Zone. OUM KY3546, 3547, from section R–S at the 65 m level, Upper Cenomanian, *hourcqi–latelobatum* fauna.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2810	53.4 (100)	22.0 (41.2)	28.4 (53.2)	0.77	7.5 (14.0)

DESCRIPTION: OUM KY3547 (Pl. 11, Figs 1, 2) is a beautifully preserved juvenile retaining nacreous aragonitic shell material. The maximum preserved diameter is 18 mm. Coiling is very involute, the tiny, deep umbilicus comprising 16.7% of the diameter. The whorl section is slightly depressed, the whorl breadth to height ratio 1.15, the flanks flattened and subparallel, the ventrolateral shoulders broadly rounded, the venter feebly convex. The surface of the shell is covered in growth lines, concave across the umbilical shoulder, prorsiradiate on the flanks, feebly concave on the ventrolateral shoulders and projected forwards on the venter in an elongated ventral peak. There are slight indications of constrictions that parallel the growth lines. OUM KY2810 (Pl. 11, Figs 3–5) retains extensive areas of recrystallized shell, and a 240° sector of body chamber, the umbilical diameter increasing markedly over the adapertural 90° sector of the outer whorl, suggesting the specimen to be an adult. Coiling is very involute on the phragmocone and adapical part of the body chamber, the umbilicus comprising 14% of the diameter, with a convex wall and narrowly rounded umbilical shoulder. The whorl section is compressed, the whorl breadth to height ratio 0.77, the flanks flattened and subparallel, the ventrolateral shoulders broadly rounded, the venter more narrowly rounded. There is no ornament preserved.

DISCUSSION: *Desmoceras* (*D.*) *inane*, so far as is known, is a diminutive species. It differs from *D.* (*D.*) *latidorsatum* in being more involute, the whorl section compressed, the growth lines, collar ribs and constrictions forming a much narrower peak on the venter.

OCCURRENCE: Upper Albian to Upper Cenomanian. southern England (?), southeastern France, KwaZulu-Natal in South Africa, Tamil Nadu, and California.

Subgenus *Desmoceras* (*Pseudouhligella*)
Matsumoto, 1938

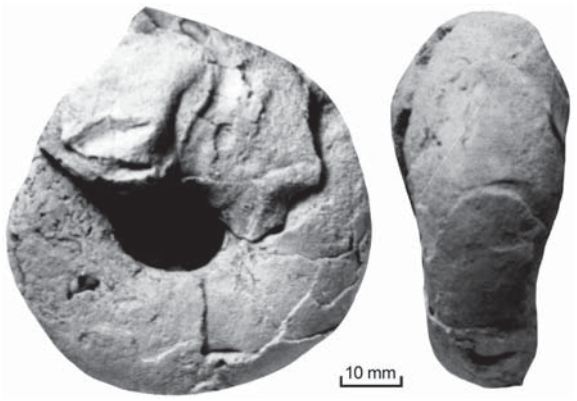
TYPE SPECIES: *Desmoceras dawsoni* var. *japonica* Yabe, 1904, p. 35, pl. 5, fig. 3, by the original designation of Matsumoto 1938, p. 22.

Desmoceras (*Pseudouhligella*) *mahabobokensis*
Collignon, 1961
(Text-fig 17)

1961. *Desmoceras* (*Pseudouhligella*) *mahabobokensis* Collignon, p. 60, pl. 24, figs 2, 3.
1964. *Desmoceras* (*Pseudouhligella*) *mahabobokensis* Collignon; Collignon, p. 56, pl. 332, fig. 1497.
2011. *Desmoceras* (*Pseudouhligella*) *mahabobokensis* Collignon, 1964; Klein and Vašíček, pp. 151, 155.

MATERIAL: OUM KY3666, from section C–D at the 79 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: The specimen is a crushed individual, deformed into an ellipse, with a major diameter of 60 mm, and retaining a 240° sector of body chamber. Coiling is involute, the umbilicus deep, with a convex wall and broadly rounded umbilical shoulder, The whorl section appears to have been slightly compressed oval, with feebly convex flanks, broadly rounded ventrolateral shoulders and a feebly convex venter. The inner whorls are poorly preserved. The surface of the internal mould is smooth, but for constrictions and associated collar ribs, conspicuous on the adapertural 120° sector of the outer whorl, where four are present. The constrictions are straight and feebly prorsirsdiate on the innermost flank, then very feebly convex before sweeping forwards in a marked concavity on the outer flank and ventrolateral shoulder, and crossing the venter in a linguoid peak. There is a well-developed adapical collar rib, best developed on ventrolateral shoulders and venter.



Text-fig. 17. *Desmoceras* (*Pseudouhligella*) *mahabobokensis* Collignon, 1961. OUM KY3666, from the Karai Formation, Lower Cenomanian *mantelli* Zone, section C–D between Odiyam and Kunnam at the 79 m level

The partially exposed, corroded suture appears to have been little-incised, with narrow-stemmed bifid saddles E/A and A/U2.

DISCUSSION: The specimen is assigned to *D.* (*P.*) *mahabobokensis* on the basis of the course of the constrictions, plus the absence of (juvenile) ornament. See Collignon (1961, p. 60) for an account of differences from other members of the subgenus.

OCCURRENCE: Lower Cenomanian of Madagascar and Tamil Nadu.

Family Kossmaticeratinae Spath, 1922b
Subfamily Marshallitinae Matsumoto, 1955
Genus *Holcodiscoides* Spath, 1922b

TYPE SPECIES: *Ammonites cliveanus* Stoliczka, 1865, p. 157, pl. 77, fig. 3, by the original designation of Spath 1922b, p. 124.

Holcodiscoides cf. *cliveanus* (Stoliczka, 1866)
(Pl. 12, Figs 11, 12)

Compare:

1865. *Ammonites Cliveanus* Stoliczka, p. 157, pl. 77, fig. 3.
1898. *Holcodiscus Cliveanus* Stoliczka; Kossmat, p. 34 (141).
1922b. *Holcodiscoides cliveanus* Stoliczka; Spath, p. 124.
1925. *Holcodiscoides cliveanus* Stoliczka; Diener, p. 124.
1991. *Holcodiscoides cliveanus* (Stoliczka, 1866); Matsumoto, pp. 54, 69, 85.

TYPE: Stoliczka (1865, p. 157) mentioned specimens from both Moraviatoor and north of Odiyam; the original of his pl. 77, fig. 3, from Moraviatoor, is designated lectotype herein.

MATERIAL: OUM KY2495, from section A–B, lower interval, 10 m level, Upper Albian, *rostrata* Zone.

DESCRIPTION: The specimen is a 120° fragment of body chamber with a maximum preserved whorl height of 17 mm. The whorl section has been deformed by compaction, but the flanks were feebly convex, the ventrolateral shoulders broadly rounded, and the broad venter feebly convex. Ornament is of delicate wiry ribs that arise at the umbilical seam and bi- or trifurcate on the umbilical shoulder, are straight and prorsiradiate on the flanks, flex forwards across the ventrolateral shoulders and cross the venter in a very shallow convexity. There are two deep and broad constrictions on the fragment that widen across the ventrolateral shoulders and venter.

DISCUSSION: The whorl section, ribbing and form of the constrictions matches that of the lectotype; the qualified identification reflects the fragmentary nature of the material.

OCCURRENCE: As for material.

Holcodiscoides sp.
(Pl. 12, fig. 4)

MATERIAL: OUM KY4356, from, section A–B, upper interval, at the 9.5–10 m level, Upper Albian, *rostrata* Zone.

DESCRIPTION: The specimen has a maximum preserved diameter of 26 mm, and retains replaced shell material. Coiling is evolute, the broad umbilicus of moderate depth, the umbilical shoulder broadly rounded, the whorl section rounded. There are two successive modes of ornament. On the adapical half of the outer whorl, well-developed umbilical bullae give rise to groups of three wiry ribs. They are straight and prorsiradiate on the inner to middle flank, flex forwards and are feebly concave across the ventrolateral shoulder and cross the venter in a very shallow convexity. A marked constriction separates this finely ornamented phase from a coarser-ornamented one, where the umbilical bullae are relatively weaker and the ribs stronger. They arise singly or in pairs and are straight and prorsiradiate across the flanks. Some

link, either singly or in pairs, at variably developed subspinose to bullate ventrolateral tubercles that may be linked across the venter by a pair of ribs.

DISCUSSION: The presence of ventrolateral tubercles separates this specimen from those referred to *Protokossmaticeras* below. Of described species, the specimen most closely resembles *Holcodiscoides aquarius* Matsumoto and Takahashi, 1991 (in Matsumoto 1991, p. 66, pl. 14, figs 1–4), from which it differs in the more evolute coiling and lower expansion rate.

OCCURRENCE: As for material.

Holcodiscoides sp. juv.
(Pl. 4, Figs 1–7)

MATERIAL: Limonitic nuclei from the section north of the Karai–Kulakkalnattam road, including OUM KY5518, from the 345–350 m level, Upper Albian; OUM KY5386–5388, from the 274–278.5 m level, Upper Albian; OUM KY5594, from the 350–355 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: These nuclei are deformed into ellipses with maximum diameters of up to 16 mm. Coiling is evolute, the umbilicus of moderate depth, comprising an estimated 40% of the diameter, the umbilical wall convex, the umbilical shoulder broadly rounded. The whorl section is depressed reniform, the expansion rate low. Crowded wiry primary ribs arise at the umbilical shoulder singly or in pairs, and additional ribs intercalate. The ribs are prorsiradiate on the inner flank, flexing back and feebly convex at mid-flank, straight on the outer flank, and straight and transverse across the venter. Constrictions are few, and widely separated.

DISCUSSION: The low expansion rate, coarse wiry ribs, and lack of clearly differentiated umbilical bullae separate these individuals from other juvenile kossmaticeratids in the present faunas. They most closely resemble juveniles of *Holcodiscoides* species described by Matsumoto and Takahashi in Matsumoto 1991 (pl. 14, figs 2–8) and are assigned to the genus on this basis.

Genus *Eogunnarites* Wright and Matsumoto, 1954

TYPE SPECIES: *Olcostephanus unicus* Yabe, 1904, p. 28, pl. 6, fig. 5, by the original designation of Wright and Matsumoto 1954, p. 125.

Eogunnarites? *elegans* sp. nov.
(Pl. 12, Figs 16–21)

DERIVATION OF NAME: *elegans* (Latin) select.

TYPE: The holotype is OUM KY3421, from section O–P, at the 285–286 m level, upper Upper Cenomanian,

DIAGNOSIS: Nucleus with five constrictions and associated collar ribs per whorl, separated by crowded, fine, flexuous ribs that bi- or trifurcate on the outer flank, with additional ribs intercalating, the ribs crossing the venter in a broad convexity. Adult body chamber with strong primary and intercalated ribs that efface over the venter.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3421 at	43.9 (100)	19.8 (45.1)	17.2 (39.2)	1.15	13.3 (30.3)

DESCRIPTION: The specimen consists of a nucleus retaining recrystallized shell and a 90° sector of the penultimate and outer whorls. Coiling is moderately involute, the shallow umbilicus comprising 30.3% of the diameter, the umbilical wall flattened and outward-inclined, the umbilical shoulder broadly rounded, the whorl section slightly depressed reniform, with a whorl breadth to height ratio of 1.15, the flanks feebly convex, the ventrolateral shoulders broadly rounded, the venter feebly convex. There are five well-developed constrictions on the outer whorl of the nucleus at a diameter of 43.9 mm. They are relatively broad, straight and rectiradiate on the flanks, feebly convex over the venter, and are either preceded or succeeded by a strong collar rib. The surface of the replaced shell between successive constrictions is ornamented by up to five very fine ribs that are straight and feebly prorsiradiate on the inner flank, flexing back and feebly convex at mid-flank, then flexing forward and feebly concave on the outer flank, where they bi- or trifurcate, additional ribs intercalate, the ribs crossing the venter in a broad convexity. The body chamber fragment also retains recrystallized shell. The maximum preserved whorl height is 43 mm, the whorl breadth to height ratio 1.0. There are three coarse, straight to feebly prorsiradiate primary ribs on the fragment, together with one long and one short intercalated rib, the ribs effacing over the venter.

DISCUSSION: The combination of finely ribbed inner whorls, and coarsely and widely ribbed outer

whorl correspond to the ontogenetc changes seen in *Eogunnarites*, but none of the described species (see Matsumoto 1991) reach the size of the present species, and none are as sparsicostate at maturity.

OCCURRENCE: As for material.

Genus *Protokossmaticeras* Collignon, 1964

TYPE SPECIES: *Protokossmaticeras madagascariense* Collignon, 1964, p. 19, pl. 321, figs 1407, 1408, by the original designation of Collignon 1964, p. 19.

Protokossmaticeras sp.
(Pl. 12, Figs 1–3, 5, 6)

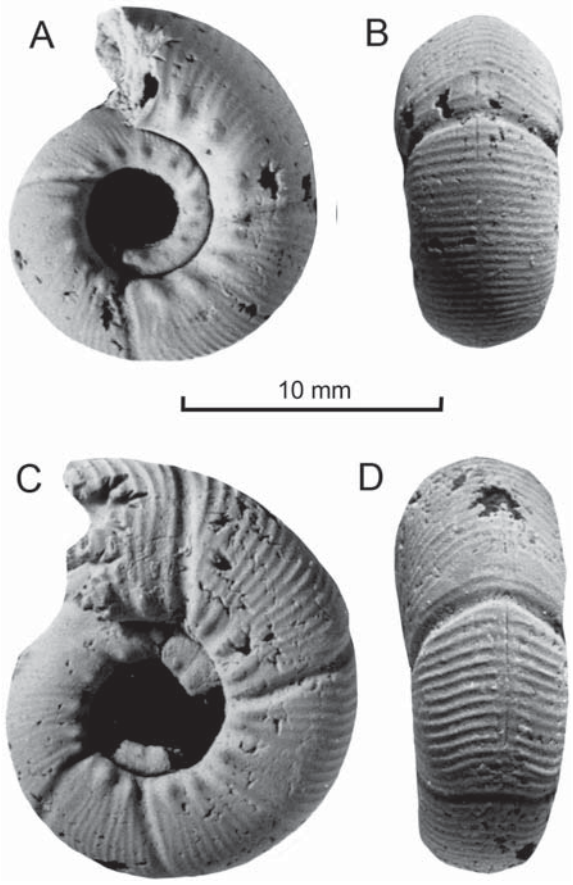
MATERIAL: OUM KY2509, from the 0 m level; KY2523–2525 from the 0–2 m level of section A–B, upper interval, Upper Albian, *rostrata* Zone.

DESCRIPTION: The material comprises poorly preserved fragments and more complete individuals up to 33 mm in diameter. Coiling is moderately involute, the whorl section depressed reniform. At a diameter of 13 mm, the penultimate whorl of OUM KY2523 (Pl. 12, Figs 5, 6) bears minute umbilical bullae that give rise to groups of three delicate riblets. The bullae are absent on the outer whorl fragment, with much stronger ribs arising singly on the umbilical wall, with additional ribs intercalating, the ribs straight and prorsiradiate on the flanks, and crossing the venter in a very feeble convexity. There is a single constriction. In OUM KY2525 (Pl. 12, Fig. 1) there is a similar abrupt change from fine to coarser ribbing, here at a diameter of 21 mm. This specimen has three constrictions per half whorl. OUM KY2524 (Pl. 12, Figs 5, 6) is a well preserved body chamber fragment of the coarser-ribbed stage.

DISCUSSION: The style of ornament of OUM KY2525 (Pl. 12, Fig. 1) is that of the tiny Madagascan specimens of *Protokossmaticeras madagascariense* Collignon, 1964 (Text-fig. 18); that of OUM KY2524 resembles that of *Protokossmaticeras yezoense* Matsumoto and Takahashi, 1991 (in Matsumoto 1991, p. 64, pl. 13, fig. 10), hence the generic assignation.

OCCURRENCE: As for material.

Protokossmaticeras sp. juv.
(Pl. 4, Figs 11–16)



Text-fig. 18. *Protokossmaticeras madagascariensis* Collignon, 1964. **A**, **B** – the holotype, the original of Collignon 1964, pl. 321, fig. 1407. **C**, **D** – the original of Collignon 1964, pl. 321, fig. 1408. Both specimens are from the Lower Cenomanian of Collignon's gisement 478, Beraketa sur Sakondry (Manera), Madagascar. The originals are in the Collignon Collection, housed in the Université de Bourgogne, Dijon

MATERIAL: OUM KY5159–5162, from the section north of the Karai–Kulakkalnattam road at the 170–175 m level; OUM KY5182, 5183, from the 175–180 m level; all upper Upper Albian.

DESCRIPTION: These tiny limonitic nuclei range from 12.5 to an estimated 22 mm in diameter. Coiling is moderately evolute, the umbilicus comprising 37% approximately of the diameter, shallow, with a feebly convex wall and broadly rounded umbilical shoulder. The whorl section is subcircular, depressed, with a whorl breadth to height ratio of 1.1. Ornament is best-preserved in OUM KY5182 (Pl. 4,

Figs 13, 14). At the beginning of the outer whorl, well-developed bullae perch on the umbilical shoulder, and give rise to groups of three delicate prorsiradiate ribs that weaken and efface across the ventrolateral shoulders, the venter apparently smooth. Ribbing coarsens markedly as size increases. There are three strong, prorsiradiate constrictions per half whorl that cross the venter in a shallow convexity, and are flanked by a well-developed narrow adapertural collar rib.

DISCUSSION: The apparent loss of ornament on the venter separate these specimens both from the types of *Protokossmaticeras madagascariense* Collignon, 1964 (p. 19, pl. 321, figs 1407–1408; text-fig. 18), from the Lower Cenomanian of Madagascar, and *Protokossmaticeras moraviatoorense* (Stoliczka, 1866) (p. 158, pl. 77, fig. 4), from Tamil Nadu.

OCCURRENCE: As for material.

Genus *Marshallites* Matsumoto, 1955

TYPE SPECIES: *Marshallites compressus* Matsumoto, 1955, p. 123, pl. 8, figs 1, 2; text-figs 1, 2, by the original designation of Matsumoto 1955, p. 119.

Marshallites papillatus (Stoliczka, 1866)
(Pl. 12, Fig. 13)

1865. *Ammonites papillatus* Stoliczka, p. 159, pl. 77, figs 7, 8.
1898. *Holcodiscus papillatus* Stoliczka; Kossmat, p. 35 (142).
1922b. *Holcodiscus papillatus*; Spath, p. 124.
1925. *Holcodiscoides papillatus* Stoliczka; Diener, p. 111.
1991. *Marshallites papillatus* (Stoliczka, 1866); Matsumoto, p. 126.

TYPES: Stoliczka (1865) illustrated two specimens (pl. 77, figs 7, 8) from Moraviatoor, and declared the species to be 'not very rare' (p. 160). The original of his pl. 77, fig. 8 is designated lectotype herein.

MATERIAL: OUM KY4563, from section T–U at the 10 m level, Upper Albian, *rostrata* Zone.

DESCRIPTION: The specimen is an incomplete external mould of one flank of an individual with an original diameter estimated as over 43 mm. Coiling is evolute, the umbilicus shallow, with a convex wall and broadly rounded umbilical shoulder. The flanks are flattened and subparallel, the ventrolateral shoulders broadly rounded. On the adapical half of the outer whorl, crowded ribs arise on the umbilical wall and strengthen into narrow bullae, perched on the umbilical shoulder. These give rise to groups of two or three delicate prorsiradiate wiry ribs, with additional ribs intercalating to produce a dense flank ornament. There is a single well-differentiated constriction. On the adapertural 60° sector of flank, there are no clearly differentiated umbilical bullae. Instead, ribs arise either singly or in pairs on the umbilical shoulder, with additional ribs intercalating. The ribs are prorsiradiate with a slightly irregular course. There are two constrictions that parallel the ribs; they are narrow on the innermost flank, broadening on the outer.

What may be juveniles of the species, referred to here as *Marshallites* cf. *papillatus*, are OUM KY5007 (Pl. 4, Figs 8, 9), from the 103.5–108 m level, and OUM KY5049 (Pl. 4, Fig. 10), from the 110 m level of the section north of the Karai–Kulakkalnattam road, both Upper Albian. The former is 10.6 mm in diameter, the latter 16 mm in diameter. Ornament consists of delicate ribs, prorsiradiate and very feebly flexuous, that arise at the umbilical shoulder in pairs without developing a clearly differentiated bulla, and intercalate. There are periodic constrictions, but poor preservation precludes determining their number. They cross the venter in a shallow convexity.

DISCUSSION: OUM KY4563 differs in no significant respects from the lectotype. A comprehensive account of *Marshallites* is provided in Matsumoto (1991). The closest species described there is *Marshallites miyakoensis* Obata and Futakami, 1991 (in Matsumoto 1991, p. 124, pl. 31, figs 1–5) from the Lower Albian of Hokkaido, Japan; its authors separated it from *papillatus* on the basis of the less flexuous ribs, less compressed whorl section, and simple prorsiradiate constrictions of the latter.

OCCURRENCE: Upper Upper Albian, *rostrata* Zone where well-dated, Tamil Nadu.

Family Brancoceratidae Spath, 1934
Subfamily Mortoniceratinae H. Douvillé, 1912
Genus and Subgenus *Pervinquieria* Böhm, 1910

TYPE SPECIES: *Ammonites inflatus* J. Sowerby, 1817, p. 170, pl. 178, by the original designation of Böhm 1910, p. 152.

DISCUSSION: *Pervinquieria* is treated as a separate genus here, rather than as a synonym of *Mortoniceras* Meek, 1876; in the type species of the latter, there are strong inner and feeble outer ventrolateral clavi in the earliest growth stage of the type species, beyond which the outer ventrolateral effaces and a lateral row appears, the ribs trituberculate thereafter, while spiral ridges are not developed.

Pervinquieria (*Pervinquieria*) *stoliczkai* Spath, 1921
(Pl. 14, Figs 4, 5; Pl. 15)

1865. *Ammonites inflatus* Sowerby 1st variety; Stoliczka, p. 48, pl. 27, pl. 29, fig. 2.
1921. *Subschloenbachia stoliczkai* Spath, p. 284.
1979. *Pervinquieria* (*Pervinquieria*) *stoliczkai* (Spath, 1921); Scholz, p. 106, pl. 22, figs 7, 8?, 9?, 10?; pl. 23, fig. 1; pl. 24, figs 1, 2 (with full synonymy).
2018. *Mortoniceras* (*Mortoniceras*) *stoliczkai* (Spath, 1921): Klein, pp. 102,125 (with additional synonymy).

TYPES: Spath introduced *Subschloenbachia stoliczkai* as a *nomen novum* for the originals of *Ammonites inflatus* Sowerby var. 1 of Stoliczka 1863, pl. 29, fig. 2, a cross section of a 'a small specimen from near Odiyam', which is the holotype by monotypy.

MATERIAL: OUM KY2501–2502, from section A–B, lower interval, at the 17 m level. OUM KY2518, 2519 and KY2578, from section A–B, upper interval, at the 0–2 m level. OUM KY5023, from the section on the north side of the Karai–Kulakkalnattam road at the 110 m level, Upper Albian, *rostrata* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2518 at ic	140.0 (100)	50.2 (35.9)	51.0 (36.4)	0.98	55.8 (39.9)
OUM KY2518 at c	140 (100)	57.8 (41.3)	51.0 (36.4)	1.13	55.8 (39.9)

DESCRIPTION: OUM KY2518 (Pl. 15) is an internal mould of an adult 190 mm in diameter, retaining a 180° sector of body chamber. Coiling is very evolute, the wide, shallow umbilicus comprising 39.9% of the diameter, the umbilical wall feebly convex on the phragmocone, becoming concave on the body chamber, the umbilical shoulder broadly rounded. The intercostal whorl section is barely compressed, with a whorl breadth to height ratio of 0.98, the flanks feebly convex, the ventrolateral shoulders broadly rounded, the venter flattened, with a strong siphonal keel. The costal whorl section is depressed polygonal, with the greatest breadth at the umbilical bullae. The costal whorl breadth to height ratio is 1.13. Twelve primary ribs arise at the umbilical seam of the adapertural 180° sector of the penultimate whorl, and strengthen into small umbilical bullae. These give rise to pairs of ribs to give a total of 20 at the ventrolateral shoulder. All ribs bear small outer lateral bullae, and rounded ventrolateral tubercles. Ornament of this type extends onto the adapical part of the outer whorl, coarsening progressively, the ventrolateral tubercles giving rise to low, broad, feebly prorsiradiate ribs. The pattern changes on the adapertural 240° sector of the outer whorl: the adapertural part of the phragmocone and the body chamber. There are 10 very widely separated coarse, prorsiradiate ribs to the half whorl, with well-developed umbilical bullae, coarse outer lateral bullae, and pinched ventrolateral clavi that rise above the level of the keel on the internal mould. OUM KY2501 (Pl. 14, Fig. 5) is also an internal mould, the 180° sector of body chamber present badly worn but for four strong, narrow, widely separated prorsiradiate primary ribs with well-developed umbilical and outer lateral bullae, together with a massive ventrolateral tubercle. There are 14 primary ribs on the adapical half whorl of the phragmocone at a diameter of 137 mm. They arise at the umbilical seam, strengthen across the umbilical wall and shoulder, where they develop into narrow umbilical bullae. These give rise either to a single rib or a pair of ribs, with additional ribs intercalating, to give a total of 22 ribs at the ventrolateral shoulder. The ribs are straight and prorsiradiate, strengthening across the flanks. All bear small outer lateral bullae, linked by a strengthening rib to a blunt, coarse, club-like ventrolateral rib, differentiated into a blunt ventrolateral tubercle. OUM KY2519 (Pl. 14, Fig. 4) is a well-preserved internal mould of a phragmocone with a maximum preserved diameter of 98.6 mm. OUM KY5023 is a 60° whorl sector with a maximum preserved whorl height of 46 mm.

DISCUSSION: *Pervinquieria* (*Pervinquieria*) *stoliczkai* differs from *P.* (*P*). *orientale* (Kossmat, 1895) (p. 186 (90), pl. 23 (19), fig. 1 = *Ammonites inflatus* Sow. Var. III of Stoliczka 1865, p. 50, pl. 29, fig. 4), which has crowded flexuous ribs on the early whorls, and if Stoliczka's specimen is conspecific with that figured by Kossmat, does not develop the very widely spaced ribs on the body chamber of the present species. The presence of both inner and outer ventrolateral tubercles during part of the

ontogeny immediately separate the present species from *Pervinquieria* (*Subschloenbachia*) *rostrata* (J. Sowerby, 1817) described below.

OCCURRENCE: Upper Upper Albian, *rostrata* Zone of Tamil Nadu, also recorded from the upper Upper Albian of Madagascar,Hungary, Ukraine (Crimea), and Angola. There are deoubtful records from Spain and Japan.

Subgenus *Subschloenbachia* Spath, 1921
(= *Durnovarites* Spath, 1932, p. 380)

TYPE SPECIES: *Ammonites rostratus* J.Sowerby, 1816, p. 163, pl. 173, by the original designation of Spath 1921, p. 284.

Pervinquieria (*Subschloenbachia*) *rostrata* (J. Sowerby, 1817)
(Pl. 13; Pl. 14, Figs 1, 2)

1817. *Ammonites rostratus* J Sowerby, p. 163, pl. 173.
1898. *Schloenbachia inflata* Sow. Typische form; Kossmat, p. 190 (40) (*pars*), pl. 23 (19), fig. 2; pl. 24, fig. 1.
1976. *Mortoniceras* (*Mortoniceras*) *rostratum* (J. Sowerby, 1817); Marcinowski and Naidin, p. 109, pl. 5, fig. 9; pl. 9, fig. 2 (with synonymy).
1998. *Mortoniceras* (*Subschloenbachia*) *rostratum* (J. Sowerby, 1817). Kennedy *et al*., p. 17, text-figs 9–11, 13–18 (with additional synonymy).
2007. *Mortoniceras* (*Subschloenbachia*) *rostratum* (J. Sowerby, 1817). Kennedy and Latil, p. 463, pl. 3, fig. 2; pl. 3, figs 3, 6–9; pl. 4, figs 7, 8 (with additional synonymy).
2007. *Mortoniceras* (*Subschloenbachia*) *rostratum* (J. Sowerby). Tavares *et al*., pl. 3, fig. 3.
2010. *Mortoniceras* (*Mortoniceras*) *rostratum* (J. de C. Sowerby). Owen *et al*., p. 190, pl. 35, fig. 1.
2018. *Mortoniceras* (*Mortoniceras*) *rostratum* (J. Sowerby, 1817); Klein, pp. 101, 122 (with additional synonymy).

TYPE: The holotype, by monotypy, is OUM K 835, the original of *Ammonites rostratus* J Sowerby, 1817, p. 163, pl. 173, from the Upper Greensand of Roke, 1.5 km NNE of Benson, Oxfordshire, refigured by Kennedy *et al*. 1998, figs 9–11.

MATERIAL: OUM KY2499, from section A–B, lower interval, at the 13 m level. OUM KY4569, from section T–U at the, 33 m level. Both Upper Albian, *rostrata* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2499 at c	75.2		27.0		31.6
	(100)	– (–)	(35.9)		(42.0)
OUM KY2499 at	116.4	– (–)	39.4	(–)	50.7
	(100)	64.3	(33.8)	(–)	(43.6)
OUM KY2499 at c	160.0	(40.2)	51.0		73.0
	(100)		(31.9)		(45.6)

DESCRIPTION: OUM KY2499 (Pl. 13; Pl. 14, Figs 1, 2) is an adult over 200 mm in diameter. Coiling is very evolute, the umbilicus of moderate depth, comprising 42–45.6% of the diameter on the phragmocone, the umbilical wall notched to accommodate the ventrolateral tubercles of the preceding whorl. The umbilical wall is feebly convex, the umbilical shoulder broadly rounded. The intercostal whorl section is depressed rectangular-trapezoidal, the ventrolateral shoulders broadly rounded, the venter flattened, with a strong siphonal keel. At a diameter of 75 mm, 16 coarse ribs arise on the umbilical wall, and strengthen into strong bullae, perched on the umbilical shoulder. The bullae give rise to single ribs, or a pair of ribs, while additional ribs intercalate, to give a total of 26–27 ribs per whorl at the ventrolateral shoulder. The ribs are coarse, straight, recti- to feebly prorsiradiate, and all bear a feebly bullate outer lateral tubercle, linked by a strong rib to a conical inner ventrolateral tubercle, from which a strong rib sweeps slightly forwards to link to a feebly differentiated conical outer ventrolateral tubercle. A smooth zone separates this tubercle from the siphonal keel. Progressively strengthening ornament of this type extends to the end of the phragmocone at a diameter of 160 mm, where there are 19 ribs per whorl at the umbilical shoulder and 29 at the ventrolateral shoulder. A 240° sector of body chamber is preserved, with an incomplete apertural rostrum. The maximum preserved diameter, at the base of the rostrum, is 210 mm. There are eight very widely separated primary ribs on the body chamber. They are coarse and narrow, with poorly differentiated umbilical bullae, and better-developed outer lateral bullae that persist to the penultimate rib. There is a prominent strong, compressed ventrolateral tubercle with a flattened facet, the angulations marking the site of the no longer differentiated inner and outer ventrolateral tubercles.

OUM KY4569 is a fragment of adult body chamber.

DISCUSSION: OUM KY2499 is interpreted as a macroconch of the species; *Schloenbachia inflata* Sow. Typische form of Kossmat (1898, p. 190 ((40)

(*pars*), pl. 23 (19), fig. 2, pl. 24, fig. 1) is interpreted as a microconch, 140 mm in diameter at the base of the rostrum. See Kennedy, Cobban *et al*. (1998, p. 17) and Kennedy and Latil (2007, p. 463) for discussion.

OCCURRENCE: Upper Albian *rostrata* Zone and correlatives**,** southern England, France, Germany, Spain, Switzerland, Hungary, Crimea (Ukraine), Iran, Texas in the United States, Angola, and Tamil Nadu.

Pervinquieria (*Subschloenbachia*)
group of *perinflata* (Spath, 1922a)
(Pl. 14, Fig. 3)

MATERIAL: OUM KY3642, from section C–D at the 68 m level, Upper Albian, *perinflata* Zone.

DESCRIPTION: The specimen is a cast taken from an external mould at outcrop. It comprises a 120° whorl sector with a rectangular, possibly depressed whorl section, the flanks flattened and subparallel, the ventrolateral shoulders broadly rounded, the venter broad and feebly convex, with a strong siphonal keel. Ornament is poorly preserved. Crowded primary ribs bear weak umbilical bullae, and there are additional intercalated ribs. All ribs bear a small lateral tubercle, a weak inner ventrolateral tubercle and a strong outer ventrolateral clavus.

DISCUSSION: Whorl section and ornament indicate a *Pervinquieria* (*Subschloenbachia*) of the *perinflata* group. See Kennedy and Latil (2007, p. 465) for discussion.

OCCURRENCE: As for material. The *perinflata* group characterise the upper Upper (but not uppermost) Albian, with a geographic range from southern England to south-eastern France, Sardinia, Switzerland, Hungary, Romania, Crimea, the lesser Caucasus, Iran, Angola, KwaZulu-Natal in South Africa, Texas in the United States, and Tamil Nadu.

Genus *Cantabrigites* Spath, 1933

TYPE SPECIES: *Mortoniceras* (*Cantabrigites*) *cantabrigense* Spath, 1932, p. 380, by original designation by Spath, 1933, p. 436.

Cantabrigites spinosum (Pervinquière, 1907)
(Pl. 4, Figs 17, 18)

1907. *Mortoniceras inflatum* Sow. Var. *spinosa* Pervinquière, p. 230, pl. 9, fig. 3.
2004. *Cantabrigites spinosum* (Pervinquière, 1907); Kennedy, p. 877, text-figs 7a–e; 10a–k; 12h–w, 13 (with full synonymy).
2005. *Cantabrigites spinosum* (Pervinquière, 1907); Kennedy *et al*., p. 363, text-fig. 4f–j.
2011. *Cantabrigites spinosum* (Pervinquière, 1907); Szives, p. 450, text-fig. 3e–g.
2018. *Cantabrigites spinosum* (Pervinquière, 1907); Klein, pp. 179, 183 (with additional synonymy).

TYPE: The lectotype, by the subsequent designation of Kennedy 2004, p. 877 is the original of Pervinquière 1907, p. 229, pl. 11 (not pl. 9 as cited), fig. 3, from the Upper Albian of Djebel Zrissa (Djerissa) in Central Tunisia.

MATERIAL: OUM KY4244, from section D, at the 24 m level, Upper Albian, *rostrata* Zone.

DESCRIPTION: The specimen is a crushed limonitic phragmocone 21.2 mm in diameter. Coiling is very evolute, the umbilicus, of moderate depth, comprising 41% of the diameter, the umbilical wall feebly convex, the umbilical shoulder broadly rounded. The original whorl proportions cannot be established. There are 19 strong conical umbilical tubercles on the outer whorl. They give rise to single coarse feebly rursiradiate ribs that link to strong inner ventrolateral tubercles, subspinose when not crushed, and linked by a strong rib to strong outer ventrolateral clavi. There is a strong siphonal keel.

DISCUSSION: See Kennedy 2004 (p. 877).

OCCURRENCE: Upper Albian, northern Algeria, Central Tunisia, Sardinia, southeast France, Switzerland, Hungary, and Tamil Nadu.

Cantabrigites sp. juv.
(Pl. 16, Fig. 5)

MATERIAL: OUM KY5218, from the 100 m level, Upper Albian *rostrata* Zone, in the section on the north side of the Karai–Kulakkalnattam road.

DESCRIPTION: OUM KY5218 (Pl. 16, Fig. 5) is an 80° sector of a corroded internal mould of a phragmocone with a maximum preserved diameter of 19 mm. Coiling is very evolute, serpenticone, the umbilicus comprising 50% of the diameter. The umbilicus is shallow, the umbilical shoulder broadly

rounded. The whorl section is depressed polygonal in costal section. There are six strong, widely separated umbilical bullae on the fragment. They give rise to single coarse, straight prorsiradiate ribs, while additional ribs intercalate, to give a total of 12–13 ribs at the ventrolateral shoulder. The ribs sweep forward and strengthen across the ventrolateral shoulder, without developing into a tubercle. They form an obtuse chevron with a siphonal keel at the apex.

OCCURRENCE: As for material.

Genus *Goodhallites* Spath, 1932

TYPE SPECIES: *Ammonites goodhalli* J. Sowerby, 1820, p. 100, pl. 255, by the original designation of Spath 1932, p. 381.

Goodhallites sp. cf. *besakatrense* Collignon, 1963
(Pl. 9, Fig. 9)

Compare:
1963. *Prohysteroceras* (*Goodhallites*) *besakatrense* Collignon, p. 178, pl. 315, fig. 1330.

MATERIAL: OUM KY4572, from section T–U at the 53 m level, Upper Albian *rostrata* Zone.

DESCRIPTION: The specimen is an external mould of a half whorl with a maximum preserved diameter of 45 mm approximately; a silicone cast is shown in Pl. 9, Fig. 9. Coiling is moderately involute, the umbilicus shallow, with a low, flattened wall and broadly rounded umbilical shoulder, the whorls high, compressed, with flattened flanks and broadly rounded ventrolateral shoulders. Twelve to thirteen low, broad, coarse ribs arise at the umbilical seam, and strengthen across the umbilical wall and shoulder. Crowded ribs that are wider than the interspaces are recti- to feebly rursiradiate on the inner flank, flexing forwards and feebly concave on the outer flank, across which they broaden markedly, then sweeping forwards across the ventrolateral shoulder with a rounded termination, separated from a well-developed siphonal keel by a narrow smooth zone. There are an estimated 18 ribs per half whorl at the ventrolateral shoulder.

DISCUSSION: The specimen is compared to *Goodhallites besakatrense* on the basis of the comparable flank ornament, with low, broad falcoid ribs that expand markedly on the outer flank.

OCCURRENCE: As for material. The type material of *besakatrense* is from Collignon's Upper Albian *Hysteroceras binum* Zone of Mont Raynaud, Madagascar

Goodhallites sp. juv.
(Pl. 16, Figs 1–4)

MATERIAL: OUM KY5045, from the section on the north side of Karai–Kulakkalnattam road, 110 m level; OUM KY5051, from the 115 m level, both Upper Albian *rostrata* Zone.

DESCRIPTION: Of the two specimens, OUM KY5045 (Pl. 16, Figs 1, 2) is the larger and better-preserved, with a maximum preserved diameter of 26.9 mm. The whorl section is compressed, the flanks flattened and subparallel, the ventrolateral shoulders broadly rounded, the venter feebly convex. Blunt bullae perch on the umbilical shoulder, and give rise to low, broad, feebly prorsiradiate ribs, with short ribs intercalating. The ribs strengthen across the ventrolateral shoulder and project forwards before weakening. A narrow smooth zone separates the rib terminations from the siphonal keel. OUM KY5051 (Pl. 16, Figs 3, 4) is a smaller 120° fragment 18.4 mm long, with the keel better preserved.

DISCUSSION: Although slight, the material can be referred to *Goodhallites*, but is inadequate for specific assignation.

OCCURRENCE: As for material.

Genus and subgenus *Algericeras* Spath, 1925b

TYPE SPECIES: *Ammonites boghariensis* Coquand, 1880, p. 35, by the original designation of Spath 1925b, p. 182.

Algericeras (*Algericeras*) *besairiei* (Collignon, 1964)
(Pl. 16, Figs 7–9; Text-fig. 13E)

1964. *Prionocycloides besairiei* Collignon, p. 22, pl. 322, fig. 1424.
2018. *Algericeras* (*Algericeras*) *besairiei* (Collignon, 1964); Klein, p. 185.

TYPE: The holotype, by original designation, is the original of Collignon 1964, p. 22, pl. 322, fig. 1424, from Collignon's Lower Cenomanian *Mantelliceras martimpreyi* Zone of gisement 478, Beraketa sur

Sakondry (Manera), Madagascar, in the collections of the Université de Bourgogne, Dijon.

MATERIAL: OUM KY3995, from section C–D at the 116 m level, Lower Cenomanian, *Mantelliceras mantelli* Zone.

DESCRIPTION: The specimen is an internal mould 12.4 mm in diameter, retaining a 90° sector of body chamber. Coiling is moderately evolute, the umbilicus comprising 27% of the diameter, with a low, feebly convex wall and broadly rounded umbilical shoulder. The whorl section is compressed, with feebly convex parallel flanks, broadly rounded ventrolateral shoulders and a feebly convex venter. Six ribs arise on the umbilical wall of the adapertural half whorl, and strengthen into six relatively coarse umbilical bullae of variable strength. They give rise to single broad, blunt prorsiradiate ribs that link to strong oblique ventral clavi. One or two short ribs intercalate between successive primaries, and strengthen to match them on the ventrolateral shoulders and venter. A groove separates the clavi from a blunt, unduolose siphonal keel. The suture (Text-fig. 13E) is very simple, with a broad, barely subdivided E/A, narrow A and broad bifid A/U2.

DISCUSSION: *Algericeras* (*Algericeras*) *proratum* (Coquand, 1862) (see revision in Kennedy and Wright 1981, p. 429, pl. 60, figs 1–5, 20–21, 33; text-figs 3h, I, 4b) is finely and densely ribbed, lacking the strong umbilical bullae of the present species, the primary ribs biconcave, branching low and high on the flanks. *A*. (*A*.) *boghariense boghariense* (Coquand, 1862) (p. 172, pl. 2, figs 3, 4; see revision in Kennedy and Wright 1981, p. 428, pl. 60, figs 6–8) is much more delicately ribbed, with fine regular umbilical bullae, and around 50 ribs per whorl. *A*. (*A*.) *boghariense paucicostatum* Kennedy and Wright, 1981 (p 428, pl. 60, figs 9–19, 27–29, text-figs 1c, 3j–l, 4a), which should, perhaps, be afforded specific status, has well-developed umbilical bullae that tend to strengthen on alternate ribs, and 35–40 ribs per whorl, with ornament near-effaced on the mid-flank region in some individuals, including the holotype. *A*. (*A*.) *numidicum* (Sornay, 1955a) (p. 31, pl. 2, fig. 15, text-fig. 17) has eight small umbilical bullae and 28 ribs at the ventrolateral shoulder, the ribs narrow and flexuous, rather than broad, straight and coarse, as in the present species; the suture is highly distinctive, with near-entire saddles.

OCCURRENCE: Lower Cenomanian of Madagascar and Tamil Nadu.

Family Lyelliceratidae Spath, 1921
Subfamily Stoliczkaiinae Breistroffer, 1953a
Genus and subgenus *Stoliczkaia* Neumayr, 1875

TYPE SPECIES: *Ammonites dispar* d'Orbigny, 1841, p. 142, pl. 45, figs 1, 2, by the subsequent designation of Diener 1925, p. 179.

DISCUSSION: Cooper (2012, p. 185) regarded *Stoliczkaia* Neumayr, 1875 as a junior primary homonym of *Stoliczkaia* Jerdon, 1870. However, the name introduced by Jerdon on p. 81 of his paper is *Stoliczkia*, which is not a homonym of *Stolizkaia*, as demonstrated by Klinger (2018).

Stoliczkaia (*Stoliczkaia*) *clavigera* (Neumayr, 1875)
(Pl. 17, Figs 10–14; Text-fig. 14A)

1864. *Ammonites dispar* Stoliczka, p. 85, pl. 45, fig. 1 only.
1875. *Stoliczkaia clavigera* Neumayr, p. 933.
1988. *Stoliczkaia* (*Stoliczkaia*) *clavigera* Neumayr, 1875; Delanoy and Latil, p. 755, pl. 2, figs 1, 3; pl. 5, fig. 1.
1994. *Stoliczkaia* (*Stoliczkaia*) *clavigera* Neumayr, 1875; Wright and Kennedy, p. 576, text-figs 5b; 11k–m, q–r; 12e–h, k–n; 13a–c; 14a–c (with synonymy).
2007. *Stoliczkaia* (*Stoliczkaia*) *clavigera* (Neumayr, 1875); Szives, p. 105, pl. 20, fig. 1 (with additional synonymy).
2007. *Stoliczkaia* (*Stoliczkaia*) *clavigera* (Neumayr, 1875); Kennedy and Latil, p. 466, pl. 4, fig. 1; pl. 5, figs 1–7; pl. 6, fig. 1 (with additional synonymy).
2013b. *Stoliczkaia* (*Stoliczkaia*) *clavigera* (Neumayr, 1875); Kennedy and Klinger, p. 4, text-figs 6a–u; 7a–i; 8a–c, f–h; 14k, l; 15d, e (with additional synonymy).
2018. *Stoliczkaiella* (*Stoliczkaiella*) *clavigera* (Neumayr, 18756); Klein, p. 222 (with additional synonymy).

TYPE: The holotype, by monotypy, is the original of Stoliczka, 1864, pl. 45, fig. 1 only, GSI. 191 from the Uttatur Group of Moraviatoor. A cast of this specimen was figured by Delanoy and Latil (1988, pl. 5, fig. 1).

MATERIAL: OUM KY2532 and KY2534, from section A–B, upper interval, at the 0–2 m level, Upper Albian, r*ostrata* Zone. OUM KY3649, from section C–D at the 70–75 m level. OUM KY3665, from section C–D at the 69 m level, both Lower Cenomanian, *mantelli* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3649 at	71.6 (100)	32.8 (45.8)	36.7 (51.3)	0.89	14.2 (19.8)

DESCRIPTION: OUM KY3649 (Pl. 17, Figs 13, 14) is a worn internal mould of an adult retaining a 60° sector of body chamber, the last few septa approximated. Coiling is moderately involute, the umbilicus comprising 19.8% of the diameter, the umbilical wall feebly convex, the umbilical shoulder broadly rounded, the whorl section compressed oval, the greatest breadth below mid-flank. The inner to mid-flank region is moderately convex, the outer flanks converging to broadly rounded ventrolateral shoulders and venter. There are 14 ribs at the ventrolateral shoulder of the outer half whorl. Primary ribs are variably developed; four arise on the umbilical wall and strengthen into a well-developed umbilical bulla that gives rise to a coarse, blunt rib, straight and prorsiradiate to mid-flank, then flexing slightly back, strengthening, and passing straight across the venter. The bullate primaries are separated by up to four ribs, some are primaries that are very weak on the umbilical wall, shoulder, and inner flank; others are intercalatories that arise at various points on the flanks and ventrolateral shoulder. OUM KY3665 (Pl. 17, Figs 10, 11) is a well-preserved 120° sector of phragmocone with a maximum preserved whorl height of 17.3 mm and a whorl breadth to height ratio of 0.96, the flanks feebly convex, the ventrolateral shoulders and venter broadly rounded. Primary ribs are separated by one or two intercalated ribs, the ornament corresponding to that of the penultimate whorl of the previous specimen. OUM KY2532 (Pl. 17, Fig. 12) is a crushed internal mould with a maximum preserved diameter of 83 mm. The umbilicus comprises 23.5% of the diameter, the umbilical wall feebly convex, the umbilical shoulder broadly rounded. The flanks are feebly convex, subparallel, the ventrolateral shoulders and venter broadly rounded. Coiling is involute at the beginning of the outer whorl of the phragmocone, the umbilical seam egressing on the succeeding 180° sector of the body chamber, suggesting the specimen to be adult. On the phragmocone there are crowded primary, long and short intercalated ribs. The primaries arise on the umbilical shoulder and are strongly prorsiradiate, strengthening across the flanks, and bifurcating once, rarely twice, to give a total of 28 ribs approximately per half whorl. There are an estimated 14–16 ribs on the body chamber, straight and prorsiradiate, and much coarser than on the phragmocone. Some of the ribs bifurcate, and there are occasional long intercalatories. The suture (Text-fig. 14A) is moderately incised, with a broad E/A with a deep median incision.

DISCUSSION: See Wright and Kennedy (1994, p. 577) and Kennedy and Klinger (2013b, p. 5).

OCCURRENCE: Upper Upper Albian *rostrata* to lower Lower Cenomanian *mantelli* Zone, with records from Southern England, southeast France, northern Spain, Switzerland, Hungary, Romania, Turkmenistan, Tunisia, Japan, Texas, Cuba, Tamil Nadu, and northern KwaZulu-Natal in South Africa.

Subgenus *Lamnayella* Wright & Kennedy, 1978

TYPE SPECIES: *Stoliczkaia* (*Lamnayella*) *juigneti* Wright and Kennedy, 1978, p. 398, pl. 37, figs 1–10; pl. 38, figs 1–12, by the original designation of Wright and Kennedy 1978, p. 394.

Stoliczkaia (*Lamnayella*) *crotaloides* (Stoliczka, 1864)
(Pl. 17, Figs 1–7, 15; Text-fig. 16B)

1864. *Ammonites crotaloides* Stoliczka, p. 88, pl. 46, fig. 3.
2013b. *Stoliczkaia* (*Lamnayella*) *crotaloides* (Stoliczka, 1864); Kennedy and Klinger, p. 7, text-figs 7q, r; 8d, e; 14a–c, g–j; 15 f, g (with full synonymy).
?2017. *Stoliczkaiella* (*Lamnayella*) *crotaloides* (Stoliczka, 1864); Tajika *et al*., p. 35, text-fig. 8s, t.
2018. *Stoliczkaiella* (*Lamnayella*) *crotaloides* (Stoliczka, 1864); Klein, pp. 235, 236.

TYPE: The holotype, by monotypy, is the original of Stoliczka, 1864, pl. 46, fig. 3, from the Uttatur Group of Moraviatoor, in the collections of the Geological Survey of India.

MATERIAL: VP 50a and 50b, from the Upper Albian in the area between Odiyam and Kunnam. OUM KY2533, from section A–B, upper interval, 0–2 m level, Upper Albian, *rostrata* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
VP 50b at c	38.0 (100)	12. 0 (31.6)	18.4 (48.2)	0.65	8.1 (21.3)

DESCRIPTION: VP 50b (Pl. 17, Figs 5–7) had a maximum preserved diameter at 44 mm approximately, the adapertural 200° body chamber, the last few sutures approximated, indicating the specimen to be an incomplete adult. Coiling is moderately involute, the umbilicus comprising 21.3% of the diameter, shallow, with a low, feebly convex, outward-inclined umbilical wall and a broadly rounded umbilical shoulder. The whorl section is compressed, the intercostal sec-

tion with flattened flanks, broadly rounded ventrolateral shoulders and a feebly convex venter. The costal whorl breadth to height ratio is 0.65, the greatest breadth low on the flanks, which are very feebly convex and subparallel; there is a slight angulation at the junction of the flanks and the feebly convex venter. There are a total of 26 ribs at the ventrolateral shoulder of the outer whorl. On the phragmocone, narrow, widely-spaced ribs arise at the umbilical seam, sweep forwards and strengthen across the umbilical wall and shoulder, and are straight and prorsiradiate on the flanks, or may flex back at mid-flank. In some cases, pairs of ribs arise on the umbilical shoulder and there are occasional long intercalated ribs. All ribs strengthen markedly over the venter, where they are straight, transverse, and separated by wide interspaces. Predominantly primary ribs dominate the ornament of the poorly preserved body chamber. VP 50a (Pl. 17, Figs 1–4) is 60 mm in diameter, and shows marked coarsening of the ribs on the adapertural 90° sector of the outer whorl. OUM KY2533 (Pl. 17, Fig. 15) is a crushed individual 65 mm in diameter retaining a 120° sector of body chamber.

The suture of VP 50b is very simple and little-incised, with a broad bifid E/A, narrow bifid A and broad, bifid U2 (Text-fig. 16B).

DISCUSSION: See Kennedy and Klinger (2013b, p. 8).

OCCURRENCE: Upper Albian, *perinflat* Zone where well-dated. The geographic distribution extends from Tamil Nadu to KwaZulu-Natal in South Africa and southern England.

Genus *Ojinagiceras* Cobban and Kennedy, 1989

TYPE SPECIES: *Ojinagiceras ojinagaense* Cobban and Kennedy, 1989, p. 138, text-fig. 2e–g, j, n, by original designation of Kennedy and Cobban 1989, p. 139.

Ojinagiceras sp.cf *ojinagaense* Cobban and Kennedy, 1989
(Pl. 17, Figs 8, 9)

Compare:
1989. *Ojinagiceras ojinagaense* Cobban and Kennedy, p. 138, text-fig. 2e–g, j, n.

MATERIAL: OUM KY3683, from section C–D at the 90 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: The specimen is an apparently complete adult 12.9 mm in diameter, partially embedded in matrix and retaining recrystallized shell material. Coiling is very involute, the umbilicus comprising less than 20% of the diameter. The umbilical shoulder is narrowly rounded, the flanks flattened and subparallel. The ventrolateral shoulders are broadly rounded, the broad venter very feebly convex. On the adapical part of the outer whorl, sparse bullae perch on the umbilical shoulder, and give rise to sparse, widely separated ribs, whilst additional ribs intercalate, all terminating in conical ventrolateral tubercles, linked over the venter by a coarse feebly convex rib. On the adapertural part of the outer whorl, the ventrolateral tubercles decline and efface, the umbilical bullae persisting, the ventrolateral shoulders ornamented by closer space ribs that cross the venter in a more pronounced linguoid peak.

DISCUSSION: The distinctive ontogenetic changes suggest the specimen to be a complete or near-complete adult. The adult size, ontogenetic changes in ornament, with loss of the ventrolateral tubercles and development of coarse ribs on the ventrolateral shoulders and venter match those of the type species, notably the sparsely and coarsely ribbed variant (Cobban and Kennedy 1989, text-fig. 2g), with which the present specimen is compared.

OCCURRENCE: As for material. *Ojinagiceras ojinagaense* was originally described from the Lower Cenomanian of Trans-Pecos Texas.

Family Forbesiceratidae Wright, 1952
Genus *Forbesiceras* Kossmat, 1897

TYPE SPECIES: *Ammonites largilliertianus* d'Orbigny, 1841 p. 320, pl. 95 (*pars*), by the subsequent designation of Diener 1925, p. 180.

Forbesiceras largilliertianum (d'Orbigny, 1841)
(Pl. 18, Figs 1, 2, 6–13; Text-fig. 14B)

1841. *Ammonites largilliertianus* d'Orbigny, p. 320, pl. 95 (*pars*).
1984. *Forbesiceras largilliertianum* (d'Orbigny, 1841); Wright and Kennedy, p. 89, pl. 11, figs 2–6; pl. 12, figs 1–3, 9; pl. 16, fig. 2; text-figs 12a–l; 13 a–z'; 14a–h (with synonymy).
2006. *Forbesiceras largilliertianum* (d'Orbigny, 1841); Kennedy *et al*. in Gauthier, p. 116, pl. 54, figs 1–3.
2008. *Forbesiceras largilliertianum* (d'Orbigny, 1841); Kennedy and Klinger, p. 120, pl. 1, figs 2–5; text-fig. 2a, f (*pars*), d, e (with additional synonymy).

2015. *Forbesiceras largilliertianum* (d'Orbigny, 1841); Kennedy in Morel, p. 136, text-figs 98; 131f–g.
2017. *Forbesiceras largilliertianum* (d'Orbigny, 1841); Kennedy in Kennedy and Gale, p. 87, pl. 1, figs 9, 10.
2017. *Forbesiceras largilliertianum* (d'Orbigny, 1841); Tajika *et al*., p. 37, text-fig. 9o, p.
2018. *Forbesiceras largilliertianum* (d'Orbigny, 1841); Klein, pp. 256, 261.

TYPES: The lectotype, by the subsequent designation of Wright and Kennedy (1984, p. 90) is MNHN F. B46129 (formerly 6120a); it was figured by Wright and Kennedy (1984, text-fig. 12d, e), and is from the Middle Cenomanian *rhotomagense* Zone phosphatised fauna of the Rouen Fossil Bed, Côte Ste Catherine, Rouen, Seine-Maritime, France; those authors also discuss the paralectotypes, as do Kennedy *et al.* (in Gauthier 2006, p. 117).

MATERIAL: OUM KY3725–3727a, b, 3771–3773a, b, from section C–D, at the 116 m level; Lower Cenomanian, *mantelli* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3727a	35.2 (100)	– (–)	22.0 (63)	–	– (–)
OUM KY3373b	48.5 (100)	12.8 (26.4)	29.6 (61.0)	0.43	2.2 (4.5)
OUM KY3771	66.1 (100)	16.7 (25.2)	41.2 (62.3)	0.40	– (–)

DESCRIPTION: Two variants are recognised, one finely ribbed, the other more coarsely ribbed. The finely ribbed variant is represented by OUM KY3771 (Pl. 18, Figs 12, 13) and 3773 (Pl. 18, Figs 8, 9). Coiling is very involute, the umbilicus minute, the whorl section very compressed with a whorl breadth to height ratio of 0.40 to 0.43, the greatest breadth very low on the flanks, which are very feebly convex, the middle and outer flanks converging to narrowly rounded ventrolateral shoulders and a narrow, flattened venter. Ornament is of fine, dense, even, crowded ribs that arise at the umbilical seam and branch both low and high on the flanks, whilst additional ribs intercalate. The ribs are straight and prorsiradiate on the inner flank, flexed back and very feebly convex at mid-flank, and very feebly concave on the outer flank, all ribs terminating in minute ventral clavi.

Of coarser ribbed variants, OUM KY3772 is a nucleus 35 mm in diameter, KY3773a (Pl. 18, Figs 6, 7, 10) a slightly smaller, damaged nucleus with an estimated diameter of 32 mm. Coiling is involute, the umbilicus tiny, the umbilical shoulder narrowly rounded, the flanks very feebly convex, the middle and outer flanks converging to the narrowly rounded ventrolateral shoulders. The narrow venter is flattened. Widely separated narrow prorsiradiate ribs are straight on the inner flanks, branch around mid-flank, where additional ribs intercalate. The ribs coarsen on the outer flank, and are feebly concave. They terminate in small ventral clavi. There are 18 ribs per half whorl at the ventrolateral shoulder. OUM KY3727 (Pl. 18, Fig. 11) is an internal mould of a nucleus 35.3 mm in diameter and part of the succeeding whorl. Relatively strong, narrow ribs arise on the umbilical shoulder and are straight and prorsiradiate on the inner flank. They bifurcate both low and high on the flanks, and additional ribs intercalate, all ribs strengthening and very feebly concave on the outer flank, terminating in tiny ventral clavi, linked across the venter by a low, broad, transverse ridge. OUM KY3726 (Pl. 18, Fig. 2) is a comparable individual with a maximum preserved whorl height of 31 mm and a low mid-ventral ridge. The suture, best preserved in OUM KY3771 (Text-fig. 14B), is deeply incised, with narrow-stemmed saddles There is a large incision dividing E/A into two asymmetric halves.

DISCUSSION: See Wright and Kennedy (1984, p. 91) and Kennedy and Klinger (2008, p. 120) for discussion.

OCCURRENCE: Lower and Middle Cenomanian, southern England, France, Switzerland, northern Spain, Germany, Iran, central Asia, Algeria, Tunisia, KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, and Japan.

Forbesiceras chevillei (Pictet and Renevier, 1866)
(Pl. 18, Figs 3–5; Pl. 19, Figs 1–8; Text-fig. 16A)

1866. *Ammonites chevillei* Pictet and Renevier, p. 102, pl. 4, fig. 2.
1984. *Forbesiceras chevillei* (Pictet and Renevier, 1866); Wright and Kennedy, p. 93, pl. 13, fig. 2; pl. 15, figs 1, 2; text-fig. 17 (with synonymy).
2008. *Forbesiceras chevillei* (Pictet and Renevier, 1866); Kennedy and Klinger, p. 124, pl. 1, figs 1, 6–12; pl. 2, figs 8, 12, 13; text-fig. 6 (with additional synonymy).
2015. *Forbesiceras chevillei* (Pictet and Renevier, 1866); Kennedy in Kennedy and Gale, p. 262, pl. 5, figs 1, 2, 6; text-fig. 13c.
2017. *Forbesiceras chevillei* (Pictet and Renevier, 1866); Kennedy in Kennedy and Gale, p. 88, pl. 3, figs 1–8.
2018. *Forbesiceras chevillei* (Pictet and Renevier, 1866; Klein, pp. 256, 258.

TYPE: The holotype, by monotypy, is no. 3402 in the collections of the Musée Géologique, Lausanne, the original of Pictet and Renevier 1866, p. 104, pl. 4, fig. 2, from the 'Couche moyenne' at Cheville, Vaud, Switzerland. It was refigured by Delamette and Kennedy (1991, text-fig. 9.1–9.3) and Kennedy and Klinger (2008, text-fig. 6).

MATERIAL: OUM KY2700, from the 169 m level; OUM KY2719 from the 172–175 m level; OUM KY2767, from the 173–175 m level of section G–H; Middle Cenomanian, *asiaticum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2767	99.7 (100)	34.8 (34.9)	66.1 (66.6)	0.53	2.0 (2.0)

DESCRIPTION: OUM KY2719 (Pl. 18, Figs 3–5; Pl. 19, Figs 1–3) is a fragmentary internal mould of a phragmocone with a maximum preserved whorl height of 41 mm approximately. The umbilicus is minute. The whorl section is compressed; a well-preserved part of the adapical end has a whorl breadth to height ratio of 0.57. The flanks are very feebly convex and subparallel, the ventrolateral shoulders narrowly rounded, the venter very feebly convex. Very distant primary ribs, three per half whorl, arise on the umbilical shoulder and are narrow and prorsiradiate across the otherwise smooth inner flanks before flexing back and becoming very feebly concave on the outer flank, across which they strengthen progressively and link to small ventral clavi. These are linked across the venter by a pair of ribs. Up to eight ribs intercalate between successive primaries, arising at mid-flank, and strengthening to match the primaries on outer flank, ventrolateral shoulders and venter. On the adapertural part of the fragment, three of these ribs develop a mid-lateral bulla, the ribs on the outer flank scale-like with an asymmetric cross section. The ventral clavi are linked over the venter by several delicate, barely detectable ribs. OUM KY2700 (Pl. 19, Figs 4–6) is a well-preserved 90° sector of phragmocone with recrystallized shell. The maximum preserved whorl height is 56.7 mm; the whorl breadth to height ratio 0.47. Coiling is very involute, the umbilicus minute. The flanks are very feebly convex and subparallel, the ventrolateral shoulders narrowly rounded, the venter very obtusely fastigiate, with a median ridge. The inner half of the flanks is smooth. There are widely separated minute bullae at mid-flank. The outer flanks are ornamented by broad scale-like ribs with an asymmetric profile in cross section, as in the previous specimen. They are feebly prorsiradiate and link to small ventral clavi; the venter is worn. OUM KY2767 (Pl. 19, Figs 7, 8) is a wholly septate individual 99.7 mm in diameter, retaining extensive traces of recrystallized shell. It continues the ontogeny, with the development of widely separated lateral bullae and scale-like ribs on the outer flanks and well-developed ventral clavi, linked across the venter by delicate ribs, which also intercalate between. The suture of this specimen is badly corroded, with deeply incised narrow-stemmed saddles, a deep incision dividing E/A into two asymmetric halves (Text-fig. 16A).

DISCUSSION: See Wright and Kennedy (1984, p. 93) and Kennedy and Klinger (2008, p. 125).

OCCURRENCE: Lower to lower Middle Cenomanian. The geographic distribution extends from southern England to France, Germany, Switzerland, northern Spain, Turkmenistan, north-eastern Algeria, Central Tunisia, Nigeria, KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, and, possibly, Texas in the United States.

Subfamily Mantelliceratinae Hyatt, 1903
Genus *Mantelliceras* Hyatt, 1903

TYPE SPECIES: *Ammonites mantelli* J. Sowerby, 1814, p. 199, by the original designation of Hyatt, 1903, p. 113 (ICZN Specific Name No. 1634).

Mantelliceras mantelli (J. Sowerby, 1814)
(Pl. 20, Figs 5, 6; Pl. 21, Figs 4, 5)

1814. *Ammonites mantelli* J. Sowerby, p. 119, pl. 55, lower figure only.
1984. *Mantelliceras mantelli* (J. Sowerby, 1814); Wright and Kennedy, p. 99, pl. 16, fig. 5; pl. 17, figs 1, 3; pl. 18, figs 1–3; pl. 19, figs 1–6; pl. 20, figs 1, 2, 4, 5; pl. 21, figs 2, 4; pl. 24, fig. 3; pl. 36, fig. 1 text-figs 20a–d, 26a, c, e, 28a–e (with synonymy).
1998. *Mantelliceras mantelli* (J. Sowerby, 1814); Kaplan *et al*., p. 115, pl. 11, figs 1, 2; pl. 17, figs 12, 13; pl. 19, figs 1–9; pl. 22, figs 3, 4; pl. 23, fig. 8; pl. 24, figs 4–6; pl. 25, figs 1–5 (with additional synonymy).
2011. *Mantelliceras mantelli* (J. Sowerby, 1814); Mosavinia and Wilmsen, p. 178, text-fig. 3a–e (with additional synonymy).
2015. *Mantelliceras mantelli* (J. Sowerby, 1814); Kennedy in Morel, p. 137, text-figs 102, 130a.
2015. *Mantelliceras mantelli* (J. Sowerby, 1814); Kennedy

in Kennedy and Gale, p. 264, pl. 7, fig. 3; pl. 8, figs 1, 5 (with additional synonymy).

2016. *Mantelliceras mantelli* (J. Sowerby, 1814); Sharifi *et al*., p. 597, fig. 7, Ke6, Ke7, Ke 8.

2018. *Mantelliceras mantelli* (J. Sowerby, 1814); Kennedy and Morris, p. 93, text-figs 6e; 7x–z; 8a–c, g–q, u–w.

2018. *Mantelliceras mantelli* (J. Sowerby, 1814); Gale *et al*. p. 111, text-fig. 10d, e.

TYPE: The lectotype, by the subsequent designation of Kennedy (1971, p. 54), is BMNH 43940a, from the Lower Cenomanian Chalk Marl of Ringmer, near Lewes, Sussex, the original of J. Sowerby (1814, pl. 55, lower figure only), re-illustrated by Wright and Kennedy (1984, pl. 18, fig. 3a–c).

MATERIAL: OUM KY3755a, b, KY3756 (cf.), 3757, 3758, 3764, from section C–D at the 116 m level, Lower Cenomanian, *mantelli* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3764c	36.7 (100)	20.9 (57.0)	17.5 (47.7)	1.19	10.3 (28.1)

DESCRIPTION: OUM KY3764 (Pl. 20, Figs 5, 6) is a typical juvenile, a half whorl 36.7 mm in diameter. Coiling is moderately involute, the umbilicus of moderate depth, comprising 28.1% of the diameter, the umbilical wall convex, the umbilical shoulder broadly rounded, the intercostal whorl section depressed reniform. The costal whorl section is depressed polygonal, with a whorl breadth to height ratio of 1.19, the greatest breadth at the lateral tubercle. Seven to eight ribs on the half whorl arise at the umbilical seam, and are strong, straight and prorsirsdiate across the flanks, bearing small umbilical bullae, conical lateral and inner ventrolateral tubercles and feebly clavate outer ventrolateral tubercles, linked across the venter by a strong transverse rib. Single ribs intercalate between successive primaries, and bear inner and outer ventrolaterl tuberecles. OUM KY3755a (Pl. 21, Figs 4, 5) is a phragmocone fragment with a maximum preserved whorl height of 24 mm, retaining a full complement of tubercles. OUM KY3755b is a larger body chamber fragment with a maximum preserved whorl height of 32mm from close to the adult aperture, showing weakening and loss of the umbiical bullae on the last few ribs, loss of the lateral and inner ventrolateral tubercles, but retention of the outer ventrolateral row.

DISCUSSION: See Wright and Kennedy (1984 p. 101).

OCCURRENCE: The species ranges throughout all but the very lowest Lower Cenomanian, and is commonest in the lower part of its range. The geographic distribution extends from England to Northern Ireland, France, Germany, Russia, Iran, Kazakhstan, North Africa, KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, and Japan.

Mantelliceras cantinum Spath, 1926a
(Pl. 18, Fig. 14; Pl. 20, Figs 3, 4, 7, 8)

1926a. *Mantelliceras cantianum* Spath, p. 82.

1984. *Mantelliceras cantianum* Spath, 1926; Wright and Kennedy, p. 103, pl. 17, fig. 2; pl. 20, fig. 3; pl. 21, fig. 3; pl. 24, figs 1, 2, 4–6; pl. 25, figs 1–6; pl. 26, figs 1, 2, 4, 5; pl. 38, fig. 1; text-figs 25a, 27e–h, j–l, ?21 a–c (with synonymy).

1998. *Mantelliceras cantianum* Spath, 1926a; Kaplan *et al*., p. 116, pl. 18, figs 5, 6,10, 11; pl. 20, figs 2, 3; pl. 21, figs 1–3, pl. 26, fig. 6 (with additional synonymy).

2011. *Mantelliceras cantianum* Spath, 1926; Mosavinia and Wilmsen, p. 180, text-fig. 4a, b, h (with additional synonymy).

2015. *Mantelliceras cantianum* Spath, 1926a; Kennedy in Morel, p. 137, text-fig. 104.

2015. *Mantelliceras cantianum* Spath, 1926a; Kennedy in Kennedy and Gale, p. 265 pl. 10, fig. 8 (with additional synonymy).

2018. *Mantelliceras* cf. *cantianum* Spath, 1926; Kennedy and Morris, p. 95, text-fig. 8d–f.

2018. *Mantelliceras cantianum* Spath, 1926; Gale *et al*., p. 113, text-fig. 9i–j.

TYPES: The holotype, by original designation, is BMNH 36834, from the Lower Cenomanian Chalk Marl of Dover, Kent; paratype BMNH C5027 is from the same unit at Lewes, Sussex. They were figured by Sharpe (1857, pl. 18, figs 1, 2) and Wright and Kennedy (1984, pl. 24, figs 2, 6).

MATERIAL: OUM KY2576, from section E–F at the 132.5 m level; OUM KY3760 and 3762, from section C–D at the116 m level, all Lower Cenomanian, *mantelli* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3760 c	42.0 (100)	22.5 (53.6)	19.5 (46.4)	1.15	12.4 (29.5)

DESCRIPTION: OUM KY3760 (Pl. 20, Figs 7, 8; Pl. 21, Figs 2, 3) is typical. It comprises a nucleus 42 mm in diameter and a fragment of body chamber

with a maximum preserved whorl height of 36.5 mm. Coiling is moderately evolute, the relatively deep umbilicus comprising 29% of the diameter, with a convex wall and broadly rounded umbilical shoulder. The whorl section is depressed reniform in intercostal section, and polygonal in costal section, with a whorl breadth to height ratio of 1.15, the greatest breadth at the inner lateral tubercle. Ten ribs per half whorl arise at the umbilical seam, strengthen across the umbilical wall, and develop into small bullae, perched on the umbilical shoulder. A strong, straight, feebly prorsiradiate rib links to a strong inner lateral tubercle, and a stronger, feebly clavate outer ventrolateral tubercle, the outer ventrolateral tubercles linked across the venter by a strong transverse rib. Single ribs intercalate between successive primaries and have an outer flank, ventrolateral and ventral development comparable to that of the primaries. On the body chamber fragment (Pl. 21, Figs 2, 3), well-developed umbilical bullae and strong inner lateral and outer ventrolateral tubercles are present on the primary ribs, the inner ventrolaterals now lost. The single intercalated ribs bear outer ventrolateral tubercles only. OUM KY2576 (Pl. 18, Fig. 14) is a very crushed individual with a maximum preserved diameter of 70 mm. There are 24 umbilical bullae per whorl, strong inner lateral tubercles, the inner ventrolateral surviving to the beginning of the outer whorl, but thereafter effacing. There are 8–9 umbilical bullae and17 ribs at the ventrolateral shoulder of the adapertural half of the outer whorl. OUM KY3762 (Pl. 20, Figs 3, 4), a 180° fragment 84 mm in diameter, is interpreted as an adult body chamber. There are 10 ribs at the umbilical seam, and 18 at the ventrolateral shoulder. At the adapical end, the primary ribs bear umbilical bullae, strong inner lateral tubercles and strong outer ventrolateral clavi, linked across the venter by a strong, transverse rib. Long intercalated ribs bear outer ventrolateral clavi only. On the adapertural part, the umbilical bullae are weak, intercalated ribs extend down to the umbilical shoulder, all ribs bearing outer ventrolateral tubercles only, which are very weak of the final few ribs.

DISCUSSION: See Wright and Kennedy (1984, p. 104).

OCCURRENCE: Lower Cenomanian, *Mantelliceras mantelli* and *M. dixoni* Zones. The geographic distribution extends from southern England across France, northern Spain, Germany, Switzerland, Romania (?), Iran, Central Tunisia, KwaZulu-Natal in South Africa, Madagascar, Tamin Nadu, and Japan.

Mantelliceras lymense (Spath, 1926b)
(Pl. 21, Figs 1, 8; Pl. 22, Figs 3, 4)

1926b. *Eucalycoceras lymense* Spath, p. 427, 431.
1984. *Mantelliceras lymense* (Spath, 1926); Wright and Kennedy, p. 102, pl. 10, fig. 9; pl. 22, figs 1–6; pl. 23, figs 1–3; pl. 31, figs 1, 2; pl. 36, fig. 4; text-figs 19; 24a, b; 26d; 28f–j (with synonymy).
2011. *Mantelliceras lymense* (Spath, 1926); Mosavinia and Wilmsen, p. 182, text-fig. 4d, e (with additional synonymy).
2015. *Mantelliceras lymense* (Spath, 1926); Kennedy in Morel, p. 138, fig. 105.
2015. *Mantelliceras lymense* (Spath, 1926); Kennedy in Kennedy and Gale, p. 265, pl. 3, fig. 1; pl. 7, figs 1, 6; pl. 8, figs 2, 6; pl. 23, fig. 2; text-fig. 14.

TYPE: The lectotype, by the subsequent designation of Wright and Kennedy 1984, p. 102, is the original of Pervinquière 1907, pl. 16, fig. 16, refigured by Wright and Kennedy 1984, text-fig. 24a, b, from south of Bargou, Tunisia, an unregistered specimen in the collections of the École des Mines, Paris, currently housed in the collections of the Université de Lyon 1-Villeurbanne

MATERIAL: OUM KY3761 and KY3763, from section C–D at the 116 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: OUM KY3761 (Pl. 21, Figs 1, 8) is a 120° sector of an adult macroconch, comprising a part of the phragmocone and the adapical part of the body chamber. The maximum preserved whorl height is 54.5 mm. Fifteen ribs are preserved on the fragment. Primary ribs arise on the umbilical wall, strengthen across the umbilical shoulder, and develop into a feeble umbilical bulla on the phragmocone that effaces on the body chamber. The ribs are straight and prorsiradiate on the flanks, reaching their greatest strength on the ventrolateral shoulders and venter, which they pass straight across. One or two long or short ribs intercalate, and strengthen to match the primary ribs on the ventrolateral shoulders and venter.

OUM KY3763 (Pl. 22, Figs 3, 4) is an adult microconch 85.8 mm in diameter, retaining an 180° sector of body chamber. Coiling is evolute, the umbilicus comprising 34.3% of the diameter, with a feebly convex wall and broadly rounded umbilical shoulder. The penultimate whorl has a rounded whorl section. An estimated 14 tiny bullae perch on the umbilical shoulder, and give rise to weak, straight, prorsiradiate ribs that bear small inner and

outer ventrolateral tubercles. On or two ribs intercalate between successive primaries, and have a comparable ventrolateral and ventral development. The inner ventrolateral tubercles survive to a diameter of 35 mm, but are thereafter lost. The outer whorl has a depressed reniform intercostal section, with a whorl breadth to height ratio of 1.13, the flanks feebly convex, the ventrolateral shoulders broadly rounded, the venter broad and convex. The costal whorl breadth to height ratio is also 1.13, the greatest breadth below mid-flank. There are 40–42 ribs at the ventrolateral shoulder of the outer whorl. On the phragmocone and adapical part of the body chamber, the primaries arise at the umbilical seam and strengthen into feeble umbilical bullae that give rise to single prorsiradiate ribs that strengthen across the flanks and link to well-developed outer ventrolateral tubercles, linked across the venter by a strong, transverse rib. Single ribs intercalate, and have a comparable ventrolateral and ventral development. The ventrolateral tubercles are lost on the adapertural end of the body chamber, where primary and long intercalated ribs alternate regularly.

DISCUSSION: See Wright and Kennedy (1984, p. 103).

OCCURRENCE: Lower Cenomanian, southern England, Northern Ireland, France from the Boulonnais south to Bouches-du-Rhône, Algeria, Central Tunisia, Madagascar, Tamil Nadu, and possibly Germany and Iran.

Mantelliceras saxbii (Sharpe, 1857)
(Pl. 20, Figs 1, 2, 9–12)

1857. *Ammonites Saxbii* Sharpe, p. 45, pl. 20, fig. 3.
1984. *Mantelliceras saxbii* (Sharpe, 1857); Wright and Kennedy, p. 121, pl. 23, fig. 4; pl. 32, figs 1–3; pl. 33, figs 1–4; pl. 34, figs 1–4; pl. 35, figs 1–5; pl. 36, figs 2, 3; pl. 39, fig.1; text-figs 25b–d, i; 26b; 28 l–p (with synonymy).
1998. *Mantelliceras saxbii* (Sharpe, 1857); Kaplan *et al*., p. 118, pl. 18, figs 1, 9; pl. 20, fig.1; pl. 24, fig. 3; pl. 26, figs 7, 8; pl. 41, figs 2, 4 (with additional synonymy).
2011. *Mantelliceras saxbii* (Sharpe, 1857); Mosavinia and Wilmsen, p. 182, text-fig. 4c, f, g (with additional synonymy*)*.
2015. *Mantelliceras saxbii* (Sharpe, 1857); Kennedy in Morel, p. 137, text-fig. 130d.
2015. *Mantelliceras saxbii* (Sharpe, 1857); Kennedy in Kennedy and Gale, p. 267, pl. 7, fig. 4; pl. 8, fig. 4 (with additional synonymy).

LECTOTYPE: BGS GSM 7763, the original of Sharpe 1857, pl. 20, fig. 3, by the subsequent designation of Wright and Wright 1951, p. 38. It was refigured by Wright and Kennedy (1984, pl. 35, fig. 2), and is from the Lower Cenomanian "Grey Chalk of Ventnor", Isle of Wight, U.K.

MATERIAL: OUM KY4379, from section C–D at the 127 m level; OUM KY3806–3808, from section C–D at the 133 m level. OUM KY2575, from section E–F at the 132.5 m level. All Lower Cenomanian, *mantelli* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY4379	60. 1 (100)	22.6 (37.6)	29.7 (49.4)	0.76	12.3 (20.5)

DESCRIPTION: OUM KY4397 (Pl. 20, Figs 1, 2) is a phragmocone with an estimated original diameter of 65 mm, the maximum preserved whorl height 30 mm. Coiling is moderately involute, the shallow umbilicus comprising 20.5% of the diameter, the low wall convex, the umbilical shoulder quite narrowly rounded. The whorl section is compressed, with a whorl breadth to height ratio of 0.76, the inner flanks subparallel and very feebly convex, the ventrolateral shoulders broadly rounded, the venter feebly convex. There are five primary ribs on the adapical 90° sector of the outer whorl. They arise at the umbilical seam and strengthen into small bullae, perched on the umbilical shoulder. These give rise to prorsiradiate ribs that may bifurcate, whilst both long and short ribs intercalate, to give a total of 12 ribs at the ventrolateral shoulder. The ribs are straight on the inner flank, flexing back on the outer flank and very feebly concave, with small, rounded inner, and stronger clavate outer ventrolateral tubercles, linked across the venter by a strong transverse rib. OUM KY3807 is a fragment with a maximum preserved whorl height of 17 mm with feeble umbilical bullae, feeble inner ventrolateral tubercles and better-developed outer ventrolateral clavi. OUM KY3808 (Pl. 20, Figs 9, 10) is a very crushed180° sector of body chamber with a maximum preserved diameter of 41 mm. Coiling is involute, the umbilical shoulder narrowly rounded, the whorl section compressed, the flanks feebly convex and subparallel, the umbilical shoulder broadly rounded, the venter very feebly convex. There are18 ribs at the ventrolateral shoulder of the fragment. Primary ribs are narrow, straight and feebly prorsirsdiate on the inner flanks, flexing forward and feebly concave on the outer flank, where they broaden.

There are one or more long or short intercalated ribs between successive primaries. All ribs bear small outer ventrolateral clavi, linked across the venter by a well-developed transverse rib.

OUM KY2575 (Pl. 20, Figs 11, 12) is a 240° whorl sector, the crushed internal mould of the body chamber of an adult macroconch, with a maximum preserved diameter of 118 mm and a maximum whorl height of 52.3 mm. Coiling is eccentric , the umbilicus comprising 25.1% of the diameter. There are 25 ribs at the ventrolateral shoulder of the fragment. Primary ribs arise at the umbilical seam, and strengthen across the umbilical wall and shoulder, without developing into a bulla. The ribs are strong, narrower than the interspaces, the primaries alternating with single long or short intercalated ribs, the ribs straight and recti- to feebly prorsiradiate, strengthening across the flanks and venter without developing ventrolateral tubercles.

DISCUSSION: See Wright and Kennedy (1984, p. 123).

OCCURRENCE: Lower Cenomanian, *mantelli* and *dixon*i zones, southern England, France, northern Spain, Switzerland, Poland, Germany, Romania, Bulgaria, Kazakhstan, northern Iran, Turkmenistan, northern Algeria, Central Tunisia, Egypt, Angola, KwaZulu-Natal in South Africa, Madgascar, Tamil Nadu, and Japan.

Mantelliceras cf. *picteti* Hyatt, 1903
(Pl. 22, Figs 1, 2)

Compare:
1903. *Mantelliceras picteti* Hyatt, p. 114 (*pars*).
1984. *Mantellicera picteti* Hyatt, 1903; Wright and Kennedy, p. 117, pl. 27, figs 1–5; pl. 28, figs 1–3; text-figs 25g; 27i, n–q (with full synonymy).

MATERIAL: OUM KY2578, from section E–F at the 148 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: The specimen is the internal mould of a 90° sector of a pathological *Mantelliceras* with a maximum preserved whorl height of 50 mm. It has undergone substantial *post-mortem* crushing. There are ten ribs on the fragment, all primaries. They arise at the umbilical seam, strengthen across the umbilical wall and link to small bullae, perched on the umbilical shoulder. These give rise to single straight ribs, rectiradiate on the innermost flank, and linking to stronger inner lateral tubercles, from which the ribs flex back, strengthen, and are feebly rursiradiate, linking to a single ventral tubercle.

DISCUSSION: See Wright and Kennedy (1984, p. 118) for a discussion of the species.

OCCURRENCE: Lower Lower Cenomanian, southern England, France, northern Spain, Switzerland, Crimea, Iran, Madagascar, and, possibly, Tamil Nadu.

Mantelliceras spp. juv.
(Pl. 16, Figs 6, 10–13)

DISCUSSION: The Karai Formation shales on the north side of the Karai–Kulakkalnattam road yielded nucei of *Mantelliceras* up to 20 mm in diameter at the 345–350 and 355–359 m levels. Specimens such as OUM KY5531b (Pl. 16, Fig. 6), 5531d (Pl. 16, Figs 10, 11) and 5569, with alternating primary ribs with subequal umbilical, lateral, inner and outer ventrolateral tubercles and intercalated ribs with inner and outer ventrolateral tubercles only, can be compared with *Mantelliceras mantelli*, such as the smaller individuals figured by Wright and Kennedy (1984, pl. 19, figs 2, 4). Others, such as KY5531a and KY5658a (Pl. 16, Figs 12, 13), have weak umbilical bullae, strong inner lateral and weak inner and outer ventrolateral tubercles on primary ribs alternating with intercalated ribs with inner and outer ventrolateral tubercles only. This pattern of tuberculation, particularly the strong inner lateral tubercle are a feature of *Mantelliceras cantianum*, as seen in the smallest specimen figured by Wright and Kennedy (1984, pl. 24, fig. 4).

OCCURRENCE: As for material.

Genus *Sharpeiceras* Hyatt, 1903

TYPE SPECIES: *Ammonites laticlavius* Sharpe, 1855, p. 31, pl. 14, fig. 1, by the original designation of Hyatt, 1903, p. 111.

Sharpeiceras indicum (Kossmat, 1897)
(Pl. 22, Figs 5, 6)

1895. *Acanthoceras laticlavium* Sharpe sp., nov. var. *indica* Kossmat, p. 199 (103), pl. 24 (10), figs 5, 6.
1987. *Acanthoceras laticlavium* var. *indica* Kossmat; Wright and Kennedy, p. 127.

TYPE: The lectotype, here designated, of *Sharpeiceras indicum* is GSI 14829, the original of Kossmat (1895, pl. 24 (10), fig. 5), from Odiyam, a cast of which (OUM KY962), is figured here (Pl. 22, Figs 5, 6). The

paralectotype (Kossmat 1895, pl. 24 (10), fig. 6) is from Uttatur.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY962 at*	97.4 (100)	33.0 (33.9)	44.0 (45.2)	0.75	27.1 (27.9)

*Cast of the holotype.

DESCRIPTION: The cast of the holotype has a maximum preserved diameter of 130 mm. The original specimen retains some body chamber, but the position of the final septum cannot be established from the cast. Coiling is evolute, the umbilicus of moderate depth, and comprising 27.8% of the diameter, with a flattened wall and broadly rounded umbilical shoulder. There are 22 umbilical bullae of variable strength present on the umbilical shoulder of the outer whorl. They give rise to predominantly single ribs with a few giving rise to pairs of ribs, most notably on the adapertural 120° sector of the outer whorl. There are a few intercalated ribs, to give a total of 30 ribs at the ventrolateral shoulder. The ribs are straight, and vary from feebly prorsi- to feebly rursirsdiate. The primaries bear a weak lateral bulla just below mid-flank, a stronger conical to feebly bullate inner ventrolateral tubercle, linked by a strong rib to an outer ventrolateral clavus. The clavi are linked across the venter by a low, broad, transverse rib. The intercalated ribs bear lateral, inner and outer ventrolateral tubercles.

DISCUSSION: The distinctive features of *Sharpeiceras indicum* are the evolute coiling, the whorl section, less compressed and lower than in *Sharpeiceras laticlavium*, which has weaker ribs. See Wright and Kennedy (1987, pp. 127, 128) for a review of *Sharpeiceras* species.

OCCURRENCE: Lower Cenomanian, Tamil Nadu.

Sharpeiceras florencae Spath, 1925b

1925. *Sharpeiceras florencae* Spath, p. 198, pl. 37.
2015. *Sharpeiceras florencae* Spath, 1925; Kennedy *et al*., p. 14, text-figs 7g–j, p, q, u, w; 12j, k, p, q; 16f–h; 17f–I; 19; 20; 21; 22c–e (with full synonymy).
2015. *Sharpeiceras florencae* Spath, 1925; Kennedy in Kennedy and Gale, p. 276, pl. 11, fig. 3; text-fig. 19.

TYPE: The holotype, by monotypy, is the original of Spath 1925b, p. 198, pl. 37, in the collections of the Ditsong Museum of Natural History (formerly the Transvaal Museum), Pretoria, from northeastern KwaZulu-Natal, South Africa ('Maputoland').

MATERIAL: OUM KY4296, from section D at the 53–60 m level, Lower Cenomanian, *mantelli* Zone

DESCRIPTION: The specimen is an internal mould of a180° sector of body chamber 250 mm in diameter with a maximum preserved intercostal whorl height of 80 mm. Coiling is evolute, the intercostal whorl section depressed, with a whorl breadth to height ratio of 1.1, the greatest breadth below mid-flank. The umbilical shoulder is broadly rounded, the flanks feebly convex, the ventrolateral shoulder broadly rounded, the venter feebly convex. Six very coarse, widely separated rectiradiate primary ribs are present on the fragment. The umbilical margin is missing. There are massive mid-lateral tubercles, a massive conical inner ventrolateral horn and a strong outer ventrolateral clavus, horn and clavus borne on a massive rib termination. The venter is smooth between the outer ventrolateral clavi.

DISCUSSION: See Kennedy *et al.* (2015, p. 15).

OCCURRENCE: Lower Cenomanian of northeastern KwaZulu-Natal, South Africa ('Maputoland'), Madagascar, Tamil Nadu, Angola, Peru, and northern Mexico.

Sharpeiceras sp.
(Pl. 21, Figs 6, 7)

1987. *Sharpeiceras* sp. Wright and Kennedy, p. 129, pl. 41, fig. 2; text-fig. 34b.

MATERIAL: OUM KY2646, from section G–H at the 160 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: The specimen is a 120° sector of body chamber with a maximum preserved measurable whorl height of 50 mm. The intercostal whorl section is depressed, with flattened subparallel flanks, broadly rounded ventrolateral shoulders and a flattened venter. The costal section is polygonal, with the greatest breadth at the lateral tubercle. There are ten ribs on the fragment, primaries and intercalated ribs alternating regularly. The primary ribs arise at the umbilical seam and link to strong umbilical tubercles that give rise to coarse straight prorsiradiate ribs that bear a strong lateral bulla, conical inner ventrolateral tubercles, linked by a strong rib to a strong outer ventrolateral clavus, the clavi linked across the

venter by a low, broad, transverse rib. The ventral costal profile is concave between the outer ventrolateral clavi.

DISCUSSSION: The present specimen is much more coarsely ribbed than the lectotype of *Sharpeiceras indicum* (Pl. 22, Figs 5, 6*)*. It compares well with the *Sharpeiceras* sp. of Wright and Kennedy (1987 p. 129, pl. 41, fig. 2; text-fig. 34b), and like that specimen is left in open nomenclature.

OCCURRENCE: Lower Cenomanian of southern England and Tamil Nadu.

Genus *Utaturiceras* Wright, 1956

TYPE SPECIES: *Ammonites vicinalis* Stoliczka, 1864, p. 84, pl. 44, figs 1, 4, 5, 7, 8, *non* 2, 3, 6, by the original designation of Wright 1956, p. 392.

Utaturiceras vicinale (Stoliczka, 1865)

(Pl. 20, Fig. 12; Pl. 23, Figs 1–8; Pl. 24, Fig. 5; Text-fig. 19)

1864. *Ammonites vicinalis* Stoliczka, p. 84, pl. 44, figs 1, 4, 5, 7, 8, *non* 2, 3, 6.
1996. *Utaturiceras vicinale* (Stoliczka, 1964); Wright and Kennedy, p. 399, pl. 122, fig. 1; text-fig. 156 (with full synonymy).
2003. *Utaturiceras vicinale* (Stoliczka, 1864); Matsumoto *et al*., p. 135, text-figs 4, 5.
2015. *Utaturiceras vicinale* (Stoliczka, 1864); Kennedy *et al*., p. 9, text-figs 7a–d; 8a–f.

TYPES: The lectotype, by the subsequent designation of Matsumoto and Sarkar 1966, p. 298, is GSI 190, from Odiyam. A cast is figured here as Text-fig. 19. There are seven paralectotypes, not all of which belong to *U. vicinale* (Matsumoto and Sarkar 1966, p. 298).

MATERIAL: OUM KY3654–3658, KY4359, from section C–D at the 79 m level. Lower Cenomanian, *mantelli* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3567	53.3 (100)	– (–)	28.9 (54.2)	– (–)	8.3 (13.6)
OUM KY3655	108.0 (100)	36.5 (33.8)	52.7 (48.8)	0.69	20.0 (18.5)
OUM KY3654	112.0 (100)	39.3 (35.1)	56.3 (50.3)	0.70	18.6 (16.6)

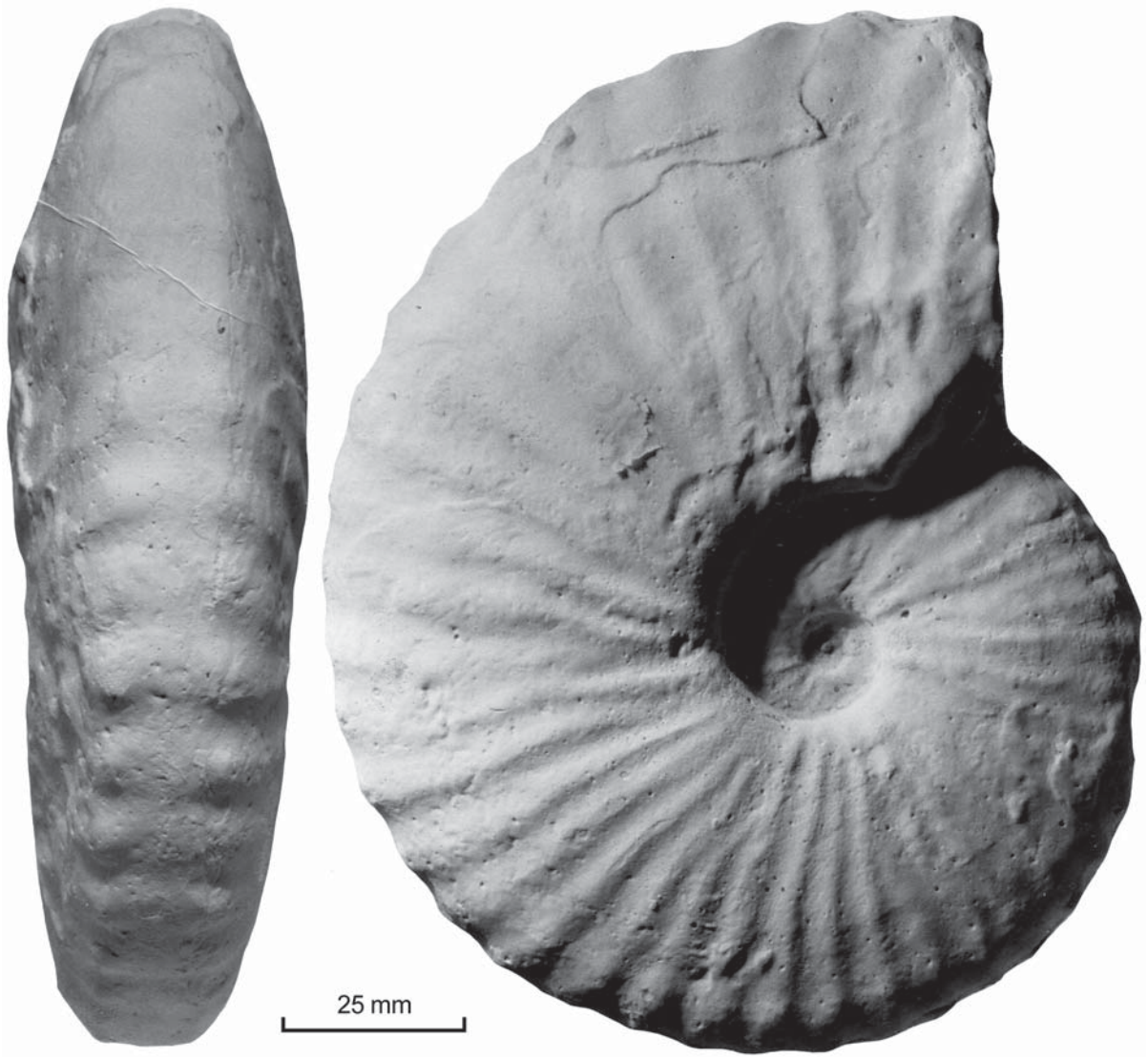
DESCRIPTION: Coiling is involute, the small, shallow umbilicus comprising between 13.6 and 16.6% of the diameter. The umbilical wall is low and convex, the umbilical shoulder narrowly rounded. The whorl section is compressed, the whorl breadth to height ratio of juveniles is 0.69–0.7. The inner flanks are feebly convex and subparallel, the outer flanks converging to rounded ventrolateral shoulders, the venter very feebly convex. There are 18–20 ribs per half whorl at the ventrolateral shoulder. Most are primaries that arise on the umbilical wall and strengthen across the umbilical shoulder without developing into a bulla. They are straight, crowded and prorsiradiate on the inner flank, flexing back and very feebly convex on the outer flank, across which they broaden and strengthen markedly, and link to tiny ventral clavi. There are a few intercalated ribs. Juveniles (Pl. 23, Figs 1–5) lack ventral ribs, and have a feeble siphonal ridge.

OUM KY4359 (Pl. 20, Fig. 12; Pl. 23, Fig. 6) is an adult body chamber 130 mm in diameter with one flank worn away. The shallow umbilicus comprises 21.5% of the diameter, the umbilical wall low and feebly convex, the umbilical shoulder quite broadly rounded. Primary ribs of variable strength arise at the umbilical seam, and some but not all strengthen across the umbilical shoulder, where others remain weak. The ribs are near-straight and prorsiradiate, broadening across the flanks, and becoming very broad on the outermost flank. There is a low, broad spiral depression on the outer flank, beyond which the ribs develop a low, feeble rounded tubercle, linked by a low, broad rib to well-developed ventral clavi, linked across the venter by a low, broad, transverse rib.

The suture is quite deeply incised with a broad bifid E/A and a narrower A.

DISCUSSION: As noted by Kennedy *et al.* (2015, p. 9), *Utaturiceras discoidale* (Kossmat, 1895) (p. 210 (105), pl. 25 (11), fig. 1; see also Matsumoto *et al*. 2003, p. 138), from Odiyam, is much more evolute, with a stouter whorl section, and coarser, distant ribs, 34 on the outer whorl, with strong inner and outer ventrolateral tubercles retained to maturity. *Utaturiceras chrysanthemum* Matsumoto, Nishida and Toshimitsu, 2003 (p. 138, figs 6–8) has an oval rather than rectangular-trapezoidal whorl section, much coarser, distant, flexuous ribs, the umbilical bullae effacing on the body chamber, the inner and outer ventrolateral tubercles merging.

OCCURRENCE: Lower Cenomanian of Tamil



Text-fig. 19. *Utaturiceras vicinale* (Stoliczka, 1864). Cast of the lectotype, GSI 190, the original of Stoliczka 1864, p. 84, pl. 44, fig. 8, from the Uttatur group of Odiyam

Nadu, Madagascar, northern KwaZulu-Natal in South Africa, Japan, and southern England.

Subfamily Acanthoceratinae de Grossouvre, 1894
Genus *Acompsoceras* Hyatt, 1903

TYPE SPECIES: *Ammonites bochumensis* Schlüter, 1871, p. 1, pl. 1, figs 1–4, by original designation by Hyatt, 1903, p. 111 = *Ammonites renevieri* Sharpe, 1857, p. 44, pl. 20, fig. 2.

Acompsoceras renevieri (Sharpe, 1857)
(Pl. 24, Figs 1–4, 8; Text-fig. 16D)

1857. *Ammonites Renevieri* Sharpe, p. 44, pl. 20, fig. 2.
1987. *Acompsoceras renevieri* (Sharpe, 1857); Wright and Kennedy, p. 140, pl. 43, fig. 2; text-figs 34g; 35d–f ; 36a–f; 37–40; 43d, e (with full synonymy).
1998. *Acompsoceras renevieri* (Sharpe, 1857); Kaplan *et al.*, p. 136, pl. 10, figs 6, 7; pl. 34; pl. 35; pl. 36, figs 1–3, pl. 37, figs 4–6; pl. 38; pl. 40; pl. 41, figs 1, 5 (with additional synonymy).

2015. *Acompsoceras renevieri* (Sharpe, 1857); Kennedy in Morel, p. 139, text-figs 107, 132b–c.
2015. *Acompsoceras renevieri* (Sharpe, 1857); Kennedy in Kennedy and Gale, p. 279, pl. 12, figs 1–3, 5–7; pl. 13, figs 1, 4, 5 (with additional synonymy).
2015. *Acompsoceras renevieri* (Sharpe, 1857);Meister and Piuz, p. 30, pl. 6, fig. 1; pl. 7, figs 1, 2; pl. 8, fig. 1.
2017. *Acompsoceras renevieri* (Sharpe, 1857); Kennedy in Kennedy and Gale, p. 91, pl. 5, figs 7–14 (with additional synonymy).
2018. *Acompsoceras renevieri* (Sharpe, 1857); Gale, Simms and Kennedy, p. 113, text-fig. 10a–c, f.

TYPES: The lectotype, designated by Wright and Wright (1951, p. 38), is GSM 7753 (figured by Wright and Kennedy 1987 pl.43, fig. 2), from Blackdown, Isle of Wight, the original of Sharpe 1857, pl. 20, fig. 2. The paralectotypes have not been traced.

MATERIAL: OUM KY3659, KY3660, from the 79 m level; OUM KY4364, from the 82 m level; OUM KY4365, from the 90 m level, section C–D, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: OUM KY3660 (Pl. 24, Figs 1, 2) is the smallest specimen seen, a 180° sector of phragmocone with a maximum preserved diameter of 64 mm. Coiling is moderately involute, the umbilicus of moderate depth with a feebly convex wall and broadly rounded umbilical shoulder. The intercostal whorl section is compressed, with the greatest breadth below mid-flank, the inner to mid-flank region feebly convex, subparallel, the outer flanks converging to broadly rounded ventrolateral shoulders and a flattened venter. The costal whorl section is also compressed, with a costal whorl breadth to height ratio of 0.82. Five ribs arise at the umbilical seam, strengthen across the umbilical wall and shoulder, where they develop into a narrow umbilical bulla. The bullae give rise to single straight rectiradiate ribs that link to conical inner ventrolateral tubercles, linked in turn by a strong rib to a stronger feebly clavate outer ventrolateral tubercle, the ventrolateral tubercles linked across the venter by a low, broad, transverse rib. Single ribs intercalate between successive primaries, arising low on the flanks; in one case a rib is feebly linked to an umbilical bulla. They bear inner and outer ventrolateral tubercles and have a ventral development comparable to that of the primary ribs. OUM KY3659 (Pl. 24, Figs 3, 4) is a 120° whorl fragment with a maximum preserved whorl height of 44 mm approximately; it is in part body chamber. The inner ventrolateral tubercles weaken progressively, whereas the ventral development of the ribs is stronger than in the previous specimen. OUM KY4364 (Pl. 24, Fig. 8) is a near-complete individual that retains a 180° sector of body chamber, and appears to be a near-complete adult, with an estimated maximum preserved diameter of 120 mm. The umbilicus comprises 18% approximately of the diameter. Twelve to thirteen strong ribs arise at the umbilical seam and strengthen across the umbilical wall and shoulder, where most, but not all develop into narrow bullae. The ribs are straight and prorsiradiate, and bear conical inner, and clavate outer ventrolateral tubercles, linked across the venter by a very broad, coarse, transverse rib.

The suture (Text-fig. 16D) is deeply incised, E/A is broad and bifid, with subphylloid folioles; A is narrow.

DISCUSSION: See Wright and Kennedy 1987, p. 140.

OCCURRENCE: Lower Cenomanian, *M. dixoni* Zone, and lower Middle Cenomanian *C. inerme* Zone and correlatives. The geographic distribution extends from southern England to Germany, Haute Normandie, Sarthe, and Provence in France, Poland, Algeria, central Tunisia, Oman, Iran, Nigeria (?), Madagascar, and Tamil Nadu.

Genus *Cunningtoniceras* Collignon, 1937

TYPE SPECIES: *Ammonites cunningtoni* Sharpe, 1855, p. 35, pl. 15, fig. 2; by the original designation of Collignon 1937, p. 64 (40).

Cunningtoniceras cunningtoni (Sharpe, 1855)
(Pls 25; 26; Pl. 27, Figs 1–4; Pl. 37, Figs 5, 6)

1855. *Ammonites cunningtoni* Sharpe, p. 35, pl. 15, fig. 2.
1897. *Ammonites cunningtoni* var. *cornuta* Kossmat, p. 11 (18), pl. 5 (16), fig. 1.
non 1907. *Acanthoceras cunningtoni* Sharpe; Pervinquière, p. 277, pl. 15, fig. 1 (= *Cunningtoniceras africanum* (Pervinquière, 1907)).
1925. *Acanthoceras cunningtoni* Sharpe; Diener, p. 159 (*pars*).
non 1928. *Acanthoceras Cunnningtoni* Sharpe var.; Böse, p. 201, pl. 2, fig. 1; pl. 3, figs 1–3 (= *Graysonites* sp.).
non 1933. *Acanthoceras Cunningtoni* Sharpe; Collignon, p. 62, text-figs 2, 3 (indeterminate).
1937. *Cunningtoniceras cunningtoni* Sharpe; Collignon, p. 64 (40).

1951. *Euomphaloceras euomphalum* (Sharpe); Wright and Wright, p. 29 (*pars*).
1964. *Euomphaloceras euomphalum* var. *pervinquierei* Collignon, p. 145, pl. 373, fig. 1619.
1971. *Euomphaloceras cunningtoni* (Sharpe); Kennedy, p. 92, pl. 60, fig. 1; pl. 61, fig. 2.
1972. *Euomphaloceras cunningtoni* (Sharpe); Thomel, p. 163, pl. 71, fig. 4; pl. 83; pl. 85, fig. 2; pl. 86, figs 1, 2; pl. 86, figs 1–6.
1978. *Euomphaloceras cunningtoni* (Sharpe); Wiedmann and Kauffman, pl. 5, fig. 5.
1980. *Euomphaloceras cunningtoni* (Sharpe); Wiedmann, pl. 5, fig. 5.
1982. *Euomphaloceras cunningtoni* (Sharpe); Martinez, p. 102, pl. 14, fig. 3.
non 1984. *Euomphaloceras cunningtoni* (Sharpe); Seyed-Emami *et al*., p. 160, figs 2.1, 5.3 (= *C. meridionale*).
non 1985. *Euomphaloceras cunningtoni cunningtoni* (Sharpe); Zaborski, p. 45, figs 47–52 (= *C. meridionale*).
1987. *Cunningtoniceras cunningtoni* (Sharpe, 1855); Wright and Kennedy, p. 196 (*pars*), pl. 52, fig. 2; pl. 53, fig. 4; text-figs 76–78.
1991. *Cunningtoniceras cunningtoni* (Sharpe, 1855); Delamette and Kennedy, p. 465, fig. 16.1–16.3.
1992. *Cunningtoniceras cunningtoni* (Sharpe, 1855); Thomel, pl. 38, figs 1, 2; pl. 39, fig. 1; pl. 40, fig. 1.
1993. *Cunningtoniceras cunningtoni* (Sharpe, 1855); Kennedy and Juignet, p. 174, fig. 15c, d; 21c; 37c, d.
1998. *Cunningtoniceras cunningtoni* (Sharpe, 1855); Kaplan *et al*., p. 146, pl. 56, fig. 5; pl. 57.
non 1999. *Cunningtoniceras cunningtoni* (Sharpe, 1855); Hayakawa and Nishida, p. 8, pl. 11, figs a–g; pl. 12, figs a–c (= *C. meridionale*).
non 2011. *Cunningtoniceras cunningtoni* (Sharpe, 1855); Mosavina and Wilmsen, p. 184, figs 6a, b; 7a, b (= *C. meridionale*)
2015. *Cunningtoniceras cunningtoni* (Sharpe, 1855); Kennedy in Kennedy and Gale, p. 284 *et seq*.

TYPE: The holotype, by monotypy, is BMNH 88704, the original of Sharpe 1855, p. 35, pl. 15, fig. 2. It was refigured by Wright and Kennedy 1987, text-figs 76–77.

MATERIAL: From section I–J: OUM KY3001, at the 13 m level; OUM KY3019, 3020, at the 20.5 m level; OUM KY4396–4400, at the 20–21 m level; from the section on the north side of the Karai–Kulakkalnattam road at the 408 m level, OUM KY6031–6035; all Middle Cenomanian *cunningtoni* Zone.

DESCRIPTION: OUM KY3001 (Pl. 37, Figs 5, 6) is an internal mould of a juvenile with a maximum preserved diameter of 53 mm. Coiling is evolute, the umbilicus deep, with a feebly convex wall and broadly rounded umbilical shoulder, the umbilical seam notched to accommodate the inner ventrolateral horns of the preceding whorl. The intercostal whorl section is depressed, the flanks feebly convex, the ventrolateral shoulders broadly rounded, the venter feebly convex. The costal whorl section is depressed polygonal, with the greatest breadth at the inner ventrolateral horns. There are 19 ribs at the ventrolateral shoulder of the outer whorl. Nine of these occupy the adapertural half of the outer whorl, and all are primaries. They arise at the umbilical seam, and strengthen across the umbilical wall and shoulder, where they develop into strong umbilical bullae. These are linked by a strong rectiradiate rib to a strong outwards and upwards directed inner ventrolateral horn. On the adapical half of the outer whorl, a broad, coarse rib links the horns across the venter, and bears subequal outer ventrolateral and siphonal tubercles. In contrast, on the adapertural half of the outer whorl, a pair of ribs with rounded to transversely elongated siphonal tubercles link the outer ventrolateral clavi across the venter. There are thus twice as many siphonal as outer ventrolateral tubercles at this growth stage, whereas in the preceding growth stage, the numbers are equal.

OUM KY3019 (Pl. 26) is a near-complete adult microconch, an internal mould retaining a 180° sector of body chamber. The maximum preserved costal diameter is 145 mm; the phragmocone is approximately 95 mm in diameter. Coiling is very evolute, the umbilical seam of the deep umbilicus notched to accommodate the ventrolateral horns of the preceding whorl. The umbilicus comprises 30% of the costal diameter. The whorl section is very depressed in intercostal section, the umbilical shoulder broadly rounded, the flanks convex, the ventrolateral shoulders broadly rounded, the venter broad, and very feebly convex. Fourteen coarse ribs arise at the umbilical seam and strengthen across the umbilical wall and shoulder, where they develop into a pinched bulla, from which a straight prorsiradiate rib broadens and strengthens across the flanks, and links to a massive conical outward and slightly upwards directed ventrolateral horn. A broad, very feebly prorsiradiate rib links to a coarse, blunt outer ventrolateral clavus, the clavi linked

across the venter by a pair of ribs that bear a blunt, transversely elongated siphonal clavus. One or two ribs, restricted to the venter, intercalate between and bear a transversely elongated siphonal tubercle only. Four primary ribs are present on the well-preserved adapical 120° sector of body chamber. The umbilical bullae strengthen and are massive, the ribs coarse and widely separated on the flanks, the inner ventrolateral horns much stronger than on the phragmocone, and linked to the outer ventrolateral clavi by a coarse, high rib. On the adapicalmost primary rib, three ventral ribs link the outer ventrolateral clavi across the venter and bear a transversely elongated siphonal tubercle. One or two ribs with siphonal tubercles only intercalate between. By the second rib the siphonal clavi are lost; by the third rib the venter is near-smooth between the outer ventrolateral tubercles, which are linked across the venter by a single low, broad undulation that barely rises above the level of the interspace.

OUM KY3020 is a complete adult macroconch with a maximum preserved diameter of 210 mm. Ornament on the phragmocone (Pl. 25) is as on the microconch phragmocone, with an estimated 16 primary ribs per whorl. The specimen retains a 120° sector of body chamber. The pattern of ribs and tubercles modifies on the adapertural 90° sector of the phragmocone, the outer ventrolateral clavi are linked at first by a pair of nontuberculate ribs, then a single low, broad, transverse rib, feebly strengthened at mid-venter.

OUM KY4398 (Pl. 27, Figs 1, 2) is a distorted 120° whorl sector with a maximum preserved whorl height of 20 mm approximately. Six coarse ribs arise at the umbilical seam, strengthen across the umbilical wall, and link to subspinose umbilical bullae from which single coarse straight prorsiradiate ribs link to huge upward and outward-directed inner ventrolateral horns. The specimen lacks outer ventrolateral tubercles, the inner ventrolateral horns linked across the venter by pairs of ribs, one bears a siphonal tubercle, the others do not. Additional ventral ribs intercalate, and also lack siphonal tubercles. The specimen is interpreted as a pathological *cunningtoni*.

DISCUSSION: The interpretation of *Cunningtoniceras* species applied here follows that of Kennedy in Kennedy and Gale (2015, p. 284), with the recognition of *C. cunningtoni*, with fewer outer ventrolateral than siphonal tubercles, and *C. meridionale* (Stoliczka, 1864) (p. 76, pl. 41, fig. 1), with equal numbers of outer ventrolateral and siphonal tubercles. See Kennedy in Kennedy and Gale 2015 (pp. 284 *et seq*) and in Kennedy and Gale 2017 (p. 92 *et seq*.) for a full account of the differences between *C. cunningtoni*, *C. africanum* (Pervinquière, 1907), *C. inerme* (Pervinquière, 1907), and *C. meridionale*.

OCCURRENCE: Lower Middle Cenomanian *inerme* Zone and the correlative *cunningtoni* Zone as used herein. Southern England, France, Spain, Switzerland, Germany, Madagascar, and Tamil Nadu,

Cunningtoniceras sp.
(Pl. 27, Figs 5–8)

MATERIAl: OUM KY2706, from section G–H at the 169 m level, lower Middle Cenomanian *cunningtoni* Zone.

DESCRIPTION: A 180° sector of the penultimate whorl (Pl. 27, Figs 6, 7) is 43 mm in diameter, with a depressed rounded-rectangular intercostal whorl section and a polygonal costal section, the greatest breadth at the umbilical bullae. Four ribs arise at the umbilical seam, strengthen across the umbilical wall and shoulder and link to very strong subspinose umbilical bullae. These give rise to broad prorsiradiate ribs that link to strong subspinose inner ventrolateral tubercles, from which a broad prorsiradiate rib links to a strong outer ventrolateral clavus, the clavi linked across the venter by a broad transverse rib that bears a strong siphonal clavus. Single ribs intercalate between successive primaries and have a comparable ventrolateral and ventral development, to give a total of eight ribs at the ventrolateral shoulder. The outer whorl (Pl. 27, Figs 5, 8) is almost wholly septate, retaining a short sector of body chamber; the greatest preserved diameter is 103mm. The deep umbilicus comprises 36% of the diameter, the umbilical seam notched to accommodate the inner ventrolateral tubercles of the preceding whorl. The umbilical wall is convex, the umbilical shoulder broadly rounded. The intercostal whorl section is depressed, rounded-rectangular, the intercostal whorl breadth to height ratio 1.33. The costal whorl section is polygonal, the greatest breadth at the inner ventrolateral horns, the costal whorl breadth to height ratio 1.38. There are eight primary ribs on the fragment. They arise at the umbilical seam, and are narrow and widely separated on the umbilical wall and shoulder, where they develop into a strong pinched umbilical bulla, from which a broad, feeble rursiradiate rib links to a massive inner ventrolateral horn. A low, transverse rib links to a long, low outer ventrolateral clavus, or, in one case, a pair of outer ventrolateral clavi. The siphonal clavi are

twice as numerous as the outer ventrolateral. The suture is deeply incised, with a broad, bifid E/A, narrower A, and smaller bifid A/U2.

DISCUSSION: The presence of more siphonal than outer ventrolateral tubercles on the outer whorl indicates affinities with *Cunningtoniceras cunningtoni*, from which the present specimen differs in the presence of equal numbers of outer ventrolateral and siphonal tubercles on the penultimate whorl, as in *Acanthoceras* Neumayr, 1875, to which it may be a passage form. It is left in open nomenclature at this time.

OCCURRENCE: As for material.

Genus *Acanthoceras* Neumayr, 1875

TYPE SPECIES: *Ammonites rhotomagensis* Brongniart, 1822, pp. 83, 391, pl. 6, fig. 2, by the subsequent designation of de Grossouvre, 1894, p. 27.

Acanthoceras rhotomagense (Brongniart, 1822)
(Pl. 28, Figs 5–7, 9–10)

1822. *Ammonites rhotomagensis* Defr.; Brongniart, pp. 83, 391, pl. 6, fig. 2.
1987. *Acanthoceras rhotomagense* (Brongniart, 1822); Wright and Kennedy, p. 156, pl. 42, fig. 8; pl. 44, figs 1–11; pl. 45, figs 1–5; pl. 46, figs 1–4, 6; pl. 47, figs 1, 2; pl. 48, figs 1, 2; pl. 49, figs 1, 5, 6; text-figs 47–54; 63f–j; 64a, b; 65a–d, k, 66d, f, g, j; 67a–g; 68; 69 (with full synonymy).
2015. *Acanthoceras rhotomagense* (Brongniart, 1822); Kennedy in Kennedy and Gale, p. 283, pl. 14, figs 5, 6; pl. 16, figs 8, 9 (with additional synonymy).
2015. *Acanthoceras rhotomagense* (Brongniart, 1822); Kennedy in Morel, p. 140, text-fig. 133a–f.
2018. *Acanthoceras rhotomagense* (Brongniart, 1822); Gale *et al*., p. 114, text-fig. 11.

TYPE: The lectotype by the subsequent designation of R. Douvillé (1904) is MNHN. F. J04190, the original of Brongniart, 1822, pl. 6, fig. 2, from Rouen, Seine-Maritime, France. It was refigured by, amongst others, Wright and Kennedy (1987, text-fig. 63f–h).

MATERIAL: OUM KY2689, from section G–H at the 170–175 m level; OUM KY2778 from the 177 m level; OUM KY2790, from the 177–181 m level, all Middle Cenomanian *asiaticum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2790	43.7 (100)	27.2 (62.2)	20.7 (47.3)	1.3	12. 4 (28.4)
OUM KY2778	91.9 (100)	– (–)	42.7 (46.4)	–	27.7 (30.1)

DESCRIPTION: OUM KY2790 (Pl. 28, Figs 5, 6) is a juvenile 43.7 mm in diameter, retaining extensive areas of shell material. Coiling is moderately evolute, the umbilicus deep, the umbilical wall convex, the umbilical shoulder broadly rounded, the whorl section depressed, the flanks feebly convex in intercostal section, with broadly rounded ventrolateral shoulders, and a broad, very feebly convex venter. The costal whorl section is polygonal, with the greatest breadth at the inner ventrolateral tubercles, the whorl breadth to height ratio 1.3. Ten ribs arise at the umbilical seam of the outer whorl, strengthen across the umbilical wall and shoulder, and develop into strong umbilical bullae. These give rise to single broad, coarse, prorsiradiate ribs that strengthen across the flanks and link to a conical inner ventrolateral tubercle, linked by a broad transverse rib to a strong outer ventrolateral clavus, the clavi linked over the venter by a broad transverse rib that bears a strong siphonal clavus. There are occasional intercalated ribs on the adapical part of the outer whorl as well as non-bullate primary ribs, all with the same ventrolateral development as the bullate primaries, to give a total of 17–18 ribs per whorl at the ventrolateral shoulder.

OUM KY2778 (Pl. 28, Figs 9, 10). is a wholly septate individual, 91.9 mm in diameter, a relatively gracile variant of the species, with 11 umbilical bullae on the outer whorl, and 12 ribs at the ventrolateral shoulder on the adapical half whorl, including both non-bullate primaries and occasional intercalatories (this specimen matches well with the original of Wright and Kennedy 1987, pl. 46, fig. 6).

OUM KY2689 (Pl. 28, Fig. 7) is a phragmocone 71.9 mm in diameter. An estimated 10 widely separated ribs arise on the umbilical wall, strengthen across the umbilical wall and shoulder, developing into strong umbilical bullae. These give rise to single broad, straight prorsiradiate primary ribs that weaken on the outer flank before strengthening and linking to strong conical to feebly bullate inner ventrolateral tubercles. These are connected to strong outer ventrolateral clavi by a low, broad, feebly prorsiradiate rib. A low, broad transverse rib links the outer ventrolateral clavi to a well-developed siphonal clavus. The primary ribs alternate with single intercalated ribs that arise below mid-flank, strengthen

and match the primary ribs on ventrolateral shoulders and venter (this specimen matches the inner whorls of the holotype of *Acanthoceras vectense* Spath, 1926a, a synonym of *rhotomagense*, figured by Wright and Kennedy 1987, text-fig. 50).

DISCUSSION: See Wright and Kennedy (1987, p. 156), and Kennedy in Kennedy and Gale (2015, p. 283).

OCCURRENCE: Lower Middle Cenomanian. Index of the *rhotomagense* Zone and correlatives, including the lower part of the *asiaticum* Zone as used here. The geographic distribution extends from Northern Ireland through England, France from the Boulonnais to Provence, Switzerland, Germany, Bornholm in the Baltic, northern Spain, Romania, Dagestan, Turkmenistan, northern Iran, Algeria, Tunisia, Tamil Nadu, New Guinea, Japan, and possibly Peru and Bathurst Island, northern Australia.

Acanthoceras whitei Matsumoto, 1959
(Pl. 28, Figs 1–4, 8; Text-fig. 20)

1865. *Ammonites Rotomagensis* Defrance; Stoliczka, p. 66 (*pars*), pl. 35, fig. 3 only.
1889. *Ammonites turneri* White (*non* J. de C. Sowerby 1825), p. 26, pl. 25, figs 1, 2.
1897. *Acanthoceras turneri* Kossmat, p. 2 (109), pl. 1 (12), fig. 1; pl. 3 (14), fig. 3.
1924. *Acanthoceras turneri* (White); Hanna, p. 156.
non 1928. *Acanthoceras* sp. aff. *turneri* C.A. White; Adkins, p. 246, pl. 30, figs 3, 4.
1958. *Calycoceras* (*Eucalycoceras*) *turneri* (White); Anderson, p. 243.
1959. *Acanthoceras whitei* Matsumoto, p. 82, pl. 22, fig. 1; pl. 39, fig. 1; text-fig. 36.
1968. *Acanthoceras turneri* White; Sastry *et al*., p. 14, pl. 2, figs 1, 2.
1987. *Acanthoceras whitei* Matsumoto, 1959; Wright and Kennedy, p. 155, text-fig. 71a–d.

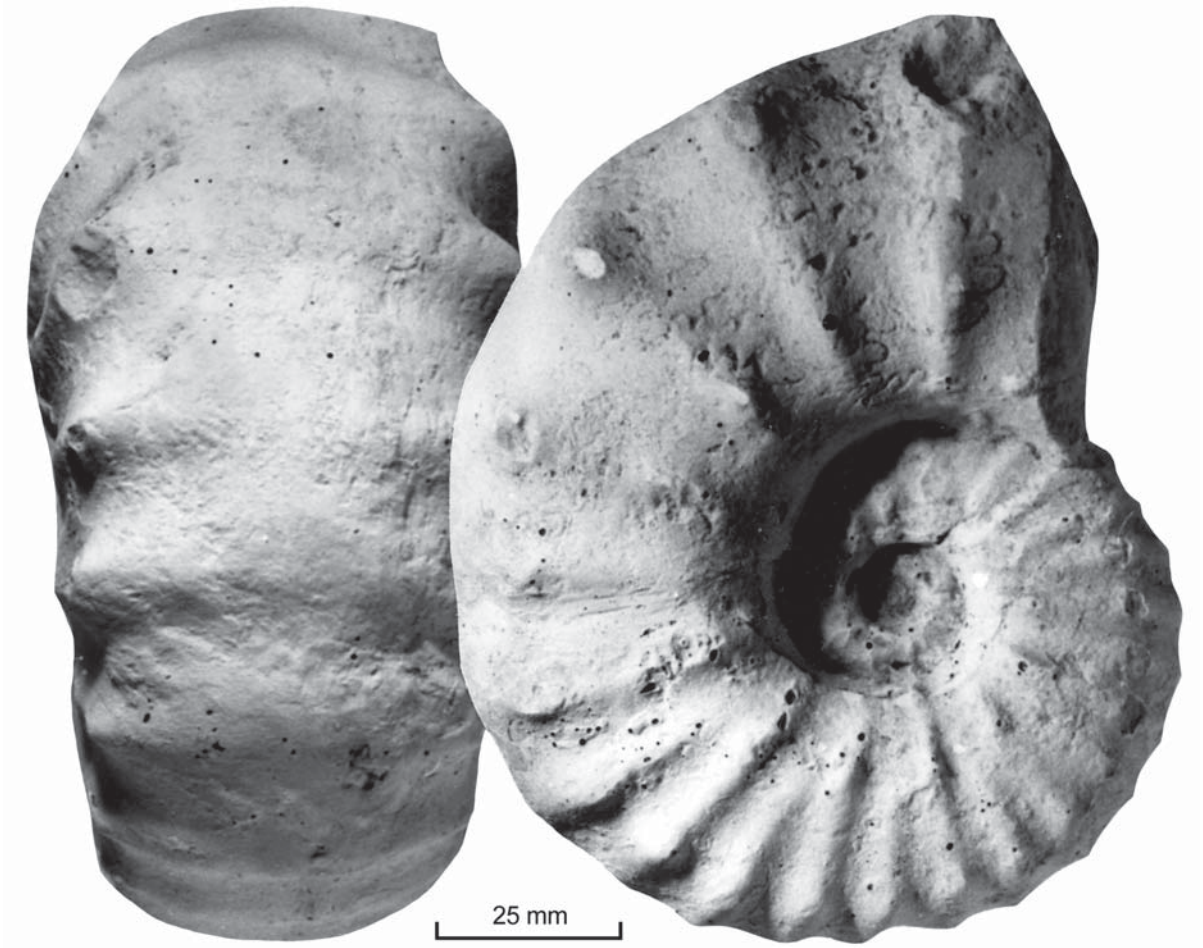
TYPE: The holotype is USNM 20121, the original of *Ammonites turneri* White, 1898 (*non* J. de C. Sowerby 1825), p. 26, pl. 25, figs 1, 2, from Currys Canada, in the Mount Diabolo area, Contra Costa County, California. It was refigured by Matsumoto (1959, pl. 22, fig. 1; pl. 39, fig. 1; text-fig. 36), and Wright and Kennedy (1987, text-fig. 71c, d).

MATERIAL: OUM KY2688, from section G–H at the 170–175 m level. OUM KY2775, from the 175 m level, Middle Cenomanian, *asiaticum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2688 c	71.1 (100)	52.7 (0.74)	34.1 (48.0)	1.55	18.9 (26.6)
OUM KY879 ic at	115.0 (100)	60.2 (52.3)	53.2 (46.3)	1.1	29.5 (25.7)

DESCRIPTION: OUM KY2688 (Pl. 28, Figs 3, 4) is an internal mould of phragmocone with a maximum preserved diameter of 71.1 mm. Coiling is evolute, the deep umbilicus comprising 26.6% of the diameter, the umbilical wall feebly convex, the umbilical shoulder broadly rounded. The whorl section is very depressed, the intercostal section rounded-rectangular, with feebly convex subparallel flanks, broadly rounded ventrolateral shoulders and a very broad, feebly convex venter. The costal whorl section is polygonal, with the greatest breadth at the umbilical bullae; the costal whorl breadth to height ratio is 1.55. Fourteen ribs arise at the umbilical seam of the outer whorl, strengthen across the umbilical wall, and link to sharp, subspinose umbilical bullae. These give rise to single ribs or a pair of ribs, while additional ribs intercalate. The ribs are strong, narrow, recti- to feebly rursiradiate, and link to a well-developed inner ventrolateral bulla. A straight transverse rib extends across the venter and bears weak conical outer ventrolateral tubercles and conical to transversely elongated siphonal tubercles. There are16 ribs at the ventrolateral shoulder of the adapertural half of the outer whorl. OUM KY2775 (Pl. 28, Figs 1, 2,8) is an internal mould of a phragmocone 70 mm in dimeter, worn on one flank. There are 13–14 umbilical bullae on the outer whorl that give rise to single ribs, with additional single ribs intercalating between successive primaries to give a total of 26–27 ribs at the ventrolateral shoulder. All ribs bear a strong conical inner ventrolateral tubercle, linked across the venter by a coarse, blunt transverse rib bearing a weaker outer ventrolateral clavus and a blunt, rounded siphonal tubercle. This specimen overlaps in size with the adapical part of the outer whorl of GSI 14835, the original of Kossmat (1895, pl. 1 (12), fig. 1), from Odiyam, a cast of which (OUM KY879) is figured here (Text-fig. 20). The cast has a maximum preserved diameter of 130 mm. Ornament on the adapical half of the outer whorl is as in the previous specimens. On the adapertural half, the ribs coarsen and become more widely separated; the final four ribs are all bullate primaries, the outer ventrolateral and siphonal tubercles are lost, and the very broad venter is feebly convex in costal section. These changes suggest the specimen to be an incomplete adult.



Text-fig. 20. *Acanthoceras whitei* Matsumoto, 1969. Cast (OUM KY879) of GSI 14835, the original of *Acanthoceras turneri* White sp. of Kossmat 1897, p. 2 (109), pl. 1 (12), fig. 1; pl. 3 (14), fig. 3, from the Uttatur Group of Odiyam

DISCUSSION: *Acanthoceras whitei* resembles *Acanthoceras rhotomagense* in the early loss of intercalated ribs, but is immediately distinguished by the very broad, feebly convex venter, and early loss of outer ventrolateral and siphonal tubercles.

OCCURRENCE: Middle Cenomanian, California; *asiaticum* Zone, Tamil Nadu.

Acanthoceras sp. juv.
(Pl. 16, Figs 14–19)

MATERIAL: OUM KY4018, from section C at the 42–43 m level; OUM KY4337, from section D at the 49 m level, both northwest of Garudamangalam.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY4018 c	16.8 (100)	8.7 (51.8)	7.4 (44.0)	1.2	4.0 (23.1)
OUM KY4337	16.6 (100)	9.3 (56.0)	7.4 (44.6)	1.26	4.4 (26.5)

DESCRIPTION: These well-preserved nuclei are moderately evolute, the deep umbilicus comprising 23–26% of the diameter, the umbilical wall convex, the umbilical shoulder broadly rounded. The whorl section is depressed, rectangular in intercostal section, with broadly rounded ventrolateral shoulders. The costal section is polygonal, with the greatest breadth at the inner ventrolateral tubercle. Ten ribs

per whorl arise at the umbilical seam and strengthen across the umbilical wall, developing into umbilical bullae that give rise to single strong, straight, prorsiradiate ribs, or in a few instances, a pair ribs. Additional ribs intercalate, to give a total of 18–20 ribs at the ventrolateral shoulder. All ribs bear conical to feebly bullate inner ventrolateral tubercles, outer ventrolateral and siphonal clavi.

DISCUSSION: These tiny specimens compare well with individuals of similar size from Madagascar described by Collignon (1928–1929, pl. 17 (3), fig. 1) as *Acanthoceras hippocastanum*. They are specifically indeterminate, and might conceivably be *Cunningtoniceras* nuclei.

OCCURRENCE: As for material.

Genus *Kunnamiceras* gen. nov.

TYPE SPECIES: *Ammonites tropicus* Stoliczka, 1865, p. 78, pl. 43, fig. 2.

DIAGNOSIS: Small. Phragmocone with ribs arising in pairs from umbilical bullae, with conical inner ventrolateral tubercles, outer ventrolateral and siphonal clavi. Ornament modifies progressively on adult body chamber, the ribs projecting forwards and concave on the outer flanks and ventrolateral shoulders, inner ventrolateral tubercles efface, siphonal clavi are lost, and outer ventrolateral tubercles reduced to a mere angulation on the last few ribs, linked across the arched venteer by a coarse transverse rib.

DISCUSSION: Wright and Kennedy (1980, p. 101) considered Stoliczka's *Ammonites tropicus* to be closely related to *Thomelites*. The present material, which includes the early growth stages of *Pseudocalycoceras harpax* (Stoliczka, 1864) (pl. 38, figs 1, 4, 10) confirms Kossmat's view that its affinities lie with *harpax*, although the present interpretation is different from that of Kossmat's and the genus is interpreted as a paedomorphic dwarf offshoot of *Pseudocalycoceras*, on the basis of the similarities between the ornament of juvenile *harpax* and adult *tropicum*. In addition to the type species, *Protacanthoceras imperatoris* Wright and Kennedy, 1980 (p. 97, text-figs 54, 59d), introduced for *Protacanthoceras tropicum* of Collignon, *non* Stoliczka (1937, p. 63, pl. 1, fig.; 1964, p. 146, pl. 373, fig. 1623) is a *Kunnamiceras*.

OCCURRENCE: Lower Upper Cenomanian, *harpax* Zone, Tamil Nadu. Upper Cenomanian of Madagascar.

Kunnamiceras tropicum (Stoliczka, 1865)
(Pl. 29, Figs 5–8)

1865. *Ammonites tropicus* Stoliczka, p. 78, pl. 43, fig. 2.
1898. *Acanthoceras tropicum* (Stoliczka); Kossmat, p. 122 (15).
1925. *Acanthoceras tropicum* (Stoliczka); Diener, p. 166.
non 1937. *Protacanthoceras tropicum* (Stoliczka); Collignon, p. 63, pl. 1, fig. 1 (= *Protacanthoceras imperatoris* Wright and Kennedy, 1980).
non 1964. *Protacanthoceras tropicum* (Stoliczka); Collignon, p. 146, pl. 373, fig. 16231 (= Protacanthoceras imperatoris Wright and Kennedy, 1980).
1972. *Protacanthoceras tropicum* (Stoliczka); Thomel, p. 99.
1980. *Ammonites tropicus* Stoliczka; Wright and Kennedy, p. 101, text-figs 4, 5, 60a–d.

TYPE: The holotype, by monotypy, is the original of Stoliczka 1865, p. 78, pl. 43, fig. 2, from the "Uttatur Group north of Odiyam".

MATERIAL: OUM KY3473, from section R–S at the 5–10 m level, Upper Cenomanian *harpax* Zone.

DESCRIPTION: The specimen is a complete adult body chamber with a maximum preserved diameter of 31.5 mm. Coiling is involute, the shallow umbilicus comprising 25% approximately of the diameter, the low umbilical wall convex and outward-inclined, the umbilical shoulder broadly rounded. The intercostal whorl section is compressed, the feebly convex flanks converging to broadly rounded ventrolateral shoulders, the venter very feebly convex. On the adapical part of the fragment, bullae give rise to pairs of blunt prorsiradiate ribs, with single short ribs intercalating. They link to feeble, near-effaced inner ventrolateral tubercles, project forwards and are concave on the ventrolateral shoulder and link to small outer ventrolateral and siphonal clavi. The ventrolateral and siphonal tubercles weaken and decline, and are absent from the final few ribs. OUMK KY3995, from the Upper Cenomanian *cunningtoni* fauna of section C, northwest of Garudamangalam at the 10 m level, a worn limonitic individual 16.3 mm in diameter, may be the inner whorls of the species, with bullate inner ventrolateral tubercles well-developed.

DISCUSSION: *Kunnamiceras imperatoris* (Wright and Kennedy, 1980), based on Collignon's *Protacanthoceras tropicum* (*non* Stoliczka: see above) differs from *K. tropicum* in its much coarser umbilical bullae on all but the most adapertural part of the body chamber, and very coarse ventrolateral and ventral ribs.

OCCURRRENCE: Lower Upper Cenomanian, *harpax* Zone, Tamil Nadu.

Genus *Protacanthoceras* Spath, 1923

TYPE SPECIES: *Ammonites bunburianus* Sharpe, 1853, p. 25, pl. 9, fig. 3, by the original designation of Spath 1923, p. 144.

Protacanthoceras parva sp. nov.
(Pl. 29, Figs 1–4, 15, 16)

DERIVATION OF NAME: *Parva* (Latin): little.

DIAGNOSIS: A small species of *Protacanthoceras* in which the mid-ventral region between the outer ventrolateral tubercles is smooth at maturity.

TYPES: The holotype is OUM KY3201 (Pl. 29, Figs 15, 16), from section M–N at the 221 m level. Paratypes OUM KY4127 and 4128 are from section B at the 10–20 m level. Paratype OUM KY3198 (Pl. 29, Figs 1–4) is from section M–N at the 221 m level, all Middle Cenomanian, *asiaticum* Zone.

DESCRIPTION: The holotype (Pl. 29, Figs 15, 16) is interpreted as a complete adult, 16.5 mm in diameter, retaining a 240° sector of body chamber. Coiling is very involute, the umbilicus comprising 20% of the diameter. The umbilical wall is feebly convex, the umbilical shoulder quite broadly rounded. The flanks are flat and parallel in intercostal section, the ventrolateral shoulders broadly rounded, the venter very feebly convex. There are four small umbilical bullae, and twice this number of ventrolateral bullae per half whorl on the body chamber. They are linked by ribs that arise in pairs from the umbilical bullae and are weak to effaced in the middle of the flanks. The ventrolateral tubercles give rise to a short sector of feeble rib, restricted to the ventrolateral shoulder, the venter smooth between.

Paratype OUM KY3198 (Pl. 29, Figs 1–4) is interpreted as a juvenile, an internal mould 13.3 mm in diameter, retaining a 180° sector of body chamber. Coiling is very involute, the umbilicus comprising 20% of the diameter, of moderate depth, with a convex wall and broadly rounded umbilical shoulder. The intercostal whorl section is as wide as high, with flat, parallel flanks, broadly rounded ventrolateral shoulders and a feebly convex venter. The costal whorl section is polygonal, the greatest breadth at the umbilical bullae. There are six well-developed umbilical bullae on the outer whorl that give rise to pairs of straight recti-to feebly prorsiradiate ribs that are weak at mid-flank and strengthen on the outer flank, linking to conical inner ventrolateral tubercles, from which a broader prorsiradiate rib links to small outer ventrolateral clavi. There are additional intercalated ribs to give an estimated 16 ribs at the ventrolateral shoulder. There are small siphonal clavi on the phragmocone, lost by the beginning of the body chamber, where the outer ventrolateral clavi are linked over the venter by a transverse rib. Both outer ventrolateral clavi and the ventral part of the ribs are markedly weakened at the greatest preserved diameter. Paratypes OUM KY4127 and KY4128 link the previous specimens, and show the loss of the inner ventrolateral tubercles and persistence of the outer ventrolateral.

The sutures have only minor incisions in both lobes and saddles; E/A is broad and bifid.

DISCUSSION: Amongst described species, the closest similarity is to *Protacanthoceras arkell arkelli* Wright and Kennedy, 1980 (p. 84, figs 24–26, 35a–h; 1987, p. 209, pl. 55, figs 1, 2, 5; text-figs 82e, g; 83i–l, o, p) and *Protacanthoceras arkelli verrucosum* Wright and Kennedy, 1980 (p. 86, figs 27, 35i, j; 1987, p. 209, pl. 55, fig. 3; text-fig. 83m, n), but the nominate subspecies develops strong ventral ribbing on the adapertural part of the adult body chamber, and the latter retains ribs and ventrolateral and siphonal tubercles throughout ontogeny, only declining at the mature aperture.

OCCURRENCE: As for types.

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, p. 198, pl. 22, fig. 5 (ICZN Specific Name No. 1633).

Calycoceras (*Calycoceras*) *bathyomphalum*
(Kossmat, 1895)
(Pl. 30, Figs 1–6)

1895. *Acanthoceras bathyomphalum* Kossmat, p. 197 (101), pl. 25 (11), fig. 4.
1990. *Calycoceras* (*Calycoceras*) *bathyomphalum* (Kossmat, 1895); Wright and Kennedy, p. 229, pl. 58, fig. 4, pl. 60, figs 2, 4; text-figs 88g; 94a–c; 95a–h (with full synonymy).
1994a. *Calycoceras* (*Calycoceras*) *bathyomphalum* (Kossmat, 1895); Kennedy and Juignet, p. 25, text-figs 5c, d; 6a, b.
2015. *Calycoceras* (*Calycoceras*) *bathyomphalum* (Kossmat, 1895); Kennedy in Morel, p. 140, text-fig. 113.

TYPE: The lectotype, by the subsequent designation of Wright and Kennedy 1990, p. 229, is GSI 14834, the original of Kossmat 1895, p. 197 (101), pl. 25 (11), fig. 4, from Uttatur, Tamil Nadu. A cast (OUM KY4702) is figured here as Pl. 30, Figs 1–3.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
*OUM KY4702 c	30.6 (100)	17.4 (56.9)	13.8 (45.1)	1.26	8.8 (28.8)

*Cast of the lectotype.

MATERIAL: OUM KY2864, 2865, from section G–H at the 200–210 m level, Middle Cenomanian, *asiaticum* Zone.

DESCRIPTION: OUM KY2864 (Pl. 30, Figs 5, 6) is a well-preserved internal mould 21.6 mm in diameter, retaining recrystallised shell. Coiling is evolute, the umbilical wall notched to accommodate the inner ventrolateral tubercles of the previous whorl. The umbilicus, of moderate depth, comprises 27.8% of the diameter, the umbilical wall convex, the umbilical shoulder broadly rounded. The whorl section is depressed reniform in intercostal section and depressed polygonal in costal section, the greatest breadth at the inner ventrolateral spines. Eleven ribs arise at the umbilical seam, strengthen across the umbilical wall and link to well-developed conical-bullate umbilical tubercles. A coarse, straight, prorsirasdiate rib links to a subspinose inner ventrolateral tubercle, linked by a feebly prorsirdiate rib to a small conical outer ventrolateral tubercle, the outer ventrolateral tubercles linked across the venter by a strong transverse rib that bears a feebly clavate siphonal tubercle. Single ribs intercalate between successive primaries. Arising below mid-flank, they bear a weak inner ventrolateral tubercle in some cases, and all bear outer ventrolateral and siphonal tubercles that correspond to those of the primaries. There are 12 ribs at the ventrolateral shoulder of the adapertural half of the outer whorl. OUM KY2865 (Pl. 30, Fig. 4) is a crushed individual 32.3 mm in diameter, retaining recrystallized shell. The ornament of the adapical half on the outer whorl is as in the previous specimen. On the adapertural half, the subspinose inner ventrolateral tubercles persist, but the outer ventral and siphonal tubercles weaken. The cast of the lectotype, a phragmocone (Pl. 30, Figs 1–3) has a maximum preserved diameter of 30.7 mm. There are thirteen subspinose umbilical bullae perched on the umbilical shoulder of the outer whorl that give rise to single coarse, straight, prorsiradiate primary ribs that link to strong, conical subspinose inner ventrolateral tubercles, from which a strong prorsiradiate rib links to a much weaker transversely elongated outer ventrolateral tubercle. At the beginning of the outer whorl, a transverse rib links the outer ventrolateral tubercles across the venter, and bears a weak siphonal tubercle. The primary ribs alternate with one, occasionally two intercalated ribs that are weaker on the flanks, to give a total of ribs 27–28 ribs at the ventrolateral shoulder of the outer whorl. The intercalated ribs lack an inner ventrolateral tubercle. At the adapical end of the outer whorl, they bear outer ventrolateral and siphonal tubercles and match the primary ribs in strength over the venter. As size increases, the siphonal tubercles weaken and efface on all ribs, and at the greatest preserved diameter, the outer ventrolateral tubercles are linked across the venter by a strong transverse rib that is feebly convex in apertural view.

DISCUSSION: See Wright and Kennedy 1990, p. 229.

OCCURRENCE: Upper Middle and lower Upper Cenomanian, *asiaticum* Zone of Tamil Nadu; also known from southern England, France, Tunisia, Romania, and Madagascar.

Calycoceras (*Calycoceras*) *naviculare* (Mantell, 1822)

(Pl. 30, Figs 9–13; Text-figs 21, 22)

1822. *Ammonites navicularis* Mantell, p. 198, pl. 22, fig. 5 (in error in explanation of plate: *Ammonites catinus*).
1981. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822); Wright and Kennedy, p. 34, pl. 4, pl. 5, figs 1–3; text-figs 13; 14c–e (with full synonymy to 1981).
1990. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822); Wright and Kennedy, p. 236, pl. 61, fig. 1; pl. 62, figs 1–6; pl. 63, figs 1–3; text-figs 88e, i; 89d; 110c (with additional synonymy).
2015. *Calycoceras (Calycoceras) naviculare* (Mantell, 1822); Kennedy in Morel, p. 140, fig. 112.

Text-fig. 21. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822). OUM KY3493, from the Karai Formation, Upper Cenomanian, *harpax* Zone, section R–S, between Odiyam and Kunnam, at the 19 m level

2014. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822); Amédro and Matrion, p. 136, pl. 2, fig. 4.
2015. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822); Kennedy in Kennedy and Gale, p. 292, pl. 22, fig. 6 (with additional synonymy).
2018. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822); Kostak *et al*., p. 156, text-fig. 5a–k.

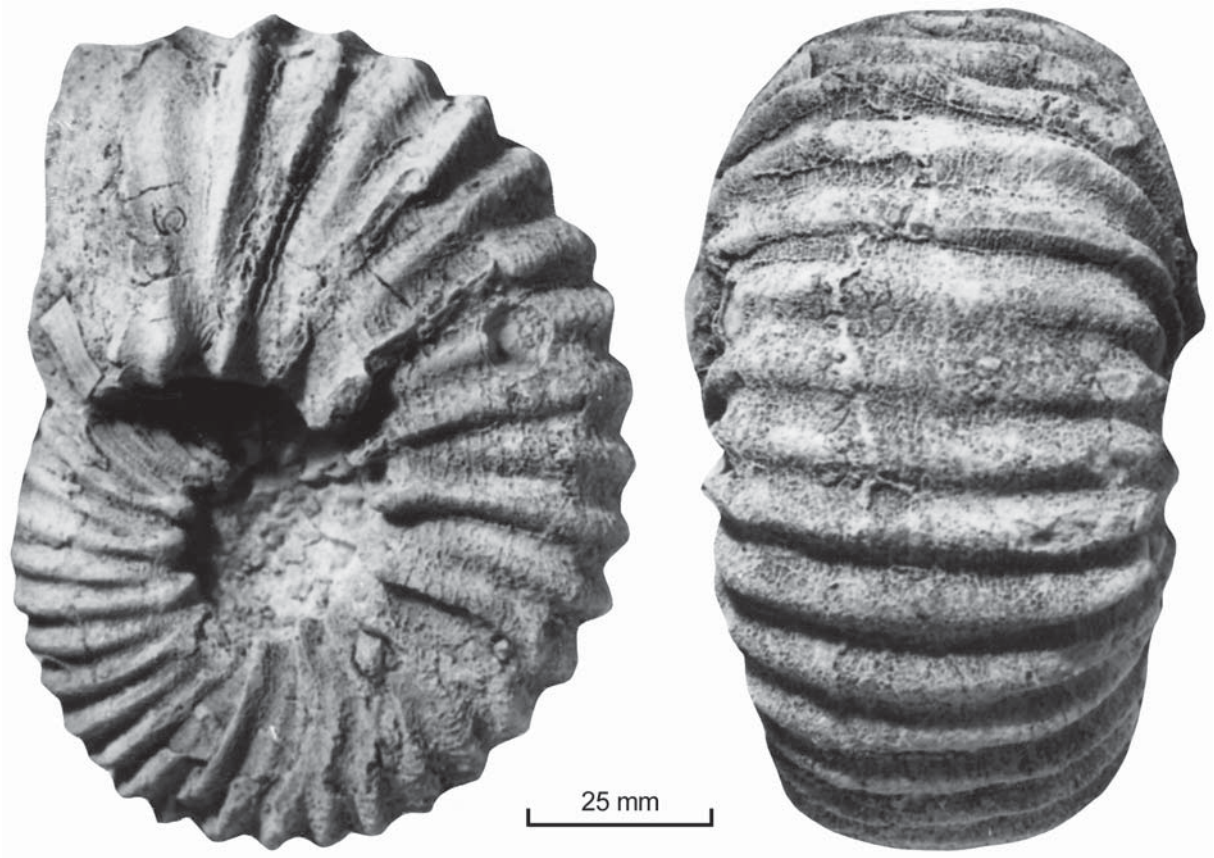
TYPE**:** The holotype, by monotypy, is BMNH 5681, the original of Mantell (1822, pl. 22, fig. 5), from 'Offham', Sussex, England, and inferred to be from the Upper Cenomanian Plenus Marl (see Wright and Kennedy 1981, pl. 4).

MATERIAL: OUM KY3492, 3493, from section R–S at the 19 m level; OUM KY3502, from section R–S at the 27 m level. OUM KY4079–4081, from section A at the 9 m level, all Upper Cenomanian, *harpax* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3502 c	51.7 (100)	– (–)	23.2 (44.9)	–	11.3 (21.9)
OUM KY3492 at c	80.7 (100)	48.8 (60.5)	35.3 (43.7)	1.38	24.5 (30.4)
OUM KY4080 c	114.6 (100)	69.2 (60.3)	48.2 (42.1)	1.43	36.5 (31.8)

DESCRIPTION: Coiling is moderately evolute, the umbilicus deep, comprising 30.4% of the diameter in OUM KY3492 (Pl. 30, Figs 11–13), with a feebly convex wall and broadly rounded umbilical shoulder, the whorl section depressed reniform, the greatest breadth at the umbilical bullae in costal section. Ten coarse ribs arise at the umbilical seam, strengthen across the umbilical wall, and link to well-developed umbilical bullae. The bullae give rise to pairs of rursiradiate ribs, with additional ribs intercalat-



Text-fig. 22. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822). OUM KY4080, from the Karai Formation, Upper Cenomanian, *harpax* Zone, from section A, north-west of Garudamangalam at the 9 m level

ing. The ribs strengthen across the flanks, and pass near-straight across the venter; there are an estimated 37 ribs per whorl at the ventrolateral shoulder of the outer whorl. OUM KY3502 (Pl. 30, Figs 9, 10) a smaller individual, retains weak outer ventrolateral tubercles. The nucleus of OUM KY4079 at a diameter of 33.3 mm has a depressed whorl section, the ventrolateral shoulder markedly angular in costal section, the venter broad and feebly convex. Primary ribs arising singly or in pairs from pinched umbilical bullae, with additional ribs intercalating, the ribs narrow, crowded, straight, recti- to feebly prorsiradiate on the flanks, and passing straight across the venter. The outer whorl of this specimen has a maximum preserved diameter of 83 mm. The deep umbilicus comprises 32.5% of the diameter, the umbilical wall flattened, the ventrolateral shoulder broadly rounded in intercostal section. Strong crowded ribs arise at the umbilical seam and pass slightly backwards across the umbilical wall and strengthen into strong, sharp, pinched bullae that give rise to narrow, straight, recti- to feebly rursiradiate ribs that strengthen across the ventrolateral shoulders and pass straight across the venter.

OUM KY4080 (Text-fig. 22) is 114.6 mm in diameter. Coiling is evolute, the deep umbilicus comprising 31.8% of the diameter, the umbilical wall flattened, the umbilical shoulder broadly rounded. The intercostal whorl section is depressed, with convergent, flattened flanks, broadly rounded ventrolateral shoulders, and a broad, very feebly convex venter. On the adapertural part of the penultimate whorl, rursiradiate ribs arise in pairs from pinched, crowded umbilical bullae. On the outer whorl, sixteen strong pinched bullae perch on the umbilical shoulder. They give rise to pairs of feebly rursiradiate ribs, very feebly convex on adapical part of the outer whorl, with additional long intercalated ribs; on the adapertural

part, single primary ribs dominate, with single long or short intercalated ribs to give a total of 34 ribs on the outer whorl at the ventrolateral shoulder. The ribs strengthen across the flanks, and there is a marked angulation at the ventrolateral shoulder, but no tubercles. The ribs are coarse, straight and transverse over the venter, which is barely convex in costal profile. OUM KY3493 (Text-fig. 21) is a 120° sector of body chamber with a maximum preserved whorl height of 51 mm, and part of the penultimate whorl. On the outer whorl, eight ribs arise at the umbilical seam and are strong, straight and feebly rursiradiate across the umbilical wall, strengthening into well-developed umbilical bullae. These give rise to pairs of ribs or a single rib, and additional long ribs intercalate to give a total of 16 at the ventrolateral shoulder of the fragment. The ribs are straight and feebly rursiradiate on the flanks, across which they strengthen, and link well-developed conical outer ventrolateral tubercles, linked across the venter by a strong transverse rib.

DISCUSSION: See Wright and Kennedy (1990, p. 235).

OCCURRENCE: Lower to middle Upper Cenomanian, *harpax* Zone of Tamil Nadu; *guerangeri* and *geslinianum* Zones and their correlatives, southern England, Sarthe, Loire-Atlantique, Eure-et-Loir, Touraine and Provence in France, Germany, Spain and Portugal, Romania, Algeria, Central Tunisia, the Middle East, Angola, Madagascar, Tamil Nadu, Japan, the United States Gulf Coast, Western Interior, and western seaboard.

Calycoceras (*Calycoceras*) cf. *barruei* (Pervinquière, 1907)
(Pl. 16, Figs 20–25, 29, 30)

Compare:

1907. *Acanthoceras barruei* Pervinquière, p. 284, pl. 15, fig. 7.
1990. *Calycoceras* (*Calycoceras*) *barruei* (Pervinquière, 1907); Wright and Kennedy, p. 230, pl. 58, fig. 3; pl. 63, fig. 4 (with synonymy).

TYPE: The holotype, by monotypy, is MNHN. F.J13703, the original of Pervinquière 1907, pl. 15, fig. 7, from Koudiat el Hamra in Central Tunisia.

MATERIAL: OUM KY3920 (collective of 7 specimens), KY3926–3928, from section A, at the 16–18 m level, Upper Cenomanian *harpax* Zone, *euomphalum* fauna.

DESCRIPTION: The material consists of a series of variably crushed nuclei up to 19 mm in diameter, and poor fragments of larger individuals. Coiling is evolute, the umbilicus deep, with a convex wall and broadly rounded umbilical shoulder. The whorl section is depressed reniform, with the greatest breadth at the inner lateral tubercles. There are six or seven small umbilical bullae per half whorl. They give rise to single ribs that link to a second, larger lateral tubercle, from which a strong rib passes near-straight across the venter. Additional ribs intercalate, to give a total of 12 ribs per half whorl at the ventrolateral shoulder. The ribs develop conical to transversely elongated ventrolateral tubercles and a weak, transversely elongated siphonal tubercle on the adapical part of the outer whorl of KY3920 and 3928, but thereafter the ventrolateral and siphonal tubercles are lost.

DISCUSSION: The tuberculate stage, followed by loss of ventrolateral tubercles characterizes *Calycoceras naviculare* described from southern England, although in these specimens the loss of the siphonal tubercle occurs first, at a diameter of 30–33 mm. In contrast, the ontogenetic changes shown by the present material corresponds to those shown by *C.* (*C.*) *barruei*, to which these specimens are compared. See Wright and Kennedy (1990, p. 236).

OCCURRENCE: As for material. *Calycoceras* (*C.*) *barruei* is otherwise known from the Upper Cenomanian *guerangeri* Zone of southern England, and correlatives in Central Tunisia.

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

TYPE SPECIES: *Ammonites gentoni* Brongniart, 1822, pp. 83, 392, pl. 6, fig. 6 from the lower Middle Cenomanian of Rouen, Seine-Maritime, France, by the original designation of Thomel 1972, p. 65.

Calycoceras (*Gentoniceras*) *boehmi* (Spath, 1926b)
(Pl. 30, Figs 7, 8; Pl. 37, Figs 3, 4; Text-figs 23–26)

1867. *Ammonites navicularis* Guéranger (*non* Mantell), p. 6, pl. 5, fig. 5 only.
1926b. *Metacalycoceras boehmi* Spath, p. 431.
1990. *Metacalycoceras boehmi* Spath, 1926; Wright and Kennedy, text-fig. 93b.
1994a. *Calycoceras* (*Gentoniceras*) *boehmi* (Spath, 1926); Kennedy and Juignet, p. 37, text-figs 5e, f; 9a–c (with synonymy).

Text-fig. 23. *Calycoceras* (*Gentoniceras*) *boehmi* (Spath, 1926b). OUM KY2757, interpreted as an adult macroconch, 180 mm in diameter, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section G–H, between Odiyam and Kunnam, at the 171 m level

2015. *Calycoceras* (*Gentoniceras*) *boehmi* (Spath, 1926); Kennedy in Morel, p. 141, text-fig. 115.

TYPE: The neotype, designated by Kennedy and Juignet 1994a, p. 37, is MNHN F. A25546, figured by

Kennedy and Juignet 1994a, text-fig. 8, and Kennedy in Morel 2015, text-fig. 115, and from the Middle Cenomanian Sables du Mans or Sables du Perche of Le Mans, Sarthe, France.

MATERIAl: From section G–H, OUM KY2757, from the 171 m level; OUM KY2776, from the 176 m level; OUM KY2783, from the 177–181 m level; OUM KY2794, from the 180 m level; OUM KY2809, from the 195–196 m level; OUM KY2901 and KY2902, from the 210–212 m level. OUM KY3054, from section M–N at the 215 m level. OUM KY4745, from section K–L, all Middle Cenomanian, *asiaticum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2794 at	85.2 (100)	52.8 (62.0)	38.3 (45.0)	1.38	24.0 (28.2)
OUM KY2783	89.6 (100)	– (–)	41.0 (45.8)	–	25.0 (27.9)
OUM KY2901 ic	150. 4 (100)	– (–)	65.6 (43.6)	–	51.7 (34.4)
OUM KY2901 c	155.0 (100)	– (–)	71.6 (46.2)	–	51.7 (33.4)
OUM KY2757 ic	175.0 (100)	– (–)	72.5 (41.4)	–	46.7 (26.7)
OUM KY2757 c	180 (100)	– (–)	73.5 (40.8)	–	46.7 (25.9)

DESCRIPTION: OUM KY3054 (Pl. 37, Figs 3, 4) is an internal mould of a phragmocone, with a maximum preserved whorl height of 43 mm. It preserves a nucleus 32 mm in diameter. OUM KY2783 (Pl. 30, Figs 7, 8), 89.6 mm in diameter, retains a short sector of body chamber. Coiling is moderately evolute, the deep umbilicus comprising 27.9% of the diameter, the high umbilical wall feebly convex, the umbilical shoulder broadly rounded. The whorl section is depressed reniform, with a costal whorl breadth to height ratio of 1.18. On the penultimate whorl eight umbilical bullae per half whorl perch on the umbilical shoulder, and give rise to single ribs or pairs of ribs**,** whilst there are occasional non-bullate primaries and intercalated ribs to give a total of 18 ribs at the ventrolateral shoulder. There are 11 ribs on the adapertural half of the outer whorl that arise at the umbilical seam, strengthen across the umbilical wall and shoulder, developing into umbilical bullae of variable strength. The bullae give rise to single narrow, prorsiradiate ribs that are straight on the inner flank, barely concave on the outer flank and ventrolateral shoulder, and cross the venter in a very feeble convexity. Single ribs intercalate low on the flanks, strengthen and match the primaries on outer flanks, ventrolateral shoulders and venter. There are feeble indications of inner and outer ventrolateral tubercles on the first few ribs. OUM KY2794 is a closely comparable individual, with phragmocone 98.3 mm in diameter, and a poorly preserved 120° sector of body chamber. There is no indication of ventrolateral tubercles.

OUM KY2757 (Text-fig. 23), with a maximum preserved diameter of 180 mm is interpreted as an adult macroconch. Ornament up to the beginning of the outer whorl is as in the previous specimens. Ornament coarsens on the outer whorl, the ribs become more widely separated, with bullate primaries alternating with single intercalated ribs, the pattern changing at a diameter of 110 mm to one of widely separated primary ribs with strong umbilical bullae only on the adapertural 120° sector. Specimens such as OUM KY2776, with a maximum preserved diameter of 114 mm (Text-fig. 24) that show this same change at a diameter of 78 mm are interpreted as microconchs.

DISCUSSION: See Kennedy and Juignet (1994a, p. 40).

OCCURRENCE: Middle Cenomanian of Sarthe, France, and *asiaticum* Zone of Tamil Nadu.

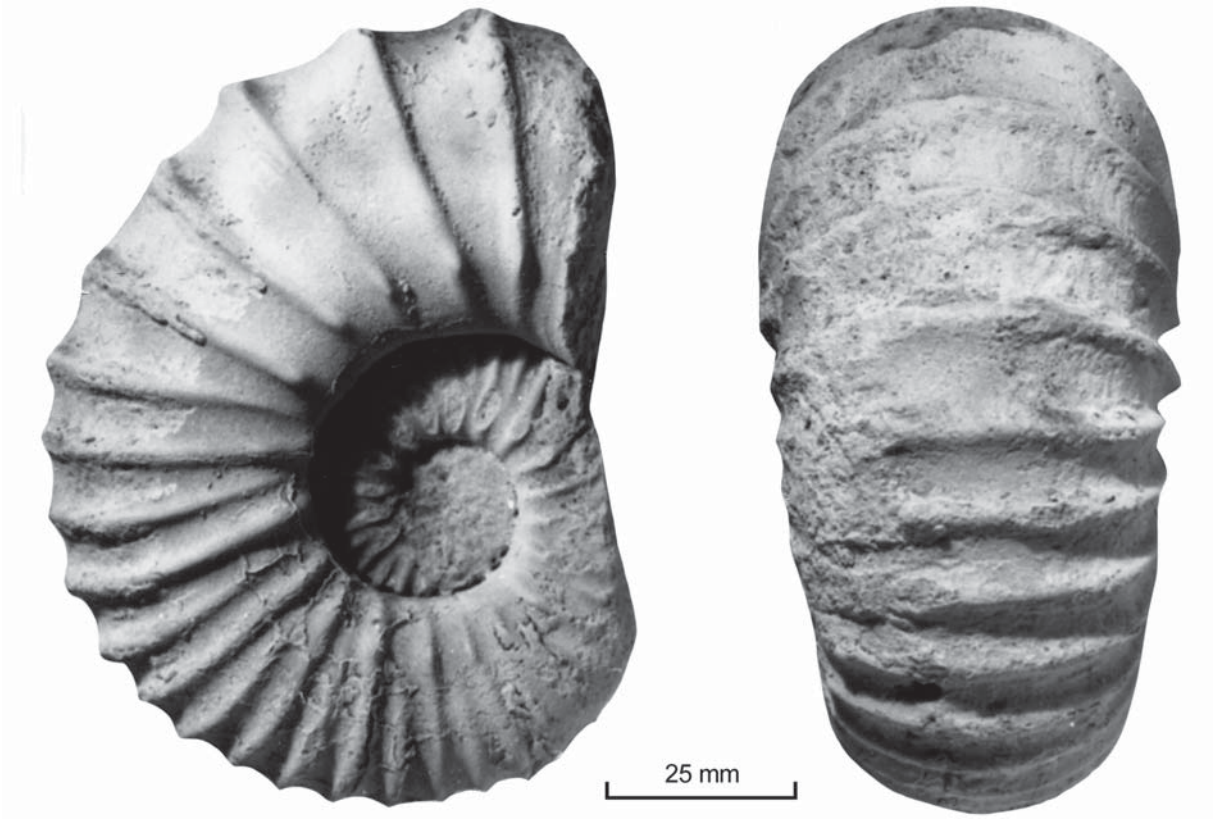
Subgenus *Proeucalycoceras* Thomel, 1972

TYPE SPECIES: *Calycoceras* (*Eucalycoceras*) *besairiei* Collignon, 1937, p. 37 (13), pl. 3, figs 1–4; pl. 8, fig. 5, by the original designation of Thomel 1972, p. 81.

Calycoceras (*Proeucalycoceras*) *choffati* (Kossmat, 1897)
(Pl. 32, Figs 1–3)

1897. *Acanthoceras choffati* Kossmat, p. 12 (119), pl. 15 (4), fig. 1.
non 1903. *Acanthoceras* sp. ind. aff. Ac. *Choffati* Kossmat; Choffat, p. 28, pl. 8, fig. 1.
non 1907. *Acanthoceras choffati* F. Kossmat; Crick, p. 205, pl. 12, fig. 5 (= *C.* (*N.*) *planecostatum*).
?1972. *Eucalycoceras* (*Proeucalycoceras*) *paucinodatum* Thomel, p. 82, pl. 28, figs 2, 3.
1990. *Calycoceras* (*Proeucalycoceras*) *choffati* (Kossmat, 1897); Wright and Kennedy, pp. 264, 265; text-fig. 87g–i.
2010. *Acanthoceras choffati* Kossmat, 1897; Kennedy and Klinger, p. 15, text-fig. 55.

TYPE: The holotype, by monotypy, is the original of



Text-fig. 24. *Calycoceras* (*Gentoniceras*) *boehmi* (Spath, 1926b). OUM KY2776, interpreted as an adult microconch, 115 mm in diameter, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section K–L, between Odiyam and Kunnam, at the 50–60 m level

Kossmat 1897, pl. 15 (4), fig. 1, from Odiyam, GSI 14844, a cast of which (OUM KY4704) is figured here (Pl. 32, Figs 1–3).

MATERIAL: OUM KY4007, 4008, from section C at the 31 m level, Middle Cenomanian *asiaticum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
*OUM KY4704	79.2 (100)	33.9 (42.8)	38.5 (48.6)	0.88	18.3 (23.1)

*Cast of the holotype.

DESCRIPTION: A cast of the holotype, OUM KY4704 (Pl. 32, Figs 1–3) shows the original to retain half a whorl of body chamber. Coiling is moderately evolute, the umbilicus of moderate depth, and comprising 23% of the diameter, with a flattened wall and quite broadly rounded umbilical shoulder. The whorl section is compressed, with feebly convex subparallel flanks, broadly rounded ventrolateral shoulders and a feebly convex venter. The greatest whorl breadth is just below mid-flank. Twenty to twenty-one ribs arise at the umbilical seam and strengthen across the umbilical wall, linking to very small bullae, perched on the umbilical shoulder. They give rise to single prorsiradiate ribs, with up to three both long and short intercalated ribs between successive primaries, some of the long ones incipiently linking to a bulla. The ribs are crowded, ribbon-like, and wider than the interspaces. At the adapical end of the outer whorl, there are small conical tubercles in an outer ventrolateral position, linked across the venter by a flat, ribbon-like rib. The only specimens in the present collection are fragments; they differ in no significant respects from the holotype.

DISCUSSION: This is a problematic species, on the one hand referred to *Proeucalycoceras* by Wright and Kennedy (1990, p. 264), who considered *paucinodatum* of Thomel (1972, p. 82, pl. 28, figs 2, 3)

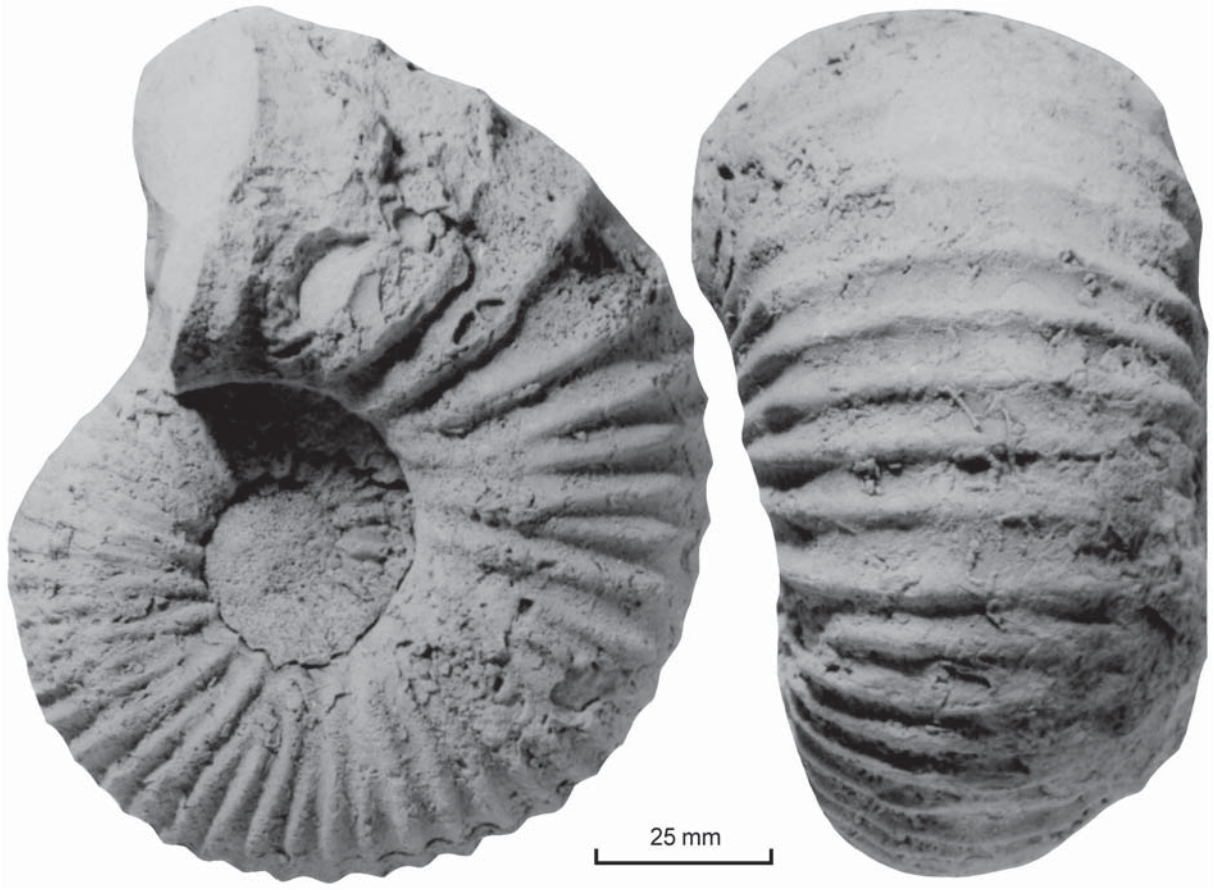
Text-fig. 25. *Calycoceras* (*Gentoniceras*) *boehmi* (Spath, 1926b). OUM KY2901, interpreted as an incomplete adult macroconch, 160 mm in diameter, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section G–H, between Odiyam and Kunnam, at the 210–212 m level (see also Text-fig. 24)

a synonym, whereas Kennedy and Klinger (2010, p. 15) wondered if it might be no more than a compressed microconch of *Calycoceras* (*Newboldiceras*) *planecostatum* (Kossmat, 1897). The matter remains unresolved.

OCCURRENCE: Middle Cenomanian, *asiaticum* Zone, Tamil Nadu. Possibly also present in the Middle Cenomanian of south-east France.

Subgenus *Calycoceras* (*Newboldiceras*) Thomel, 1972

TYPE SPECIES: *Acanthoceras newboldi* Kossmat, 1897, p. 5 (112), pl. 1 (12), figs 2, 3, pl. 3 (14), fig. 2, by original designation by Thomel 1972, p. 105 = *Acanthoceras rhotomagense* var. *asiatica* Jimbo, 1894, p. 177, pl. 20, fig. 1 (*fide* Wright and Kennedy 1990, p. 239).



Text-fig. 26. *Calycoceras* (*Gentoniceras*) *boehmi* (Spath, 1926b). Inner whorls of OUM KY2901, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section G–H, between Odiyam and Kunnam, at the 210–212 m level (see also Text-fig. 23)

Calycoceras (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894)

(Pl. 16, Fig. 28; Pl. 31; Pl. 33, Figs 1, 2, 11, 12; Text-figs 27–30)

1865. *Ammonites Rotomagensis* Defrance; Stoliczka, p. 66 (*pars*), including *typicus* (p. 68) (*pars*) and var. *subcompressus* (p. 68), pl. 34, figs 3, 4: pl. 35, fig. 1; pl. 36, fig. 1; pl. 37, figs 1, 2.

1894. *Acanthoceras rhotomagense* var. *asiatica* Jimbo, p. 177, pl. 20, fig. 1.

1897. *Acanthoceras Newboldi* n.sp. (Typische Form) Kossmat, p. 5 (112); pl. 1 (12), figs 2, 3; pl. 3 (14), fig. 2.

1990. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894); Wright and Kennedy, p. 239, pl. 58, fig. 1; pl. 64, figs 1, 2; pl. 65, figs 1–3, 5, 7; pl. 72, fig. 3; text-figs 87d–f; 88f; 97, 98 (with full synonymy).

1992. *Calycoceras* (*Newboldiceras*) *newboldi* (Kossmat); Vašiček, p. 68, pl. 1, fig. 1; pl. 2, figs 1, 2; pl. 3, figs 2, 3; pl. 6, fig. 1 (with additional synonymy).

2010. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894); Kennedy and Klinger, p. 10, figs 32; 33a–f; 34j–l, p, q; 36–38; 44d, e, h; 57a–f (with additional synonymy).

non 2013. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894); Ahmad *et al*., p. 27, text-fig. 6a–b (= *Pseudocalycoceras judaicum* (Taubenhaus, 1920).

2015. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894); Kennedy in Morel, p. 141, text-fig. 135f.

2015. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894); Kennedy in Kennedy and Gale, p. 295, pl. 10, fig. 9; pl. 20, fig. 6; pl. 22, fig. 3 (with additional synonymy).

Text-fig. 27. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894). OUM KY2742, an adult microconch, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section G–H, between Odiyam and Kunnam, at the 168–173 m level

2017. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894); Kennedy in Kennedy and Gale, p. 96, pl. 11, figs 5, 6.
2018. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894); Gale *et al*., p. 116, text-fig. 14d–f.

TYPE: The holotype , by monotypy is the original of Jimbo, 1894, pl. 20, fig. 1, no. 1-105 in the Collections of the Geological Institute, Tokyo University, from the Middle Cenomanian *Trigonia* Sandstone of the Ikushumbets, Hokkaido, Japan. A cast was figured by Wright and Kennedy (1990, text-fig. 97) and Kennedy and Klinger (2010, text-fig. 38).

MATERIAL: There are numerous specimens. From section G–H, OUM KY2742, from the 168–173 m level; KY2758, from the 171 m level KY2894 and 2899, from the 210–212 m level. OUM KY3140, from section M–N at the 214–16 m level. OUM KY2873 from the 196–200 m level, and OUM KY2812 from the 203 m level of section G–H. OUM KY4042, from section C, north-west of Garudamangalam at the 42–43 m level, all Middle Cenomanian, *asiaticum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2742 c	91.1 (100)	– (–)	45.0 (49.4)	–	25.4 (27.9)
OUM KY3140 at	134.5 (100)	64.2 (47.7)	57.7 (42.9)	1.1	31.0 (23.0)
OUM KY2873	160.0 (100)	84.5 (52.8)	71.3 (44.6)	1.19	50.5 (31.6)

DESCRIPTION: OUM KY2894 (Pl. 33, Figs 1, 2) is a juvenile 48.5 mm in diameter that closely resembles that figured in Kossmat's pl. 1 (12), fig. 3. Nine ribs arise at the umbilical seam of the adapertural half of the outer whorl, strengthen across the umbilical wall, and link to small, sharp umbilical bullae. These give rise to single ribs or, occasionally, a pair of ribs, with additional ribs intercalating low on the flanks to give a total of 20–21 ribs per half whorl at the ventrolateral shoulder. The ribs are recti- to feebly prorsiradiate, and in some cases, feebly flexuous. They bear feebly bullate inner ventrolateral tubercles, from which a stronger prorsiradiate rib links to feebly clavate outer ventrolateral tubercles, linked across the venter by a strong transverse rib.

OUM KY2742 (Text-fig. 27), with a maximum

Text-fig. 28. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894). OUM KY2874, an incomplete adult macroconch, 190 mm in diameter, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section G–H, between Odiyam and Kunnam, at the 196–201 m level (see also Text-fig. 29)

preserved diameter of 91.1 mm is an adult microconch. Coiling is evolute, the deep umbilicus comprising 27.9% of the diameter, with a feebly convex wall and broadly rounded ventrolateral shoulder. The intercos-

Text-fig. 29. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894). OUM KY2874, the inner whorls of an adult macroconch, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section G–H, between Odiyam and Kunnam, at the 196–201 m level (see also Text-fig. 28)

tal whorl section is depressed reniform, the costal section rounded-polygonal, with the greatest breadth at the umbilical bullae. The nucleus, at a diameter of 40 mm, has 14 primary ribs on its outer whorl that arise at the umbilical seam, strengthen across the umbilical wall, and link to strong subspinose umbilical bullae. The bullae give rise to strong, straight, prorsiradiate ribs that link to conical inner ventrolateral tubercles, linked in turn by a strong prorsirsdiate rib to a feebly clavate outer ventrolateral tubercle, the tubercles connected across the venter by a strong transverse rib that bears a well-developed siphonal clavus. Single intercalated ribs separate successive primaries, and bear a full complement of ventrolateral and siphonal tubercles. This pattern of ornament extends onto the adapical part of the outer whorl. On the body chamber, which occupies a 180° sector of the outer whorl, the umbilical bullae strengthen, and inner ventrolateral and siphonal tubercles efface.

OUM KY2758 (Pl. 33, Figs 11, 12) is a well-pre-

served 180° sector of body chamber 81.5 mm in diameter with a costal whorl breadth to height ratio of 1.38, the inner and outer ventrolateral tubercles persisting, the siphonal row lost. It may also be a microconch.

OUM KY2899, a wholly septate 200° whorl fragment 110 mm in diameter, closely resembles the original of Kossmat's pl. 1 (12). fig. 3. It retains well-developed inner and outer ventrolateral tubercles, but the siphonal row has effaced. OUM KY3140, an internal mold with a maximum preserved diameter of 145 mm, is an adult with approximated sutures and a 180° sector of body chamber. Coiling is moderately involute, the deep umbilicus comprising 23% of the diameter, the umbilical wall convex and deeply undercut on the mould, the umbilical shoulder broadly rounded. The whorl section is depressed reniform in intercostal section and rounded-trapezoidal in costal section, with the greatest breadth below mid-flank. Twenty ribs arise at the umbilical seam of the outer whorl, strengthen across the umbilical wall, become progressively more rursiradiate as size increases, and link to relatively weak umbilical bullae that give rise to straight prorsiradiate ribs that strengthen and broaden markedly across the flanks. One or two long or short ribs intercalate between successive primaries on the phragmocone, and there are a few intercalatories on the body chamber, to give a total of 38 ribs at the ventrolateral shoulder of the outer whorl. All ribs bear blunt inner and outer ventrolateral clavi. The adapical part of the phragmocone bears blunt siphonal tubercles. Because of damage to the venter, the point at which the siphonal row are lost is unclear; they are absent on the body chamber.

OUM KY2873 (Pl. 31; Text-fig. 30) is an internal mould of an incomplete macroconch with a maximum preserved diameter of 220 mm, the specimen retaining a 120° sector of body chamber. Coiling is evolute, the deep umbilicus comprising 31.6% of the diameter, the umbilical seam crenulated to accommodate the inner ventrolateral tubercles of the preceding whorl, the umbilical wall feebly convex, the umbilical shoulder broadly rounded. The whorl section is depressed in intercostal section, with convex flanks, broadly rounded ventrolateral shoulders and a broad, feebly convex venter. The costal whorl section is rounded-polygonal on the outer whorl of the phragmocone, with a whorl breadth to height ratio of 1.19, the greatest breadth below mid-flank. Twenty six ribs arise at the umbilical seam, strengthen and are feebly rursiradiate across the umbilical wall. They develop into a small umbilical bulla. The bullae give rise to single feebly rursiradiate ribs that pass straight across the flanks and link to small conical/feebly bullate inner ventrolateral tubercles. Well-developed, feebly convex ribs extend across the venter, and bear feebly clavate outer ventrolateral tubercles. The ventral rib is feebly convex in profile, without developing a siphonal tubercle. There are a few long intercalated ribs that strengthen to match the primary ribs on the outer flanks, ventrolateral shoulders and venter, to give a total of 43–44 ribs per whorl at the ventrolateral shoulder of the phragmocone. On the somewhat worn body chamber, the ribbing coarsens, the ribs predominantly primaries, some lacking an umbilical bulla. There are indications of an angulation at the position of the outer ventrolateral tubercles at the adapical end; thereafter, the venter is broadly and evenly rounded. There are 37 ribs on the outer whorl. OUM KY2874 (Text-figs 28, 29) is a further macroconch 185 mm in diameter, retaining a 120° sector of body chamber showing comparable ontogenetic changes.

The well-preserved suture is moderately incised; a large E/A has a deep median incision.

DISCUSSION: See Wright and Kennedy (1990, p. 240) and Kennedy and Klinger (2010, p. 12). Following the former, *Calycoceras pseudoporthaulti* Phansalkar, 1977 (p. 211, pl. 2, fig. 5), *C. tapwasii* Phansalkar, 1977 (p. 213, pl. 2, figs 1, 4), and *C. sastrii* Phansalkar, 1977 (p. 215, pl. 3, figs 3, 4) are probably synonyms of a variable *C.* (*N.*) *asiaticum asiaticum*. *Calycoceras* (*Newboldiceras*) *asiaticum spinosum* (Kossmat, 1997) has much stronger tuberculation that persists to a late ontogenetic stage. *C.* (*N.*) *asiaticum hunteri* (Kossmat, 1897) (p. 9 (116), pl. 3 (14), fig. 4) has a subquadrate whorl section, low expansion rate, and widely separated primary ribs only for much of the ontogeny. *C.* (*N.*) *planecostatum* (Kossmat, 1897 (p. 9 (16), pl. 2 (13), fig. 1) has feeble umbilical bullae, crowded ribs, and outer ventrolateral tubercles only from an early ontogenetic stage, as described below.

OCCURRENCE: Upper Middle and lower Upper Cenomanian, southern England, France, Germany, northern Spain, Iran, Morocco, northeastern Algeria, Central Tunisia, KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, and James Ross Island (Antarctica).

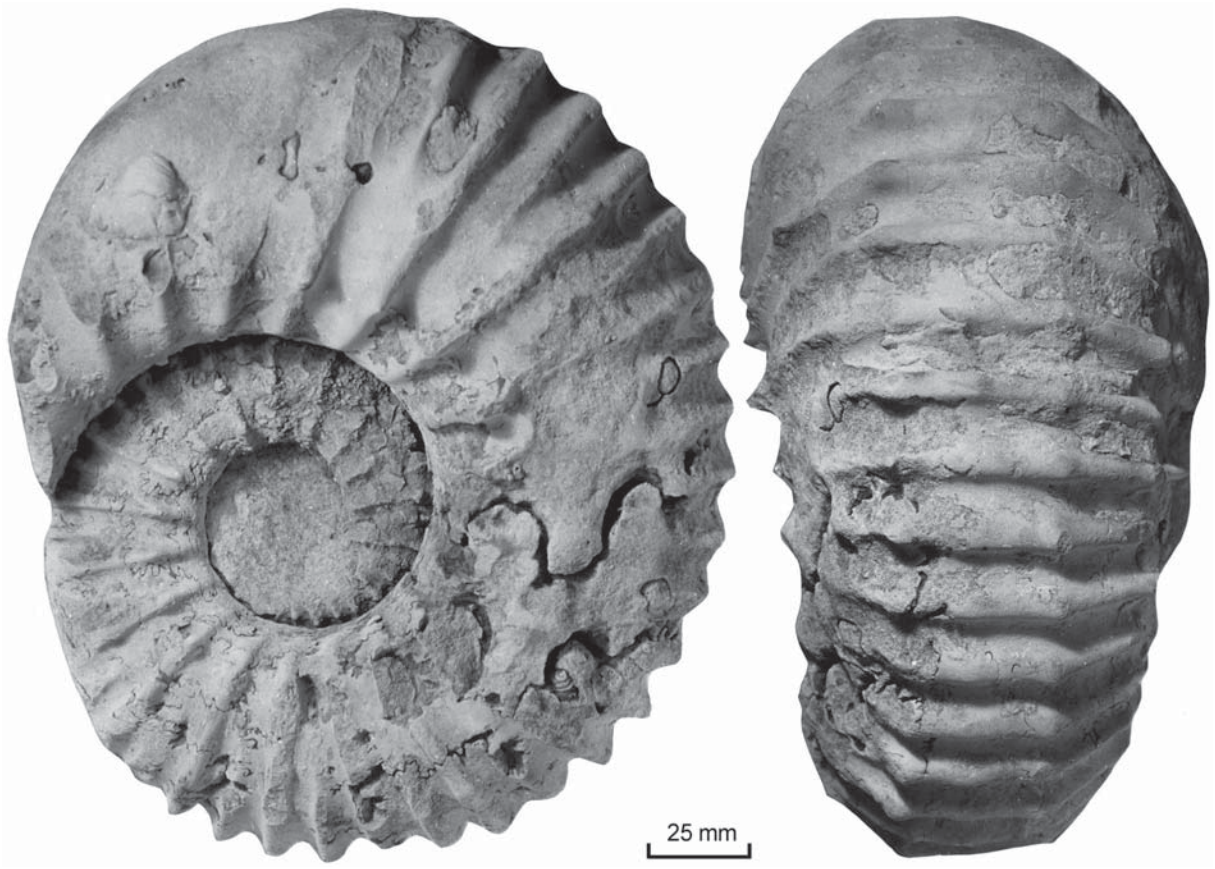
Calycoceras (*Newboldiceras*) *asiaticum spinosum* (Kossmat, 1897)
(Text-figs 31, 32)

1897. *Acanthoceras Newboldi* var. *spinosa* Kossmat, p. 7 (114), pl. 2 (13), figs 2, 3; pl. 3 (14), fig. 1.

1990. *Calycoceras* (*Newboldiceras*) *asiaticum spinosum*

Text-fig. 30. *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894). OUM KY2873 an adult macroconch 220 mm in diameter, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section G–H, between Odiyam and Kunnam, at the 196–201 m level

(Kossmat, 1897); Wright and Kennedy, p. 249, pl. 64, fig. 3; pl. 65, figs 4, 6; pl. 66, figs 3, 4; pl. 69, fig. 1; pl. 70, fig. 3; text-figs 87a–c; 88d, l; 99; 100; 102; 107k (with full synonymy).



Text-fig. 31. *Calycoceras* (*Newboldiceras*) *asiaticum spinosum* (Kossmat, 1897). OUM KY3433, an incomplete macroconch, with a maximum preserved diameter of 220 mm, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section R–S, between Odiyam and Kunnam, at the 1 m level

2010. *Calycoceras* (*Newboldiceras*) *asiaticum spinosum* (Kossmat); Kennedy and Klinger, p. 12, text-figs 33g–r; 34m, o; 35a–j, m–o, r, s; 39–43.
2015. *Calycoceras* (*Newboldiceras*) *asiaticum spinosum* (Kossmat); Kennedy in Morel, p. 141, fig. 116.
2015. *Calycoceras* (*Newboldiceras*) *asiaticum spinosum* (Kossmat); Kennedy in Kennedy and Gale, p. 296, pl. 21, figs 2, 4; pl. 23, fig. 1 (with additional synonymy).

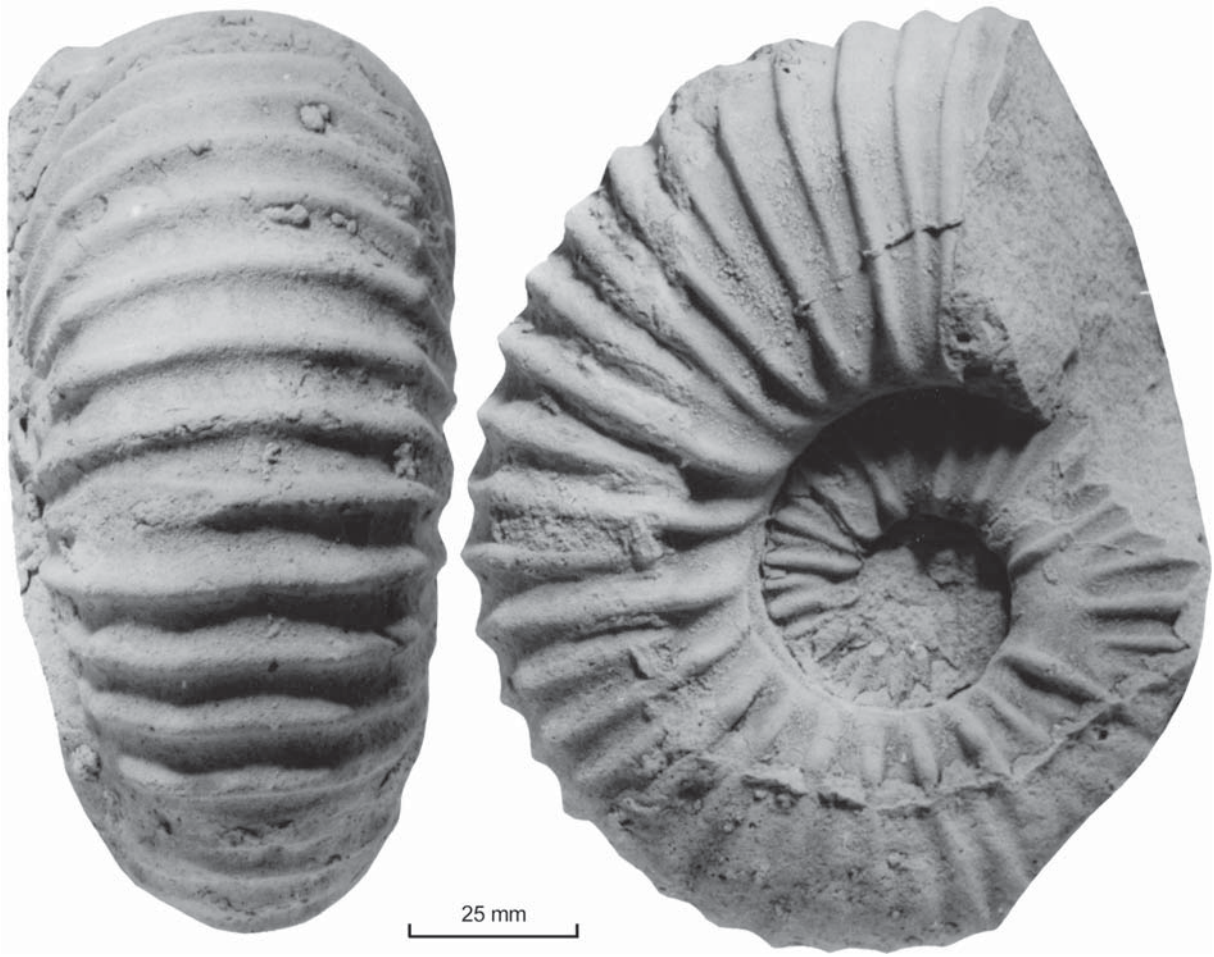
TYPES: The lectotype, by the subsequent designation of Wright and Kennedy (1990, p. 250) is the original of Kossmat 1897, pl. 2 (13), fig. 2, from the Uttatur Group of Odiyam, South India. Paralectotypes are the originals of Kossmat's pl. 2 (13), fig. 3, and pl. 3 (14), fig. 1. The paralectotype of Stoliczka, 1865, pl. 35, fig. 2 is pathological.

MATERIAL: OUM KY2874, from section G–H at the 196–201 m level. OUM KY3236, from section M–N at the 221 m level. OUM KY3433, from section R–S at the 1 m level. OUM KY4414, from section K–L at the 50–60 m level; all Middle Cenomanian, *asiaticum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY4414 c	139.0 (100)	63.5 (45.7)	55.2 (39.7)	1.15	45.5 (32.7)
OUK KY2874 c	195.0 (100)	(–)	77.8 (39.9)	–	68.2 (35.0)
OUM KY3433 c	210.0 (100)	– (–)	93.2 (44.4)	–	70.0 (33.7)

DESCRIPTION: The inner whorls are well-represented by specimens such as OUM KY3236 at a diameter of 32 mm. Coiling is evolute, the umbilicus comprising 34% of the diameter. An estimated six to seven primary ribs arise at the umbilical seam of the



Text-fig. 32. *Calycoceras* (*Newboldiceras*) *asiaticum spinosum* (Kossmat, 1897). OUM KY4414, an adult microconch, with a maximum preserved diameter of 135 mm, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section K–L, between Odiyam and Kunnam, at the 50–60 m level

adapertural half of the outer whorl. They strengthen across the umbilical wall, and develop into strong spinose umbilical bullae. These give rise to strong, straight, prorsiradiate primary ribs, singly or in pairs, with one or two long intercalated ribs between successive primaries to give a total of 16 ribs at the ventrolateral shoulder. All ribs bear weak inner ventrolateral bullae and strong outer ventrolateral clavi, linked across the venter by a strong transverse rib with a feeble, transversely elongated siphonal tubercle.

OUM KY4414 (Text-fig. 32) is an adult microconch, 139 mm in diameter. Coiling is evolute, the deep umbilicus comprising 32.7% of the diameter, with a high convex wall and broadly rounded umbilical shoulder. The whorl section is depressed in intercostal section, the flanks, ventrolateral shoulders and venter broadly rounded. The costal whorl breadth to height ratio is 1.15, the section rounded-polygonal, with the greatest breadth at the umbilical bullae on all but the final rib, where the bulla is lost and the costal section is rounded. There are 10–11 primary ribs on the adapical half of the outer whorl. They arise at the umbilical seam, strengthen across the umbilical wall, and develop into strong, sharp umbilical bullae. The bullae give rise to strong, straight prorsiradiate ribs with from one to three long or short ribs intercalating between successive primaries to give a total of 19 ribs per half whorl on the outer flank (the outermost flank and venter are missing). On the adapertural half of the outer whorl, there are13 umbilical bullae and 23 ribs at the ventrolateral shoulder, the intercalated ribs mostly arising on the inner flank. The

ribs are straight and prorsirsdiate, with blunt, bullate inner ventrolateral tubercles and feebly clavate outer ventrolaterals, linked over the venter by a transverse rib, the costal profile convex over the venter, and no siphonal tubercle. The umbilical bullae weaken on the last few ribs and the ventrolateral tubercles are lost, leaving rounded ventrolateral shoulders and venter, without even an angulation.

OUM KY3433 (Text-fig. 31) is an internal mould of an adult macroconch with a maximum measurable diameter of 210 mm that retains a 180° sector of body chamber. Coiling is evolute, the umbilical seam notched to accommodate the inner ventrolateral tubercles of the preceding whorl. The umbilicus is broad and deep, comprising 33% of the diameter, the umbilical wall convex, the umbilical shoulder broadly rounded. The intercostal whorl section is depressed reniform, the costal section polygonal, with a whorl breadth to height ratio of 1.23, the greatest breadth at the umbilical bullae. Twenty ribs arise at the umbilical seam at a diameter of 170 mm. They strengthen, are slightly rursirsdiate across the umbilical wall, and link to a strong, pinched umbilical bulla. The bullae give rise to single strong, straight, prorsiradiate ribs that link to a strong inner ventrolateral tubercle, linked by a strong rib to a strong outer ventrolateral clavus, the clavi linked across the venter by a strong transverse rib that bears a feeble, blunt, transversely elongated siphonal tubercle. Single intercalated ribs separate successive primaries, and have a comparable ventrolateral and ventral development. On the body chamber, the flank ornament is as on the phragmocone, the inner and outer ventrolateral tubercles persist, but the siphonal row are lost, the ventral profile of the ribs broad and evenly convex.

DISCUSSION: See above, together with Wright and Kennedy (1990, p. 250), who suggest that *Calycoceras lativentris* Phansalkar, 1977 (p. 209, pl. 1, figs 1, 2), is a synonym of the present subspecies.

OCCURRENCE: Upper Middle and lower Upper Cenomanian, southern England, France, Spain, Romania, Bulgaria, Central Tunisia, KwaZulu-Natal in South Africa, Madagascar, South India, Tibet (?), Japan and California.

Calycoceras (*Newboldiceras*) *planecostatum* (Kossmat, 1897)

(Pl. 32, Figs 4–5; Pl. 33, Figs 3–10; Pls 34, 35)

1897. *Acanthoceras Newboldi* var. *planecostata* Kossmat, p. 9 (116), pl. 2 (13), fig. 1.

1977. *Calycoceras* sp. ind. Phansalkar, p. 219, pl. 216, figs 1, 2.

1990. *Calycoceras* (*Newboldiceras*) *planecostatum* (Kossmat, 1897); Wright and Kennedy, p. 252, pl. 61, figs 2, 3; pl. 67, figs 1–4; text-fig. 101c–e (with full synonymy).

2015. *Calycoceras* (*Newboldiceras*) *planecostatum* (Kossmat, 1897); Kennedy in Morel p. 143, text-fig. 118.

2015. *Calycoceras* (*Newboldiceras*) *planecostatum* (Kossmat, 1897); Kennedy in Kennedy and Gale, p. 297, pl. 20, fig. 7 (with additional synonymy).

TYPE: The lectotype, by the subsequent designation of Wright and Kennedy 1990, p. 252, is GSI 14842 (cast OUM KY4703; see here Pl. 32, Figs 4, 5), the original of Kossmat 1897, p. 9 (116), pl. 2 (13), fig. 1, from the Uttatur Group of Odiyam, South India.

MATERIAL: OUM KY2900, from section G–H at the 210–212 m level. OUM KY3140–3143, KY3145–3147, KY3149–3150, KY3152–3156, from section M–N at the 216 m level. OUM KY3212–3214, KY3216–3217, KY3219–3221, KY3223–3228, from section M–N at the 221 m level. All Middle Cenomanian, *asiaticum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3149 c	37.0 (100)	20.0 (54.0)	17.4 (47.0)	1.15	10.3 (27.8)
OUM KY2900 at	48.9 (100)	23.4 (66.3)	21.7 (43.4)	1.1	– (–)
at	61.0 (100)	– (–)	28.7 (42.6)	–	16.8 (27.5)
at	87.5 (100)	– (–)	38.8 (44.3)	–	24.5 (28.0)
OUM KY3220c	56.6 (100)	28.2 (49.8)	26.2 (46.3)	1.08	16.2 (28.6)
OUM KY3223c	72.2 (100)	32.9 (45.6)	32.0 (44.3)	1.03	21.2 (29.4)
OUM KY3213c	91.7 (100)	39.2 (42.7)	44.3 (48.3)	0.88	22.7 (24.8)
OUMK KY3142c	94.7 (100)	45.1 (47.6)	42.8 (45.2)	1.05	29.4 (31.0)
OUM KY32314c	100.0 (100)	– (–)	47.3 (47.3)	–	24.1 (24.1)
OUM KY4703*	109.5 (100)	51.9 (47.4)	54.2 (49.5)	0.96	26.5 (24.2)

*Cast of the lectotype

DESCRIPTION: OUM KY3149 (Pl. 33, Figs 4, 5) is a juvenile, well-preserved to a diameter of 37 mm. Coiling is moderately evolute, the shallow umbilicus comprising 27.8% of the diameter, the umbilical wall flattened, the umbilical shoulder broadly rounded.

The whorl section is slightly depressed, with a whorl breadth to height ratio of 1.15, the flanks feebly convex, subparallel, the ventrolateral shoulders broadly rounded, the venter feebly convex. Nine primary ribs arise at the umbilical seam, strengthen across the umbilical wall, and link to small umbilical bullae. These give rise to single ribs or a pair of ribs, with additional ribs intercalating to give a total of 20 ribs at the ventrolateral shoulder. The ribs are straight to feebly flexed, prorsirsdiate, and link to tiny inner and outer ventrolateral tubercles at the beginning of the outer half whorl, the outer ventrolateral linked across the venter by well-developed feebly convex transverse ribs that bear a tiny siphonal clavus. Both the inner ventrolateral and siphonal tubercles weaken progressively, and are lost at the greatest preserved diameter. OUM KY3154 (Pl. 33, Figs 6–8) continues the ontogeny to a diameter of 58 mm, with weak umbilical bullae and well-developed outer ventrolateral clavi, linked across the venter by a strong rib, the costal profile convex. OUM KY3222 (Pl. 33, Fig. 3), and OUM KY3225 (Pl. 33, Figs 9, 10) are interpreted as coarsely ornamented juveniles of the species.

The lectotype (Pl. 32, Figs 4, 5) is a phragmocone of an inflated variant, crushed at the apertural end. Coiling is slightly involute, with 67% of the previous whorl covered, the umbilical wall convex and undercut, the umbilical shoulder narrowly rounded. Nineteen to twenty primary ribs arise at the umbilical seam, strengthen across the umbilical wall and shoulder, and develop into weak, feebly concave umbilical bullae. These give rise to one, occasionally two ribs, with single ribs intercalating at or below mid-flank to give a total of 36 ribs at the ventrolateral shoulder on the outer whorl. The ribs are low, crowded, and broaden across the flanks. They are concave on the innermost flank, straight and prorsiradiate on the inner flank, very feebly convex at mid-flank, flexing back and feebly concave on the outer flank, where they broaden markedly and link to feeble outer ventrolateral clavi. A low, broad, feebly convex rib links the clavi across the broad, feebly convex venter. The ribs become broad, flat-topped and ribbon-like on the adapertural half of the outer whorl (from Kennedy and Klinger 2010, p. 15).

OUM KY3212 (Pl. 35) is interpreted as a near-complete adult macroconch with as maximum preserved diameter of 160 mm, retaining a 180° sector of body chamber; one flank is worn away. On the adapertural part of the body chamber, blunt umbilical bullae give rise to low, broad, prorsiradiate ribs, with single ribs intercalating both high and low on the flanks. They strengthen and broaden across the ventrolateral shoulder, producing an incipient inner ventrolateral tubercle. There is a weak, blunt outer ventrolateral tubercle, the tubercles linked across the venter by a low, broad, transverse rib. There are eight primary ribs on the surviving part of the adult body chamber; the umbilical bullae weakening progressively.

The suture is moderately incised, with a broad, bifid E/A and much narrower bifid A (Kossmat 1897, pl. 2 (13) fig. 1c).

DISCUSSION: See Wright and Kennedy 1990 (p. 253). The distinctive features are the crowded ribbing, combined with very early loss of inner ventrolateral and siphonal tubercles.

OCCURRENCE: Upper Middle and lower Upper Cenomanian, southern England, France, Germany, northern Spain, Iran, Morocco, Central Tunisia, KwaZulu-Natal in South Africa, Tamil Nadu, and James Ross Island, Antarctica.

Calycoceras (*Newboldiceras*) *tunetanum* (Pervinquière, 1907)

(Pl. 24, Figs 6, 7; Pl. 36, Figs 1–4; Pl. 37, Figs 1, 2)

1907. *Acanthoceras confusum* (Guéranger) var. *Tunetana* Pervinquière, p. 268, pl. 13, fig. 4.
1971. *Acanthoceras tunetana* Pervinquière; Kennedy, p. 90, pl. 40, fig. 5.
1972. *N.* (*Newboldiceras*) *tunetanum* (Pervinquière); Thomel, p. 105.
?1973. *Acanthoceras* cf. *tunetana* Pervinquière; Cooper, p. 59, fig. 2f, g.
1978. *Acanthoceras matsumotoi* Chiplonkar and Phansalkar, p. 472, pl. 2, figs 1, 2.
1978. *Acanthoceras hunteri* Chiplonkar and Phansalkar, *non* Kossmat, p. 475, pl. 1, fig. 3.
1978. *Acanthoceras rhotomagense* var. *confusum* Chiplonkar and Phansalkar *non* Guéranger, p. 474, pl. 2, figs 3, 4.
1978. *Acanthoceras intermedium* Chiplonkar and Phansalkar, p. 473, pl. 1, fig. 4.
1990. *Calycocera*s (*Newboldiceras*) *tunetanum* (Pervinquière, 1907); Wright and Kennedy, p. 251, pl. 69, fig. 2; text-figs 10; 106; 107 m; 110f.
1996. *Calycocera*s (*Newboldiceras*) *tunetanum* (Pervinquière, 1907); Wright and Kennedy, p. 401, pl. 124, fig. 1.
2015. *Calycoceras* (*Newboldiceras*) *tunetanum* (Pervinquière, 1907); Kennedy in Morel, p. 143, text-fig. 119.

TYPE: The holotype, by monotypy, is the original of

Acanthoceras confusum (Guéranger) var. *Tunetana* Pervinquière 1907, p. 268, pl. 13, fig. 4, from Djebel Habbes in Central Tunisia. It has not been traced.

MATERIAL: OUM KY2799, from section G–H at the 187 m level. OUM KY2808, from section G–H at the 195–196 m level, KY2816 at the 205 m level, and KY2901 from the 210–212 m level. OUM KY4416, from section K–L at the 50–60 m level; all Middle Cenomanian, *asiaticum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY2799 ic	117.6 (100)	– (–)	46.7 (39.7)	–	41.9 (35.6)

DESCRIPTION: The nucleus, of OUM KY2799 (Pl. 37, Figs 1, 2) has 24 ribs per whorl at the ventrolateral shoulder. The primary ribs arise on the umbilical wall, and strengthen into small umbilical bullae that give rise to straight, narrow, prorsiradiate ribs that link to subspinose inner ventrolateral tubercles, from which a feebly prorsiradiate rib links to a very feeble transversely elongated outer ventrolateral tubercle, the tubercles linked across the venter by a straight, transverse rib without any indication of a siphonal tubercle. Single ribs intercalate, are weaker than the primaries across the flanks, and have much weaker or no inner ventrolateral tubercles, with a ventral development as the primaries. The succeeding 120° sector of phragmocone shows the abrupt disappearance of the intercalated ribs, the primaries very widely separated, with strong umbilical bullae, and strong conical inner ventrolateral tubercles that become subspinose at the greatest preserved diameter. The outer ventrolateral tubercles are transversely elongated, and correspond to a marked angulation in the rib profile. They are linked across the venter by a strong transverse rib, the venter flat in costal profile.

OUM KY2808 (Pl. 36) is a better-preserved internal mould, retaining a 60° sector of body chamber. Coiling is evolute, the umbilical seam notched to accommodate the inner ventrolateral tubercles of the previous whorl. The broad, deep umbilicus comprises 31.9% of the diameter, the umbilical wall high and feebly convex, the umbilical shoulder broadly rounded. The whorl section is depressed in intercostal section, with a whorl breadth to height ratio of 1.19, the flanks feebly convex, the ventrolateral shoulders broadly rounded, the very broad venter feebly convex. The costal whorl section is polygonal, with the greatest breadth at the umbilical tubercle, the whorl breadth to height ratio 1.33. The ornament of the phragmocone is as in the previous specimen, and as in that specimen, there is an abrupt change in ornament, here at a diameter of 89 mm. The ribs become widely separated, the intercalated ribs are lost, or reduced to a non-tuberculate rib, confined to the venter. The inner ventrolateral tubercles are transformed into conical horns, the outer ventrolateral tubercles transversely elongated, the ventral rib profile feebly convex, with no indication of a siphonal tubercle.

OUM KY4416 is an internal mould of a near-complete adult with a maximum preserved diameter of 180 mm; it retains a 180° sector of body chamber. The change in ribbing described above is marked by a wide interspace 90° from the beginning of the outer whorl. Beyond this, the ribs are predominantly primaries, arising from well-developed umbilical bullae, straight and rectiradiate across the flanks, strengthening progressively, and linking to well-developed transversely elongated inner ventrolateral tubercles, linked across the venter by a strong transverse rib. OUM KY2901, with a maximum preserved diameter of 160–170 mm is a further adult, with a 120° sector of incomplete body chamber.

DISCUSSION: The distinguishing features of *C.* (*N.*) *tunetanum*, which separate it from all other *Calycoceras* (*Newboldiceras*) is the abrupt change from crowded primary and intercalated ribs to widely separated primary ribs with ventrolateral horns. On the basis of the present material, *Acanthoceras matsumotoi* Chiplonkar and Phansalkar, 1978 (p. 472, pl. 2, figs 1, 2), *Acanthoceras hunteri* Chiplonkar and Phansalkar, *non* Kossmat (1978, p. 475, pl. 1, fig. 3), *Acanthoceras rhotomagense* var. *confusum* Chiplonkar and Phansalkar, *non* Guéranger (1978, p. 474, pl. 2, figs 3, 4) and *Acanthoceras intermedium* Chiplonkar and Phansalkar, 1978 (p. 473, pl. 1, fig. 4) are synonyms of *tunetanum*.

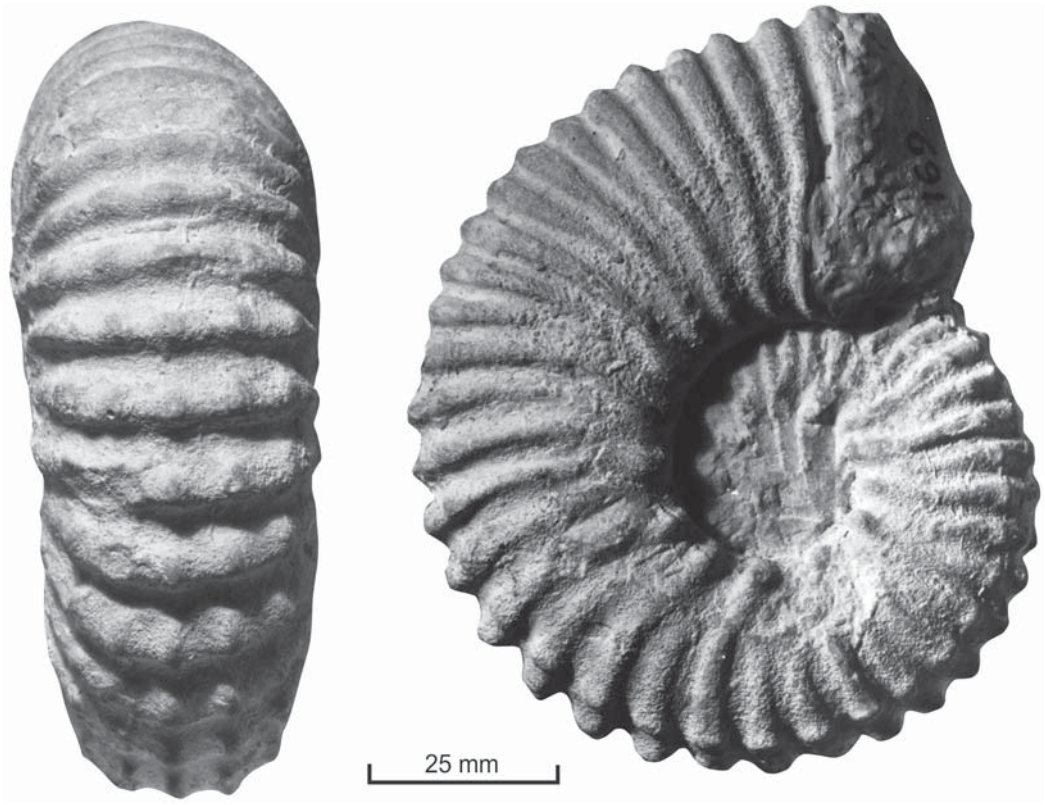
OCCURRENCE: Lower Middle Cenomanian, southern England and Central Tunisia, *asiaticum* Zone of Tamil Nadu.

Genus *Pseudocalycoceras* Thomel, 1969

TYPE SPECIES: *Ammonites harpax* Stoliczka, 1864, p. 72, pl. 39, figs 1, 2, by the original designation of Thomel 1969, p. 650.

Pseudocalycoceras harpax (Stoliczka, 1864)

(Pl. 38, Figs 1–10; Text-fig. 33)



Text-fig. 33. *Pseudocalycoceras harpax* (Stoliczka, 1864). Cast of the lectotype, GSI 169, the original of Stoliczka 1864, p. 72, pl. 39, fig. 1, from west of Odiyam, near Moravitoor

1864. *Ammonites harpax* Stoliczka, p. 72 (*pars*), pl. 39, fig. 1 only.
1864. *Ammonites morpheus* Stoliczka, p. 80, pl. 38, fig. 1.
1897. *Acanthoceras harpax* Stoliczka; Kossmat, p. 13 (120), pl. 4 (15), fig. 2.
2010. *Pseudocalycoceras harpax* (Stoliczka, 1864); Kennedy and Klinger, p. 18, fig. 63 (with full synonymy).
non 2013. *Pseudocalycoceras harpax* (Stoliczka, 1864); Ahmad *et al*., p. 28, text-fig. 7a, b (= *Pseudocalycoceras judaicum* (Taubenhaus, 1920).

NAME OF THE SPECIES: Kennedy and Klinger (2010, p. 18) regarded *morpheus* of Stoliczka as a pathological *harpax*, and selected the latter as the name of the species.

TYPE: The lectotype, by the subsequent designation of Matsumoto and Kawano 1975, p. 8 is GSI 169, the original of Stoliczka 1864, pl. 39, fig. 1. A cast is figured here (Text-fig. 33).

MATERIAL: From section O–P at the 246 m level: OUM KY3254–3268; from section R–S: OUM KY3428–3430, KY3432, from the 1 m level; OUM KY3443–3447 from the 8 m level; OUM KY3448–3461, from the 5–10 m level; all Upper Cenomanian *harpax* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3449c	67.2 (100)	29.8 (44.3)	33.0 (49.0)	0.90	16.5 (24.6)
OUM KY960*	78.4 (100)	32.3 (41.2)	33.2 (42.3)	0.97	21.8 (27.8)
OUIM KY3457c at	81.1 (100)	30.9 (38.1)	35.0 (43.2)	0.88	25.1 (30.9)
OUM KY3479 c	85.3 (100)	– (–)	34.9 (40.9)	–	26.6 (30.7)
OUM KY3480 c	91.4 (100)	– (–)	37.4 (40.9)	–	27.0 (29.5)
OUM KY3448 c	94.1 (100)	36.5 (38.8)	39.0 (41.4)	0.94	(31.0)

*Cast of Kossmat's original specimen

DESCRIPTION: The earliest growth stages seen are represented by OUM KY3263 (Pl. 38, Figs 4, 10) at a diameter of 25 mm. Four coarse bullae per half whorl give rise to pairs of relatively coarse ribs that are straight and prorsiradiate across the flanks, with one or two long or short ribs intercalating between successive primaries. The ribs coarsen across the flanks, and link to strong outer ventrolateral clavi; a strong transverse rib links the clavi across the venter, and bears a subequal siphonal clavus. OUM KY3454 (Pl. 38, Fig. 1) is a half whorl 48 mm in diameter, the umbilicus comprising 25% of the diameter, with a flattened wall and broadly rounded umbilical shoulder, the intercostal section with feebly convex subparallel flanks, broadly rounded ventrolateral shoulders and a feebly convex venter. Six umbilical bullae per half whorl give rise to pairs of prorsiradiate ribs with additional ribs intercalating to give a total of 16 ribs per half whorl at the ventrolateral shoulder. The ribs are straight on the inner flanks, coarser on the outer, and projected slightly forwards with a very feeble inner ventrolateral bulla and stronger outer ventrolateral and siphonal clavi. OUM KY3481 (Pl. 38, Figs 2, 3) is interpreted as a more densicostate variant at the same growth stage.

Kossmat's figured specimen (1897, pl. 4 (15), fig. 2), a cast of which is figured here (Pl. 38, Figs 5, 6) shows the original to retain a 120° sector of body chamber. Coiling is evolute, the umbilicus of moderate depth, comprising 27.8% of the diameter, the umbilical wall flattened, the umbilical shoulder broadly rounded. The intercostal whorl section is compressed oval, with feebly convex flanks, broadly rounded ventrolateral shoulders, and a broadly convex venter. The costal whorl section is polygonal, the greatest breadth at the umbilical bullae, the whorl breadth to height ratio 0.97. On the outer whorl, 14–15 ribs arise at the umbilical seam. They are weak on the umbilical wall, but strengthen on the umbilical shoulder, the overwhelming majority strengthening into umbilical bullae of variable strength. Most of the bullae give rise to a pair of ribs, a few to a single rib. The ribs strengthen across the flanks, and are recti- to feebly prorsiradiate on the inner flank, flexing back and rursiradiate on the outer flank. There are occasional intercalated ribs on the phragmocone, to give a total of an estimated 30 ribs at the ventrolateral shoulder of the outer whorl. All ribs strengthen across the ventrolateral shoulder, and bear conical to very feebly clavate inner ventrolateral tubercles that give rise to a strong transverse rib that bears strong outer ventrolateral and siphonal clavi. There are a numerous individuals of this type.

The final ontogenetic stage occupies most of the adult body chamber, and is well shown by OUM KY3435 (Pl. 38, figs 8, 9) and 3457 (Pl. 38, Fig. 7). The umbilical bullae weaken, and give rise to pairs of ribs that weaken and crowd, with additional ribs intercalating. Inner and outer ventrolateral tubercles are present on the adapical part of the body chamber, but first the inner ventrolateral, then the outer ventrolateral and siphonal rows are lost, leaving broad, rounded ventrolateral shoulders and venter, as in the lectotype (Stoliczka 1864, pl. 39, fig. 1; Text-fig. 33 herein).

The suture line (Kossmat 1897, pl. 4 (15), fig. 2c) is little-incised, with a broad, asymmetrically bifid E/A and narrow A.

DISCUSSION: *Ammonites morpheus* Stoliczka, 1864 (p. 80, pl. 38, fig. 1) is interpreted as an adult macroconch that has suffered non-lethal damage, leading to the asymmetrical development of the inner ventrolateral tubercles and the loss of the siphonal row. *Eucalycoceras harpax* var. *lattensis* Thomel, 1966 (p. 429, pl. 9, figs 1–3; 1972, p. 89, pl. 32, figs 1, 2) and var. *tulearensis* of Thomel, 1972, *non* Collignon (p. 429, pl. 110, figs 1, 2; 1972, p. 89), *Pseudocalycoceras harpax moustieriensis* Thomel, 1972, p. 90, pl. 31, figs 4, 5) and *Pseudocalycoceras harpax talinorensis* Thomel, 1972, *non* Collignon (p. 90, pl. 29, fig. 3) are *Thomelite sornayi* (Thomel, 1966) (see revision in Wright and Kennedy 1990, p. 286). *Pseudocalycoceras morpheus* of Thomel (1972, p. 91, pl. 32, figs 3, 4) based on a 180° whorl fragment, belongs to some other genus. The *Pseudocalycoceras* group of *harpax* of Kennedy and Juignet (1994b, p. 487, text-fig. 10a–e) are characterized by an early loss of the inner ventrolateral tubercles.

OCCURRENCE: Lower Upper Cenomanin, Tamil Nadu, Madagascar, KwaZulu-Natal in South Africa, southeastern France, and Japan.

Genus *Eucalycoceras* Spath, 1923
(ICZN Generic Name no. 1354)

TYPE SPECIES: *Ammonites pentagonus* Jukes-Browne, 1896, p. 156, pl. 5, fig. 1, by the original designation of Spath, 1923, p. 144 (ICZN Specific name no. 1635).

Eucalycoceras pentagonum (Jukes-Browne, 1896)
(Pl. 39, Figs 1–10; Pl. 40, Figs 11, 12)

1896. *Ammonites pentagonus* Jukes-Browne, p. 156, pl. 5, fig. 1.

1990. *Eucalycoceras pentagonum* (Jukes-Browne, 1896);

Wright and Kennedy, p. 282, pl. 78, figs 1, 3; pl. 79, figs 1–5, text-figs 89e; 123a, b (with full synonymy).

1996. *Eucalycoceras pentagonum* (Jukes-Browne, 1896); Kennedy *et al*., p. 316, pl. 39, figs 6, 7; pl. 40, figs 1, 2, 4 (with additional synonymy).

2010. *Eucalycoceras pentagonum* (Jukes-Browne, 1896) Kennedy in Morel, p. 143, text-fig. 123.

2015. *Eucalycoceras pentagonum* (Jukes-Browne, 1896) Kennedy in Kennedy and Gale, p. 305, pl. 21, fig. 1 (with additional synonymy).

TYPE: The holotype, by monotypy, is BGS GSM 53481, the original of Jukes-Browne 1896, p. 156, pl. 5, fig. 1, from the remanié phosphatic fauna of bed C of the Cenomanian Limestone at Humble Point, west of Lyme Regis, Devon. It was refigured by Wright and Kennedy (1990, pl. 79, fig. 5).

MATERIAL: OUM KY3325, from section O–P, 254 m level; OUM KY3326, 3328, 3330, from section O–P, 250–255 m level; OUM KY3462–3465, from section R–S, 5–10 m level; OUM KY3488–3491, from section R–S, 19 m level. OUM KY4177–4179, from section B, 24–26 m leve. OUM KY3932, identified as cf. *pentagonum*, from section section A, 16–18 m level. All Upper Cenomanian *harpax* Zone

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3464c	39.6 (100)	16.7 (42.2)	19.0 (48.0)	0.88	9.6 (24.2)
OUM KY3326	69.1 (100)	31.9 (40.8)	33.3 (48.2)	0.96	18.6 (26.9)
OUM KY3463	91.7 (100)	– (–)	37.4 (40.8)	–	22.9 (25.0)
OUM KY3325 at	101.4 (100)	– (–)	51.4 (50.7)	–	24. 7 (24.4)
OUM KY3489	126.0 (100)	(–)	53.9 (42.7)	–	32. 4 (25.7)

DESCRIPTION: The early whorls between 20 and 50 mm in diameter are represented by OUM KY3464–3466, and KY4177–4179. OUM KY3464 (Pl. 39, Figs 1, 2) 39.6 mm in diameter, is typical. Coiling is moderately evolute, the umbilicus shallow, with a low convex wall and broadly rounded umbilical shoulder. The whorl section is compressed, with feebly convex flanks, broadly rounded ventrolateral shoulders, and a feebly convex venter in intercostal section. The costal section is compressed, rounded-polygonal, with the greatest breadth below mid-flank; the whorl breadth to height ratio is 0.88. Eleven ribs per whorl arise at the umbilical seam, and strengthen into small bullae, perched on the umbilical shoulder. They give rise single ribs or a pair of ribs, with additional long and short ribs intercalating, to give a total of 36 at the ventrolateral shoulder, the ribs straight and prorsirsdiate on the inner flank, flexing forwards and feebly concave across the outer flank and ventrolateral shoulder. There are feeble inner ventrolateral bullae, stronger outer ventrolateral and siphonal clavi, borne on a straight transverse rib.

OUM KY3326 is a well-preserved phragmocone 69.1 mm in diameter. Coiling is evolute, the umbilicus deep, with a flattened wall and quite narrowly rounded umbilical shoulder. The flanks are flattened and subparallel in intercostal section, the ventrolateral shoulders broadly rounded, the venter feebly convex. The costal section is slightly depressed polygonal, with the greatest breadth below mid-flank. Ten ribs per half whorl arise at the umbilical seam, and strengthen across the umbilical wall, developing into small sharp bullae that project slightly into the umbilicus. They give rise to crowded straight rectiradiate to feebly rursiradiate ribs, usually in pairs, with additional long intercalated ribs to give a total of 22 per half whorl at the ventrolateral shoulder. All ribs bear small, feebly clavate inner ventrolateral tubercles, larger clavate outer ventrolateral tubercles, and conical to feebly transversely elongated siphonal tubercles, all borne on a strong transverse rib.

OUM KY3491 (Pl. 39, Figs 5, 6) is an incomplete microconch comprising part of the penultimate whorl with a maximum preserved diameter of 90 mm and the adapertural part of the adult body chamber, the maximum preserved whorl height of which is 38.3 mm, the costal whorl breadth to height ratio 1.15 at the adult aperture, and 0.95 90° before this. The body chamber fragment shows the changing ornament that typifies adults of the species. On the adapical part there are strong umbilical bullae, projecting slightly into the umbilicus.They give rise to relatively broad, ribbon-like ribs in pairs that bear feebly clavate inner and stronger clavate outer ventrolateral and transversely elongated siphonal tubercles. On the adapertural part, the ventrolateral and siphonal tubercles are abruptly lost, only the umbilical persisting, the interspaces between the flat-topped, ribbon-like ribs narrow markedly, and the ventrolateral shoulders and venter become evenly rounded. OUM KY3462 although worn, is a near-complete adult microconch with an estimated original diameter of 80 mm; OUM KY3463 (Pl. 40, Figs 11, 12) is a complete microconch 91.7 mm in diameter, showing the same ontogenetic changes as those described above.

OUM KY3489 (Pl. 39, Figs 9, 10) is a complete

adult macroconch 126 mm in diameter that retains much of the original shell material. There are 18 umbilical bullae on the outer whorl; the changes in ventrolateral and ventral ornament are as in the microconch. Although one flank is worn away, this was clearly a compressed individual, like that figured by Stoliczka (1864, pl. 38, fig. 2 only, *sub Ammonites harpax*).

DISCUSSION: See Wright and Kennedy (1984, p. 282).

OCCURRENCE: The species first appears in the lower Upper Cenomanian *Calycoceras guerangeri* Zone in Western Europe, and extends into the succeeding *Metoicoceras geslinianum* Zone, with records from southern England, Sarthe, Provence and Peche de Foix, Ariège, France, Spain, and Portugal. There are also records from Tadjikistan, Algeria, Central Tunisia, Madagascar, Tamil Nadu (where it is restricted to the *harpax* Zone), Japan, and Colorado and New Mexico in the United States.

Eucalycoceras gothicum (Kossmat, 1895)
(Pl. 16, Figs 26, 27; Pl. 40, Figs 8–10)

1965. *Ammonites Rotomagensis* (var. *compressus*) Stoliczka, p. 69, pl. 34, fig. 5 (= homonym of *Ammonites compressus* of authors; *fide* Sherborn 1925, p. 1430).
1895. *Acanthoceras gothicum* Kossmat, p. 198 (102), pl. 25 (11), fig. 3.
1990. *Eucalycoceras gothicum* (Kossmat, 1895); Wright and Kennedy, p. 279, pl. 76, figs 1, 3, 4, 6; text-fig. 94i–k (with full synonymy).

TYPE: The holotype, by monotypy, is GSI 14833 (cast OUM KY4701, see Pl. 40, Figs 8–10), the original of Kossmat, 1895, p. 198 (102), pl. 25 (11), fig. 3, from the Middle Cenomanian *Acanthoceras* beds of Odiyam, South India.

MATERIAL: OUM KY4138, 4139 from section B at the 10–20 m level; OUM KY4036–4039, from section C at the 42–43 m level, all Middle Cenomanian *asiaticum* Zone, northwest of Garudamangalam.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY4701	79.1 (100)	31.0 (39.2)	33.3 (42.1)	0.93	27.3 (34.5)

DESCRIPTION: The cast of the holotype (Pl. 40, Figs 8–10) shows the original to be a well-preserved internal mould of an almost, or perhaps wholly septate individual. Coiling is evolute, the umbilicus comprising 34.5% of the diameter, of moderate depth, with a concave umbilical wall, the umbilical shoulder broadly rounded. The intercostal whorl section is slightly compressed, the flanks feebly convex, the ventrolateral shoulders broadly rounded, the venter convex. The costal whorl section is compressed polygonal, with the greatest breadth around mid-flank. There are an estimated 16 tubercles on the umbilical shoulder. On the penultimate whorl and the adapical part of the outer whorl, they are short cones, but as size increases, they develop into blunt spines of variable strength that project into the umbilicus. On the adapical part of the outer whorl, the ribs are narrow, straight and prorsiradiate, with long intercalated ribs that are incipiently linked to a bulla, and short intercalated ribs. All ribs bear feebly bullate inner ventrolateral tubercles, a conical outer ventrolateral and a feebly transversely elongated siphonal tubercle, the tubercles linked across ventrolateral shoulders and venter by a strong, transverse rib. On the adapertural parts of the outer whorl, the umbilical spines typically give rise to pairs of ribs, with a few long intercalated ribs, to give a total of 39–40 ribs at the ventral shoulder. All ribs have a full complement of inner and outer ventrolateral and siphonal tubercles.

Additional material in the present collections consists of limonitic nuclei. OUM KY4039 (Pl. 16, Figs 26, 27), 27.5 mm in diameter, is typical; it has already developed the prominent bullae projecting into the umbilicus that characterize this species, separated by single intercalated ribs, all ribs bearing inner and outer ventrolateral and siphonal tubercles.

DISCUSSION: The spines projecting into the umbilicus characterize the species. See Wright and Kennedy (1990, p. 280).

OCCURRENCE: Upper Middle Cenomanian, *asiaticum* Zone of Tamil Nadu. Also known from southern England, south-eastern France, northern Spain, Romania, and possibly Tunisia. It may range into the lower Upper Cenomanian in southern England.

Eucalycoceras cf. *jeanneti* (Collignon, 1939)
(Pl. 45, Figs 1, 2)

Compare:
1939. *Calycoceras* (*Eucalycoceras*) *jeanneti* Collignon, p. 74, pl. 6, fig. 1.
2014. *Eucalycoceras jeanneti* Collignon, 1937; Kennedy and Bilotte, p. 30, text-figs 2, 5c, d.

TYPE: The holotype, by monotypy, is the original of Collignon 1939, p. 74, pl. 6, fig. 1, from the Upper Cenomanian of Ankilimanarivo, Madagascar. Originally in the collections of the École des Mines, Paris, no. EM 1632, it is currently in the collections of the Université de Lyon 1-Villeurbanne. It was refigured by Kennedy and Bilotte (2014, text-fig. 2).

MATERIAL: OUM KY3376, from section O–P at the 267–269 m level, Upper Cenomanian, *footeanum* Zone.

DESCRIPTION: The specimen is a 120° sector of body chamber with a maximum preserved whorl height of 40 mm and a whorl breadth to height ratio of 1.12, the greatest breadth well below mid-flank. There are an estimated 16 ribs on the fragment; most are narrow primaries that arise on the umbilical wall, strengthen across the wall and umbilical shoulder, without developing into an umbilical bulla. They are straight and prorsirsdiate across the flanks, strengthening progressively, and passing straight across the venter. On the adapical part of the fragment, one or two ribs intercalate between successive primaries, giving the fragment a highly distinctive appearance in ventral view.

DISCUSSION: Although only a fragment, the style of ribbing, with strong, narrow primaries and very weak primaries/long intercalatories between, matches well with that of the holotype.

OCCURRENCE: As for material.

Genus *Tarrantoceras* Stephenson, 1955

TYPE SPECIES: *Tarrantoceras rotatile* Stephenson, 1955, p. 59, pl. 5, figs 1–10 = *Mantelliceras sellardsi* Adkins, 1928, p. 239, pl. 25, fig. 1; pl. 26, fig. 4.

Subgenus *Sumitomoceras* Matsumoto, 1969

TYPE SPECIES: *Sumitomoceras faustum* Matsumoto and Muramoto, 1969, p. 283, pl. 38, figs 1–4; text-fig. 8, by the original designation of Matsumoto in Matsumoto *et al.* 1969, p. 280.

Tarrantoceras (*Sumitomoceras*) *faustum* Matsumoto and Muramoto, 1969
(Pl. 40, Figs 1–6)

1969. *Sumitomoceras faustum* Matsumoto and Muramoto, p. 283, pl. 38, figs 1–4; text-fig. 8.

1981. *Tarrantoceras* (*Sumitomoceras*) *faustum* Matsumoto and Muramoto, 1969; Wright and Kennedy, p. 38, text-fig. 16d–g.

1988. *Tarrantoceras* (*Sumitomoceras*) *faustum* Matsumoto and Muramoto, 1969; Kennedy, p. 46.

1996. *Tarrantoceras* (*Sumitomoceras*) *faustum* Matsumoto and Muramoto, 1969; Wright, p. 158, text-fig. 122. 4.

TYPES: The holotype is no. H5595, in the collections of the Department of Geology of Kyushu University, the original of Matsumoto and Muramoto 1969, pl. 38, fig. 1, from the Mikasa Formation, Upper Cenomanian *Inoceramus labiatus*/*Kanabiceras septemseriatum* Zone of Matsumoto *et al*., 1969 (p. 286) in the Ikushumbets Vallley, Hokkaido. There are five paratypes from the same locality.

MATERIAL: OUM KY3339, 3341–3343, from section O–P at the 261 m level; OUM KY3505, from section R–S, at the 26.5 m level, all Upper Cenomanian, *Kanabiceras septemseriatum* Zone.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3339 c	76.1 (100)	22.5 (29.6)	26.6 (35.0)	0.85	25.2 (33.1)

DESCRIPTION: OUM KY3339 (Pl. 40, Figs 1–3) and KY3505 (Pl. 40, Figs 6, 7) both retain their original aragonitic shell. Coiling is evolute, the shallow umbilicus comprising 25.2% of the diameter in OUM KY3339, the umbilical wall low, concave on the outer whorl, and flattened in KY3505, the umbilical shoulder quite narrowly rounded. The whorl section is compressed, the flanks flattened and convergent, the ventrolateral shoulders broadly rounded, the venter feebly convex in costal and intercostal section, the greatest breadth at the umbilical bullae. The costal whorl breadth to height ratio is 0.85. On the outer whorl, strong narrow ribs arise on the umbilical wall, and strengthen into eight small bullae on the adapical half. These give rise to pairs of ribs, and additional short ribs intercalate. The primary ribs are straight and prorsiradiate on the inner flank, flex back and are very feebly concave on the outer flank, strengthen, and cross the venter (where they number over 20 per half whorl) near-straight. The umbilical bullae and the ribs strengthen on the adapertural half of the outer whorl. The bullae give rise to a single rib or a pair of ribs, with additional ribs intercalating to give a total of 21at the umbilical shoulder. The penultimate whorl, only partially exposed, is very finely ribbed. OUM KY3505 differs in no significant

respects. OUM KY3341 (Pl. 40, Fig. 5) is a crushed juvenile with a maximum preserved whorl height of 45 mm.

DISCUSSION: Of described species (see Wright and Kennedy 1981, p. 38; Kennedy 1988, p. 44 *et seq.*), the closest to *faustum* is *T.* (*S.*) *cautisalbae* Wright and Kennedy, 1981 (p. 39, pl. 6, figs 1, 2, 4?, 5?); which has a less compressed whorl section, straight rather than feebly flexed ribs, more persistent tubercles, and stronger constrictions.

OCCURRENCE; Upper Cenomanian *septemseriatum* Zone, Hokkaido, Japan, and Tamil Nadu.

Genus *Watinoceras* Warren, 1930

TYPE SPECIES: *Watinoceras reesidei* Warren, 1930, p. 67, pl. 3, fig. 2, pl. 4, figs 9–12, by the original designation of Warren, 1930, p. 66.

Watinoceras elegans sp. nov.
(Pl. 29, Figs 9–14)

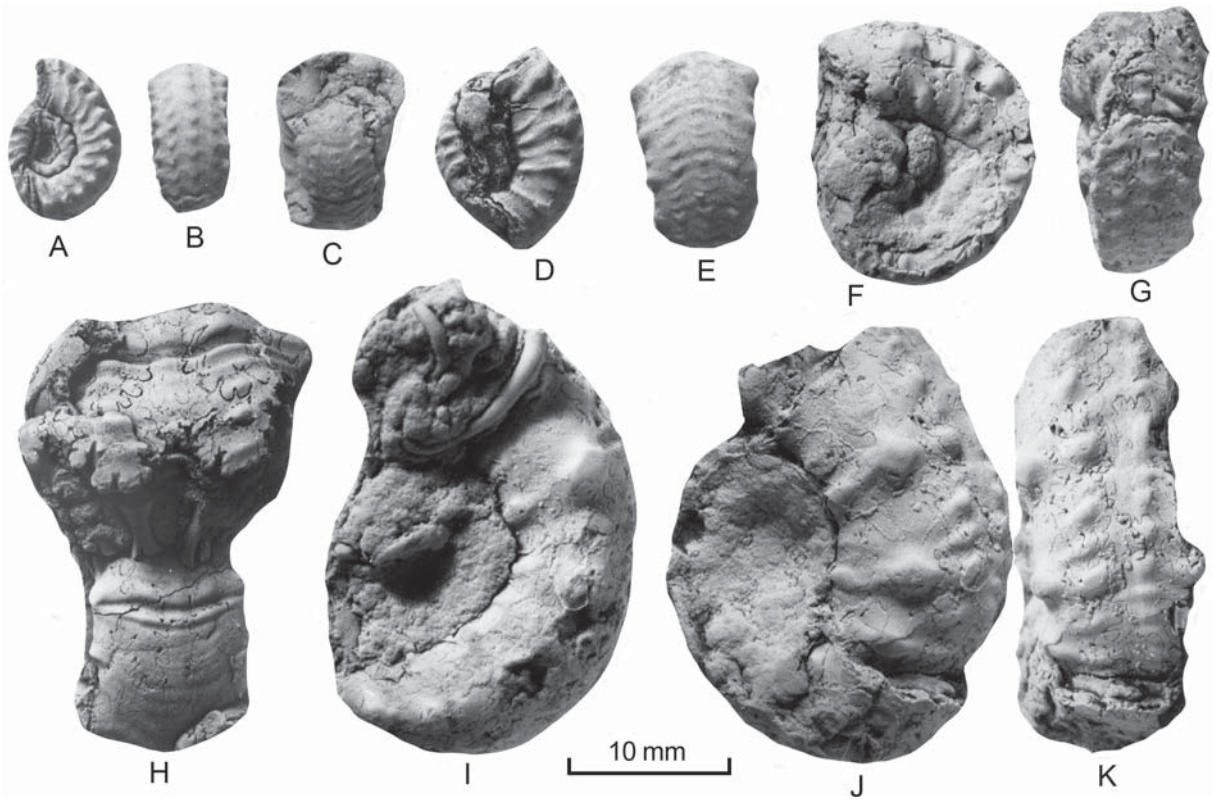
TYPE: The holotype is OUM KY3377, paratypes are OUM KY3379 and KY3380 from section O–P, 265 m level, Upper Cenomanian, *septemseriatum* Zone.

DIAGNOSIS: *Watinoceras* with a depressed whorl section, the primary ribs separated by long or short intercalated ribs, the latter lacking an inner ventrolateral tubercle in some cases; ventrolateral tuberculation weakens on adult body chamber, where only the outer ventrolateral tubercle survives, or is represented by a mere angulation in the rib profile.

DESCRIPTION: The holotype (Pl. 29, Figs 9–12) has a maximum preserved diameter of 57 mm, and retains a 60° sector of body chamber. Coiling is evolute, the inner ventrolateral tubercles of the preceding whorl housed in notches in the umbilical seam of the succeeding whorl. The umbilicus comprises 32.4% of the diameter, and is quite deep, with a feebly convex wall and broadly rounded umbilical shoulder. The intercostal whorl section is depressed reniform, with a whorl breadth to height ratio of 1.27, the greatest breadth below mid-flank, the costal whorl section polygonal, with the greatest breadth at the umbilical bullae. On the penultimate whorl, strong umbilical bullae give rise to strong conical inner ventrolateral tubercles, from which a strong prorsiradiate rib links to a smaller oblique outer ventrolateral clavus, the clavi linked across the venter by a coarse rib, projected forwards into a very obtuse ventral chevron. There are occasional short intercalated ribs that lack an inner ventrolateral tubercle. There are 14 sharp bullae on the outer whorl, linked to the umbilical seam by a feeble rib. On the adapical part of the whorl, They give rise to a strong, straight, feebly prorsirsdiate rib that links to a strong conical inner ventrolateral tubercle from which a feebly prorsiradiate rib links to a feebly clavate outer ventrolateral tubercle. These tubercles are linked over the venter by a coarse, transverse rib. There are occasional long intercalated ribs with a full complement of inner and outer ventrolateral tubercles, and short intercalated ribs that lack the inner ventrolateral tubercle. The inner ventrolateral tubercles weaken markedly on the adapertural 60° sector of the outer whorl. OUM KY3379 (Pl. 29, Figs 13, 14) is a phragmocone 71.5 mm in diameter, retaining traces of original shell material, and heavily encrusted with a carbonate overgrowth that obscures the fine detail of the ornament. The adapical part of the outer whorl has primary ribs that arise from umbilical bullae, together with long intercalated ribs, all of which have inner and outer ventrolateral tubercles, together with short intercalated ribs that bear only outer ventrolateral tubercles. The inner ventrolateral tubercles efface and are lost, and at the adapertural end of the specimen, only transversely elongated blunt outer ventrolateral tubercles persist. OUM KY3380 is a somewhat worn individual with a maximum preserved diameter of 93 mm. Coiling is evolute, the umbilicus comprising 34% approximately of the diameter. The umbilical wall, partially obscured by matrix, appears to have been concave, the umbilical shoulder broadly rounded. The original whorl section cannot be established, as one flank is worn away. Primary ribs arise on the umbilical wall, and strengthen across the shoulder, developing into feeble bullae. These give rise to strong primary ribs, straight and rectiradiate across the flanks, and flexing very feebly forwards across the ventrolateral shoulder, where there is a marked angulation, interpreted as marking the site of an effaced outer ventrolateral tubercle. Single long or short ribs intercalate.

DISCUSSION: *Watinoceras* species are comprehensively reviewed by Cobban (1988). The species closest to *elegans* is the Lower Turonian. *W. thomsonense* Cobban, 1988 (p. 9, pl. 3, figs 1–3, 6–8). This reaches a much larger size, has ribs arising in pairs from umbilical bullae, and inner and outer ventrolaterl tubercles on all ribs throughout ontogeny.

OCCURRENCE: As for types.



Text-fig. 34. *Euomphaloceras euomphalum* (Sharpe, 1855). **A**, **B** – OUM KY3921; **C-E** – OUM KY3922; **F**, **G** – OUM KY3923; **H** – OUM KY3924; **I** – OUM KY39119a; **J**, **K** – OUM KY3926, all from the Karai Formation, Uppper Cenomanian *harpax* Zone, *euomphalum* fauna, from section A, north-west of Garudamangalam, at the 16–18 m level

Subfamily Euomphaloceratinae Cooper, 1978
Genus *Euomphaloceras* Spath, 1923

TYPE SPECIES: *Ammonites euomphalus* Sharpe, 1855, p. 31, pl. 13, fig. 4, by monotypy.

Euomphaloceras euomphalum (Sharpe, 1855)
(Text-fig. 34A–K)

1855. *Ammonites euomphalus* Sharpe, p. 31, pl. 13 fig. 4.
1990. *Euomphaloceras euomphalum* (Sharpe, 1855); Wright and Kennedy, p. 294, pl. 85, figs 1, 2, 7, 9; pl. 86, figs 1–10; text-figs 94f–h, 107h (with full synonymy)

TYPE: The holotype, by monotypy, is BMNH 50185, the original of Sharpe 1855, p. 31, pl. 13, fig. 4, said by Sharpe to be from Man o'War Cove, Dorset, but from Humble Point, Devon (Wright and Kennedy 1990, p. 294).

MATERIAL: OUM KY3919 (collective of seven specimens); KY3921–3925, from section A, 16–18 m level, Upper Cenomanian, *harpax* Zone, *euomphalum* fauna.

DESCRIPTION: All specimens are limonitic internal moulds of phragmocones that range from 7.5 to 24 mm in diameter. Coiling is evolute, the whorl section depressed oval in intercostal section and depressed polygonal in costal section, with the greatest breadth at the inner ventrolateral tubercles. OUM KY3921 (Text-fig. 34A, B) is 9.7 mm in diameter. Twelve umbilical bullae perch on the umbilical shoulder of the adapical half of the outer whorl, and vary slightly in strength, especially at the greatest preserved diameter. They give rise to single prorsiradiate ribs that link to well-developed conical inner ventrolateral tubercles. A feeble markedly prorsiradiate rib links to weaker oblique outer ventrolateral clavi, linked in turn by a prorsiradiate rib to a conical siphonal tubercle at the apex of an obtuse chevron. OUM KY3922 (Text-fig. 34C–E) shows the succeeding ontogenetic stage.

Stronger bullate primary ribs with well-developed inner ventrolateral tubercles alternate with weaker ribs that may arise on the umbilical shoulder without developing into a bulla, have a weak inner ventrolateral tubercle or may lack one. Secondary ribs arise in pairs from the inner ventrolateral tubercles and intercalate, such that there are many more obliquely aligned outer ventrolateral bullae than inner ventrolateral tubercles. The bullae on the primary ribs are stronger than those on the secondary and intercalated ribs, as are the transversely elongated siphonal tubercles. OUM KY3923 (Text-fig. 34F, G), 15.8 mm in diameter, has less markedly differentiated outer ventrolateral and siphonal tubercles. OUM KY3925 (Text-fig. 34J, K) is a larger individual, with an estimated diameter of over 25 mm. Primary ribs with well-developed umbilical bullae are separated by intercalated ribs such that there are many more outer ventrolateral and siphonal tubercles than inner ventrolateral; the outer ventrolateral and siphonal row are variable in both strength and shape. This specimen shows the incipient development of ventral constrictions. These are well-developed between the pairs of ribs that arise from the stronger inner ventrolateral tubercles in OUM KY3924 (Text-fig. 34H). The siphonal tubercles are very feeble on these ribs, and absent on the intercalated ribs. The suture has a long, narrow E/A, and a broad, bifid A with a large median element.

DISCUSSION: See Wright and Kennedy 1990, p. 294.

OCCURRENCE: Upper Cenomanian, *guerangeri* Zone, southern England, and correlatives in Central Tunisia and Madagascar, *harpax* Zone in Tamil Nadu.

Euomphaloceras septemseriatum (Cragin, 1893)
(Pl. 41, figs 4, 5)

1893. *Scaphites septemsertiatus* Cragin, p. 240.
1981. *Euomphaloceras septemseriatum* (Cragin, 1893); Wright and Kennedy, p. 55, pl. 12, figs 1–8; pl. 13, figs 1–6; pl. 14, figs 5–9 (with synonymy).
1989. *Euomphaloceras septemseriatum* (Cragin, 1893); Cobban *et al*., p. 35, text-figs 35; 76q–t, z–ff, hh–pp (with additional synonymy).
2003. *Euomphaloceras septemseriatum* (Cragin, 1893); Kennedy *et al*., p. 10, pl. 2, figs 9, 10, 13, 15, 18–23 (with additional synonymy).
2014. *Euomphaloceras septemseriatum* (Cragin, 1893); Wilmsen and Nagm, p. 214, text-fig. 6c (with additional synonymy).
2015. *Euomphaloceras septemseriatum* (Cragin, 1893); Kennedy in Morel, p. 144, fig. 127m, n.
2017 *Euomphaloceras septemseriatum* (Cragin, 1893); Kóšták *et al*., p. 159, text-figs 6l; 7a–f. (with additional synonymy).

TYPE: The holotype, by monotypy, is no. 21058 in the collections of the Texas Memorial Museum, Austin, from the Britton Formation, Upper Cenomanian *Sciponoceras gracile* Zone, Keenan's Crossing on the Trinity River, Dallas County, Texas. It was refigured by Cobban and Scott (1973, pl. 12, figs 24, 25).

MATERIAL: OUM KY3356–3358, from section O–P, at the 261 m level; Upper Cenomanian, *septemseriatum* Zone

DESCRIPTION: The present material retains original nacreous aragonitic shell material in some cases, and consists of fragments and one relatively well-preserved specimen, OUM KY3358 (Pl. 41, Figs 4, 5). This has a maximum preserved diameter of 57 mm, and retains a 90° sector of body chamber. Coiling is evolute, the deep umbilicus comprising 31.6% of the diameter, the umbilical wall flattened and outward-inclined, the umbilical shoulder broadly rounded. The intercostal whorl section is depressed oval, the costal whorl section depressed polygonal. Narrow primary ribs strengthen across the umbilical wall, and link to small umbilical bullae. Weakly prorsiradiate ribs link to much stronger feebly bullate inner ventrolateral tubercles that are clearly, in some cases, the bases of septate spines. There are more numerous small, oblique outer ventrolateral clavi that give rise to a prorsiradiate rib that links to a strong siphonal ridge, the ribs forming an obtuse chevron with a siphonal clavus, borne on the ridge, at the apex. OUM KY3356 is the internal mould of the dorsum of a fragment with an estimated whorl width of 18 mm, with comparable ventral ornament of the penultimate whorl preserved. OUM KY3357 is a fragment of the body chamber of an adult.

DISCUSSION: Although slight, the present material agrees well with the holotype and other material from the Britton Formation of north-east Texas (Kennedy 1988, p. 53, pl. 8, figs 1–6; pl. 9 figs 1–3, 5–7, 9–12; pl. 22, fig. 3). See Wright and Kennedy (1981, p. 55) for further discussion.

OCCURRENCE: Upper Cenomanian, *septemseriatum* Zone and correlatives, Texas, New Mexico, Arizona, Colorado, Kansas, Montana, Utah, and California, northern Mexico, Brazil, Japan, Tamil Nadu, southern England, northern France, Germany, Angola, and Nigeria.

Euomphaloceras varicostatum sp. nov.
(Pl. 41, Figs 1–3, 6–8; Pl. 42, Figs 2, 4–6)

TYPES: The holotype is OUM KY3562, paratypes OUM KY3553–3561, from section R–S, at the 65 m level, Upper Cenomanian, *Hourcqiceras lateloba-tum–Pseudaspidoceras hourcqi* fauna.

DIAGNOSIS: A *Euomphaloceras* with widely separated ribs, the wide interspaces between which are ornamented by growth lines and delicate riblets, some of which strengthen into the feeblest of inner ventrolateral tubercles.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3558c	23.5 (100)	10.4 (44.3)	9.2 (39.1)	1.13	5.8 (24.7)

DESCRIPTION: The best-preserved of the juvenile paratypes is OUM KY3558 (Pl. 41, Figs 6–8), 23.5 mm in diameter. Coiling is evolute, the umbilicus of moderate depth, and comprising 24.7% of the diameter. The convex umbilical wall is outward-inclined, the umbilical shoulder broadly rounded. The intercostal whorl section is depressed, with convex flanks, broadly rounded ventrolateral shoulders and a broad, feebly convex venter. The costal whorl section is depressed polygonal, with a whorl breadth to height ratio of 1.13. Twelve ribs arise at the umbilical seam, and strengthen across the umbilical wall and shoulder, where they develop into weak umbilical bullae. These give rise to feebly flexuous ribs that strengthen across the flanks and link to blunt inner ventrolateral bullae that may have been the bases of septate spines. A feebly prorsiradiate rib links to conical outer ventrolateral tubercles, one of which bears a spine, confirming them as the bases of septate spines. A low, broad, transverse rib links to a smaller siphonal clavus. There are a few intercalated ribs, and where the shell surface is well preserved the interspaces are ornamented by well-developed flexuous growth lines.

Paratype OUM KY3555 (Pl. 42, Fig. 4), 34 mm in diameter, is a crushed individual with one flank well-preserved. The ribs become progressively more widely separated, and there are well-developed riblets as well as growth lines in the interspaces that become increasingly prominent at the greatest preserved diameter. This style of ornament is already present in paratype OUM KY3554 (Pl. 42, Fig. 5) at a diameter of 13.7 mm.

The holotype, OUM KY3562 (Pl. 41, Figs 1–3) is a crushed but otherwise well-preserved individual 121 mm in diameter, retaining the original nacreous aragonitic shell. Coiling is very evolute, the umbilicus comprising 38% of the diameter. There are 15 primary ribs on the outer whorl. They are strong, widely separated, strengthening across the umbilical wall and developing into strong rounded bullae. These give rise to strong, widely separated prorsiradiate ribs that link to strong conical-bullate inner ventrolateral tubercles that are the bases of septate spines, linked in turn by a broad rib to an outer ventrolateral spine, one of which is preserved. There is no clear evidence for the presence or absence of siphonal tubercles. The wide interspaces between successive primaries are ornamented by growth lines and delicate riblets, some of which strengthen into the feeblest of inner ventrolateral tubercles. The adapertural primary rib is very weak, the umbilical bulla lost; preservation is poor, but it appears to have borne both inner and outer ventrolateral spines.

DISCUSSION: The very widely separated ribs, with interspaces ornamented by weak riblets that either lack, or have only very feeble inner ventrolateral tubercles distinguish the holotype from all other species assigned to the genus. Paratype OUM KY3558 (Pl. 41, Figs 6–8) is interpreted as a more closely ribbed variant.

OCCURRENCE: As for types.

Genus *Lotzeites* Wiedmann, 1960

TYPE SPECIES: *Acanthoceras aberrans* Kossmat, 1895, p. 202 (106), pl. 24 (10), fig. 4, by the original designation of Wiedmann 1960, p. 731.

Lotzeites aberrans (Kossmat, 1895)
(Pl. 42, Figs 1, 3, 7–12)

1895. *Acanthoceras aberrans* Kossmat, p. 202 (106), pl. 24 (10), fig. 4.
1990. *Lotzeites aberrans* (Kossmat, 1895); Wright and Kennedy, p. 292, pl. 85, figs 3–6, 8, 10; text-fig. 94f–h (with full synonymy).
2017. *Lotzeites aberrans* (Kossmat, 1895); Košťák *et al*., p. 159, text-fig. 6d–k (with additional synonymy).

TYPE: The holotype, by monotypy, is the original of *Acanthoceras aberrans* Kossmat 1895, p. 202 (106), pl. 24 (10), fig. 4, no. 14828 in the collections of the Geological Survey of India, from the Uttatur Group

of Odiyam. A cast (OUM KY4700) is figured here (Pl. 42, Figs 7–9).

MATERIAL: OUM KY3468–3470, from section R–S at the 5–10 m level; OUM KY3313, from section O–P at the 250 m level, all Upper Cenomanian *harpax* Zone.

DESCRIPTION: OUM KY3468 (Pl. 42, Fig.1) is a nucleus 26.5 mm in diameter. The whorl section is very depressed, reniform. There are 10 primary ribs per whorl that strengthen across the umbilical wall. The flanks are damaged, but there are massive ventrolateral tubercles, linked over the venter by pairs of ribs, with additional ribs intercalating, the ribs feebly convex. Occasional interspaces are deepened into constrictions, conspicuous on the ventrolateral shoulders. OUM KY3469 is a fragment of a slightly larger individual, 25 mm long. Small umbilical bullae give rise to strong, narrow, widely separated prorsiradiate ribs that link to large ventrolateral tubercles, linked across the venter by a pair of feebly convex ribs with no indication of a siphonal tubercle. OUM KY3470 (Pl. 42, Fig. 3) is a battered individual 34mm in diameter with comparable ornament, and well-developed constrictions on the adapical part.

A plaster cast of the holotype, OUM KY4700 (Pl. 42, Figs 7–9) has the following dimensions:

	D	Wb	Wh	Wb:Wh	U
OUM KY4700	62.1 (100)	43.1 (69.4)	25.8 (41.5)	1.67	(38.3)

Coiling is very evolute, the deep umbilicus comprising 23.8% of the diameter, the high umbilical wall feebly convex on the inner whorls and adapical part of the outer whorl, but feebly concave thereafter. The umbilical shoulder is broadly rounded, the intercostal whorl section depressed reniform, with markedly convex flanks and a broad, convex venter. The costal whorl section is depressed polygonal, with the greatest breadth at the inner ventrolateral tubercles. There are 18 primary ribs on the penultimate whorl. They arise on the umbilical wall, strengthen across the umbilical shoulder and develop into small bullae. These give rise to narrow, straight recti- to feebly rursiradiate ribs that link to small ventrolateral bullae. Umbilical and ventrolateral tubercles coarsen markedly on the outer whorl. On the adapical part, the ventrolateral tubercles give rise to pairs of narrow ribs that either loop across the venter to the ventrolateral tubercle on the opposite flank, or intercalate, producing a zigzag pattern in places. There is a slight angulation on the ribs associated with a minor strengthening into an incipient outer ventrolateral bulla. On the adapertural part of the outer whorl, this pattern of ribbing modifies, and weaker intercalated ribs appear, lacking a ventrolateral tubercle, whilst the tuberculate ribs develop a feeble transversely elongated outer ventrolateral tubercle. OUM KY3313 (Pl. 42, Figs 10–12) is slightly larger than the holotype; damage to the venter precludes accurate estimation of the maximum diameter. It is better preserved in places, revealing that the umbilical and inner ventrolateral tubercles are spinose.

The suture (Kossmat 1895, pl. 24 (10), fig 4c) is moderately incised, with a broad, asymmetrically bifid E/A and a broad, asymmetrically bifid A with as large median element.

DISCUSSION: See Wright and Kennedy (1990, p. 292). *Lotzeites elegans* Kennedy, 2015 (in Kennedy and Gale 2015, p. 307, pl. 16, figs 2,3; Kennedy in Kennedy and Gale 2017, p. 100, pl. 13, figs 1–3; pl. 14, figs 1–6, 10, 11; text-fig. 11) differs most obviously in the presence of outer ventrolateral and siphonal tubercles on the inner whorls.

OCCURRENCE: Upper Cenomanian, *guerangeri* Zone of southern England; Madagascar, and *harpax* Zone of Tamil Nadu.

Genus *Hourcqiceras* Collignon, 1939

TYPE SPECIES: *Calycoceras* (*Hourcqiceras*) *hourcqi* Collignon, 1939, p. 78, pl. 4, figs 1–3; pl. 4, fig. 1; figs 1–3; text-figs c, d, herein designated.

Hourcqiceras latelobatum Collignon, 1939
(Pl. 43, Figs 4, 5)

1939. *Calycoceras* (*Hourcqiceras*) *latelobatum* Collignon, p. 76, pl. 3, figs 1–3, text-figs a, b.
1964. *Hourcqiceras latelobatum* Collignon, p. 148, pl. 374, fig. 1626.

TYPES: The lectotype, here designated, is EM 1630, the original of Collignon 1939, pl. 3, fig. 1, from the Upper Cenomanian of Andranovoritelo, Madagascar, there are two paralectotypes from this locality, and five from Ankilimanarivo (Collignon 1939, p. 78). Originally in the collections of the École des Mines, Paris, they are currently housed in the collections of the Université Claud Bernard, Lyon 1, Villeurbanne.

MATERIAL: OUM KY3351, from section R–S at the

65 m level, Upper Cenomanian, *Hourcqiceras latelobatum–Pseudaspidoceras hourqi* fauna.

DESCRIPTION: OUM KY3351 is a 180° sector of crushed body chamber 85 mm in diameter. Coiling is evolute, the umbilicus of moderate depth, comprising 30% approximately of the diameter, the umbilical wall convex, the umbilical shoulder broadly rounded. The whorl section is depressed reniform, the costal whorl section depressed rounded-polygonal, with the greatest breadth below mid-flank. Ten primary ribs arise at the umbilical seam, and strengthen across the umbilical wall and shoulder; seven intercalated ribs arise below mid-flank to give a total of 17 ribs at the ventrolateral shoulder. At the adapical end of the fragment, the primary ribs bear small umbilical bullae, and are near-straight across the flanks and venter, where they bear well-developed transversely elongated outer ventrolateral and siphonal clavi, As size increases, the umbilical bullae decline and are lost, the outer ventrolateral tubercles are reduced to angulations in the rib profile and the siphonal tubercles weaken. The specimen is interpreted as a small adult.

DISCUSSION: *Hourcqiceras latelobatum* differs from *H. coleroonense* (Stoliczka, 1865) (p. 71, pl. 37, figs 3–6), described below, in lacking an inner ventrolateral tubercle and not developing the distinctive concavity of the ventral rib profile.

OCCURRENCE: Upper Cenomanian of Madagascar and Tamil Nadu.

Hourcqiceras coleroonense (Stoliczka, 1864)
(Pl. 43, Figs 1–3, 6, 7; Pl. 44, Figs 5, 6;
Pl. 45, Figs 5, 6; Pl. 47, Figs 2, 3)

1864. *Ammonites Coleroonensis* Stoliczka, p. 71, pl. 37, figs 4–6.
1898. *Acanthoceras Colerunense* Stol. (*sic*); Kossmat, p. 20 (127), pl. 5 (16), fig. 2.
1925. *Mammites colerunense* Stoliczka; Diener, p. 173.

TYPES: Stoliczka based this species on several specimens. The original of his pl. 37, fig. 5 is designated lectotype herein; it is from Kunnam [Coonam]

MATERIAL: OUM KY3378, from section O–P, at the 265 m level; OUM KY3368–3372, from section O–P at the 267–269 m level, Upper Cenomanian *footeanum* Zone VP Kn 2 from Kunnam, and VP OD188, from Odiyam.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
VP Kn2	74.2 (100)	37.4 (46.4)	30.4 (41.0)	1.23	23.6 (32.8)
OUM KY3368	114.6 (100)	53.1 (46.3)	47.3 (41,3)	1.12	38.8 (33.9)

DESCRIPTION: The earliest growth stages seen are represeted by OUM KY3378 (Pl. 43, Fig. 3). The maximum preserved whorl height is 22.5 mm. At the beginning of the outer whorl, the ventral region is well-preserved. Strong conical inner ventrolateral tubercles give rise to a strong prorsiradiate rib that links to a well-developed oblique outer ventrolateral clavus, the clavi linked to a weaker siphonal tubercle by a prorsiradiate rib, forming an obtuse chevron, the rib profile concave between the outer ventrolateral tubercles. There are also short intercalated ribs that bear only outer ventrolateral and siphonal tubercles. One interspace is strengthened into a broad ventral and ventrolateral constriction. The adapertural part of the specimen has strong umbilical bullae that give rise to coarse, straight, radial ribs that bear blunt inner ventrolateral bullae, linked by a broad rib to transversely elongated outer ventrolateral tubercles, linked across the venter by a coarse transverse rib, the rib profile slightly concave between the tubercles. There are both long and short intercalated ribs, the latter bearing outer ventrolateral tubercles only.

VP Kn 2 (Pl. 45, Figs 5, 6; Pl. 47, Figs 3, 4) is a corroded specimen 74.2 mm in diameter. Coiling is very evolute, the deep umbilicus comprising 23.6% of the diameter, the umbilical seam notched to accommodate the inner ventrolateral tubercles of the preceding whorl, the umbilical wall feebly convex, the umbilical shoulder broadly rounded. The whorl section is depressed, rounded-trapezoidal in intercostal section, the flanks feebly convex, the greatest breadth below mid-flank, the flanks converging to broadly rounded ventrolateral shoulders, the venter broad, and very feebly convex. On the penultimate whorl, widely separated primary ribs arise at the umbilical seam, strengthen across the umbilical wall, and develop into small umbilical bullae. These give rise to a single straight, prorsiradiate rib that links to an inner ventrolateral tubercle, subspinose where shell material is preserved. On the outer whorl, which is in part body chamber, eighteen primary ribs arise at the umbilical seam, pass straight up the umbilical wall, and link to crowded umbilical bullae, subspinose where shell is preserved, and of variable strength. They give rise to single ribs, or, occasionally, a pair of ribs. One or two ribs intercalate between successive primaries on the

adapical half of the outer whorl, to be replaced by predominantly primaries on the adapertural half; there are an estimated 40 ribs at the ventrolateral shoulder. All ribs link to well-developed conical to feebly bullate inner ventrolateral tubercles. A strong rib links to a transversely elongated outer ventrolateral tubercle, in turn linked across the venter by a strong, transverse rib. The ventral profile of the ribs is concave.

VJ OD188 (Pl. 43, Figs 6, 7) is a well-preserved internal mould of a 180° sector of body chamber with parts of the three preceding whorls preserved. The maximum preserved whorl height is 43 mm; the costal whorl breadth to height ratio is 1.23. The venter of the innermost whorl has clear constrictions. On the outer whorl, the coiling is very evolute, the umbilical wall flattened and outward-inclined, the ventrolateral shoulder broadly rounded, the whorl section rounded-trapezoidal in intercostal section. There are 18 ribs at the ventrolateral shoulder; most are primaries that arise at the umbilical seam. Some but not all strengthen into a narrow umbilical bulla. There are both long and short intercalated ribs, the ribs straight and prorsiradiate on the flanks, with a slight indication of inner ventrolateral bullae, and a clearer indication of blunt, transversely elongated outer ventrolateral tubercles, linked across the venter by a weakened transverse rib, the mid-venter feebly concave between the tubercles in profile. This weakening of the ventral depression in the rib profile is also shown by OUM KY3368 (Pl. 44, Figs 5, 6); at the greatest preserved diameter of 114.6 mm, the ventral whorl profile is rounded.

DISCUSSION: Differences from *Hourcqiceras latelobatum* are discussed above. *Hourcqiceras coleroonense percostata* Collignon, 1964 (p. 118, pl. 361, fig. 1584) appears to be Middle Cenomanian, both in Madagascar and Angola (Cooper 1973, p. 53, text-fig. 7a, b); it occurs at his locality 29/6, associated with *Turrilites acutus* Passy, 1832). I am uncertain as to its affinities.

OCCURRENCE: Upper Cenomanian *footeanum* Zone, Tamil Nadu.

Hourcqiceras sp.
(Pl. 45, Figs 3, 4)

MATERIAL: OUM KY3550, from section R–S at the 65 m level; Upper Cenomanian, *Hourcqiceras latelobatum–Pseudaspidoceras hourcqi* fauna.

DESCRIPTION: OUM KY3550 is a 120° body chamber fragment. A silicone cast of the dorsum (Pl. 45, Fig. 4) reveals the ornament of the venter of the penultimate whorl. The costal section is angular, the ribs straight and prorsiradiate across the venter, with well-developed conical inner and outer ventrolateral tubercles and siphonal clavi. The outer whorl has a depressed whorl section, the umbilical wall concave, the umbilical shoulder broadly rounded, the inner flanks feebly convex, subparallel, the outer flanks converging to broadly rounded ventrolateral shoulders, the broad venter feebly convex, the costal whorl breadth to height ratio is 1.3, the greatest breadth just outside the umbilical shoulder. Seven ribs arise on the umbilical wall of the fragment, and strengthen across the umbilical wall and shoulder, developing into feeble bullae of variable strength. These give rise to straight prorsiradiate ribs, with a second rib incipiently linked to a bulla in some cases, while there are long intercalated ribs, to give a total of seventeen ribs at the ventrolateral shoulder. The ribs are straight across the flanks, and projected very slightly forwards over the ventrolateral shoulder, where they link to a feeble outer ventrolateral tubercle, the tubercles linked across the venter by a strong transverse rib, with no indication of a siphonal tubercle. One interspace near the adapical end of the fragment is slightly broader and deeper than the others.

DISCUSSION: If correctly interpreted, the presence of deepened interspaces suggests *Hourcqiceras*, and the pattern of ribbing resembles that of all three species referred to *Hourcqiceras* by Collignon (1939). The presence of an inner ventrolateral tubercle distinguishes the material from both *H. latelobatum* Collignon, 1939 (p. 76, pl. 3, figs 1–3; text-figs a, b) and *H. hourcqui* (Collignon, 1937) (p. 78, pls 4, 5; text-figs c, d), a character shared, however, with the *H. andranovoritelense* Collignon, 1939 (p. 75, pl. 2, figs 5–7). All three of the Madagscan species are recorded from the same locality, and may or may not be conspecific; the material and available information on their stratigraphic distribution at Andranovoritelo leave the possibility unresolved. The present slight material differs from *H. coleroonense*, described above, in lacking the distinctive slight ventral concavity to the costal profile. It is left in open nomenclature.

OCCURRENCE: As for material.

Genus *Pseudaspidoceras* Hyatt, 1903

TYPE SPECIES: *Ammonites footeanus* Stoliczka,

1864, p. 101, p. 52, figs 1, 2, by the original designation of Hyatt 1903, p. 106.

*Pseudaspidoceras hourcqi (*Collignon, 1939)
(Pl. 45, Figs 7, 8)

1939. *Mammites hourcqi* Collignon, p. 82, pl. 7, figs 1, 2.

TYPES: The lectotype, here designated, is EMP 1363, the original of Collignon 1939, pl. 7, fig. 1, from Andranovoritelo, Madagascar. EMP 1637, from Ankilimananarivo is the paralectotype, Originally in the collections of the École des Mines, Paris, they are currently housed in the collections of the Université Claude Bernard, Lyon 1, Villeurbanne.

MATERIAL: OUM KY3563, 3564, from section R–S at the 65 m level, Upper Cenomanian, *Hourcquiceras latelobatum–Pseudaspidoceras hourcqi* fauna

DESCRIPTION: OUM KY3563 (Pl. 45, Figs 7, 8) is a crushed phragmocone retaining original aragonitic shell material, the maximum preserved diameter 114 mm. The umbilicus comprises 41.5% of the diameter, the umbilical shoulder broadly rounded. The original whorl proportions cannot be determined because of the crushing. The flanks are very feebly convex, the ventrolateral shoulders broadly rounded, the venter broad and flattened. There are five primary ribs on the fragment, and part of a sixth. They arise on the umbilical wall, and strengthen into strong, blunt, rounded umbilical tubercles. These give rise to low, broad, straight prorsiradiate ribs that link to a strong conical to feebly bullate inner ventrolateral tubercles. A low, very broad rib sweeps forwards and links to a feeble, low outer ventrolateral clavus. There is a single intercalated rib with inner and outer ventrolateral tubercles, and indications of additional feeble outer ventrolateral tubercles in the wide interspaces between successive ribs at one point. OUM KY3564 is a further crushed fragment of body chamber, retaining the original aragonitic shell, the whorl height 45 mm where best-preserved. It bears four primary ribs with strong umbilical and inner ventrolateral tubercles, together with weak, broad, low, outer ventrolateral clavi.

DISCUSSION: Although slight, the present material has the widely separated ribs and tubercle development of *hourcqi*. The whorl section is compressed rather than depressed as in *hourcqi*, but this is the result of *post-mortem* crushing. *Pseudaspidoceras footeanum* of comparable size (Pl. 44, Figs 1–3; Text-fig. 35) have pairs of ribs arising from the inner ventrolateral tubercles, and linking to well-developed transversely elongate outer ventrolateral tubercles, together with additional intercalated ribs with outer ventrolateral tubercles only. *Pseudaspidoceras pseudonodosoides* (Choffat, 1898) (p. 65, pl. 16, figs 5–8; pl. 22, figs 32, 33) (see revision in Hook and Cobban 1981, pl. 1, figs 1–4, 9–11; pl. 2, figs 6–11; pl. 3, figs 1–4; Cobban *et al*. 1989, p. 40, figs 41, 81–83) is a highly variable species, typically more densely ribbed, the ribs effacing on the flanks in many individuals (Cobban *et al*. 1989, figs 82k, 83a, d).

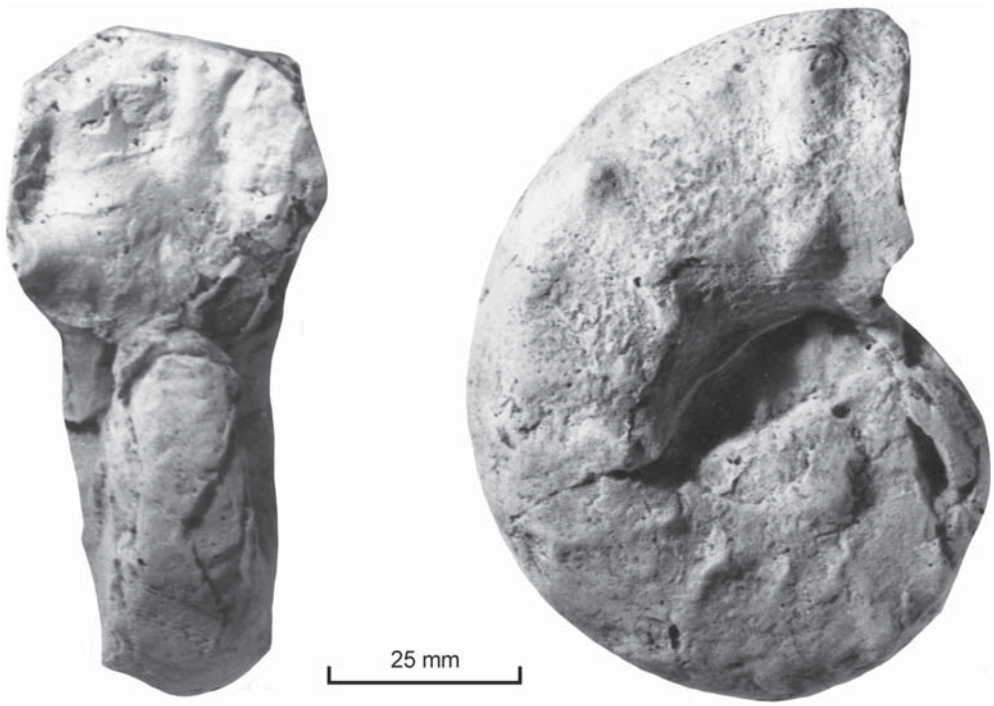
OCCURRENCE: Upper Cenomanian of Madagascar and Tamil Nadu.

Pseudaspidoceras footeanum (Stoliczka, 1864)
(Pl. 44, Fgs 1–4; Pl. 46; Text-figs 35, 36)

1864. *Ammonites Footeanus* Stoliczka, p. 101, pl. 52, figs 1, 2.
1898. *Acanthoceras Footeanum* Stol.; Kossmat, p. 20 (127).
non 1902. *Mammites footeanus* Stol. Spec; Petrascheck, p. 144, pl. 9, fig. 7 (= *Pseudaspidoceras flexuosum* Powell, 1963).
?1915. *Mammites* (*Pseudaspidoceras*) *footeanus*? Stol. Sp.; Greco, p. 208, pl. 17, fig. 5.
1925. *Pseudaspidoceras footeanum* Stoliczka; Diener, p. 177.
?1969. *Pseudoceras footeanum* (Stoliczka); Freund and Raab, p. 14.
?1981. *Pseudaspidoceras* cf. *footenanum* (Stoliczka, 1864); Wright and Kennedy, p. 82, pl. 21, fig. 3.
1996. *Pseudaspidoceras footeanumum* (Stoliczka); Wright, p. 167, text-fig. 128. 1a, 1c.
non 2013. *Pseudaspidoceras footeanum* (Stoliczka, 1864); Wilmsen and Nagm, p. 660, text-figs 11, 12a, b (= *Pseudaspidoceras flexuosum*).
non 2014. *Pseudaspidoceras footeanum* (Stoliczka, 1864); Wilmsen and Nagm, p. 215, text-figs 8a, 11, 12a, b (= *Pseudaspidoceras flexuosum*).

TYPES: The lectotype, by the subsequent designation of Wright and Kennedy 1981, p. 82, is GSI 213,the original of Stoliczka 1864, p. 102, pl. 52, fig. 1, from north of Odiyam, Tamil Nadu. A cast, OUM KY889, is figured here (Pl. 46). There are six paralectotypes, including GSI 212 (cast OUM KY1006), the original of Stoliczka 1864, pl. 52, fig. 2, illustrated here as Text-fig. 35.

MATERIAL: OUM KY3364–3367, from section O–P, 267–269 m level; OUM KY3388–3390, from



Text-fig. 35. *Pseudaspidoceras footeanum* (Stoliczka, 1864). Cast (OUM KY1006) of GSI 212, the original of Stoliczka 1864, pl. 52, fig. 2, from the Uttatur Group north of Odiyam

section O–P, 267–268 m level; OUM KY3384–3386, section O–P, 268 m level, Upper Cenomanian; VP Ku 100, from Kunnam, all Upper Cenomanian *footeanum* Zone.

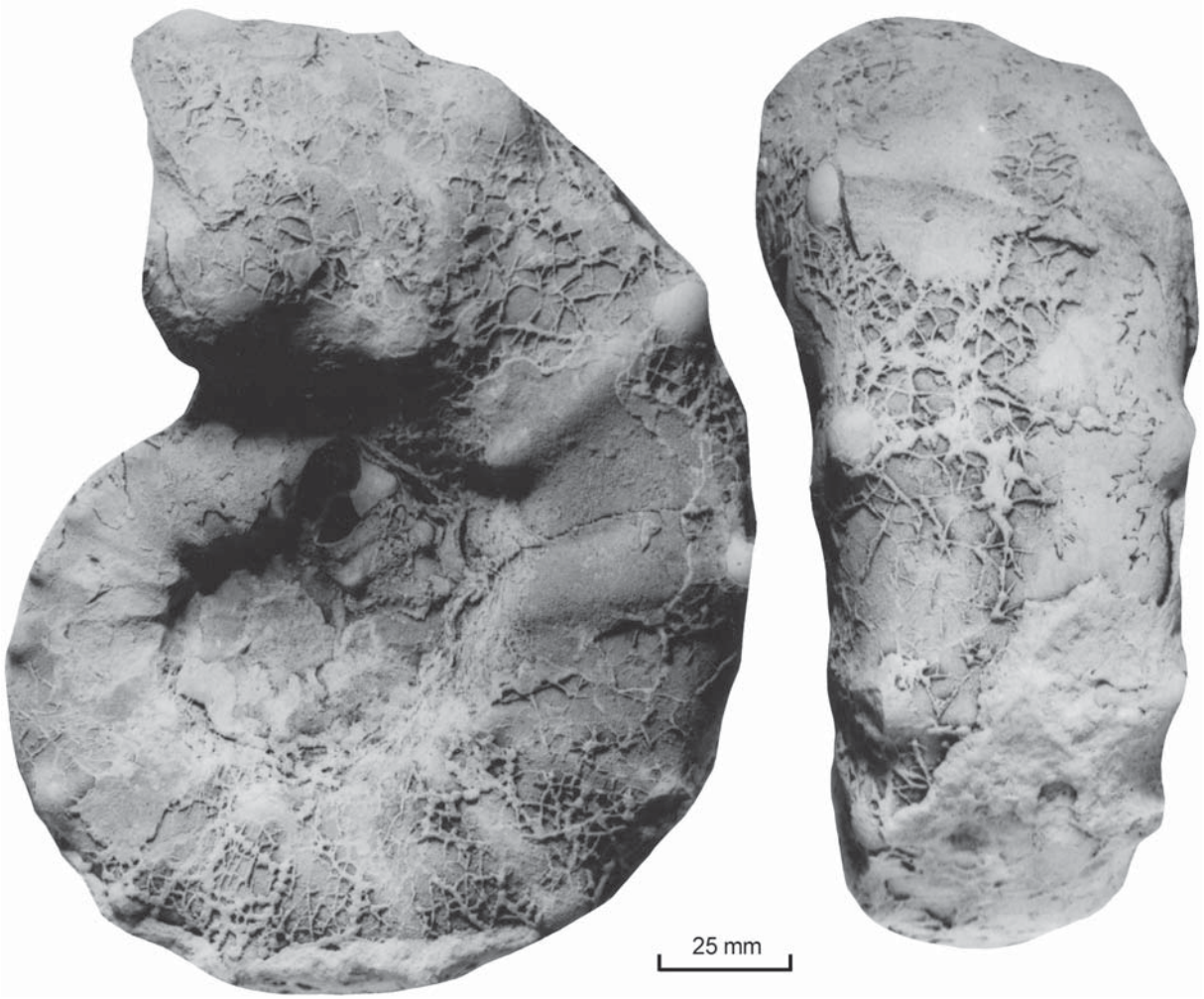
DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
VP KU 100	96.4 (100)	45.0 (46.7)	40.5 (42.0)	1.1	33.3 (34.5)
OUMK KY3385	140.0 (100)	(–)	56.5 (40.4)	–	51.5 (36.8)
OUM KY889*	260.0 (100)	117.0 (45.0)	108.7 (47.8)	1.08	120.0 (46.2)

*Cast of the lectotype, GSI 213

DESCRIPTION: The smallest specimen seen is OUM KY3390 (Pl. 44, Fig. 4), a 180° whorl sector 24.3 mm in diameter, covered in a thick coating of diagenetic calcite. There are four strong conical inner ventrolateral tubercles. These give rise to a feeble transverse rib that bears weaker feebly prorsiradiate elongated outer ventrolateral tubercles, linked across the venter by a feeble transverse rib. An adapical prorsiradiate rib links to a further elongate outer ventrolateral tubercle, again very feebly prorsiradiate and linked across the venter by a feeble rib, such that a pair of ribs are associated with each inner ventrolateral tubercle. There are also occasional intercalated ribs with outer ventrolateral tubercles only.

VP Ku 100 (PL. 44, Figs 1–3) is a phragmocone 96.4 mm in diameter. Coiling is very evolute, the broad umbilicus comprising 34.5% of the diameter. The umbilical wall is flattened and outward-inclined, the umbilical shoulder broadly rounded. The intercostal whorl section is slightly depressed, with a rounded-rectangular section; the whorl breadth to height ratio is 1.1, the greatest breadth around mid-flank. The flanks are feebly convex, subparallel, the ventrolateral shoulders broadly rounded, the broad venter feebly convex. The costal section is polygonal, the greatest breadth at the inner ventrolateral tubercles. Twelve low, broad ribs arise at the umbilical seam, and strengthen into conical umbilical tubercles. These give rise to low, broad, feeble recti- to feebly rursiradiate ribs that strengthen into large conical to feebly clavate inner ventrolateral tubercles. Ventral ornament is poorly preserved, but on the adapical part of the outer whorl, the arrangement of ribs and



Text-fig. 36. *Pseudaspidoceras footeanum* (Stoliczka, 1864). OUM KY3388, an individual 180 mm in diameter, from section O–P, between Odiyam and Kunnam, at the 267–268 m level

tubercles appears to have been as in the previous specimen, with pairs of ribs with feebly prorsiradiate elongated outer ventrolateral tubercles linked to the inner ventrolateral, together with additional intercalated ribs. The ornament of this specimen matches to a degree that of the paralectotype illustrated in Stoliczka's pl. 52, fig. 1, a cast of which is figured here (Text-fig. 35). It will be seen that Stoliczka's figure is heavily restored. OUM KY3385, 140 mm in diameter, has 13–14 umbilical bullae per whorl, the ribs markedly effaced at mid-flank, the ventrolateral ornament, other than the inner ventrolateral tubercle subdued. The specimen retains a 90° sector of body chamber. OUM KY3388 is a phragmocone 185 mm in diameter.

The lectotype, a cast of which is figured here (Pl. 46) is 260 mm in diameter, and retains a 180° sector of body chamber. Coiling is very evolute, the umbilical seam notched to accommodate the inner ventrolateral tubercles of the preceding whorl. The umbilicus is deep, the umbilical wall flattened to very feebly convex, becoming outward-inclined on the body chamber. The whorl section is depressed, rounded-rectangular in intercostal section, with a whorl breadth to height ratio of 1.1, feebly convex flanks, broadly rounded ventrolateral shoulders and a broad, feebly convex venter. Eighteen to nineteen ribs arise at the umbilical seam of the outer whorl, strengthen across the umbilical wall, and link, on the phragmocone, to strong conical-bullate umbilical

tubercles. Low, broad, straight recti- to feebly rursiradiate ribs extend across the flanks, and link to strong conical inner ventrolateral tubercles. A very feeble prorsiradiate rib links to a low, rounded outer ventrolateral tubercle, the tubercles linked across the venter by a low transverse rib. A second, feebly prorsiradiate rib links to an outer ventrolateral tubercle, in turn linked across the venter by a feeble transverse rib. On the adult body chamber, the umbilical tubercles weaken into bullae of variable strength. The flank ribs weaken, and split into riblets at the adapertural end of the body chamber. The inner ventrolateral tubercles strengthen, and are linked across the venter by a blunt, coarse rib with blunt outer ventrolateral tubercles. The second, prorsiradiate rib, present on the adapical part of the outer whorl is lost.

The suture, well-shown by OUM KY3389, has a very large A with a large median element, as in Stoliczka's figure (1864, pl. 52, fig. 1c).

DISCUSSION: See Wright and Kennedy 1981, p. 83.

OCCURRENCE: As for material; there are possible records from southern England, Israel, and Egypt.

Genus *Kamerunoceras* Reyment, 1954

TYPE SPECIES: *Acanthoceras eschii* Solger, 1904, p. 124, pl. 4, figs 1–4, by the original designation of Reyment 1954, p. 250.

Kamerunoceras multinodosum sp. nov.
(Pl. 47, Figs 1, 2)

TYPE: The holotype is OUM KY4549, from the 74 m level in the Karai Formation, section R–S, between Odiyam and Kunnam, Lower Turonian.

DIAGNOSIS: A small species of *Kamerunoceras*, the body chamber with primary ribs that bear umbilical, outer lateral, inner and outer ventrolateral and siphonal tubercles.

DESCRIPTION: The holotype and only known specimen is an internal mould of a 180° sector of body chamber 79 mm in diameter with part of the final camera. Coiling appears to have been evolute, the umbilicus of moderate depth, the umbilical wall flattened and outward-inclined, the umbilical shoulder broadly rounded. The whorl section is depressed oval in intercostal section, with feebly convex, parallel flanks, broadly rounded ventrolateral shoulders and a broad, feebly convex venter. The costal whorl section is depressed polygonal, with the greatest breadth at the umbilical tubercles. There are nine widely separated primary ribs on the fragment. They arise at the umbilical seam, sweep back across the umbilical wall, and strengthen into umbilical bullae of variable strength, from incipient to coarse. The ribs are narrower than the interspaces, straight and prorsiradiate, and are markedly weakened at mid-flank, then strengthening into a small outer lateral bulla in close proximity to a much stronger inner ventrolateral bulla. A strong, high, feebly prorsiradiate rib links to a strong oblique outer ventrolateral clavus, linked by a strong rib to a strong, feebly clavate siphonal tubercle.

DISCUSSION: The massive whorl, coarse distant ribs, with an outer lateral tubercle distinguish the species from other *Kamerunoceras* that reach maturity at a relatively small size; both *Kamerunoceras douvillei* (Pervinquière, 1907) (p. 274, pl. 12, figs 2, 3; Chancellor *et al*. 1994, p. 28, pl. 6, figs 1–4; pl. 12, figs 4, 5) and *Kamerunoceras isovokyense* (Collignon, 1965) (p. 32, pl. 388, fig. 1633; p. 39, pl. 392, fig. 1674; Kennedy and Cobban1988, p. 596, text-fig. 3.10, 3.15).

OCCURRENCE: As for type.

Kamerunoceras turoniense (d'Orbigny, 1850)
(Pl. 47, Figs 5, 6)

1850. *Ammonites turoniensis* d'Orbigny, p. 190.
1979a. *Kamerunoceras turoniense* (d'Orbigny, 1850); Kennedy and Wright, p. 1170, pl. 2, figs 1–11; pl. 3, figs 1, 2; pl. 4, figs 1–3, text-figs 2, 3) (with synonymy).
1994. *Kamerunoceras turoniense* (d'Orbigny, 1850); Chancellor *et al*., p. 26, pl. 4, figs 1–3; pl. 5, figs 1–3; pl. 6, figs 6, 7; pl. 7, figs 3, 4; pl. 8, figs 8, 9; text-fig. 11a, g (with synonymy).
2007. *Kamerunoceras turoniense* (d'Orbigny, 1850); Barroso-Barcenilla, p. 153, pl. 12, figs d, e; pl. 13, figs a–f (with additional synonymy).
2009. *Kamerunoceras turoniense* (d'Orbigny, 1850); Amédro, text-fig. 4.
2014. *Kamerunoceras turoniense* (d'Orbigny, 1850); Amédro and Devalque in Robaszynski *et al*., p. 138, pl. 14, fig. 2.
2015. *Kamerunoceras turoniense* (d'Orbigny, 1850); Kennedy *et al*., p. 457, text-fig. 15m, n.
2016. *Kamerunoceras turoniense* (d'Orbigny, 1850); Kennedy and Gale, p. 271, text-fig. 8c.
2018. *Kamerunoceras turoniense* (d'Orbigny, 1850); Amédro and Matrion in Amédro and Robaszynski, p. 193, text-figs 132a, b; 133a, b; 134a, b.

TYPE: The lectotype, by the subsequent designation of Kennedy and Wright 1979, p. 1173, is MNHN. F. A25623, from the Middle Turonian of Deux Sèvres, France. It was figured by Kennedy and Wright (1979, pl. 3).

MATERIAL: VP Kn 101a, collected *ex situ* in the environs of Kunnam.

DESCRIPTION: The specimen is a very well-preserved internal mould of a 120° whorl sector of an adult body chamber and the final few chambers of the phragmocone, the last few septa crowded and interfering. The coiling is very evolute, the umbilicus of moderate depth, the umbilical wall feebly convex and outward inclined, merging imperceptibly with the umbilical shoulder. The whorl section is as wide as high in intercostal section, the flanks feebly convex, the ventrolateral shoulders broadly rounded, the venter feebly convex. There are seven widely separated primary ribs on the fragment. They arise at the umbilical seam, and are low and weak, strengthening into umbilicolateral bullae, incipient on the phragmocone, but strengthening on the body chamber. They give rise to weak, straight, recti- to feebly rursiradiate ribs that link to inner ventrolateral bullae, well-developed on the phragmocone, less-so on the body chamber. A broad rib links to an oblique rounded to feebly clavate outer ventrolateral tubercle. Delicate intercalated ribs are present on the umbilical wall and inner flank. There is a well-developed low, rounded siphonal ridge. The suture is moderately incised, with a broad, bifid E/A and a long, narrow, and trifid A.

DISCUSSION: See Kennedy and Wright (1979a, p. 1170, pl. 2, figs 1–11; pl. 3, figs 1, 2; pl. 4, figs 1–3, text-figs 2, 3) and Chancellor *et al*. (1994, p. 26, pl. 4, figs 1–3; pl. 5, figs 1–3; pl. 6, figs 6, 7; pl. 7, figs 3, 4; pl. 8, figs 8, 9; text-fig. 11a, g).

OCCURRENCE: Lower Turonian, *Mammites nodo*soides Zone, and ranging into the lower Middle Turonian *Romaniceras kallesi* Zone in Western Europe. There are records from southern England, France, Spain, Tunisia, Israel, Madagascar, Tamil Nadu, New Mexico in the United States, and Venezuela.

Family Vascoceratidae H. Douvillé, 1912
Genus *Vascoceras* Choffat, 1898

TYPE SPECIES: *Vascoceras gamai* Choffat, 1898, p. 54, pl. 7, figs 1–4; pl. 8, fig. 1; pl. 10, fig. 2; pl. 21, figs 1–5, by the subsequent designation of Diener 1925, p. 182.

Vacoceras diartianum (d'Orbigny, 1850)
(Pl. 48, Figs 1, 2, 6, 7; Text-fig. 16F)

1850. *Ammonites diartianus* d'Orbigny, p. 146.
1989. *Vascoceras diartianum* (d'Orbigny); Cobban *et al*., p. 47, text-figs 48, 88t–aa (with full synonymy).
1994b. *Vascoceras diartianum* (d'Orbigny, 1850); Kennedy and Juignet, p. 497, text-figs 1b, 12b–e.
2015. *Vascoceras diartianum* (d'Orbigny, 1850); Kennedy in Morel, p. 144, text-fig. 131a–b.

TYPE: The holotype, by monotypy, is MNHN F. A25549 (formerly d'Orbigny collection 6121), the original of d'Orbigny 1850, p.146. It was figured by Kennedy and Juignet (1977, pl. 1, figs 1, 2; pl. 2, fig. 1; 1994b, text-figs 1b, 12b–e) and Kennedy in Morel 2015 text-fig. 131a–b). It is from the remanié *Metoicoceras geslinianum* Zone fauna at the base of the Craie à *Terebratella carantonensis* of Saint Calais, Sarthe, France.

MATERIAL: OUM KY3916–3918, from section A, at the 16–18 m level, Upper Cenomanian, *harpax* Zone, *euomphalum* fauna.

DESCRIPTION: The specimens are limonitic phragmocones that range from 13.5 to 16.9 mm in diameter. The sutures of OUM KY3917 (Pl. 48, Figs 1, 2) and OUM KY3918 are approximated, indicating them to be adult. Coiling is involute, the deep, conical umbilicus comprising 27% of the diameter. The umbilical shoulder is broadly rounded, the intercostal whorl section depressed reniform, as is the costal section, the whorl breadth to height ratio 1.9 approximately, the greatest breadth at the umbilical tubercles. These are massive, conical-bullate, and number 11 per whorl, displaying some variation in strength. They give rise to a single rib or pairs of ribs, whilst additional ribs intercalate. They are prorsiradiate on the flanks, and cross the venter in a broad shallow convexity. Some weaken; others are strong and form a collar rib or ribs to well-developed constrictions, in some cases inserted between a pair of ribs arising from a single umbilical tubercle. The sutures are little-incised, with broad, bifid E/A and shallow A (Text-fig. 16F).

DISCUSSION: The present specimens differ in no significant respects from the holotype, and the

well-preserved specimens from the Cookes Range in New Mexico (Cobban *et al*. 1989, text-fig. 88t–aa). Small adult size combined with coarse umbilical tubercles distinguish *diartianum* from all other species of *Vascoceras.*

OCURRENCE: Upper Cenomanian*, Metoicoceras geslinianum* Zone in southern England and Sarthe, France; *Sciponoceras gracile* and *Metoicoceras mosbyense* Zones in New Mexico; *harpax* Zone in Tamil Nadu.

Genus *Fagesia* Pervinquière, 1907

TYPE SPECIES: *Olcostephanus superstes* Kossmat, 1897, p. 26 (133), pl. 6 (17), fig. 1 only, by the original designation of Pervinquière 1907, p. 322

Fagesia rudra (Stoliczka, 1865)
(Pl. 48, Figs 3–5)

1865. *Ammonites Rudra* Stoliczka, p. 122, pl. 60, fig. 1.
2009. *Fagesia rudra* (Stoliczka, 1965); Barroso-Barcenilla and Goy, p. 28, text-figs 5.2–5.5; 6.1–6.4 (with full synonymy).

TYPE: The lectotype, by the subsequent designation of Kennedy and Wright 1979b, p. 666, is the original of Stoliczka 1865, pl. 60, fig. 1, from Odiyam.

MATERIAL: VP Kn 230, collected *ex situ*, Kunnam.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
VP Kn 230	97.3 (100)	90.8 (0.93)	43.5 (44.7)	2.2	25.9 (26.6)

DESCRIPTION: The specimen is an evolute cadicone with a maximum preserved diameter of 97.3 mm. The deep conical umbilicus comprises 26.6% of the diameter, the umbilical wall flattened and outward-inclined. The umbilical shoulder is quite narrowly rounded; there are no flanks. The venter is broadly and evenly rounded. Fifteen to sixteen well-developed conical tubercles perch on the umbilical shoulder. There are traces of delicate, feebly convex riblets and grooves on the venter. The sutures are not exposed.

DISCUSSSION: See Kennedy and Wright (1979b, p. 668) and Barroso-Barcenilla and Goy (2009, p. 28). *Fagesia superstes* (Kossmat, 1897) (p. 26 (133), pl. 6 (17), fig. 1), the second species of *Fagesia* described from Tamil Nadu has much stronger ribs that arise from strong umbilical bullae, the umbilicus crater-like, with an outward-inclined wall.

OCCURRENCE: predominantly upper Lower Turonian, but extending into the lower Middle Turonian. The geographic distribution extends from Tamil Nadu to Madagascar, Spain, France, and, possibly, Japan.

Genus *Neoptychites* Kossmat, 1895

TYPE SPECIES: *Ammonites telinga* Stoliczka, 1865, p. 125, pl. 62, figs 1, 2, by the subsequent designation of Solger 1904, p. 105; = *Ammonites cephalotus* Courtiller, 1860, p. 248, pl. 2, figs 1–4.

Neoptychites cephalotus (Courtiller, 1860)
(Pl. 49, Figs 1–5)

1860. *Ammonites cephalotus* Courtiller, 1860, p. 248, pl. 2, figs 1–4.
1983. *Neoptychites cephalotus* (Courtiller); Cobban and Hook, p. 14, pl. 3, figs 9–11; pls 9–12; text-fig. 9 (with synonymy).
1994. *Neoptychites cephalotus* (Courtiller, 1860); Chancellor *et al*., p. 70, pl. 16, figs 1–9; pl. 17, figs 1–5; pl. 18, figs 1–3; pl. 26, figs 2–4 (with synonymy).
2009. *Neoptychites cephalotus* (Courtiller, 1860); Barroso-Barcenilla and Goy, p. 34, text-figs 9.4–9.6; 10.1–10.3.
2015. *Neoptychites cephalotus* (Courtiller, 1860); Kennedy *et al*., p. 474, text-figs 20a, 23j–m (with additional synonymy).
2016. *Neoptychites cephalotus* (Courtiller, 1860); Kennedy and Gale, p. 281, text-fig. 20a–b, g–i.
2017. *Neoptychites cephalotus* (Courtiller, 1860); Benzaggagh *et al*., text-fig. 6c–k.

TYPES: The lectotype, by the subsequent designation of Kennedy and Wright 1979b, p. 674, is the original of their pl. 83, figs 1–3, no. CS631, in the collections of the Château de Saumur, Touraine, France. There are three additional surviving paralectotypes. All are inferred to be from the Middle Turonian Tuffeau de Saumur in the environs of Saumur.

MATERIAL: OUM KY3604, from section R–S at the 70 m level; OUM KY3607, from the 70–75 m level, both Lower Turonian, *Neoptychites cephalotus–Mytiloides mytiloides* fauna.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
OUM KY3604 at	64.6 (100)	29.9 (46.3)	38.1 (59.0)	0.78	4.6 (7.1)
OUM KY3607	108.0 (100)	55.5 (51.4)	62.3 (57.7)	0.89	–

DESCRIPTION: OUM KY3607 (Pl. 49, Figs 3–5) is an internal mould of a phragmocone 108 mm in diameter, retaining extensive areas of recrystallized shell on the adapical parts. Coiling is very involute, the minute umbilicus comprising 7.1% of the diameter, the umbilical shoulder broadly rounded. The whorl section is compressed, rounded-triangular, the greatest breadth just outside the umbilical shoulder, the whorl breadth to height ratio 0.78. The flanks are feebly convex, and strongly convergent, the ventrolateral shoulders broadly rounded, the narrow venter very feebly convex. Ornament consists of crowded rursiradiate ribs that arise low on the flanks, across which they broaden and strengthen, reaching their maximum development on the ventrolateral shoulders and venter, which they pass straight across.

OUM KY3604 (Pl. 49, Figs 1, 2) comprises a nucleus 92 mm in diameter and an incomplete adult body chamber that extends to 120° and has a maximum whorl height of 76 mm. Coiling of the nucleus is very involute, the minute umbilicus with a feebly convex wall and quite narrowly rounded umbilical shoulder. The whorl section is more compressed than in the previous specimen, the whorl breadth to height ratio 0.78, the greatest breadth just outside the umbilical shoulder. The inner to middle flanks are feebly convex, the outer flanks flattened and convergent, the ventrolateral shoulders broadly rounded, the narrow venter very feebly convex. Ornament on the adapical 180° sector consists of somewhat coarser ribs than in the previous specimen, strengthening across the flanks, and at maximum development on the ventrolateral shoulders and venter. The outer whorl fragment includes all of the adult body chamber. The coiling is markedly eccentric, the umbilicus deep, with a feebly convex wall and broadly rounded umbilical shoulder. At the adapical end, the whorl section is trigonal, with feebly convex inner and flattened middle and outer flanks, the ventrolateral shoulders broadly rounded, the venter feebly convex. The whorl section broadens markedly towards the adapertural end of the body chamber, notably in the inner flank region, before narrowing and contracting in the final sector before the adult aperture.

DISCUSSION: See Cobban and Hook (1983, p. 14) and Chancellor *et al*. (1994, p. 70).

OCCURRENCE: The species first occurs in the Lower Turonian *Thomasites rollandi* Zone in Tunisia, and extends to the lower part of the MiddleTuronian *Collignoniceras woollgari* Zone in France. The geographic range is France, Spain, Morocco, Algeria, Tunisia, Egypt, Israel, Syria, Cameroon, Madagascar, Tamil Nadu, Colorado, New Mexico, and Trans-Pecos Texas in the United States; northern Mexico, Trinidad, Venezuela, Colombia, Brazil, Niger and Nigeria

Suborder Ancyloceratina Wiedmann, 1966
Superfamily Turrilitoidea Gill, 1871
Family Anisoceratidae Hyatt, 1900
Genus *Anisoceras* Pictet, 1854

TYPE SPECIES: *Hamites saussureanus* Pictet in Pictet and Roux, 1847, p. 118, pl. 13, figs 1–4, by the original designation of Pictet 1854, p. 705.

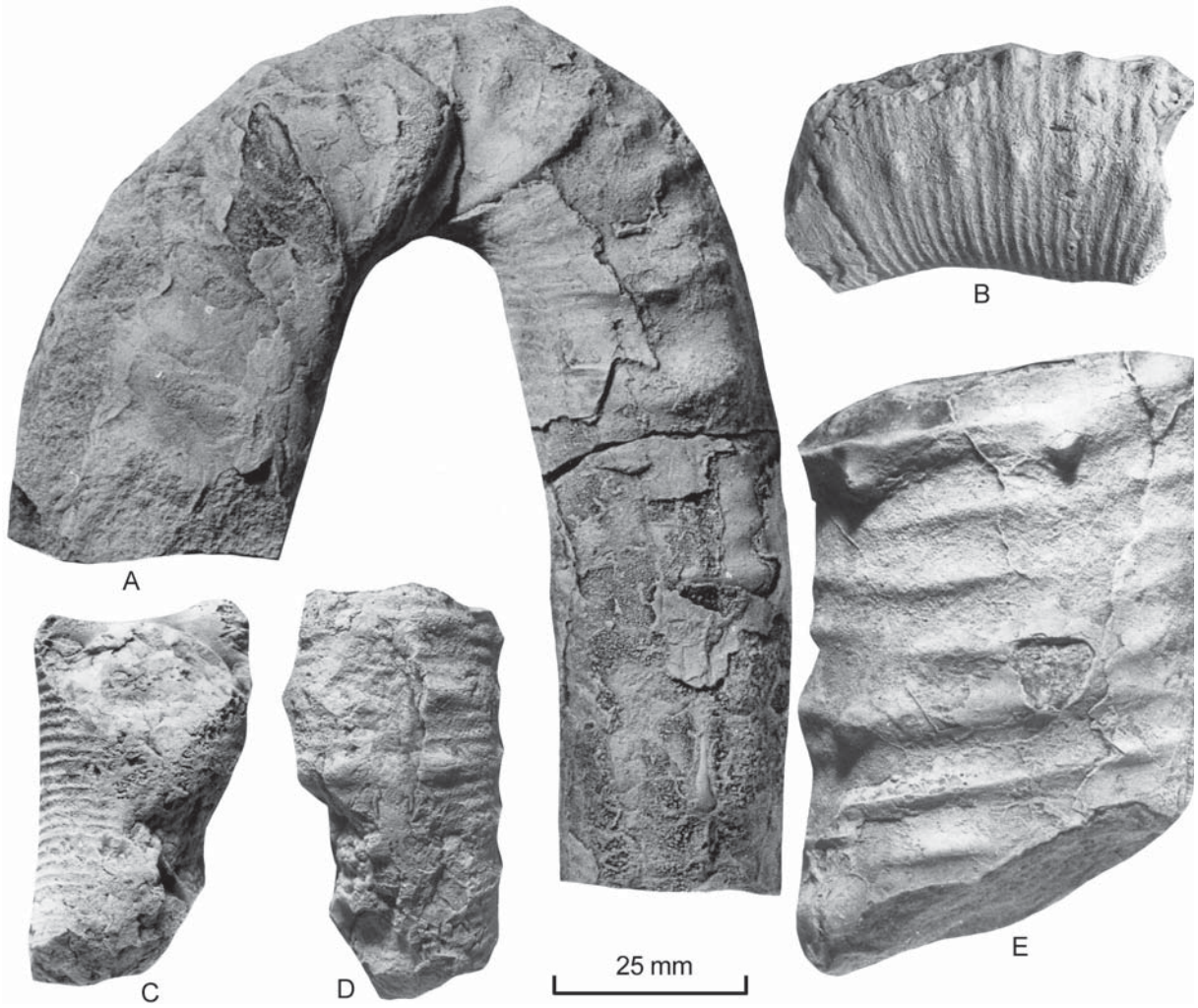
*Anisoceras saussureanum saussureanum (*Pictet, 1847)
(Pl. 50, Fig. 1; Text-fig. 37A)

1847. *Hamites Saussureanus* Pictet, p. 374, pl. 13, figs 1–7.
2015. *Anisoceras saussureanum saussureanum (*Pictet, 1847); Klein, pp. 27, 43 (with full synonymy).

TYPE: The lectotype, by the subsequent designation of Whitehouse (1926, p. 231) is the original of Pictet 1847, pl. 13, fig. 2a, from the Upper Albian of Mont Saxonet, Haute-Savoie, France. It was refigured by Delamette *et al*. (1997, pl. 39, fig. 1).

MATERIAL: OUM KY4346, 4347, from section A–B, lower interval, at the 9.5–10 m level, Upper Albian *rostrata* Zone.

DESCRIPTION: The specimens comprise fragments of straight shafts and recurved sectors. OUM KY4347 (Pl. 50, Fig. 1) is a 195 mm long shaft with a maximum preserved whorl height of 34 mm; the whorl section is compressed oval. Ornament is poorly preserved. There are three sets of tubercles in a distance equal to the whorl height, rounded lateral tubercles situated ventrally of the mid-flank, and slightly elongated ventrolateral tubercles, the rows linked by a pair of coarse transverse ribs. There are indications of pairs of delicate riblets between successive tuberculate groups that



Text-fig. 37. **A** – *Anisoceras saussureanum saussureanum* (Pictet, 1847), OUM KY4346, from the Karai Formation, Upper Albian *rostrata* Zone, section A–B, between Odiyam and Kunnam at the 9.5–10 m level. **B-D** – *Anisoceras plicatile* (J. Sowerby, 1819), OUM KY2741, from the Middle Cenomanian *asiaticum* Zone, section G–H, between Odiyam and Kunnam, at the 168–173 m level. **E** – *Anisoceras angulatum* (Stoliczka, 1866), OUM KY4345, from the Karai Formation, Upper Albian *rostrata* Zone, section A–B, north-west of Garudamangalam, at the 9.5–10 m level

extend across the flanks and dorsum, although it is not clear if they extended across the venter. OUM KY4346 (Text-fig. 37A) consists of a straight shaft 100 mm long, a curved sector, and a second shaft set at an acute angle to the first. The whorl section is compressed oval, the greatest preserved whorl height 39.5 mm, the whorl breadth to height ratio 0.74. The dorsum and venter are broadly rounded, the flanks feebly convex. Where replaced shell is preserved, the dorsum is seen to be covered in crowded narrow transverse riblets that extend onto the inner flanks; they are absent from the internal mould. A coarse rounded outer lateral tubercle is linked to a larger ventrolateral tubercle by a single strong rib, the ventrolateral tubercles linked across the venter by a single coarse rib.

DISCUSSION: The present specimens compare well with the lectotype, and the large specimen figured by Spath (1939, pl. 61, fig. 1). Subspecies/variants of *saussureanum* are discussed by Klinger (1976, p. 24). Var. *spinosa* Haas, 1942 (p. 192, pl. 46, figs 1–3; text-fig. 30a–e) has three ribs linking the tubercles and lacks intermediate ribs for part of the ontogeny. Subspecies *trifasciatum* Renz, 1968 (p. 77, pl. 15, fig. 5; text-fig. 28h) has three ribs linking the tubercles, and intermediate ribs between. Subspecies

quadrifasciatum Klinger, 1976 (p. 23, pl. 4, fig. 3, pl. 5, figs 1–6; pl. 6, fig. 1; text-figs 5l, 6j) has four ribs linking the tubercles, with two ribs intercalating between.

OCCURRENCE: Upper Upper Albian, France, Sardinia, Switzerland, southern England, Poland, Spain, Hungary, Romania, KwaZulu-Natal in South Africa, Madagascar, and Tamil Nadu.

Anisoceras angulatum (Stoliczka, 1866)
(Pl. 50, Figs 5, 6; Text-fig. 37E)

1865. *Anisoceras angulatum* Stoliczka, p. 176, pl. 84, figs 1, 2.
1895. *Hamites* (s. str.?) *angulatus* Stoliczka; Kossmat, p. 149 (53).
1925. *Anisoceras angulatum* Stoliczka; Diener, p. 71.
1939. *Anisoceras angulatum* Stoliczka; Spath, p. 542.

TYPE: The lectotype, here designated, is the original of Stoliczka 1865, p. 176, pl. 84, fig. 1, from near Odiyam.

MATERIAL: OUM KY4345, from section A–B, lower interval, at the 9.5–10 m level; OUM KY2555, from section A–B, upper interval at the 56 m level; both Upper Albian *rostrata* Zone.

DESCRIPTION: OUM KY4345 (Pl. 50, Figs 5, 6) is a 58 mm long fragment of body chamber with a maximum preserved whorl height of 46 mm. The whorl section is compressed oval, with a whorl breadth to height ratio of 0.71, the dorsum flattened, the dorsolateral margin broadly rounded, the flanks feebly convex, ventrolateral shoulders broadly rounded, the venter convex. The dorsum is ornamented by delicate crowded transverse riblets that extend onto the dorsolateral margin. In contrast, the flanks are ornamented by widely separated narrow, oblique ribs, two of which link to a conical inner lateral tubercle, from which a pair of ribs loop to strong ventral clavi, linked across the venter by a transverse rib. Two nontuberculate ribs separate the tuberculate ones. OUM KY4345 (Text-fig. 37E) is a larger body chamber fragment, 95 mm long, with a maximum preserved whorl height of 58.5 mm and a very compressed whorl section, with one flank worn away. There are parts of 7–8 narrow, widely separated ribs on the fragment. Tuberculate ribs have a small sharp conical tubercle low on the flanks, and a second row on the ventrolateral shoulder, with two or three nontuberculate ribs between.

DISCUSSION: The present specimens, although fragmentary, have the very compressed whorl section and same basic disposition of ribs and tubercles as the lectotype, features quite distinct from those of other large fragments of *Anisoceras* in the present faunas.

OCCURRENCE: As for material.

Anisoceras perarmatum Pictet and Campiche, 1861
(Pl. 50, Figs 2–4, 7: Pl. 51, Figs 9–12)

1861. *Anisoceras perarmatum* Pictet and Campiche, p. 65, pl. 49, figs 1–5, *non* 6.
2015. *Anisoceras perarmatum perarmatum* Pictet and Campiche, 1861; Klein, pp. 26, 37 (with full synonymy).
2015. *Anisoceras perarmatum dorsocostatum* Chiriac, 1981; Klein, pp. 26, 36 (with full synonymy).
2015. *Anisoceras perarmatum renzi* Kotetishvili, 1977; Klein, pp. 26, 39 (with full synonymy).
2015. *Anisoceras perarmatum simplex* Renz, 1968; Klein, pp. 26, 39 (with full synonymy).
2017. *Anisoceras perarmatum* Pictet and Campiche, 1861; Tajika *et al*., p. 40, text-fig. 10g.

TYPE: The lectotype, by the subsequent designation of Renz 1968, p. 74 is the original of Pictet and Campiche 1861, pl. 49, fig. 1, no. 21280 in the collections of the Musée Géologique, Lausanne. It was refigured by Renz (1968, pl. 13, fig. 5; text-figs 27a, 28g), and is from the upper Upper Albian south of La Vraconne, Vaud, Switzerland.

MATERIAL: OUM KY2526–2529, from section A–B, upper interval, 2 m level. OUM KY2494, from section A–B, lower interval, 10 m level. OUM KY2554 from section A–B, upper interval, 56 m level, all Upper Albian *rostrata* Zone.

DESCRIPTION: OUM KY2528 (Pl. 51, Figs 11, 12) is an internal mould of a 80 mm long shaft, with a septal face at the adapical end; the maximum preserved whorl height is 28 mm, the whorl section circular. The dorsum is ornamented by crowded narrow, straight ribs. Most efface at the dorsolateral margin. Others strengthen in pairs and link to strong conical dorsolateral tubercles, elongated parallel to the shaft, and linked in turn by a pair of strong ribs to strong clavate ventrolateral tubercles, the ventrolateral tubercles linked across the venter by a pair of strong ribs. OUM KY2527 (Pl. 51, Figs 9, 10) is a 75 mm long fragment, a straight shaft with the beginnings of a recurved sector. There is a septal face at the adapical end of the fragment, which appears to be

body chamber, As in the previous specimen, the dorsum is ornamented by numerous fine transverse ribs, pairs of which strengthen and link to conical inner lateral tubercles, linked in turn by a pair of ribs to strong ventrolateral clavi, linked across the venter by a pair of ribs. OUM KY2526 (Pl. 50, Fig. 7) is a much larger fragment of two shafts linked by a curved sector, the maximum preserved whorl height 39 mm. The tubercles are linked by a pair of ribs, with occasional strong nontuberculate intercalated ribs. OUM KY2494 (Pl. 50, Figs 2, 3) is a hook-shaped fragment of body chamber with a maximum preserved length of 90 mm; one flank is badly worn. The intercostal whorl section is subcircular. Parts of seven very widely separated ribs are preserved. They arise on the dorsolateral margin, strengthen, and develop into strong inner lateral bullae from which strong, narrow, single ribs arise on the adapical part of the shaft and link to strong conical to feebly clavate ventrolateral tubercles, linked over the venter by a pair of looped ribs. There is a single intercalated rib on the shaft. On the curved sector, the dorsolateral bullae give rise to a pair of ribs, the adapical one effacing on the ventrolateral shoulder, the adapertural one developing into a strong ventrolateral tubercle, the tubercles linked across the venter by a pair of looped ribs. OUM KY2554 is a crushed fragment of a straight shaft and recurved sector, the maximum preserved whorl height 34 mm. Pairs of ribs are present on the dorsolateral margin, and link to well-developed conical inner lateral bullae, linked by a pair of ribs to strong ventrolateral tubercles, linked across the venter by a pair of ribs. The rib direction is feebly prorsirsdiate on the shaft, becoming rursiradiate around the recurved sector.

DISCUSSION: The species in interpreted widely here, as indicated in the synonymy. The present material compares well with the lectotype. See Kennedy, Cobban *et al*. (1998, p. 42) for discussion.

OCCURRENCE: Upper Upper Albian, and possibly occurring in the Lower Cenomanian. The geographic distribution extends from Switzerland to southern England, France, Sardinia, Spain, Germany, Hungary, Romania, Ukraine, Georgia, North Africa, Nigeria, KwaZulu-Natal in South Africa, Mozambique, Tamil Nadu, and Texas.

Anisoceras plicatile (J. Sowerby, 1819)
(Text-fig. 37B–D)

1819. *Hamites plicatilis* J. Sowerby, p. 281, pl. 234, fig. 1.

2015. *Anisoceras plicatile* (J. Sowerby, 1819); Klein, pp. 26, 39 (with full synonymy)

TYPE: The lectotype, by the subsequent designation of Kennedy (1971, p. 120) is the original of J. Sowerby 1819, p. 281, pl. 224, fig. 1, from the Chalk Marl of Bishopstrow, near Warminster, Wiltshire, in southern England. It is no, 72991 (BC 528) in the collections of the Academy of Natural Sciences of Philadelphia, and was refigured by Wright and Kennedy (1995, text-fig. 130k).

MATERIAL: OUM KY2741, from section G–H at the 168–173 m level, Middle Cenomanian, *asiaticum* Zone.

DESCRIPTION: The specimen is a 51 mm long slightly curved fragment of phragmocone retaining recrystallized shell. The maximum preserved whorl height is 29 mm; the whorl section is slightly compressed oval. Ornament consists of fine, crowded, wiry ribs; the rib index is 17–18 on the dorsum, where the ribs are transverse and near-straight. The ribs are straight on the flanks, varying from feebly rursiradiate at the adapical end to slightly prorsiradiate at the adapertural end of the fragment. The ribs link in pairs at well-developed dorsolateral bullae, of which there are seven on the fragment. Groups of two or three ribs link the bullae to conical to feebly transversely elongate ventral tubercles of comparable strength, linked across the venter by a pair of ribs. On or two nontuberculate ribs separate successive tuberculate groups.

DISCUSSION: See Wright and Kennedy (1995, p. 307); the present specimen compares well with the original of their pl. 90, fig. 9.

OCCURRENCE: Middle Cenomanian, southern England, France, Spain, Germany, Poland, Romania, Tamil Nadu, and, possibly, Texas and Japan.

Anisoceras sp.
(Pl. 51, Figs 6–8; Pl. 58, Figs 6, 7)

MATERIAL: OUM KY2849, from section G–H at the 209 m level, Middle Cenomanian *asiaticum* Zone. OUM KY6024, from the basal shell bed of the *asiaticum* Zone channel on the north side of the Karai–Kulakkalnattam road, Middle Cenomanian.

DESCRIPTION: OUM KY2849 (Pl. 51, Figs 6–8) is a whorl of a low helix with a maximum preserved

diameter of 73 mm, and a maximum preserved whorl height of 26 mm. Where undeformed, the whorl section is circular. The ornament is markedly asymmetric. The dorsum is ornamented by fine oblique riblets; on one flank (Pl. 51, Fig. 7) they are crowded, rursiradiate and markedly sinuous, linking in groups of two or three at flat-topped tubercles that are the bases of septate spines, with occasional riblets intercalating between, and linking to a tubercle on the other side of the venter. Pairs of ribs link the ventrolateral tubercles over the venter (Pl. 51, Fig. 6), sometimes looping, in other cases zig-zagging between successive tubercles. In contrast, the other flank (Pl. 51, Fig. 8), albeit worn, is ornamented by very coarse, strongly rursirsdiate and feebly convex ribs that link singly to a coarse ventral tubercle/spine. The specimen is in part or whole body chamber. OUM KY6024 (Pl. 58, Figs 6, 7) is interpreted as a juvenile of the species; it has a maximum preserved whorl height of 15 mm.

DISCUSSION: The type material of *Anisoceras oldhamianum* Stoliczka, 1866 (p. 175, pl. 83, figs 1–4) includes helicoid fragments (pl. 83, figs 3, 4), but these differ from the present material in having the lateral and ventrolateral tubercles linked by a single coarse rib, without non-tuberculate ribs between successive tuberculate groups, although these appear on the shaft (pl. 83, fig. 1).

OCCURRENCE: As for material.

Anisoceras auberti Pervinquière, 1907
(Pl. 51, Figs 1–5; Text-fig. 14E)

?1866. *Hamites problematicus* Stoliczka, p. 191 (*pars*), pl. 90, fig. 2 only.
1907. *Hamites* (*Anisoceras*) *auberti* Pervinquière, p. 85, pl. 3, fig. 32.
2015. *Anisoceras auberti* (Pervinquiere, 1907); Klein, pp. 25, 32 (with full synonymy).

TYPE: Pervinquère (1907, pl. 3, fig. 32) figured a cast of the holotype (refigured by Wright and Kennedy 1995, text-fig. 130j), the original of which has not been traced. It was from Toukabeur, Tunisia.

MATERIAL: OUM KY3780–3789, from section C–D at the 116 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: The material consists of internal and external moulds of slightly curved fragments of both phragmocone and body chamber with whorl heights of up to 26 mm, the whorl section compressed with a whorl breadth to height ratio of 0.72, the whorl section ovoid, with the venter more narrowly rounded than the dorsum. The rib index is 12, the fine ribs are even and crowded, straight and transverse on the dorsum, strengthening slightly and transverse to feebly prorsiradiate on the flanks. They link in groups of two or three at rounded-conical ventral tubercles that are linked across the venter by groups of two or three ribs. One or two nontuberculate ribs separate successive tuberculate groups. The imperfectly exposed sutures are deeply and intricately incised (Text-fig. 14E).

DISCUSSION: See Wright and Kennedy1995 (p. 304). *Hamites problematicus* Stoliczka, 1866 (p. 191, pl. 90, figs 1, 2) was based on several fragments from 'the yellow sandstone near Odiyam'. The original of Stoliczka's pl. 90, fig 1 is here designated lectotype. So defined, the species differs from *auberti* in the presence of an inner lateral tubercle. Stoliczka's other figured specimen (pl. 90, fig. 2), lacks this tubercle, and may be a member of the present species.

OCURRENCE: Lower Cenomanian of southern England, Spain, Poland, Romania, Tunisia, Tamil Nadu, and, possibly, New Zealand.

Anisoceras? sp. juv.
(Pl. 53, Figs 6, 7)

MATERIAL: OUM KY5300, from the section on the north side of the road between Odiyam and Kulakkalnattam, Upper Albian, at the 225 level.

DESCRIPTION: The specimen is a crushed limonitic mould 23 mm long, with a maximum preserved whorl height of 11 mm. The whorl section is compressed oval, the compression accentuated by the crushing. The rib index is four, the ribs coarse, straight, and feebly rursiradiate across the flanks. Tuberculate and nontuberculate ribs alternate; towards the anterior end of the fragment, a pair of ribs link at a ventral tubercle.

DISCUSSION: The linking of a pair of ribs at a single ventral tubercle suggests *Anisoceras* rather than *Idiohamites*. Of described Upper Albian taxa, the specimen is closest to *Anisoceras perarmatum simplex* of Renz (1968, p. 75, pl. 13, fig. 7; pl. 14, fig. 4; text-fig. 27k) from Saint Croix, Switzerland.

OCCURRENCE: As for material.

Family Hamitidae Gill, 1871
Genus *Hamites* Parkinson, 1811

TYPE SPECIES: *Hamites attenuatus* J. Sowerby, 1814, p. 137, pl. 61, figs 4, 5, by the subsequent designation of Diener 1925, p. 65

Hamites duplicatus Pictet and Campiche, 1861
(Pl. 52, Figs 4–6, 8–10, 15 (*pars*), Pl. 53, Fig. 1)

1861. *Hamites duplicatus* Pictet and Campiche, p. 98.
2015. *Hamites* (*Hamites*) *duplicatus* Pictet and Campiche 1861; Klein, pp. 74, 82 (with full synonymy).
2017. *Hamites duplicatus* Pictet and Campiche, 1861; Tajika *et al*., p. 40, text-fig. 16t.
2018. *Hamites* (*Hamites*) *duplicatus* Pictet and Campiche 1861; Kennedy and Morris, p. 84, text-figs 9f–i; 10a.

TYPE: The lectotype, by the subsequent designation of Spath 1941, p. 641, is the original of Pictet in Pictet and Roux 1847, pl. 14, fig. 7, from the Upper Albian of Mont Saxonnet, Savoie, France.

MATERIAL: OUM KY5989, Lower Cenomanian, *mantelli* Zone, section on the north side of the Karai–Kulakkalnattam road. OUM KY3746–3752a, KY3753 (collective of seven specimens), 3754, section C–D at the 116 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: OUM KY5989 (Pl. 53, Fig. 1) is a slightly crushed limonitic internal mould retaining limonitised shell, a curved fragment with a maximum preserved whorl height of 9 mm, the whorl section compressed ovoid, the compression accentuated by crushing. The dorsum is more broadly rounded than the venter. The rib index is nine. The ribs are near-effaced on the dorsum, but strengthen across the dorsolateral margin and flanks, where they are feebly rursiradiate, straight on the inner flanks, but flexing back slightly on the outer flank, and passing straight across the venter, where they are at their maximum strength.

OUM KY3746–3752a, 3753 (collective of seven specimens), 3754, a series of straight and curved fragments (Pl. 52, Figs 4–6, 8–10, 15 (*pars*) have whorl heights of up to 17 mm, the whorl section compressed oval, with a whorl breadth to height ratio of 0.65, the dorsum and venter broadly rounded, the flanks feebly convex. The rib index is 8–11, the ribs weak on the dorsum, strengthening across the dorsolateral margin, straight and recti- to feebly rursiradiate on the flanks, strengthening progressively and passing straight across the venter.

DISCUSSION: SeeWright and Kennedy (1995, p. 298) and Kennedy and Morris (2018, p. 97). *Hamites simplex* d'Orbigny, 1841, described below, has a lower rib index, of 4–5.

OCCURRENCE: Upper Upper Albian to lower Upper Cenomanian. The Cenomanian distribution extends from southern and eastern England to France, Poland, Dagestan, Kazakhstan, Iran, Tanzania, and Tamil Nadu.

Hamites cf. *subvirgulatus* Spath, 1941
(Pl. 53, Figs 2, 3)

Compare:
1941. *Hamites* (*Stomohamites*) *subvirgulatus* Spath, p. 645, text-fig. 234a–h.
1995. *Hamites subvirgulatus* Spath, 1941; Wright and Kennedy, p. 299, pl. 87, figs 3–5.
2015. *Hamites* (*Hamites*) *subvirgulatus* Spath; Klein, pp. 75, 96 (with full synonymy).
2017. *Hamites subvirgulatus* Spath, 1941; Tajika *et al*., p. 41, text-fig. 10p.

TYPES: The holotype is BMNH C39920, the original of Spath 1941, text-fig. 234a, b; BMNH 39921 is a paratype. Both are from the upper Upper Albian of White Nothe, Dorset.

MATERIAL: OUM KY4906 from the 63–67.5 m level; OUM KY4959 from the 80 m level of the section on the north side of the Karai–Kulakkalnattam road, both Upper Albian.

DESCRIPTION: OUM KY4959 (Pl. 53, Figs 2, 3) is a crushed curved fragment 21.9 mm long, with a maximum preserved whorl height of 7 mm; the original whorl section and proportions cannot be established The rib index is five, the ribs slightly weakened on the dorsum, strengthening across the dorsolateral margin, straight and prorsiradiate on the flanks, across which they strengthen, and transverse over the venter. OUM KY4906 is a 10.2 mm long fragment of phragmocone with a maximum preserved whorl height of 7.8 mm. Undeformed, it has a slightly compressed subcircular whorl section, the whorl breadth to height ratio 0.9.

DISCUSSION: OUM KY4959 closely resembles the uncrushed holotype. The present material differs from *Hamites duplicatus* in its lower rib index, and from *H. simplex* in its greater compression, and slightly higher rib index.

OCCURRENCE: As for material. *Hamites subvirgulatus* is typically upper Upper Albian, and ranges into the lower Lower Cenomanian. The geographic distribution extends from southern England to southern Belgium, south-east France, Sardinia, Switzerland, Poland, Madagascar, and Tamil Nadu.

Hamites simplex d'Orbigny, 1850
(Pl. 52, Figs 14, 15 (right))

1842. *Hamites simplex* d'Orbigny, p. 550, pl. 134, figs 3, 12–14.
2015. *Hamites simplex* d'Orbigny. 1842; Klein, pp. 74, 94 (with full synonymy).
2015. *Hamites simplex* d'Orbigny, 1842; Kennedy in Morel, p. 145, text-fig. 137f, h–i, m, q.
2017. *Hamites simplex* d'Orbigny, 1842; Tajika *et al*., p. 40, text-fig. 10n.

TYPES: The lectotype, by the subsequent designation of Sornay (1955b) is MNHN F. R00983; there are seven paralectotypes, refigured by Wright and Kennedy (1995, text-fig. 133d–l). They are from the Middle Cenomanian Rouen Fossil Bed of Rouen, Seine-Maritime, France.

MATERIAL: OUM KY2560, section A–B at the 56 m level, Upper Albian or Lower Cenomanian. OUM KY3752b and 3745, both from section C–D, 116 m level, Lower Cenomanian, *mantelli* Zone. OUM KY3574, from section R–S at the 65 m level, Upper Cenomanian *hourcqi–latelobatum* fauna.

DESCRIPTION: Curved and straight fragments have a circular cross section. The rib index is five, the ribs strong, annular, not noticeably weakened on the dorsum, strong and straight on the flanks, and straight and transverse over the venter. OUM KY2560 (Pl. 52, Fig. 3) is a straight body chamber shaft 55 mm long, the ribs annular and feebly prorsiradiate. There is a strong constriction at the adapertural end of the fragment, succeeded by a strong-collar rib at the adult aperture.

The sutures are poorly exposed in the present material, the lobes and saddles are broad, and little-incised.

DISCUSSION: Whorl section low rib density, and the strong ribs on the dorsum separate *simplex* from other species in the present faunas. See Wright and Kennedy (1995, p. 297) for further discussion.

OCCURRENCE: The species ranger from Lower to lower Upper Cenomanian. The geographic distribution extends from southern England, to France, Germany, Poland, Ukraine, Dagestan, Iran, Madagascar, Tamil Nadu, Bathurst Island (northern Australia), and the United Stated Western Interior.

Hamites spp. indet.

Three different forms of *Hamites*, represented by fragments only, are described below, but left in open nomenclature.

Hamites sp. A
(Pl. 52, Figs 1, 2)

MATERIAL: OUM KY3004, from section I–J, at the 13 m level, Middle Cenomanian, *cunningtoni* Zone.

DESCRIPTION: The specimen consists of a curved sector and a 39 mm long shaft with a maximum preserved whorl height of 12.8 mm. The whorl section is compressed ovoid (the compression possibly accentuated by compaction). The rib index is 10, the ribs narrow, straight, crowded, and strongly rursirsdiate on the curved sector, less markedly so on the straight shaft; they pass straight across the venter.

Hamites sp. B

MATERIAL: OUM KY4556, 4557, from section T–U at the 10 m level, Upper Albian.

DESCRIPTION: There are two fragments of internal mould; the larger has a whorl height of 13mm approximately. The whorl section is subcircular, the rib index 5, the ribs coarse, straight, and feebly rursiradiate on the flanks, and transverse on the venter.

Hamites sp.C
(Pl. 53, Figs 4, 5)

MATERIAL: OUM KY5158, from section north of the Karai–Kulakkalnattam road at the 170–175 m level, Upper Albian.

DESCRIPTION: The specimen is an 18 mm long near-straight phragmocone fragment retaining limonitised shell. The whorl section is compressed, the maximum preserved whorl height 5 mm, the whorl breadth to height ratio 0.67, the dorsum more broadly rounded than the venter, the flanks very feebly convex. The rib index is 11–12, the ribs very fine,

crowded, of uniform strength on dorsum, flanks and venter, transverse on the dorsum, straight and prorsiradiate across most of the flanks, flexing slightly back across the ventrolateral margin, and straight and transverse across the venter.

DISCUSSION: The delicate ornament, high rib density and uniform strength of ribs on dorsum, flanks and venter distinguish the specimen from all others in the collection. What appear to be further representatives are the fragments described by Stoliczka as *Hamites nereis* Forbes, 1846, from near Odiyam (1866, p. 182 (*pars*), pl. 85, figs 17–18); true *nereis* is an Upper Maastrichtian *Glyptoxoceras* Spath, 1925c, and is revised by Kennedy and Henderson (1992b).

Genus *Hemiptychoceras* Spath, 1925b

TYPE SPECIES: *Ptychoceras gaultinum* Pictet, 1847, p. 359, pl. 15, figs 5, 6, by the original designation of Spath 1925b, p. 189.

Hemiptychoceras cf. *tropicum (*Kossmat, 1895)
(Pl. 53, Figs 9–12; Text-fig. 38D)

Compare:
1866. *Ptychoceras Gaultinum* Stoliczka, p. 195, pl. 90, fig. 10.
1895. *Hamites* (*Ptychoceras*) *tropicu*s Kossmat, p. 150 (54).
2015. *Hemiptychoceras tropicum* (Kossmat, 1895); Klein, pp. 105, 108 (with full synonymy).

TYPE: The holotype, by monotypy, is the original of Stoliczka 1866, p. 195, pl. 90, fig. 10, from Odiyam.

MATERIAL: OUM KY3699a, from section C–D between Odiyam and Kunnam at the 116 m level, Lower Cenomanian *mantelli* Zone. OUM KY4243, from section D, north-west of Garudamangalam at the 28 m level, Upper Albian. OUM KY5626, from the section on the north side of the Karai–Kulakkalnattam road, 350 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: The present material consists of limonitic internal moulds of phragmocone fragments with whorl heights of up to to 10 mm. They are straight, with a circular whorl section. Ornament consists of very fine transverse wiry riblets that encircle the whorl without interruption; the rib index 12. There are widely separated annular constrictions; their spacing cannot be established, even on OUM KY5626 (Pl. 53, Fig. 10) 20 mm long, which has only a single constriction. The suture is only moderately incised, with bifid lobes and saddles (Text-fig. 38D).

DISCUSSION: These specimens are too fragmentary for confident identification, but correspond in ribbing style and density to the penultimate shaft of the holotypeof *tropicum*.

OCCURRENCE: Lower Cenomanian of Tamil Nadu; Lower or Middle Cenomanian of Cassis, Bouches-du-Rhône, France.

Family Turrilitidae Gill, 1871

DISCUSSION: The classification of Wright (1996) and Wright and Kennedy(1996) is followed here. See Cooper (199) and Klein (2015) for a different approach.

Genus and Subgenus *Ostlingoceras* Hyatt, 1900

TYPE SPECIES: *Turrilites puzosianus* d'Orbigny, 1842, p. 587, pl. 143, figs 1, 2, by the original designation of Hyatt 1903, p. 587.

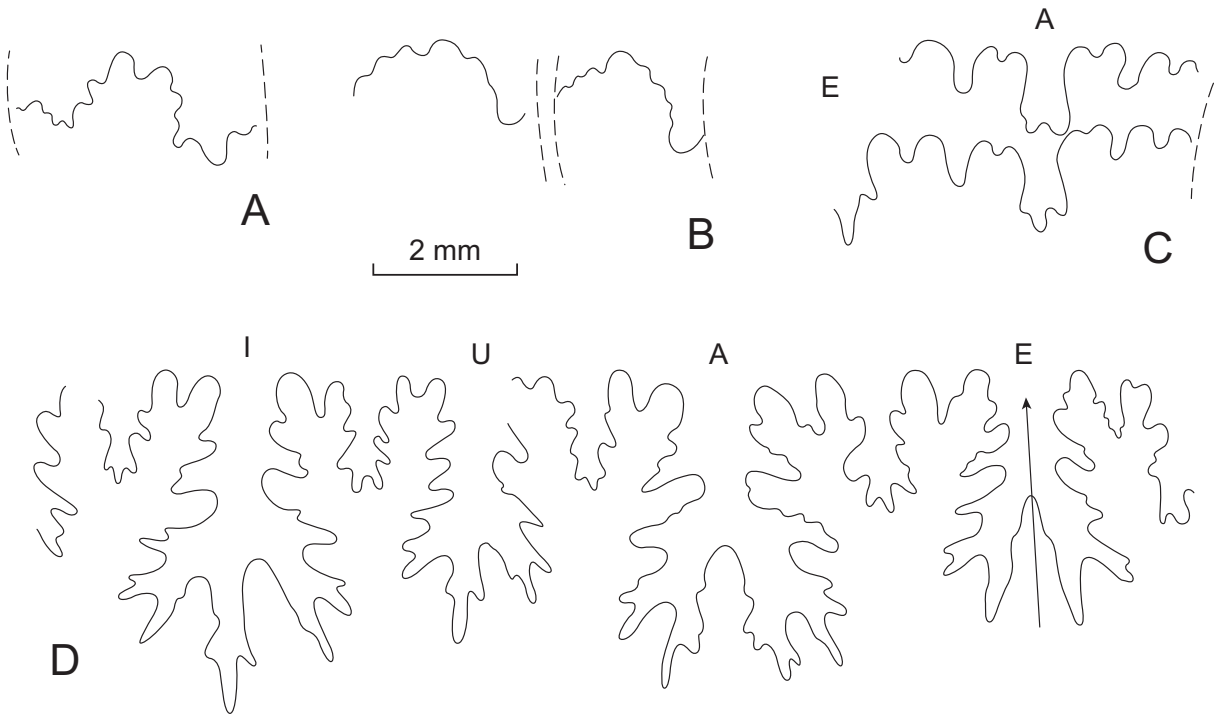
Ostlingoceras (*Ostlingoceras*) *rorayense* (Collignon, 1964)
(Pl. 58, Figs 2–4, 14, 15, 19)

1964. *Turrilites rorayensis* Collignon, p. 49, pl. 330, fig. 1479.
2015. *Ostlingoceras* (*Ostlingoceras*) *rorayense* (Collignon, 1964); Klein, pp. 192, 197 (with full synonymy).

TYPE: The holotype is the original of Collignon 1964, p. 49, pl. 330, fig. 1479, from the Lower Cenomanian of Lac Roray (Manera), Madagascar, in the Collignon Collection, housed in the Université de Bourgogne, Dijon. It was refigured by Wright and Kennedy (1996, text-fig. 136i).

MATERIAL: OUM KY3653 and KY4370 (collective of five specimens), from section C–D, at the 79 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: Fragments have whorl heights of up to 12.3 mm. The outer whorl face is flattened. There are 13–15 ribs per half whorl. They are narrow, feebly prorsirsdiate, crowded, and extend from the junction of upper and outer whorl faces across most of the outer whorl face, weakening on the lower part, before strengthening again into small, rounded tubercles. A narrow smooth zone separates these



Text- fig. 38. Sutures: **A** – *Carthaginites* sp., OUM KY4122. **B** – *Carthaginites multituberculatus* sp. nov., OUM KY3913. **C** – *Worthoceras* sp., OUM KY4202. **D** – *Hemiptychoceras* cf. *tropicum* (Kossmat, 1895), OUM KY3699a

tubercles from a second, adaperturally displaced row at the junction of the outer and lower whorl faces. These are developed into flattened spines where shell material is present. There is a third row of much smaller tubercles on the lower whorl face that give rise to radial ribs that weaken and decline across the lower whorl face.

DISCUSSION: See Klinger and Kennedy (1978, p. 13) and Wright and Kennedy (1996, p. 323).

OCCURRENCE: Lower Cenomanian, *mantelli* Zone, southern England, Iran, Mozambique, KwaZulu-Natal in South Africa, Madagascar, and Tamil Nadu.

Ostlingoceras (*Ostlingoceras*) *colcanapi* (Boule, Lemoine and Thévenin, 1907)
(Pl. 57, Figs 10, 11)

1907. *Turrilites colcanapi* Boule, Lemoine and Thevenin, p. 59 (39), pl. 13 (6), fig. 3.
2015. *Mesoturrilites* (*Mesoturrilites*) *colcanapi* (Boule, Lemoine and Thévenin, 1907); Klein, pp. 170, 173 (with full synonymy).

TYPE: The holotype, by monotypy, is MNHN F.R0111, the original of *Turrilites colcanapi* Boule, Lemoine and Thevenin 1907 p. 59 (39), pl. 13 (6), fig. 3, from the ‘vallée de la Betaitra, Madagascar.

MATERIAL: OUM KY5766 from the Karai–Kulakkalnattam section at the 377.5–382 m level, OUM KY5865 from the 405–410 m level; both Lower Cenomanian, *mantelli* Zone

DESCRIPTION: OUM KY5766 (Pl. 57, Fig. 10) consists of two whorls with a maximum preserved whorl height of 9.5 mm approximately. The outer, exposed whorl face is broadly rounded. Strong, narrow, feebly prorsirsdiate ribs extend over most of the outer whorl face; there are five ribs in a distance equal to the whorl height. There is a well-developed spiral ridge at the base of the whorl face, differentiated into feeble spirally elongate tubercles that correspond to the ribs. A third row of small, rounded tubercles give

rise to radial ribs that extend across the lower whorl face. OUM KY5865 (Pl. 57, Fig. 11) is a larger whorl fragment with a maximum preserved whorl height of 6.7 mm (although reduced by *post-mortem* deformation). The outer whorl face is ornamented by feebly concave, feebly prorsirsdiate crowded ribs.

DISCUSSION: See Wright and Kennedy (1996, p. 323) who make the case for referring the species to *Ostlingoceras* rather than *Mesoturrilites.*

OCCURRENCE: Lower Cenomanian, Madagascar, Tamil Nadu, Japan, Turkmenistan, and, possibly Poland and Germany.

Ostlingoceras (*Ostlingoceras*) sp.
(Pl. 57, Figs 9, 15)

MATERIAL: OUM KY5549, from the 348 m level, Lower Cenomanian, *mantelli* Zone; KY5855, from the 400–404.5 m level, Middle or Upper Cenomanian, both from the section north of the Karai–Kulakkalnattam road.

DESCRIPTION: OUM KY5855 (Pl. 57, Fig. 15) is a crushed individual 19 mm high with a maximum preserved whorl height of 4 mm approximately and an apical angle of 20° approximately. The greater part of the whorl face is covered in delicate crowded transverse ribs. On the lowermost part there is a narrow ridge, parallel to the inter-whorl suture that bears delicate conical tubercles that correspond to the lower termination of the ribs. OUM KY5549 (Pl. 57, Fig. 9), consists of five whorls with a total height of 12.4 mm and a maximum preserved whorl height of 4.5 mm. The outer whorl face is ornamented by feebly prorsiradiate ribs, the rib density much lower than in the previous specimen. There is a spiral ridge near the base of the whorl, bearing tiny tubercles corresponding to the rib terminations. A narrow groove separates this ridge from a second one, also bearing tiny spirally elongated tubercles. The base of the whorl bears delicate radial ribs.

DISCUSSION: The specimens are comparable to *Ostlingoceras* (*Ostlingoceras*) *collignoni* Wright and Kennnedy, 1996 (p. 325, text-figs 134m, n; 138e), introduced as *nomen novum* for *Turrilites laevigatus* Collignon, 1931 (p. 90 (50), pl. 9 (5), figs 18, 19, *non* Coquand 1862, p. 175, pl. 2, fig. 6) on the basis of the delicacy and number of the ribs, but given the poor preservation, they are left in open nomenclature.

OCCURRENCE: As for material.

Genus *Neostlingoceras* Klinger and Kennedy, 1978

TYPE SPECIES: *Turrilites carcitanensis* Matheron, 1842, p. 267, pl. 41, fig. 4, by the original designation of Klinger and Kennedy, 1978, p. 14.

Neostlingoceras carcitanense (Matheron, 1842)
(Pl. 57, Figs 7, 8; Pl. 58, Figs 11, 13)

1842. *Turrilites carcitanensis* Matheron, p. 267, pl. 41, fig. 4.
2015. *Neostlingoceras carcitanense* (Matheron, 1842); Klein, p. 199 (with full synonymy).
2017. *Neostlingoceras carcitanense* (Matheron, 1842); Tajika *et al*., p. 43, text-fig. 11p.

TYPE: The holotype, by monotypy, is the original of Matheron, 1842, p. 267, pl. 41, fig. 4, from the remanié fauna of the Banc des Lombards at Cassis, Bouches-du-Rhône, refigured by Fabre 1940, pl. 5, fig. 7.

MATERIAL: OUM KY5493, 341–346 m level; KY5546, 348 m level; KY5614, 350 m level, all Lower Cenomanian *mantelli* Zone, and from the section north of the Karai–Kulakkalnattam road.

DESCRIPTION: The largest specimen, OUM KY5493 (Pl. 57, Fig.7), has a maximum preserved whorl height of 6.5 mm approximately. The whorl face is flattened in intercostal section. Ornament consists of an upper row of larger conical tubercles, a second row of twice as many much smaller tubercles, and a third row, equal in number to those in the second row, and housed in crenulations in the inter-whorl suture. Strong radial ribs extend across the base of the whorl from the lowest row of tubercles. The other specimens are similar but smaller fragments.

DISCUSSION: The species differs from *Neostlingoceras oberlini* (Dubourdieu, 1953) (p. 59, pl. 4, figs 28–30) (see revision in Wright and Kennedy 1996, p. 228, pl. 99, figs 8, 16, 17, 24, 32; pl. 110. fig. 1; pl. 111, fig. 22; text-figs 129d; 137d, h, i; 142b, c) in having only three rows of tubercles. In *oberlini*, three rows of tubercles are exposed on the outer whorl face, with a fourth row concealed below the inter-whorl suture.

OCCURRENCE: Index of the Lower Cenomanian *N. carcitanense* Subzone of the *M. mantelli* Zone in

Europe. There are records from southern England, France, Germany, Switzerland, Poland, Turkmenistan, Kazakstan, Iran, Algeria, Central Tunisia, Kwa Zulu-Natal in South Africa, Madagascar, Tamil Nadu, and Hokkaido.

Neostlingoceras sp.
(Pl. 57, Fig. 19)

MATERIAL: OUM KY4153, from section B at the 14–26 m level, Middle Cenomanian *asiaticum* Zone.

DESCRIPTION: The specimen is crushed flat, and consists of three whorls, the maximum whorl height 10 mm. The upper part of the outer whorl face forms an obtuse angle with the flattened remainder of the face. There are six to seven transversely elongated tubercles visible on a face of the specimen at a point above the middle of the whorl face, where the change in slope occurs, and 10–11 smaller, weaker, transversely elongated tubercles at the junction of outer and lower whorl faces, the two rows separated by a broad smooth zone. The base of the whorl is not preserved.

DISCUSSION: The flattened whorl face, shape and disposition of the tubercles indicate the specimen to be a *Neostlingoceras*. It most closely resembles the Upper Cenomanian *Neostlingoceras virdense* Cobban, Hook and Kennedy, 1989 (p. 61, text-figs 63, 95t), but this has more numerous tubercles per whorl: 19 in the upper row and 23 in the lower row on the outer whorl face, together with a third row on the lower whorl face, the presence/absence of which cannot be established in the present specimen, which is left in open nomenclature. The record is significant as it fills the gap between previously described Lower and Upper Cenomanian representatives of the genus.

OCCURRENCE: As for material.

Genus *Carthaginites* Pervinquière, 1907

TYPE SPECIES: *Turrilites* (*Carthaginites*) *kerimensis* Pervinquière, 1907, p. 101, pl. 4, figs 18, 19, by the original designation of Pervinquière 1907, p. 96.

Carthaginites multituberculatus sp. nov.
(Pl. 57, Figs 17, 18, 20, 22; Text-fig. 38B)

TYPES: The holotype is OUM KY3912, paratypes are OUM KY3913–3915, from section A at the 16–18 m level, Upper Cenomanian, *harpax* Zone, *euomphalum* fauna.

DIAGNOSIS: A species of *Carthaginites* with sixteen large tubercles per whorl in the middle of the outer whorl face, and a feebly crenulate ridge at the junction of outer and lower whorl faces.

DESCRIPTION: Apical angle low, around 18–20°. Upper whorl face smooth, concave, junction between upper and outer whorl faces narrowly rounded, outer whorl face flattened. Junction between outer and lower whorl faces rounded, lower whorl face smooth. Sixteen low, broad ribs arise on the upper part of the outer whorl face and strengthen into large transversely elongate tubercles at mid-flank. A smooth zone separates these tubercles from a blunt, rounded ridge at the base of the outer whorl face, with more numerous small transversely elongated tubercles, the interspaces corresponding to crenulations in the junction of outer and lower whorl faces. The suture (Text-fig. 38B) is very simple, with E at the top of the outer whorl face, and E/A occupying the remainder of the face.

DISCUSSION: The numerous tubercles and the crenulated ridge at the base of the outer face distinguish *multinodosus* from all other species of *Carthaginites*. *C. kerimensis* has only six tubercles per whorl, versus 16 in the present species, and lacks the crenulate ridge. *Carthaginites* sp., described below, lacks tubercles in the middle of the outer whorl face and has numerous small tubercles at the base of the outer whorl face. *Carthaginites asiaticus* (Matsumoto and Takahashi, 2000, p. 266, text-figs 5a–i; 6; Matsumoto 2002, p. 358, text-fig. 1a, b) from the Middle Cenomanian of Hokkaido is a close ally, the tubercles in the upper row weaker than in the present species, with a second row of more numerous minute tubercles at the base of the outer whorl face. *Carthaginites yamashitai* Matsumoto, 2002, p. 359, text-figs 2a–e; 3) has near-smooth early whorls, with a feeble groove in the middle of the outer whorl face; when tubercles appear, they are much weaker than in the present species.

OCCURRENCE: As for material.

Carthaginites sp.
(Pl. 57, Fig. 14; Text-fig. 38A)

MATERIAL: OUM KY4122, from section B at the 10–20 m level, Middle Cenomanian *asiaticum* Zone.

DESCRIPTION: The specimen consists of four

whorls, the maximum whorl height 5.4 mm; the total height of the fragment is 18.4 mm. The apical angle is low, the outer whorl face flattened, the junction of upper and outer and lower and outer whorl faces angular. There is a broad very feeble depressed zone in the middle of the face. There are 20–22 feebly oblique conical tubercles at the junction of outer and lower whorl faces. In place there are indications of a near obsolete rib extending upwards from these tubercles, but preservation is defective. The upper and lower whorl faces are smooth. The poorly preserved suture (Text-fig. 38A) is simple with E at the top of the outer whorl face, and only minor incisions in both lobes and saddles.

DISCUSSION: Coiling, flattened whorl face and feeble median depression on the outer whorl face indicate assignation to *Carthaginites*. Preservation of ornament is deficient, but the presence of numerous tubercles at the junction of outer and lower whorl faces separates the specimen from the type, species, *Carthaginites kerimensis*, which has six or seven tubercles per whorl on the upper part of the outer whorl face.

OCCURRENCE: As for material.

Genus and subgenus *Mariella* (*Mariella*) Nowak, 1916

TYPE SPECIES: *Turrilites bergeri* Brongniart, 1822, p. 395, pl. 7, fig. 3, by the original designation of Nowak 1916, p. 10.

Mariella (*Mariella*) *circumtaeniata* (Kossmat, 1895)
(Pl. 52, Fig. 11; Pl. 56, Figs 4, 8)

1866. *Turrilites gresslyi* Pictet et Campiche; Stoliczka, p. 186, pl. 87, figs 1–5.
1895. *Turrilites circumtaeniatus* Kossmat, p. 141 (45), pl. 18 (4), figs 4, 5.
2015. *Pseudhelicoceras circumtaeniatum* (Kossmat, 1895); Klein, pp. 118, 121 (with full synonymy).

TYPE: The lectotype, by the subsequent designation of Klinger and Kennedy (1978, p. 26) is the original of Kossmat 1895 pl. 18 (4), fig. 4, from Odiyam.

MATERIAL: OUM KY2503–2505, from section A–B, lower interval, 17 m level. OUM KY2513–2517, section A–B, upper interval, 0–2 m level. OUM KY348, KY4350–4351, from section A–B, 9.5–10 m level, all Upper Albian *rostrata* Zone.

DESCRIPTION: The species reaches a large size, with whorl heights of up to 55 mm. The upper whorl face is flattened, with radial grooves to accommodate the ribs on the base of the previous whorl, and the inter-whorl suture is notched to accommodate the lowest row of tubercles of the preceding whorl. The outer whorl face is convex, the lower whorl face flattened. There are three rows of 26–27 tubercles per whorl, the tubercles of each row displaced adapertural of the row above. Those of the first, upper row, are placed a little above the middle of the outer whorl face, and are rounded, and slightly transversely elongated. They are linked to the inter-whorl suture by one or two delicate, concave feebly prorsirsdiate ribs, with additional ribs intercalating. The tubercles of the second row are also rounded and slightly transversely elongated. They are placed low on the outer whorl face, and connected to those in the first row by a low, broad, prorsiradiate rib. The third, smaller row of tubercles lie at the junction of outer and lower whorl faces, housed in notches in the inter-whorl suture. They are linked to those in the second row by a low, broad, prorsiradiate rib, and give rise to a radial rib that extends across the lower whorl face. OUM KY2513 (Pl. 56, Fig. 8) is interpreted as an incomplete macroconch. OUM KY4348 (Pl. 52, Fig. 11) is interpreted as an adult microconch. The adapertural half of the final whorl detaches from the spire at a whorl height of 29 mm, the three rows of tubercles are spinose, the ribs on the lower whorl face link to a fourth row of tubercles at the junction of the lower and inner whorl faces. The adult aperture is flared, the flare preceded by a marked constriction.

DISCUSSION: Recent authors (myself included) have referred *circumtaeniata* to both *Pseudhelicoceras* Spath, 1922a (p. 112, type species *Turrilites robertianus* d'Orbigny, 1842, p. 585, pl. 142, figs 1–6) and *Mariella*. The present material shows the siphuncle to lie at the top of the outer, exposed whorl face, rather than around the middle, as it does in *Pseudhelicoceras robertianum*. Spath (1937, p. 530) regarded this as a diagnostic feature of the genus, hence the present assignation. The pattern of ribs and tubercles distinguishes the present species from all other *Mariella* (*Mariella*) species.

OCCURRENCE: Upper Upper Albian, Tamil Nadu, Madagascar, KwaZulu-Natal in South Africa, Angola, and south-eastern France.

Mariella (*Mariella*) *lewesiensis* (Spath, 1926b)
(Pl. 52, Figs 7, 12)

1857. *Turrilites bergeri* Sharpe, p. 65 (*pars*), pl. 26, fig. 110 only.
1926b. *Turrilites lewesiensis* Spath, pp. 429, 431.
1996. *Mariella* (*Mariella*) l*ewesiensis* (Spath, 1926); Wright and Kennedy, p. 339, pl. 100, fig. 4; pl. 101, figs 2, 3; pl. 103, figs 6–8 (with synonymy).
2015. *Cenomariella lewesiensis lewesiensis* (Spath, 1926); Klein, p. 153 (with full synonymy).
2017. *Mariella lewesiensis* (Spath, 1926); Mosavina and Wilmsen, p. 118, text-fig. 4b, g (with additional synonymy).

TYPE: The holotype, by monotypy, is BMNH 33558, the original of Sharpe 1857, pl. 26, fig. 10, from the Chalk Marl near Lewes, Sussex. It was refigured by Wright and Kennedy (1996, pl. 101, fig. 3).

MATERIAL: From section C–D, OUM KY3652, from the 79 m level; KY3678–3680, from the 90 m level; KY3701–3719, from the 116 m level. OUM KY4297–4300, from section D at the 53–60 m level. All Lower Cenomanian *mantelli* Zone.

DESCRIPTION: Fragments have diameters of up to 75 mm. The upper whorl face is feebly concave and ornamented by well-developed radial grooves to accommodate the ribs on the base of the preceding whorl. The narrowly rounded junction between upper and outer whorl faces is deeply crenulated to accommodate the lowest row of tubercles of the preceding whorl. The outer whorl face is convex in intercostal section, the junction of outer and lower whorl faces rounded, the lower whorl face flattened. There are four rows of tubercles, six in a distance equal to the whorl height. Those in the first, upper row, are separated from the inter-whorl suture by a broad smooth zone. They are conical to transversely elongated. A broad smooth zone separates them from the second row of smaller, adaperturally displaced tubercles, and a narrow smooth zone separates the second and third rows, the latter also displaced adaperturally and lying just above the junction of the outer and lower whorl faces. A fourth row of tubercles, again adaperturally displaced, are housed in notches in the inter-whorl suture; they give rise to weak radial ribs that extend across the base of the whorl. OUM KY4299 preserves the contracted adult aperture, the better-preserved tubercles subspinose.

Poorly preserved limonitic *Mariella* from the section on the north side of the Karai–Kulakkalnattam road include juveniles comparable to *lewesiensis* (Pl. 57, Figs 3, 4, 8, 12, 13): OUM KY5526–5527, from the 345–350 m level; OUM KY5636–5638, from the 352 m level; OUM KY5492, from the 341.5–346 m level; OUM KY6009, 6010 (collective of 11 specimens), all Lower Cenomanian *mantelli* Zone.

DISCUSSION: See Wright and Kennedy (1996, p. 340).

OCCURRENCE: Lower Cenomanian, southern England, France, Germany, Switzerland, Poland, Iran, Turkmenistan, KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, Japan, and Peru.

Mariella (*Mariella*) sp. juv.
(Pl. 57, Figs 1, 2, 5)

MATERIAL: OUMK KY5396 (collective of six specimens) from the section on the north side of the Karai–Kulakkalnattam road at the 275–280 m level, Upper Albian *rostrata* Zone.

DESCRIPTION: The specimens are all crushed and deformed to varying degrees. The largest whorl has a diameter of 15 mm. There are four rows of tubercles. Three are on the outer whorl face, and are linked by a low oblique rib. Those in the upper row are feebly transversely elongated, as are those in the second row. Those in the third row are conical, in some cases subspinose, and housed in crenulations in the inter-whorl suture. A fourth smaller, radially elongated row lie on the outer part of the lower whorl face, and give rise to coarse radial ribs.

DISCUSSION: These tiny specimens are specifically indeterminate.

OCCURRENCE: As for material.

Genus *Turrilites* Lamarck, 1801

TYPE SPECIES: *Turrilites costatus* Lamarck, 1801, p. 102, by original designation by Lamarck, 1801, p. 102.

Turrilites scheuchzerianus Bosc, 1801
(Pl. 57, Figs 16, 21)

1708. *Turbinites* Langius, p. 112, fig. 6.
1801. *Turrilites scheuchzerianus* Bosc in Buffon, p. 190 (copy of Langius).
1996. *Turrilites scheuchzerianus* Bosc, 1801; Wright and Kennedy, p. 349, pl. 106, figs 7, 8, 11, 12; pl. 107, figs 1–7; text-figs 137g, j, 138c, d, f, g, h, i, n; 139h, i; 140a, d, e, f, g, h, i; 143h; 147a, b (with synonymy).

2015. *Turrilites scheuchzerianus* Bosc, 1801; Kennedy in Morel, p. 146, text-fig. 136a, c.
2015. *Turrilites scheuchzerianus* Bosc, 1801; Kennedy in Kennedy and Gale, p. 314, pl. 24, figs 6–8, 11–13, 16, 19.
2015. *Turrilites scheuchzerianus* Bosc, 1801; Klein, pp. 176, 186 (with synonymy).
2017. *Turrilites scheuchzerianus* Bosc, 1801; Kennedy in Kennedy and Gale, p. 102, pl, 17, figs 3, 12, 16, 18.
2017. *Turrilites scheuchzerianus* Bosc, 1801; Mosavina and Wilmsen, p. 121, text-fig. 5d, e, g.

TYPE: Bosc's figure is a copy of Langius 1708, pl. 112, fig. 6. The status and whereabouts of the type material of this species has not been established.

MATERIAL: OUIM KY5836–5837, from the section on the north side of the Karai–Kulakkalnattam road at the 390–400 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: OUM KY5836 (Pl. 57, Fig. 22) is a crushed juvenile 25 mm high, consisting of five and a half whorls; the greatest preserved whorl height is 6.7 mm. Ornament is of oblique ribs that arise at the top of the outer whorl face, strengthen across the face, and terminate in a well-developed tubercle. A smooth zone separates the tubercle from a second transversely elongated tubercle at the base of the outer whorl face. OUM KY5837 (Pl. 57, Fig. 17) is a half whorl fragment with a maximum preserved whorl height of 16 mm. There are seven strong, oblique ribs, slightly weakened at mid-flank.

DISCUSSION: *Turrilites scheuchzerianus* is rare in the present faunas. The larger fragment is typical. In contrast, the smaller fragment resembles juvenile *Turrilites costatus* in developing tubercles, although there are only two rows, as opposed to three in *costatus.* That it is a juvenile *scheuchzerianus* is confirmed by comparison with the early whorls of SMC B35810 (Wright and Kennedy 1996, pl. 107, fig. 2), where ribs strengthened into two rows of tubercles are succeeded by later whorls with ribbing typical of *scheuchzerianus.*

OCCURRENCE: Upper Lower and Middle Cenomanian. There are records from Bornholm in the Baltic, England, France, Switzerland, Germany, Poland, Spain, southern Italy, Crimea, Iran, Kazakhstan, Turkmenistan, Iran, Morocco, Algeria, Central Tunisia, Israel, Nigeria, KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, Tibet, Japan, the U.S. Gulf Coast and Western Interior.

Turrilites aff. *scheuchzerianus* Bosc, 1801
(Pl. 58, Fig. 21)

MATERIAL: OUM KY3014, from section I–J at the 20 m level, Middle Cenomanian, *cunningtoni* Zone.

DESCRIPTION: The specimen consists of three whorls, two of which are body chamber. On the first, adapical whorl, the upper whorl face is concave, with faint ribs that correspond to crenulations in the narrowly rounded junction between the upper and outer whorl faces. The upper part of the outer whorl face is feebly convex, the lower part is flattened. The junction between the outer and lower whorl faces is feebly convex. There are 20 ribs per whorl. They arise at the top of the outer whorl face and are strong, straight and prorsirsdiate, strengthening into incipient bullae before weakening markedly around mid-flank, then strengthening and extending to the base of the outer whorl face. The zone of weakening of ornament in the middle of the outer whorl face becomes less obvious on the second whorl, and is entirely lost on the third. The adapertural part of the body chamber is marked by the appearance of a lower zone of weakening of the ribs, the ribs at this point extending onto the lower whorl face.

DISCUSSION: The presence of an incipient tubercle on the ribs just above the mid-point of the outer whorl face, and the development of a second zone of weakening of the ribs on the lower part of the outer whorl face separate this specimen from typical *Turrilites scheuchzerianus*, to which is clearly related.

OCCURRENCE: As for material.

Turrilites costatus Lamarck, 1801
(Pl. 58, Figs 20, 22–25)

1801. *Turrilites costata* Lamarck, p. 102 (*pars*).
1996. *Turrilites costatus* Lamarck, 1801; Wright and Kennedy, p. 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 synonymy).
2015. *Turrilites costatus costatus* Lamarck, 1801; Klein, pp. 176, 179 (with additional synonymy).
2016. *Turrilites costatus* Lamarck, 1801; Sharifi *et al*., p. 606, text-fig. 9, Ni8, Ni9.
2017. *Turrilites costatus* Lamarck, 1801; Kennedy in Kennedy and Gale, p. 103, pl. 17, figs 5, 10, 14.
2017. *Turrilites costatus* Lamarck, 1801; Mosavina and

Wilmsen, p. 122, text-fig. 5f (with additional synonymy).

TYPE: The holotype, by the subsequent designation of Douvillé (1904, fiche 54a, fig. 1) as 'type' is MNHN F. A25610, figured by and Wright and Kennedy (1987, text-fig. 142 f). It is from Rouen, Seine-Maritime, France.

MATERIAL: From section E–F, OUM KY2591, 2592, from the 155 m level, KY2659, 2660, from the 168–170 m level; KY2676 from the 170 m level; KY2682–2684, from the 170–175 m level, all Middle Cenomanian. From section G–H, KY2656, 2657, from the 168 m level; KY2692–2698, from the 169 m level; KY2762, 2763, from the 171.3 m level, all Middle Cenomanian *asiaticum* Zone. KY6030, a phosphatised specimen from 4–5 m above the base of the *asiaticum* Zone channel, section on the north side of the Karai–Kulakkalnattam road, Middle Cenomanian.

DESCRIPTION: Specimens have whorl heights of between 6 and 23 mm. The largest and most complete specimen, OUM KY2698 (Pl. 58, Fig. 22), consists of parts of six whorls. The upper whorl face is smooth and concave, the inter-whorl suture feebly crenulated to accommodate the lowest row of tubercles of the preceding whorl. The outer whorl face is convex in intercostal section, the junction of outer and lower whorl faces rounded, the lower whorl face feebly convex. There are up to 28 ribs per whorl. They arise at the junction of the upper and outer whorl faces, and are coarse, blunt, and feebly prorsirsdiate, extending to just below the middle of the outer whorl face, where they strengthen into an incipient to well-developed tubercle. They are succeeded by a narrow zone of feeble to obsolete ornament, in turn succeeded by a row of oblique bullae in some; in others, the bulla is transitional to a short rib that is interrupted by a second narrow near-smooth zone. A ridge at the junction of outer and lower whorl faces bears smaller oblique bullae/short ribs, housed in crenulations in the inter-whorl suture.

OUM KY2763 (Pl. 58, Fig. 24) is interpreted as an adult microconch. It consists of 1.5 whorls, and retains the adult aperture. The penultimate whorl has a whorl height of 9.6 mm; there are 23 ribs per whorl. The aperture is preceded by a deep constriction, the apertural margin flared, the lower part of the margin produced into a linguoid extension.

DISCUSSION: See Wright and Kennedy (1996, p. 357).

OCCURRENCE: Index of the lower Subzone of the lower Middle Cenomanian *Acanthoceras rhotomagense* Zone in Europe, 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, Turkmenistan, Iran, Algeria, Central Tunisia, the Middle East, Nigeria, Angola, KwaZulu-Natal in South Africa, Mozambique, Madagascar, Tamil Nadu, Tibet, northern Australia, Mexico, the U.S. Gulf Coast and California.

Turrilites acutus Passy, 1832

1832. *Turrilites acutus* Passy, p. 9, pl. 16, figs 3, 4.
1996. *Turrilites acutus* Passy, 1832; Wright and Kennedy, p. 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 acutus* Passy, 1832; Klein, p. 175, 177 (with synonymy).
2015. *Turrilites acutus acutus* Passy, 1832; Kennedy in Morel, p. 46.
2017. *Turrilites acutus* Passy, 1832; Kennedy in Kennedy and Gale, p. 104, pl. 7, figs 9, 11, 15, 17.

TYPE: The lectotype by the subsequent designation of Juignet and Kennedy, 1976, p. 65, is the original of Passy, 1832, pl. 16, fig. 3, MNHN. F. R03993. It is from the Middle Cenomanian of Rouen, Seine-Maritime, France, and was refigured by Juignet and Kennedy (1976, pl. 4, fig. 2) and Wright and Kennedy (1996, pl. 108, fig. 8).

MATERIAL: OUM KY6602, from the basal shell bed of the *asiaticum* Zone channel on the north side of the road between Karai and Kulakkalnattam (Text-fig. 5).

DESCRIPTION: The specimen is a crushed composite mould of a 60º whorl fragment with a maximum preserved whorl height of 13 mm. The costal whorl section is markedly angular. The ribs are strong, coarse, and terminate in a strong tubercle tubercle above the middle of the outer whorl face. The ribs weaken and efface below this, and a relatively wide zone separates them from a second row of weaker, transversely displaced tubercles that lie below the middle of the whorl face, with a third smaller, transversely elongated row low on the outer

whorl face and closer to the second row than is the first row.

DISCUSSION: Although a small fragment only, the lower whorl and three rows of well-developed tubercles immediately separate the species from *Turrilites costatus*, described above. See Wright and Kennedy (1996, p. 359) for a discussion of differences from other species

OCCURRENCE: Middle Cenomanian, index of the upper Subzone of the *Acanthoceras rhotomagense* Zone, to lower Upper Cenomanian *Calycoceras guerangeri* Zone of Western Europe and correlatives. The geographic distribution extends from England to France, Germany, Poland, Spain, northern Russia, Kazakhstan, Turkmenia, Iran, Algeria, Central Tunisia, Israel, Nigeria, Angola, KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, Tibet, Texas, and the Unite States Western Interior and California.

Genus *Hypoturrilites* Dubourdieu, 1953

TYPE SPECIES: *Turrilites gravesianus* d'Orbigny, 1842, p. 596, pl. 144, figs 3–5, by the original designation of Dubourdieu 1953, p. 44.

Hypoturrilites gravesianus (d'Orbigny, 1842)
(Pl. 58, Figs 8, 9, 12)

1842. *Turrilites gravesianus* d'Orbigny, p. 596, pl. 144, figs 3–5.
1996. *Hypoturrilites gravesianus* (d'Orbigny, 1842); Wright and Kennedy, p. 364, pl. 102, fig. 10; pl. 109, figs 1–6; pl. 110, figs 2, 8, 9; pl. 111, fig. 6; pl. 112, figs 1, 3; pl. 113, figs 1, 2, 5, 7, 10–12; text-figs 134r; 140j, k 141e; 145f; 147e–g (with synonymy).
2015. *Hypoturrilites gravesianus* (d'Orbigny, 1842); Klein, pp. 156, 161 (with additional synonymy).
2017. *Hypoturrilites gravesianus* (d'Orbigny, 1842); Mosavina and Wilmsen, p. 119, text-fig. 5a (with additional synonymy).
2017. *Hypoturrilites gravesianus* (d'Orbigny, 1842); Tajika *et al*., p. 43, text-fig. 11e.

TYPE: The lectotype (International Commission on Zoological Nomenclature Opinion 1925, 1999) is BMNH C5762b, the original of Mantell 1822, pl. 24, fig. 6, from the Lower Chalk of Middleham, near Ringmer, Sussex. It was refigured by Wright and Kennedy 1996, pl. 113, fig. 10.

MATERIAL: OUM KYKY556a–g, from the section on the north side of the Karai–Kulakkalnattam road at the 346–350 m level. OUM KY3809, from section C–D between Odiyam and Kunnam, at the 123 m level. All Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: OUM KY556a–g, are worn limonitic fragments (Pl. 58, Figs 8, 9, 12), the largest with a whorl height of 9.5 mm. There are four rows of tubercles. Those in the first, upper row are massive, numbering six per half whorl. Those in the second row are smaller, spirally elongated and more numerous, and are sited low on the outer whorl face. Those in the third row are similar, but displaced adapically; those in the fourth row are housed in the inter-whorl suture, and give rise to strong radial ribs that extend across the lower whorl face. OUM KY3809 consists of parts of two successive phragmocone whorls with a maximum preserved measurable whorl height 35 mm. Ornament consists of a first, upper row of very large, rounded tubercles in the middle of the outer, exposed whorl face, two in a distance equal to the exposed whorl height. There are three rows of smaller tubercles, five in a distance equal to the exposed whorl height. Those in the second row and the third row are close-spaced, and situated on the lower part of the outer, exposed whorl face. Those in the fourth row are radially elongated, and lie at the junction of outer and lower whorl faces. They give rise to narrow radial ribs that extend across the lower whorl face.

DISCUSSION: See Wright and Kennedy 1986, p. 366. The closely related *H. tuberculatus* Bosc, 1801 (see revision in Wright and Kennedy, 1996, p. 367, pl. 102, figs 1, 13, 15; pl. 110, fig. 6; pl. 111, figs 4, 5, 7; pl. 112, figs 2, 4; pl. 113, fig. 13; text-figs 137a; 144c, d) has more and smaller tubercles in the upper row: 20 per whorl versus 12 in *gravesianus*.

OCCURRENCE: Lower Cenomanian, England, France, Spain, Switzerland, Germany, Poland, Romania, Iran, Turkmenistan, Kazakhstan, Morocco, Algeria, Central Tunisia, KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, Japan, Northern Australia, the U.S. Gulf Coast region, Brazil, and Argentina.

Hypoturrilites tuberculatoplicatus (Seguenza, 1883)
(Pl. 56, Figs 1–3, 5–7; Pl. 58, Fig. 1; Text-fig. 39)

1883. *Turrilites tuberculatoplicatus* Seguenza, p. 115, pl. 5, fig. 3.

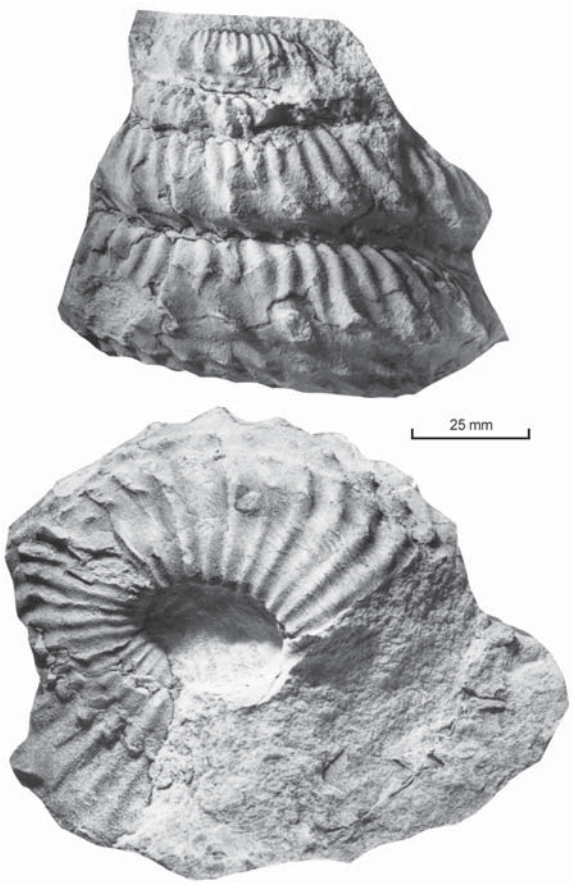
1996. *Hypoturrilites tuberculatoplicatus* (Seguenza, 1883); Wright and Kennedy, p. 374, pl. 108, fig. 7; pl. 113, figs 3, 4, 6, 8, 9 (with synonymy).
2015. *Hypoturrilites tuberculatoplicatus* (Seguenza, 1887); Klein, pp. 157, 166 (with additional synonymy).

TYPE: The holotype, by monotypy, is the original of *Turrilites tuberculatoplicatus* Seguenza 1883, p. 113, pl. 5, fig. 3, from the Cenomanian of San Giorgio, Brancaleone, Italy.

MATERIAL: OUM KY5821, from the north side of the Karai–Kulakkalnattam road, at the 386.5–391 m level. OUM KY2713–27817, from section G–H at the 173–175 m level; OUM KY3002, from section I–J at the 13 m level; OUM KY3008–3012, from the 15.4 m level; OUM KY3027 and 4395, from the 20–21 m level, all between Odiyamand Kunnam. All are from the Middle Cenomanian *cunningtoni* Zone.

DESCRIPTION: The earliest growth stage seen is OUM KY5821 (Pl. 58, Fig. 1), a crushed limonitic fragment of 1.5 whorls, the maximum whorl height 6.5 mm approximately. On the adapical part of the fragment, widely separate strong ribs develop into large tubercles, the tuberculate ribs separated by two non-tuberculate ribs; there is a well-developed spiral ridge at the base of the outer whorl face. On the adapertural part of the fragment, two ridges are visible, the lower undulose, and differentiated into feeble spirally elongated tubercles.

A series of larger, well-preserved fragments have whorl heights of 13.5–29 mm (Pl. 56, Figs 1–3, 5–7). The upper whorl face is concave, with grooves to accommodate the radial ribs on the base of the previous whorl. The junction of upper and outer whorl faces is quite narrowly rounded, and crenulate. The outer and lower whorl faces are convex in intercostal section. There are six large, rounded, flat-topped tubercles per half whorl in the upper, first row, situated in the middle of the outer whorl face, two in a distance equal to the whorl height; they are interpreted as the bases of septate spines. The tubercles are linked to the inter-whorl suture by two or three delicate, prorsiradiate riblets, and one, two or three ribs intercalate between successive tubercles. A second row of smaller, spirally elongated tubercles, twice as numerous as those in the upper row, are borne on a ridge on the lower part of the outer whorl face. A narrow groove separates the second row from the third row of tubercles, housed in notches in the inter-whorl suture. A fourth row, on the outer part of the lower whorl face, gives rise to narrow radial ribs that extend across the lower whorl face, weakening progressively but extending to the junction of lower and inner whorl faces.



Text-fig. 39. *Hypoturrilites tuberculatoplicatus* (Seguenza, 1883). OUM KY4395, from the Middle Cenomanian *cunningtoni* Zone, section I–J, between Odiyam and Kunnam at the 20–21 m level

OUM KY4395 (Text-fig. 39) is a composite internal mould of a larger individual, crushed along the axis of coiling to produce a very depressed whorl section. Ornament is as in the previous individuals, whilst the base of the fragment confirms the presence of septate spines associated with the upper row of tubercles.

OUM KY3027 (Pl. 56, Fig. 5) is interpreted as a coarsely ribbed variant, a juvenile consisting of three whorls, the maximum preserved whorl height 19.2 mm. There are 13 conical spines per whorl at mid-flank. They are linked to the crenulated inter-whorl suture by a pair of relatively coarse ribs, with single ribs intercalating between. A groove separates these tubercles from a second row of spirally elongated tubercles, 22–23 per whorl, borne on a ridge low on the

outer whorl face. They are, in some cases linked to ribs arising from the upper row of tubercles. A second groove separates these tubercles from a third row, also spirally elongated, in part housed in the crenulations in the inter-whorl suture, and equal in number to those in the second row. A radial rib links the tubercles in the third row to a fourth row, on the outer part of the lower whorl face. They give rise to single straight radial ribs that extend across the base of the whorl.

OUM KY3012 is the largest specimen seen, a battered single whorl 120 mm in diameter.

DISCUSSION: The combination of ribs and tubercles characterizes a limited number of *Hypoturrilites* species. *Hypoturrilites tuberculatoplicatus* (Seguenza, 1883) (p. 115, pl. 5, fig. 3; see revision in Wright and Kennedy 1987, p. 374, pl. 108, fig. 7; pl. 113, figs 3, 4, 6, 8, 9) has four rows of tubercles, as in the present material. *Hypoturrilites schneegansi* Dubourdieu, 1953 (p. 63, pl. 4, figs 34–41) is based on tiny limonitic individuals from Central Tunisia. It too has four rows of tubercles, but those in the lower three rows are larger than those in *tuberculatoplicatu*s, and elongated transversely, parallel to the axis of coiling, rather than spirally. *H. laevigatus* (Coquand, 1862) (see revision in Wright and Kennedy 1986, p. 373, pl. 102, fig. 2; text-fig. 146k–m, p, q and Kennedy in Kennedy and Gale 2015, p. 312, pl. 24, fig. 18; text-fig. 34a–d) has only three rows of tubercles, as does *H. nodiferus* (Crick, 1907) (p. 177, pl. 11, fig. 6 see revision in Klinger and Kennedy 1978, p. 22, pl. 4, fig. 1). Most problematic is *Hypoturrilites cunliffeanus* (Stoliczka, 1866) (p. 190, pl. 89, fig. 1), based on a huge fragment of body chamber 150 mm in diameter, from Odiyam. It has only three rows of tubercles, which separates it from the present material. It is conceivable that the presence of only two rows of small tubercles is a feature of the adult body chamber, and that the present material represents the earlier growth stages of *cunliffeanus*; the ornament of the outer whorl face of our largest specimen (Text-fig. 39) is certainly strikingly similar to that of the holotype of *cunliffeanus*, but this must remain speculation at this time.

OCCURRENCE: Lower Cenomanian of southern Italy, southern England, and, possibly, Ukraine. Middle Cenomanian, *cunningtoni* Zone, Tamil Nadu.

Hypoturrilites wiedmanni Collignon, 1964
(Pl. 58, Figs 16–18; Text-fig. 16G)

1964. *Hypoturrilites wiedmanni* Collignon, 1964, p. 44, pl. 328, fig. 1467.
1996. *Hypoturrilites wiedmanni* Collignon, 1964; Wright and Kennedy, p. 375, pl. 192, fig. 9; text-fig. 145a, b.
2015. *Hypoturrilites wiedmanni* Collignon, 1964; Klein, pp. 157, 169 (with additional synonymy).

TYPE: The holotype, by original designation, is the original of Collignon 1964, p. 44, pl. 328, fig. 1467, from the Lower Cenomanian, 'Ouest des chutes de Mahaboboka (Manera)', Madagascar. It was refigured by Wright and Kennedy (1996, text-fig. 145 a, b), and is in the Collignon Collection, housed in the Université de Bougogne, Dijon.

MATERIAL: OUM KY3804, from section C–D at the 123 m level, Lower Cenomanian *mantelli* Zone.

DESCRIPTION: The specimen is an internal mould of a 180° whorl sector of phragmocone with a maximum diameter of 26 mm and a maximum preserved whorl height of 13 mm. The upper whorl face is concave, with wide, deep grooves to accommodate the ribs on the base of the preceding whorl, the inter-whorl suture crenulated to accommodate the lower row of tubercles of the previous whorl. The outer whorl face is convex between the tubercle rows. Seven strong conical tubercles per half whorl are present just above the mid-point of the face; they are separated by a smooth zone from a second row of smaller pinched and bulla-like tubercles, 10 per half whorl, displaced adaperturally from those in the upper row. They give rise to a strong radial rib that extends across the base of the whorl. The suture (Text-fig. 16G) is deeply incised, with asymmetric bifid E/A and A.

DISCUSSION: The presence of only two rows of tubercles characterises the species. See Wright and Kennedy (1996, p. 375) for further remarks.

OCCURRENCE: Lower Cenomanian of Madagascar, Tamil Nadu, and southern England.

Family Baculitidae Gill, 1871
Genus and subgenus *Lechites* Nowak, 1908

TYPE SPECIES: *Baculites gaudini* Pictet and Campiche, 1861, p. 112, pl. 55, figs 5–9, by the original designation of Nowak 1908, p. 350.

Lechites (*Lechites*) *gaudini* (Pictet and Campiche, 1861)
(Pl. 58, Fig. 5)

1861. *Baculites gaudini* Pictet and Campiche, p. 112, pl. 55, figs 5–9.
1977. *Lechites gaudini* (Pictet and Campiche); Cooper and Kennedy, p. 644, text-figs 1.1–1.38; 2.1–2.30; 3; 4.1–4.18; 5.1–15; 6; 7; 8.16–26 (with synonymy).
2016a. *Lechites* (*Lechites*) *gaudini* (Pictet and Campiche, 1861); Klein, pp. 2, 4 (with synonymy).
2016a. *Lechites* (*Lechites*) *communis* Spath, 1941; Klein, pp. 2, 3 (with synonymy).
2016a. *Lechites* (*Lechites*) *campichei* Renz, 1968; Klein, pp. 2, 3 (with synonymy).
2016a. *Lechites* (*Lechites*) *italicus* Wiedmann and Dieni, 1969; Klein, pp. 2, 6 (with synonymy).
2016a. *Lechites* (*Lechites*) *raricostatus* Breistroffer, 1947; Klein, pp. 2, 3 (with synonymy).
2016a. *Lechites* (*Lechites*) *vraconensis* Renz, 1968; Klein, pp. 2, 8 (with synonymy).

TYPE: The lectotype, by the subsequent designation Spath 1941, p. 663 is the original of Pictet and Campiche 1861, p. 112, pl. 55, fig. 5, refigured by Renz 1968, pl. 17, fig. 3. It is no. 40012 in the collections of the Musée Geologique, Lausanne, and from theUpper Albian of Sainte-Croix, Vaud, Switzerland.

MATERIAL: OUM KY4357, from section A–B, upper interval, at the 9.5–10 m level, Upper Albian, *rostrata* Zone OUMK KY4735, from section T–U, Upper Albian, *rostrata* Zone.

DESCRIPTION: OUM KY4357 (Pl. 58, Fig. 5) is a 58 mm long fragment that has suffered *post-mortem* crushing, such that the whorl section is now compressed oval, with a maximum preserved whorl height of 12.3 mm. The rib index is three, the ribs effaced on the dorsum, strengthening across the dorsolateral margin, narrow and widely separated on the flanks, where they are straight and prorsiradiate, crossing the venter near-transverse. OUM KY4753 is a further crushed fragment, with a comparable style of ornament.

DISCUSSION: The species is interpreted broadly here, following Cooper and Kennedy (1997).

OCCURRENCE: Upper Albian, particularly common and widespread in the upper part of the substage. There are records from southern England, France, Switzerland, Hungary, Romania, Sardinia, Iran, Algeria, Central Tunisia, Madagascar, KwaZulu-Natal in South Africa, Madagascar, Tamil Nadu, Japan, Mexico, Australia and Alexander Island, Antarctica.

Genus *Sciponoceras* Hyatt, 1894

TYPE SPECIES: *Hamites baculoides* Mantell, 1822 p. 123, pl. 23, figs 6, 7, by the original designation of Hyatt 1894, p. 578.

Sciponoceras cucullatum Collignon, 1964
(Pl. 54, Figs 13, 14; Pl. 55, Figs 1–5, 11–17)

1964. *Sciponoceras cucullatum* Collignon, p. 38, pl. 326, fig. 1458.
1995. *Sciponoceras cucullatum* Collignon, 1964; Wright and Kennedy, p. 317, text-fig. 132 g–k.
2001. *Sciponoceras cucullatum* Collignon, 1964; Klinger and Kennedy, p. 258.
2016a. *Sciponoceras cucullatum* Collignon, 1964; Klein, pp. 9, 15 (with full synonymy).

TYPE: The holotype, by original designation, is the original of Collignon 1964, p. 38, pl. 326, fig. 1458, from the Lower Cenomanian of his gisement 505, west of the chutes de la Mahababoka (Manera), Madagascar, refigured by Wright and Kennedy (1995, text-fig. 132g–k), Klinger and Kennedy (1997, text-fig. 6a–c) and Kennedy (in Kennedy *et al*. 2013, text-fig. 7k, l). It is in the Collignon collection, housed in the Université de Bourgogne, Dijon.

MATERIAL: OUM KY2726, from section G–H at the 168–173 m level, OUM KY2691, from section G–H, 221 m, OUM KY3178a, b, from section M–N, 221 m, all Middle Cenomanian *asiaticum* Zone. OUM KY4407, from I–J at the 24–25 m level, Middle Cenomanian, *cunningtoni* Zone.

DESCRIPTION: OUM KY2691 (Pl. 55, Figs 1, 2) is a 86 mm long body chamber fragment with a maximum preserved whorl height of 15 mm and a subcircular cross section, the whorl breadth to height ratio 0.93. The rib index is six, the ribs effaced on the dorsum, strengthening across the dorsolateral margin, straight and prorsiradiate across the flanks, strengthening progressively, and crossing the venter in a feeble convexity. There are two constrictions on the fragment, widely spaced, and separated by a distance that is more than twice the whorl height. That at the adapical end of the fragment is feeble and transverse across the dorsum, strengthening across the dorsolateral margin and strongly rursiradiate across the inner and middle flanks, then flexing forwards, strengthening, markedly concave on the outermost flank and ventrolateral margin, and passing near-straight across the venter. The second constric-

tion has a similar course and development. OUM KY4407 (Pl. 55, Figs 11–14) is a 116 mm long body chamber fragment with a maximum preserved whorl height of 19 mm and a subcircular whorl section, the whorl breadth to height ratio 0.95. Ornament is as in the previous specimen, with a rib index of 5–6. There are three widely spaced constrictions on the fragment. That at the adapical end is weak and transverse across the dorsum (Pl. 55, Fig. 11), strengthens markedly across the dorsolateral margin, where it is concave, thereafter projecting forwards, paralleling the ribs, and crossing the venter in a shallow convexity. The succeeding constriction is feeble and transverse across the dorsum. On one flank (Pl. 55, Fig. 12) it sweeps back, and is strongly rursiradiate across the inner and middle flank, flexing forwards and feebly concave on the ventrolateral margin, and crosses the venter in a feeble convexity. On the other flank (Pl. 55, Fig. 14), the constriction is feebly concave and transverse. The third constriction is transverse and concave on both flanks (Pl. 55, Figs 12, 14). OUM KY2726 (Pl. 54, Figs 13, 14) is an internal mould of a body chamber 109 mm long that has suffered dorso-ventral crushing, distorting the whorl section. Ornament on the dorsum is effaced, but strengthens across the dorsolateral margin such that the flanks are ornamented by crowded ribs, straight and prorsirsdiate on the inner to middle flank region, feebly convex across the outer flank and ventrolateral shoulder, and feebly convex across the venter. There is a single well-developed constriction towards the adapical end of the fragment that parallels the ribs, broad and shallow across the dorsum, strengthening across the flanks, and at maximum development across the venter. The sutures are not seen.

DISCUSSION: The species is distinguished from *Sciponoceras antanimangaensis*, described below, on the basis of the finer, denser ribbing (compare Pl. 54, Figs 1–4, 7–12 and Pl. 54, Figs 13, 14). The course of the constrictions, variable and in some cases following a quite different course to the ribs is distinctive, but it is unclear if this is a specific character, or a pathological condition. The holotype, an adult body chamber with aperture preserved, lacks constrictions (Collignon 1964, p. 38, pl. 326, fig. 1458).

OCCURRENCE: Lower Cenomanian of Madagascar, Lower or Middle Cenomanian of northern KwaZulu-Natal, South Africa, imprecisely dated within the Upper Albian to Cenomanian of northern Mozambique. Middle Cenomanian, *cunningtoni* and *asiaticum* Zones of Tamil Nadu.

Sciponoceras antinamanganesis (Collignon, 1964)
(Pl. 53, Figs 8, 18 19, 23, 24, 31–33; Pl. 54, Figs 1–4, 7–12; Pl. 55, Figs 6–10)

1866. *Baculites gaudini* Pictet; Stoliczka, p. 199 (*pars*), pl. 91, figs 7, 8, *non* 10.
1964. *Lechites antanimangaensis* Collignon, p. 34, pl. 325, fig. 1451.
2016a. *Sciponoceras antanimangaensis* (Collignon, 1964); Klein, pp. 9, 10 (with synonymy).

TYPE: The holotype, by original designation, is the original of Collignon 1964 p. 34, pl. 325, fig. 1451, from the Lower Cenomanian of his gisement 362, Signal Antanimananga I (Mandabe), Madagascar, in the Collignon collection housed in the Université de Bourgogne, Dijon. It was refigured by Kennedy (in Kennedy *et al*. 2013, pl. 10, figs 10, 11).

MATERIAL: From sections between Odiyam and Kunnam: OUM KY2650, from section G–H at the 167 m level, OUM KY4732–4733, from section C–D at the 97 m level, OUM KY3699 (collective of 7 specimens) from section C–D at the 116 m level, all Lower Cenomanian, *mantelli* Zone. OUM KY4406, 4408, and 4409, from section I–J at the 24–25 m level, Middle Cenomanian, *cunningtoni* Zone. OUM KY2721, from section G–H, at the 172–175 m level, OUM KY2680, from section G–H at the 170.5 m level, OUM KY2764 (collective of three specimens), section G–H at the 172 m level, OUM KY2862, from section G–H at the 209–210 m level, OUM KY3178 (collective of six specimens), from section M–N at the 221 m level. OUM KY4133a, from section B, NW of Garudamangalam, at the 10–20 m level, all Middle Cenomanian, *asiaticum* Zone. OUM KY4746, from section T–U at the 193 m level, Cenomanian. From sections on the north side of the Karai–Kulakkalnattam road: OUM KY5883–5884, from the 410–412 m level, Middle Cenomanian; OUM KY6002, from the Lower Cenomanian, without precise level.

DESCRIPTION: There are numerous specimens. OUM KY2650 (Pl. 54, Fig. 12) is an adult microconch comprising the adapertural end of the phragmocone and body chamber, 141 mm in total length, the maximum preserved whorl height 12.5 mm approximately, the specimen embedded in matrix. The rib index is 3–4, the ribs straight and prorsiradiate, strengthening markedly across the flanks. The constrictions parallel the ribs and are separated by a distance equal to two and a half times the whorl height. The specimen preserved a damaged aperture, the venter flexed in a

dorsal direction, such that the aperture faces dorsally, with a flared margin; the ventral part is damaged. OUM KY3178c (Pl. 55 Figs 6–8) is a comparable fragment of the aperture with a maximum preserved whorl height of 11.8 mm. OUM KY3817d (Pl. 55, Figs 9, 10) with a marked constriction indicating the proximity of the adult aperture has a maximum preserved whorl height of 14.2 mm and a whorl breadth to height ratio of 0.8. OUM KY2721 (Pl. 54, Figs 10, 11) is a 150 mm long internal mould of a macroconch body chamber, with a maximum preserved whorl height of 29.6 mm and a whorl breadth to height ratio of 0.87, the whorl section oval. The dorsum is smooth. The flanks are ornamented by low, broad, prorsirsdiate ribs, three in a distance equal to the whorl height, that cross the venter in a feeble convexity at the adapical end of the specimen. The ribbing is irregularly developed over the remainder of the specimen, near-effacing in the middle section of the fragment before strengthening and becoming more closely spaced on the adapertural part. The adult aperture is preserved, and is preceded by a constriction, the apertural margin flared, concave across the dorsum, feebly concave across the flanks, paralleling the dorsum, and then curved dorsally into a hood. OUM KY4408 and 4409 (Pl 54, Figs 1–4). are smaller but comparable fragments with a rib index of up to 4. There are numerous juveniles (Pl. 53, Figs 8, 18, 19, 23–24, 31–33) with comparable sparse ribbing, and sutures with moderately incised bifid lobes and saddles. A further juvenile, OUM KY6002 (Pl. 53, Figs 13–15), referred to as *Sciponoceras* aff. *antanimangaensis*, has ribs of variable strength that are well-developed on the dorsolateral margin.

DISCUSSION: See under *Sciponoceras cucullatum* (above).

OCCURRENCE: Lower Cenomanian of Madagascar, Lower and Middle Cenomanian, *mantelli*, *cunningtoni*, and *asiaticum* Zones of Tamil Nadu.

Sciponoceras cf. *gracile* (Shumard, 1860)
(Pl. 58, Fig. 10)

Compare:

1860. *Baculites gracilis* Shumard, p. 596.
2016a. *Sciponoceras gracile* (Shumard, 1860); Klein, pp. 9, 16 (with full synonymy).
2017. *Sciponoceras gra*cile (Shumard, 1860); Kóšták *et al*., p 160, text-figs 4l; 6i; 7l–r (with additional synonymy).

MATERIAL: OUM KY3510, from section R–S between Odiyam and Kunnam at the 41 m level, Upper Cenomanian, *septemseriatum* Zone.

DESCRIPTION: The specimen is a 33 mm long fragment of body chamber retaining extensive areas of recrystallised shell. The maximum preserved whorl height is 13 mm. The flanks are ornamented by weak, crowded, prorsiradiate ribs on the inner to middle flank. They flex back, strengthen markedly on the outer flank and ventrolateral shoulder, where they are feebly convex, and the rib index is 7–8; they are straight and transverse across the venter.

DISCUSSION: The specimen is compared to the contemporaneous *Sciponoceras gracile* on the basis of the style of the ribbing, comparing well with individuals of comparable size from the United States Western Interior (Cobban and Scott 1973, pl. 17, figs 9–19).

OCCURRENCE: As for material. *Sciponoceras gracile* has a wide geographic distribution in the *Sciponoceras gracile*/*Metoicoceras geslinianum* Zone and correlatives, with records from The United States Western Interior, Texas, California, northern Mexico, southern England, northern France, southern Germany, and, possibly, south-east France, the Czech Republic, and Angola.

Sciponoceras sp. (smooth)
(Pl. 53, Figs 16, 17, 20–22, 25–30; Pl. 54, Figs 5, 6)

MATERIAL: OUM KY3700 (collective of 10 specimens) from section C–D at the 116 m level. OUM KY4303, from locality D at the 53–60 m level, both Lower Cenomanian, *mantelli* Zone. OUM KY3933 (collective of 25 specimens), from section A at the 16–18 m level, Upper Cenomanian, *euomphalum* fauna.

DESCRIPTION: There are numerous specimens, both limonitic juveniles (Pl. 53, Figs 16, 17, 20–22, 25–30), and fragments of presumed adult body chambers (Pl. 54, Figs 5, 6) with whorl heights of up to 17 mm. The whorl section is circular. The surface of the mould is smooth. Constrictions are separated by a distance of just over one and a half whorl heights. They are weak and transverse on the dorsum, strong, straight and feebly prorsiradiate across the flanks, and very feebly convex across the venter. The sutures are moderately incised, with bifid ribs and saddles.

DISCUSSION: The holotype of *Sciponoceras kossmati* (Nowak, 1908) is the original of *Baculites* n. sp. aff *bohemicum* of Kossmat (1895, pl. 19 (5), fig.

18), from 'Garudamungalam'. It differs from the present species in the compressed oval whorl section, the presence of a strong collar rib associated with the single constriction present on the specimen, and the presence of what appear to be very feeble, distant ribs. As interpreted by Matsumoto (1959, p.106, pl. 31, figs 2, 3; text-figs 4a, b, 5a, b, 6a, b) and Matsumoto and Obata (1963 p.13, pl. 3, fig. 2; pl. 4, fig. 1; pl. 5, figs 1–3; pl. 6, figs 3–5; text-figs 5–25) it is a strongly ribbed species. *Hamites* (*Ptychoceras*) *glaber* Whiteaves of Kossmat (1895, p. 176 (80), pl. 20 (6), fig. 7) is a *Sciponoceras*, from Odiyam. It differs from the present species in having constrictions that are concave on the dorsolateral margin, and strongly prorsiradiate on the middle and outer flank. *Sciponoceras roto* Cieśliński, 1959 (pp. 39, 75, 89; pl. 4, fig. 10; text-fig. 14 (2) has constrictions separated by a distance equal to three times the whorl height, and develops ribs on the adult body chamber (see revision in Wright and Kennedy 1995, p. 315, pl. 94, figs 13–19; pl. 95, fig. 4; pl. 98, fig. 28; text-fig. 131j–l, n).

OCCURRENCE: As for material.

Superfamily Scaphitaceae Gill, 1871
Superfamily Scaphitoidea Gill, 1871
Family Scaphitidae Gill, 1871
Subfamily OtoscaphitinaeWright, 1953
Genus *Worthoceras* Adkins, 1928

TYPE SPECIES: *Macroscaphites platydorsus* Scott, 1924, p 18, pls 5, 6; pl. 9, fig. 6 by the original designation of Adkins 1928, p. 218.

Worthoceras sp.
(Pl. 60, Fig. 1; Text-fig. 38C)

MATERIAL: OUM KY4202, from the Upper Cenomanian, *harpax* Zone, *euomphalum* fauna 4–5 km north-west of Garudamangalam.

DESCRIPTION: The specimen is a limonitic internal mould of the outer whorl of the coiled portion of the shell, and the adapical, septate part of the shaft. The spire has a maximum preserved diameter of 8.4 mm; the shaft has a maximum preserved whorl height of 3.7 mm. The coiling of the spire is very evolute, serpenticone, with a flattened umbilical wall, broadly rounded umbilical shoulder, flattened flanks, broadly rounded ventrolateral shoulders, and a feebly convex venter. The flanks are ornamented by weak, low, broad, straight ribs that arise from incipient umbilical bullae, and efface on the outermost flank and ventrolateral shoulder. Similar transverse ribs persist onto the shaft. The suture (Text-fig. 38C) has a broad, bifid E/A with three minor incisions, A is narrow and incipiently trifid, U/A broad and bifid, with three minor incisions.

DISCUSSION: The present specimen can only be identified to generic level. The feeble blunt ribs recall some individuals of *Worthoceras minor* Kennedy, 1988 (p. 116, pl. 21, figs 1–10, 13, 14, 25). Vartak and Ghare (1987) described specimens they identified as *Worthoceras vermiculum* Shumard, *W.gibbosum* Moreman, and *W.* aff *rochatianum* d'Orbigny from 'yellowish clay, of Cenomanian age, Uttatur Group at Odiyam.'

OCCURRENCE: As for material.

Genus *Yezoites* Yabe, 1910

TYPE SPECIES: *Scaphites perrini* Anderson, 1902, p. 114, pl. 2, figs 71–73, by the subsequent designation of Diener 1925, p. 213.

Yezoites kingianus (Stoliczka, 1866)
(Pl. 59, Fig. 2; Pl. 60, Figs 2–14)

1866. *Scaphites Kingianus* Stoliczka, p. 169, pl. 81, fig. 7.
1897. *Scaphites Kingianus* Stoliczka; Kossmat, p. 30 (127).
1925. *Scaphites Kingianus* Stoliczka; Diener, p. 200.
non 1965. *Scaphites* cf. *kingianus* Collignon, p. 17, pl. 170, fig. 174.
2016b. *Scaphites kingianus* Stoliczka, 1866; Klein, pp. 45, 82 .

TYPE: The holotype, by monotypy, is the original of Stoliczka 1866, pl. 81, fig. 7, from "about a mile north of Odium in yellowish calcareous sandstone" (Stoliczka 1866, p. 170).

MATERIAL: OUM KY3803, from section C–D between Odiyam and Kunnam at the 123 m. level. OUM KY5499, collective of four specimens from the 341.5–346 m level; OUM KY5535 (collective of 41 specimens); KY5536–5538, OUM KY5539 (collective of 105 specimens), from the 345–350 m level; OUM KY5560 (collective of 4 specimens), from the 346–350.5 m level; all from the section on the north side of the Karai–Kulakkalnattam road. All

specimens are from the Lower Cenomanian *mantelli* Zone.

DESCRIPTION: There are over 150 limonitic individuals, the majority phragmocones, distorted to varying degrees. Nuclei interpreted as those of macroconchs (Pl. 60, Figs 5–14) are up to 19.2 mm in diameter. Coiling is involute, the umbilicus of moderate depth, the umbilical wall feebly convex, the umbilical shoulder broadly rounded. The whorl section of the least deformed individuals varies from slightly compressed to slightly depressed, the flanks feebly convex, the ventrolateral shoulders broadly rounded, the venter feebly convex. The innermost whorls appear to have been smooth. The succeeding ontogenetic stage occupies between 180° and 240° of the outer whorl, and in most specimens, ornament is very feeble to obsolete, perhaps in part a result of weathering. Where better developed, it consists of feeble prorsiradiate primary ribs that branch around mid-flank, with additional ribs intercalating, these delicate ribs passing straight across the venter. The beginning of the following ontogenetic stage is marked by an abrupt strengthening in the ornament. Wiry primary ribs, of variable density between individuals, are straight and prorsirsdiate on the inner to middle flank, then flexing back and bifurcating on the mid to outer flank, with additional ribs intercalating, the ribs strengthening and passing straight across the venter. A feature of these nuclei is the increasing involution at the greatest preserved diameter. OUM KY3803 (Pl. 59, Fig. 2) is a fragmentary adult, consisting of one flank of part of the shaft and the recurved sector, preserving the adult aperture. The total length is 20 mm. The shaft is ornamented by narrow, straight, feebly prorsiradiate ribs on the flank. On the outer flank, the ribs bifurcate once, sometimes twice, and additional ribs intercalate. This pattern continues around the recurved sector. The adult aperture is marked by a slightly flared, thickened rib.

Microconchs (Pl. 60, Figs 2, 3) consist of a tiny evolute spire, corresponding in morphology to the inner whorls of the macroconch phragmocones, but remaining evolute throughout, and lacking ornament. Only the adapical part of the shaft of the body chamber is preserved in the present material, and is narrow straight and compressed, with feeble ornament of blunt prorsirsdiate flank ribs in the best-preserved individual; others are smooth, probably due to wear.

DISCUSSION: The distinctive change in ornament of the spires of the present specimens matches that shown in the figure of the holotype, while the body chamber ornament of OUM KY3803 is closely comparable. The species is assigned to *Yezoites* rather than *Scaphites* on the basis of the morphology of the microconch (Pl. 60, Fig. 2), following Wright (1996, text-fig. 201c, d, g, h, j k).

OCCURRENCE: As for material.

Subfamily Scaphitinae Gill, 1871
Genus *Scaphites* Parkinson, 1811

TYPE SPECIES: *Scaphites equalis* J. Sowerby, 1813, p. 53, pl. 18, figs 1–3, by the subsequent designation of Meek 1876, p. 413.

Scaphites dailyi Wright, 1963
(Pl. 59, Figs 6–16)

1963. *Scaphites dailyi* Wright, p. 602, pl. 81, fig. 6.
1977. *Scaphites dailyi* C.W. Wright; Tanabe, p. 123, pl. 4, figs 1–12; text-figs 11.1–11.6; 12, 13.
1982. *Scaphites dail*yi C.W. Wright; Szász, p. 37, pl. 4, figs 6, 7.
1988. *Scaphites dailyi* Wright; Szász and Ion, pl. 4, fig. 7.
2016b. *Scaphites dailyi* Wright; Klein, pp. 53, 62.

TYPE: The holotype is no. F.15806, the original of Wright 1963, pl. 81, fig. 6; paratypes are F.15807–8, in the collections of the Department of Geology of the University of Adelaide, from the Middle Cenomanian of Bathurst Island, northern Australia.

MATERIAL: OUM KY3790a–c, KY3791a–b, KY3792, KY3793, from section C–D between Odiyam and Kunnam at the 116 m level, Lower Cenomanian, *mantelli* Zone.

DESCRIPTION: The present specimens are interpreted as macroconchs, with lengths of 26–34.5 mm. The spire is very involute, the whorl section depressed, with convex flanks, broadly rounded ventrolateral shoulders and a broad, feebly convex venter. Ornament is of crowded wiry rectiradiate riblets that cross the venter in the feeblest of convexities. The body chamber has a depressed reniform whorl section. In profile, the course of the venter is curved. The line of the umbilical margin of the shaft is characterized by a convex bulge that totally conceals the umbilicus and part of the flanks of the spire. The margin adaperturally of this bulge is straight, before curving up to the aperture. Ornament on the shaft is of

crowded delicate wiry riblets that are feebly rursirsdiate on the adapical part, becoming feebly prorsirsdiate on the adapertural part. They increase by branching and intercalation across the flanks, strengthen, and pass straight across the venter. The ornament coarsens markedly around the recurved sector, where the ribs are prorsirsdiate. The aperture is preceded by a strong constriction that is prorsiradiate and feebly convex on the flanks and transverse on the venter. It is succeeded by a flared margin to the aperture.

OUM KY3791a (Pl. 59, Fig. 6), much smaller specimen, 20 mm long, is too poorly preserved to be assigned to either the microconch or macroconch of the species.

DISCUSSION: The overall shell shape, size (the holotype is 26 mm long according to Wright's figure), umbilical bulge and differentiated flank ribbing (notably of OUM KY3791a; Pl. 49, Fig. 6) correspond to those features in the holotype. As noted by Wright, the umbilical bulge links *Scaphites dailyi* to *Scaphites bassei* Collignon, 1929 (see revision in Wright and Kennedy 1996, p. 386, pl. 114, figs 2–6; text-figs 150c; 151a, d, f, g, ?j; 152m, ?p), the species differing in the fine even ribbing of *bassei*, the ribs not branching and intercalating on the body chamber. See Wright and Kennedy (1997, p. 387) for further discussion.

OCCURRENCE: Lower Cenomanian of Tamil Nadu and Madagascar. Middle Cenomanian of Bathurst Island, northern Australia, and Romania.

Scaphites collignoni Wiedmann, 1965
(Pl. 59, Figs 3–5)

1963. *Scaphites meriani* Pictet et Camp.; Collignon, p. 56, pl. 262, fig. 1142.
1965. *Scaphit*es (*Scaphites*) *collignoni* Wiedmann, p. 427, pl. 57, fig. 5; text-fig. 5f.
1996. *Scaphites meriani* Pictet and Campiche of Collignon; Wright and Kennedy, text-fig. 151c.
2016b. *Scaphites collignoni* Wiedmann, 1965; Klein, pp. 53, 61.

TYPE: The holotype, by the original designation of Wiedmann (1965, p. 427) is the original of *Scaphites meriani* Pictet et Camp.of Collignon 1963, p. 46, pl. 262, fig. 1142, from the Upper Albian zone à *Hysteroceras binum* of Mont Raynaud, Madagascar, in the Collignon Collection, housed in the Université de Bourgogne, Dijon. It is refigured by Wiedmann (1965, pl. 57, fig. 5) and Wright and Kennedy (1996, text-fig. 151c).

MATERIAL: OUM KY2565, from section A–B, upper interval, 5 m level, Upper Albian or Lower Cenomanian *mantelli* Zone

DESCRIPTION: The specimen is an internal mould of a corroded spire and a well-preserved body chamber; the total length is 19 mm. The whorl section of the short shaft is depressed, with feebly convex flanks, broadly rounded ventrolateral shoulders and a broad, feebly convex venter. The flanks are near-smooth, but for an indication of faint prorsiradiate ribs that link to narrow delicate outer lateral/ventrolateral bullae, and intecalate between. There are five bullae on the shaft; they give rise to pairs of ribs, with additional ribs intercalating. The ribs strengthen and cross the venter; they vary only slightly from very feebly convex to near-straight. The recurved sector of the body chamber is damaged, but the flank ribs appear to strengthen, and the ventrolateral tubercles efface.

DISCUSSION: Small size, and the presence of ventrolateral bullae on the body chamber show the specimen to belong to what Wiedmann (1965, p. 423) termed the *meriani* stock. Of other members referred to this group, *Scaphites hugardianus* d'Orbigny, 1842 is a *nomen dubium* (*fide* Wright and Kennedy 1996, p. 389). *Scaphites meriani* Pictet and Campiche 1861 (p. 16 (*pars*), pl. 44, figs 1–4, 8 only), lectotype refigured by Wiedmann (1965, pl. 54, fig. 6) is a much larger species, with a highly distinctive body chamber ornament in which ribs link in pairs at the conical ventrolateral tubercles and loop between tubercles across the venter and intercalate between.

OCCURRENCE: Upper Albian of Madagascar. Upper Albian or Lower Cenomanian of Tamil Nadu.

Scaphites similaris Stoliczka, 1868
(Pl. 59, Fig. 1; Pl. 60, Figs 15–36)

1865. *Scaphites aequalis* Sowerby; Stoliczka, p. 167, pl. 81, figs 4–6.
1868. *Scaphites similaris* Stoliczka, p. 36.
1965. *Sc*. (*Scaphites*) *similaris* Stoliczka; Wiedmann, p. 422, text-fig. 4c.
2016b. *Scaphites similaris* Stoliczka, 1868; Klein, pp. 56, 92 (with additional synonymy).

TYPE: The lectotype, by the subsequent designation of Wiedmann 1965, p. 422 is the original of *Scaphites aequalis* Sowerby of Stoliczka 1865, p. 167 (*pars*), pl. 81, fig. 5, from the 'neighborhood of Odiyam'.

MATERIAL: OUM KY3179–3194; KY3195 (collective of 12 specimens); KY3196 (collective of eight specimens); KY3197 (collective of 11 specimens), from section M–N at the 221 m level, Middle Cenomanian *asiaticum* Zone.

DESCRIPTION: Two variants are recognized: robust and gracile. Complete adults of the robust form (Pl. 60, Figs 22–36) are up to 24.2 mm long. The coiled whorls are involute, the umbilical wall low, feebly convex, the umbilical shoulder broadly rounded. The whorl section is compressed, with very feebly convex flanks, broadly rounded ventrolateral shoulders, and a very feebly convex venter. Primary ribs arise on the umbilical wall, and strengthen across the umbilical shoulder and inner flank. They bifurcate, and additional ribs intercalate, all projecting forwards and feebly concave across the ventrolateral shoulder, and passing straight across the venter. The shaft section of the body chamber is compressed, and relatively high, the umbilical wall low and convex, the margin straight, the umbilical shoulder narrowly rounded. The flanks are flattened and subparallel, the ventrolateral shoulders broadly rounded, the venter very feebly convex. There are up to five primary ribs on the shaft. In some the transition from the primaries of the spire is gradual, as in OUM KY3182 (Pl. 59, Fig. 1); in others it is more abrupt (Pl. 60, Figs 22–36). The ribs strengthen and then weaken at the adapertural end of the shaft. They are strongly prorsirsdiate, convex, strengthening across the flanks and developing into a feeble bulla, weakening and effacing before reaching the ventrolateral shoulder. The ventrolateral shoulders and venter are smooth on internal molds; where shell is preserved, groups of delicate transverse riblets link the primary ribs over the venter, with additional riblets intercalating between. Flank ribs may efface on the adapical part of the recurved sector, then strengthen, where they are straight and prorsirsdiate, strengthening across the flanks and linking to a feeble ventrolateral bulla, from which pairs of secondary ribs and additional intercalated ribs extend across the venter, and become relatively coarse on the final sector. The adult aperture is preceded by a strong sinuous prorsiradiate constriction, succeeded by a flared margin, at its greatest height on the venter. Gracile variants (Pl. 60, Figs 15–21) are up to 16.5 mm long. The whorl section is much more compressed and lower than in than in the robust form, as a result of which the umbilicus is larger; ornament is comparable. The shaft is slender when compared to that of the robust form, and the primary ribs are weaker. The recurved sector of the best-preserved individual, which retains recrystallized shell, is smooth. The adult aperture is preceded by a strong constriction succeeded by a flared margin at its greatest height on the venter.

DISCUSSION: The co-occurring robust and gracile forms are linked by the distinctive flank ornament which is similar in both. It is probable that the robust individuals are the macroconch and the gracile forms the microconch of a dimorphic pair. *Scaphites similaris* differs from *Scaphites equalis* (see revision in Wright and Kennedy (1996, p. 394, pl. 116, figs 1–5, 7–11; pl. 117, figs 1–11; Pl. 118, figs 1–13; text-figs 129b, c; 153.1–2; 154c, d, who regarded it as a synonym) in the combination of smaller size, compressed whorl section, and weak to effaced ventral ornament. These differences apply to all of the numerous specimens studied here; there is nothing in the assemblage that approaches the lectotype of *equalis* (Wright and Kennedy 1996, pl. 116, fig. 11).

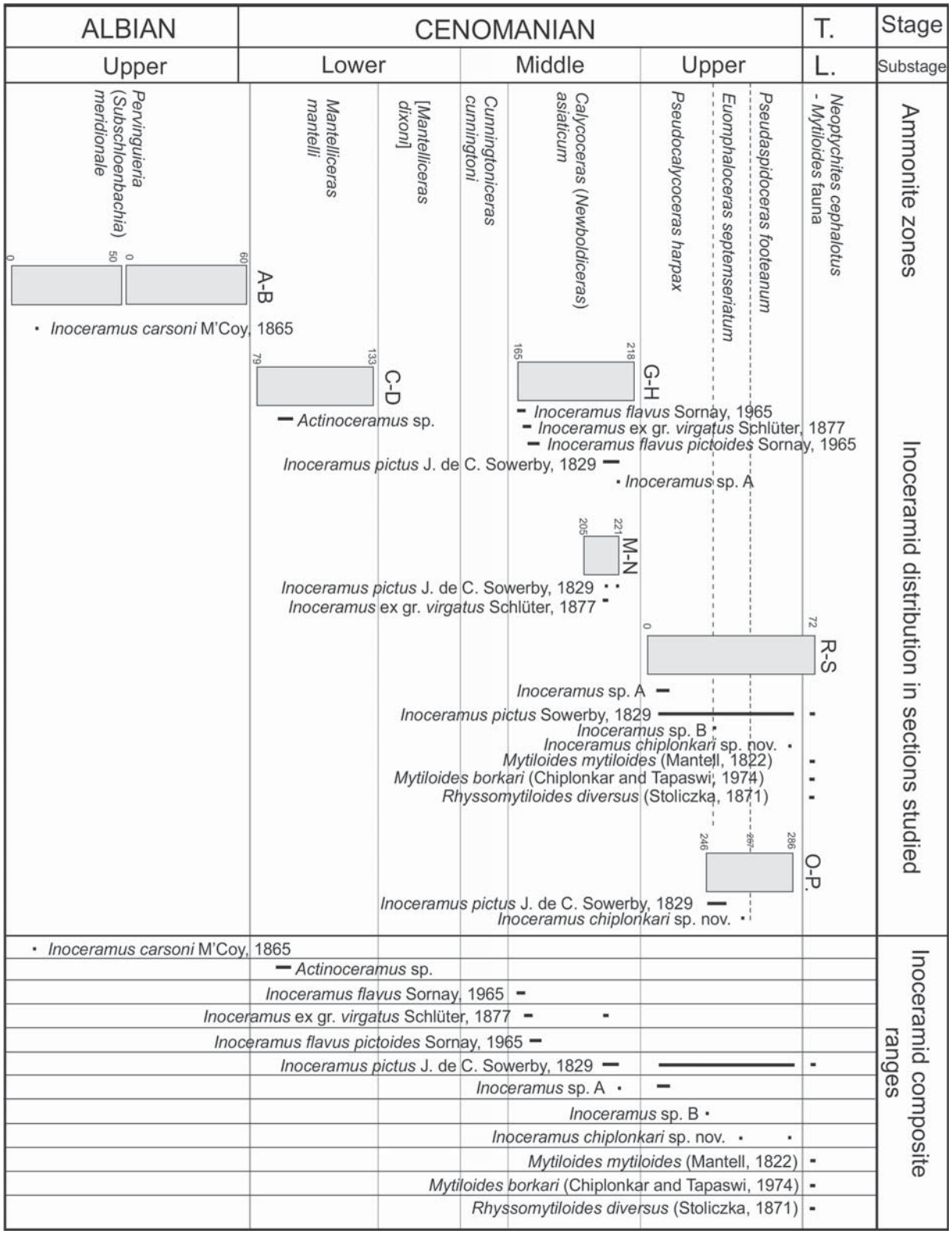
OCCURRENCE: Middle Cenomanian, *asiaticum* Zone, Tamil Nadu; condensed Upper Albian to Cenomanian Glauconitkalk of central Iran.

INOCERAMIDAE (I. WALASZCZYK)

Introduction

Inoceramid bivalves (in all more than 150 specimens), are present in the Upper Albian, Cenomanian, and Lower Turonian: the whole of the interval studied here (Text-fig. 40). There is wide variation in abundance, with 20 specimens from the Upper Albian, only two from the Lower Cenomanian, and 40 from each of the Middle Cenomanian, Upper Cenomanian, and Lower Turonian

The Upper Albian inoceramids are from a few discrete horizons within the *Pervinquieria* (*S.*) *rostrata* ammonite Zone some tens of metres below the top of the substage. Three species-level taxa are recognized, with the assemblage dominated by *Inoceramus carsoni* M'Coy, 1865 (Text-fig. 41) which makes up approximately 80% of the material. This species was originally described from Queensland in north-eastern Australia (M'Coy 1865; see also Ludbrook 1966), and has been subsequently recorded from the Antarctic Peninsula (Crame 1985; Medina 2007), and the Trichinopoly area of Tamil Nadu (Ayyasami and Rao 1994). It is accompanied by *Inoceramus* cf. *sutherlandi* M'Coy, 1865 in



Text-fig. 40. Inoceramid ranges plotted against ammonite zonation for the Upper Albian, Cenomanian and Lower Turonian of the Cauvery Basin, based on the present collections

Tamil Nadu (see Text-fig. 42D, E) and this association was also reported from Australia and Antarctica (Ludbrook 1966; Crame 1985; Medina 2007). The third species recognized is referred to *Inoceramus* sp. (Text-fig. 42A–C). The two deformed specimens of this taxon (OUM KY4209, KY4211) do not allow its more precise determination, however, they clearly belong to the same species: equivalve, inequilateral, subquadrate, with a relatively short, slightly concave anterior margin, and with regular concentric rugae. The rugae are similar to the type characteristic of *Gnesioceramus anglicus* (Woods, 1911); however, the specimens show no sign of the oblique ridge typical for this genus.

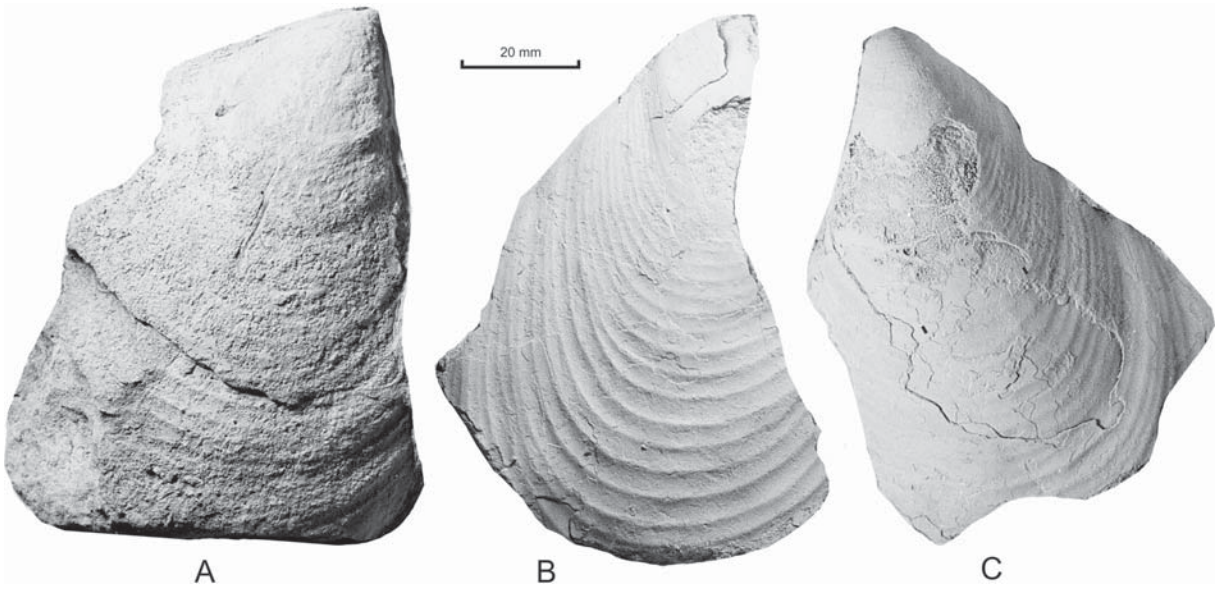
There is no inoceramid record from the uppermost Upper Albian and there are only two specimens from the Lower Cenomanian. They come from the *Mantelliceras mantelli* ammonite Zone at the 90 m level in section C–D between Odiyam and Kunnam (Text-fig. 40), and are assigned to the genus *Actinoceramus*. This had a wide geographical distribution during the Albian (see discussion in Crampton 1996) and is known from adjacent areas of South Africa (Kauffman 1978b) and the Antarctic Peninsula (Crame 1985), and may have been cosmopolitan during the Cenomanian (Crampton 1996). It is best represented in the North Pacific Province, and the Indian specimens do show some resemblance to *Actinoceramus nipponicus* (Nagao and Matsumoto, 1939), but more material is required for a confident specific identification.

The lower part of the Middle Cenomanian *Calycoceras* (*Newboldiceras*) *asiaticum* Zone yielded only few specimens, making up a relatively diverse assemblage, with *Inoceramus flavus* Sornay, 1965 (Text-fig. 44), *Inoceramus* ex gr. *virgatus* Schlüter, 1877 (Text-fig. 43), and *I. flavus pictoides* Sornay, 1965 (Text-fig. 45). *Inoceramus flavus* is known from its rich occurrence in Madagascar, where it occurs in what appear to be monospecific assemblages in the upper Lower and lower Middle Cenomanian (Walaszczyk *et al*. 2014). The taxonomic status of *Inoceramus flavus pictoides* (Text-fig. 45), which may be a transitional form between *I. flavus* and *I. pictus*, is not clear, however, and further study is needed. The *Inoceramus virgatus* group is widely recorded from the upper Lower and lower Middle Cenomanian, originally in Europe (see for example Wilmsen *et al*. 2001), but has also been recorded from the North Pacific Province (Matsumoto *et al*. 1987; Elder and Box 1992). It appears to be related to the group of *Inoceramus arvanus* Stephenson, 1953 – *I. rutherfordi* Warren, 1930, species known from the North American Western Interior. Heinz (1933) recorded (but did not figure) what he referred to as this species from the Cenomanian of Madagascar; the material was subsequently assigned to *Inoceramus flavus pictoides* by Sornay (1965).

Inoceramus pictus first appears in the upper Middle Cenomanian, an event marking a major turnover in Cenomanian inoceramid faunas. This species dominates assemblages throughout most of the remainder of the Upper Cenomanian. It declines gradually in the highest part of the substage in Tamil Nadu, where a distinct assemblage of small inoceramids with a regular outline dominates, here assigned to *Inoceramus chiplonkari* sp. nov (Text-fig. 50A–D, F, G). *Inoceramus* cf. *schoendorfi* (Heinz) of Matsumoto and Tanaka (1988), described from the Cenomanian of Japan are members of this species, and co-occur with *Inoceramus nodai* Matsumoto and Tanaka, 1988, which is not, however present in our material. At approximately the same level in the present sequence *Inoceramu*s cf. *kamuy* Matsumoto and Asai, 1996 appears (Text-fig. 50E, I, J). In the mid upper Cenomanian, a very distinctive form appears, referred to here as *Inoceramus* sp. B (Text-fig. 50H) . It appears to be conspecific with *Inoceramus tenuistriatus* sensu Kauffman and Powell, 1977, based on the material from the Cimarron County, Oklahoma.

The lower Turonian *Neoptychites cephalotus* ammonite fauna of Tamil Nadu is associated with a typical Southern Hemisphere assemblage of the *Mytiloides* ex gr. *labiatus* and *Rhyssomytiloides*. *Mytiloides* is represented by cosmopolitan *Mytiloides mytiloides* (Mantell, 1822) and *Mytiloides borkari* (Chiplonkar and Tapaswi, 1974). The latter was originally described from the Cauvery Basin; the better-known *Mytiloides goppelnensis* (Badillet and Sornay, 1980), originally described from Touraine in France, is a junior synonym. *Rhyssomytiloides*, assigned to *R. diversus* Stoliczka (1871), a species originally described from the Cauvery Basin, is abundant in association with the *Neoptychites cephalotus* ammonite fauna. *Rhyssomytiloides* is known exclusively from the Southern Hemisphere (Brazil: Hessel 1986, 1988; Andrade 2005; Madagascar: Walaszczyk *et al*. 2014); the record from Germany (Tröger *et al*. 2009) cannot be confirmed. The genus first appears some distance above the base of the stage.

Associated with the *Mytiloides/Rhyssomytiloides* assemblage are small *Inoceramus*, assigned to *I.* cf. *pictus*; there are four *Inoceramus* specimens in the material studied: two left and two right valves. This is a distinctly inaequivalve, inequilateral, nearly orthocline species, with long anterior margin, reg-



Text-fig. 41. *Inoceramus carsoni* M'Coy, 1865. **A** – OUM KY2500, from the 14 m level; **B** – OUM KY2496, **C** – OUM KY2497, from the 10 m level, Karai Formation, Upper Albian *rostrata* Zone, section A–B, between Odiyam and Kunnam

ularly rounded ventral margin, pointed umbo, and regular ornament, composed of concentric rings (*Anwachsringen*). In these respects they resemble inaequivalve representatives of *I. pictus*. Early Turonian *Inoceramus* are commonly reported from the Northern Pacific Province (see for example Takahashi 2005, 2009). In regions where the early Turonian record is dominated by *Mytiloides*, representatives of *Inoceramus* are rare, however, quite rich *Inoceramus* material was recently reported from the *Mytiloides*-dominated lower Turonian of the Canadian Western Interior (Walaszczyk *et al*. 2016).

Systematic palaeontology

The terminology and measurements used follow Harries *et al.* 1996. The measurements to all the specimens described are contained in Table 2.

Order Pterioida Newell, 1965
Suborder Pteriina Newell, 1965
Family Inoceramidae Giebel, 1852
Genus *Inoceramus* J. Sowerby, 1814

TYPE SPECIES: *Inoceramus cuvieri* J. Sowerby, 1814, p. 455, pl. 25, by the subsequent designation of Cox (1969, p. N315).

Inoceramus carsoni M'Coy, 1865
(Text-fig. 41)

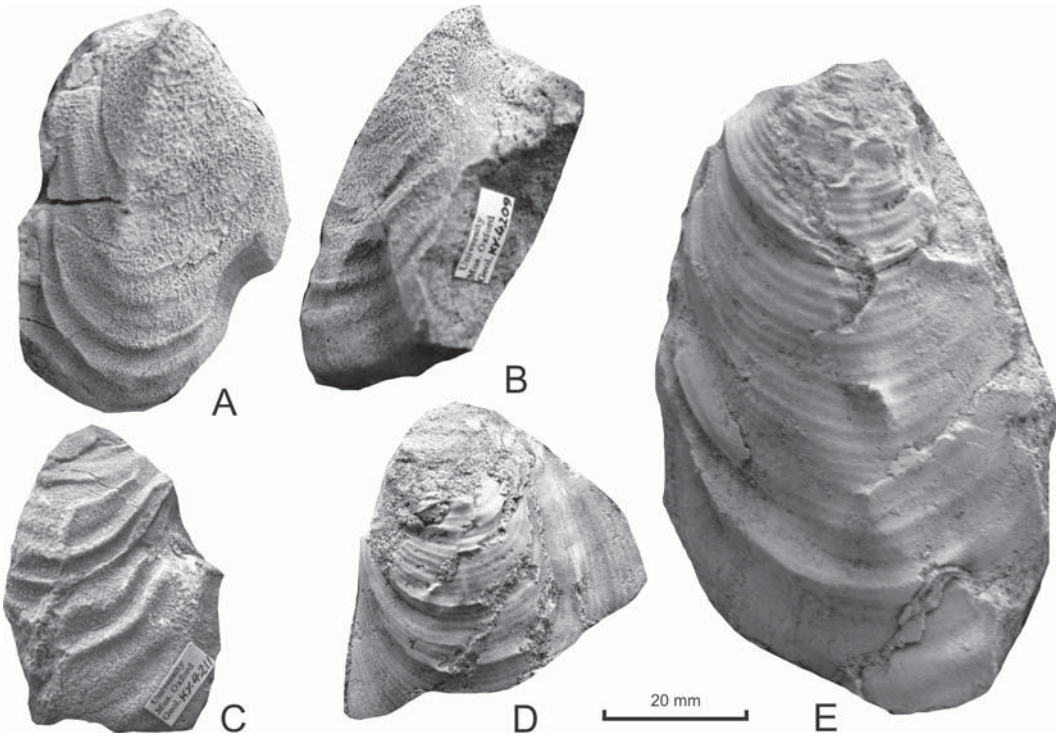
1865. *Inoceramus carsoni* M'Coy, p. 334.
1867. *Inoceramus carsoni* M'Coy, p. 196.
1872. *Inoceramus pernoides*, Etheridge, pl. 22, fig. 3.
1892. *Inoceramus* sp. ind. (?Young of *I. pernoides*, Etheridge); Etheridge Jr., pl. 21, fig. 19.
1892. *Inoceramus pernoides* Etheridge; Etheridge, pl. 25, figs 7, 8, 12 (= *Inoceramus pernoides* in Etheridge, 1872, pl. 22, fig. 3).
?pars 1966. *Inoceramus carsoni* McCoy; Ludbrook, p. 157, pl. 17, fig. 3 (?non pl. 17, fig. 2).
1985. *Inoceramus carsoni* M'Coy; Crame, p. 498, pl. 57, figs 1–3; pl. 58, fig. 2; text-fig. 7.
1994. *Inoceramus carsoni* M'Coy; Ayyasami and Rao, pl. 1, fig. d.
1996. *Inoceramus carsoni* McCoy, 1865; Olivero and Martinioni, p. 272, fig. 3.1.
2007. *Inoceramus carsoni* M'Coy; Medina, fig. 1b.

TYPE: The lectotype, by the subsequent designation of Ludbrook (1966, p. 157), is no. P2172, housed in the collections of the National Museum of Victoria, Melbourne, Australia, one of M'Coy's syntypes, figured by Ludbrook (1966 pl. 17, fig. 3), and from the base of the Walker's Table Mountains, on the west bank of the Flinders River, Queensland, Australia.

Specimen	Illustration	Valve	hmax	h	l	H	L	B	s	AV	α	δ
***Inoceramus carsoni* McCoy, 1865**												
KY 2500	Text-fig. 41A	RV	101	66	48	59	50	11	30*	44*	88	63
KY 2496	Text-fig. 41B	RV	92	–	–	–	–	–	–	–	–	–
KY 2497	Text-fig. 41C	LV	87*	62	44	–	–	12*	–	39	–	64*
***Inoceramus* sp.**												
KY 4209	Text-fig. 42A, B	RV	54	45	35	40*	35*	15*	15	22*	115	75
KY 4211	Text-fig. 42C	LV	44*	–	–	–	–	–	–	–	–	–
***Inoceramus* ex gr. *virgatus* Schlüter, 1877**												
KY 3064	Text-fig. 43A-C	LV	47	44	40	–	–	19	–	30	–	80
		RV	45	43	39	42	36	15	22	34	100	80
KY 2749	Text-fig. 43D-E	LV	36	–	–	–	–	–	–	–	–	–
***Inoceramus flavus* Sornay, 1965**												
KY 2709	Text-fig. 44A	LV	65	–	–	–	–	–	–	–	–	–
KY 2649	Text-fig. 44B	LV	64	–	–	–	–	–	–	–	–	–
***Inoceramus flavus pictoides* Sornay, 1965**												
KY 2722	Text-fig. 45A	LV	67	52	33	46*	32*	16	22*	34	90	70
	Text-fig. 45B	RV	62	–	–	–	–	–	–	–	–	–
***Inoceramus pictus* J. de C. Sowerby, 1829**												
KY 2907	Text-fig. 46A	RV	28	28	23	26	22	11	12*	21	100	80
KY 2857	Text-fig. 46B	LV	29	29	22	26	22	11	14*	19	100	80
KY 2863	Text-fig. 46C	LV	33	26	19	24	19	11	11*	18	95	80
KY 2856	Text-fig. 46D	RV	35	30	24	28	23	9	11*	20	100	80
KY 2851	Text-fig. 46E left	LV	33	33	21	–	–	15	–	23	90	75
KY 2852	Text-fig. 46F-H	LV	42	36	25*	32	25	13	13*	21	90	70
KY 2837	Text-fig. 46L	LV	32	–	–	–	–	–	–	–	–	–
KY 2911	Text-fig. 46I, J	LV	42	34	23	32	22	15	13	22	90	75
KY 2906	Text-fig. 46K, M	LV	41	41	30	35	28	15	14	25	94	75
KY 2902	Text-fig. 46N	RV	38	–	–	–	–	–	–	–	–	–
KY 2850	Text-fig. 46O	LV	48	42	29	38	28	15	16	29	93	70
KY 3164	Text-fig. 47C	RV	28	–	–	–	–	–	–	–	–	–
KY 3163	Text-fig. 47D	LV	64	61	46	–	–	22	–	39	95	80
KY 3495	Text-fig. 48A, E	RV	23	–	–	–	–	–	–	–	–	–
KY 3499	Text-fig. 48B	LV	50	43	33	40	33	18	18	30	90	75
KY 3327	Text-fig. 48C	RV	47	39	35	37	35	18	13	23	100	70
KY 3496	Text-fig. 48G	RV	43	–	–	–	–	–	–	–	–	–
KY 3322	Text-fig. 48H	LV	55	50	38	46	35	23	16	38	95	75
KY 3497	Text-fig. 48I	LV	29	29	21	26	19	12	10	20	93	75
KY 3321	Text-fig. 48J	RV	55	44	35	43	32	21	13	31	95	75
KY 3512	Text-fig. 48L	LV	95	64	51	60	42	26	18	40	95	70
KY 3334	Text-fig. 48M	RV	66	–	–	–	–	–	–	–	–	–
KY 3334	Text-fig. 48N	LV	72	60	45	58	41	22	21	42	95	75
***Inoceramus* sp. A**												
KY 3477	Text-fig. 49A, B	LV	74	48	37	46	32	16*	24	36	90	70
KY2910	Text-fig. 49C-E	LV	42	38	27	35	25	14	17	26	90	70

Specimen	Illustration	Valve	hmax	h	l	H	L	B	s	AV	α	δ
***Inoceramus chiplonkari* sp. nov.**												
KY 3362	Text-fig. 50A	RV	37	34	24	31	25	12	9	22	95	68
KY 3360	Text-fig. 50B	RV	30	–	–	–	–	–	–	–	–	–
KY 3361	Text-fig. 50C	LV	36	28	23	25	26	12	9	20	90	72
KY 3359	Text-fig. 50D	LV	25	23	16	21	15	10	8	17	90	70
KY 3580	Text-fig. 50F	RV	17	–	–	–	–	–	–	–	–	–
KY 3582	Text-fig. 50G	LV	23	–	–	–	–	–	–	–	–	–
***Mytiloides mytiloides* (Mantell, 1822)**												
KY 3628	Text-fig. 52A	RV	53	42	27	34	35	13*	9	9	115	55
I. l.obliquus holotype	Text-fig. 52B	RV	54	46	28	36	36	15	8	7	115	58
KY 3623	Text-fig. 52C	RV	49	39	20	29	33	13	7	8	105	50
KY 5977	Text-fig. 52D	RV	63	–	–	–	–	–	–	–	–	–
KY 3606	Text-fig. 52E, F, I	LV	95	84	46	62	70	27	12	14	100	55
KY 3626	Text-fig. 52G	LV	41	–	–	–	–	–	–	–	–	–
KY 3623	Text-fig. 52H	RV	49	39	19	30	31	13	7	9	110	48
***Mytiloides borkari* (Chiplonkar and Tapaswi, 1974)**												
KY 3618	Text-fig. 53A	LV	53	48	32	37	41	16	9	7	140	55
KY 3609	Text-fig. 53B	LV	31	–	–	–	–	–	–	–	–	–
KY 3621	Text-fig. 53C	RV	36	35	30	32	33	13	7	–	125	62
KY 3614	Text-fig. 53D	LV	54	49	37	41	42	16	8	9	125	60
holotype	Text-fig. 53E	LV	55*	42	35	37	40	18	7	10*	135	60
KY 3622	Text-fig. 53F	RV	51*	–	–	–	–	–	–	–	–	–
KY 3641	Text-fig. 53G	LV	60	50	41	42	46	18	10	12*	120*	60
***Rhyssomytiloides diversus* (Stoliczka, 1871)**												
Specimen	**Illustration**	**Valve**	**hmax**	**hjuv**	**ljuv**	**Hjuv**	**Ljuv**	**sjuv**	**αjuv**	**δjuv**	**gen**	**had**
KY 3634	Text-fig. 54A, E	LV	41	16	12	–	–	–	–	–	–	27
KY 3635	Text-fig. 54B	RV	42	26	22	21	25	14	115	55	60	25*
KY 3638	Text-fig. 54C	LV	50	26	23	21	24	14*	115	55	65	29
KY 3632	Text-fig. 54D	RV	50*	–	–	–	–	–	–	–	–	–
KY 3631	Text-fig. 54F	LV	23	–	–	–	–	–	–	–	–	–
KY 3637	Text-fig. 54G	RV	52	27	19	23	25	14	95	55	60	32
KY 3636	Text-fig. 54H	LV	65	–	–	–	–	–	–	–	–	–
KY 3630	Text-fig. 54I, J	RV	63	24	20	19	23	13	105	55	60	43

Table 2. Dimensions of inoceramid specimens studied; terminology and measurements after Harries *et al.* 1996. Measurement abbreviations are as follows: hmax – maximum axial length; h – axial length at which all of the measurements on a specimen are done; l – secondary axis (maximum dimension perpendicular to axial length); H – valve height; L – valve length; B – valve width (perpendicular to commissural plane); s – hinge line length; AV – length of anterior margin; α – anterior angle (between anterior margin and hinge line); δ – angle of inclination (angle between hinge line and axial length). Measurements used in *Rhyssomytiloides diversus*: hmax – maximum axial length; hjuv – maximum axial length of juvenile stage (between beak and start of radial ribs); ljuv – secondary axis of juvenile stage; Hjuv – height of juvenile stage; L – length of juvenile stage; s – length of juvenile hinge line; αjuv – anterior angle of juvenile stage; δjuv – angle of inclination of juvenile stage; gen – angle of geniculation (the angle between juvenile and adult stages); had – axial length of adult stage (the stage with radial ribs). All distance measurements are in millimetres and angles in degrees. Asterisks mark estimated values



Text-fig. 42. **A-C** – *Inoceramus* sp.; A-B – OUM KY4209, C – OUM KY4211. Both specimens are from the Karai Formation section D at 24 m level. **D**, **E** – *Inoceramus* cf. *sutherlandi* M'Coy, 1865; C – WG ZI/95/063, D – WG ZI/95/064 from the Karai Formation, east of Karai. All specimens are from the Upper Albian *perinflata* Zone

MATERIAL: OUM KY2496 and KY2497, both from the Karai Formation, Upper Albian, *rostrata* Zone, section A–B at the 10 m level, and OUM KY2500 from the 14 m level, between Odiyam and Kunnam. Another 11 specimens (WG ZI/95/051 to ZI/95/062), are from the Upper Albian of the Karai Formation, east of the town of Karai.

DESCRIPTION: The species is of medium size for the genus, inequilateral, slightly inequivalve. The valves are elongated parallel to the growth axis; this is particularly well seen in the LV, in which l/h ratio ranges from 0.65 to 0.67. In the RV the l/h ratio ranges between 0.75 and 0.85. The valves are weakly inflated, with maximum inflation dorsocentral. The disc is subtriangular, strongly elongated ventralward. The posterior auricle is poorly separated from the disc. The beak is pointed, curved dorsally. The umbonal part of the left valve is distinctly inflated, that of the right valve less so. The anterior margin is straight (in RV) to slightly concave (LV), moderately long (AV/h = 0.64). The ventral margin is almost rounded in the LV and subtrapezoidal in the RV. The posterior margin is broadly rounded. The hinge line is straight and of moderate length. The anterior face is steep and rounded.

The juvenile (umbonal region) ornament is composed of raised growth lines, sometimes superimposed on low, broad rugae. In the adult stage, the dominant elements of the ornament are raised ribs, with narrowly rounded edges and variable interspaces; variably developed rugae are usually superimposed on a part of, or on all of the adult stage. In some specimens the ribs dominate (OUM KY2496, Text-fig. 41B). On internal moulds, preserved in poorly cemented matrix, the ribs are usually strengthened by compression.

The ligament is strong and thick; up to 7 mm in measured specimens. The ornament is well seen on the inner part of shell.

DISCUSSION: In both valve outline and ornament *Inoceramus carsoni* is similar to some less typical individuals of *Gnesioceramus comancheanus* Cragin, 1894 (see Walaszczyk and Cobban 2016, p. 42, figs 4; 5A–D; 6A–C, E, H; 7; 8; 9; 10A, B, D). Typical examples of this species have a straight or slightly convex anterior margin, and distinctly less regular rugae, whilst *Inoceramus. carsoni* lacks

the postero-dorsal oblique internal rib diagnostic of *Gnesioceramus*.

OCCURRENCE: Upper Upper Albian *rostrata* Zone in Tamil Nadu, occurring some tens of metres below the base of the Cenomanian. Well dated records from the Antarctic Peninsula region are apparently from a comparable interval (Medina 2007). Other reports, from Australia and the Antarctic Peninsula (Ludbrook 1966; Crame 1985) are assumed to be from a similar interval.

Inoceramus ex gr. *virgatus* Schlüter, 1877
(Text-fig. 43)

Compare:

1834–1840. *Inoceramus lamarcki* Sowerby; Goldfuss, pl. 111, fig. 2.
1877. *Inoceramus virgatus* sp. nov.; Schlüter, p. 257–260.
1881. *Inoceramus convexus* Etheridge; R. Etheridge, p. 143, pl. 2, figs 6, 6a.
1911. *Inoceramus etheridgei* nom. nov.; Woods, p. 278 –279, pl. 49, fig. 3.
1915. *Inoceramus scalprum* nom. nov.; Böhm, p. 599.
1930. *Inoceramus rutherfordi* sp. nov. Warren, pl. 7, figs 1–3.
1953. *Inoceramus arvanus* sp. nov. Stephenson, p. 65, pl. 12, figs 6–9.
1962. *Inoceramus virgatus* Schlüter, 1877; Bräutigam, p. 189, pl. 1, figs 3–8.
1967. *Inoceramus virgatus* Schlüter, 1877; Tröger, p. 29, pl. 1, figs 1–7 .
1978. *Inoceramus virgatus* Schlüter; Sornay, p. 510, pl. 2, fig. 4.
1978. *Inoceramus virgatus scalprum* J. Böhm; Sornay, p. 510, pl. 2, figs 2, 5.
1982. *Inoceramus virgatus virgatus* Schlüter, 1877; Keller, p. 51, pl. 1, fig. 1.
1982. *Inoceramus virgatus scalprum* Böhm, 1914; Keller, p. 54, pl. 1, fig. 2.
1984. *Inoceramus virgatus virgatus* Schlüter; Kaplan *et al*., p. 323, pl. 8, figs 3, 4.
1987. *Inoceramus virgatus* Schlüter, 1877; Matsumoto *et al*., p. 157, text-figs 6–8.
2001. *Inoceramus virgatus virgatus* Schlüter, 1877; Wilmsen *et al*., pl. 2, figs 2–7; pl. 3, figs 2a, b, 3; pl. 4, figs 3a, c.
2001. *Inoceramus virgatus scalprum* Böhm, 1914 Wilmsen *et al*., pl. 3, figs 4–7; pl. 4, figs 2; 3a, b.

TYPE: The holotype, by the original designation of Schlüter (1877, p. 257), is the original of *Inoceramus lamarcki* in Goldfuss (1834–1840, pl. 111, fig. 2); the specimen has not been traced, and its exact stratigraphic horizon is uncertain (see Wilmsen *et al*. 2001, p. 132).

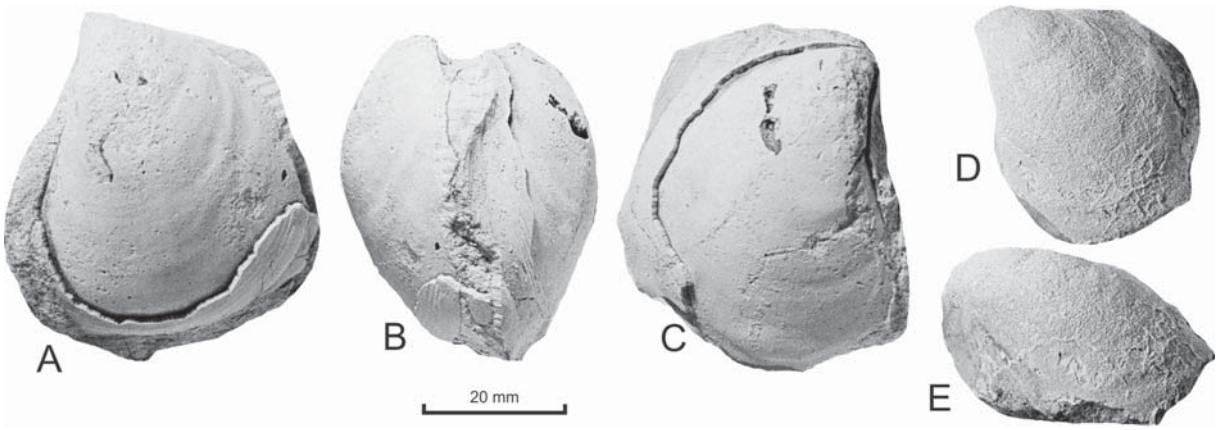
MATERIAL: 3 specimens from the Karai Formation, Middle Cenomanian *asiaticum* Zone between Odiyam and Kunnam; OUM KY3064 from section M–N at the 214–215 m level; OUM KY2594, from section E–F at the 155 m level, and OUM KY2749 from section G–H at the 168–173 m level.

DESCRIPTION: OUM KY3064 (Text-fig. 43A–C) is the best-preserved specimen. It is a double-valve internal mould of an apparently complete specimen, with traces of shell preserved along the margins. It is of a moderate size for the group (hmax = 45 mm; lmax = 40 mm), inaequilateral, slighly inaequivalve. The disc is subtriangular, with maximum inflation dorsocentral. The valves are subquadrate, prosocline, moderately inflated, with the beak pointed and curved antero-dorsally. The anterior margin is moderately long (AV = 31 mm by h = 45 mm), slightly concave, passing into the broadly rounded ventral margin, and then into an almost straight posterior margin. The anterior wall is steep to overhanging. The hinge line is straight, and of moderate length (s = 25 mm by h = 45 mm). The posterior auricle is narrow, elongated, and well separated from the disc along the auricular sulcus. The ligament is preserved in part; it is 2 mm thick. The ligament area is slightly concave; the resilifers slightly suboval, and separated by very narrow, delicate ridges. There are five resilifers on a six mm long section of the LV. Only the disc of the LV is preserved; the posterior auricle lacking as a result of *post-mortem* crushing.

The two other specimens are internal moulds of single valves; RV (OUM KY2594) and LV (OUM KY2749, Text-fig. 43D, E). Both lack their posterior parts.

The shell is preserved only in marginal parts of the valves. Based on these fragments, a relatively simple ornament, represented by slightly raised growth lines (weakly lamellate) is inferred. Irregular, low rugae may occur. The surface of the internal mould is characterized by poorly developed weak concentric rugae, better seen in the juvenile part and disappearing ventralward; growth lines are not seen.

DISCUSSION: The subquadrate outline, moderate inflation, straight to slightly concave anterior margin and type of ornament corresponds to that of some representatives of *Inoceramus virgatus* Schlüter,



Text-fig. 43. *Inoceramus* ex gr. *virgatus* Schlüter, 1877. **A**-**C** – OUM KY3064 from section M–N at the 214–215 m level. **D**, **E** – OUM KY2749, from section G–H at the 168–173 m level. Both specimens are from the Karai Formation, Middle Cenomanian, *asiaticum* Zone between Odiyam and Kunnam

1877. Having only a few specimens, we take a conservative position, and refer them to the *Inoceramus virgatus* group, interpreted as also including *Inoceramus scalprum* Böhm, 1914 and forms of the *Inoceramus arvanus* Stephenson, 1953 – *Inoceramus ruthefordi* Warren, 1930 lineage. Our best specimen, OUM KY3064 (Text-fig. 43A–C), corresponds most closely to *Inoceramus virgatus*, but differs in not developing internal radial striae, which, may, however, be variably developed in that species; its general architecture and ornament are, however, very similar. Our specimens are also similar to *Inoceramus* aff. *arvanus* Stephenson, 1953, from the Lower Cenomanian *Forbesiceras brundretti* Zone and the Middle Cenomanian *Acanthoceras bellense* Zone of Trans-Pecos Texas (see Kennedy *et al*. 1989, p. 103, text-fig. 32a–c, e, f).

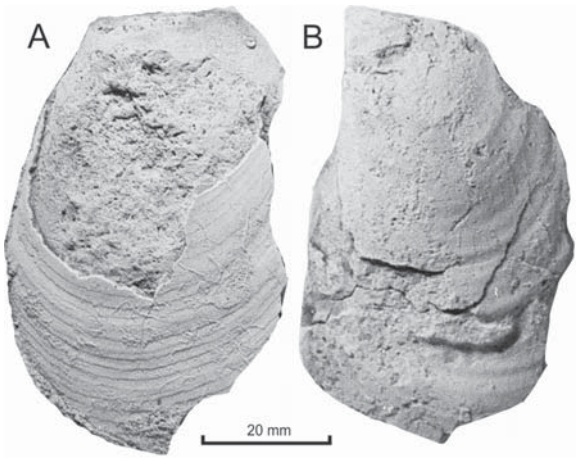
OCCURRENCE: The *virgatus* group, as here understood, is widely recorded, but not all reports are convincing. The sulcate forms, of the lineage *I. arvanus – I. rutherfordi*, seem to be limited to the North American Western Interior (Stephenson 1953, 1955; Kauffman *et al*. 1994), although Kauffman (1978a) reported *I. arvanus* from England, and some radially sulcate forms of *I. virgatus* are also known from other parts of Europe (Wilmsen *et al*. 2001). Two morphotypes are distinguished in the *virgatus* group in Europe: *I. virgatus* and *I. scalprum*, treated usually as subspecies (Sornay 1978; Keller 1982; Wilmsen *et al*. 2001). No stratigraphical differentation is recognized and consequently, both morphotypes are regarded as upper Lower to lower Middle Cenomanian. Both morphotypes, referred to a single species, *I. virgatus*, were recognized in Japan apparently from an equivalent stratigraphic interval (Matsumoto *et al*. 1987). Members of the group, under the name of *I. scalprum*, were reported also from the Pacific Russia (Pergament 1966). The report of *Inoceramus virgatus* from Madagascar by Heinz (1933) was questioned by Sornay (1965) who claimed it to be *I. flavus pictoides*.

Inoceramus flavus Sornay, 1965
(Text-fig. 44)

1965. *Inoceramus flavus* spec. nov.; Sornay, p. 4; pl. A, figs 1, 2; text-fig. 2.
non 1975. *Inoceramus flavus* Sornay; Hattin, pl. 5, figs q, r.
non 1977. *Inoceramus flavus flavus* Sornay; Kauffman, pl. 6, fig. 2 (= ?*Inoceramus heinzi* Sornay, 1965).
non 1978. *Inoceramus flavus flavus* Sornay; Kauffman *et al*., pl. 10, fig. 2 (= ?*Inoceramus heinzi* Sornay, 1965).
2014. *Inoceramus flavus* Sornay, 1965; Walaszczyk *et al*., p. 100, text-fig. 13e, f.

TYPE: The holotype, by original designation, is MNHN. R. 61301 (formerly 632A) the original of of Sornay (1965, pl. A, fig. 2), from the Sakondry Gorge in the southern Morondava Basin, southern Madagascar. Sornay (1965) assigned the species to the Middle and Upper Cenomanian; the species is definitely older, and from the Lower/ Middle Cenomanian boundary interval (see Walaszczyk *et al*. 2014).

MATERIAL: OUM KY2649, KY2658, and KY2709,



Text-fig. 44. *Inoceramus flavus* Sornay, 1965. **A** – OUM KY2709, from the 169 m level; **B** – OUM KY2649, from the 168 m level. Both specimens are from the Karai Formation, Middle Cenomanian *asiaticum* Zone of section G–H between Odiyam and Kunnam

from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section G–H between Odiyam and Kunnam at the 165 m, 168 m, and 169 m levels.

DESCRIPTION AND DISCUSSION: The best specimen of *Inoceramus flavus* amongst the present material is OUM KY2649 (Text-fig. 44B). This is the internal mould of an incomplete LV, with posterior and postero-ventral parts missing. The valve is strongly prosogyral, with pointed beak, curved anteriorly, and elongated parallel to the growth axis. The concave anterior margin is very long (80% of the corresponding axial length), the anterior wall steep. The valve is weakly inflated, with maximum inflation dorsocentral. The ornament is composed of irregularly spaced low, concentric rugae; traces of growth lines are not preserved on the internal mould.

The two other specimens are fragmentary. OUM KY2709 (Text-fig. 44A), apparently a double-valve specimen, is represented by fragments of the adult growth stages; the juvenile parts are not preserved. The LV retains a large fragment of the prismatic shell layer, the surface of which is ornamented with low, sub-regularly spaced concentric rugae with superimposed simple growth lines. The same ornament is shown by OUM KY2658, a small shell fragment that may belong to *I. flavus*.

The general valve outline and type of ornament of these specimens correspond well to those of the holotype of *I. flavus* (Sornay 1965, pl. A, fig. 2) and to a second figured specimen (Sornay 1965, pl. A, fig. 1).

OCCURRENCE: The species is restricted to the Lower and lower Middle Cenomanian according to Walaszczyk *et al*. (2014; see also Kennedy *et al*. 2013). Sornay's (1965) stratigraphic placement of the species in the Middle to Upper Cenomanian was based on a different stratigraphic scheme for the Cenomanian as applied in Madagascar. The convincing reports of the species are from Madagascar and from the Cauvery Basin (herein). Records from the United Stated Western Interior are not conspecific, and are based on either the group of *Inoceramus pictus* (Hattin 1975, pl. 5, figs q, r) or forms close to *Inoceramus heinzi* Sornay, 1965 (Kauffman 1977, pl. 6, fig. 2; Kauffman *et al*. 1978, pl. 10, fig. 2).

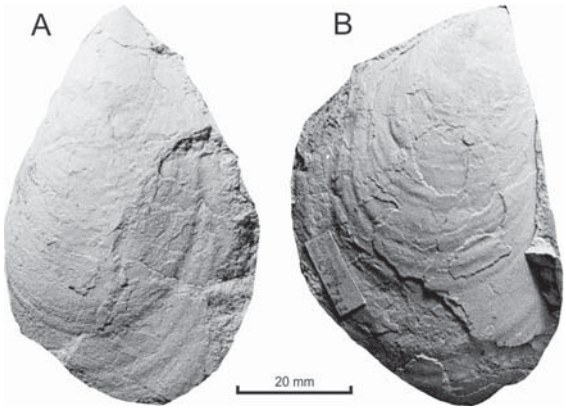
Inoceramus flavus pictoides Sornay, 1965
(Text-fig. 45)

1933. *Cricoceramus pictus* Sow.; Heinz, p. 245, pl. 16, fig. 3 (non 4).
1933. *Smodingoceramus virgatus* Heinz, p. 248.
1965. *Inoceramus flavus* n. sp. var. *pictoides* n. var. Sornay, p. 6,
?non 1977. *Inoceramus flavus pictoides* Sornay; Kauffman and Powell, p. 57, pl. 1, fig. 4; pl. 2, fig. 4.
?non 1977. *Inoceramus flavus pictoides* Sornay; Kauffman, pl. 5, fig. 2.
?non 1978. *Inoceramus flavus pictoides* Sornay; Kauffman *et al.*, pl. 9, fig. 2.

TYPE: The holotype, by the original designation of Sornay (1965, p. 6) is the original of *Cricoceramus pictus* (Sowerby) Heinz, 1933, pl. 16, from Ranonda, Madagascar. The specimen is housed in the collections of the Palaeontological Institute of the Muséum National d'Histoire Naturelle, Paris.

MATERIAL: 3 single valves (two left and one right), OUM KY2722, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section G–H between Odiyam and Kunnam at the 172–175 m level.

DESCRIPTION: The species is medium-size, weakly inflated, prosocline, with straight growth axis, inaequilateral, equivalve. All three specimens are weakly inflated single valves, with maximum inflation dorsocentral. The beak is small, pointed anterodorsally, not projecting above the hinge line. The anterior margin is straight, passing into a rounded ventral margin, and then into a broadly rounded posterior margin. The hinge line is straight and of moderate length. The posterior auricle is not preserved on any of the specimens; it is inferred, however, to



Text-fig. 45. *Inoceramus flavus pictoides* Sornay, 1965. **A**, **B** – OUM KY2722, from the Karai Formation, Middle Cenomanian *asiaticum* Zone, section G–H at the 172–175 m level

be narrow, and subtriangular. The ligament is not preserved.

Ornament is composed of weakly raised growth lines, represented by relatively flat *Anwachsringen*, well seen also on the internal mould. Weak and low rugae appear in the most ventral part, where the *Anwachsringen* disappear.

DISCUSSION: Sornay (1965) characterised his variety *pictoides* as a form with the general outline similar to *Inoceramus flavus* combined with an *Inoceramus pictus*-like ornament. It differs from *pictus* in its greater size, larger antero-dorsal angle, longer hinge line, and the general lack of rugae. The *Anwachsringen*, the most characteristic elements of *pictus* ornament, are more delicate and limited to the juvenile part in *I. flavus pictoides* (see Sornay 1965, p. 6).

The problem with *I. flavus pictoides* arises, however, from the difference between the concept of this taxon as based on the holotype and the concept inferred from Sornay's original description: his '*intentio auctoris*'. The holotype (Heinz 1933, pl. 16, fig. 3), has a similar general outline to *Inoceramus flavus*, combined with ornament similar to that of *Inoceramus pictus*. Heinz' specimen was put into the synonymy of *Inoceramus pictus neocaledonicus* Jeannet, 1922 (in Heim and Jeannet 1922, p. 251, fig. 5) by Tröger (1967, p. 50), and subsequently referred to his new subspecies, *rabenauensis* Tröger 2015, (p. 383). In contrast, we adhere here to Sornay's '*intentio auctoris'*, and interpret *I. flavus pictoides* accordingly. That Sornay's *pictoides* be retained at all can only be established from an investigation of a topotype population from Ranonda, which would unequivocally demonstrate the characteristics of the taxon, and provide a reliable basis for interpretation.

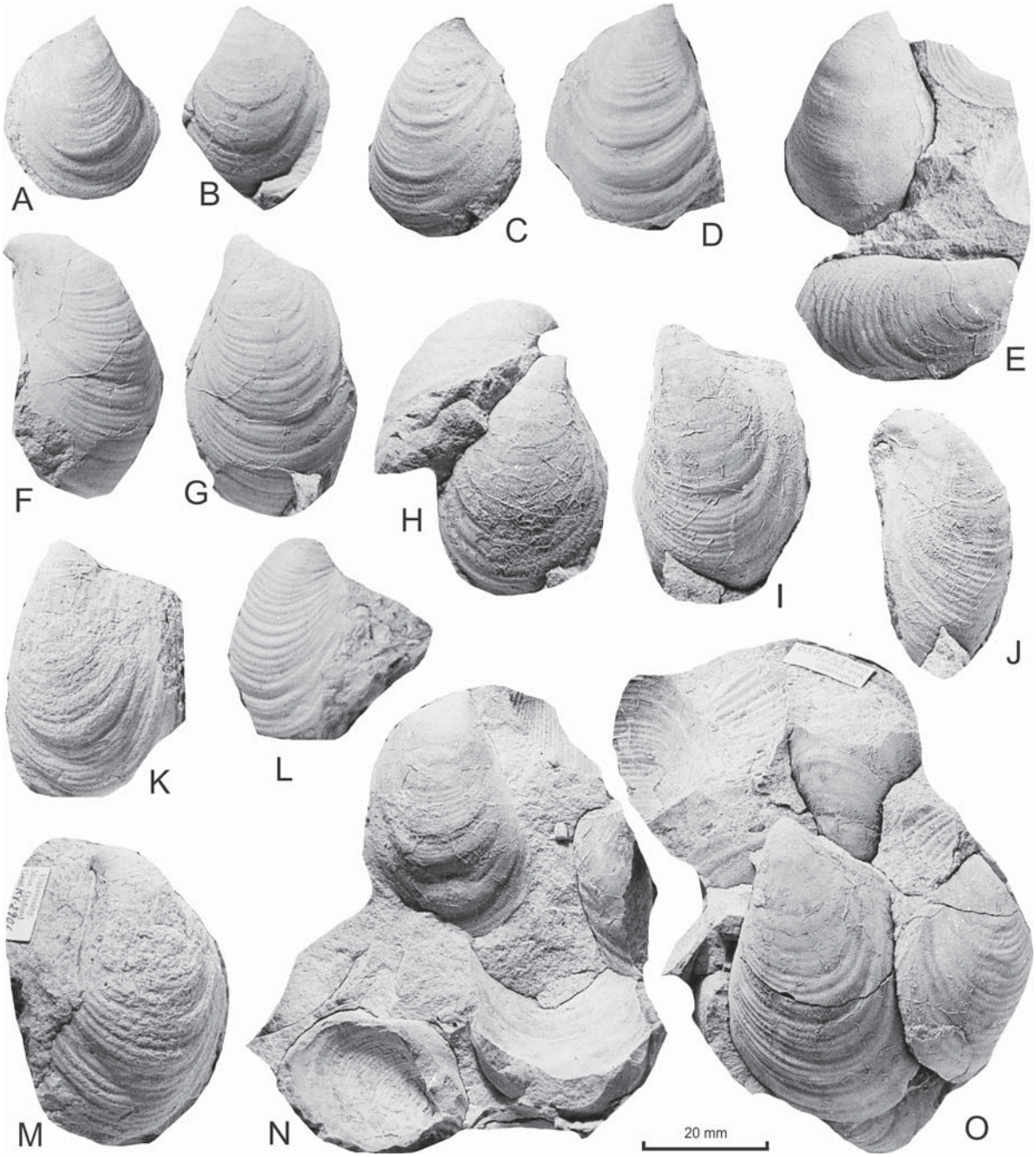
Inoceramus flavus pictoides of Kauffman and Powell (1977, pl. 1, fig. 4; pl. 2, fig. 4) from the US Western Interior belongs to the *Inoceramus pictus* group and seems to be conspecific with *Inoceramus prefragilis* Stephenson, 1953.

OCCURRENCE: The present specimens come from the Middle Cenomanian *asiaticum* Zone. The Madagascan specimens are, according to Sornay (1965, p. 6), from the Middle and Upper Cenomanian. As in the case with *Inoceramus flavus flavus*, this reflects the different substage subdivision of the Cenomanian used by Sornay compared to that used here. The actual range of the species in Madagascar is Lower and Middle Cenomanian.

Inoceramus pictus J. de C. Sowerby, 1829 *sensu lato*

(Text-figs 46–48)

1829. *Inoceramus pictus* J. de C. Sowerby, p. 215, pl. 604, fig. 1.
1897. *Inoceramus bohemicus* n. sp., Leonhard, p. 26, pl. 5, fig. 1a–c.
1911. *Inoceramus pictus* Sowerby, 1829; Woods, p. 279, pl. 49, figs 5, 6; text-fig. 36.
1942. *Inoceramus capulus* Shumard; Moreman, p. 197, pl. 31, figs 1, 3.
1951. *Inoceramus pictus* var. *vardonensis* var. nov., Sornay, p. 321, unnumbered figure.
1953. *Inoceramus prefragilis* Stephenson, p. 64, pl. 12, figs 1–12; pl. 13, figs 1, 2.
1967. *Inoceramus pictus pictus* Sowerby; Tröger, p. 36, pl. 3, figs 1–6 (with synonymy).
1967. *Inoceramus pictus bannewitzensis* n.ssp.; Tröger, p. 41, pl. 2, fig. 3; pl. 4, figs 1–3.
1967. *Inoceramus pictus concentricoundulatus* n. ssp.; Tröger, p. 46, pl. 3, figs 1–3; pl. 2, figs 1, 2.
1967. *Inoceramus pictus neocaledonicus* Jeannet, 1922; Tröger, p. 50, pl. 4, fig. 4.
1967. *Inoceramus pictus bohemicus* Leonhard; Tröger, p. 52, pl. 3, figs 9–11.
1977. *Inoceramus pictus gracilistriatus* n. subsp., Kauffman and Powell, p. 56, pl. 1, fig. 3.
1977. *Inoceramus prefragilis stephensoni* n. subsp., Kauffman and Powell, p. 62, pl. 2, figs 1, 3, 6, 8, 10.
1989. *Inoceramus pictus minus* subsp. nov. Matsumoto, p. 16, figs 1–10.
1994. *Inoceramus bohemicus* Leonhard; Houša, p. 182, pls 1–6.

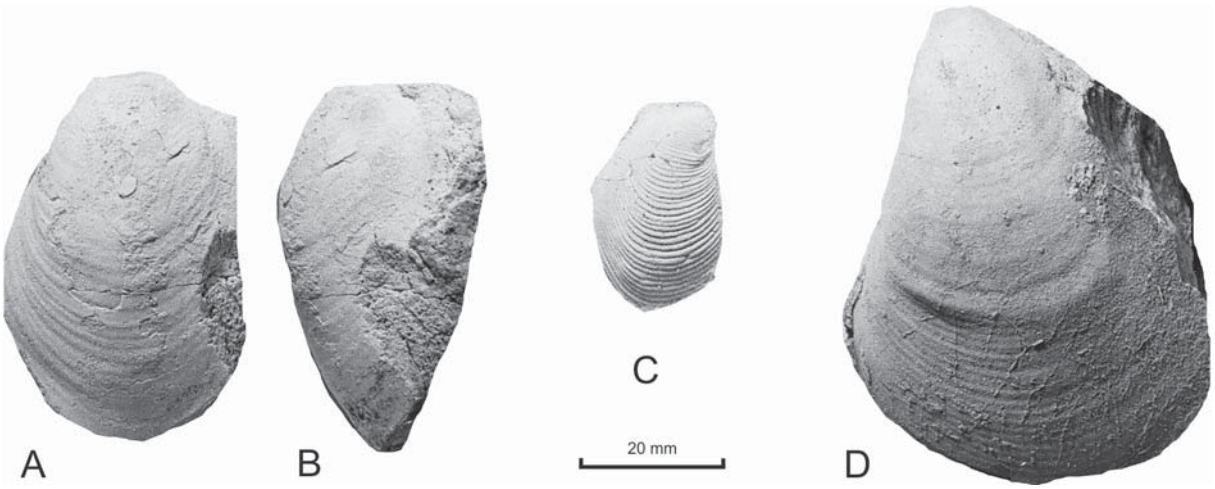


Text-fig. 46. *Inoceramus pictus* J. de C. Sowerby, 1829. **A** – OUM KY2907; **B** – OUM KY2857; **C** – OUM KY2853; **D** – OUM KY2856; **E** – OUM KY2851; **F-H** – OUM KY2852; **I**, **J** – OUM KY2911; **K**, **M** – OUM KY2906; **L** – OUM KY2837; **N** – OUM KY2902; **O** – OUM KY2850. All specimens are from the Karai Formation, Middle Cenomanian *asiaticum* Zone of section G–H, between Odiyam and Kunnam. A, I, J, K, M, and N are from the 210–212 m level; B, C, D, E, F, H, O are from the 209 m level

2015. *Inoceramus pictus rabenauensis* n. ssp.; Tröger, p. 383, pl. 2, fig. 1; pl. 3, fig. 2; appendices 22, 23.

2018. *Inoceramus pictus* J. de C. Sowerby, 1829; Košták *et al*., p. 162, text-fig. 8a, c, d–g (with synonymy).

TYPE: The holotype, by monotypy, is BMNH 43272, the original of J. de C. Sowerby (1829, pl. 604, fig. 1), from the Cenomanian Grey Chalk Group of Guildford, Surrey.



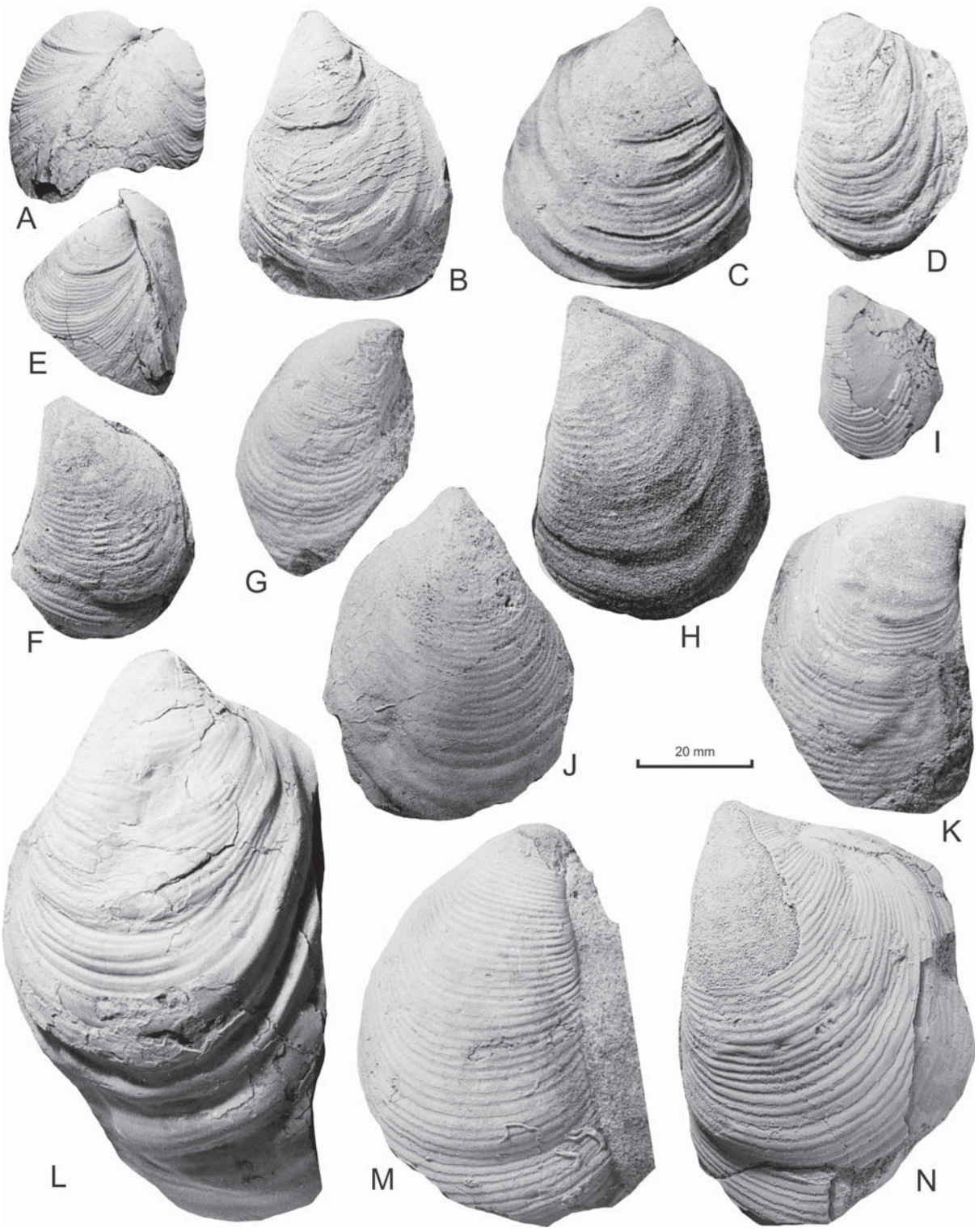
Text-fig. 47. *Inoceramus pictus* J. de C. Sowerby, 1829. **A**, **B** – OUM KY3115; **C** – OUM KY3164; **D** – OUM KY3163. All specimens are from the Karai Formation, Middle Cenomanian *asiaticum* Zone of section M–N between Odiyam and Kunnam. A and B are from the 213–216 m level; C and D are from the 214–215 m level

MATERIAL: From the Karai Formation, Middle Cenomanian *asiaticum* Zone, between Odiam and Kunnam, section G–H: OUM KY2823 from the 205 m level; OUM KY2837 from the 206 m level; OUM KY2850–2860 from the 209 m level; OUM KY2902–2913 from the 210–212 m level; section M–N: OUMK KY3115 from the 213–216 m level; OUM KY3065, KY3163, KY3164, KY4540, KY4541, from the 214–215 m level; OUM KY3238 from the 221 m level. From the Upper Cenomanian *harpax* Zone of section O–P: OUM KY3293 from the 246 m level; OUM KY3314 and KY3315, from the 250 m level; OUM KY3321, KY3322, KY3323 from the 253 m level; OUM KY3334 from the 255 m level; section R–S: OUM KY3484 and KY3485 from the 6–8 m level; OUM KY3475, KY3476, KY3477, from the 5–10 m level; OUM KY3494, KY3495, KY3496, KY3497, from the 19 m level; OUM KY3499 from the 26 m level; OUM KY3505 from the 26.5 m level, all Upper Cenomanian *harpax* Zone; OUM KY3512 from the 41 m level, Upper Cenomanian *septemseriatum* Zone; OUM KY3585 from the 65 m level, Upper Cenomanian *latelobatum–hourcqi* fauna.

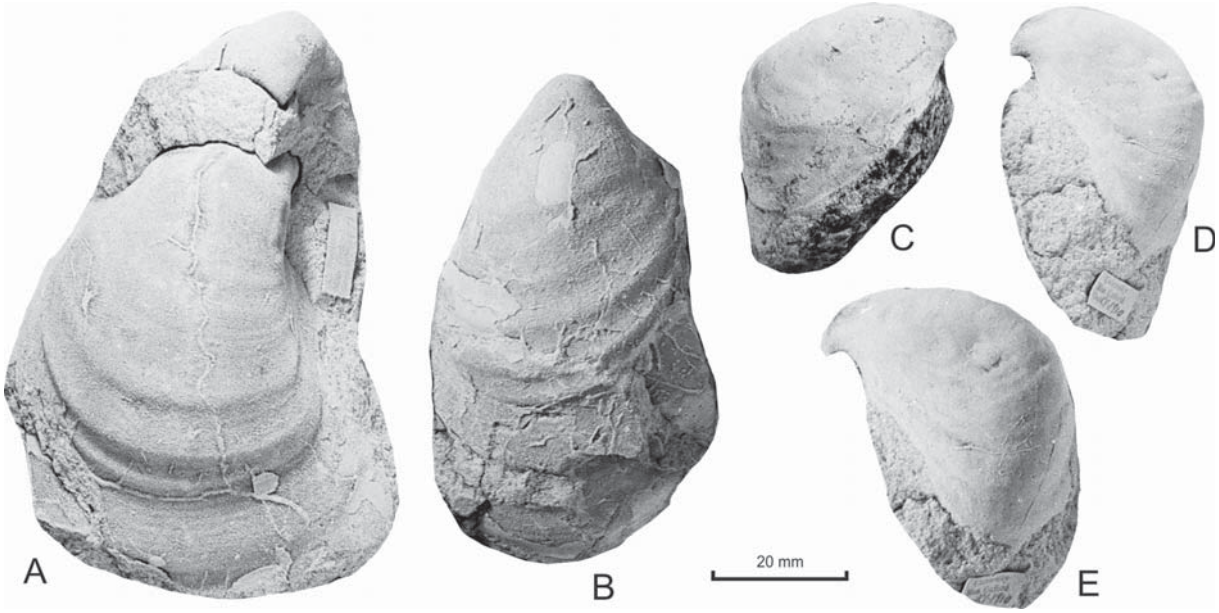
DESCRIPTION: The species is of small to moderate size for the genus, inaequilateral, variably inaequivalve, and moderately inflated; LV larger and more inflated than RV. Valves prosocline and prosogyrous. Beak pointed, curved anterordorsally. In the LV the disc is subtriangular, well separated from the posterior auricle. In the RV the posterior auricle is poorly separated. The anterior margin is slightly concave below the umbo, then straight. The anterior face is steep, and of variable height. The ventral margin is regularly rounded. The posterior margin is broadly rounded. The hinge line is straight, and of moderate length.

The ornament consists of sub-even to irregular rugae, with superimposed raised growth lines (*Anwachringen*), well developed on the juvenile and early adult stage, variably in late adult stage.

DISCUSSION: *Inoceramus pictus* is a variable species, with an apparently pandemic / cosmopolitan distribution. The morphological variability present has resulted in the recognition of a range of separate species and subspecies, the most important of which are: *Inoceramus pictus* J. de C. Sowerby, 1829 (and the nominate subspecies, *pictus pictus*), *Inoceramus prefragilis* Stephenson, 1953, *Inoceramus bohemicus* Leonhard, 1897, *Inoceramus capulus* (Shumard) Moreman, 1942, *Inoceramus pictus vardonensis* Sornay, 1951, *Inoceramus pictus rabenauensis* Tröger 2015 (= *I. pictus neocaledonicus* sensu Tröger, 1967), *I. pictus concentricoundulatus* Tröger, 1967, *I. pictus bannewitzensis* Tröger, 1967, *Inoceramus pictus minus* Matsumoto, 1989, and possibly others. The subspecies-level taxa were mostly treated only as morphological variants, with neither geographical and/or temporal attributes. At the present state of knowledge, it makes sense to refer this plethora of taxa to the group of *I. pictus*. Further study is needed to find out the mode of distribution of observed vari-



Text-fig. 48. *Inoceramus pictus* J. de C. Sowerby, 1829. **A**, **E** – OUM KY3495 from section R–S at the 19 m level; **B** – OUM KY3499 from section R–S at the 26 m level; **C** – OUM KY3327, from section O–P at the 254–255 m level ; **D** – OUM KY3314 from section O–P at the 250 m level; **F** – OUM KY3484 from section R–S at the 6–8 m level; **G** – OUM KY3496 from section R–S at the 19 m level; **H** – OUM KY3322 from section O–P at the 253 m level; **I** – OUM KY3497 from section R–S at the 19 m level; **J** – OUM KY3321 from section O–P at the 253 m level; **K** – OUM KY3485 from section R–S at the 6–8 m level; **L** – OUM KY3512 from section R–S at the 41 m level; **M**, **N** – OUM KY3334 from section O–P at the 255 m level. All specimens are from the Karai Formation, Upper Cenomanian *harpax* Zone, between Odiyam and Kunnam



Text-fig. 49. *Inoceramus* sp. A. **A**, **B** – OUM KY3477, from the section R–S at the 10 m level, Upper Cenomanian *harpax* Zone. **C**-**E** – OUM KY2910, from section G–H at the 210–212 m level, Middle Cenomanian *asiaticum* Zone. Both specimens are from the Karai Formation between Odiyam and Kunnam

ability and to reveal its potential evolutionary and/or geographical meaning. Abundant and stratigraphically well-constrained material is needed.

The question as to how much of the variation may simply be intraspecific in nature is well demonstrated by the sample referred to *Inoceramus bohemicus* Leonhard, 1897, from the type locality, Korycany, in the Czech Republic, discussed by Houša (1994). An assemblage of almost 400 specimens showed that characters critical in understanding the taxonomy of the group such as inequivalvedness, presence/absence and strength of rugae, and pattern of growth-lines, differed greatly between individuals in the population. These features vary both between specimens and through ontogeny. As an example, inaequivalvness, which has been treated as a critical taxonomical feature, varies from well-expressed in some individuals to others that are near-equivalve, and its prominence decreases ontogenetically (Houša 1994, p. 183).

Added to this, most of the taxa listed above are based on single type specimens (with few exceptions), have imprecise stratigraphic information, and some are poorly preserved. These reservations apply to the holotype of *I. pictus*. The original specimen came from Guilford, Surrey, U. K., but the precise horizon within the Grey Chalk Group is not known. Although the specimen is deformed, it is quite complete and both valves are present. Woods (1911, p. 279) interpreted the species as equivalve (see Košták *et al*. 2018). The preliminary reconstruction of the original shape of the type specimen suggests, however, that it is inaequivalve, as interpreted by Tröger (1967, 2015).

Taking into account all current limitations to proper understanding of the group, as interpreted above, the present material is referred to *Inoceramus pictus* J. de C. Sowerby 1829, *sensu lato*.

OCCURRENCE: *Inoceramus pictus sensu lato* is a cosmopolitan species (Tröger 1967, 2015; Matsumoto 1989; Kauffman *et al*. 1994; Košták *et al*. 2018), that first appears in the upper Middle Cenomanian (Kauffman *et al*. 1994; Gale 1995; Gale *et al*. 2002), dominates Upper Cenomanian inoceramid assemblages (Tröger 1989) and ranges in to the basal Lower Turonian (Gale *et al*. 2005; Walaszczyk *et al*. 2016).

Inoceramus sp. A
(Text-fig. 49)

MATERIAL: OUM KY3477, from the Karai Formation, Upper Cenomanian *harpax* Zone, section R–S between Odiyam and Kunnam, at the 5–10 m

level. OUM KY2910, from the Middle Cenomanian *asiaticum* Zone of section G–H at the 210–212 m level.

DESCRIPTION: OUM KY3477 is a double valved individual of moderate-size (hmax of LV = 72 mm; hmax of RV = 60 mm), with the RV pressed into the LV in a direction perpendicular to the sagittal plane, as a result of which the relationship between the valves is slightly uncertain. The specimen is moderately inaequivalve, inaequilateral. The valves have a subrectangular outline, widening slowly ventralwards, and elongated parallel to the growth axis. The beak is pointed, small, curved dorsoanteriorly, particularly in the RV. In both valves, the anterior margin is long, concave, with a steep anterior face. The ventral margin is rounded, and slightly asymmetrical in the posteroventral part. The valves are markedly inflated, with maximum inflation in the early adult stage. Up to 40 mm of the axial length, the valves are ornamented with raised growth lines (in a form of *Anwachringen*; poorly visible on the internal mould), superimposed on low, indistinct rugae. Irregular distinct rugae appear later, and continue to the ventral margin.

OUM KY2910 (Text-fig. 49C–E) is a smaller individual (hmax = 43 mm), the LV an internal mould, complete, and geniculated. The beak is pointed, curved slightly dorsoanteriorly, projecting slightly above the hinge line. The valve is markedly inflated (B/h = 0.5), with maximum inflation central. The anterior margin is straight, with a high, steep anterior face. The ventral margin is rounded. Ornament is poorly preserved; the juvenile part (beakward of the geniculation point) is rather smooth, apparently composed exclusively of growth lines, and the adult stage (ventralward of the geniculation point) is covered with irregular rugae.

DISCUSSION: These specimens are similar to the North Pacific Province *Inoceramus reduncus* Pergament, 1966 (p. 40, pl, 16, figs 1, 2; pl. 17, figs 1, 2; pl, 18, figs 1–3; Matsumoto *et al.* 1988, figs 5.2–5.4, 6) in terms of general outline, type of ornament, and the geniculation, but do not show the strong inaequivalvness that characterizes the Pacific forms. This reservation is, however, based on a single double-valved specimen (OUM KY3477, Text-fig. 49A, B).

OCCURRENCE: As for material.

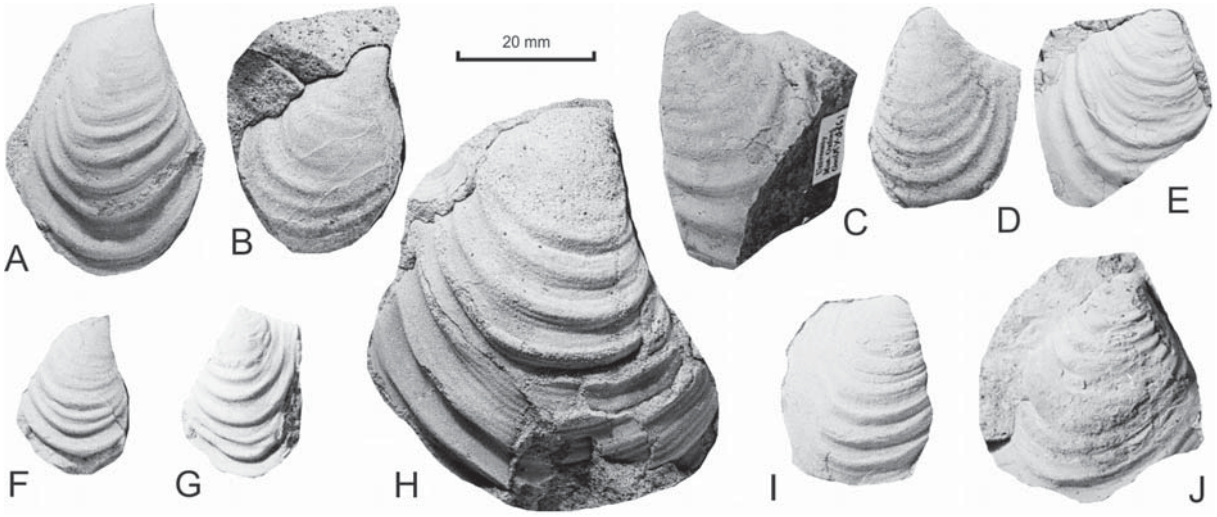
Inoceramus sp. B
(Text- fig. 50H)

1977. *Inoceramus tenuistriatus*? Nagao and Matsumoto; Kauffman and Powell, p. 67 (*pars*), pl. 3, fig. 9 only.

MATERIAL: Two specimens from the Karai Formation, Upper Cenomanian *harpax* Zone section, R–S, between Odiyam and Kunnam, OUM KY3504 from the 27 m level and KY4548 from the 28 m level.

DESCRIPTION: OUM KY4548 (Text-fig. 50H) is the better-preserved of the specimens. It is a double-valve internal mould, with the RV well preserved, undeformed, and the LV incomplete (the dorsal part, and posterior and anterior margins are missing) and deformed. The RV is medium-sized (Hmax = 55 mm), subquadrate (slighly subtrapezoidal) (l/h = 51/55), inequilateral, moderately inflated (Bmax = 17 mm), with maximum inflation dorsocentral. The valve is composed of a triangular disc and well separated posterior auricle. The valve is prosogyrous, moderately prosocline, with the growth axis convex slightly toward hinge line. The beak is pointed, not projecting above the hinge line, and curved slightly postero-dorsally. The anterior margin is long (AV/h = 44/55), and slightly concave in the juvenile part. The ventral margin is broadly rounded. The posterior margin is not preserved. The anterior face is steep to slightly overhanging, and high. The hinge line is straight, and of moderate length. OUM KY3504 is an incomplete RV, with the posterior and postero-ventral parts missing. Most of the shell is intact. It is a relatively large specimen (hmax = 58 mm), showing well the moderate inflation and long anterior margin, slightly concave in the juvenile stage. Up to 20 mm axial length the ornament is dominated by raised growth lines, with superimposed very weak rugae. The rugae dominate on the rest of the valves. They rapidly become well-developed, distant, sharp-edged, with inter-rugae spaces remaining more or less the same over the rest of the shell. The rugae are covered with raised growth lines (*Anwachringen*), visible both on the shell and on the internal mould. The same ornament is seen on the incomplete LV of OUM KY4548.

DISUSSION: This species is represented by only two specimens, of which only the RV is well-enough preserved for adequate description. The LV bears the same ornament type, however, its precise outline cannot be established. As a result the taxon is left in open nomenclature here, although it clearly represents a new species. The subquadrate outline, long and slightly concave anterior margin, high, steep anterior face, and the type of concentric ornament suggest it is conspecific with *Inoceramus tenuistriatus*? Nagao and Matsumoto, 1939, *sensu* Kauffman and Powell 1977 p. 67 (*pars*), pl. 3, fig. 9 only), from the Upper Cenomanian of Oklahoma (the three other specimens



Text-fig. 50. **A-D**, **F**, **G** – *Inoceramus chiplonkari* sp. nov. **A** – the holotype, OUM KY3362; **B** – paratype OUM KY3360; **C** – paratype OUM KY3361; **D** – paratype OUM KY3359; **F** – paratype OUM KY3580; **G** – paratype OUM KY3582; A-D are from section O–P at the 261 m level, Upper Cenomanian *septemseriatum* Zone; F and G are from section R–S at the 65 m level, Upper Cenomanian, *Hourcqiceras latelobatum–Pseudaspidoceras hourcqi* fauna. **E**, **I**, **J** – *Inoceramus* cf. *kamuy* Matsumoto and Asai, 1996. **E** – OUM KY3584; **I** – OUM KY3583; **J** – OUM KY3582; all are from section R–S at the 65 m level, Upper Cenomanian, *Hourcqiceras latelobatum–Pseudaspidoceras hourcqi* fauna. **H** – *Inoceramus* sp. B. OUM KY4548, Upper Cenomanian *harpax* Zone section R–S, at the 28 m level. All specimens are from the Karai Formation between Odiyam and Kunnam

illustrated by Kauffman and Powell 1977, pl. 2, fig. 5; pl. 3, figs 7, 10, belong to some other species). As demonstrated by Noda (1988 p. 584, figs 5.1–5.7, 6.1–6.11, 7.1–7.11, 8.1–8.6, 9), *Inoceramus tenuistriatus* is a quite distinct Japanese Upper Turonian species.

OCCURRENCE: The two Indian specimens are from the Upper Cenomanian *harpax* Zone of the Cauvery Basin; the Oklahoma specimen is from the Upper Cenomanian *Sciponoceras gracile* Zone.

Inoceramus chiplonkari sp. nov.
(Text-fig. 50A–D, F, G)

1988. *Inoceramus nodai* sp. nov.; Matsumoto and Tanaka, p. 571 (*pars*), text-fig. 2 only.
1988. *Inoceramus* cf. *schoendorfi* (Heinz); Matsumoto and Tanaka, p. 577, text-figs 14, 15.
1996. *Inoceramus kamuy* sp. nov.; Matsumoto and Asai, p. 376 (*pars*), text-figs 2.1, 5.3, ?5.4.

TYPES: The holotype is OUM KY3362 from the Karai Formation, Upper Cenomanian *septemseriatum* Zone, section O–P between Odiyam and Kunnam at the 261 m level, as are paratypes OUM KY3359–3361. Paratypes OUM KY3580, KY3581, KY3582, KY3588, and KY3589 are from the Upper Cenomanian *latelobatum–hourcqi* fauna of section R–S at the 65 m level.

DERIVATION OF NAME: For the late Professor G.W. Chiplonkar, formerly of Maharastra Research Institute, Poone, palaeontologist, stratigrapher, and the principal researcher on Indian inoceramids.

DIAGNOSIS: Small for the genus, inequilateral, equivalve, prosocline, elongated parallel to growth axis. Subquadrate in outline, with small subtriangular posterior auricle. Ornamented by regularly spaced rugae.

DESCRIPTION: Small for the genus, inequilateral, ?equivalve, moderately inflated. Maximum inflation is dorsocentral. The valves are strongly prosogyrous, the beak small, pointed, curved antero-dorsally, and projecting slightly above the hinge line. The disc has a regular triangular outline. The posterior auricle is small, subtriangular in outline, narrowly elongated parallel to the hinge line; the auricular sulcus usually developed. The anterior margin is straight to slightly concave, relatively long (60% of corresponding axial length), passing abruptly into the regularly rounded ventral margin. The posterior margin is straight and

concave at the auricular sulcus. The hinge line is straight, short, approximately 40% of corresponding axial length. The growth axis is straight to slightly convex anteriorly. The anterior wall is vertical.

The juvenile ornamentation is composed of raised growth lines. The regularly to subregularly spaced rugae start at 10–12 mm axial length. The rugae are symmetrical in cross-section, with rounded crests, the interspaces dominating over rugae crests. Slightly weaker intercalated rugae may appear. The growth lines are poorly visible on the shell of the post-juvenile stages.

DISCUSSION: Specimens compared to *Inoceramus schoendorfi* Heinz, 1928 by Matsumoto and Tanaka (1988, p. 577, text-figs 14, 15) belong to the present species. Although juveniles of some of the specimens of *I. schoendorfi* are very similar to the present species indeed (e.g., Sornay 1980, pl. 1, fig. 4) the present species is more distinctly inflated, its anterior margin is longer, and it has an outward growth in the postero-dorsal part, never observed in the Heinz' species.

The Japanese specimens co-occured with *Inoceramus nodai*, an Upper Cenomanian form previously referred to *Inoceramus tenuistriatus* Nagao and Matsumoto, 1939 (Matsumoto and Tanaka 1988). Nagao and Matsumoto's name was widely used for small Upper (and Middle) Cenomanian *Inoceramus* clearly different from *Inoceramus pictus* (see Pergament 1965; Kauffman and Powell 1977; Kauffman 1977; Kauffman *et al.* 1978; Keller 1982). Not all of the Cenomanian reports of *I. tenuistriatus* are, however, conspecific. Pergmanent's material (1966, pl. 13, figs 2–4; pl. 14, figs 2–4) is definitely *I. nodai* (see also Matsumoto and Tanaka (1988)), whereas the other citations are doubtfully conspecific. *Inoceramus tenuistriatus* was shown to be a morphologically distinct Upper Turonian species by Noda (1988).

Some of Matsumoto and Tanaka's specimens of I*noceramus nodai* (e.g. 1988, text-fig. 2) fit better the concept of *I. chiplonkari* sp. nov., with which they are regarded as conspecific.

OCCURRENCE: Upper Cenomanian *septemseriatum* Zone and *latelobatum–hourcqi* fauna in sections between Odiyam and Kunnam. Specimens from Japan assigned to the species (see synonymy) are from the Upper Cenomanian and basal Turonian.

Inoceramus cf. *kamuy* Matsumoto and Asai, 1996
(Text-fig. 50E, I, J)

1996. *Inoceramus kamuy* sp. nov.; Matsumoto and Asai, p. 376 (*pars*), text-figs 1.1–1.3, 2.2–2.6 (*non* fig. 2.1, = *Inoceramus* sp. nov. A, 3.1–3.5, 4.1–4.3, 5.1, 5.2, 5.5 (*non* text-fig. 5.3 and 5.4, = *Inoceramus chiplonkari* sp. nov.).

MATERIAL: Four specimens: OUM KY3583, KY3584, KY3585, KY3587a and b; all from the Karai Formation, Upper Cenomanian *latelobatum–hourcqi* fauna, section R–S at the 65 m level.

DESCRIPTION: The RV of OUM KY3587 is typical. It is quite large (l = 40 mm), prosocline, the disc with a triangular outline and moderately large, poorly differentiated posterior auricle. The beak is curved anterodorsally and projects slightly above the hinge line. The valve is moderately inflated, the maximum inflation in the dorsal part. The growth axis is straight. The anterior margin is relatively long, comprising 65% of the corresponding axial length; so too is the hinge line, which is straight and comprises around 60% of the corresponding axial length. The ventral margin is regularly rounded. The posterior margin is straight or slightly concave at the passage through the auricular sulcus. The anterior wall is overhanging.

The juvenile ornament is composed of raised growth lines. The adult ornament consists of subregularly spaced, distinct rugae; growth lines are irregularly developed, showing partial oblique curvature, and there are intercalations of secondary rugae.

OUM KY3584 (Text-fig. 50E) is a single RV, of medium size with l = 49 mm. The shell shares many characteristics with OUM KY3587, from which it differs only in having extended juvenile ornament. OUM KY3583 (Text-fig. 50I) and the smaller specimen on OUM KY3587 are small (both approximately 26 mm in length) RV fragments. Although both are partly concealed by matrix they match well with the two larger specimens in general outline and ornamentation. OUM KY3585 is a RV, poorly exposed in the postero-dorsal part. The specimen differs from the others in having a shorter anterior margin and curved growth axis, as a result of which it is posteroventrally elongated in the adult stage.

DISCUSSION: The present specimens have a valve outline and ornament that is very close to that of *Inoceramus kamuyi*. They are left in open nomenclature here only because of the small number of specimens available, and uncertainty as to how typical they are of the population.

We agree with Matsumoto and Asai (1996) that *Inoceramus kamuy* differs clearly from *Inoceramus*

saxonicus Petrascheck, 1903 (p. 185, pl. 8, fig. 5; text-fig. 2), with which it was formerly compared.

OCCURRENCE: Upper Cenomanian *latelobatum–hourcqi* fauna, co-occuring with *Inoceramus chiplonkari* sp. nov., and *Inoceramus pictus*. In Japan *Inoceramus kamuy* is reported exclusively from the Lower Turonian (Matsumoto and Asai 1996).

Genus *Actinoceramus* Meek, 1864

TYPE SPECIES: The type species, by the original designation of Meek 1864, p. 32, is *Inoceramus sulcatus* Parkinson, 1819, p. 59, pl. 1, fig. 5 from the "blue marle near Folkestone" that is to say the Gault Clay where it has a limited range in the Upper Albian. See Crampton (1996) for an extensive discussion on the genus.

Actinoceramus sp. ?*nipponicus* (Nagao and Matsumoto, 1939)
(Text-fig. 51)

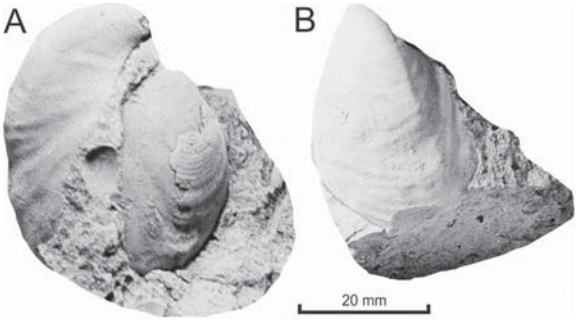
Compare:

1939. *Inoceramus concentricus* Parkinson var. *nipponicus* Nagao et Matsumoto var. nov.; Nagao and Matsumoto, p. 267, pl. 25, figs 1, 3, 6 (*non* pl. 24, fig. 2; pl. 25, figs 2, 4, 5).
1966. *Inoceramus nipponicus* (Nagao and Matsumoto); Pergament, p. 32, pl. 2, figs 1–4.
1989. *Birostrina nipponica* (Nagao and Matsumoto, 1939); Matsumoto and Asai, p. 179, text-figs 1–28, 32.
1989. *Birostrina* aff. *nipponica* (Nagao and Matsumoto, 1939); Matsumoto and Asai, p. 192, text-figs 29–31.

TYPE: The lectotype, by the subsequent designation of Pergament (1966, p. 32), is the original of Nagao and Matsumoto (1939, pl. 25, fig. 1) from the Cenomanian of the Ugui-zawa tributary to the Naibuchi (Naiba) River, South Sakhalin.

MATERIAL: Two specimens from the Karai Formation, Lower Cenomanian *mantelli* Zone, section C–D between Odiyam and Kunnam, OUM KY4374 a double-valved internal mould from the 97 m level, and OUM KY3675, from the 90 m level.

DESCRIPTION: OUM KY4374 (Text-fig. 51A, B) is an undeformed double-valved internal mould with a fragment of shell preserved on the anterior part of the RV. It is small, with a 34 mm maximum LV axial length and 27 mm RV axial length. The specimen is



Text-fig. 51. *Actinoceramus* ex gr. *nipponicus* (Nagao and Matsumoto, 1939). **A**, **B** – OUM KY4374, from the Karai Formation, Lower Cenomanian *mantelli* Zone section C–D between Odiyam and Kunnam at the 97 m level

strongly inaequivalve, with both valves inaequilateral. The LV is larger and strongly inflated, with B to H ratio almost 0.34. The valve is distinctly prosocline, oblique (with a δ angle of about 50°), the growth axis concave toward the hinge line, and with a parabolical outline. The beak is pointed, and strongly curved antero-dorsally. The anterior margin is straight, slightly concave below the umbo, moderately long, with AV to h ratio c. 0.65. The anterior wall is vertical, steep to overhanging. The antero-ventral margin is broadly convex, relatively short, passing into a regularly rounded ventral margin, and then into broadly convex posteror-ventral and posterior margins. The hinge line, although poorly preserved, appears to be short and straight. The posterior auricle is poorly preserved.

The RV is distinctly smaller and less inflated than the RV, with the B to h ratio about 0.15. The valve is prosocline, with similar obliquity to the LV (50°), subtrapezoidal in outline. The beak is directed antero-dorsally. The posterior auricle is small, subtriangular, and elongated. The hinge line is relatively short and straight. The anterior margin is long and straight, and slightly concave below the umbo. It passes into the relatively long antero-ventral margin, which is almost parallel to the hinge line. The ventral margin is regularly rounded, the posterior margin long, and broadly convex.

The valves are weakly ornamented. The ornament consists of fine, raised growth lines up to an axial length of 20 mm on the LV, and up to 18 mm in the RV. Ventralwards, the valves are ornamented by closely spaced, slightly irregular, weakly developed rugae.

OUM KX3675 is a small (hmax = 28 mm) single LV, strongly inflated (with B to h ration 0.46), narrow, with l to h ratio 0.66. The anterior margin is long,

straight, with AV to h ratio being almost 0.8. The valve is distinctly less prosocline than KY4374. The posterior auricle is not visible. The valve is almost smooth.

DISCUSSION: Because there are only two specimens we cannot establish the range of variation, and leave them in open nomenclature. They resemble specimens assigned to the '*nipponicus* group' by previous authors, considered here to comprise *Actinoceramus nipponicus* and *A*. aff. *nipponicus*, as defined by Matsumoto and Asai (1989). The double-valve specimen OUM KY4374 (Text-fig. 51) resembles forma α of *A*. *nipponicus*, however, it is more oblique and has a more curved (concave towards the hinge line) growth axis. This curvature is similar to that of *A*. aff. *nipponicus* of Matsumoto and Asai (1989). OUM KX3675 resembles forma γ of *A*. *nipponicus* (as defined by Matsumoto and Asai 1989): a narrow, elongated morphotype. It is, however, a small (?juvenile) single valve, the taxonomic position of which remains uncertain.

OUM KY4374 possesses an indistinct radial ridge, which may be an indication of a radial sulcus. Unfortunately, no shell material is preserved across this element, which would confirm the presence of a sulcus. Radial morphological elements are not uncommon in the *Actinoceramus* clade (Crampton 1996). Among the Cenomanian representatives of the genus the radial posterior sulcus on the LV is a characteristic feature of *Actinoceramus tamurai* (Matsumoto and Noda 1986) (p. 411, pl. 81, figs 1–6; pl. 82, figs 1–3; pl. 83, figs 1–3; pl. 85, figs 4, 5), from the Middle Cenomanian of Japan.

OCCURRENCE: The present material comes from the lower part of the Lower Cenomanian *mantelli* Zone.

Genus *Mytiloides* Brongniart, 1822

TYPE SPECIES: *Ostracites labiatus* Schlotheim, 1813, p. 93, by monotypy.

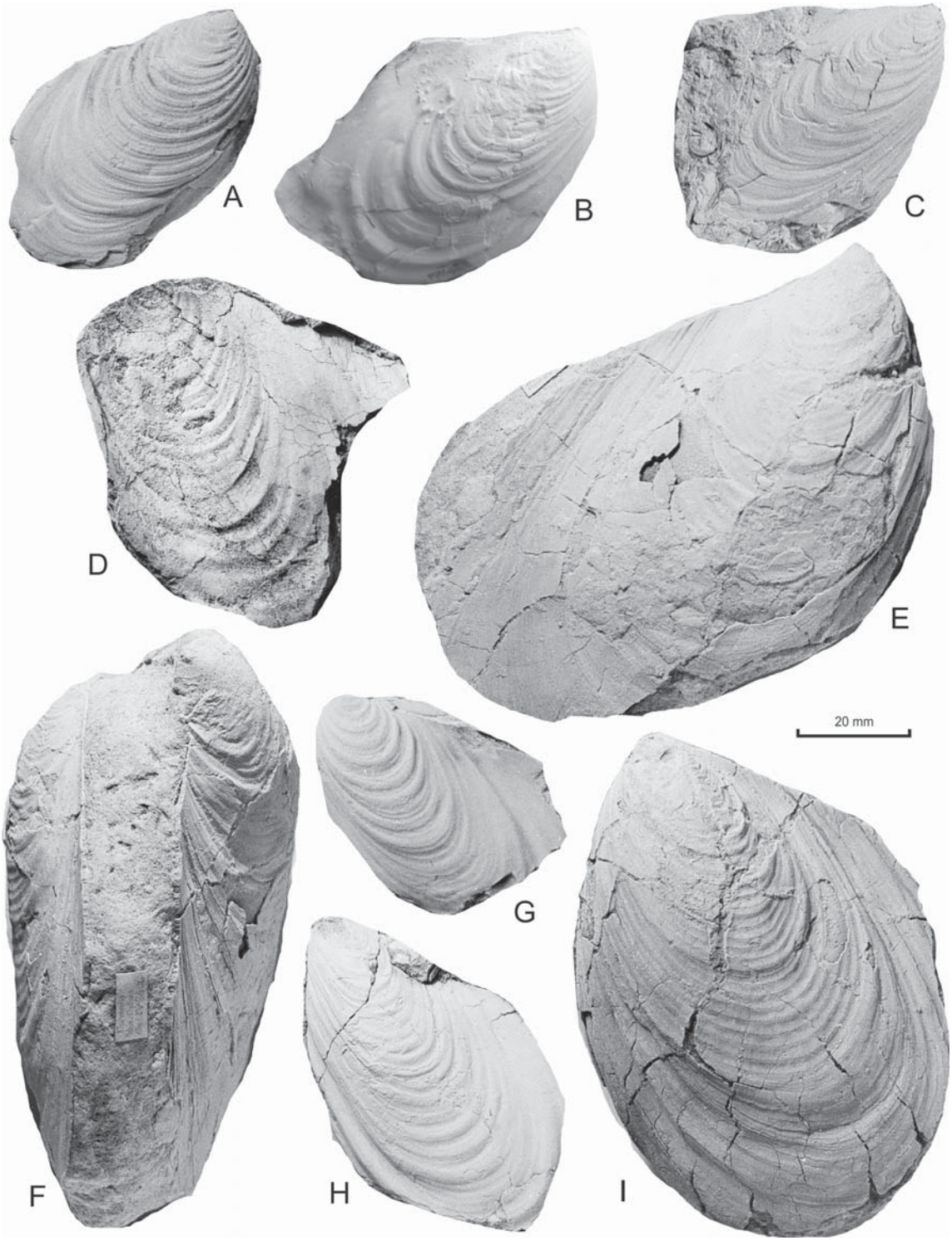
DISCUSSION: *Mytiloides* of the *labiatus* group are well-represented in the Lower Turonian of the Cauvery Basin, although how complete the stratigraphic record is remains to be established. The presence of the group in South India was first reported by Stoliczka (1871, pl. 29, fig. 1), who treated them as a single species. In contrast, Chiplonkar and Tapaswi (1974), divided the group into a series of mostly new taxa, describing *Inoceramus* (*Mytiloides*) *borkari* Chiplonkar and Tapaswi, 1974, p. 106, pl. 3, fig. 3, *Inoceramus* (*Mytiloides*) *labiatus obliquus* Chiplonkar and Tapaswi, 1974, p. 105; pl. 3, fig. 6, *Inoceramus* (*Mytiloides*) *labiiformis* Chiplonkar and Tapaswi, 1974, p. 106, pl. 3, fig. 8 and *Inoceramus* (*Mytiloides*) *labiiformis kunnamensis* Chiplonkar and Tapaswi, 1974, p. 107, pl. 3, fig. 4. *Mytiloides kunnamensis* is a junior synonym of *Mytiloides labiatus*. *Inoceramus* (*Mytiloides*) *labiatus obliquus* is a typical *Mytiloides mytiloides* (see discussion below). *Mytiloides borkari* is the senior synonym of *Mytiloides goppelnensis* (Badillet and Sornay, 1980).

Mytiloides mytiloides (Mantell, 1822)
(Fig. 52)

1822. *Inoceramus mytiloides*, Mantell, p. 215 (*pars*), pl. 28, fig. 2. (*non* pl. 27, fig. 3 = *Mytiloides labiatus*).
1911. *Inoceramus labiatus* (Schlotheim); Woods, p. 283 (*pars*), text-fig. 37 only.
1935. *Inoceramus labiatus* var. *mytiloides* Mantell; Seitz, p. 435 (*pars*), pl. 36, figs 1–4; text-figs 2a–f; 3a–c.
1974. *Inoceramus* (*Mytiloides*) *labiatus* (Schloth.) *obliquus* subsp. nov.; Chiplonkar and Tapaswi, p. 105, pl. 3, fig. 6.
1985. *Inoceramus* (*Mytiloides*) *labiatus*; Chiplonkar, pl. 3, fig. 3 (re-illustration of the original of *Inoceramus* (*Mytiloides*) *labiatus obliquus* of Chiplonkar and Tapaswi, 1974, pl. 3, fig. 6).
?1994. *Mytiloides mytiloides* (Mantell); Ayyasami and Rao, pl. 3, fig. a.
2000. *Mytiloides mytiloides* (Mantell, 1822); Walaszczyk and Cobban in Kennedy *et al*., pl. 12, figs 4–5, 7–12; pl. 13, fig. 7 (with synonymy).
2005. *Mytiloides mytiloides* (Mantell, 1822); Andrade, p. 63, pl. 2, figs 5–12; pl. 3, figs 1–6.
2014. *Mytiloides mytiloides* (Mantell); Walaszczyk *et al*., text-figs 14d, 16e.
2014. *Mytiloides labiatus* (Schlotheim, 1813); Trőger and Niebuhr, p. 182, text-fig. 6b.
2016. *Mytiloides mytiloides* (Mantell); Walaszczyk *et al*., text-fig. 5b, c, e, f.

TYPE: The lectotype is BMNH UK Pl OR 5859, the original of Mantell (1822, pl. 28, fig. 2), refigured by Woods (1911, text-fig. 37), from Plumpton, Sussex, and inferred to be from the lower part of the White Chalk Group (the lower part of the Middle Chalk of authors).

MATERIAL: Seven specimens from the Karai Formation, Lower Turonian *Neoptychites cephalotus* fauna, section R–S between Odiyam and Kunnam at the 70 m level: OUM KY3606; KX3612; KY3616; KY3620 (RV); KY3623; KY3626, together with tran-



Text-fig. 52. *Mytiloides mytiloides* (Mantell, 1822. **A** – OUM KY3616 (transitional to *Mytiloides borkari* Chiplonkar and Tapwasi, 1974). **B** – the holotype of *Inoceramus* (*Mytiloides*) *labiatus obliquus* Chiplonkar and Tapaswi 1974, pl. 3, fig. 6, from the Karai Formation, Lower Turonian, south of Kunnam, Kn40/70 in the collections of the Maharastra Research Institute, Poone. **C** – OUM KY3623, **D** – OUM KY5977 (an external mould); **E**, **F**, **I** – OUM KY3606 (E – RV, F, posterior view, I – LV), **G** – OUM KY3626: **H** – OUM KY3616. A, C, G, and H are from the Karai Formation, Lower Turonian, *Neoptychites cephalotus* fauna of section R–S between Odiyam and Kunnam at the 72 m level; E, F, I, are from the 70 m level in the same section. D is from the same fauna in the Karai Formation at the 463.9 m level in the section north of the Karai–Kulakkalkattam road

sitional forms between *Mytiloides mytiloides* and *M. borkari*: OUM KY3625 and KY3628. OUM KY5972, KY5973, and KY5977 from the same horizon at the 463.9 m level on the north side of the road between Karai and Kulakkalnattam. We have also examined the holotype of *Inoceramus* (*Mytiloides*) *labiatus obliquus* Chiplonkar and Tapaswi 1974, no. Kn 40/70 in the collections of the Marahastra Research Institute, Poone, and from the Karai Formation south of Kunnam.

DESCRIPTION: Medium to large size for genus; inequilateral, equivalve. Valves oblique, with δ usually 35°, outline elongated oval, with very low b/l ratio. Valves weakly inflated, with maximum inflation dorso-central, prosocline, with pointed beak, displaced slightly toward center. Anterior margin very short (30% of corresponding axial length), passing into very long, broadly convex antero-ventral margin. Ventral margin narrowly convex; posterior margin long, almost straight. Posterior auricle narrow, elongated parallel to hinge line; hinge line short and straight, comprising 30–35% of corresponding axial length. Growth axis weakly convex anteriorly in juvenile stage, straight in adult.

Ornament composed of concentric rugae, subregular in juvenile, subregular to irregular in adult stage, with superimposed slightly raised asymmetrical growth lines. Growth lines well seen on outer shell surface; variably recorded on inner surface (as seen on internal moulds), ranging from smooth to moderately well developed.

DISCUSSION: This is an elongate, prosocline, weakly inflated form of the group. Some of the specimens, however (OUM KY3606: Text-fig. 52 E, F, I; OUM KY3623: Text-fig. 52C) develop a steep, relatively high anterior margin, resembling *Mytiloides arcuata* (Seitz 1935) (described originally as *Inoceramus labiatus* var. *mytiloides* forma *arcuata* Seitz, 1935, p. 439, pl. 37, fig. 4; fig. 3d–f). The species is less prosocline than the illustration in Woods (1911, text-fig. 37) suggests. The umbonal part of the type specimen is not preserved and its beak and juvenile umbonal part are sculptured in a way suggesting artificial enhancement, carved in the matrix; the beak is actually curved more toward posterior.

The holotype of *Inoceramus* (*Mytiloides*) *labiatus obliquus* of Chiplonkar and Tapaswi, 1974 (pl. 3, fig. 6), figured here as Text-fig. 52B, is a typical form of Mantell's species. It is an axially elongated, narrow, prosocline, and weakly inflated morphotype. Chiplonkar and Tapaswi compared their new taxon with *Mytiloides labiatus*, from which their subspecies *obliquus* is clearly different.

OCCURRENCE: *Mytiloides mytiloides* is an upper Lower Turonian species, with an apparently worldwide distribution (Harries *et al*. 1996); North America (e.g., Kauffman and Powell 1977; Kauffman *et al*. 1978; Kennedy *et al*. 2000; Walaszczyk *et al*. 2016); South America (e.g., Hessel 1988; Andrade 2005); Madagascar (Sornay 1965; Walaszczyk *et al*. 2014); India (Chiplonkar and Tapaswi 1974 and herein); the western North Pacific (Matsumoto and Noda 1975; Takahashi 2009); western Asia (Kharitonov *et al*. 2007) and Europe (e.g., Seitz 1935; Lopez 1992; Tröger and Niebuhr 2014; Košťák *et al*. 2017).

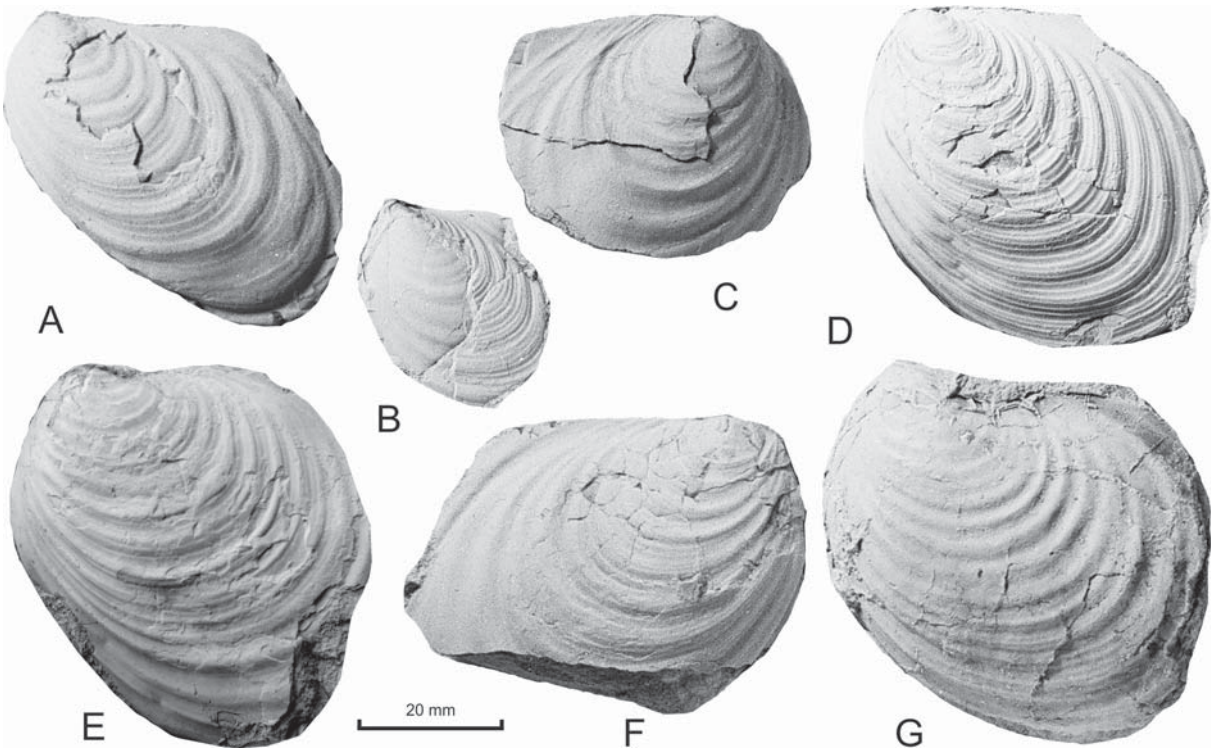
Mytiloides borkari (Chiplonkar and Tapaswi, 1974)
(Text-fig. 53)

1935. *Inoceramus labiatus* var. *opalensis* Böse; Seitz, p. 457, pl. 39, fig. 1.
1935. *Inoceramus labiatus* var. *opalensis* Böse n.f. *elongata*; Seitz, p. 458, pl. 38, figs 4–6; pl. 39, figs 2–4; text-figs 14–15.
1935. *Inoceramus labiatus* n. var. *subhercynica*; Seitz, p. 465 (*pars*), pl. 40, figs 2, 4–5; text-fig. 18.
1974. *Inoceramus* (*Mytiloides*) *borkari* sp. nov.; Chiplonkar and Tapaswi, p. 106, pl. 3, fig. 3.
1980. *Inoceramus goppelnensis* nom. nov.; Badillet and Sornay, p. 324.
2000. *Mytiloides goppelnensis* (Badillet and Sornay 1980); Walaszczyk and Cobban in Kennedy *et al*., pl. 7, figs 9–11; pl. 8, figs 12, 14; pl. 9, figs 1–3; pl. 10, figs 2, 5, 9, 10, 12; pl. 11, figs 2, 5, 7, 10; pl. 12, fig. 6; pl. 13, fig. 6 (with additional synonymy)

TYPE: The holotype, by original designation, is the original of Chiplonkar and Tapaswi (1974, pl. 3, fig. 3), from the Lower Turonian south of Kunnam, no. KN 43/70 in the collections of the Maharastra Research Institute, Pune.

MATERIAL: OUM KY3610; KY3614; KY3618; KY3620 (LV); KY3621; KY3622; KY3627; and KY3641, from the Karai Formation, Lower Turonian, *Neoptychites cephalotus* fauna, section R–S between Odiyam and Kunnam at the 72 m level; OUM KY3641 from the 74 m level.

DESCRIPTION: Medium sized for genus; inequilateral, ?equivalve, elongate-ovate in outline, strongly oblique, with δ ranging between 55° in juvenile to 40° in adult stage. Valves weakly inflated, with max-

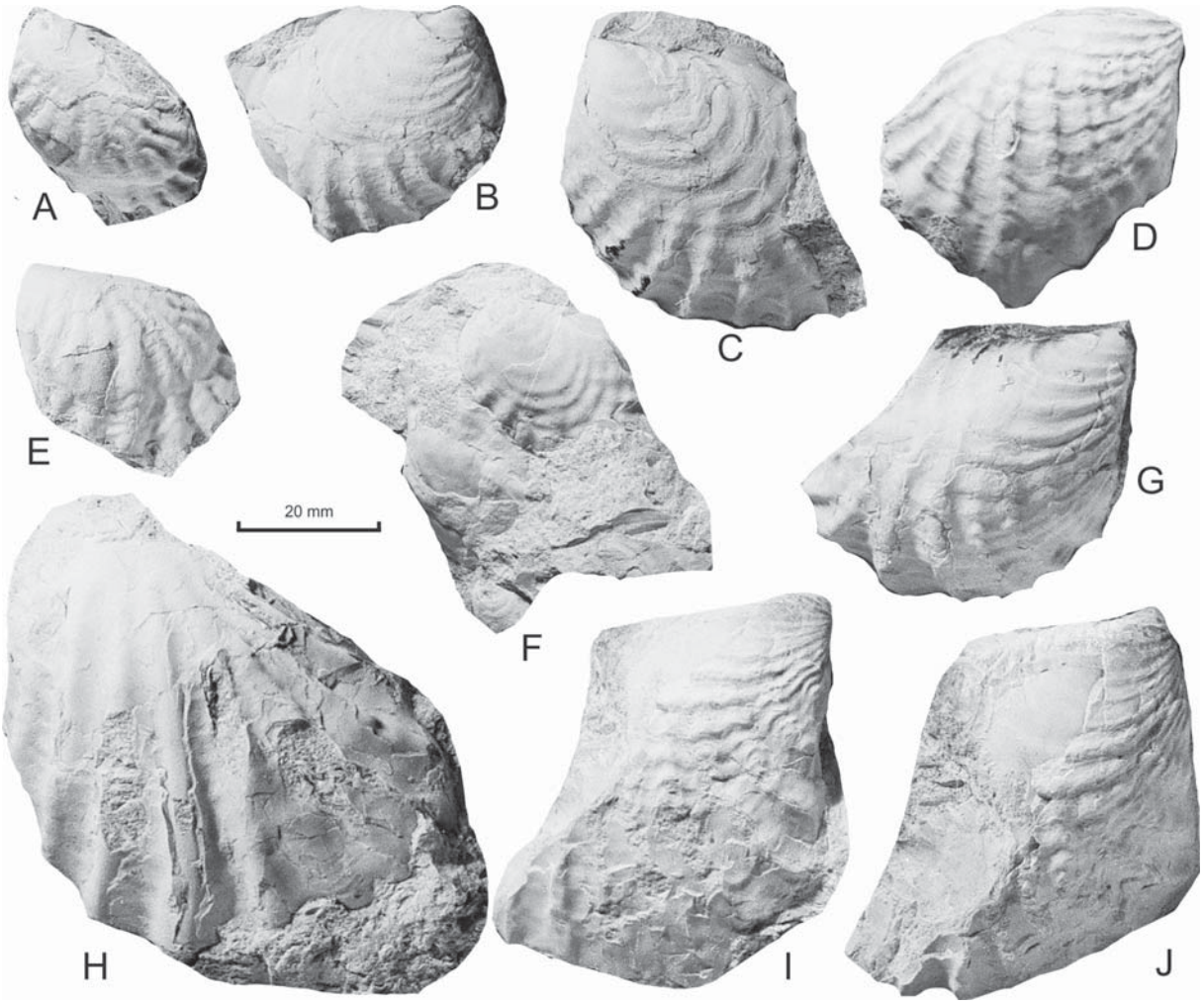


Text-fig. 53. *Mytiloides borkari* (Chiplonkar and Tapaswi, 1974) **A** – OUM KY3618; **B** – OUM KY3609; **C** – OUM KY3621; **D** – OUM KY3614; **E** – the holotype of *Inoceramus* (*Mytiloides*) *borkari* Chiplonkar andTapaswi, 1974, pl. 3, fig. 3; Kn43/70 in the collections of the Maharastra Research Institute, Poone, and from the Lower Turonian Karai Formation south of Kunnam; **F** – OUM KY3622; **G** – OUM KY3641. A-D, F, G are from the Karai Formation, Lower Turonian *Neoptychites cephalotus* fauna, section R–S between Odiyam and Kunnam at the 72 m level

imum inflation dorsocentral. Anterior margin short, straight, passing into broadly convex anteror-ventral margin, and then into evenly rounded ventral margin. Posterior margin short, straight, or slightly convex. Hinge line relatively short, straight. Anterior wall flattened. Posterior auricle small, separated from disc in umbonal part, then inseparable from disc. Growth axis broadly anteriorly convex in juvenile stage, then straight.

Ornament composed of regularly spaced commarginal rugae, with interspaces increasing slowly ventralward; leading margins of rugae slighly steeper. Outer shell surface with well-developed growth lines, evenly to subevenly developed, with 4–5 lines on a single ruga. Ornament of inner shell surface, judging from the record on internal moulds, more variable, ranging from smooth rugae to rugae with well-developed traces of growth lines.

DISCUSSION: *Mytiloides borkari* (Chiplonkar and Tapaswi, 1974) was based on a single specimen (Text-fig. 53E) from a shelly limestone south-west of Kunnam, the source of our specimens, which are thus topotypes. It is the senior synonym of *Mytiloides goppelnensis* (Badillet and Sornay, 1980, p. 324), which was introduced as a *nomen novum* for *Inoceramus labiatus* var. *opalensis* n.f. *elongata* of Seitz (1935, p. 458, pl. 38, figs 4–6; pl. 39, figs 2–4; text-figs 14, 15). Badillet and Sornay (1980) correctly recognized the validity of Seitz' taxon and its distinctness from *Inoceramus opalensis* of Böse (1923), which the taxon was originally referred to. *Mytiloides goppelnensis* resembles *Mytiloides kossmati* (Heinz, 1935) (see revision in Walaszczyk and Cobban in Kennedy *et al*. 2000 p. 322, pl. 9, figs 4–9), from which it differs only in its ornament. Based on this similarity, Walaszczyk (1992) treated *goppelnensis* (= *borkari* herein) as a junior synonym of *kossmati*. A rich fauna of both morphotypes from the Turonian Global Stratotype Section at Pueblo, Colorado demonstrated them to be separate species (see Walaszczyk and Cobban in Kennedy *et al*. 2000, p. 324).



Text-fig. 54. *Rhyssomytiloides diversus* (Stoliczka, 1871) **A, E** – OUM KY3634; **B** – OUM KY3635; **C** – OUM KY3638: **D** – OUM KY3632: **F** – OUM KY3631: **G** – OUM KY3637: **H** – OUM KY3636; **I**, **J** – OUM KY3630 (I – anterior-lateral view; J – lateral view); all specimens are from the Karai Formation, Upper Cenomanian *Neoptychites cephalotus* fauna of section R–S, between Odiyam and Kunnam at the 72 m level

OCCURRENCE: Lower (but not lowest) Lower Turonian of Europe, North America, South America, Madagascar, India, and Japan.

Genus *Rhyssomytiloides* Hessel, 1988

TYPE SPECIES: *Rhyssomytiloides mauryae* (Hessel, 1986, p. 228, pl. 1, figs 1–3; text-fig. 5), by the original designation of Hessel 1998, p. 25.

Rhyssomytiloides diversus (Stoliczka, 1871)
(Text-fig. 54)

1871. *Inoceramus diversus* Stoliczka, p. 407, pl. 27, fig. 6.
1974. *Sphenoceramus diversus* (Stoliczka); Chiplonkar and Tapaswi, p. 115.
1985. *Inoceramus* (*Sphenoceramus*) *diversus* Stoliczka; Chiplonkar, pl. 3, fig. 6.
1986. *Sphenocermus mauryae* n. sp., Hessel, pp. 228–234, pl. 1, figs 1–3; text-fig. 5.
1988. *Rhyssomytiloides mauryae* (Hessel, 1986); Hessel, p. 26, text-figs 35, 36a–c.
1988. *Rhyssomytiloides bengtsoni* n.sp.; Hessel, p. 29, p. 29, figs 36f–g, 37.
1994. *Rhyssomytiloides diversus* (Stoliczka); Ayyasami and Rao, p. 342, text-fig. 2d.

2014. *Rhyssomytiloides* sp.; Walaszczyk et al., fig. 16a, b.

TYPE: The lectotype, here designated, is the original of Stoliczka (1871, p. 407, pl. 27, fig. 6) from the lower Turonian of Anapady, Cauvery Basin, SE India. The original is housed in the collections of the Geological Survey of India, Kolkata.

MATERIAL: Ten single valves: OUM KY3629–38 and numerous fragments from a mass occurrence in the Karai Formation, Lower Turonian *Neoptychites cephalotus* fauna, section R–S between Odiyam and Kunnam at the 72 m level.

DESCRIPTION: Small to medium sized; inequilateral, ?equivalve. There are two distinct growth stages: an oblique (with δ approximately 40°), weakly to moderately inflated juvenile stage with commarginal ornament; and an adult stage, separated by a geniculation from the juvenile stage, and ornamented with strong, radial ribs that dominate the commarginal rugae and are curved broadly toward the commissure.

The juvenile growth stage is 28–30 mm long parallel to growth axis; the anterior margin is straight to slightly convex, short (usually less than 40% of the respective axial length), passing into a broadly convex antero-ventral margin. The ventral margin is narrowly convex; the hinge line straight, short (less than 50% of the respective axial length). The concentric rugae bear superimposed regular growth lines; the edges of rugae are distinct, and round-topped. Two to three of the most ventralward rugae of the juvenile stage are feebly undulose.

The adult growth stage may be distinctly longer (measured parallel to the growth axis) than the juvenile. The change of growth direction (geniculation) is distinct but oval in outline in the view perpendicular to the commissural plane. The radial ribs arise at ventral part of the juvenile stage as indistinct tubercles on the edges of rugae, with which they are parallel. The radial ribs have a nodular appearance, passing into strong, distinct ridges in the ventralmost parts of the adult stage. The nodular character of the radial ribs is not seen (or very poorly seen) on internal moulds.

DISCUSSION: The juvenile growth stage of *Rhyssomytiloides diversus* is identical to that of juveniles of transitional forms between *Mytiloides mytiloides* and *Mytiloides borkari*, both in general outline and in ornamentation. *Rhyssomytiloides mauryae* (Hessel, 1986) is a junior synonym of *diversus*. The differences listed by Hessel (1988, p. 28) stem from the antero-ventral and not lateral orientation of the specimen of *S. diversus* illustrated by Ayyasami and Rao (1994, text-fig. 2d), to which she refers; *diversus* and *mauryae* agree in all specific characters.

Specimens with a rather small juvenile stage and relatively large adult stage (e.g. OUM KY3636: Text-fig. 54H) resemble *Rhyssomytiloides bengtsoni* Hessel, 1988 (p. 29, figs 36F–G, 37). There are, however, no other difference between such specimens and the holotype of *diversus*, and *bengtsoni* is a further synonym.

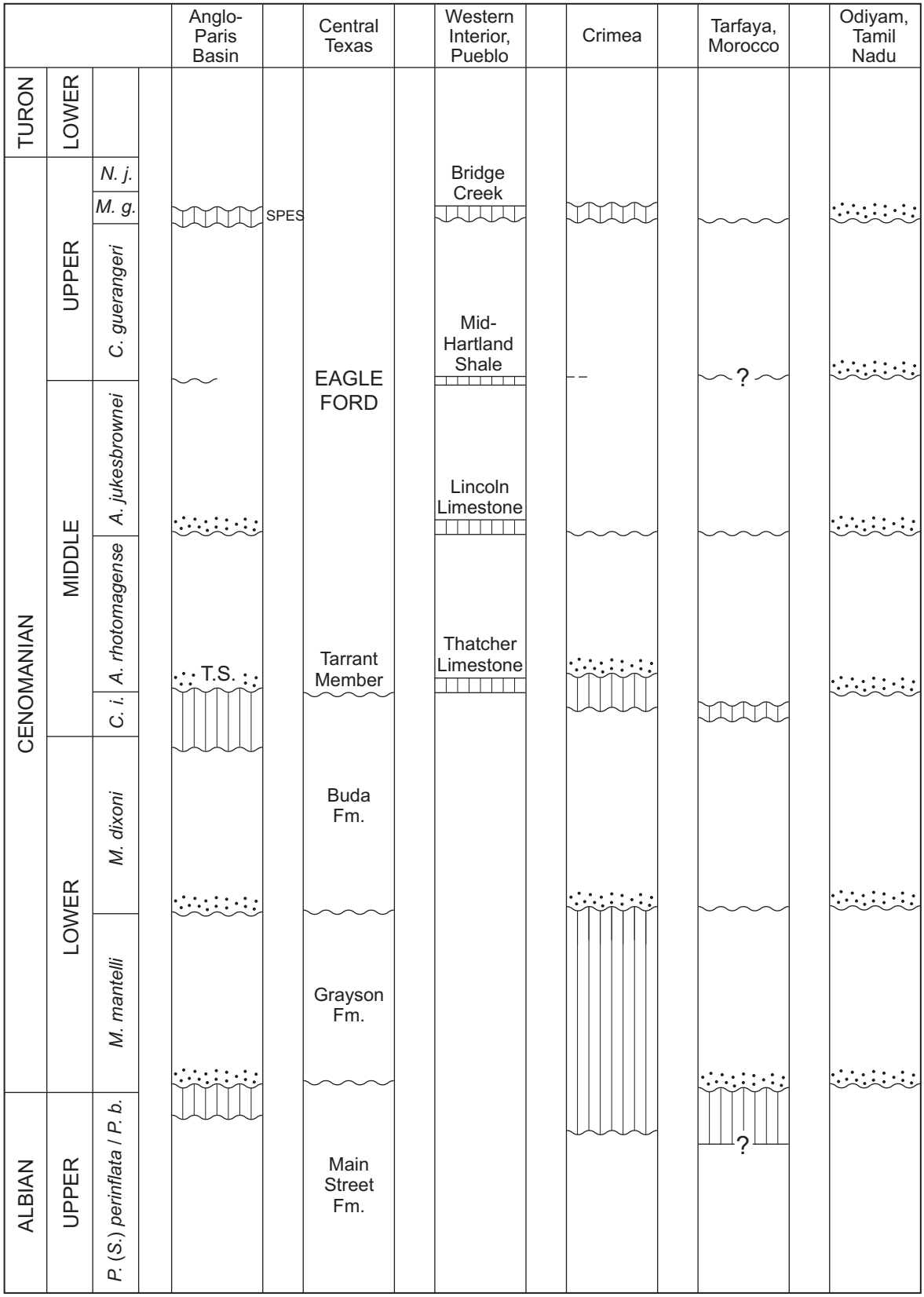
OCCURRENCE: Middle Lower Turonian of Brazil (Hessel 1988), Tamil Nadu, and Madagascar (Walaszczyk *et al*. 2014).

DISCUSSION: THE SEQUENCE STRATIGRAPHY OF THE KARAI FORMATION

Over the past twenty years, it has become evident that marine deposits of Cenomanian age were controlled partly by eustatic sea level changes (e.g. Gale 1995; Robaszynski *et al.* 1998; Wilmsen 2003, 2007; Gale *et al*. 2002, 2008). The evidence for this is based on the precise dating and correlation of erosional surfaces from across the globe using high-resolution ammonite biostratigraphy. Here, we employ the new ammonite records from the Cauvery Basin to identify the equivalent eustatic events in the Odiyam–Kunnam sections.

As to factors controlling eustatic changes in sea level, increasing evidence for global warmth during the mid-Cretaceous makes the presence of polar ice in this interval unlikely, but we are less than convinced by arguments for groundwater storage as a control on Cenomanian sea levels (e.g. Wendler *et al*. 2014, 2016). The presence of these eustatic changes during the Cenomanian thus remains a poorly understood, but well documented phenomenon. The principal indicators of global sea level change in the Cenomanian interval are summarized in Text-fig. 55, and plotted against the standard zonal scheme for Western Europe Details are as follows.

1. The basal Cenomanian erosion surface. In all but deep basinal successions, the lowermost Cenomanian is marked by an erosional surface, often an omission surface or hardground. At some locations, such as Folkestone and Beddingham in southern England, the lowest part of the Cenomanian sequence, the Glauconitic Marl, yields unphosphatized ammonites and other fossils of the lowest, *carcitanense* Subzone of the *mantelli* Zone, so the basal erosion surface there is pre-*carcitanense*. At other localities in south-



Text-fig. 55. Sequence stratigraphy of the Cenomanain Stage in selected areas

ern England such Eastbourne the Glauconitic Marl yields a phosphatized *carcitanense* Subzone fauna; the matrix, where dated, is referred to the succeeding *schlueteri* Subzone of the *mantelli* Zone. The erosion surface has been described in southern England and northern France in the Anglo-Paris Basin (Kennedy 1969, 1970; Robaszynski *et al*. 1998), Crimea, Ukraine and Mangyschlak, Kazakhstan (Gale *et al*. 1999), Iran (Wilmsen *et al.* 2013), Germany (Wilmsen 2003), Morocco (Khunt *et al*. 2009) and Texas. In the last case the top of the Main Street Limestone, which is a hardground (Kennedy *et al*. 2005). Lowermost Cenomanian ammonites of the *carcitanense* Subzone occur above the surface, and latest Albian (*perinflata* or *briacensis* Zone) beneath it. However, in central Texas, the lower Cenomanian ammonite *Graysonites* occurs in the uppermost 2 m of the Main Street Limestone, beneath the hardground (Kennedy *et al*. 2005) where it overlies a *perinflata* Zone fauna. In the Odiyam sections, the correlative surface is overlain by a thin conglomerate (Text-fig. 9, section C–D at the 81 m level, and the lowest Cenomanian ammonites here occur 10 m above the highest *perinflata* Zone fauna.

2. Base *dixoni* Zone surface. Widely developed in the Anglo-Paris Basin (Robaszynski *et al*. 1998), northern Germany (Wilmsen 2003, 2007), across into the Crimea and Mangyschlak (Gale *et al.* 1999). In Texas, the event is marked by the contact between the Grayson Formation and the overlying Buda Limestone (Kennedy *et al*. 2005). The conglomerate developed at the 122 m level in section C–D between Odiyam and Kunnam (Text-fig. 9) is a likely representation of this event in India. Although *Mantelliceras dixoni* is absent, *M. saxbii* is present.

3. *Cunningtoniceras inerme* Zone–lower *Acanthoceras rhotomagense* Zone (*Turrilites costatus* Subzone) erosion surface. This surface often represents the Lower–Middle Cenomanian boundary, as erosion has widely removed the *inerme* Zone (Gale 1995; Wilmsen 2003), and *costatus* Subzone sediments rests directly upon those of the *Mantelliceras dixoni* Zone across northern Europe to central Asia (Gale *et al*. 1999). In the section between Odiyam and Kunnam, conglomerates are well developed around the level of first occurrence of *Turrilites costatus* (Text-fig. 10, section E–F, I–J) and rest upon *Cunningtoniceras inerme* Zone sediments. In the Karai section, the fill of the *asiaticum* Zone channel (Text-figs 4, 5) a deep channel floored by a coral conglomerate, yielded a reworked, phosphatised *Turrilites costatus* and an unphosphatized *Turrilites acutus*. In Morocco, a sharp sea-level fall occurs within the *inerme* Zone (Khunt *et al*. 2009). The surface is also present in Iran (Wilmsen *et al*. 2013). In central Texas, the sharp contact between the Woodbine Formation and the basal Tarrant Member of the Eagle Ford Group (Kennedy and Cobban 1990) represents this break. The basal Tarrant Member is of *Conlinoceras tarrantense* Zone age, equivalent to the *inerme* Zone–*costatus* Subzone in Europe. In the Western Interior Basin, this event is represented by the base of the Thatcher Limestone Member (Gale *et al*. 2008).

4. *Acanthoceras jukesbrownei* Zone erosion surface. This is widely developed across northern Europe, from the Anglo-Paris Basin (Robaszynski *et al*. 1998) through Germany (Wilmsen 2003) east to the Crimea and Mangyschlak, Kazakhstan (Gale *et al*. 1999), and is also present in Morocco (Khunt *et al*. 2009). In the Odiyam sections, thin conglomerates overlying an erosion surface at the base of the range of *Calycoceras planecostatum*, the first occurrence of which is a proxy for the first occurrence of *A. jukesbrownei*, (Text-fig. 10, sections G–H at the 205 m level; section M–N at the 209–211 m level) represent this event. In the Western Interior Basin, this sea level change is recorded by the development of the Lincoln Limestone (Gale *et al.* 2008).

5. Basal upper Cenomanian *guerangeri* Zone hiatus. This event is present locally in the Anglo-Paris Basin (Gale *et al*. 2002, 2008), where it falls at the base of the *Calycoceras guerangeri* Zone. In the sections between Odiyam and Kunnam, a conglomerate of the same age is found at the base of the *harpax* Zone (Text-fig. 11, section O–P at the 246 m level; section Q at the 250 m level).

6. Basal *Metoicoceras geslinianum* event. In the Anglo-Paris Basin, this is called the sub-plenus erosion surface (Jefferies 1962; Robaszynski *et al*. 1998), and the *Fazieswechsel* in Germany (Wilmsen 2003). The erosional event is also widely found in the Crimea and Mangyschlak (Gale *et al*. 1999), and in western Morocco (Khunt *et al*. 2009). In the Western Interior Basin, this is recorded at the base of the Bridge Creek Limestone (Gale *et al.* 2008). In the Odiyam sections in India, a thin conglomerate is present at the base of *septemseriatum* Zone (Text-fig. 11, section O–P, at the 265 m level; section R–S at the 41 m); the index species of which first appears in bed 7 of the Plenus Marls in the Anglo-Paris Basin (Wright and Kennedy 1981, table 2 on p. 119).

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PLATES 1–60

PLATE 1

1, 2, 6-10 – *Phyllopachyceras whiteavesi* (Kossmat, 1897). 1, 2 – OUM KY2511, from section A–B, between Odiyam and Kunnam, upper interval, 0 m level, Upper Albian, *rostrata* Zone; 6-8 – OUM KY2891, section G–H, between Odiyam and Kunnam, 210–212 m level, Middle Cenomanian, *asiaticum* Zone; 9, 10 – OUM KY2543, section A–B, between Odiyam and Kunnam, upper interval, 0–2 m level, Upper Albian, *rostrata* Zone.

3-5 – *Phylloceras* (*Hypophylloceras*) *velledae velledae* (Michelin, 1834), section C–D, between Odiyam and Kunnam, 79 m level, Lower Cenomanian, *mantelli* Zone.

11-18 – *Phylloceras* (*Hypophylloceras*) *seresitense seresitense* Pervinquière, 1907; 11-13 – OUM KY3474, section R–S, between Odiyam and Kunnam, 5–10 m level, Upper Cenomanian, *harpax* Zone; 14, 15 – OUM KY3732, from section C–D, 116 m level, Lower Cenomanian, *mantelli* Zone; 16, 17 – OUM KY6006, from the section on the north side of the Karai–Kulakkalnattam road; 18 – OUM KY4756, section T–U, between Odiyam and Kunnam, Upper Albian, *rostrata* Zone.

Figures 1–10, 14–18 are × 1; figures 11–13 are × 2

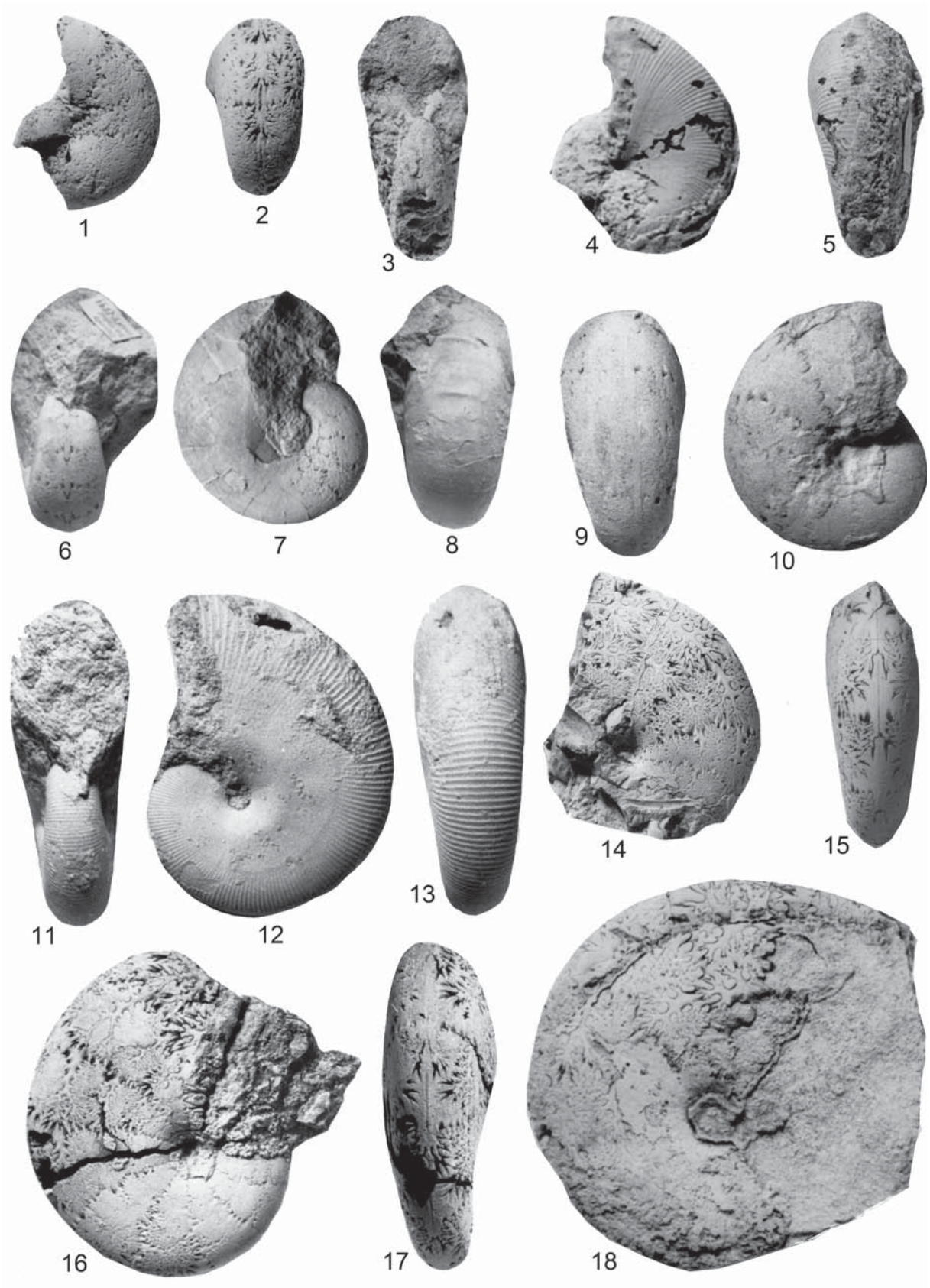
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PLATE 2

1-6 – *Gabbioceras beraketense* (Collignon, 1964). 1-3 – OUM KY3794b; 4-6 – OUM KY3794a, from section C–D, between Odiyam and Kunnam, 116 m level, Lower Cenomanian, *mantelli* Zone.

7-12 – *Tetragonites subtimotheanus* Wiedmann, 1962. 7-9 – OUM KY3965b; 10-12 – OUM KY3965c, both from section A, 4.5 km north-west of Garudamangalam, Upper Cenomanian, *euomphalum* fauna, 16–18 m level.

13, 14, 21, 22 – *Phylloceras* (*Hypophylloceras*) *seresitense seresitense* Pervinquière, 1907. 13, 14 – OUM KY6005b; 21, 22 – OUM KY6005a, from the Lower Cenomanian, section on the north side of the Karai–Kulakkalnattam road.

15-17 – *Phyllopachyceras whiteavesi* (Kossmat, 1897). OUMKY4126a, from section A, 4.5 km north-west of Garudamangalam, Upper Cenomanian, *harpax* Zone, *euomphalum* fauna, 10–20 m level.

18-20 – *Phylloceras* (*Hypophylloceras*) *ellipticum* Kossmat, 1895. OUM KY4125, from section B, 10–20 m level, 4.5 km north-west of Garudamangalam, Middle Cenomanian, *asiaticum* Zone, 10–20 m level.

All figures are × 2


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PLATE 3

1-6 – *Tetragonites subtimotheanus* Wiedmann, 1962. 1 – OUM KY3661, from section C–D, between Odiyam and Kunnam, 79 m level, Lower Cenomanian, *mantelli* Zone; 2-4 – OUM KY3767, from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level; 5, 6 – OUM KY3355, from section O–P, between Odiyam and Kunnam, Upper Cenomanian, *septemseriatum* fauna, 261 m level.

7, 8 – *Gaudryceras* (*Gaudryceras*) *mite* (Hauer, 1866). OUM KY3639, from section R–S, between Odiyam and Kunnam, Lower Turonian, *Neoptychites cephalotus–Mytiloides borkari* fauna, 74 m level.

All figures are × 1


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PLATE 4

1-7 – *Holcodiscoides* sp. juv. 1-3 – OUM KY5386, Upper Albian, *rostrata* Zone, 274–278.5 m level; 4-6 – OUM KY5518, Lower Cenomanian, *mantelli* Zone, 345–350 m level; 7 – OUM KY5594, Lower Cenomanian, *mantelli* Zone, 350.5 – 355 m level.

8-10 – *Marshallites* cf. *papillatus* (Stoliczka, 1865). 8,9 – OUM KY5007, Upper Albian, *rostrata* Zone, 103.5–108 m level; 10 – OUM KY5049, Upper Albian, *rostrata* Zone 110 m level.

11-16 – *Protokossmaticeras* sp. juv. 11 – OUM KY51860, Upper Albian, *rostrata* Zone, 170–175 m level; 12 – OUM KY5183, Upper Albian, *rostrata* Zone, 175–180 m level; 13, 14 – OUM KY5182, Upper Albian, *rostrata* Zone, 175–180 m level; 15, 16 – OUM KY5159, Upper Albian, *rostrata* Zone, 170–175 m level. The originals of 1–16 are from the section north of the Karai–Kulakkalnattam road.

17, 18 – *Cantabrigites spinosum* (Pervinquière, 1907). OUM KY4244, from section D, 4.5 km north-west of Garudamangalam, Upper Albian, *rostrata* Zone, 24 m level.

19-25 – *Desmoceras* (*Desmoceras*) *latidorsatum* (Michelin, 1838). 19-21 – OUM KY3974b; 22, 23 – OUM KY3974a, both from section A, north-west of Garudamangalam, Upper Cenomanian, *euomphalum* fauna, 16–18 m level; 24, 25 – OUM KY4323a, from section D, north-west of Garudamangalam, Middle Cenomanian, *asiaticum* Zone, 149 m level.

All figures are × 2

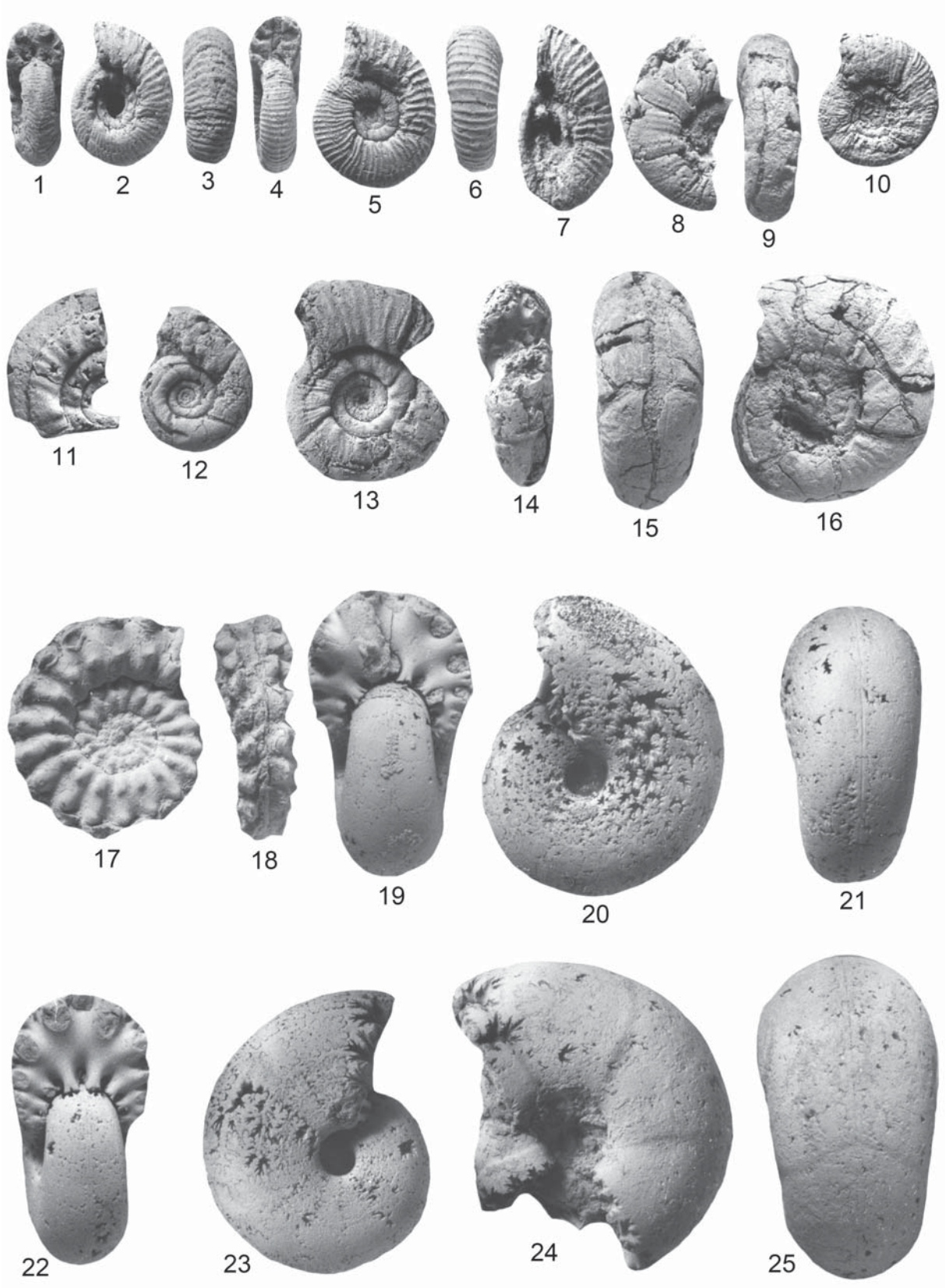
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PLATE 5

1, 2 – '*Gaudryceras*' sp. A. 1 – OUM KY55160a; 2 – OUM KY55160b, both from the Lower Cenomanian, *mantelli* Zone, 345–350 m level.

3 – '*Gaudryceras*' sp. B. OUM KY5552a, Lower Cenomanian, 346–350.5 m level.

4-9 – '*Gaudryceras*' sp. C. 4-6 – OUM KY6007a, Lower Cenomanian; 7, 8 – OUM KY6008a, Lower Cenomanian, 346–350.5 m level; 9 – OUM KY5857, Middle Cenomanian, 400–405 m level.

10, 11 – *Kossmatella marut* (Stoliczka, 1865). 10 – OUM KY5021b; 11 – OUMK KY5021a, both Upper Albian, *rostrata* Zone, 104.5–108 m level.

12-18 – *Puzosia* (*Bhimaites*) *stoliczkai* Kossmat, 1898. 12, 13 – OUM KY5102, Upper Albian, *rostrata* Zone, 138 m level; 14-16 – OUM KY5982a, Lower Cenomanian, *mantelli* Zone; 17-18 – OUM KY5125, Upper Albian, 162–166.5 m level.

19-21 – *Eogaudryceras* (*Eogaudryceras*) sp. OUM KY5141, Upper Albian, *rostrata* Zone, 171–175.5 m level.

All specimens are from the section on the north side of the Karai–Kulakkalnattam road; all figures are × 2

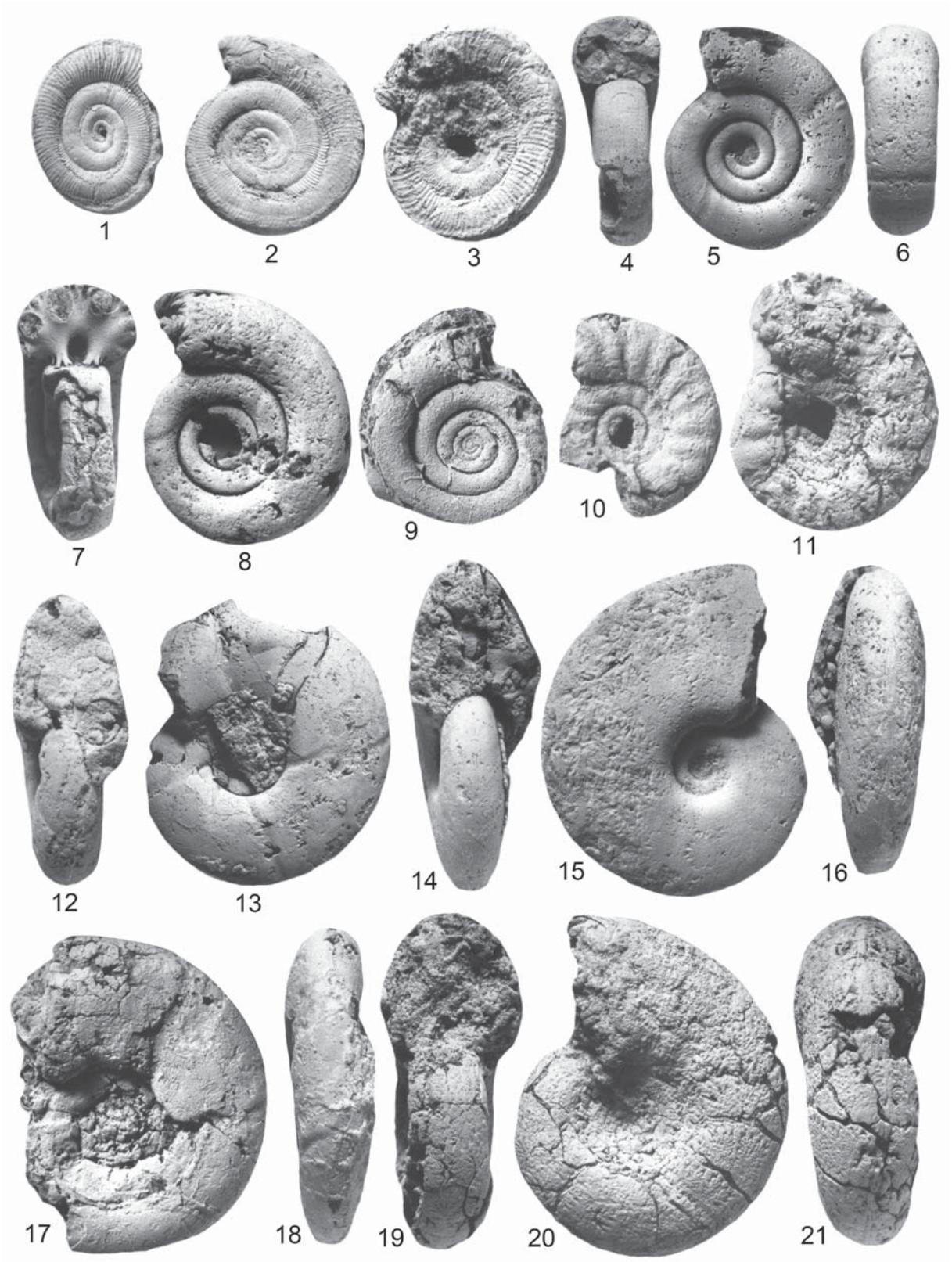
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PLATE 6

1-5, 10, 16 – *Anagaudryceras multiplexum* (Stoliczka, 1865). 1, 2 – OUM KY3005, from section I–J, Middle Cenomanian, *cunningtgoni* Zone, 13 m level; 3-5 – OUM KY2521–22 (parts of one specimen), from section A–B, upper interval, Upper Albian, *rostrata* Zone, 0–2 m level; 10 – OUM KY3548, from section R–S, Upper Cenomanian, *harpax* Zone, 65 m level; 16 – OUM KY2889, from section G–H, Middle Cenomanian, *asiaticum* Zone, 210–212 m level.

6-9, 11-13 – *Anagaudryceras utaturense* Shimizu, 1935. 6, 7 – OUM KY3203, from section M–N, Middle Cenomanian, *asiaticum* Zone, 221 m level; 8 – OUM KY3741, from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level; 9 – OUM KY3744, from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level; 11-13 – OUM KY3202, from section M–N, Middle Cenomanian, *asiaticum* Zone, 221 m level.

14, 15 – *Gaudryceras vertebratum* (Kossmat, 1895). OUM KY6013, from the basal shell bed of the Middle Cenomanian, *asiaticum* Zone channel, section on the north side of the Karai–Kulakkalnattam road.

Unless otherwise indicated, specimens are from sections between Odiyam and Kunnam; figures 1–7, 9, 11–16 are × 1; figure 10 is × 2


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PLATE 7

1-5, 8-11 – *Puzosia* (*Puzosia*) *compressa* Kossmat, 1898. 1-3 – OUM KY2536; 4, 5, 11 – OUM KY2535; 8-10 – OUM KY2540, all from section A, north-west of Garudamangalam, upper interval, Upper Albian, *rostrata* Zone, 0–2 m level.

6, 7 – *Puzosia* (*Puzosia*) *insculpta* Kossmat, 1898. OUM KY2805, from section G–H, between Odiyam and Kunnam, Middle Cenomanian, *asiaticum* Zone, 195–196 m level.

All figures are × 1


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PLATE 8

1-4, 8, 9 – *Puzosia* (*Puzosia*) *crebrisulcata* Kossmat, 1898. 1, 2 – OUM KY2755, section G–H, 170 m level, Middle Cenomanian, *rostrata* Zone; 3, 4 – OUM KY3346, section O–P, 261 m level, Upper Cenomanian, *septemseriatum* Zone; 8, 9 – OUM KY4411, section I–J, 25 m level, Middle Cenomanian, *cunningtoni* Zone.

5-7, 10 – *Puzosia* aff. *crebrisulcata* Kossmat, 1898. OUM KY2785, section G–H, 177–181 m, Middle Cenomanian, *asiaticum* Zone.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1


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PLATE 9

1-8, 10, 11 – *Puzosia* (*Puzosia*) *odiensis* Kossmat, 1898. 1, 2 – OUM KY2739, section G–H, Middle Cenomanian, *asiaticum* Zone, 168–173 m level; 3, 4 – OUM KY4412, section K–L, Middle Cenomanian, *asiaticum* Zone, 10 m level; 5, 6 – OUM KY3063, section M–N, Middle Cenomanian, *asiaticum* Zone, 214–215 m level; 7, 8 – OUM KY2804, 10, 11 – OUM KY2802, both from section G–H, 195–196 m level, Middle Cenomanian, *asiaticum* Zone.

9 – *Goodhallites* cf. *besakatrense* Collignon, 1963, silicone squeeze from OUM KY4572, from section T–U, Upper Albian, *rostrata* Zone, 52 m level.

12, 13 – *Puzosia* (*Mesopuzosia*) sp. – OUM KY3572, from section R–S, Upper Cenomanian, 65 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1


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PLATE 10

1-4 – *Puzosia* (*Puzosia*) *odiensis* Kossmat, 1898. 1, 2 – OUM KY3569; 3 – OUM KY3571; 4 – OUM KY3565, section R–S, Upper Cenomanian, *Hourcqiceras latelobatum–Pseudaspidoceras hourcqi* fauna, 65 m level.

5-7, 10-14 – *Puzosia* (*Bhimaites*) *stoliczkai* Kossmat, 1898. 5-7 – OUM KY4576, section T–U, Upper Albian, *rostrata* Zone, 52 m level; 10, 11 – OUM KY4363, section C–D, Lower Cenomanian, *mantelli* Zone, 79 m level; 12, 13 – OUM KY3729, 14 – OUM KY3728, both section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level.

8-9 – *Puzosia* (*Bhimaites*) *bhima* (Stoliczka, 1865). OUM KY3205, section M–N, Upper Cenomanian, *harpax* Zone, 221 m level.

All specimens are from sections between Odiyam and Kunnam; figures 1–13 are × 1; figure 14 is × 2


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PLATE 11

1-6 – *Desmoceras* (*Desmoceras*) *inane* (Stoliczka, 1865). 1, 2 – OUM KY3547, 3-5 – OUM KY2810, section G–H, Middle Cenomanian, *asiaticum* Zone, 195–196 m level, 6 – OUM KY3546, section R–S, Upper Cenomanian, *Hourcqiceras latelobatum–Pseudaspidoceras hourcqi* fauna, 65 m level.

7-14 – *Desmoceras* (*Desmoceras*) *latidorsatum* (Michelin, 1838). 7-9 – OUM KY3354, section O–P, Upper Cenomanian, *septemseriatum* Zone, 261 m level; 10, 11 – OUM KY2651, section G–H, Middle Cenomanian, *asiaticum* Zone, 168 m level; 12-14 – OUM KY2744, section G–H, Middle Cenomanian, *asiaticum* Zone, 168–173 m level.

All specimens are from sections between Odiyam and Kunnam; figures 1, 2, and 6 are × 2; figures 3-5, 7-14 are × 1


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PLATE 12

1-3, 5, 6 – *Protokossmaticeras* sp. 1 – OUM KY2525, 2, 3 – OUM KY2523, 5, 6 – OUM KY2524, all from section A–B, upper interval, Upper Albian, *rostrata* Zone, 0–2 m level.

4 – *Holcodiscoides* sp. OUM KY4356, from section A–B, lower interval, Upper Albian, *rostrata* Zone. 9.5–10 m level.

7-10 – *Puzosia (Bhimaites) falx* sp. nov. The holotype, OUM KY3209, from section section M–N, Middle Cenomanian, *asiaticum* Zone, 221 m level.

11, 12 – *Holcodiscoides* cf. *cliveanus* (Stoliczka, 1866). OUM KY2495, from section A–B, lower interval, Upper Albian, *rostrata* Zone, 10 m level.

13 – *Marshallites papillatus* (Stoliczka, 1865). OUM KY4563, from section T–U, Upper Albian, *rostrata* Zone, 10 m level.

14, 15 – *Puzosia* (*Bhimaites*) *bhima* (Stoliczka, 1865). OUM KY4404, from section I–J, Middle Cenomanian, *cunningtoni* Zone, 20–21 m level.

16-21 – *Holcodiscoides*? *elegans* sp. nov. The holotype, OUM KY3241, from section O–P, Upper Cenomanian, *footeanum* Zone, 285–286 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1

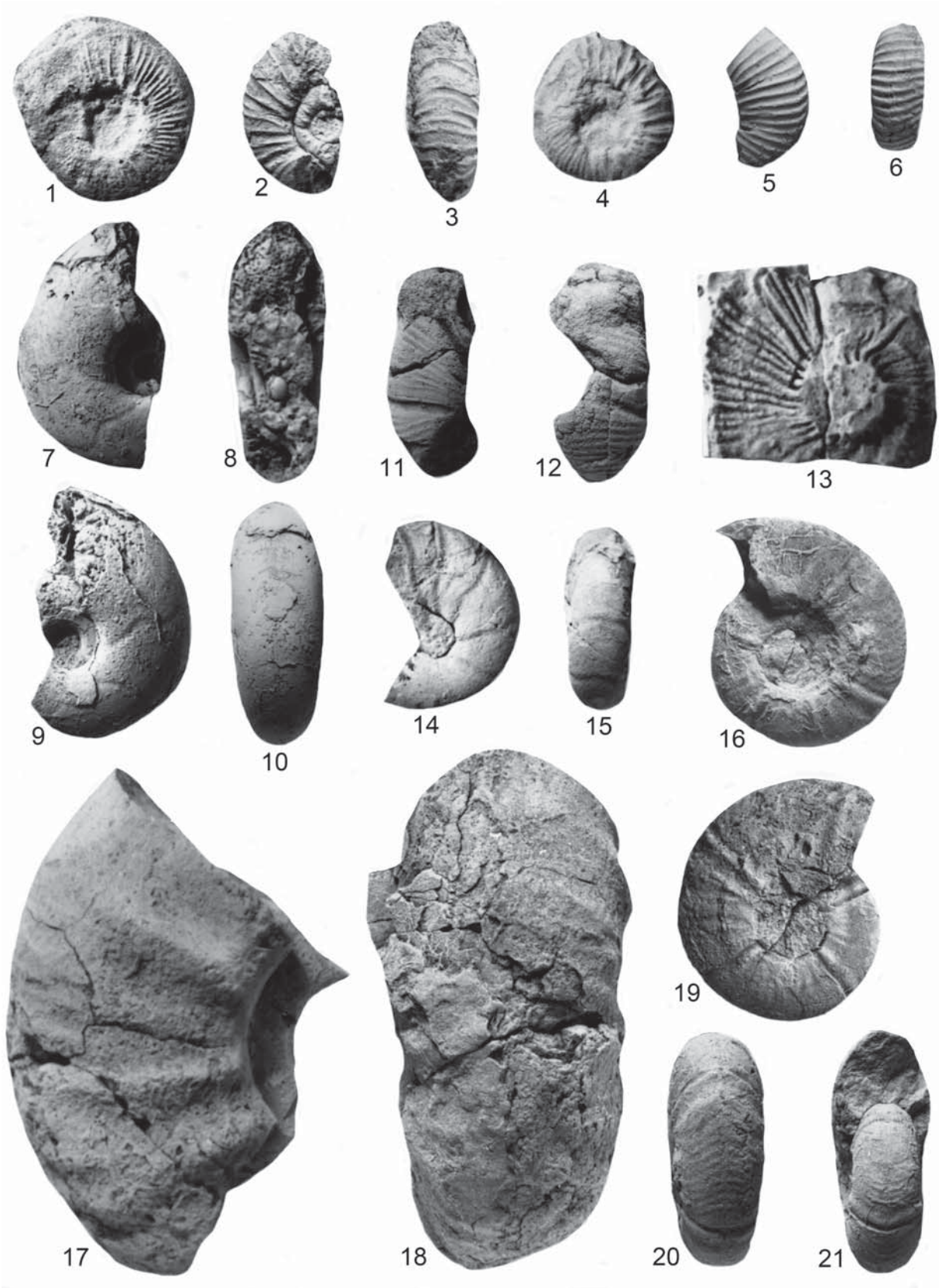
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PLATE 13

Pervinquieria (*Subschloenbachia*) *rostrata* (J. Sowerby, 1817)

OUM KY2499, section A–B between Odiyam and Kunnam, lower interval, Upper Albian, *rostrata* Zone, 13 m level.

The figure is × 1

PLATE 14

1, 2 – *Pervinquieria* (*Subschloenbachia*) *rostrata* (J. Sowerby, 1817). Inner whorls of OUM KY2499, section A–B lower interval, Upper Albian, *rostrata* Zone, 13 m level.

3 – silicone cast, OUM KY3642, of an outcrop external mould of *Pervinquieria* (*Subschloenbachia*) sp. group of *perinflata* (Spath, 1922), section C–D, 68 m level.

4, 5 – *Pervinquieria* (*Pervinquieria*) *stoliczkai* Spath, 1921. 4 – OUM KY2519, 5 – OUM KY2501, both from section A–B, upper interval, Upper Albian, *rostrata* Zone, 0–2 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1


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PLATE 15

Pervinquieria (*Pervinquieria*) *stoliczka*i Spath, 1921

OUM KY2578, from section A–B between Odiyam and Kunnam, upper interval, Upper Albian, *rostrata* Zone, 0–2 m level.

Figures are × 1

PLATE 16

1-4 – *Goodhallites* sp. juv. 1, 2 – OUM KY5045, from the 110 m level; 3, 4 – OUM KY5051, from the 115 m level, section north of the road between Karai and Kulakkalnattam, both Upper Albian, *rostrata* Zone.

5 – *Cantabrigites* sp. juv. OUM KY5218, section north of the road between Karai and Kulakkalnattam, Upper Albian, *rostrata* Zone, 100 m level.

6, 10, 11 – *Mantelliceras* sp. juv. cf. *mantelli* (J.Sowerby, 1814). 6 – OUM KY5531b; 10, 11 – OUM KY5531d, both from the section north of the road between Karai and Kulakkalnattam, Lower Cenomanian, *mantelli* Zone, 345–350 m level.

7-9 – *Algericeras* (*Algericeras*) *besairiei* (Collignon, 1964). OUM KY3795, from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level.

12, 13 – *Mantelliceras* sp. juv. cf. *cantianum* Spath, 1926a. OUM KY5658a, from the section north of the road between Karai and Kulakkalnattam, Lower Cenomanian, *mantelli* Zone, 355–359.5 m level.

14-19 – *Acanthoceras* sp. juv. 14-16 – OUM KY4337, from section D, north-west of Garudamangalam, 49 m level; 17-19 – OUM KY4018, section C, north-west of Garudamangalam, 42–43 m level, both Middle Cenomanian, *asiaticum* Zone.

20-25, 29, 30 – *Calycoceras* (*Calycoceras*) *barruei* (Pervinquière, 1907), 20-22 – OUM KY3928; 23-25 – OUM KY3920a; 29, 30 – OUM KY3920, all from section A, north-west of Garudamangalam, Upper Cenomanian, *harpax* Zone, *euomphalum* fauna, 16–18 m level.

26, 27 – *Eucalycoceras gothicum* (Kossmat, 1895). OUM KY4039, from section C, north-west of Garudamangalam, Middle Cenomanian, *asiaticum* Zone, 42–43 m level.

28 – *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Kossmat, 1897). OUM KY4042, section C, north-west of Garudamangalam, Middle Cenomanian, *asiaticum* Zone, 42–43 m level.

All figures are × 2

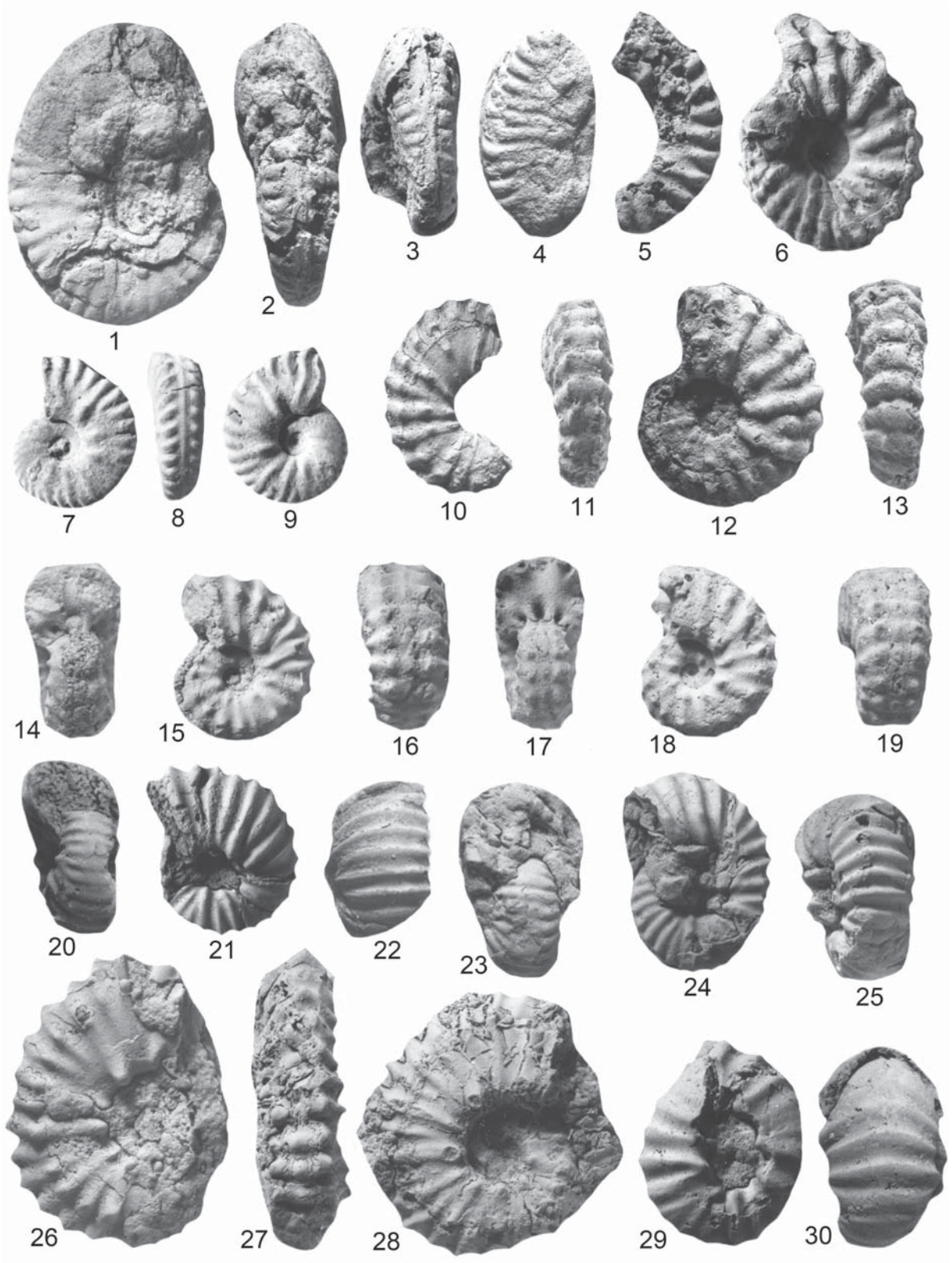
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PLATE 17

1-7, 15 – *Stoliczkaia* (*Lamnayella*) *crotaloides* (Stoliczka, 1864). 1-4 – VP 50a; 5-7 – VP 50b, from the upper Albian in the area between Odiyam and Kunnam; 15 – OUM KY2533, from section A–B, between Odiyam and Kunnam, Upper Albian, *rostrata* Zone, 0–2 m level.

8, 9 – *Ojinagiceras* sp. cf. *ojinagaense* Cobban and Kennedy, 1989. OUM KY3683, from section C–D, between Odiyam and Kunnam, Lower Cenomanian, *mantelli* Zone, 90 m level.

10-14 – *Stoliczkaia* (*Lamnayella*) *clavigera* (Neumayr, 1875). 10, 11 – OUM KY3649, from section C–D, between Odiyam and Kunnam, Lower Cenomanian, *mantelli* Zone, 69 m level; 12 – OUM KY2532, from section A–B**,** between Odiyam and Kunnam, upper interval, Upper Albian, *rostrata* Zone, 0–2 m level; 13, 14 – OUM KY3649, from section C–D, between Odiyam and Kunnam, Lower Cenomanian, *mantelli* Zone, 70–75 m level.

Figures 1–7, 10–15 are × 1; figures 8, 9, are × 2

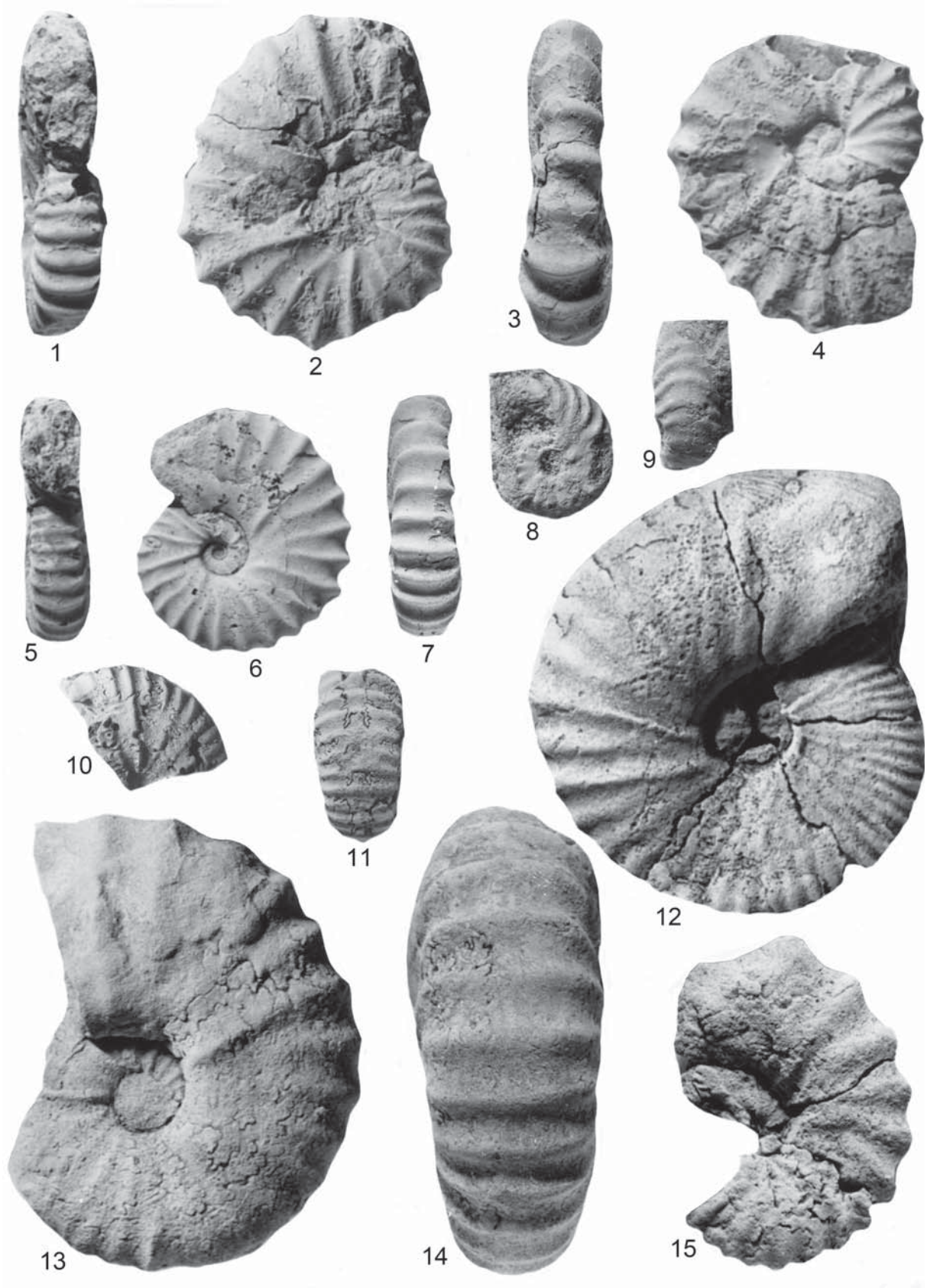
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PLATE 18

1, 2, 6-13 – *Forbesiceras largilliertianum* (d'Orbigny, 1841). 1 – OUM KY3725; 2 – OUM KY3726; 6, 7, 10 – OUM KY3773a; 8, 9 – OUM KY3773b; 11 – OUM KY3727; 12, 13 – OUM KY3771, all from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level.

3-5 – *Forbesiceras chevillei* (Pictet and Renevier, 1866). OUM KY2719a, from section G–H, Middle Cenomanian, *asiaticum* Zone, 172–175 m level (see also Pl. 19, Figs 1–3).

14 – *Mantelliceras cantianum* Spath, 1926a. OUKM KY2576, from section E–F, Lower Cenomanian, *mantelli* Zone, 132.5 m level.

All specimens are from sections between Odiyam and Kunnam; figures 1–5, 8–14 are × 1; figure 6 is × 2

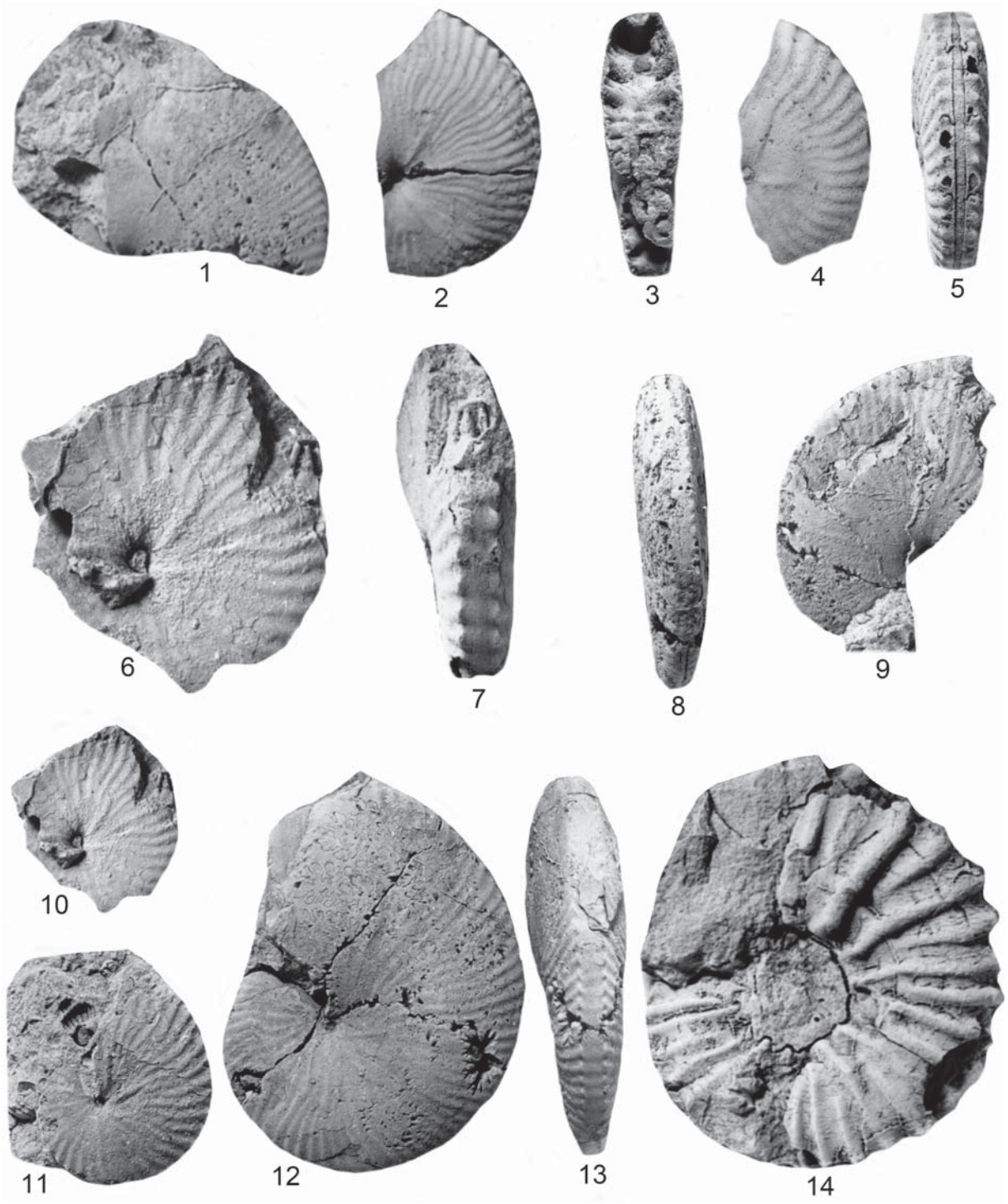
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PLATE 19

Forbesiceras chevillei (Pictet and Renevier, 1866)

1-3 – OUM KY2719 (see also Pl. 18, Figs 3–5); 4-6 – OUM KY2700, 169 m level; 7, 8 – OUM KY2767, all from section G–H between Odiyam and Kunnam, Middle Cenomanian, *asiaticum* Zone, 173–175 m level.

All figures are × 1


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PLATE 20

1, 2, 9-11 – *Mantelliceras saxbii* (Sharpe, 1857). 1, 2 – OUM KY4379, from section C–D, 127 m level; 9, 10 – OUM KY3808, from section C–D, 133 m level; 11 – OUM KY2575, from section E–F, 132.5 m level.

3, 4, 7, 8 – *Mantelliceras cantianum* Spath, 1926a. 3, 4 – OUM KY3762, from section C–D, 161 m level; 7, 8 – OUM KY3760, from section C–D, 116 m level. **5, 6** – *Mantelliceras mantelli* (J. Sowerby, 1814). OUM KY3764, from section C–D, 116 m level (see also Pl. 21, Figs 2, 3).

12 – *Utaturiceras vicinale* (Stoliczka, 1864). OUM KY4359, from section C–D, 79 m level (see also Pl. 23, Fig. 6).

All specimens are from the Lower Cenomanian, *mantelli* Zone, in sections between Odiyam and Kunnam; all figures are × 1


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PLATE 21

1, 8 – *Mantelliceras lymense* (Spath, 1926b). OUM KY3761, from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level.

2, **3** – *Mantelliceras cantianum* Spath, 1926a. OUM KY3760 (see also Pl. 20, Figs 5, 6), from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level.

4, 5 – *Mantelliceras mantelli* (J. Sowerby, 1814). OUM KY3755a, from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level.

6, 7 – *Sharpeiceras* sp. OUM KY2646, from section G–H, Lower Cenomanian, *mantelli* Zone, 160 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1


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PLATE 22

1, 2 – *Mantelliceras* cf. *picteti* Hyatt, 1903. OUM KY2578, a pathological individual from section E–F, between Odiyam and Kunnam, Lower Cenomanian, *mantelli* Zone, 148 m level.

3, 4 – *Mantelliceras lymense* (Spath, 1926b). OUM KY3763, from section C–D, between Odiyam and Kunnam, Lower Cenomanian, *mantelli* Zone, 116 m level.

5, 6 – *Sharpeiceras indicum* (Kossmat, 1895). A cast (OUM KY2646) of the original of Kossmat 1897, pl. 24 (10), fig. 5, GSI 14829, from Odiyam.

All figures are × 1


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PLATE 23

Utaturiceras vicinale (Stoliczka, 1864)

1-3 – OUM KY3656; 4, 5 – OUM KY3657; 6 – OUM KY4359 (see also Pl. 20, Fig. 5); 7, 8 – OUM KY3655. All are from section C–D, between Odiyam and Kunnam, Lower Cenomanian, *mantelli* Zone, 79 m level.

All figures are × 1


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PLATE 24

1-4, 8 – *Acompsoceras renevieri* (Sharpe, 1857). 1, 2 – OUM KY3660, 3 – OUM KY3659, both from the 79 m level; 8 – OUM KY4364, from the 82 m level, all from section C–D, Lower Cenomanian, *mantelli* Zone.

5 – *Utaturiceras vicinale* (Stoliczka, 1864). OUM KY3656, from section C–D, Lower Cenomanian, *mantelli* Zone, 79 m level.

6, 7 – *Calycoceras* (*Newboldiceras*) *tunetanum* (Pervinquière, 1907). OUM KY2816, from section G–H, Middle Cenomanan, *asiaticum* Zone, 205 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1


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PLATE 25

Cunningtoniceras cunningtoni (Sharpe, 1855)

OUM KY3020, from section I–J, between Odiyam and Kunnam, Middle Cenomanian, *cunningtoni* Zone, 20.5 m level.

Figures are × 1

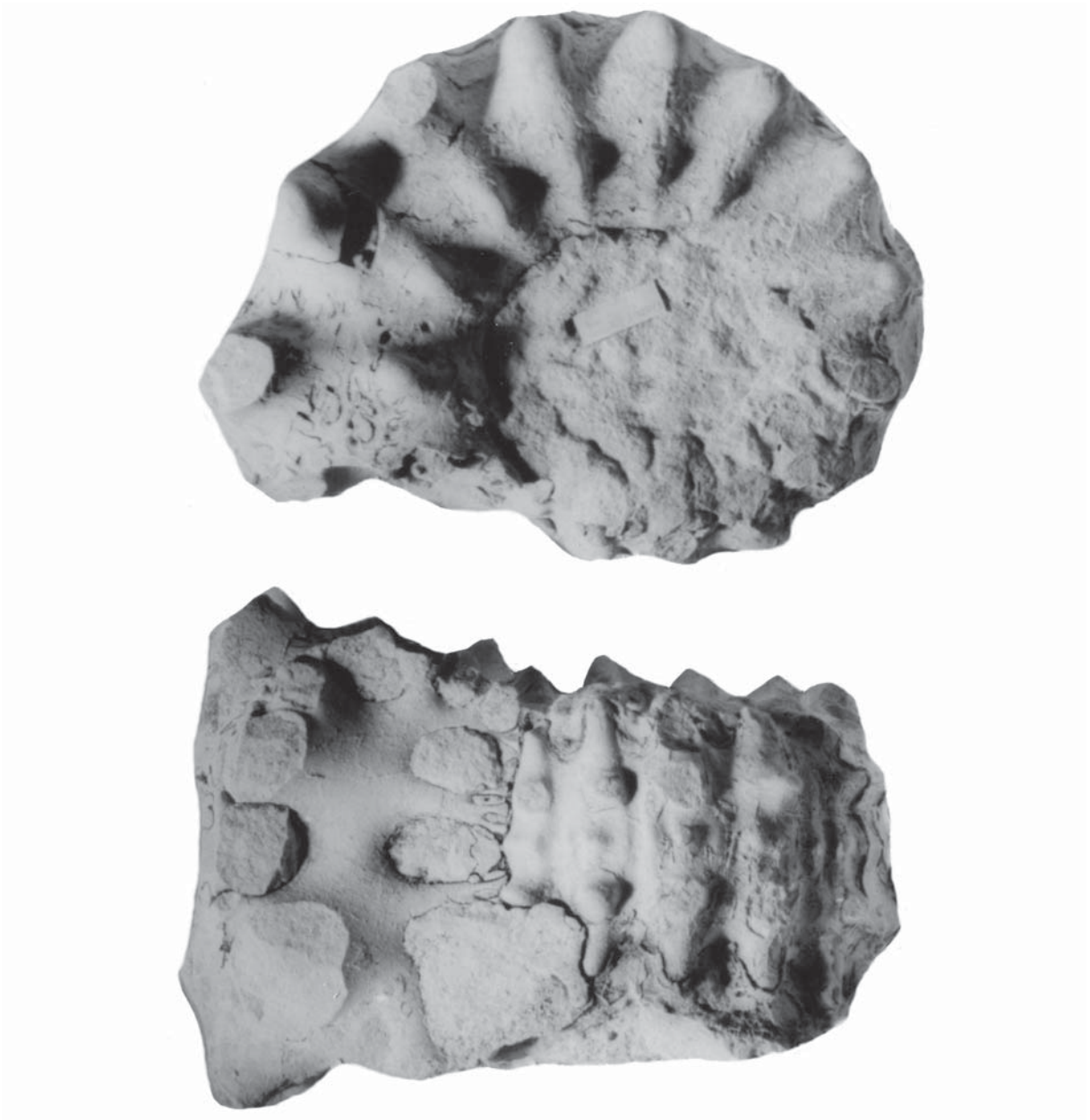

PLATE 26

Cunningtoniceras cunningtoni (Sharpe, 1855)

OUM KY3019, from section I–J, between Odiyam and Kunnam, Middle Cenomanian, *cunningtoni* Zone, 20.5 m level.

Figures are reduced × 0.9; the original is 145 mm in diameter

PLATE 27

1-4 – *Cunningtoniceras cunningtoni* (Sharpe, 1855). 1, 2 – OUM KY4398, a pathological individual from section I–J between Odiyam and Kunnam, Middle Cenomanian, *cunningtoni* Zone, 20–21 m level.

3, 4 – OUM KY6304, Middle Cenomanian, *cunningtoni* Zone, section north of the road between Karai and Kulakkalnattam, 408 m level.

5-8 – *Cunningtoniceras* sp. OUM KY2706, from section G–H, between Odiyam and Kunnam, Middle Cenomanian, *asiaticum* Zone, 169 m level.

All figures are × 1


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PLATE 28

1-4, 8 – *Acanthoceras whitei* Matsumoto, 1969. 1, 2, 8 – OUM KY2775, from the 175 m level; 3, 4 – OUM KY2688, from the 170–175 m level.

5-7, 9, 10 – *Acanthoceras rhotomagense* (Brongniart, 1822). 5, 6 – OUM KY2790, from the 177–181 m level; **7** – OUM KY2689, from the 170–175 m level; 9, 10 – OUM KY2778, from the 177 m level.

All specimens are from section G–H, between Odiyam and Kunnam, Middle Cenomanian, *asiaticum* Zone; all figures are × 1


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PLATE 29

1-4, 15, 16 – *Protacanthoceras parva* sp. nov. 1-4 – paratype OUM KY3198; 15, 16 – the holotype, OUM KY3201, both from section M–N, between Odiyam and Kunnam, at the 221 m level, Middle Cenomanian, *asiaticum* Zone.

5-8 – *Kunnamiceras tropicum* (Stoliczka, 1865). OUM KY3473, from section R–S, Upper Cenomanian, *harpax* Zone, 5–10 m level.

9-14 – *Watinoceras elegans* sp. nov. 9-12 – the holotype, OUM KY3377; 13, 14 – paratype, OUM KY3379, both from section O–P, Upper Cenomanian, *septemseriatum* Zone (?), 265 m level.

Figures 1–4, 6–8, 15, 16, are × 2; figures 5, 9–14 are × 1


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PLATE 30

1-6 – *Calycoceras* (*Calycoceras*) *bathyomphalum* (Kossmat, 1897). 1-3 – cast (OUM KY4702) of the lectotype, GSI 14834, from the Uttatur Group south of Uttatur; 4 – OUM KY2865, 5, 6 – OUM KY2684, both from section G–H, Middle Cenomanian, *asiaticum* Zone, 200–210 m level.

7, 8 – *Calycoceras* (*Gentoniceras*) *boehmi* (Spath, 1926b). OUM KY2783, from section G–H, Middle Cenomanian, *asiaticum* Zone, 177–181 m level.

9-13 – *Calycoceras* (*Calycoceras*) *naviculare* (Mantell, 1822). 9, 10 – OUM KY3502; 11-13 – OUM KY3492, both from section R–S, Upper Cenomanian, *harpax* Zone, 19 m level.

All specimens are from sections between Odiyam and Kunnam; figures 1–3, 7–13 are x 1; figures 5 and 6 are × 2

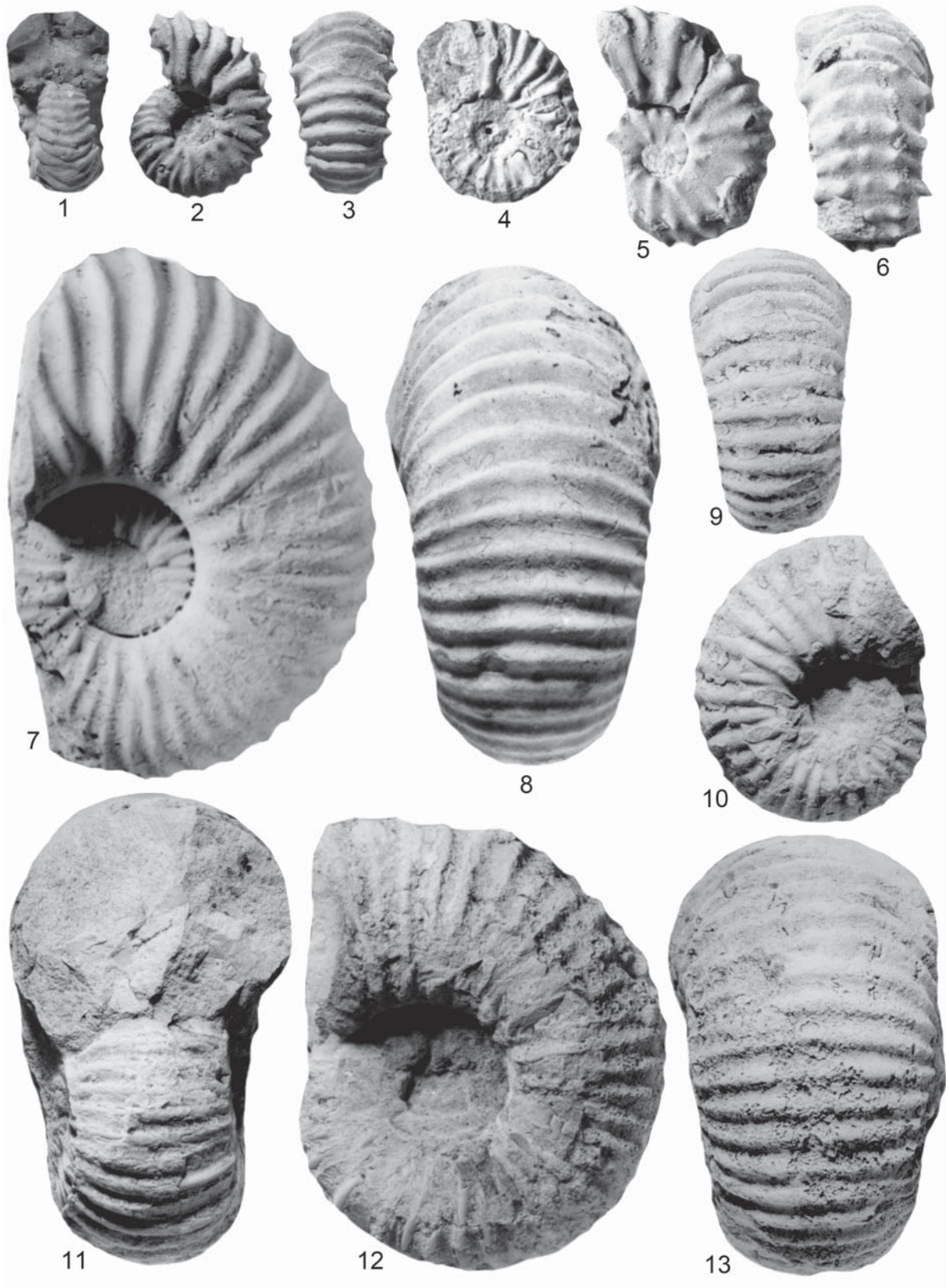
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PLATE 31

Calycoceras (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894)

OUM KY2873 from section G–H, Middle Cenomanian, *asiaticum* Zone, 196–200 m level. Phragmocone of a macroconch.

Figures are × 1

PLATE 32

1-3 – *Calycoceras* (*Proeucalycoceras*) *choffati* (Kossmat, 1897). Cast (OUM KY4704) of the holotype, GSI 1488, the original of Kossmat 1897, pl. 15 (4), fig. 1.

4, 5 – *Calycoceras* (*Newboldiceras*) *planecostatum* (Kossmat, 1897), cast (OUM KY4703) of the lectotype, GSI 14842, the original of Kossmat 1897, pl. 2 (13), fig. 1. Both originals are from the Uttatur Group of Odiyam.

All figures are × 1

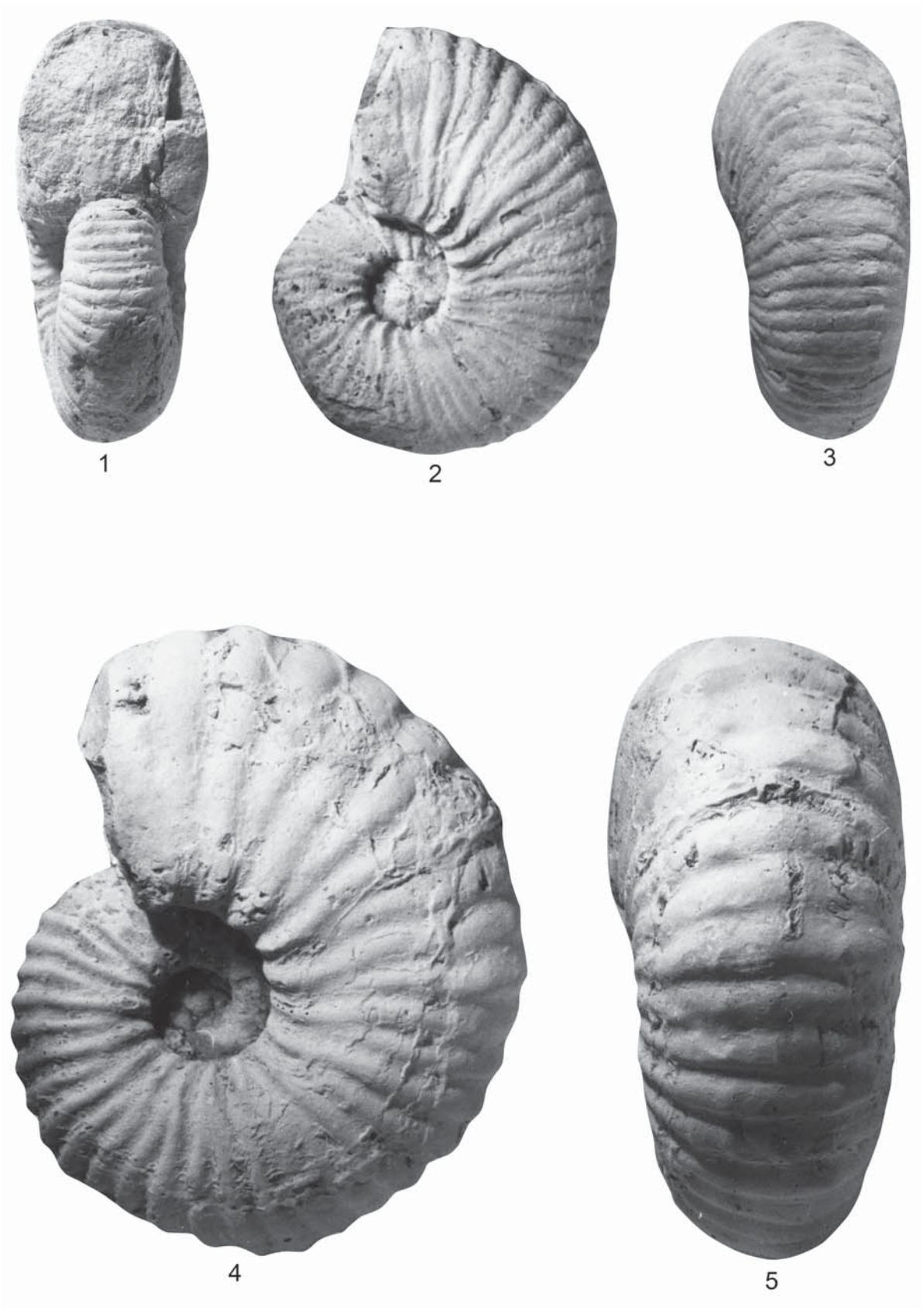
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PLATE 33

1, 2, 11, 12 – *Calycoceras* (*Newboldiceras*) *asiaticum asiaticum* (Jimbo, 1894). 1, 2 – OUM KY2894, from section G–H, at the 210–212 m level; 11, 12 – OUM KY2758, from section G–H at the 171 m level.

3-10 – *Calycoceras* (*Newboldiceras*) *planecostatum* (Kossmat, 1897). 3 – OUM KY3222 from the 221 m level; 4, 5 – OUM KY3149; 6-8 – OUM KY3154, both from the 214–216 m level; 9, 10 – OUM KY3225, from the 221 m level, section M–N, all from the Middle Cenomanian, *asiaticum* Zone in sections between Odiyam and Kunnam.

All figures are × 1

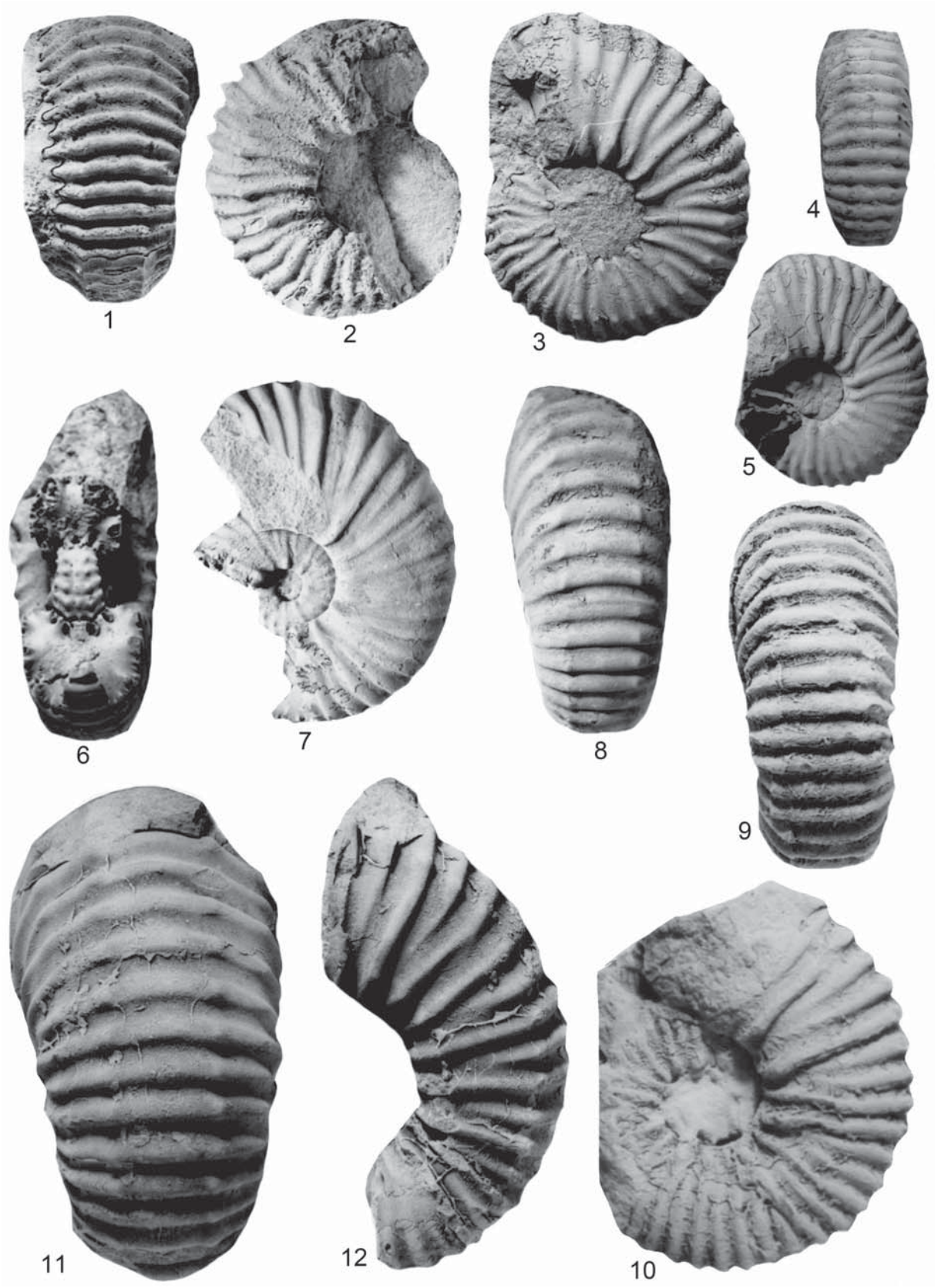
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PLATE 34

Calycoceras (*Newboldiceras*) *planecostatum* (Kossmat, 1897)

OUM KY3140, from section M–N, between Odiyam and Kunnam, Middle Cenomanian, *asiaticum* Zone, 214–216 m level.

Figures are × 1

PLATE 35

Calycoceras (*Newboldiceras*) *planecostatum* (Kossmat, 1897)

OUM KY3212, from section M–N between Odiyam and Kunnam, Middle Cenomanian, *asiaticum* Zone, 221 m level.

Figures are × 1

PLATE 36

Calycoceras (*Newboldiceras*) *tunetanum* (Pervinquière, 1907)

OUM KY2808, from section G–H between Odiyam and Kunnam, Middle Cenomanian, *asiaticum* Zone, 195–196 m level.

Figures are × 1

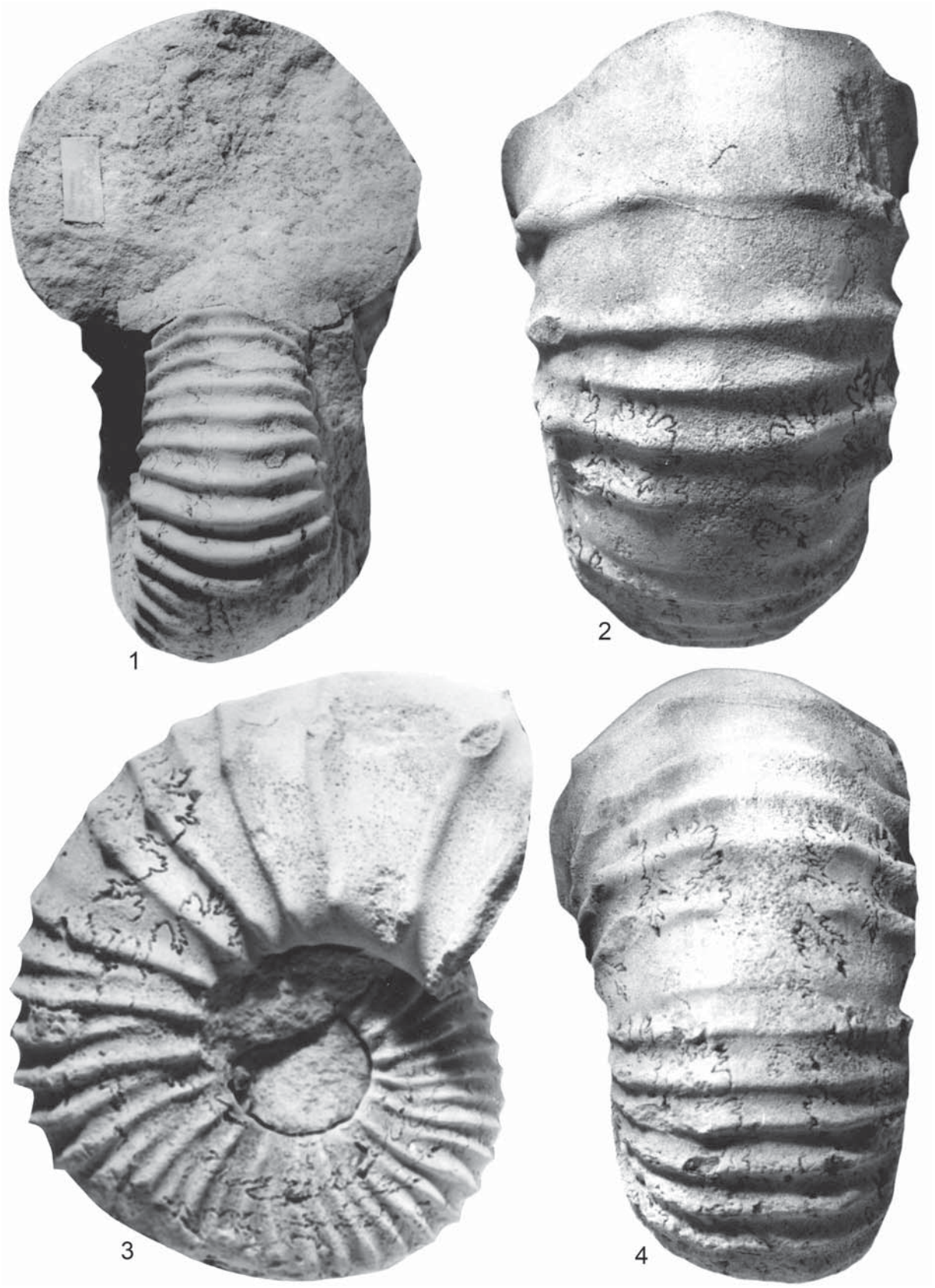
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PLATE 37

1, 2 – *Calycoceras* (*Newboldiceras*) *tunetanum* (Pervinquière.1907). OUM KY2799, from section G–H, Middle Cenomanian, *asiaticum* Zone, 187 m level.

3, 4 – *Calycoceras* (*Gentoniceras*) *boehmi* (Spath, 1926b). OUM KY3054, from section M–N, Middle Cenomanian, *asiaticum* Zone, 215 m level.

5, 6 – *Cunningtoniceras cunningtoni* (Sharpe, 1855). OUM KY3001, from section I–J, Middle Cenomanian, *cunningtoni* Zone, 13 m level.

All figures are × 1


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PLATE 38

Pseudocalycoceras harpax (Stoliczka, 1864)

1 – OUM KY3454, from section R–S, 8 m level; 2, 3 – OUM KY3481, from section R–S, 6–8 m level; 4, 10 – OUM KY3263, from section O–P, 246 m level; 7 – OUM KY3457, from section R–S, 5–10 m level; 8, 9 – OUM KY3435, from section R–S, 4.5 m level; all specimens are from the Upper Cenomanian, *harpax* Zone between Odiyam and Kunnam. 5, 6 – cast (OUM KY960) of GSI 14843 the original of Kossmat 1897, pl. 4 (15), fig. 2, from the Uttatur Group of Odiyam.

Figures 1–3, 5–9 are × 1; figures 4 and 10 are × 2


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PLATE 39

Eucalycoceras pentagonum (Jukes-Browne, 1896)

1, 2 – OUM KY3464, 5–10 m level; 3, 4 – OUM KY4546, 28 m level; 5, 6 – OUM KY3491, 5–10 m level; 7, 8 – OUM KY3465, 5–10 m level; 9, 10 – OUM KY3489, 19 m level; all specimens are from section R–S , between Odiyam and Kunnam, Upper Cenomanian, *harpax* Zone.

All figures are × 1


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PLATE 40

1-7 – *Tarrantoceras* (*Sumitomoceras*) *faustum* Matsumoto and Muramoto, 1969. 1-3 – OUM KY3339; 4 – OUM KY3342, 5 – OUM KY3341, all from section O–P, Upper Cenomanian, *septem-seriatum* Zone, 261 m level. 6, 7 – OUM KY3505, section R–S, Upper Cenomanian, ?post-*harpax* Zone, 26.5 m level.

8-10 – *Eucalycoceras gothicum* (Kossmat, 1895). Cast (OUM KY4701) of GSI 14833, the holotype, the original of Kossmat's (1895) pl. 25 (11), fig. 3, from the Middle Cenomanian, *Acanthoceras* beds of Odiyam.

11, 12 – *Eucalycoceras pentagonum* (Jukes-Browne, 1896). OUM KY3463, from section R–S, Upper Cenomanian, *harpax* Zone, 19 m level.

Figures 1–7, 11, 12 are from sections between Odiyam and Kunnam; all figures are × 1

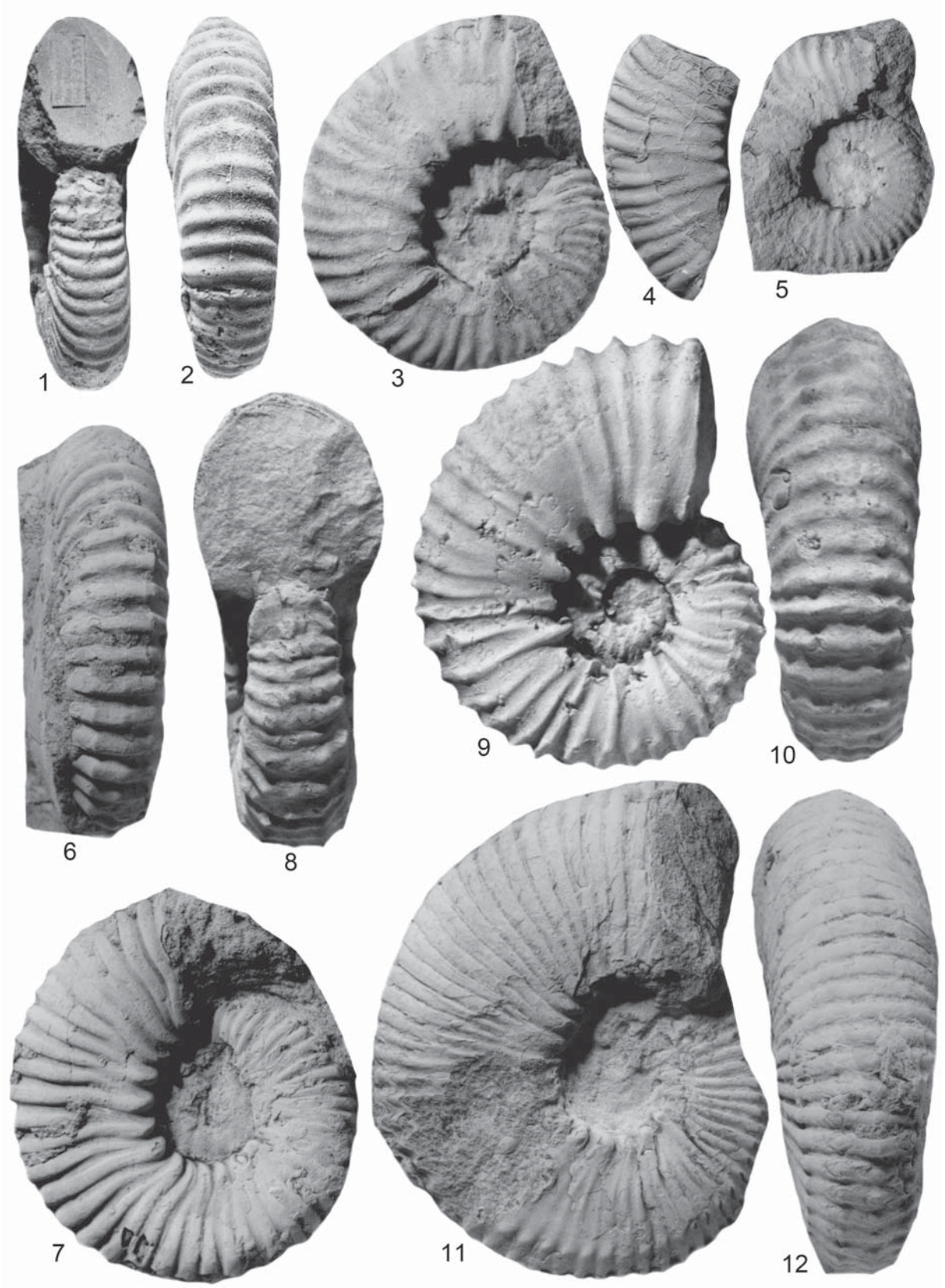
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PLATE 41

1-3, 6-8 – *Euomphaloceras varicostatum* sp. nov. 1-3 – the holotype, OUM KY3562; 6-8 – paratype OUM KY3558, both from section R–S, Upper Cenomanian, *Hourcqiceras latelobatum–Pseudaspidoceras hourcqi* fauna, 65 m level.

4, 5 – *Euomphaloceras septemseriatum* (Cragin, 1893). OUM KY3358, from section O–P, Upper Cenomanian, *septemseriatum* Zone, 261 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1

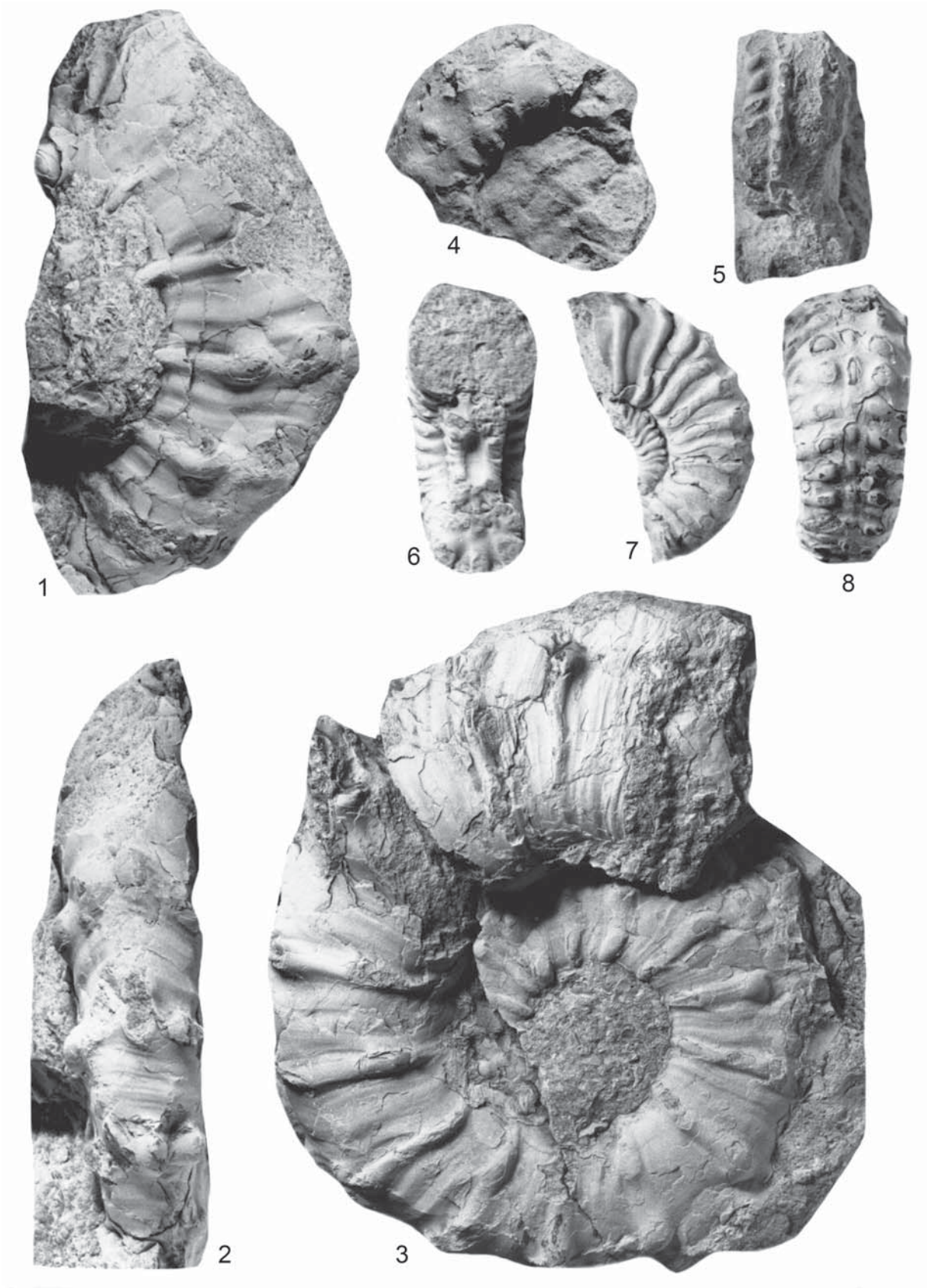
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PLATE 42

1, 3, 7-12 – *Lotzeites aberrans* (Kossmat, 1895). 1 – OUM KY3468; 3 – OUM KY3470, both from section R–S, Upper Cenomanian, *harpax* Zone, 5–10 m level. 7-9 – cast (OUM KY4700) of the holotype, GSI 14828, the original of Kossmat 1895, pl. 24 (10), fig. 4, from the Uttatur Group of Odiyam. 10-12 – OUM KY3313, from section O–P, Upper Cenomanian, *harpax* Zone, 250 m level.

2, 4-6 – *Euomphaloceras varicostatum* sp. nov. 2 – paratype OUM KY3553; 4 – paratype OUM KY3555; 5 – paratype OUM KY3554; 6 – paratype OUM KY3561, all from section R–S, Upper Cenomanian, *Hourcqiceras latelobatum* – *Pseudaspidoceras hourcqi* fauna, 65 m level.

All specimens are from sections between Odiyam and Kunnam; figures 1, 2, 4–6 are × 2; figures 3, 7–12 are × 1

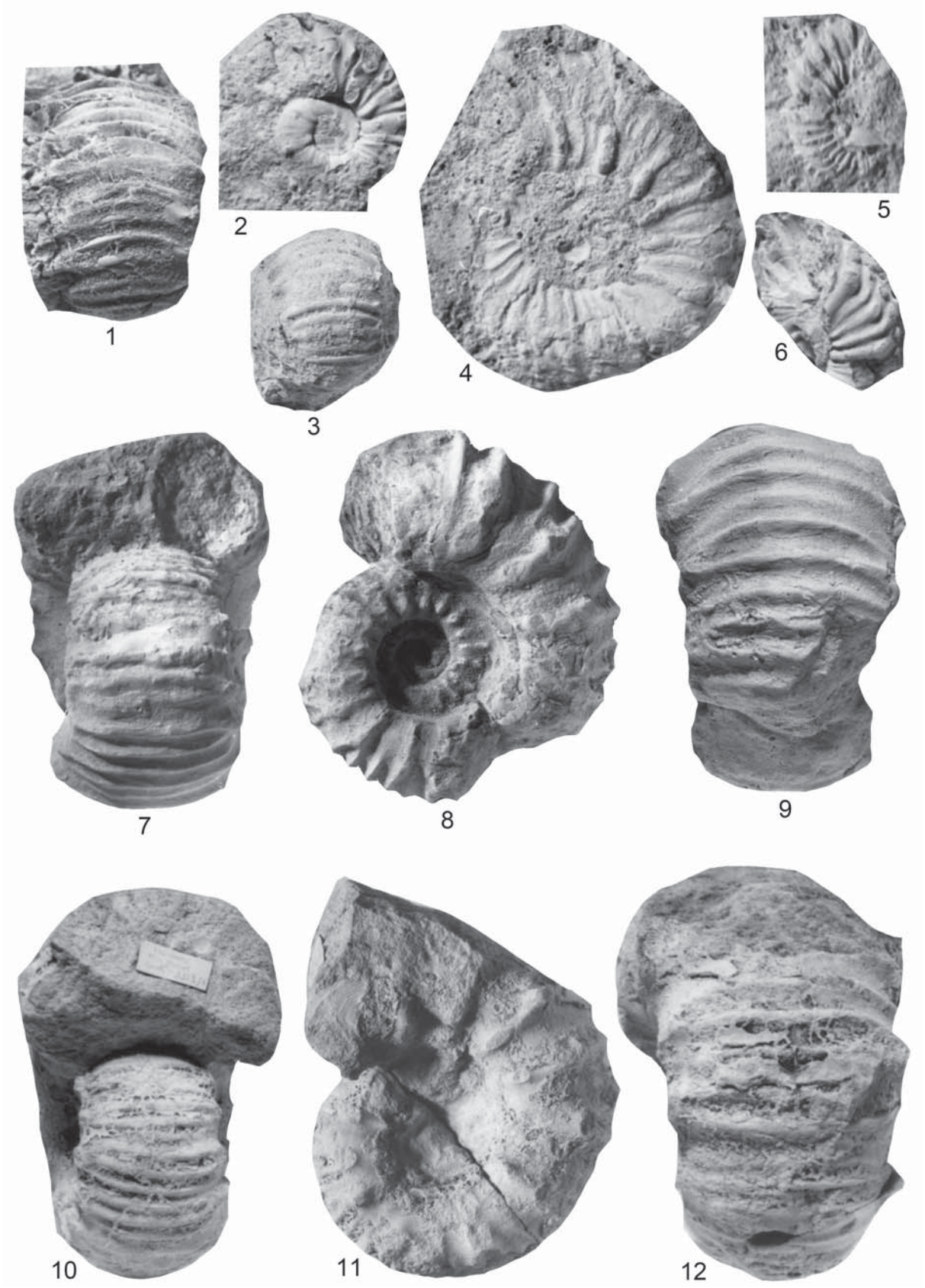
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PLATE 43

1-3, 6, 7 – *Hourcqiceras coleroonensis* (Stoliczka, 1864). 1, 2 – OUM KY3380; 3 – OUM KY3378, both from section O–P, Upper Cenomanian, *footeanum* Zone (?), 265 m level; 6, 7 – VJ OD188, *ex-situ*, Odiyam.

4, 5 – *Hourcqiceras latelobatum* Collignon, 1939. OUM KY3551 from section R–S, Upper Cenomanian, *Hourcqiceras latelobatum – Pseudaspidoceras hourcqi* fauna, 65 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1


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PLATE 44

1-4 – *Pseudaspidoceras footeanum* (Stoliczka, 1864). 1-3 – VP Ku100, *ex-situ*, Kunnam; 4 – OUM KY3390, from section O–P, Upper Cenomanian, *footeanum* Zone, 267–269 m level.

5, 6 – *Hourcqiceras coleroonensis* (Stoliczka, 1864). OUM KY3368, from section O–P, Upper Cenomanian, *footeanum* Zone, 267–269 m level. All specimens are from sections between Odiyam and Kunnam.

All figures are × 1


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PLATE 45

1, 2 – *Eucalycoceras* cf. *jeanneti* (Collignon, 1939). OUM KY3376, from section O–P, Upper Cenomanian, *footeanum* Zone, 267–269 m level.

3, 4 – *Hourcqiceras* sp. OUM KY3550, from section R–S, Upper Cenomanian, *Hourcqiceras latelobatum – Pseudaspidoceras hourcqi* fauna, 65 m level.

5, 6 – *Hourcqiceras coleroonensis* (Stoliczka, 1864). VP Kn 2, *ex-situ*, Kunnam (see also Pl. 47, Figs 3, 4).

7, 8 – *Pseudaspidoceras hourcqi* (Collignon, 1939). OUM KY3563, from section R–S, Upper Cenomanian, *Hourcqiceras latelobatum–Pseudaspidoceras hourcqi* fauna, 65 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1


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PLATE 46

Pseudaspidoceras footeanum (Stoliczka, 1864)

Cast (OUM KY889) of the lectotype, GSI 213, the original of Stoliczka, 1864, pl. 52, fig. 1, from the Uttatur group north of Odiyam.

Reduced × 0.54; the original is 260 mm in diameter

PLATE 47

1, 2 – *Kamerunoceras multicostatum* sp. nov. The holotype, OUM KY4549, from section R–S, Lower Turonian, *Neoptychites cephalotus–Mytiloides mytiloides* fauna, 74 m level.

3, 4 – *Hourcqiceras coleroonensis* (Stoliczka, 1864). VP Kn 2, *ex-situ*, Kunnam (see also Pl. 45, Figs 5, 6).

5, 6 – *Kamerunoceras turoniense* (d'Orbigny, 1850). VP Kn101 *ex-situ*, from Kunnam.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1

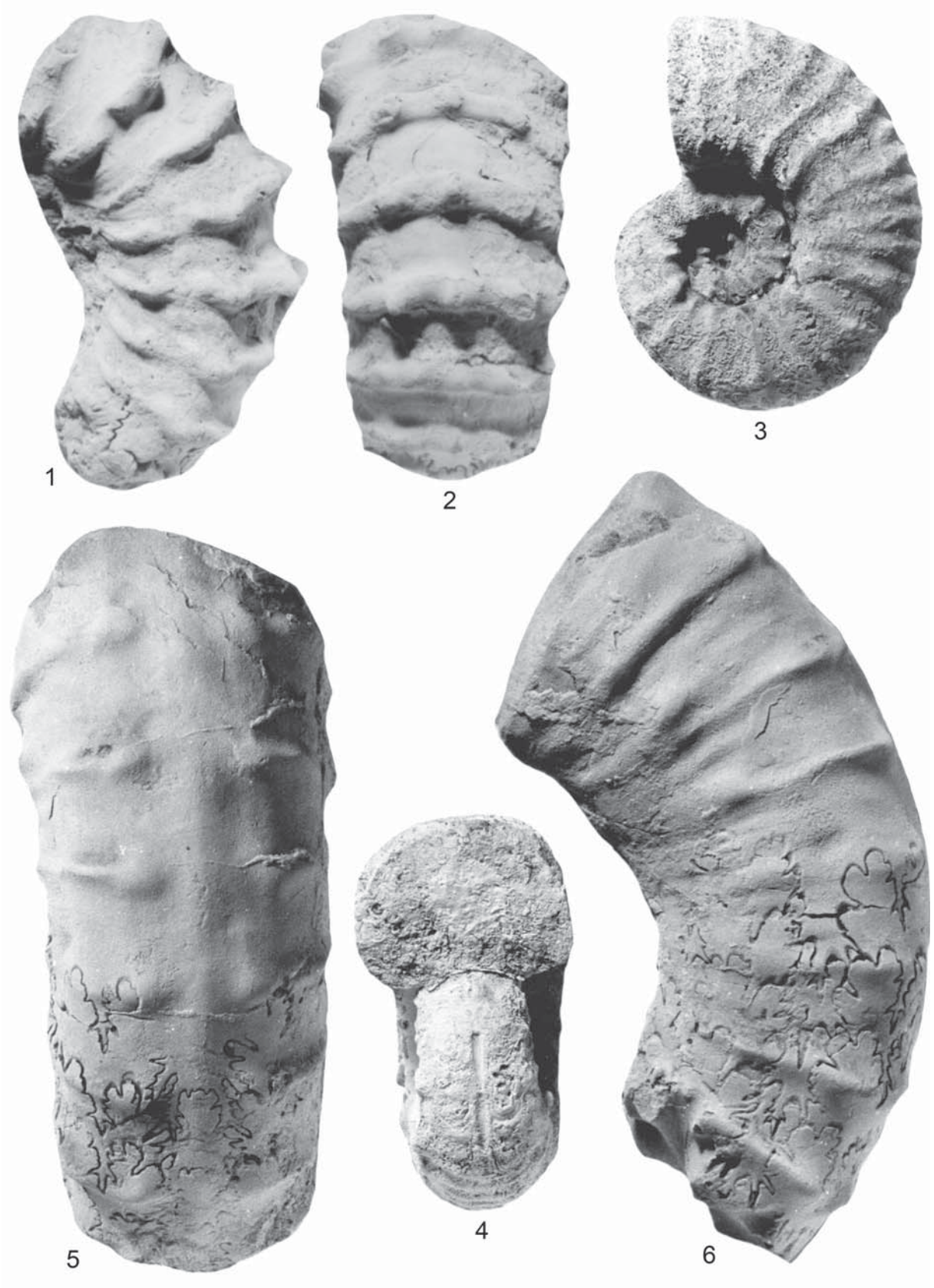
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PLATE 48

1**, 2, 6, 7** – *Vascoceras diartianum* (d'Orbigny,1850). 1, 2 – OUM KY3917; 6, 7 – OUM KY3918, from section A, 4–5 km north-west of Garudamangalam, Upper Cenomanian, *euomphalum* fauna, 16–18 m level.

3-5 – *Fagesia rudra* (Stoliczka, 1865). VP Kn 230, *ex-situ*, Kunnam.

Figures 1, 2, 6, 7 are × 3; figures 3–5 are × 1


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PLATE 49

Neoptychites cephalotus (Courtiller, 1860)

1, 2 – OUM KY3604, 70 m level; 3-5 – OUM KY3607, from the 70–75 m level, both from section R–S between Odiyam and Kunnam, Lower Turonian, *Neoptychites cephalotus–Mytiloides mytiloides* fauna.

All figures are × 1

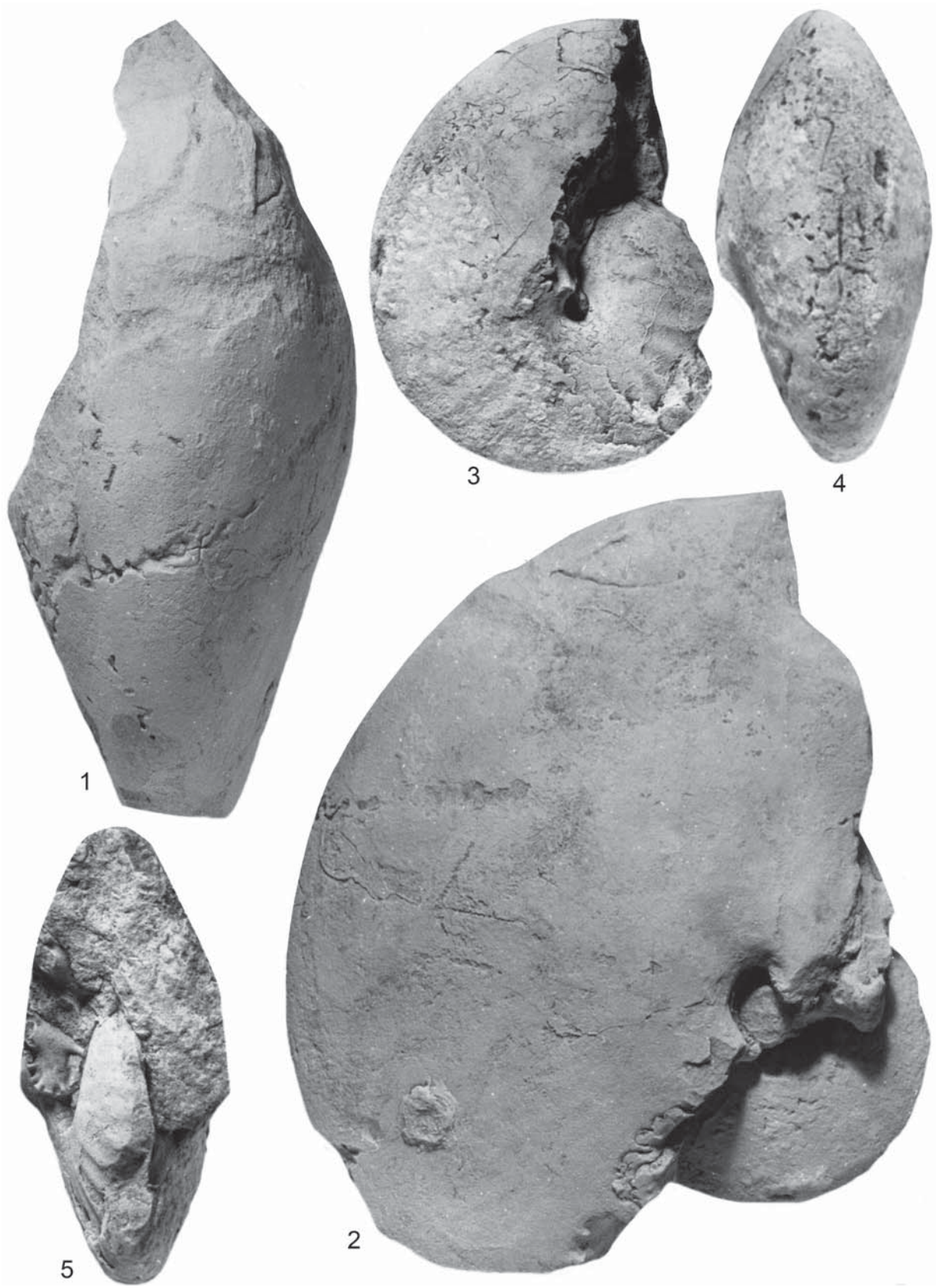
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PLATE 50

1 – *Anisoceras saussureanum* Pictet, 1847. OUM KY4347, 9.5–10 m level.

2-4, 7 – *Anisoceras perarmatum* Pictet and Campiche, 1861. 2, 3 – OUM KY2494; 4 – OUM KY2529; 7 – OUM KY2526, all from the 0–2 m level.

5, 6 – *Anisoceras angulatum* Stoliczka, 1866, from the 56 m level.

All specimens are from section A–B between Odiyam and Kunnam, Upper Albian, *rostrata* Zone; all figures are × 1


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PLATE 51

1-5 – *Anisoceras auberti* Pervinquière, 1907. 1, 2 – OUM KY3783; 3 – OUM KY3781; 4, 5 – OUM KY3787, all from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level.

6-8 – *Anisoceras* sp. OUM KY2849, from section G–H, Middle Cenomanian, *asiaticum* Zone, 209 m level.

9-12 – *Anisoceras perarmatum* Pictet and Campiche, 1861. 9, 10 – OUM KY2527; 11, 12 – OUM KY2528, both from section A–B, Upper Albian, *rostrata* Zone, 0–1 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1


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PLATE 52

1, 2 – *Hamites* sp. A. OUM KY3004, from section I–J, Middle Cenomanian, *cunningtoni* Zone, 13 m level.

3, 14, 15 (*pars*, right) – *Hamites simplex* d'Orbigny, 1850. 3 – OUM KY2560, from section A–B, Upper Albian or Lower Cenomanian, 50 m level; 14 – from section C–D, Lower Cenomanian, *mantelli* Zone 116 m level.

4-6, 8-10, 15 (*pars*) – *Hamites duplicatus* Pictet and Campiche, 1861. 4 – OUM KY3754a; 5 – OUM KY3754b; 6 – OUM KY3754c; 8 – OUM KY3754d; 9 – OUM KY374, all from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level. 10 – OUM KY2530, from section A–B, upper interval, Upper Albian, *rostrata* Zone, 0–2 m level; 15 (*pars*, left) – OUM KY3752, section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level.

7, **12** – *Mariella* (*Mariella*) *lewesiensis* (Spath, 1926b). 7 – OUM KY3706; 12 – OUM KY3652, from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level.

11 – *Mariella* (*Mariella*) *circumtaeniata* (Kossmat, 1895). OUM KY4348, from section A–B, Upper Albian, *rostrata* Zone, 9.5–10 m level.

13 – *Turrilites costatus* Lamarck, 1801. OUM KY4402, from section I–J, Middle Cenomanian, *cunningtoni* Zone, 20–21 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1

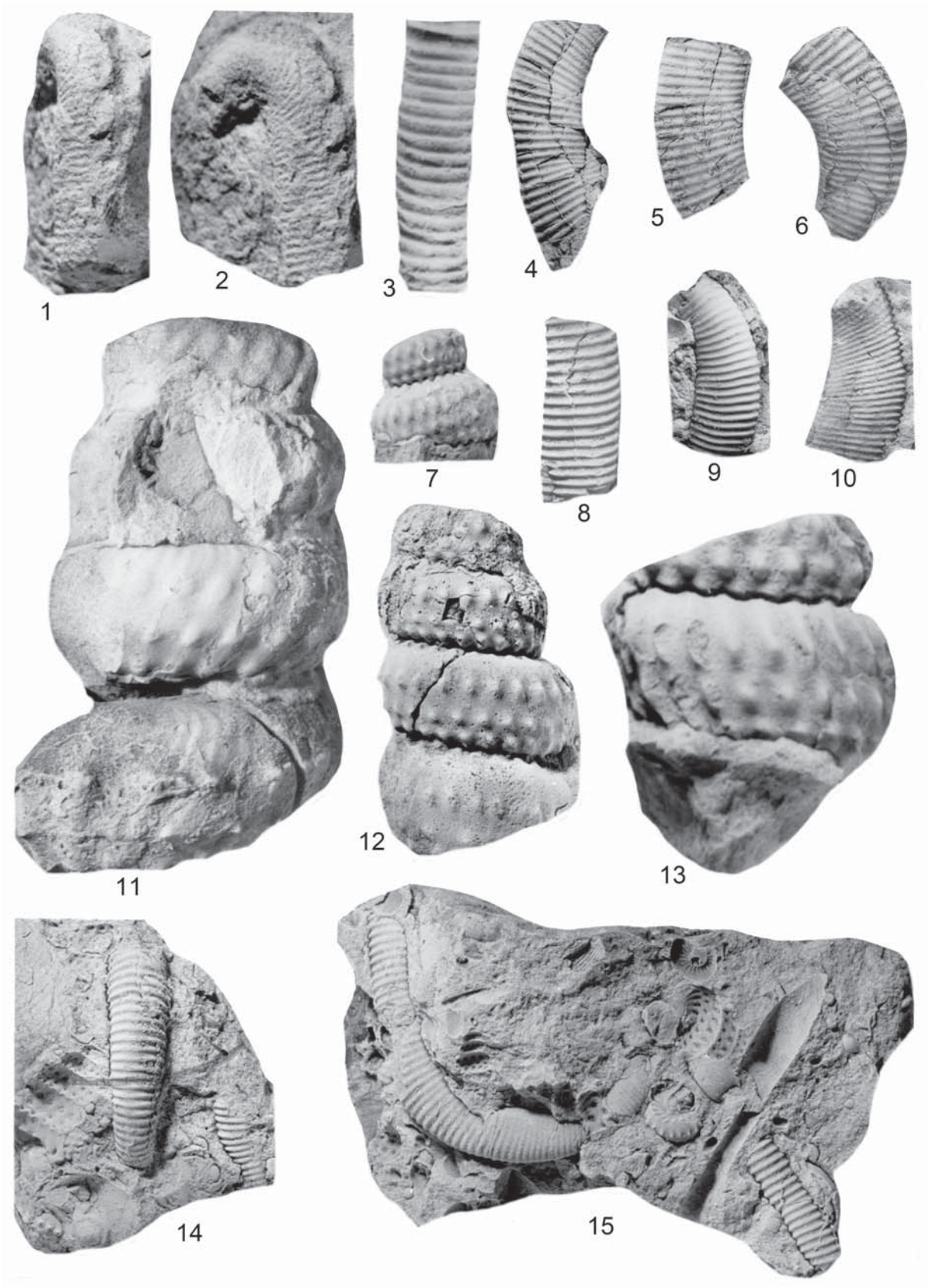
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PLATE 53

1 – *Hamites duplicatus* Pictet and Campiche, 1861. OUM KY5989, Lower Cenomanian, section on north side of road between Karai and Kulakkalnattam.

2, 3 – *Hamites* cf. *subvirgulatus* Spath, 1941. OUM KY4959, section on north side of road between between Karai and Kulakkalnattam, Upper Albian, *rostrata* Zone, 80 m level.

4, 5 – *Hamites* sp. C. OUM KY5158, section on north side of road between between Karai and Kulakkalnattam, Upper Albian, *rostrata* Zone 170–175 m level.

6, 7 – *Anisoceras*? sp. juv. OUM KY5300, section on north side of road between Karai and Kulakkalnattam, Upper Albian, *rostrata* Zone, 225 m level.

8, 18, 19, 23, 24, 31-33 – *Sciponoceras antanimangaensis* (Collignon, 1964). 8 – OUM KY3699d; 18, 19 – OUM KY3699b; 23, 24 – OUM KY3699c, all from section C–D between Odiyam and Kunnam, Lower Cenomanian, *mantelli* Zone, 116 m level; 31-33 – OUM KY4133a, from section B, 4–5 km north-west of Garudamangalam, Middle Cenomanian, *asiaticum* Zone, 10–20 m level.

9-12 – *Hemiptychoceras* cf. *tropicum* (Kossmat, 1895). 9 – OUM KY4243, from section D, north-west of Garudamangalam, Upper Albian, *rostrata* Zone, 28 m level; 10 – OUM KY5626, from the section on the north side of the road between Karai and Kulakkalnattam, Lower Cenomanian, *mantelli* Zone, 250 m level; 11, 12 – OUM KY3699a, from section C–D between Odiyam and Kunnam, Lower Cenomanian, *mantelli* Zone, 116 m level.

13-15 – *Sciponoceras* aff. *antanimangaensis* (Collignon, 1964). OUM KY6002, Lower Cenomanian, *mantelli* Zone, section on north side of the road between Karai and Kulakkalnattam.

16, 17, 20-22, 25-30 – *Sciponoceras* sp. (smooth). 16, 17 – OUM KY3933a; 20-22 – OUM KY3933e; 25, 26 – OUM KY3933b; 27, 28 – OUM KY3933c; 28-30 – OUM KY3933d, all from section A, north-west of Garudamangalam, Upper Cenomanian, *euomphalum* Zone, 16–18 m level.

All figures are × 2

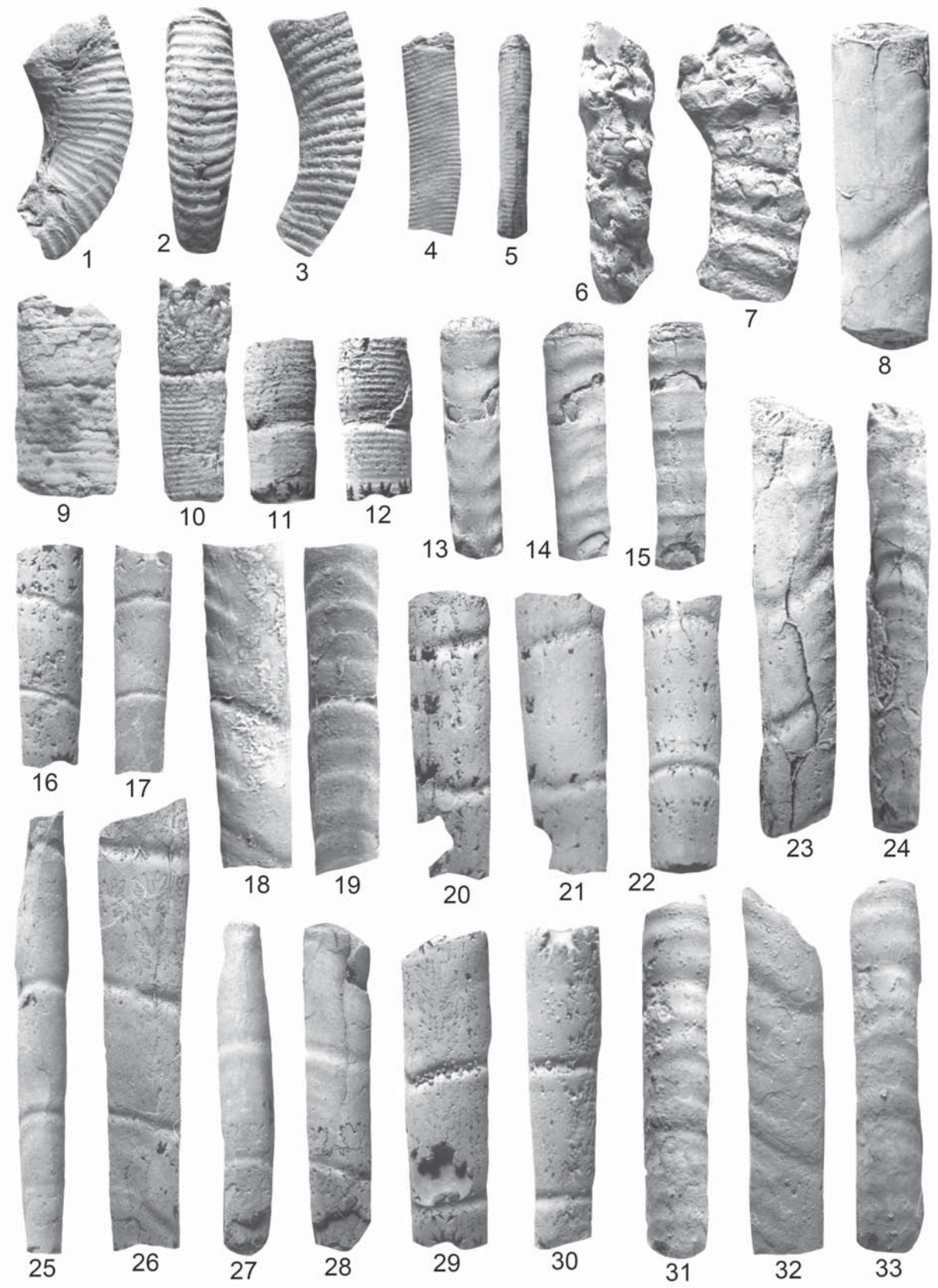
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PLATE 54

1-4, 7-12 – *Sciponoceras antanimangaensis* (Collignon, 1964). 1, 2 – OUM KY4408; 3, 4 – OUM KY4409, both from section I–J, Middle Cenomanian, *cunningtoni* Zone, 24–25 m level; 7, 8 – OUM KY2862, from section G–H, Middle Cenomanian, *asiaticum* Zone, 209–210 m level; 9 – OUM KY4373, from section C–D, Lower Cenomanian, *mantelli* Zone, 97 m level; 10, 11 – OUM KY2721, from section G–H, 172–175 m level; 12 – OUM KY2650, from section G–H, Middle Cenomanian, *asiaticum* Zone, 172–175 m level.

5, 6 – *Sciponoceras* sp. (smooth). OUM KY2585, from section E–F, Middle Cenomanian, *asiaticum* Zone, 155 m level.

13, 14 – *Sciponoceras cucullatum* Collignon, 1964. OUM KY2726, from section G–H, Middle Cenomanian, *asiaticum* Zone, 168–173 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1


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PLATE 55

1-5, 11-17 – *Sciponoceras cucullatum* Collignon, 1964. 1, 2 – OUM KY2691, from section G–H, Middle Cenomanian, *asiaticum* Zone, 221 m level; 3-5 – OUM KY3178a from section M–N, Middle Cenomanian, *asiaticum* Zone, 221 m level; 11-14 – OUM KY4407, from section I–J, Middle Cenomanian, *cunningtoni* Zone (?), 24–25 m level; 15-17 – OUM KY31778b, from section G–H, Middle Cenomanian, *asiaticum* Zone, 221 m level.

6-10 – *Sciponoceras antanimangaensis* (Collignon, 1964). 6-8 – OUM KY3178c; 9, 10 – OUM KY3178d, from section G–H, Middle Cenomanian, *asiaticum* Zone, 221 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 1

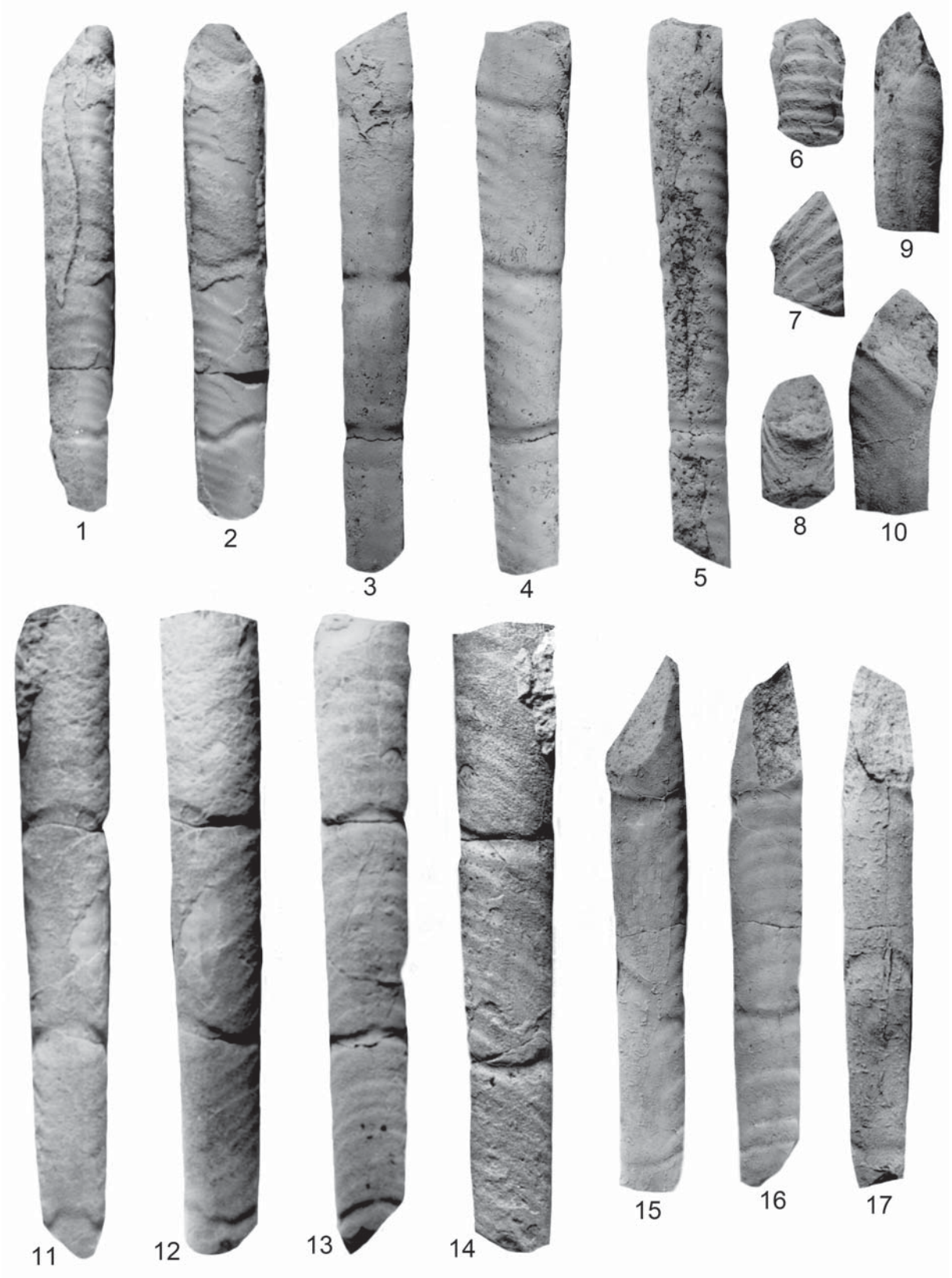
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PLATE 56

1-3, 5-7 – *Hypoturrilites tuberculatoplicatus* (Seguenza, 1883). 1, 2 – OUM KY2715; 3 – OUM KY2716, both from section G–H, Middle Cenomanian, *asiaticum* Zone, 172–175 m level; 5 – OUM KY3027, from section I–J, Middle Cenomanian, *cunningtoni* Zone, 20–21 m level; 6, 7 – OUM KY2716, from section G–H, Middle Cenomanian, *asiaticum* Zone, 172–175 m level.

4, 8 – *Mariella* (*Mariella*) *circumtaeniata* (Kossmat, 1895). 4 – OUM KY2504, from section A–B, lower interval, Upper Albian, *rostrata* Zone 17 m level; 8 – OUM KY2513, from section A–B, upper interval, Upper Albian, *rostrata* Zone, 0–2 m level.

All specimens are from sections between Odiyam and Kunnam; figures 1, 3, 4 8 are × 1; figure 3 is × 2

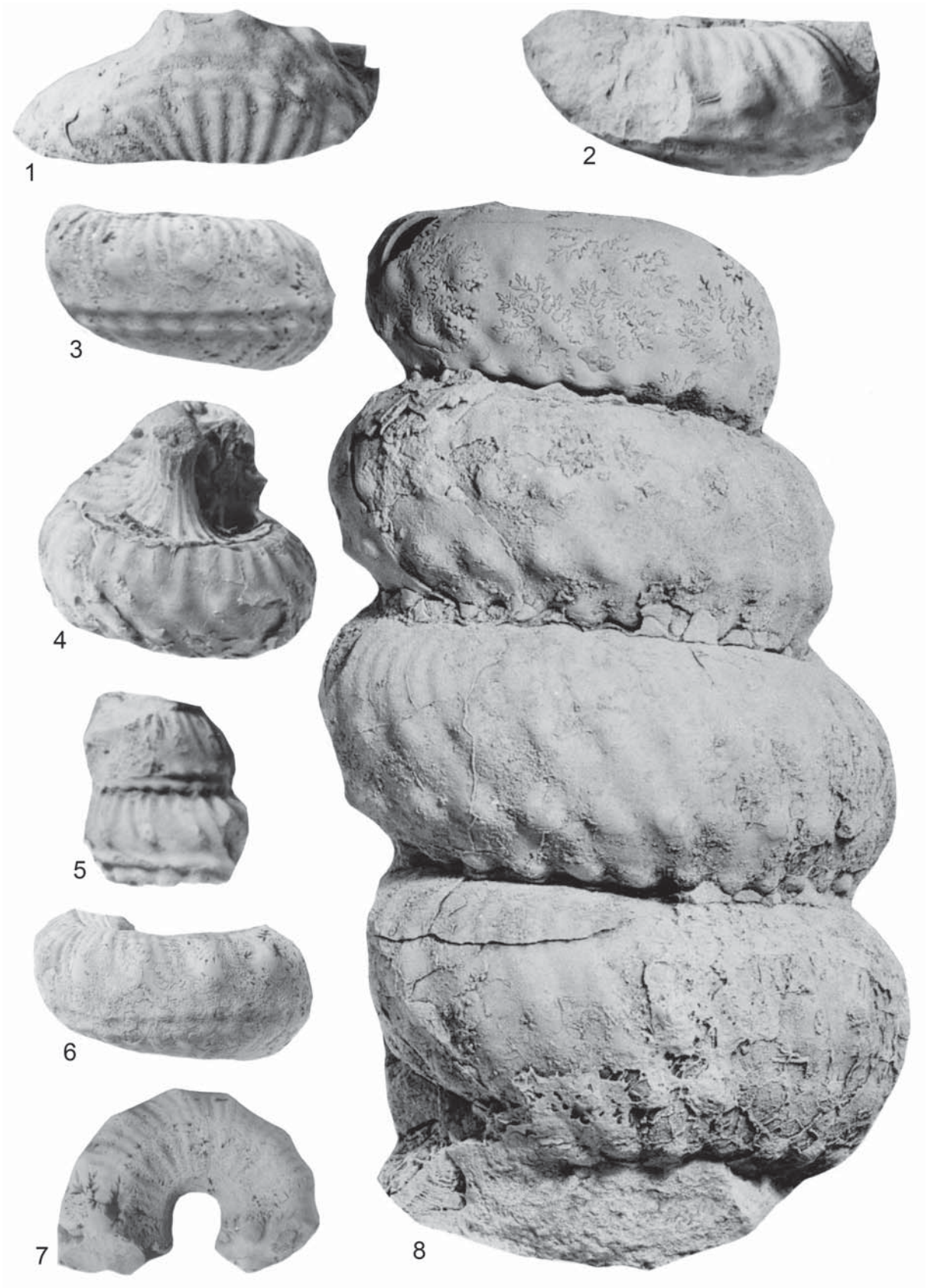
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PLATE 57

1, 2, 5 – *Mariella* (*Mariella*) sp. juv. 1 – OUM KY5396b; 2 – OUM KY5396c; 5 – OUM KY5396a, all Upper Albian, *rostrata* Zone, 275–280 m level.

3, 4, 8, 12, 13 – *Mariella* (*Mariella*) cf. *lewesiensis* (Spath, 1926b). 3 – OUM KY5527; 4 – OUM KY5526, both from the 345–350 m level; 8 – OUM KY5636, from the 352 m level; 12 – OUM KY5637, from the 352 m level; 13 – OUM KY6010a, all Lower Cenomanian, *mantelli* Zone.

6 – *Hypoturrilites* sp. juv. OUM KY5492, Lower Cenomanian, *mantelli* Zone, 341–346 m level.

7 – *Neostlingoceras carcitanense* (Matheron, 1842). OUM KY5493, Lower Cenomanian, *mantelli* Zone 341–346 m level.

9, 15 – *Ostlingoceras* (*Ostlingoceras*) sp. 9 – OUM KY5549, 348 m level; 15 – OUM KY5855, 400–404.5 m level, both Lower Cenomanian, *mantelli* Zone.

10, 11 – *Ostlingoceras* (*Ostlingoceras*) *colcanapi* (Boule, Lemoine and Thévenin, 1907). 10 – OUM KY5766, 377.5–382 m level; 11 – OUM KY5865, 409–410 m level, both Lower Cenomanian, *mantelli* Zone.

14 – *Carthaginites* sp. OUM KY4122, section B, north-west of Garudamangalam, 10–20 m level, Middle Cenomanian, *asiaticum* Zone.

16, 21 – *Turrilites scheuchzerianus* Bosc, 1801. 16 – OUM KY5837; 21 – OUM KY5836, both Lower Cenomanian, *mantelli* Zone, 390–400 m level.

17, 18, 20, 22 – *Carthaginites multituberculatus* sp. nov. 17 – paratype OUM KY3915; 18 – paratype OUM KY3913; 20 – holotype, OUM KY3912; 22 – paratype OUM KY3914, all from section A, north-west of Garudamangalam, Upper Cenomanian, *euomphalum* fauna, 16–18 m level.

19 – *Neostlingoceras* sp. OUM KY4153, from section B, north-west of Garudamangalam, Middle Cenomanian, *asiaticum* Zone, 14–16 m level.

Unless otherwise indicated, specimens are from the section north of the road between Karai and Kulakkalnattam; all figures are × 2

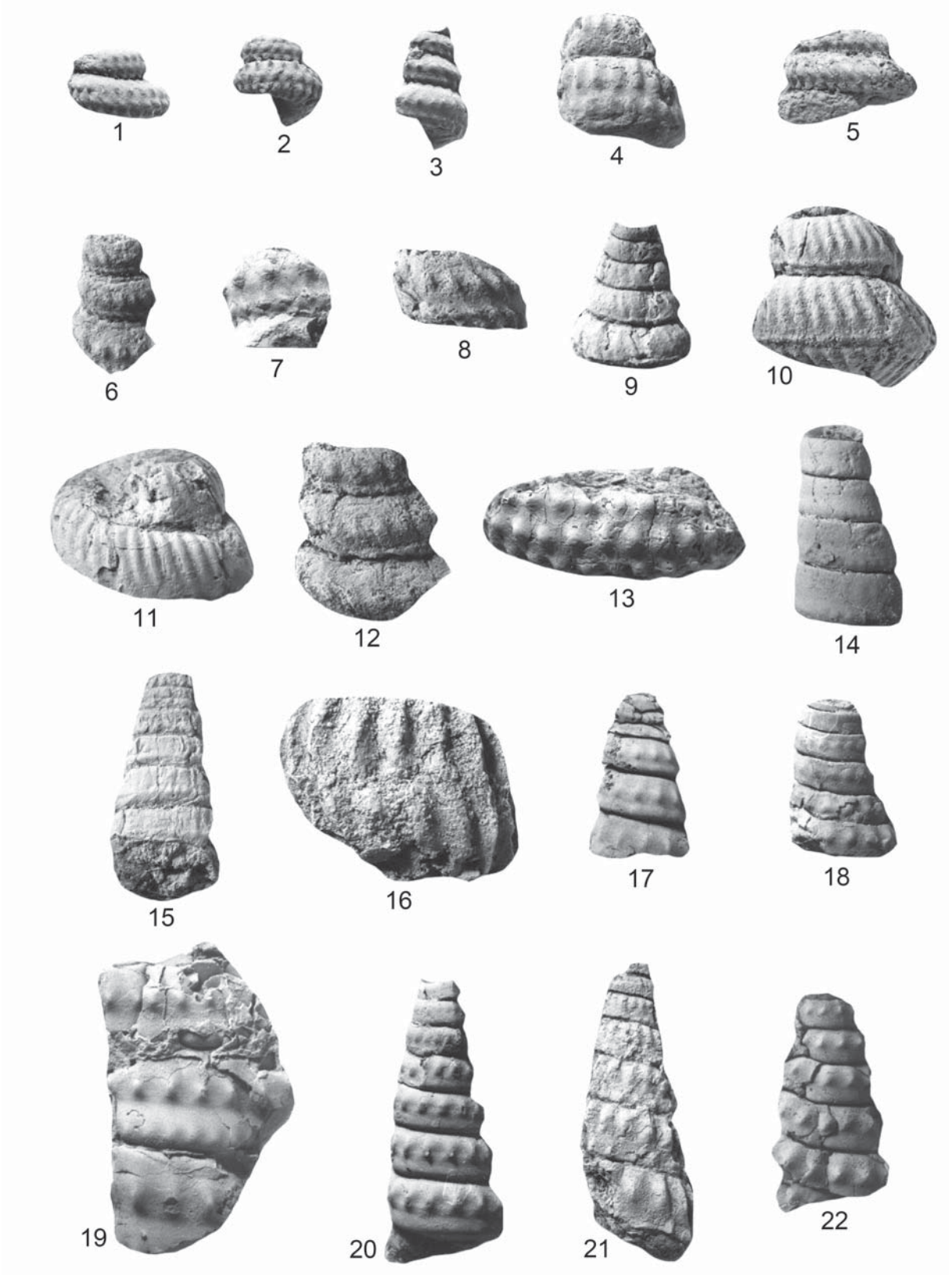
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PLATE 58

1 – *Hypoturrilites tuberculatoplicatus* (Seguenza, 1883). OUM KY5821, from the section on the north side of the Karai–Kulakkalnattam road, Lower Cenomanian, *mantelli* Zone at the 386.5–391 m level.

2-4, 14, 15, 19 – *Ostlingoceras rorayense* (Collignon, 1964). 2 – OUM KY4370a; 3, 4 – OUM KY7653; 14 – OUM KY4370b; 15 – OUM KY4370c; 19 – OUM KY4370d, all from section C–D, Lower Cenomanian, *mantelli* Zone, 97 m level.

5 – *Lechites gaudini* Pictet and Campiche, 1841. OUM KY4357, from section A–B, Upper Albian, *rostrata* Zone, 9–10 m level.

6, 7 – *Anisoceras* sp. OUM KY6024, from section A–B, Upper Albian, *rostrata* Zone, 9–10 m level.

8, 9, 12 – *Hypoturrilites gravesianus* (d'Orbigny, 1841). 8, 9 – OUM KY5556a; 12 – OUM KY556b, both from the section on the north side of the Karai–Kulakkalnattam road, Lower Cenomanian, *mantelli* Zone at the 346–350 m level.

10 – *Sciponoceras* cf. *gracile* (Shumard, 1860). OUM KY3510, from section R–S, Upper Cenomanian, *septemseriatum* Zone, 41 m level.

11, 13 – *Neostlingoceras carcitanense* (Matheron, 1841). 11 – OUM KY5546; 13 – OUM KY5614, both from the section on the north side of the Karai–Kulakkalnattam road, Lower Cenomanian, *mantelli* Zone at the 348 m and 350 m levels respectively.

16-18 – *Hypoturrilites wiedmanni* Collignon, 1964. OUM KY3804, from section C–D, Lower Cenomanian, *mantelli* Zone, 123 m level.

20, 22-25 – *Turrilites costatus* Lamarck, 1801. 20 – OUM KY6030, a phosphatised specimen from 4–5 m level above the base of the *asiaticum* Zone channel, section on the north side of the Karai–Kulakkalnattam road, Middle Cenomanian, *asiaticum* Zone. 22 – OUM KY2698; 23 – OUM KY2796, both from section G–H, Middle Cenomanian, *asiaticum* Zone, 169 m level. 24 – OUM KY2763, from section G–H , Middle Cenomanian, *asiaticum* Zone, 171.3 m level. 25 – OUM KX2659, from section G–H, Middle Cenomanian, *asiaticum* Zone, 169 m level.

21 – *Turrilites* aff. *scheuchzerianu*s Bosc, 1801. OUM KY3014, from section I–J, Middle Cenomanian, *cunningtoni* Zone, 20 m level.

Unless indicated otherwise, specimens are from sections between Odiyam and Kunnam; figures 1–4, 8, 9, 11–15, 19 are × 2; figures 5–7, 16–25 are × 1


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PLATE 59

1 – *Scaphites similaris* Stoliczka, 1868. OUM KY3182, from section M–N, Middle Cenomanian, *asiaticum* Zone, 221 m level.

2 – *Yezoites kingianus* (Stoliczka, 1865). OUM KY3803, from section C–D, Lower Cenomanian, *mantelli* Zone, 123 m level.

3-5 – *Scaphites collignoni* Wiedmann, 1965. OUM KY2565, from section A–B, upper interval, Upper Albian, *rostrata* Zone, 5 m level.

6-16 – *Scaphites dailyi* Wright, 1963. 6 – OUM KY3791a; 7-9 – OUM KY3790b; 10 – OUM KY3790c; 11-13– OUM KY3790a; 14, 15 – OUM KY3792; 16 – OUM KY3793, all from section C–D, Lower Cenomanian, *mantelli* Zone, 116 m level.

All specimens are from sections between Odiyam and Kunnam; all figures are × 2

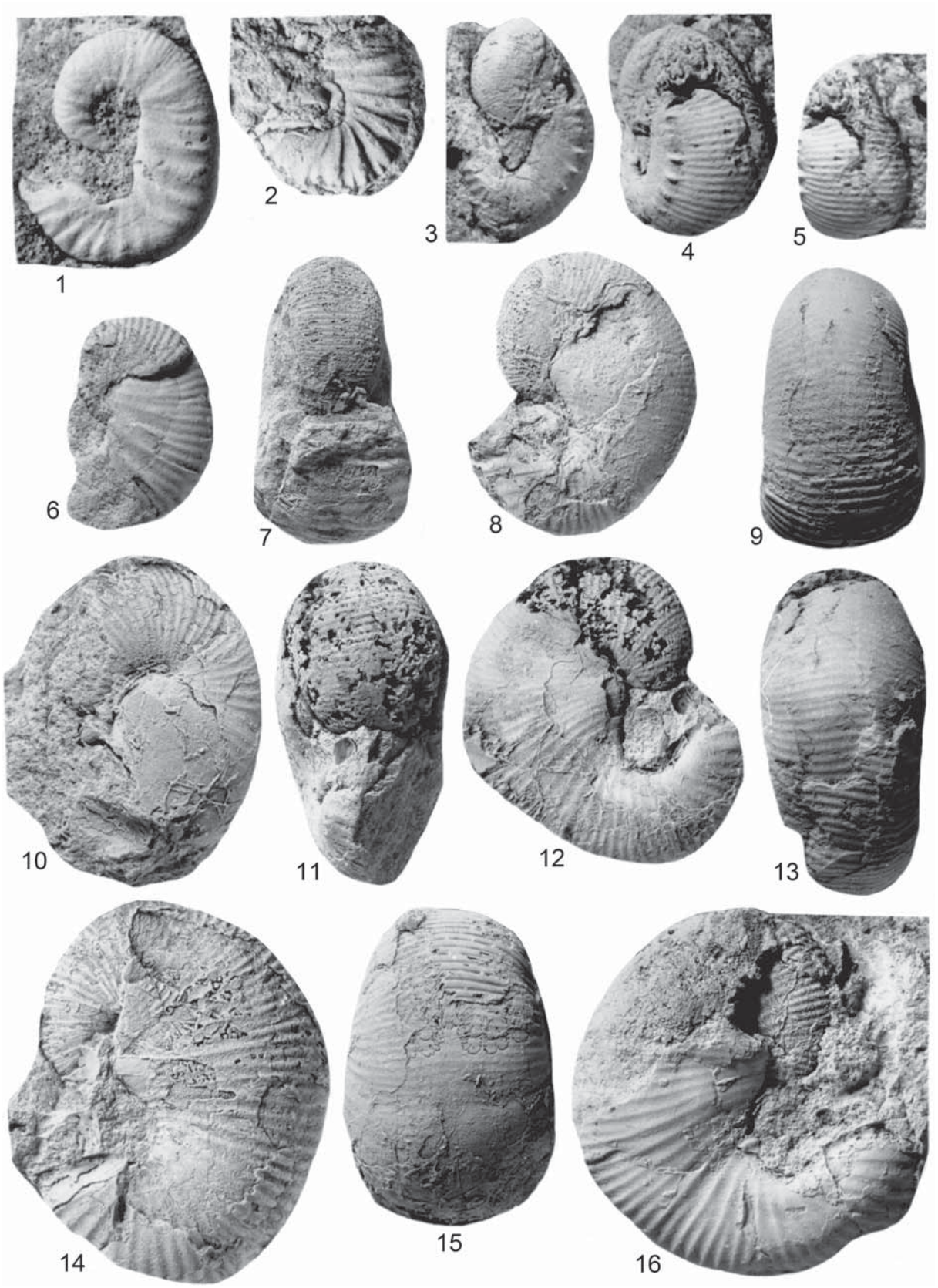
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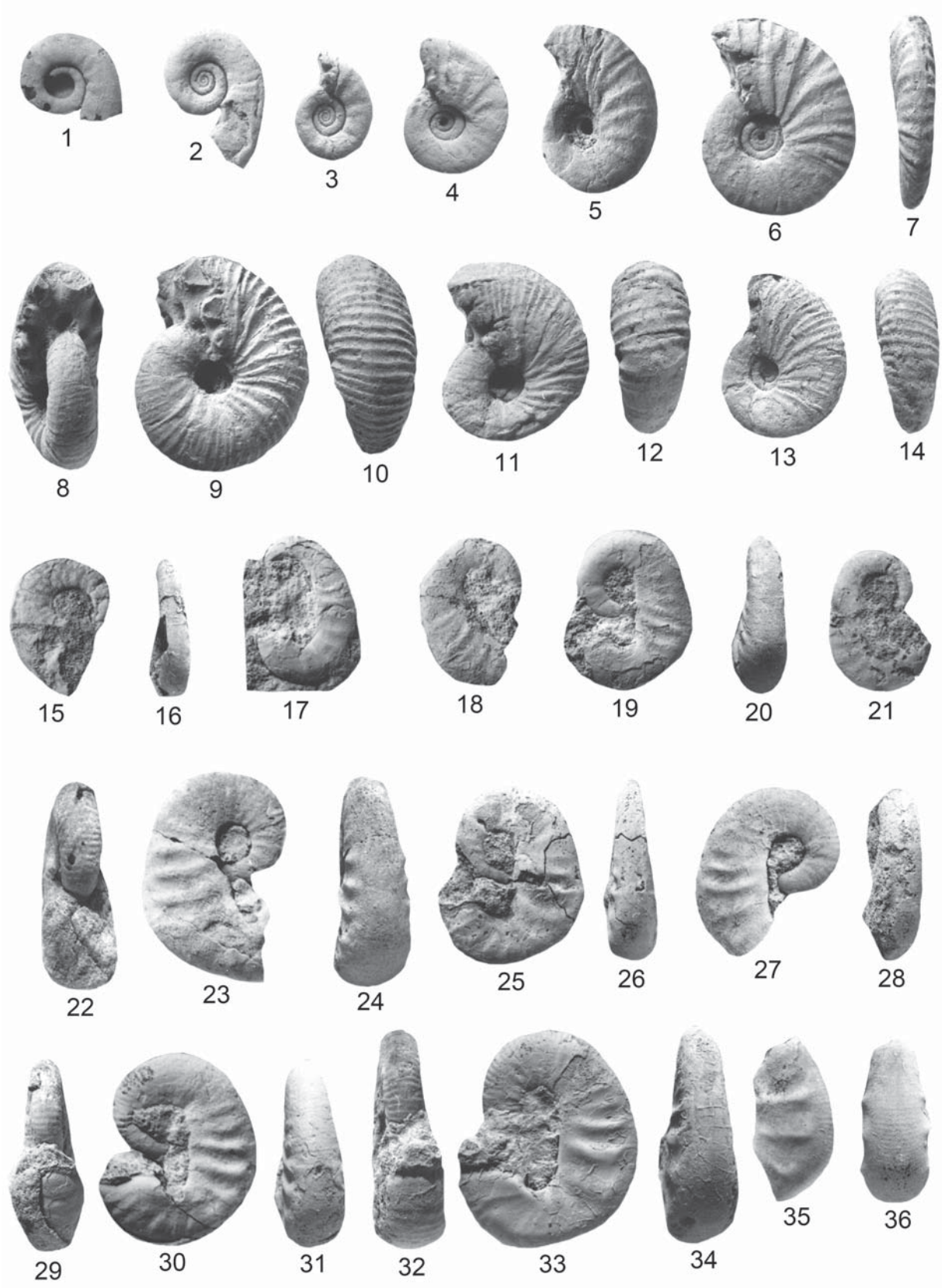
PLATE 60

1 – *Worthoceras* sp. OUM KY4202, Upper Cenomanian, *euomphalum* fauna, *harpax* Zone, northwest of Garudamangalam.

2-14 – *Yezoites kingianus* (Stoliczka, 1865). 2 – OUM KY5536; 3 – OUM KY3357; 4– OUM KY5538; 5 – OUM KY5535a; 6, 7 – OUM KY5535b, 345–350 m level; 8-10 – OUM KY5560a; 11, 12 – OUM KY5560b, 346–350.5 m level; 13, 14 – OUM KY5535c, 345–350 m level, all Lower Cenomanian, and from the section on the north side of the Karai–Kulakkalnattam road.

15-36 – *Scaphites similaris* Stoliczka, 1868. 15, 16 – OUM KY3195a; 17 – OUM KY3195b; 18 – OUM KY3195c; 19, 20 – OUM KY3195d; 21 – OUM KY3195e; 22-24 – OUM KY3195f; 25, 26 – OUM KY3195g; 27, 28 – OUM KY3195h; 29-31 – OUM KY3195i; 32-34 – OUM KY3195j; 35-36 – OUM KY3195k, all from section M–N between Odiyam and Kunnam, Middle Cenomanian, *asiaticum* Zone, 221 m level.

Figures 1–14 are × 2; figures 15–36 are × 1.5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