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The Kimmeridgian ammonite faunas of Milne Land, central East Greenland

by

Tove Birkelund and John H. Callomon

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Abstract

Extensive new collections of ammonites made bed by bed in many sections through the Kimmeridgian (Lower Kimmeridgian *sensu anglico*) of Milne Land are described. These are used to revise and amplify the earlier accounts in a classical monograph of 1935 by Spath.

The ammonites occur at ten sharply defined and well separated faunal horizons in the Bays Elv, Cardioceraskløft and Gråkløft Members of the Kap Leslie Formation (Birkelund *et al.*, 1984, faunas 14–23). These horizons are readily correlated with the well-known successions of NW Europe, and their precise stratigraphical positions within the framework of the standard NW European Sub-Boreal zonation are discussed. All five Zones – Baylei, Cymodoce, Mutabilis, Eudoxus and Autissiodorensis – are represented. The more tenuous correlations with the analogous successions of the Barents Shelf and northern Siberia are also discussed.

The faunas belong almost wholly to the two Sub-Boreal families Cardioceratidae and Aulacostephanidae. In the former, eight species of *Amoeboceras* are described, one of them new: *A. (Amoebites) bayi* sp. nov., closely related to European *A. (A.) bauhini*. In the latter family ten species of the genera *Pictonia, Rasenia, Pachypictonia?, Aulacostephanoides* and *Aulacostephanus* are described. Those of *Pictonia* and *Rasenia* are particularly significant in comparison with European and Siberian forms. Other families continue to be represented by but a single specimen of the Oppeliidae, *Streblites?* cf. *S. taimyrensis* Mesezhnikov.

Some key sections of stratigraphical importance are recorded in an Appendix.

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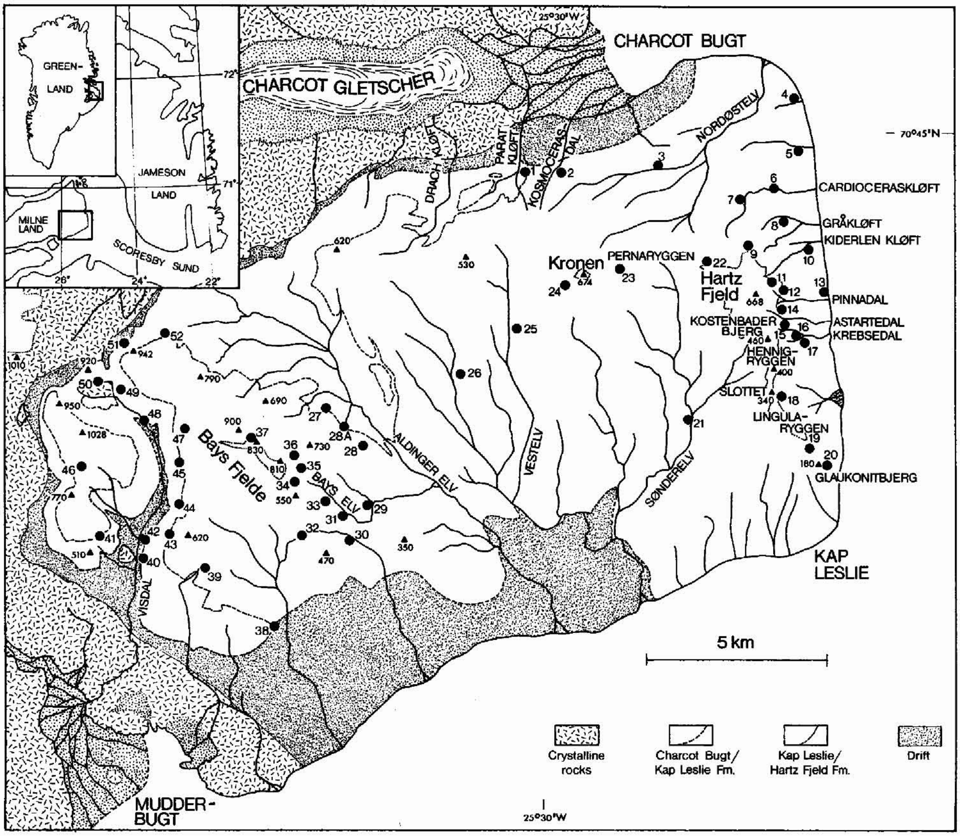

Fig. 1. Map of the Jurassic and Cretaceous deposits in Milne Land, giving place names and the localities of principal measured sections (nos. M1-M52).

INTRODUCTION

The Upper Jurassic deposits of Milne Land lie in a key area for Jurassic Boreal ammonite stratigraphy. Early collections brought back to Copenhagen by Rosenkrantz (1929) and Aldinger (1935) were described in two classical monographs by Spath (1935, 1936), and all these works continue to form the basis for subsequent stratigraphical and palaeontological revisions. Since then extensive field work and collecting have yielded important new material and much more detailed stratigraphical information (Callomon, 1961; Håkansson *et al.*, 1971; Birkelund *et al.*, 1978a; Higgins & Håkansson, 1980; Birkelund, Callomon & Fürsich, 1984). The biostratigraphy of the ammonites in particular has revealed a rich succession that can be used to provide close chronostratigraphic control. Some 48 ammonite faunas range from Boreal Upper Bathonian (Middle Jurassic) resting on crystalline basement to Valanginian (Lower Cretaceous). Of these, faunas 1–19 were summarized previously (Callomon & Birkelund, 1980), and the descriptions of the ammonites given there and in Sykes & Callomon (1979) leave little to add up to and including the Upper Oxfordian, faunas 1–13. Faunas 24–48, covering Lower Volgian, Middle Volgian and Lower Valanginian, were also described previously (Callomon & Birkelund, 1982).

In the present work we describe the succession through the Kimmeridgian, used in the international sense (Lower Kimmeridgian *sensu anglico*). This covers faunas 14–23 (table 1). The choice is largely one of convenience, for the faunas in this range coincide roughly with the material treated in Spath's first monograph (1935), are bounded by a sharp faunal change at the top, and consist of a closely circumscribed group of forms belonging almost wholly to only two families, the Cardioceratidae and Aulacostephanidae.

The area from which the material came is shown on the map (fig. 1). It was collected bed by bed in about half of the total of some 50 or so recorded sections, the detailed descriptions of which are deposited together with the collections in the Geological Museum of the University of Copenhagen.

Table 1. Kimmeridgian faunas of Milne Land

Fauna 14:	*Pictonia* sp. nov. A. aff. *P. normandiana* Tornquist *Pictonia?* sp. indet. B (age not quite certain) *Amoeboceras (Amoebites) bayi* sp. nov. *Amoeboceras (Amoebites)* sp. aff. *A. (A.) schulginae* Mesezhnikov *Amoeboceras (Amoebites)* cf. *A. (A.) ernesti* (Fischer) (age not quite certain)
Fauna 15:	*Rasenia inconstans* Spath (M and m) *Amoeboceras (Amoebites) subkitchini* Spath (M) *Amoeboceras (Amoebites)* aff. *A. (A.) rasenense* Spath (m)
Fauna 16:	*Rasenia inconstans* Spath (M) *Pachypictonia?* sp. nov. C (M and m) *Amoeboceras (Amoebites)* aff. *A. (A.) subkitchini* Spath (M) *Amoeboceras (Amoebites)* aff. *A. (A.) rasenense* Spath (m)
Fauna 17:	*Rasenia cymodoce* (d'Orbigny) (M and m) *Amoeboceras (Amoebites)* aff. *A. (A.) subkitchini* Spath (M) *Amoeboceras (Amoebites)* aff. *A. (A.) rasenense* Spath (m)
Fauna 18:	*Rasenia evoluta* Spath (M and m) *Amoeboceras (Amoebites)* cf. *A. (A.) rasenense* Spath (m)
Fauna 19:	*Rasenia borealis* Spath (M) *Aulacostephanoides mutabilis* (Sowerby) (M) *Aulacostephanus (Aulacostephanites)* cf. *Au. (Au.) eulepidus* (Schneid) (m) *Amoeboceras (Amoebites)* cf. *A. (A.) beaugrandi* (Sauvage) (m) *Streblites?* cf. *S. taimyrensis* Mesezhnikov (m)
Fauna 20:	*Amoeboceras (Euprionoceras) kochi* Spath (M and m?)
Fauna 21:	*Aulacostephanus eudoxus* (d'Orbigny) (m) *Amoeboceras (Hoplocardioceras) decipiens* Spath (M and m)
Fauna 22:	*Amoeboceras (Amoebites) elegans* Spath (M and m)
Fauna 23:	*Aulacostephanus* sp. cf. or aff. *Au. kirghisensis* (d'Orbigny)

(M) macroconchs, (m) microconchs

LITHOSTRATIGRAPHY

The Kimmeridgian deposits of Milne Land belong in part to three members of the Kap Leslie Formation: Bays Elv Member (lowest), Cardioceraskløft Member, and Gråkløft Member (highest) (fig. 2). Of these, the Gråkløft Member has recently been fully defined and described by Birkelund, Callomon & Fürsich (1984) although it had already been recognized as a separate unit by Aldinger (1935) and Spath (1935). The Bays Elv and Cardioceraskløft Members have so far been described only in outline (Callomon & Birkelund, 1980). We therefore now amplify these descriptions.

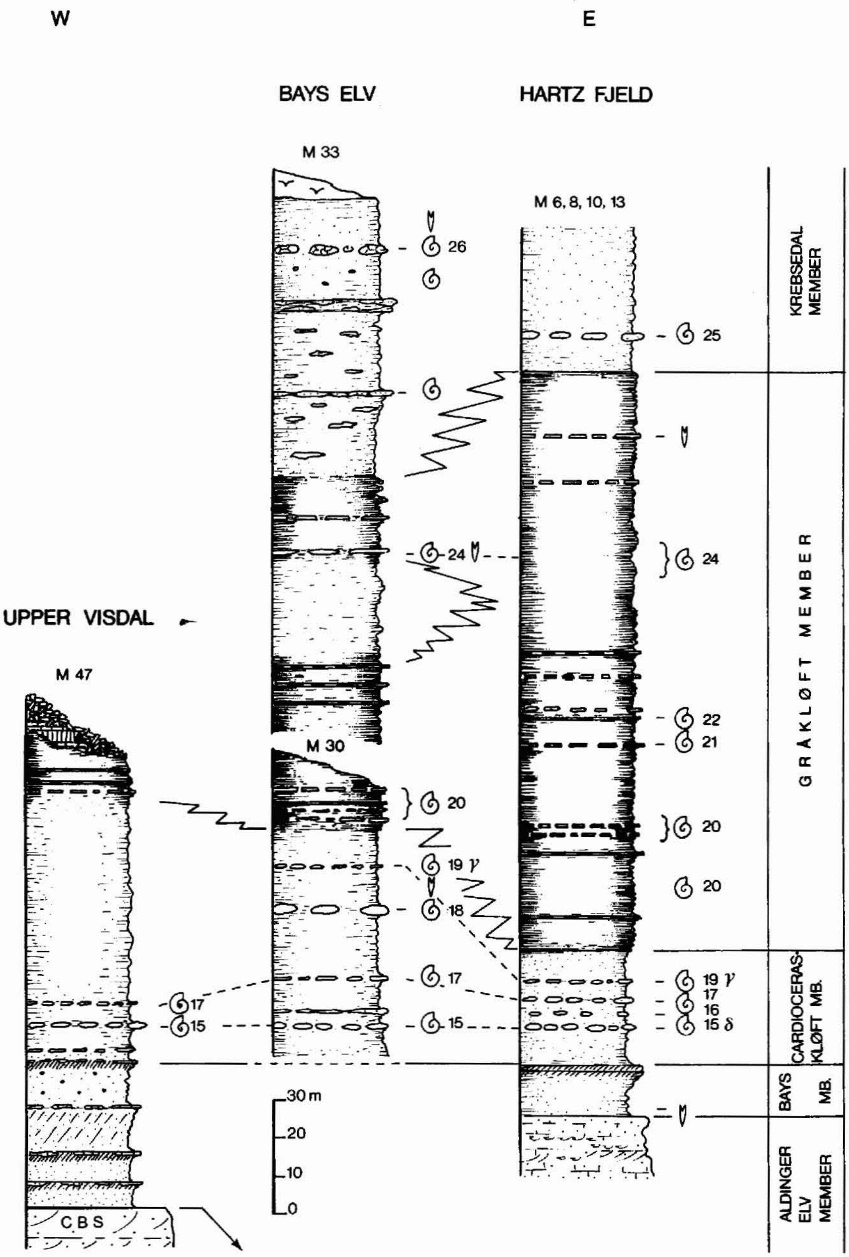

Fig. 2. Schematic representative sections through the Bays Elv, Cardioceraskløft and Gråkløft Members of the Kap Leslie Formation. Numbers at the heads of columns refer to sections in fig. 1. Ammonite faunas are also labelled by numbers.

Bays Elv Member (Callomon & Birkelund, 1980)

Bays Elv is a tributary of Aldinger Elv, south-east of Bays Fjelde (fig. 1), and section 29 is here designated type-section. To the east the member is well exposed in Cardioceraskløft (section 6); and to the west, around Visdal, the most important sections are nos. 39, 47 and 50. Detailed descriptions of sections 6, 29 and 39 are given in the Appendix, and diagrammatic representations are shown in fig. 3.

The member consists of a succession of thin, rapidly alternating beds of bioturbated, dark, micaceous siltstones or fine-grained sandstones many of which are more or less glauconitic, in some cases up to the grade of rich greensands. Its thickness shows little lateral variation, decreasing from 20 m in the east to 15–17 m around Bays Elv and lower Visdal. It overlies with sharp, probably somewhat erosive contact the sandy Aldinger Elv Member where this is developed, in the east (fig. 4) and around Bays Elv. In the Visdal area, where the Aldinger Elv Member is no longer recognizable because of wedging-out, the lower boundary is placed at the top of a sandy concretionary layer terminating a series of non-glauconitic silts or fine sandstones, but this choice is somewhat arbitrary. The top of the member can be placed everywhere above a greensand which is followed sharply by non-glauconitic micaceous silty shales uniformly characteristic of the Cardioceraskløft Member.

Although thus so uniform in overall lithological development, the Bays Elv Member is strongly heterogeneous in detail and, as revealed by ammonites, diachronous. At least five faunal horizons have been recognized, although the material is abundant and well-preserved enough to distinguish only three faunas so far: fauna 12, with *Amoeboceras regulare* and *Ringsteadia* cf. *R. pseudocordata,* of the Upper Oxfordian, Regulare Zone; fauna 13 with *Amoeboceras rosenkrantzi* and *Ringsteadia* aff. *R. pseudocordata,* of the Upper Oxfordian, Rosenkrantzi Zone; and fauna 14, with *Pictonia* cf. *P. normandiana* and *Amoeboceras bayi* sp. nov., (= aff. *A. bauhini* (Oppel)), indicating early Kimmeridgian, Baylei Zone. The member thus traverses the Oxfordian-Kimmeridgian boundary. In the Bays Elv area, fauna 14 occurs in the lowest 4 m together with at least some of fauna 13. There is no sign of fauna 12, and it is followed by another 13 m of silts and greensands. Near lower Visdal, in section 39, fauna 14 now occurs at the very top, 16 m above the base. The upper boundary of the member is thus diachronous between Bays Elv and Visdal to the extent of at least some 12 m of glauconitic silts.

Cardioceraskløft Member (Callomon & Birkelund, 1980; lower part of Spath's '*Amoebites* Shales', 1935)

Cardioceraskløft is a gorge on the east coast of Milne Land. It exposes by far the best section through this member (section 7, described in the Appendix, and fig. 4), here designated type-section. Other important sections have been recorded in Gråkløft, south of Cardioceraskløft (section 8); south of Bays Fjelde (section 30; see Appendix); and in Visdal (section 47).

The member consists of grey, bioturbated, highly micaceous siltstone with a

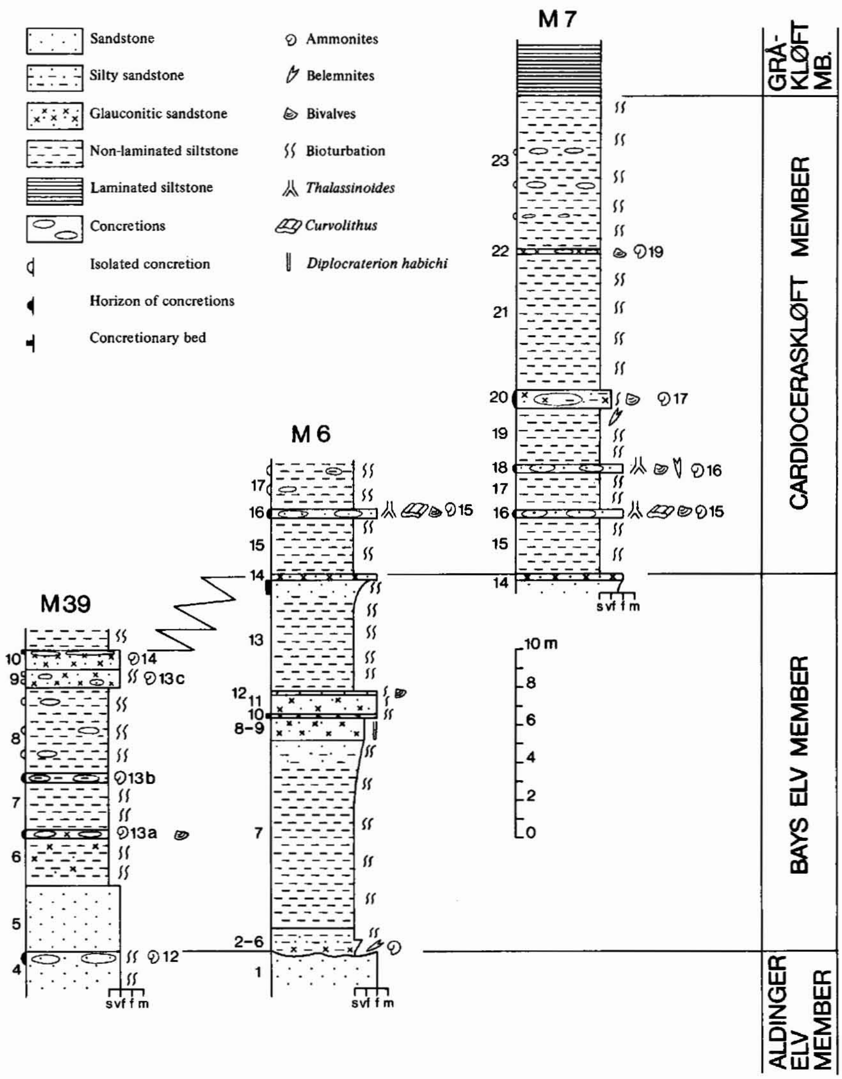

Fig. 3. Lithological logs of the Bays Elv Member and the Cardioceraskløft Member. Numbers at the heads of the columns refer to sections in fig. 1.

number of layers of yellow- or purple-weathering concretionary sandstone doggers. The beds are uniformly developed and change little over the whole area, so that the layers of doggers make excellent markers. Aldinger (1935) treated them as if they were just two layers, and labelled the lower and higher of them, 3 and 30 m above the base, 'concretions δ and γ' respectively. There are in fact at least five levels of concretions characterized by distinct ammonite faunas (15–19 inclusive), and they are therefore relabelled here correspondingly, δI-δIV and γ.

Fig. 4. The Bays Elv Member at section 6 in Cardioceraskløft. Note the sharp lower contact with the clean white sands of the underlying unconsolidated Aldinger Elv Member of the Upper Oxfordian.

The lower boundary is defined by the top of the terminal glauconite of the Bays Elv Member. It lies at beween 3 and 8 m below the *Rasenia inconstans* bed, δI, at the east coast and in upper Visdal respectively, so it must be close to isochronous. The upper boundary is defined by a change to dark, non-bioturbated laminated shales of the overlying Gråkløft Member. From the east coast, all around Hartz Fjeld, to about Kronen, this change is sharp and prominent, but further to the west it becomes less easy to recognize. It is not clear whether this is due to changes of facies, or whether the distinction has been blurred by weathering in poorer exposures. Thicknesses in this member increase westwards, in contrast to all other formations and members in the Mesozoic sediments of Milne Land. Thus, the total thickness is 25 m at Cardioceraskløft, rising to 59 m at Bays Elv. That this is not simply a reflection of a diachronously rising upper boundary is revealed by the ammonites in the layers of concretions. The interval δI-δIII (*R. inconstans – R. cymodoce*) increases from 6 m in Cardioceraskløft to 13 m at Bays Elv, and the interval δI-γ (*R. inconstans – R. borealis*) from 13 m to 43 m in the same distance.

The age of the member is entirely Lower Kimmeridgian: fauna 15, *Rasenia inconstans,* lowest Cymodoce Zone, to fauna 19, *Rasenia borealis* and *Aulacostephanoides mutabilis,* about middle Mutabilis Zone.

Gråkløft Member ('Oil Shales' of Aldinger, 1935 and Spath, 1935; *Amoebites* Shales (pars) of Spath, 1935; fully described in Birkelund, Callomon & Fürsich, 1984)

Type-locality in the well-exposed sections on the north bank of the stream in the gorge of Gråkløft (section 8), on the east coast of Milne Land. Parts of the member are also well exposed in the other gorges on the east coast (sections 10,13,17) and extensively along the west bank of Sønderelv (section 21). The succession is summarized in fig. 2. It attains a thickness of 160 m at the east coast. To the west, around Kronen and Bays Fjelde it is poorly exposed. When weathered it may be difficult to recognize the diagnostic laminated black-shale lithology. Nevertheless, the thicknesses seem to have considerably decreased around Bays Fjelde (see fig. 2), largely as the result of facies-changes, so that particularly the upper boundary of the member is diachronous.

The lithology is dominated by black, finely laminated, non-bioturbated carbonaceous silty shales. Very small-scale ripple lamination is found at a few levels. Bioturbated horizons do occur, most commonly in the middle part. Thin pyritic horizons are scattered throughout, and calcareous concretionary induration produces some thin, hard beds that weather into tabular slabs and locally make excellent markers for correlating scattered part-sections.

The lower boundary of the member is defined by the first appearance of non-bioturbated laminated shales, and on Hartz Fjeld at least, the upper boundary by a sharp change to sediments of coarser grain-size and lighter colour belonging to the overlying Krebsedal Member, often marked by a prominent spring-line.

Ammonites occur at a number of highly localized but widely scattered levels throughout the member. They belong to faunas 20–24 indicating the Eudoxus and Autissiodorensis Zones of the Kimmeridgian (20–23), and, at least in the eastern part of the area, the Elegans Zone of the Lower Volgian (24).

AMMONITE ZONATION

The separation of ammonites into faunal provinces reached a peak in the Upper Oxfordian. As a result it has become necessary to set up three independent schemes of standard ammonite zones (chronozones) for three large provinces north of the Tethys (Sykes & Callomon, 1979): Sub-Mediterranean, Sub-Boreal and Boreal. The Boreal Province, to which Greenland belongs, is characterized above all by ammonites of the family Cardioceratidae, while the Sub-Boreal and Sub-Mediterranean Provinces are dominated by members of the Perisphinctidae and their descendents. In the Kimmeridgian the boundary between Boreal and Sub-Boreal Provinces becomes less distinct as a branch of the Perisphinctaceae migrated northwards, and the currently used standard zonation of the Sub-Boreal Province as typified in Great Britain, based on the genera *Pictonia, Rasenia* and *Aulacostephanus,* could be at least partly adopted in the Boreal Province as well. Nevertheless, the provincialism is still there, and with a few notable exceptions the Cardioceratidae dominate. In many places they may in fact be the only group represented. Their stratigraphic value is therefore high, and to work out their succession becomes a matter of some importance.

The faunas collected in Milne Land are rich in individuals, poor in species and highly sporadic in the succession, separated by long intervals devoid of fossils. Many of the assemblages can be recognized very widely over the Boreal Province and hence make excellent markers. At the same time there are few Kimmeridgian faunas known from elsewhere around the North Atlantic that have not also been found in Milne Land, suggesting that the sporadic colonization seen there was regionally widespread and more general. Correlations both within the Boreal Province and with adjacent provinces can therefore be rarely more precise than the limits set by these non-fossiliferous gaps, and it seems unnecessary, at least at present, to go beyond the stage of characterizing the faunas and their sequences. The levels of the faunas will therefore be treated here as merely horizons within the framework of the standard NW European Sub-Boreal zonation.

The Kimmeridgian faunas from Milne Land are listed in table 1. Their positions within the NW European zonal scheme is shown in fig. 5, which includes also the zonal scheme that has been adopted for the analogous succession worked out in northern Siberia (Mesezhnikov, 1969). There arise many questions of correlation, and these will be discussed further below.

SYSTEMATIC DESCRIPTION OF AMMONITES

Family CARDIOCERATIDAE Siemiradzki, 1891

Subfamily CARDIOCERATINAE Siemiradzki, 1891

Genus *Amoeboceras* Hyatt, 1900

Type species *Amm. alternans* v. Buch, 1831

Subgenus *Amoebites* Buckman, 1925 (February)

Type species *A. akanthophorus* [= *A. kitchini* (Salfeld, 1915) subj.]
[= *Plasmatites* Buckman, 1925 (December)?]

Differs from *Amoeboceras* s.s. and *A.* (*Prionodoceras*) characterizing the Upper Oxfordian in abandoning mid-lateral tuberculation of the primary ribbing and developing instead strongly accentuated secondary ribbing on angular ventro-lateral shoulders, particularly in highly variocostate macroconchs. The first step is seen in the development of a smooth spiral band separating long primary and short secondary ribbing in *A. bauhini. A. subkitchini* is then intermediate to the extreme seen in the type-species which develops massive ventro-lateral spines or clavi, sometimes by the refusion, or looping, of two or more secondary ribs.

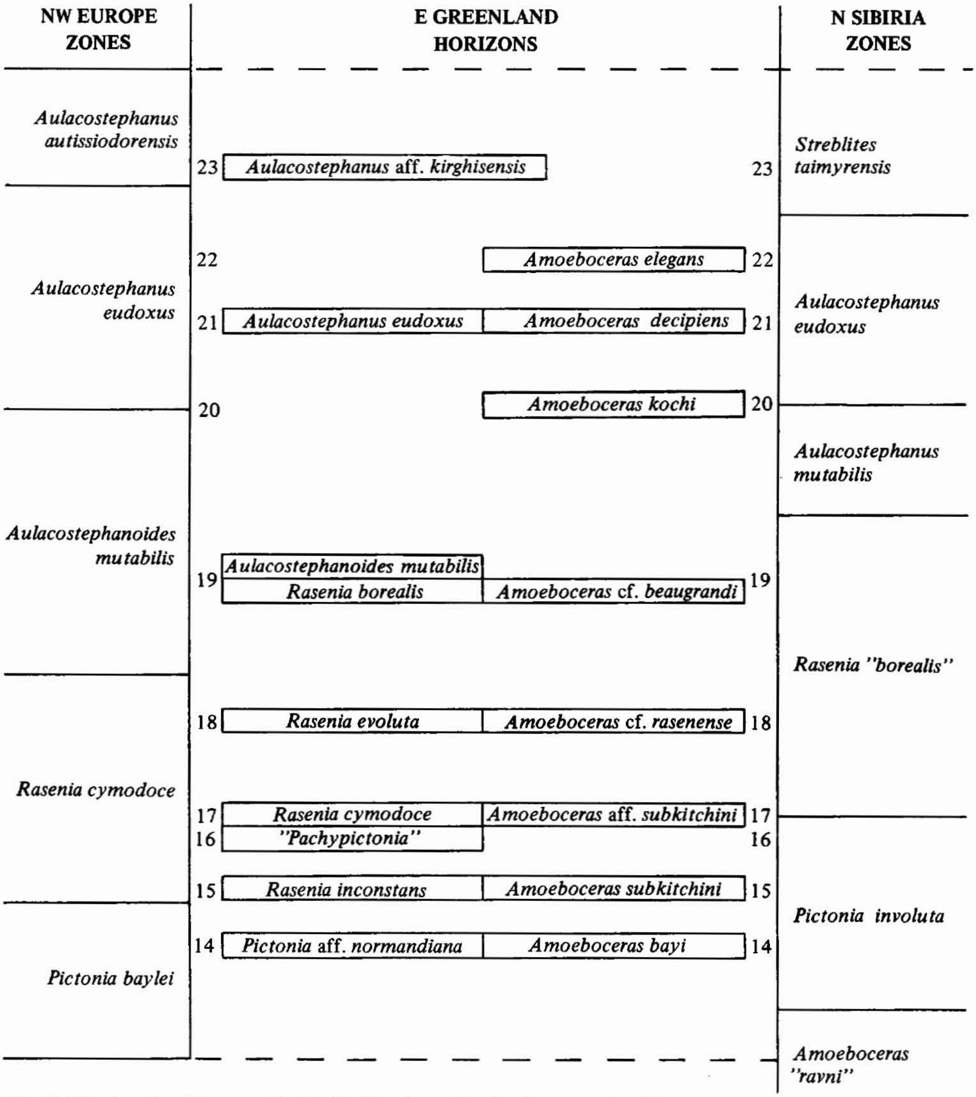

Fig. 5. The levels of faunas 14–23 of Milne Land in the framework of the standard Kimmeridgian zonation of NW Europe and northern Siberia.

Amoeboceras (*Amoebites*) *bayi* sp. nov.

Pl. 1, figs 1–12; pl. 4, figs 4,5

1979 *Amoeboceras bauhini* (Oppel): Sykes & Callomon, pl. 121, figs 2,3.
Holotype. MGUH 16659 (JHC 836) (Pl. 1, fig. 6).
Locus typicus. Milne Land, Bays Elv in Bays Fjelde, section 31.

Stratum typicum. Bays Elv Member, beds equivalent to bed 3 in section 29 (see Appendix); fauna 14, Baylei Zone.

Material. 14 specimens: 2 in concretions from bed 10b of section 39 (see Appendix), loose in a gully ½ km to the NW (GGU 234071, pl. 1, figs 10,11), associated with *Pictonia* cf. *P. normandiana*; 3 from bed 3 of section 29 (see Appendix) (JHC 636: Sykes & Callomon, 1979, pl. 121, fig. 3); 9 macroconchs (M), including the holotype, and 4 microconchs (m), from section 31 in beds equivalent to bed 3 of section 29. Inner whorls are represented in all cases by flattened imprints only, and the bodychambers by partly crushed moulds in siltstone.

Description. Macroconchs.
Mean maximum adult diameter: 41.5 mm; σ = 6.2 mm (11 specimens)
Mean length of adult bodychamber: 0.7 whorl
Mean number of primary ribs, last whorl: 40.1; σ = 3.8 (9 specimens)
(σ: standard deviation)

Inner whorls have dense, straight ribbing with totally differentiated crenulate keel, typical of almost all late *Amoeboceras*. On the adult bodychamber the ribbing differentiates further into simple primaries separated by a characteristic more or less smooth spiral band high on the whorlside from short but accentuated secondaries on the ventro-lateral shoulder, sometimes offset from the primaries. Near the adult peristome, which carries a long spirally projected ventral rostrum, the umbilical seam markedly uncoils, and the ribbing may briefly resimplify with increase in density. As in most Cardioceratinae, the sculpture is highly variable, as may be seen in plate 1, ranging from dense, fine ribbing on a relatively involute, compressed whorl-section to coarser, sparser, more accentuated ribbing on more evolute, quadrate whorls. There are a number of extremely coarsely-ribbed specimens that seem to stand apart. Material is not sufficient to characterize them more closely and they are therefore briefly described separately below, as *A.* aff. *A. schulginae.*

The differentiation of primary and secondary ribbing on the adult bodychamber represents a form of variocostation suggesting that, contrary to previous belief (Sykes & Callomon 1979, p. 889), these shells are the macroconchs of what is a small species.

Microconchs. The microconchs appear to be the even smaller forms than the small macroconchs and are shown in plate 4, figs 4,5.

Maximum adult diameter: 25 mm (2 specimens)
Number of primary ribs, last whorl: 34–34

The maturity of the specimens is indicated by the uncoiling of the umbilical seam. The ribbing remains isocostate and strong to the end.

The dimorphism in Kimmeridgian *Amoeboceras* has been elusive but becomes apparent, here as elsewhere, when a series of successive faunas is considered as a whole rather than individually. Thus the series *A. bayi* (M)/(m) (fauna 14, Baylei Zone) – *A. subkitchini* (M)/(m) (faunas 15–17, see below; lower–middle Cymodoce Zone) – *A. kitchini* (M)/(m) ((m) = *A. rasenense* Spath) (upper Cymodoce–lower Mutabilis Zones) reveals a consistent division into two groups, of smaller isocostate and larger variocostate forms evolving in parallel that leave the dimorphism in little doubt, despite similar adult peristomes and highly variable relative abundances.

Comparisons. Morphologically, *A. bayi* occupies a position intermediate between *A. bauhini* (Oppel) and *A. subkitchini* Spath, described more fully below. *A bauhini* shares with *A. bayi* the highly distinctive smooth band high on the whorl-side, but differs from it principally in being even smaller. A cast of the holotype of *A. bauhini* was figured by Sykes & Callomon (1979, pl. 121, fig. 1; and see p. 889 for synonymy and discussion), but as no further material was available at the time, the variability could not be assessed. *A. bayi* and *A. bauhini* were therefore placed in synonymy. Reinstatement of the collection in the Staatliches Museum für Naturkunde in Stuttgart has now brought to light a considerable amount of material from the Swabian Alps, of which a representative sample is shown here in plate 9, figs 8–13. It shows at a glance the differences from *A. bayi.* Its resemblance seems close, however, to the crushed material from Skye in Scotland (Sykes & Callomon, 1979, p. 121, figs 4,5) recently augmented by very similar forms from eastern England, just south of the Humber (Cox & Richardson, 1982, pl. 6, fig. 1; and see below, pl. 9, fig. 13).

Some Greenland specimens of *A. bayi* bear quite a close resemblance to the holotype and still only known specimen of *Plasmatites crenulatus* Buckman (1925, pl. 618). This has similar coiling and ribbing except that the secondaries are much less differentiated. Its systematic position was discussed previously (Sykes & Callomon, 1979, p. 547) and the main uncertainty remains its horizon. Recent exposures of the beds around the Oxfordian-Kimmeridgian boundary near Swindon produced a wealth of ammonites but not a single specimen of *A. crenulatus.* It seems almost certain, therefore, that *P. crenulatus* did not come from the Baylei Zone; and the most probable source was an old brick-pit at Wootton Bassett, Wiltshire, as Arkell surmised (1943, p. lxxxii). Its horizon would then have been roughly that of *Ringsteadia pseudoyo* (Upper Oxfordian, Regulare/ Rosenkrantzi Zones), and it could well be the microconch of *Amoeboceras marstonense* from the same level.

Amoeboceras praebauhini Salfeld (1915, p. 178), as defined by the lectotype (pl. 17, fig. 5), is also very close to *A. crenulatum,* and may be a senior synonym. It came, however, from the glacial drift of Norfolk, so even less is known of its age; and in view of the difficulty in identifying *Amoeboceras* microconchs at all closely because of the frequency of close homoeomorphy, the name is best treated as a *nomen dubium.* No other material of Regulare or Rosenkrantzi Zone ages has been found in the glacial drift of southern or eastern England.

The microconchs of *A. bayi* differ little from those of *A. subkitchini, A. kitchini* and even younger forms. A number of more or less well-defined names exist that may belong here. *A. cricki* (Salfeld, 1915, p. 191) (*non* 1914, p. 129, *nomen nudum*) had a type-series of more than 20 specimens, of which the largest number came from Market Rasen. Many of these, in turn, are indeterminable nuclei. Their precise age is not known, but must have been somewhere in the upper Cymodoce Zone. The best of them is here designated lectotype (Salfeld, 1915, pl. 19, figs 2a-c; B.M. C.7700). At 24 mm it carries about a third of a whorl of bodychamber with uncoiling umbilical seam. It is, however, more involute and much more densely ribbed than *A. bayi* (m), with over 50 ribs on the last whorl. *A. pingue* (Salfeld), as defined by the lectotype (1915, pl. 19, figs 1a-d, designated by Spath, 1935, p. 32) is another nucleus from Market Rasen and, at a maximum diameter of only 10 mm, barely interpretable. *A. rasenense* Spath (1935, p. 29) is a third Market Rasen species and well defined. Its holotype (pl. 1, figs 6a,b) is a nearly complete adult of 35 mm diameter and its relative age, at least, precisely known. It came out of the same concretion as the holotype of *Rasenia involuta,* which characterized an *involuta* horizon in the upper Cymodoce Zone (Birkelund *et al.,* 1978a, p. 35; 1983, p. 306). It differs from *A. bayi* (m) mainly in being bigger and probably more inflated, and is interpreted here as the microconch of *A. kitchini.*

Age and distribution. Although morphologically intermediate between *A. bauhini* and *A. subkitchini,* the position of *A. bayi* above *A. bauhini* has not yet been demonstrated directly. Such a sequence is, however, indirectly indicated by reference to the succession of faunas of *Pictonia,* discussed more fully below. In Britain and Normandy, two faunal horizons are well established: a lower horizon of *P. densicostata* Salfeld, marking the base of the Baylei Zone and of the Kimmeridgian Stage by definition; and a higher horizon of *P. baylei* Salfeld, which includes *P. normandiana* Tornquist.

The position of *A. bauhini* has now been clarified by much new stratigraphical information in Scotland and eastern England. In Skye, the small steeply-dipping outcrops between tidemarks are heavily obscured by basalt boulders and, for most of the year, by seaweed. The highest beds exposed, around the Oxfordian-Kimmeridgian boundary, had therefore remained the least well understood, and much depended on the correlation of thin, impersistent, calcareous concretionary cementstones between small, patchy exposures. During the exceptionally cold winter of 1981–82 the sea froze locally and cleared the shores of seaweed. The Jurassic beds were therefore unusually well exposed in the spring of 1982 and a re-examination clarified the succession. The basic outline of the top beds, 35–39, given in Sykes & Callomon (1979, p. 899) remains unchanged, but the classification has to be modified. The top 1–2 m of bed 35 contain abundant *Ringsteadia frequens* and *evoluta* Salfeld, with *Amoeboceras rosenkrantzi.* Bed 36, a thin limestone and the most important marker in the sections, is barren. The lowest 1–1½ m of bed 37 contain abundant *Pictonia densicostata; Amoeboceras bauhini* occurs at *c.* 2 and 4–5 m above the base of bed 37. The Oxfordian-Kimmeridgian boundary has therefore to be redrawn at bed 36 instead of bed 38; and the Bauhini Subzone is largely if not exactly equivalent to the Baylei Zone, depending on how the upper limits are defined, and is entirely Kimmeridgian in age.

The *Pictonia densicostata* horizon has now also been precisely located in the area of the Humber in eastern England. It is well exposed in a clay-pit for cement-making at South Ferriby, briefly described by Cox (*in* Smart & Wood, 1974, p. 592), and can be followed sub-surface in borings (Cox & Richardson, 1982). This area shows one of the thickest, most complete and fossiliferous successions through the Oxfordian-Kimmeridgian boundary in NW Europe, and will be fully described elsewhere. The relevant part may, however, be summarized as follows. From below:

Ampthill Clay		Thickness
Bed no.		(metres)
1–8	Clays, dark, pyritic, with calcareous horizons. *Ringsteadia pseudocordata* (Blake & Hudleston, 1877) (Pseudocordata Subzone) in the lower part, *Ringsteadia pseudoyo* Salfeld (Pseudoyo Subzone) in the middle part and *Ringsteadia evoluta* Salfeld (Evoluta Subzone) in the upper part. Upper Oxfordian, Pseudocordata/Rosenkrantzi Zone	19
Kimmeridge Clay		
9	*Pictonia* Bed. Clays (9a,c), highly calcareous and fossiliferous, somewhat current-bedded, the fossils frequently in current-accumulated lenticles, including lumachelles of disarticulated oysters (*Deltoideum delta*) and *Oxytoma*; phosphatic nodules in the lower part (9a), with common serpulae; the middle part (9b) locally consolidated into marly limestone with a layer of large, septarian concretions, often around an oyster lumachelle as nucleus. *Pictonia densicostata* (Salfeld MS) Buckman, 1924 (M) and (m), common, typical, throughout the bed; also many juveniles. *Amoeboceras* aff. *A. cricki* (Salfeld) and *A. lorioli* (Oppenheimer), all juveniles. Lower Kimmeridgian, Baylei Zone	1
10	(a) Clays, calcareous, hard, slightly fissile, *Pictonia* cf. *P. densicostata, Pictonia* sp. juv. and (m) (common), *Amoeboceras bauhini* (Oppel) (cf. pl. 9, figs 13a-c and Cox & Richardson, 1982, pl. 6, fig. 1), *Amoeboceras* sp. (m) aff. *A. cricki* (common)	0.40
	(b-c) Clays, only slightly fossiliferous, *Pictonia* sp. aff. *P. densicostata,* small	1.1
	(d) Clays, calcareous, with an indistinct phosphatic layer at the base. Many fossils, crushed, *Pictonia baylei* Salfeld, 1913, *P. normandiana* Tornquist, 1896, *Deltoideum delta.* Lower Kimmeridgian, Baylei Zone	1.8
11	Mudstone, phosphatic	0.1
12	Clays, somewhat laminated, with scattered phosphatic nodules. Ammonites with uncrushed bodychambers, *Rasenia* cf. or aff. *R. berryeri* (Dollfus) and forms transitional from *Pictonia* (M), *Prorasenia* sp. (m), *Amoeboceras schlosseri* (Wegele). Lower Kimmeridgian, Cymodoce Zone	3.0
	Sharp erosion-plane	
–	Melton Carstone, with basal pebble-bed containing pebbles of ages from Lower Liassic age, Sinemurian, to Upper Volgian. Aptian.	
–	Red Chalk and Chalk	

The position of *A. bauhini* here is thus exactly analogous to that in Skye. In its type-area of southern Germany, *A. bauhini* occurs in the upper, Galar Subzone of the Planula Zone, just below the White Jura β-γ boundary. The implications are discussed again below.

A. bayi has so far not been identified in Europe. The forms of *Pictonia* associated with it (see below) most closely resemble those found at South Ferriby in about bed 10(b-c), in so far as these are identifiable. This suggests that *A. bayi* does lie above *A. bauhini*, but the precise ranges remain to be established.

Amoeboceras (*Amoebites*) sp. aff. *A.* (*A.*) *schulginae* Mesezhnikov, 1967

Pl. 4, figs 1–3

aff. 1967 *Amoeboceras* (*Prionodoceras*) *schulginae* Mesezhnikov, p. 123, pl. 1, fig. 4; pl. 3, fig. 1.

Material. 3 specimens; 1 *in situ* in bed 10b of section 39 (GGU 234070), 1 from section 29, bed 3, 1 from the same level in section 31 – all associated with *A. bayi.*

Description and discussion.

JHC 637: max. dia. 34 mm, 0.75 whorl bodychamber, 29 ribs
JHC 820: max. dia. 43 mm, 0.8 whorl bodychamber, 18–19 ribs.

Small forms with very to extremely coarse ribbing. They may well be merely the end-members in the range of variability of *A. bayi* with which they are associated, but the material is neither sufficiently abundant nor well-preserved either to test this or to give it a new name. Such a range of variability appears to be a common feature in Cardioceratinae at many levels. Joined together in a 'vertical' classification, these coarse variants would appear as the 'lineage-genus' *Vertebriceras* and its descendents. *A. schulginae* stands in this relation to *A. freboldi* at about the base of the Regulare Zone. It appears to be the form stratigraphically nearest to the ones considered here to have been described so far.

Age. Baylei Zone, occurring together with *Pictonia* cf. *P. normandiana* and *A. bayi.*

Amoeboceras (*Amoebites*) cf. *A.* (*A.*) *ernesti* (Fischer, 1913)

Pl. 6, figs 9–10

1913 *Cardioceras ernesti* Fischer, p. 45, pl. 5, figs 17,17a

Material. 3 specimens and bodychamber fragments, others seen; all from section 31, in beds equivalent to section 29, bed 3.

Description and discussion. Maximum diameters 25–30 mm. Section compressed, involute, oval, with strong, wholly differentiated, crenulate keel. Inner whorls smooth or with vestigial striations; ribbing reappearing on the last half-whorl of the adult bodychamber as dense, subdued, well-rounded primaries fading on the higher flank of the whorl-side, to be replaced by short, faint vestigial secondaries. There is a strong resemblance to earlier cardioceratids, e.g. *C.* (*Plasmatoceras*) (m) of the Cordatum Zone, *C.* (*Miticardioceras*) (m) of the Tenuiserratum Zone, and *Amoeboceras koldeweyense* (m) of the Serratum Zone. The dimorphic status of the present forms is, however, not clear.

The holotype of *A. ernesti* has an adult diameter of 23 mm and is wholly striate. It came from the Platynota Zone of Swabia, i.e. from about the level of *A. bauhini* or slightly higher. The collections in Stuttgart contain a fair amount of similar material, and the variability suggests that the interrelations between *A. ernesti* and the two closely-related species *Cardioceras haizmanni* Fischer, 1913 and *C. fraasi* Fischer, 1913, may be no higher than varietal.

The Greenland material came from the same locality as the type of *A. bayi*; but, as the horizon 'bed 3' encompasses up to 4 m of greensands with both faunas 13 (*Ringsteadia pseudocordata*) and 14 (*A. bayi*), the age cannot be specified more precisely. It could still just be Upper Oxfordian.

Amoeboceras (Amoebites) subkitchini Spath, 1935

Pl. 2, figs 1–7; pl. 3, figs 1–11

1935 *Amoeboceras (Amoebites) subkitchini* Spath, p. 30, pl. 1, figs 3a–b.
1935 *Amoeboceras (Euprionoceras?) aldingeri* Spath, p. 28, pl. 2, figs 6a–b.
1935 *Amoeboceras (Amoebites) irregulare* Spath, p. 32, pl. 1, figs 1a–b.
1935 *Amoeboceras (Prionodoceras?) prorsum* Spath, p. 24, pl. 5, fig. 5.
cf. 1973 *Amoeboceras (Amoebites) subkitchini* Spath: Mesezhnikov & Romm, p. 318–20.
1980 *Amoeboceras (Amoebites) subkitchini* Spath: Callomon & Birkelund, p. 221, 222.
1982 *Amoeboceras (Amoebites) subkitchini* Spath: Mesezhnikov & Shulgina, p. 22, pl. 1, figs 3, 5.
1982 *Amoeboceras (Amoebites)* cf. *kitchini* (Salfeld): Wierzbowski, p. 116, pl. 37, figs 3, 4.

Holotype. MGUH 8142, figured by Spath, 1935, pl. 1, figs 3a–b.

Locus typicus. Milne Land.

Stratum typicum. Cardioceraskløft Member, first level of concretions (Aldinger's 1935 level δ), 3–5 m above the top greensand of the Bays Elv Member; *Rasenia inconstans* horizon of the Cymodoce Zone, fauna 15. The holotype is from Cardioceraskløft (section 7).

Material. c. 90 specimens, including 35 topotypes (section 7, Cardioceraskløft), from many localities. Others seen in the field, common and easily recognizable.

Description. Macroconchs.

Mean maximum adult diameter, fauna 15: 71.5 mm; σ: 3.5 mm (15 specimens).
Mean length of adult bodychamber: 0.7 whorl.
Mean number of primary ribs, last whorl, fauna 15: 43; σ: 6.0 (9 specimens).
As all specimens are crushed, the thickness of the whorls cannot be measured. This applies also to the holotype.

The largest specimens from the type horizon (fauna 15) – apparently with most of the bodychamber preserved – measure up to 72 mm in diameter, while related specimens from higher levels (fauna 17) may reach a size of up to 80 mm. The umbilicus ranges from 32 to 38% in 10 specimens from the type horizon and from 40 to 44% in 3 specimens from fauna 17.

The sculpture of specimens from the type horizon shows wide variation. The inner whorls tend to be very finely and simply ribbed, as seen in the holotype, with occasional scattered dichotomous ribbing. At about diameters of 25 mm the ribs begin to modify and to develop ventro-lateral clavi or nodes, and at 30–35 mm these become heavier, more pointed, and more or less separated from the ribs. On the youngest part of the shell the nodes are spaced independently of the ribs, but are often almost as dense, the ratio of nodes to ribs per half-whorl at diameters of 53–71 mm being between 1:1 and 2:3. In specimens with the shell preserved it can be seen that the ribs extend from the nodes or clavi across the ventral sulci to the keel. The serration of the keel varies from fine to extremely coarse.

The few specimens known from fauna 17 tend to be more coarsely ribbed. Because of this difference, together with small differences in size and umbilical ratio mentioned above, they are separated as late forms (aff. *A. (A.) subkitchini*).

Microconchs. Microconchs are rare in fauna 15. They are extremely finely ribbed as are inner whorls of macroconchs. Scattered dichotomous ribs are present and ventro-lateral clavi are developed from a diameter of about 20 mm. Microconchs from faunas 16 and 17 are slightly coarser ribbed.

Discussion. Macroconchs. The types of *A. aldingeri, A. irregulare, A. prorsum* and *A. subkitchini* all came from the same horizon, fauna 15, and are merely variants of a single, highly variable species. That of *A. subkitchini* seems the most representative, so we take it to define the senior synonym. It marks forms with the most finely ribbed inner whorls. *A. prorsum* is the most coarsely ribbed. The rarer specimens from higher levels, fauna 17, are slightly more evolute and somewhat more coarsely ribbed than those of fauna 15.

A closely related, later group is that of *A. kitchini* (Salfeld, 1914). The rich new collections of *A. subkitchini* now make a closer comparison possible.

The type-series of *A. kitchini* was rather indefinite. In his first, summary publication (1914, p. 129), Salfeld referred to only two specimens: *Amm. alternans* de

Fig. 6. *Amoeboceras (Amoebites) kitchini* Salfeld, 1914. Lectotype. British Museum (N.H.) C. 13322 (Salfeld, 1915, pl. 20, fig. 16).

Loriol, 1878, pl. 1, fig. 17 (*non* von Buch) (syntype I), and *Amm. alternans* Woodward, 1895, p. 155, fig. 68 (*nec* von Buch) (syntype II). In his second, fuller publication (1915, p. 189) he includes a further 30 specimens that he had available, of which he figured 12. It seems a safe assumption that he had already included these in his type-series in 1914 even though he did not explicitly refer to them then, for the two publications were complementary in subject-matter within a single topic of investigation. No holotype was designated, so that all 32 specimens were syntypes, including the one he figured in 1915 as plate 20, fig. 16 (syntype III) from Cromarty in Scotland. Syntype I was not seen by him. Syntype II does not exist: Woodward's figure is a synthetic redrawing of v. Buch's figures of *Amm. alternans* (we are indebted to Dr B. M. Cox of the British Geological Survey for establishing this from its archives). Syntype III was selected as type specimen by Spath (1935, p. 31), although he referred to it erroneously as neotype under the mistaken impression that syntype I had been holotype subsequently lost. To dispel any residual uncertainties, syntype III (BM C.13322) is here formally designated lectotype and refigured in fig. 6. It came most probably from the small exposure of Kimmeridge Clay redescribed by Waterston (1951) at Eathie where the species is common, and is preserved in a hard dark calcareous concretion.

The lectotype has a rather small umbilicus (29%), is coarsely ribbed both on inner and outer whorls, and has ventro-lateral nodes on the last whorl well separated from the primary ribs by a smooth band from already a diameter of 24 mm onwards. Heavy nodes develop at 32 mm and fuse into clavi just before the end of the shell.

A number of other specimens variously referred to *A. kitchini,* from similar concretions from Cromarty, have been described in the past: (a) *A. akanthophorum* Buckman, 1925 (pl. 550; referred to *A. kitchini* by Spath, 1935, p. 31); (b) *A. kitchini* in Spath (1935, pl. 1, figs 9a,b); (c) *A. kitchini* in Waterston (1951, pl. 2, figs 4a,b). Other specimens belonging to the same group have been variously named:

Fig. 7. *Streblites?* cf. *S. taimyrensis* Mesezhnikov, 1976. MGUH 14348; Section 32, beds with fauna 19, Cardioceraskløft Member, Mutabilis Zone.

(d) *A. subkitchini* in Waterston (1951, p. 2, figs 3a,b); (e) *A.* aff. *A. rasenense* Spath, ibid. (pl. 2, figs 1a,b); (f) *A.* sp. nov., ibid. (pl. 2, figs 2a,b); (g) *A. salfeldi* Spath, 1935, p. 31, holotype (= *Card. pingue* Salfeld, 1915, p. 193, pl. 20, figs 14a,b); and (h) *A. salfeldi* Spath (1935, pl. 2, figs 7a,b). These specimens show a wide range of variation, but it is not certain that they are precisely of the same age for, although their preservation is similar, there is no single persistent horizon of concretions from which they could have come (C. D. Waterston, personal communication, 1979). There is additional undescribed material in the British Museum and British Geological Survey.

The principal differences between *A. subkitchini* and *A. kitchini* lie in a rather smaller size, smaller umbilical width, coarser ribbing, heavier and more strongly differentiated nodes and clavi, and deeper ventral sulci in the latter. The relation between them appears to be phyletic, showing an evolutionary change from finely to coarsely ribbed, strongly tuberculate forms.

A number of forms very closely related to, if not identical with, *A. subkitchini* have been described from the northern regions of the U.S.S.R. by Shulgina (1960) as *A. kitchini* (pl. 1, figs 3,5; pl. 2, fig. 1) or *A. spathi* partim (pl. 2, fig. 2; pl. 3, figs 1–3); and by Meszhnikov & Romm (1973) as *A. pulchrum* and *A. alticarinatum*. The holotype of the latter (pl. 3, fig. 4) appears particularly close to *A. subkitchini* from Greenland. Mesezhnikov & Romm's attempts to differentiate species on the strength of differences in the development of the keel and ventral sulci do not appear to be valid beyond the level of conventional morphospecies within the limits of a wide variability in the sulci as selected character.

Microconchs. Microconchs from the beds with *A. subkitchini* in Greenland are closely similar to the holotype of *A. rasenense* Spath from Market Rasen, Lincolnshire, discussed above, and specimens from Cromarty (e.g. BM C. 71126), but differ in being more finely ribbed. Taking *A. rasenense* to be the microconch of *A.*

kitchini, the microconchs thus seem to show the same trend to coarser ribbing as do the macroconchs.

Stratigraphy. A. subkitchini and sp. aff. *A. kitchini* occur in faunas 15–17 in Greenland, characterized by *Rasenia inconstans* (15–16) and *R. cymodoce* (17) belonging to the lower part of the Cymodoce Zone. *A. kitchini* or forms indistinguishable from it when crushed occur at Eathie in Cromarty at numerous levels. These range from the First Limestone in the section given by Waterston (1951, p. 36) to the top of the section (personal observations, 1979). This range extends from the *R. evoluta* horizon (Birkelund *et al.*, 1978) in the upper Cymodoce Zone, formerly Uralensis Zone of Spath (1935) and Waterston (1951), to the lower part of the Mutabilis Zone (see Birkelund *et al.*, 1983) with *Rasenioides askeptus* (Ziegler, 1962b), the type of which also came from Eathie. Occasional specimens in the collections large enough to be identifiable came from Market Rasen. Together with the much commoner *A. rasenense* these are also from the Cymodoce Zone. Other specimens from the lower Mutabilis Zone have been figured by Arkell & Callomon, 1963 (pl. 32, figs 26a,b, from eastern England, and pl. 33, figs 12, 13 from Mull).

In the U.S.S.R. *A. kitchini* and *A. subkitchini* are cited as more or less overlapping in range, extending from the zone of *Pictonia involuta* below through the zone of *Rasenia borealis* to the zone of *A. mutabilis* above.

Distribution. A. subkitchini has been described from East Greenland; Spitsbergen (Wierzbowski, 1982) and Franz Josef Land on the Barents Shelf (Mesezhnikov & Shulgina, 1982); and the Khatanga Basin and Taymyr Peninsula in northern Siberia (Mesezhnikov & Romm, 1973). The group of *A. kitchini* has been recorded from a much wider area: England, Scotland; Spitsbergen (Sokolov & Bodylevsky, 1931); Petchora, sub-polar Urals, Khatanga Basin and Taymyr (Mesezhnikov & Romm, 1973).

Amoeboceras (Amoebites) cf. *A. (A.) beaugrandi* (Sauvage, 1871)

Pl. 4, figs 6–8

1871 *Ammonites beaugrandi* Sauvage, p. 349 (vol. 19) and p. 165, pl. 10, fig. 6 (vol. 20).
1874 *Ammonites beaugrandi* Sauvage & Rigaux: Loriol & Pellat, p. 31, pl. 2, fig. 4.
1915 *Cardioceras beaugrandi* Sauvage: Salfeld, p. 193.
cf. 1935 *Amoeboceras (Amoebites) beaugrandi* (Sauvage): Spath, p. 31, pl. 5, fig. 4; pl. 4, fig. 8.
1980 *Amoeboceras (Amoebites)* cf. *beaugrandi* (Sauvage): Callomon & Birkelund, p. 223.

Type. The specimen figured by Sauvage & Rigaux, 1871, pl. 10, fig. 6 appears to be holotype by monotypy, for they indicate that the species is rare and mention no other specimens.

Stratum typicum. 'Niveau à *Trigonia Rigauxiana*' according to Sauvage & Rigaux. This is bed K 27 of Pellat, 1880 (p. 676), in the Calcaires or Marnes du Moulin-Wibert of the Boulonnais, northern France, associated with *Aspidoceras caletanum* and *Sutneria eumela* indicating the lower Eudoxus Zone.

Material. Gråkløft, section 8: Gråkløft Member, shales with concretions 'γ' (GGU 234024), a bedding-plane covered with crushed shells; Bays Elv, section 30, bed 8: 1 (JHC 499); section 32, bed 8: 3 (JHC 597–9).

Description. Microconchs. The specimens are all badly flattened. They are up to 27 mm in size and rather evolute, the umbilical ratio being 32–33%. The ribbing pattern is very fine, with many secondaries: up to every second primary rib divides into two secondaries half to two-thirds of the way up the flanks. Usually the ribs form weak clavi on the ventro-lateral shoulder. The venter is poorly preserved. The serration of the keel is fine, and the keel is sharply separated from the ribs on each side by a smooth band. Sutures are not preserved.

Macroconchs. One indeterminate fragment of a macroconch belonging to the *A. kitchini* group has been found at the same level as the microconchs in section 32.

Discussion. As far as it goes, up to a diameter of 11 mm, the specimen figured by Sauvage & Rigaux shows no obvious differences from specimens from Greenland. However, it is so small as to be hardly diagnostic. The species seems to be very rare in the type area. Sauvage, Loriol & Pellat and Salfeld may have had only three specimens between them, all very small. Salfeld stresses in his description the relatively low number of primaries in this species, 10 primaries and 17 secondaries on the last half whorl in the type. In this respect agreement with the material described here is very good. The specimen figured by Spath (1935, pl. 5, fig. 4) from Culgower (Cymodoce Zone) shows a relatively higher number of primaries, while his plate 4, fig. 8 from the Mutabilis Zone, Culgower, is again close to the type.

The use of the name *A. beaugrandi* for microconchs from these levels is largely conventional, pending a more thorough investigation of the relatively numerous material now known from the European Mutabilis Zone.

Stratigraphy. The Greenland material occurs together with *Rasenia borealis* and *Aulacostephanoides mutabilis* in fauna 19, Mutabilis Zone.

Distribution. Northern France, Scotland, ?England, ?Spitsbergen (Frebold 1930, pl. 22, fig. 3), ?northern Siberia, Khatanga Basin (*A. modestum* Mesezhnikov & Romm, 1973, pl. 3, fig. 2).

Amoeboceras (Amoebites) elegans Spath, 1935

Pl. 5, figs 1–7; pl. 6, figs 1–8

1935 *Amoeboceras (Amoebites) elegans* Spath, p. 33, pl. 4, figs 1–3.
1935 *Amoeboceras (Amoebites) pseudacanthophorum* Spath, p. 35, pl. 5, figs 7–8.
cf. 1960 *Amoeboceras (Amoebites) bodylevskii* Shulgina, p. 142, pl. 4, figs 1–2.
1976 *Amoeboceras (Amoebites) elegans* Spath: Sykes & Surlyk, p. 431, fig. 7C.

Holotype. MGUH 8155, figured by Spath, 1935, pl. 4, fig. 2.

Locus typicus. Milne Land, East Greenland.

Stratum typicum. Gråkløft Member. The holotype is from Aldinger's loc. J on upper Sønderelv, near the spot-height 144 m marked on his map. In the nearby section 21 the species characterizes a level 58 m above the base of Gråkløft Member.

Material. c. 10 specimens east of Pinnadal (section 13) and *c.* 40 specimens from Sønderelv (section 21).

Description. Macroconchs. All the specimens are flattened. The largest specimen, still incomplete, is about 115 mm in diameter. The umbilical ratio is 29–39% at diameters between 30 and 100 mm (14 specimens). The umbilical edge is very gently rounded. The shell is smooth to a diameter of 8 mm. Thereafter, the rest of the shell is covered by dense, nearly straight, evenly spaced, long primaries. At the ventro-lateral shoulder these twist forward sharply and thicken into short diagonally-projected clavi. The density of the primary ribbing varies widely and increases slowly during ontogeny. At diameters between 30 and 50 mm, there are 18–32 ribs per half whorl (mean 26, 9 specimens). Between 80 and 100 mm this has risen to 46 ribs per half whorl. On early and middle whorls there are additional intercalated secondaries, so that the ventro-lateral clavi outnumber the primaries by up to 4:3. On the outer whorl they can become heavier, more nodate and widely spaced, fusing the ribs together in looped pairs as in the earlier *kitchini* group. In compressed specimens the secondaries form a very characteristic thickened rim, well separated from the primaries. In some specimens the keel is seen outside this rim, but no details of the venter are known. The suture-line is also unknown.

Microconchs. At least the specimens figured in plate 6, figs 7–8 appear to be microconchs, the umbilical seam uncoiling on the last whorl and the ribbing remaining isocostate.

Discussion. The new material of *A. elegans* shows the full range of the variability in ribbing, which then incorporates *A. pseudacanthophorum* as merely a coarsely ribbed variant. The specimens referred by Spath to *A.* (*A.*) cf. *A. (A.) elegans* and cf. *A. (A.) dubium* (Hyatt) (1935, pl. 3, fig. 1), on the other hand, do not belong here, as they have much longer secondaries than *A. elegans.* They are assigned to *A.* (*E.*) *kochi.*

A. (*A.*) *bodylevskii* Shulgina is probably conspecific with *A.* (*A.*) *elegans,* differing only in a slightly coarser ribbing at comparable diameters.

Stratigraphy. In Milne Land *A.* (*A.*) *elegans* characterizes fauna 22, which occurs at a single sharply-defined level 58 m above the base of the Gråkløft Member and 3 m above the level of *A.* (*H.*) *decipiens* – *A. eudoxus,* fauna 21. In Franz Josef Land *A.* (*A.*) *bodylevskii* is said to occur together with *A.* (*H.*) *decipiens,* and a coarse-ribbed variety 25 m higher (Shulgina, 1960).

Distribution. East Greenland: Milne Land, Kuhn Ø (Sykes & Surlyk, 1976), and possibly Jameson Land (Hareelv Formation, GGU 144141). Closely related forms occur in Franz Josef Land.

Subgenus *Euprionoceras* Spath, 1935

Type species *A. (E.) kochi* Spath, 1935

In separating this subgenus Spath was influenced by supposed phyletic affinities to the earlier *Prionodoceras* (Upper Oxfordian) more than purely morphological characters, for his original diagnosis (1935, p. 12) is not very helpful: "...large Boreal forms that have young stages like ... the earlier genus *Prionodoceras,* but that remain evolute and ornamented instead of becoming involute and smooth". Such a description could encompass almost all post-Oxfordian *Amoeboceras.* The affinities of the type species are closest with *Amoebites* and, sandwiched stratigraphically between the *A. subkitchini/kitchini* group below and *A. elegans* above, the only character of note differentiating it from these is a temporary reversion to simple secondary ribbing at the ventro-lateral shoulder without accentuated clavi or looped tubercles. Whether this merits the retention of a separate subgeneric category seems doubtful.

Amoeboceras (Euprionoceras) kochi Spath, 1935

Pl. 7, figs 1–5; pl. 8, figs 1–7

1935 *Amoeboceras (Euprionoceras) kochi* Spath, p. 26, pl. 15, figs 2a–b.
1935 *Amoeboceras (Amoebites)* cf. *elegans* and cf. *dubium* (Hyatt): Spath, p. 34, pl. 3, fig. 1.
cf. 1930 *Cardioceras* cf. *nathorsti* var. *robusta* Pompeckj: Frebold, pl. 8, fig. 1.
cf. 1931 *Cardioceras sokolovi* Sokolov & Bodylevski, p. 86, pl. 6, figs 1–2.
1982 *Amoeboceras (Euprionoceras) kochi* Spath: Mesezhnikov & Shulgina, p. 25, pl. 2, figs 2,5.

Holotype. MGUH 8159, figured by Spath, 1935, pl. 5, fig. 2a.

Locus typicus. Milne Land, East Greenland.

Stratum typicum. 30–40 m above layer of concretions 'δ' on the east coast of Milne Land, 20 m above sea-level.

Material. c. 35 specimens from Gråkløft, section 8, bed 6; and 8 specimens from Kiderlen Kløft, section 10. Level: 15–30 m above base of Gråkløft Member.

Description. All the specimens are badly flattened, but nevertheless rather well preserved.

Macroconchs. Most specimens are 70–80 mm in diameter and incomplete. Some specimens, including the holotype, are about 100 mm in diameter and a few fragments show that complete specimens could attain much greater sizes (pl. 7, fig. 2).

The umbilical ratio is 30–32% at diameters of 65–90 mm (9 specimens) and shows very little variation. The umbilical slope is rounded. The ornamentation is rather uniform from early to late stages of growth. The ribs are sharp, single and nearly straight except at the ventro-lateral shoulder, where they bend strongly forward. Mean number of primaries per whorl at diameters of 65–90 mm is 51.6 (σ 6–7, 9 specimens). Occasional bifurcating ribs may be seen. Bullate tubercles may be developed on the ribs and between ribs on the ventro-lateral shoulder, where they are more or less well separated from the ribs. On the outermost whorl, bullae tend to be weak or missing, remnants being developed as intercalated ribs which may coalesce with the primaries close to the venter. Where shell is preserved the transition from ribs to keel is gradational, weak ribs being visible between the bullae and the keel. When the shell is missing, as in Spath's plate 5, fig. 2b, the keel is well separated. The ratio of crenulae on the keel to primary ribs is about 2:1. Sutures are not visible.

Microconchs. Small isocostate specimens that occur together with the macroconchs and show a tendency to uncoil may be the microconchs, but this cannot be verified as the sutures are not preserved.

Discussion. This species is close to or conspecific with *A. sokolovi,* which would have priority. Spath thought that *A. sokolovi* was more coarsely ribbed, especially on the septate whorls, and that it reaches a greater size. He also mentioned differences in ventral aspect, *A. (P.) sokolovi* having a keel integral with the venter. However, the new material of *A. kochi,* together with *A. sokolovi* from Spitsbergen in the British Museum, shows that the two species may attain similar sizes, that differences in ribbing are minor, and that supposed differences in ventral aspect may be ascribed to differences in preservation. As the available material of *A. sokolovi* is, however, too poor to tell if the species differ in other ways, the name *A. kochi* is retained here for the time being.

Frebold's specimen may also be conspecific; but even if his 'var. *robusta*' (I. F. Pompeckj MS) is accorded subspecific rank (pre-1931), the specimen in question would not be the type (Frebold 1930, p. 30) and the formal problem of synonymy with *A. kochi* could always be circumvented by fixing the name *robusta* on some other specimen as lectotype.

Stratigraphy. A. (P.) kochi belongs to fauna 20 in Milne Land, lying between the *Rasenia borealis – Aulacostephanus mutabilis* fauna and the *Amoeboceras (Hoplocardioceras) decipiens – Aulacostephanus eudoxus* fauna. It is not clear if it belongs to the Mutabilis Zone or the Eudoxus Zone.

Distribution. The species has been described from East Greenland, Franz Josef Land (Mesezhnikov & Shulgina, 1982), ?Spitsbergen and the Ust'-Yenisei anticline (Little Kheta anticline; see Shulgina, 1960). Undescribed material from Scotland in the British Geological Survey, Edinburgh (M2166^{g}–2190^{g}), from the shore 330 yards south-west of Saon Rudha na Gaoithe, Wester Garty, Sutherland, seems to belong to the same species.

Subgenus *Hoplocardioceras* Spath, 1935

Type species *A. (H.) decipiens* Spath, 1935

This subgenus was founded for essentially a single known species characterized by strong to extreme tuberculation of the ribbing in up to three rows, at the umbilical edge, at mid-flank, and on the ventro-lateral shoulders. It stands stratigraphically in the middle of a series of non-tuberculate or only mildly tuberculate forms of *Amoebites,* the phyletic relations to which remain obscure.

Amoeboceras (Hoplocardioceras) decipiens Spath, 1935

Pl. 9, figs 1–7

1933 *Aspidoceras* sp. indet. Frebold, p. 12, pl. 1, figs 1–4.
1935 *Amoeboceras (Hoplocardioceras) decipiens* Spath, p. 36, pl. 2, figs 1–2; pl. 3, fig. 2; pl. 4, fig. 7.
1960 *Amoeboceras (Hoplocardioceras) decipiens* Spath: Shulgina, p. 143, pl. 3, fig. 4.
1982 *Amoeboceras (Hoplocardioceras)* cf. *decipiens* Spath: Mesezhnikov & Shulgina, p. 27, pl. 2, figs 1,4.

Holotype. MGUH 8153, figured by Spath, 1935, pl. 3, fig. 2.

Locus typicus. Milne Land, East Greenland.

Stratum typicum. Gråkløft Member. The holotype is from Pinnadal, probably close to section 13.

Material. 6 specimens from upper Cardioceraskløft, section 7; 7 specimens from Kiderlen Kløft, section 10, bed 9; 3 specimens east of Pinnadal, section 13; *c.* 60 specimens from Sønderelv section 21, 2–3 m below bed with *A. elegans*; 1 specimen west of Kronen, section 24, bed 3.

Description. All the specimens are flattened, but the rich material nevertheless gives a good impression of the range of variability.

The holotype seems to be complete and measures 140 mm in diameter. It is the largest specimen known up to now. The umbilical ratio is 26% to 34% at diameters of 16 to 140 mm (7 specimens). The earliest whorls are very finely ribbed. Already at diameters of about 6 mm, three rows of nodes begin to develop. The inner row forms by radial thickening of the primary ribs on the umbilical edge. The middle row involves thickening of the primaries at mid-flank, swelling into more or less widely-spaced nodes or coarse tubercles on the middle and outer whorls. The outer row forms by thickening of the more or less differentiated, short, projected secondary ribs on the ventro-lateral shoulders. In some specimens these outer nodes swell into enormous widely-spaced radial tubercles on the last whorl, strongly resembling the earlier *A. kitchini* both in style and variability. All three rows are highly variable, both in themselves and relative to each other. They may remain joined by ribs or become wholly differentiated. The ratio of outer to lateral nodes is typically 4:3. In some adult macroconchs, e.g. the holotype, the sculpture reverts to simple ribbing on the final quarter whorl. A number of specimens show a prominent keel with coarse serrations (pl. 9, fig. 2). Sutures are not visible.

Discussion. This species is so distinct that it is hard to confuse with any other species of *Amoeboceras*. Spath (1935) compared it with a specimen from Culgower, Scotland (BM C13205) with "at least two strong nodes of tubercles", from a lower stratigraphical level (Cymodoce Zone). This specimen is a small flattened fragment. Only the ventro-lateral nodes are well-developed, while the second row are merely swellings of the higher part of the primaries as are often to be seen in *Amoeboceras (Amoebites) kitchini*; and it seems that the fragment belongs rather to that group.

Stratigraphy. A. (H.) decipiens characterizes a single, sharply-defined level 55 m above the base of the Gråkløft Member, and makes this an excellent, widely-recognizable stratigraphical marker. Fauna 21; associated with rare *Aulacostephanus eudoxus* – Eudoxus Zone.

Distribution. Known from central and northern East Greenland; Franz Josef Land (Shulgina, 1960); and Ust'-Yenisei region in Siberia (not figured, see Shulgina, 1960). Possible occurrences of the subgenus have been mentioned by Callomon & Cope (1971, p. 158) from the Warlingham borehole, Surrey, and Marton brick-pit, Yorkshire, both in the Eudoxus Zone.

Family Aulacostephanidae Spath, 1924
Subfamily Pictoniinae Spath, 1924

[incl. Raseniinae Schindewolf, 1925, and Ringsteadiinae Schneid, 1939]

Genus *Pictonia* Bayle, 1878

[incl. *Triozites* Buckman, 1924]

Type species *Pictonia baylei* Salfeld, 1913 [ICZN Opinion 426; = *Pictonia cymodoce* Bayle, 1878 (*non* d'Orbigny, 1850)]

Much new material and stratigraphical information obtained in the last 30 years shows the genera *Decipia-Ringsteadia-Pictonia-Rasenia* to have been merely successive segments of a smoothly evolving lineage of perisphinctids that forsook the more southerly habitats of ancestral *Perisphinctes* at the beginning of the Upper Oxfordian and occupied a new Sub-Boreal faunal province, represented *par excellence* in Britain. To the south, its members rarely penetrated much further than Normandy and the northern parts of the Paris and Aquitaine Basins. To the north it included Milne Land and, in the Kimmeridgian, extended as far as the Barents Shelf and northern Siberia. Faunal successions tend locally to be disjointed and fragmentary, and this was historically the reason behind the rather numerous generic and familial names coined in the past. The boundaries between genera are, however, purely arbitrary and represent no clearly discernible breaks in the morphological evolution of the group as a whole. The strongly-flared and collared constrictions usually regarded as characteristic of macroconch *Pictonia* occur already on inner whorls of some late *Ringsteadia* and persist at least as far as *Rasenia cymodoce,* while they may not be developed at all in some variants of most species of *Pictonia.* The microconchs intergrade even more strongly and deviate little from a common isocostate morphology usually referred to *Prorasenia* Schindewolf, 1925, ranging from the upper Pseudocordata Zone to the lower Mutabilis Zone. The assemblages from Milne Land being relatively few and well-spaced, no particular demarcation problems arise.

Pictonia sp. nov. A. aff. *P. normandiana* Tornquist

Pl. 10, figs 1–6; pl. 11, figs 1–3

cf. 1896 *Pictonia cymodoce* (d'Orbigny): Tornquist, p. 11, *partim,* and vars.; pl. 1, fig. 2; pl. 2, fig. 1; pl. 3, fig. 1; pl. 5, fig. 2.

cf. 1896 *Pictonia normandiana* Tornquist, p. 20, pl. 5, fig. 1; pl. 6, fig. 2.

cf. 1896 *Pictonia parva* Tornquist, p. 25, pl. 4, fig. 2.

aff. 1913 *Pictonia baylei* Salfeld, p. 423 (= *Pictonia cymodoce* Bayle, 1878, *non Amm. cymodoce* d'Orbigny; photograph of lectotype refigured by Arkell, 1956, pl. 40, fig. 5, as 'holotype', 1957, p. L325, fig. 417).

non 1935 *Pictonia* sp. indet., Spath, p. 41, pl. 14, fig. 4, *nec* pl. 8, fig. 5a,b.

Material. 9 specimens; 5 (M) and 4 (m), from the Bays Elv Member between Visdal and Aldinger Elv, fauna 14.

Description. Macroconchs. Most of the specimens appear to be immature, but the early fading of the ribbing gives the impression that the species was a small one. If the bodychamber shown in plate 10, fig. 1 was that of a mature individual, the maximum diameter was only about 120 mm. The other characteristic features are the evolute coiling (umbilical ratio 45–47%); dense and fine ribbing on the innermost whorls, becoming irregular and variably bi- and polyplicate; and deep, broad constrictions associated with flared primary ribs and irregular ventral collars.

Microconchs. Maximum diameters of what appear to be all adults, 30–45 mm. Ribbing on the inner whorls also dense and fine, sometimes with constrictions, modifying slightly on the adult bodychamber into strong biplicate ribs typical of *Prorasenia sensu lato.*

Comparisons. The evolute, irregularly ribbed and constricted character of the macroconchs has been found in only one other assemblage known so far, that of the 'degenerated (*sic*) perisphinctids' of Le Havre, Normandy, described by Tornquist (1896). Most of the forms described by him almost certainly came from a single faunal horizon and are but variants of one biospecies. Although he misidentified most of it as *Pictonia cymodoce* (d'Orbigny), he did introduce, besides numerous varietal names, four new specific ones for some of the forms: *P. normandiana, P. latecostata, P. parva* (merely a wholly septate nucleus) and *P. bigoti.* Of these the first is based on types fairly typical of the assemblage as a whole and makes a very appropriate name for it.

It is possible that the syntypes of *Pictonia baylei* Salfeld, 1913, (Bayle, 1878, pl. 66, figs 1,2) also belong to the same assemblage, in which case *P. baylei,* deeply entrenched in the literature above all as index of the Baylei Zone, would become junior synonym of *P. normandiana.* Pending the necessary systematic and stratigraphical investigations, both names and species are best retained. Certainly *P. normandiana* and *P. baylei* together would still fit easily into the range of variability of the other now well-known species of *Pictonia, P. densicostata* Buckman, 1924.

The Greenland species differs from *P. normandiana* principally in size. *P. normandiana* is larger, typically still septate at 120 mm, with correspondingly later onset of the variocostate loss of ribbing. Its inner whorls appear not yet to have been described. *P. densicostata* parallels *P. normandiana* in size, style and variability of coiling, but is much more regularly ribbed. The specimen illustrated by Spath as a *Pictonia* would certainly fit on morphological grounds. It came, however, from the east coast of Milne Land, from a higher level, in the concretions with faunas 15–17; fauna 13 has not been found in this area. The specimen is therefore probably merely an extreme variant of the *Rasenia inconstans* assemblage.

The microconchs of *P. normandiana* have not yet been described. The nearest to them may be two species described by Spath: *Prorasenia bowerbanki* (1935, p. 43, pl. 14, fig. 3) and *P. hardyi* (1935, p. 40, pl. 15, fig. 5), of which only the former, a complete adult 34 mm in diameter, is closely interpretable. Both were said to have come from "Lower Kimmeridge Clay, Wootton Bassett", but it seems much more likely that their true horizon lay still in the Pseudocordata Zone of the Upper Oxfordian. The successions exposed in the old brick-pits of Wootton Bassett were never described, and can only be surmised from the material in museums. This includes rich collections of macroconchs; and although occasional specimens of *Pictonia densicostata* are to be found among them (e.g. *Pictonia costigera* Buckman, 1927, pl. 716, and *P. baylei* Salfeld: Spath, 1935, pl. 8, fig. 4a,b), by far the majority are *Ringsteadia* species as figured, for example, by Salfeld (1917). Typical *Prorasenia bowerbanki* occurs in profusion also in the Pseudocordata Zone of South Ferriby (see above, bed 8), but not in the Baylei Zone there.

Age and distribution. Associated in Milne Land with *Amoeboceras bayi* sp. nov. (q.v.), fauna 13: above *Ringsteadia* ex gr. *R. pseudocordata* and below *Rasenia inconstans* (fauna 15). Its close similarity to *P. normandiana* indicates that its level lies above that of *P. densicostata.* At South Ferriby similarly small forms appear to occur in bed 10b–c, between *P. densicostata* and *P. normandiana*/*baylei.*

Pictonia? sp. indet. B

Pl. 11, fig. 4

Material. 1 specimen (JHC 638), from Bays Elv, section 29, bed 3.

Description and comparisons. The specimen is crushed and the whole of the last whorl is bodychamber. Sutures are not visible, and the absence of any modification of the ribbing suggests that the shell was not yet fully grown. Both the relatively involute coiling (umbilical ratio *c.* 30%), subdued ribbing and absence of prominent constrictions suggest assignment to *Ringsteadia* rather than to *Pictonia.* In *Ringsteadia* of comparable rib-density, e.g. *R. pseudocordata* (cf. Buckman 1925, pl. 560A, B), primaries and secondaries are, however, invariably more strongly differentiated, the short secondaries deriving indistinctly from the primaries high on the converging, ogivale whorl-side and rapidly fading. In contrast, shells similar to the present one occur as extreme variants in most assemblages of *Pictonia,* e.g. *P. costigera* Buckman (1927, pl. 716) and others in the collections, variants of *P. densicostata*; *P. bigoti* Tornquist (1896, pl. 7, fig. 2), variant of *P. normandiana*; and even *P. caliginosa* Schneid (1940, pl. 16 (12), fig. 4), variant of *P. albinea* (Oppel). It is not inconceivable, therefore, that the present specimen is merely an extreme variant of the same assemblage described above as *P.* aff. *P. normandiana,* but much more material would be needed to establish this.

Age. Found in the same bed and at the same locality as typical *Amoeboceras bayi,* fauna 14, but as this bed is rather thick and may include a number of separable glauconitic horizons, the precise age of the present specimen relative to those af *A. bayi* and *P.* aff. *P. normandiana* is not certain. It may be even still just Upper Oxfordian.

Genus *Rasenia* Salfeld, 1913

Type species *Rasenia involuta* (Salfeld MS) Spath, 1935

Rasenia inconstans Spath, 1935

Pl. 12, figs 1–4; pl. 13, figs 1–5; pl. 14, figs 1–4

1935 *Rasenia inconstans* Spath, p. 45, pl. 8, figs 7–8; pl. 10, fig. 6 (M).
1935 *Rasenia orbignyi* (Tornquist): Spath, p. 43, pl. 8, figs 1–2; pl. 9, figs 1, 3, 4; pl. 10, figs 1–2; pl. 11, fig. 1; pl. 12, fig. 1 (M); – pl. 10, fig. 3 (m?).
1935 *Rasenia* sp. indet.: Spath, p. 41, pl. 13, figs 1a–b (M).
1935 *Pictonia* sp. indet.: Spath, p. 41, pl. 14, fig. 4 (M).
1935 *Pictonia* sp. juv.: Spath, p. 43, pl. 8, figs 5a–b (m).
1980 *Rasenia inconstans* Spath: Callomon & Birkelund, p. 221.

Holotype. MGUH 8187, figured by Spath, 1935, pl. 10, fig. 6.

Locus typicus. Milne Land.

Stratum typicum. Cardioceraskløft Member, first level of concretions (Aldinger's 1935 level δ), 3–5 m above the top greensand of the Bays Elv Member. *Rasenia inconstans* horizon of the Cymodoce Zone, fauna 15. The holotype is from Cardioceraskløft (section 7).

Material. c. 16 specimens (+ many fragments) from section 7 (Cardioceraskløft), 1 specimen west of section 39 (SSE of point 620), 2 specimens (+ fragments) from section 41 (Visdal), 3 specimens from section 45 (Visdal), 4 specimens from section 47 (Visdal), 1 specimen from section 49 (Visdal); and widespread field-records.

Description. Macroconchs. All specimens are flattened. The largest specimen with most of the bodychamber preserved is 210 mm in diameter. The diameter at last suture may vary from 120 to 170 mm. The umbilical ratio is 36–43% at diameters of 50–150 mm (14 specimens).

The sculpture of the innermost whorls is not well-preserved, but good enough to show that the primary ribs never become bullate before a diameter of 20 mm. Some specimens tend to keep non-bullate or only very slightly bullate primary ribs also on later whorls. There occur gradations between such weakly bullate forms with elongated bullae and forms with fairly pointed bullae. The ribs are very slightly curved backwards at the umbilical margin, but otherwise nearly straight. The number of primary ribs per half whorl at diameters of 55–110 mm is 8–11 (11 specimens). The ratio of primaries to secondaries is 1:3.5 – 5 at diameters of 50–150 mm (11 specimens). The secondaries are usually completely covered by younger whorls. The ribbing tends to disappear at about a diameter of 90–120 mm. In some cases the secondaries remain after the primaries have disappeared. The late part of the shell is smooth, or more rarely retains straight, blunt, rounded ribs. The suture-lines are not well preserved. They seem to be very close to those of *R. cymodoce* as shown in plate 18, fig. 1. Constrictions are not as prominent as in *Pictonia,* and flared collars do not stand out above the more bullate primary ribbing of *Rasenia.*

Microconchs. The specimens figured in plate 12, fig. 4 and Spath plate 8, fig. 5 are taken to be the microconchs of *R. inconstans*. In plate 12, fig. 4 the ribs become biplicate very close to the umbilical seam, as in the holotype of *Prorasenia hardyi* Spath (1935, pl. 15, figs 5a–b).

Discussion. The rich material of this species from one horizon (fauna 15) shows a variation of the outer whorls ranging from forms close to *Pictonia* with non-bullate primaries (pl. 14, fig. 1), referred to *Pictonia* sp. indet. and *Pictonia* sp. juv. by Spath (1935), to forms with heavy bullate ribs, referred to *Rasenia orbignyi* (Tornquist) and *R. orbignyi* var. *ornata* by Spath. The dominant type, however, has elongated, nearly straight and not strongly pointed bullae as in the forms referred to *R. inconstans* by Spath. This variation both in sculpture and in density of ribbing (used to differentiate *R. orbignyi* var. *suburalensis* Spath, 1935, p. 44, pl. 8, fig. 2), as well as the fading of the ribbing (used to differentiate *R. orbignyi* var. *ornata* Spath, 1935, p. 44, pl. 10, fig. 1; pl. 11, fig. 1) cannot therefore be used taxonomically above varietal level. *R. orbignyi* var. *apertum* Spath, 1935, p. 44, pl. 9, fig. 1, was differentiated on the basis of an umbilical ratio of 50%, but this also falls within the range of variation of other specimens except in the youngest part of the shell, which seems to be deformed.

The few specimens known from fauna 16 differ from those of fauna 15 by having slightly more curved primaries.

Comparisons. The name *orbignyi* was introduced by Tornquist (1896, p. 29, as *Pictonia orbignyi*) for a new species that included in its type series one of the figured syntypes of *Amm. cymodoce* d'Orbigny (1850, pl. 202, figs 1, 2). D'Orbigny's specimen was then designated lectotype of *Pictonia orbignyi* by Lemoine (1904, no. 55). Modern interpretations of the species seem unanimous in assigning it to *Rasenia*; and an examination of the lectotypes of *R. cymodoce* and *R. orbignyi* – both from the same locality in Charente – suggests that they are themselves conspecific. *R. orbignyi* sensu Spath from Milne Land, faunas 15–16, is distinct from what is now identified as *R. cymodoce* in Milne Land in fauna 17 (see below), and the next available name to label the assemblages of faunas 15–16 is therefore *R. inconstans* Spath.

R. inconstans is close to *R. similis* Spath, 1935 (p. 46, pl. 14, figs 2a–b). Spath figured only the inner whorls of the holotype, although outer whorls are partly preserved (BM C.36504). Umbilical ratio and relations between primaries and secondaries are the same (at a diameter of 109 mm the umbilicus is 45.5 mm (umbilical ratio 42%) and number of primaries and secondaries on a half whorl is 12 and 46 respectively), but the ribs are more straight and *Pictonia*-like than in *R. inconstans* (see Birkelund *et al.*, 1978b). Some specimens of *R. inconstans* are rather similar to *R. involuta* Spath, 1935 (p. 48, pl. 10, fig. 5a–b; see also Birkelund *et al.* 1978b, p.

50, pl. 3, fig. 6). Main differences are less bullate primaries on inner whorls and straighter ribs in *R. inconstans* than in *R. involuta.*

Stratigraphy. Rasenia inconstans characterizes the earliest *Rasenia*-bearing horizons in Milne Land (fauna 15 and 16), although, as mentioned previously, the dividing-line between *Pictonia* and *Rasenia* is to some degree arbitrary. These horizons are here also assigned already to the Cymodoce Zone, although the base of this zone remains to be properly defined.

Distribution. Up to now the species has only been described from Milne Land. The poorly-preserved material found at South Ferriby in bed 12 includes occasional crushed specimens that are barely distinguishable.

Rasenia cymodoce (d'Orbigny, 1850)

Pl. 17, figs 1, 2; pl. 18, figs 1–6

1850 *Ammonites cymodoce* d'Orbigny, p. 534, pl. 202, figs 1–4; pl. 203, fig. 1.
1896 *Pictonia cymodoce* d'Orbigny: Tornquist, p. 11.
1896 *Pictonia orbignyi* Tornquist, p. 29.
1904 *Pictonia cymodoce* (d'Orbigny): Lemoine, no. 55, figs $T^{1, 1a, 1b}$, $T^{2, 2a, 2b}$.
1980 *Rasenia cymodoce* (d'Orbigny): Callomon & Birkelund, p. 222.
cf. 1982 *Rasenia (Zonovia) evoluta* Spath: Wierzbowski, p. 117, pl. 37, fig. 8.

Lectotype. The specimen figured by d'Orbigny, 1850, plate 202, figs 3–4 was designated as lectotype by Tornquist, 1896, p. 11, while the specimen figured in plate 202, figs 1–2 was designated type of *Pictonia orbignyi* Tornquist. Lemoine (1904) refigured the two d'Orbigny specimens and referred both of them to *Pictonia cymodoce.*

Locus typicus. Belle-Croix at Dompierre-sur-Mer (Charente Inférieure) (see Hantzpergue, 1979, p. 721).

Stratum typicum. Lower part of Cymodoce Zone, horizon VII in Hantzpergue (1979, p. 721).

Material. 3 specimens and 8 rubber casts from section 7 (Cardioceraskløft), 5 specimens and about 30 specimens photographed in the field from section 30 (south of Bays Elv), 1 specimen from section 32 (pass west of Bays Elv), 2 specimens from section 47 (Visdal); all Cardioceraskløft Member, fauna 17.

Description. Macroconchs. All the specimens are flattened. The largest seen in the field with bodychamber fully preserved was 345 mm in diameter, but complete specimens generally vary between 170–250 mm. The diameter at the last suture is usually 150 to 230 mm. Some of the size variation may be due to immaturity, as the last sutures show no signs of crowding in phragmocones less than 200 mm in diameter. The length of the bodychamber is a little less than $\frac{3}{4}$ whorl. The umbilical ratio is 43–47% at the last suture, at diameters of 150–220 mm.

The inner whorls are very finely ribbed. A rasenid ribbing pattern with slightly bullate primaries develops very early, at diameters less than 20 mm. Nearly straight, only slightly bullate primaries continue to a diameter of 80–100 mm, with 3–4 secondaries per primary. The secondaries are just exposed at the umbilical margin. The last whorls are either smooth or show residual straight, rather sharp well-spaced primaries and no secondaries. Sutures are well preserved (see pl. 17, figs 1, 2; pl. 18, fig. 1) and similar to the ones figured by d'Orbigny and Lemoine.

Microconchs. The specimens figured in plate 18, figs 3–6 are the associated microconchs of *R. cymodoce.* Both biplicate and triplicate forms are represented.

Discussion. The specimens from Greenland seem to be very close to the specimens figured by d'Orbigny from Charente and specimens from the Fleet shore, Wyke Regis, Dorset, (Birkelund *et al.*, 1978b, p. 35; N. J. Morris coll., now British Museum). Besides differences in sculpture, *R. cymodoce* differs from *R. inconstans* in being larger and more evolute.

Stratigraphy. Rasenia cymodoce characterizes the third level of *Rasenia*-bearing concretions in the Cardioceraskløft Member of Milne Land. In the type-region Charente it occurs in the lower part of the Cymodoce Zone in Hantzpergue's classification (1979, horizon VII). In England it occurs in the Wyke Siltstone of Dorset (Birkelund *et al.*, 1978b, p. 35, horizon I; Arkell, 1947, p. 88; Cox & Gallois, 1981, p. 4) and is followed by the horizons of *R. involuta* and *R. evoluta.* Both Arkell and Cox & Gallois took this level to mark the base of the Cymodoce Zone, but a formal definition of the zone in terms of a marker in a type-section has not yet been finally proposed. If drawn at the base of the Cymodoce horizon, fauna 17 in Milne Land, it would leave the horizons with *Rasenia inconstans,* faunas 15 and 16, still in the Baylei Zone. There remain some other faunas of *Rasenia* known from England, well characterized but isolated stratigraphically, to be slotted into the succession, including that of the Abbotsbury Ironstone of Dorset and that of bed 12 at South Ferriby. It seems best to defer the formal definition of the Baylei-Cymodoce Zone boundary until the sequence of faunas of *Rasenia* has been fully worked out.

Rasenia evoluta Spath, 1935

Pl. 19, fig. 1; pl. 20, figs 1–7

1935 *Rasenia evoluta* (Salfeld MS) Spath, p. 48, pl. 14, figs 6a–b.

1978b *Rasenia (Zonovia) evoluta* Spath; Birkelund *et al.*, p. 50, pl. 1, figs 4, 5; pl. 2, figs 1–4; pl. 3, figs 1–5; text-fig. 5 (lectotype, (M)).

1980 *Rasenia* cf. or aff. *evoluta* Spath; Callomon & Birkelund, p. 222.

1983 *Rasenia evoluta* Spath; Birkelund *et al.*, p. 294, figs 4C–E, 5A–C.

Lectotype. The specimen figured in Birkelund *et al.*, 1978, text-fig. 5 (BM 39801) was labelled *R. evoluta* by Salfeld and designated as lectotype by Birkelund *et al.*, 1978b, p. 50, this specimen being better determinable than the barely interpretable nucleus figured by Spath, 1935.

Locus typicus. Market Rasen.

Stratum typicum. Not precisely known; presumed to belong to the Market Rasen fauna B, as defined in Birkelund *et al.* (1978b), horizon III.

Material. 3 specimens from section 30 (south of Bays Elv) and 4 specimens from section 32 (pass west of Bays Elv).

Description. Macroconchs. The material of this species is scarce. The largest specimen is 234 mm in diameter and seems to be nearly complete (field photo only, cf. pl. 19). Another large specimen is 200 mm in diameter and 150 mm at the last suture. The umbilical ratio is 41–47%. The inner whorls are finely ribbed and rasenid ribbing with bullate primaries is developed from a very early stage. The primaries usually become quasituberculate and rursiradiate very early in ontogeny. The ratio of primaries to secondaries is 1:3 at a diameter of *c.* 70 mm in the specimen shown in plate 19, fig. 1. The roots of the secondaries are not covered by younger whorls and are thus visible in the umbilicus. In the two large specimens the shell tends to become smooth on the youngest part of the phragmocone, but blunt, rounded ribs may reappear on the final part of the adult bodychamber.

Microconchs. The material is often too poor to be able always to distinguish juveniles, nuclei and microconchs with certainty. The specimen in plate 20, fig. 5 shows a lappet, while the prorasenid dichotome ribbing-pattern of the nuclei shown in plate 20, figs 6, 7 suggests that they, too, are microconchs. The specimens shown in plate 20, figs 3, 4 are wholly septate and may be nuclei of macroconchs.

Discussion. The specimen shown in plate 20, fig. 7 is very close to the lectotype of *R. evoluta* in shape, umbilical ratio and ribbing pattern. Other specimens show a variation similar to that of the material from the *locus typicus* Market Rasen and from Andøya, as described by Birkelund *et al.* (1978b). The species is closely related to *R. uralensis* (d'Orbigny, 1845) (see Birkelund *et al.*, 1978b).

Age and distribution. In Milne Land the species has been found in the Cardioceraskløft Member in the area of Bays Elv only, in the fourth level of concretions, fauna 18, 18 m above the third with *R. cymodoce,* fauna 17. It has now also been found more widely. Its position in England has been clearly identified at the top of the Cymodoce Zone, from Dorset to East Anglia (Gallois & Cox, 1976; Cox & Gallois, 1981, Birkelund *et al.*, 1983). It reached as far south as the Aquitaine Basin (Hantzpergue, 1979, horizon XII) and as far north as Andøya (Birkelund *et al.*, 1978b).

Rasenia borealis Spath, 1935

Pl. 15, fig. 2; pl. 21, figs 2–3

cf. 1911 *Aulacostephanus (?)groenlandicus* Ravn, p. 492, p. 37, figs 3a–c.
1935 *Rasenia borealis* Spath, p. 48, pl. 6, fig. 1 (paratype); pl. 7 (holotype).
1935 *Rasenia polaris* Spath, p. 48–49 (*nomen nudum*; obj.)
cf. 1976 *Aulacostephanus (Xenostephanus)* cf. *groenlandicus* Ravn: Sykes & Surlyk, p. 431, fig. 7A.
1980 *Rasenia (Zonovia) borealis* Spath: Callomon & Birkelund, p. 222.

Holotype. MGUH 8187, figured by Spath, 1935, pl. 7.

Locus typicus. Milne Land.

Stratum typicum. Cardioceraskløft Member, the fifth layer or group of layers of concretions, *c*. 60 m above the base of the member (Aldinger's (1935) level γ). The holotype is from Gråkløft (section 8).

Material. 6 topotypes from section 8 (Gråkløft) and 2 specimens from section 30 (south of Bays Elv).

Description. *Macroconchs* attain a very large size, up to 270 mm (the types, and pl. 21, fig. 3). Diameters at the last suture are about 175 mm, and the adult bodychamber occupies 0.85 whorl. The shape is evolute, the umbilical ratio being 44 to 49%. Innermost whorls show a typical rasenid ribbing pattern. It then changes to an *Aulacostephanus*-like pattern at *c*. 50 mm diameter that characterizes the species. Dense, short primaries, around 35 per whorl, bi- and trifurcate low on the flat whorl-side into secondaries of comparable strength. Venters are not well enough exposed to be able to tell whether the secondaries cross with undiminished strength. Sutures are as in *R. cymodoce*. At around 100 mm the ribbing and coiling revert to that more typical of *Rasenia* s.s.; and from about 150 mm the whorls become smooth, the primaries being reduced to well-spaced ridges of low relief, the secondaries fading altogether. On the last half-whorl of the adult macroconch bodychamber rather dense, strong, straight primaries reappear, but this appears to be only a feature indicative of maturity found commonly in many Perisphinctaceae.

The *microconchs* have not yet been positively identified.

Discussion and comparisons. These forms probably marked a stage in an evolutionary process that led from Sub-Boreal *Rasenia* s.s. of the Cymodoce Zone to truly Boreal *Xenostephanus* Arkell & Callomon, 1963, of the middle Mutabilis Zone (see discussions in Callomon, 1981, p. 153 and in Birkelund *et al.*, 1983, p. 294 et seq.). The possibility cannot at present be ruled out that *Xenostephanus* was, in turn, a direct forerunner of *Aulacostephanus* itself. The first steps in this process led proterogenetically to the development of a mid-ventral weakening of the secondary ribbing on the inner whorls, later to strengthen into a smooth band and, finally, to develop into a ventral groove between rows of ventro-lateral tubercles.

What may have been various stages along this path were assigned separate generic names in the past.

The earliest stage probably lay in *Zonovia* Sazonov, 1960, type species *Amm. uralensis* d'Orbigny, 1845. Uncertainties attach to this species because of ambiguities in wording of what could be regarded as lectotype designations, and the specimen first validly selected (d'Orbigny's larger figure, pl. 23, figs 6, 7, designated by Salfeld, 1913, p. 429, confirmed by Spath, 1935, p. 48) being lost. Both a surviving paralectotype (Douvillé, 1912, no. 210, fig. C^1, C^{1a}) and topotypes (Mesezhnikov collection, Leningrad) agree in confirming that d'Orbigny's figure gives a faithful impression of the species, which is therefore morphologically very close to *Rasenia involuta* (M) or some variants of *R. evoluta*. The only difference of substance lies in the ventral interruption of the ribbing in *Amm. uralensis* on at least the whole of the macroconch phragmocone. This has also long been the popular interpretation of the species, so that *uralensis* was the name applied to the coarser-ribbed and more robust forms of *Rasenia* found at Market Rasen, and an Uralensis Zone (in a chronostratigraphical sense by implication) introduced for the relevant part of the Kimmeridge Clay of NW Europe, either as replacement-name on grounds of suitability for Salfeld's Cymodoce Zone, or as subdivision of this zone for the beds exposed at Market Rasen (Spath, 1935, p. 72; Ziegler, 1962a). The British forms do not, however, generally show a ventral interruption of the ribbing, although it may on occasion be found fleetingly. As an assemblage they and the Russian species are thus distinguishable. The positions of the British *involuta-evoluta* assemblages at the top of the Cymodoce Zone are now firmly established (Birkelund *et al.*, 1983). That of *uralensis* remains uncertain, so that it is at present not known whether *uralensis* and *evoluta* were contemporaries, hence possibly geographic subspecies, or whether *uralensis* was younger, hence possibly a descendent of *evoluta*. Even less is known of the precise relationships between *uralensis, borealis* and *Xenostephanus,* and hence no attempt at generic distinction is made here: both *uralensis* and *borealis* are retained in *Rasenia* for the time being.

The aulacostephanid ribbing-pattern on the inner whorls of *R. borealis* is similar to that of *Aulacostephanus (?)groenlandicus* Ravn, the holotype of which is refigured in plate 21, figs 1a–b. Spath (1935, p. 49) stressed the affinity of this species to *Aulacostephanus,* considering its long ribs, short umbilical bullae, and suggestion of a ventral sulcus. However, the ventral sulcus is only apparent, as an illusion caused by preservation of some of the shell on parts of the venter. The affinity of *Au. groenlandicus* with *R. borealis* from Milne Land certainly seems close (cf. plate 21); it may even be the microconch. However, it is so poorly-known that the separate name is retained for the time being for the Milne Land species. Apart from the holotype, only one additional specimen of *Au. (?)groenlandicus* has been described, by Sykes & Surlyk (1976, p. 431, fig. 7A), from Kuhn Ø. It is also similar to *R. borealis*. Specimens referred to *Rasenia* sp. indet. cf. *R. groenlandica* Ravn by Frebold from Spitsbergen (1930, p. 62, pl. 9, figs 3, 4; pl. 22, fig. 2) seem to be even more evolute, and may well be more closely related to *Xenostephanus,* recently described from nearby Franz Josef Land (Mesezhnikov & Shulgina, 1982).

Rasenia borealis bojarkensis Mesezhnikov, 1969 (p. 111, pl. 11, fig. 3; pl. 12, fig. 1) described from the Kheta River basin, is not closely related to *R. borealis* Spath. Together with *R. coronata* and *R. repentina* Mesezhnikov, it seems to form a group that retained all the characters of *Rasenia* s.s., particularly on the inner whorls. Its age appears to be younger than that of *R. evoluta,* however, for it coexisted over some range (horizons VI–XI of the Kheta succession) with typical *Xenostephanus,* found in Britain in the lower Mutabilis Zone. The choice of *Rasenia borealis bojarkensis* as index for a Siberian Borealis Zone seems unfortunate, therefore, and a possible source of confusion.

Age and distribution. In Milne Land the species has been found in the Cardiocerasklφft Member of Cardiocerasklφft and in the area of Bays Elv only. It occurs in the fifth layer (or group of layers) of concretions, fauna 19, 7–12 m above the fourth, with *R. evoluta.* Outside Milne Land the only (uncertain) record is from Kuhn Ø (Sykes & Surlyk, 1976).

Genus *?Pachypictonia* Schneid, 1940

Type species *Pictonia indicatoria* Schneid.

?Pachypictonia sp. nov. C.

Pl. 14, figs 5, 6; pl. 15, fig. 1; pl. 16, fig. 1

1980 *Pachypictonia* cf. and aff. *perornatula* (Schneid) or *corniculata* Schneid: Callomon & Birkelund, p. 222.

Material. Holotype (GGU 234302) and 4 fragments from section 7, bed 18 (Cardiocerasklφft) and 1 specimen from section 31 (Bays Elv).

Description. Macroconchs. All specimens are crushed flat. Dimensions:

I (holotype, pl. 15, fig. 1): diameter 125 mm, wholly septate. Umbilical ratio 47% at 120 mm. Ribs/diameter: 14/40, 18/60, 21/80, 23/100, 25/120.

II (pl. 16, fig. 1): diameter 280 mm, septate to 200 mm, 0.7 whorl bodychamber. Umbilical ratio 48% at 120 mm, 51% at 240 mm. Ribs/diameter: 24/100, 25/150, 20/200, 18–19/250.

The sculpture of the innermost whorls is not preserved. Strong, straight, regularly and widely-spaced primaries are visible from a diameter of 20 mm. These divide indistinctly at mid-flank into sets of two or three secondaries with occasional additional intercalatories. At 70–100 mm, the ratio of secondaries to primaries is 1:3–4. The secondaries are not exposed in the umbilicus, and disappear at around 100 mm, leaving only coarse, blunt primaries on the flanks of the outer whorls. Sutures are poorly preserved, but show a well-developed suspensive umbilical lobe.

Microconchs. Two fragments of the presumed microconchs are shown in plate 14, figs 5, 6. The larger is part of a mature bodychamber, suggesting a fully-grown diameter of about 90 mm. The ribbing on the inner whorls is as widely-spaced as in the macroconchs at comparable diameters and the secondaries are equally sparse, reverting to simple biplication on the outer whorl at maturity.

Comparisons. The overall affinities of this species are certainly with *Rasenia* (cf. pl. 13, fig. 1), as opposed to any other known contemporary family of Perisphinctaceae. It differs consistently, however, from the true *Rasenia inconstans* with which it is associated. It is larger; the coiling is more evolute, *Perisphinctes*-like, particularly on the outer whorls; and the ribbing is straighter, more rectiradiate, without the forward curve of the bullate primaries and projected fasciculate sheaves of secondaries typical of *Rasenia*. In the microconchs, the primaries furcate high on the whorl-side, more as in *Stephanoceras*.

There is instead an overall similarity with some of the 'German Rasenids' from the White Jura γ of Franconia and Swabia, Tenuilobatus Zone, equivalent roughly to the whole of the Cymodoce Zone taken down to the first *Rasenia* above *Pictonia baylei*. These German forms have been known since the earliest times and described in profusion by Oppel (1863), Quenstedt (1888), Wegele (1929) and above all Schneid (1939–40). Their morphological diversity has generated an enormous number of more than 90 nominal species, which the most recent revision by Geyer (1961) helps only moderately to sort out. The principal source of uncertainty is the lack of precise stratigraphy for almost all the type specimens. The group as a whole has some vertical range over which there does appear to have been some evolutionary development, in ways that parallel to some extent that of the British succession. The earlier macroconch forms, from the White Jura γ_1 of the traditional Franconian classification, e.g. *Amm. albineus* Oppel, are still in part *Pictonia*-like, while the later ones, from $\gamma_2 - \gamma_3$, e.g. *Amm. trimerus* Oppel, resemble *Rasenia* of the *cymodoce* group. Two separate generic names are available to label these German faunas: *Pachypictonia* Schneid, 1940, and *Eurasenia* Geyer, 1961 (type species *Amm. rolandi* Oppel, 1863). The morphological variability at every level appears to be very wide, however, extending among macroconchs into discoidal forms assigned by Schneid to *Ringsteadia*. Taking this variability into account, it becomes clear that the German and British faunas are quite distinct, for the discoidal variants in the former have no analogues in the assemblages of true *Pictonia* and *Rasenia* either in Britain or in Milne Land. It also becomes hard to see any systematic differences between *Pachypictonia* and *Eurasenia* worthy of generic rank, especially as defined by their type species.

The microconchs of the German faunas also differ significantly from those of *Pictonia* and *Rasenia*. They are larger, stouter and more coarsely ribbed, and include the group of *Nautilus trifurcatus* Reinecke (neotype figured by Schneid, 1939, pl. 1 (4), figs 4, 4a, designated by Geyer, 1961, p. 94), *Amm. stephanoides* Oppel, 1863 (cf. Schneid, 1939, pl. 8, fig. 13, and *Rasenia witteana* (Oppel) Geyer, 1961, pl. 18, fig. 3), and *Prorasenia quenstedti* Schindewolf, 1925, the type species of this genus.

The new species from Milne Land under discussion therefore resembles the German forms in that its macroconchs have the size and style of ribbing of some of the evolute variants of *Pachypictonia,* although the involute variants appear to be wholly absent. Its microconchs are certainly closer to those of *Pachypictonia* than those of *Rasenia:* cf. pl. 14, fig. 5 with *Pachypictonia divergens* Schneid (1940, pl. 12(8), figs 2–4); and pl. 14, fig. 6 with *Prorasenia stephanoides,* Geyer (1961, pl. 19, fig. 1). They are, however, again consistently even more evolute.

Genus *Aulacostephanoides* Schindewolf, 1925

Type species *Amm. desmonotus* Oppel, 1863

The systematic position of this genus has been discussed recently (Callomon, 1981, p. 153; Birkelund *et al.,* 1983). It is interpreted in the sense of Ziegler (1962), who used it to encompass the "early fine-ribbed Aulacostephanitids" including *Au. linealis* (Quenstedt), *Au. circumplicatus* (Quenstedt), and *Au. mutabilis* (Sowerby). *Au. desmonotus* is not really typical of this assemblage of species, representing perhaps one of the extremes of morphology; and *Au. mutabilis* then represents another. Conventionally, the group is treated as a subgenus of *Aulacostephanus* with which it shares the common character of ventral interruption of the secondary ribbing. But apart from this feature, the morphological similarities are much closer to the ancestral rasenids, *Rasenioides* and *Involuticeras,* than with the younger *Aulacostephanus* s.s. There appears also to be a sharp and widespread morphological discontinuity between the youngest *Aulacostephanoides* and the oldest *Aulacostephanus,* leaving it by no means certain that the latter was the direct phyletic descendant of the former. It seems best, therefore, to retain *Aulacostephanoides* as a separate genus for the time being. Its microconchs fall into *Aulacostephanites* Ziegler (type species *Rasenia eulepida* Schneid).

Aulacostephanoides mutabilis (Sowerby, 1823)

Pl. 22, fig. 1,2

1823 *Ammonites mutabilis* Sowerby, p. 145, pl. 405, fig. 1.

1933 *Pararasenia mutabilis* (Sowerby): Arkell, pl. 34, fig. 5 (holotype refigured).

1956 *Rasenia (Rasenioides) mutabilis* (Sowerby): Arkell, pl. 40, fig. 4 (holotype refigured).

1962a *Aulacostephanus (Aulacostephanoides) mutabilis* (Sowerby): Ziegler, p. 62, pl. 4, figs 1, 3–7, 9–11; text-figs 8a, 12, 18a, 32b, c, 33a, b, d.

1963 *Aulacostephanus (Aulacostephanoides) mutabilis* (Sowerby): Arkell & Callomon, p. 229, pl. 31, fig. 3.

cf. 1969 *Aulacostephanus (Aulacostephanoides) mutabilis* (Sowerby): Mesezhnikov, p. 115, pl. 21, fig. 1.

1980 *Aulacostephanus (Aulacostephanoides) mutabilis* (Sowerby): Callomon & Birkelund, p. 223.
1983 *Aulacostephanoides mutabilis* (Sowerby): Birkelund *et al.*, p. 298, fig. 5I.

Holotype. The specimen figured by Sowerby, 1823, pl. 405, fig. 1, BM 43934; refigured by Arkell, 1933, 1956, and Ziegler, 1962a (see synonymy). For a discussion of the holotype, see Arkell & Callomon, 1963 (p. 229).

Locus typicus. Horncastle (Lincolnshire).

Stratum typicum. Kimmeridge Clay, Mutabilis Zone.

Material. One macro- and one microconch, crushed, from a shallow stream-exposure west of Bays Elv, section 32.

Description. Macroconchs. The macroconch, part of a large specimen, is evolute, has a ribbing pattern characterized by strong, elongated primaries and fine secondaries on the inner whorls, and is smooth from a diameter of about 95 mm. At around 70 mm the number of primaries and secondaries on half a whorl is 8 and 48 respectively. Strong constrictions are developed on the inner whorls. The venter is not visible.

Microconchs. The specimen figured on plate 22, fig. 2, is probably the microconch. It can be referred tentatively to *Aulacostephanoides (Aulacostephanites) eulepidus* (Schneid, 1939) and is especially close to *A. (A.)* cf. *A. (A.) eulepidus* as described from Lincolnshire by Arkell & Callomon (1963, p. 227, pl. 32, figs 1–8).

Both the macro- and the microconch accord well with European material of *A. mutabilis*/*A. eulepidus* as far as preservation allows.

Stratigraphy and age. In Milne Land, the species was found in the same beds as *Rasenia borealis,* fauna 19, even if not in direct association. In NW Europe, *A. mutabilis* is now known to be common particularly at one level in the upper Mutabilis Zone *(sensu anglico):* the Mutabilis Limestone of southern England, bed M18 at Westbury (Birkelund *et al.,* 1983), and Horizon XX in the Aquitaine Basin (Hantzpergue, 1979). Fauna 19 is thus firmly dated to the Mutabilis Zone.

Distribution. A. mutabilis has a wide distribution, ranging from Sub-Mediterranean Swiss Jura through southern Germany (Ziegler, 1962) and the Paris and Aquitaine Basins (Hantzpergue, 1979) into Sub-Boreal Britain and hence into Boreal East Greenland and even the Kheta River basin of northern Siberia (Mesezhnikov, 1969) (rare).

Genus *Aulacostephanus* Tornquist, 1896

Type species *Amm. pseudomutabilis* de Loriol, 1874 [incl. *Aulacostephanoceras* Ziegler, 1962 (type species *Amm. eudoxus* d'Orbigny, 1850)].

Much new information has become available since Ziegler's comprehensive monograph (1962a). The expanded and richly fossiliferous Kimmeridge Clay of Britain reveals a succession of faunas of *Aulacostephanus* probably as numerous and closely-spaced as those of *Kosmoceras* in the Oxford Clay studied by Brinkmann. The first appearance of true, *Hoplites*-like *Aulacostephanus* is everywhere abrupt, at least in Britain, and is used to define the base of the Eudoxus Zone. *Aulacostephanus* s.s. and *Aulacostephanoceras* as defined by their type species, and as largely interpreted by Ziegler, represent merely the macro- and microconchs respectively of the same group. The 15 species retained by Ziegler reflect in part differences of age and in part ranges of intraspecific variability that remain to be established by detailed stratigraphical collecting. The material from Greenland is too scanty to contribute much that is new, and is identified here only in general terms.

Aulacostephanus eudoxus (d'Orbigny, 1850)

Pl. 23, figs 1–3

1850 *Ammonites eudoxus* d'Orbigny, p. 552, pl. 213, figs 5, 6 (*non* figs 3, 4).

1962 *Aulacostephanus (Aulacostephanoceras) eudoxus eudoxus* (d'Orbigny): Ziegler, p. 80, pl. 5, figs 18–24; pl. 7, figs 1 (lectotype), 2–13; text-figs 9g, h, 13a, 15b, 19, 40d–g, 41d–f, 42, 79 (with further synonymies).

1978a *Aulacostephanus eudoxus* (d'Orbigny): Birkelund *et al.*, p. 103.

1983 *Aulacostephanus eudoxus* (d'Orbigny): Birkelund *et al.*, figs 6B, C.

Lectotype. The specimen thought to be the basis of the figure by d'Orbigny (1850, pl. 213, figs 5, 6), designated by Ziegler (1962, p. 80). D'Orbigny collection, Paris, no. 4605.

Locus typicus. St. Jean d'Angely (Charente-Maritime, France).

Stratum typicum. Kimmeridgian, Eudoxus Zone.

Material. One specimen and some fragments from section 21 (west banks of Sønderelv) and one specimen from section 7 (Cardioceraskløft).

Description. The specimen figured in plate 23, fig. 1 is about 73 mm in diameter, and the umbilical ratio is about 38%. Sutures are not preserved. The ribbing consists of very strong, slightly elongated and pointed primaries and strong, coarse secondaries, 2–3 per primary (10 primaries, 24 secondaries per half-whorl). Fragments in the same block show a similar coarse sculpture, and one fragment (pl. 23, fig. 2) shows a smooth, slightly concave venter. A rather poorly preserved but complete specimen from another locality (pl. 23, fig. 3) is only 50 mm in diameter. It shows a strong constriction at the aperture. It is much finer ribbed than the other specimens and seems to have less pointed primaries. The ratio of secondaries to primaries is about the same as in the coarsely-ribbed specimen.

Discussion. The finely-ribbed specimen may be slightly finer ribbed than those of *A. eudoxus* figured by Ziegler, but not more so than might be expected within the usual range of variability. It shows the strong constriction at the aperture characteristic of the species.

Stratigraphy. The species occurs together with *Amoeboceras (Hoplocardioceras) decipiens* in fauna 21, 55 m above the base of the Gråkløft Member, and identifies the age of that fauna as Eudoxus Zone.

Distribution. Very widespread: from Sub-Mediterranean southern France throughout the Rhodano-Argovian-Swabian-Franconian Jura, Aquitaine and Paris Basins, to Sub-Boreal central Poland, Pomerania, Lower Saxony and the whole of Britain, as far as Boreal Greenland. This appears to be the most northerly record so far, and it is perhaps significant that the genus is there but a minor accessory to the dominant group of *Amoeboceras.*

Aulacostephanus sp. cf. or aff. *Au. kirghisensis* (d'Orbigny, 1845)

Pl. 23, fig. 4

1845 *Ammonites kirghisensis* d'Orbigny, p. 431, pl. 33, figs 6–8.
1886 *Hoplites syrti* Pavlow, p. 23, 80, pl. 6, fig. 1.
1886 *Hoplites eudoxus* (d'Orbigny): Pavlow, p. 34, 78, pl. 9, figs 1, 2.
1886 *Hoplites kirghisensis* (d'Orbigny): Pavlow, p. 34, 81, pl. 10, figs 1a, b.
1886 *Hoplites subeudoxus* Pavlow, p. 34, 78, pl. 10, fig. 3 (*non* pl. 4, figs 3–7).
1911 *Ammonites kirghisensis* d'Orbigny: Douvillé, no. 211, figs C^2, C^3, C^5, C^6, C^7 (non C^1, C^4).
1962a *Aulacostephanus (Aulacostephanus) kirghisensis* (d'Orbigny): Ziegler, p. 95, pl. 11, figs 1–4; text-figs 44a, 79 (with further synonymies).
1978a *Aulacostephanus* cf. *jasonoides* (Pavlow): Birkelund *et al.*, p. 103.

Lectotype. The original of d'Orbigny (1845, pl. 33, figs 6, 7) refigured by Douvillé (1911, fig. C^3); designated by Ziegler (1962a, p. 95). Collections of the Ecole des Mines, Paris, now housed in the Université Claude-Bernard, Lyon.

Locus typicus. Sary-gul at Tschkalov, southern Urals, USSR.

Stratum typicum. Kimmeridgian, '*Aulacostephanus* beds'.

Material. One loose specimen from Kiderlen Kløft, 135 m above sea-level.

Description. The fragment shows the characteristic large size of the species and the evolute outer whorls. The primaries are elongated on the inner whorls and become increasingly stronger and more pointed on the outer whorls. The secondaries are fine on the inner whorls, but become coarse and strong on the outer. There are 2–3 secondaries per primary on most of the shell, rising to 3 on the very last part of the bodychamber.

Discussion. The specimen agrees well with *A. kirghisensis* as far as preservation permits. The variability of *A. kirghisensis* is still poorly-known, as the Russian fauna has not been redescribed since Pavlow's monograph. The species is here interpreted in accordance with Ziegler.

Age. According to Ziegler, probably Autissiodorensis Zone. Cursory examination of the outcrops at Kimmeridge supports this. It would fit well with the position of the species in Milne Land, where it occurs above *A. eudoxus.*

Distribution. Described up to now only from the southern Urals and Milne Land, but probably quite widespread, as microconch in part of *A. autissiodorensis.*

Family Oppeliidae Douvillé, 1890
Subfamily Streblitinae Spath, 1925?
Genus *Streblites* Hyatt, 1900?

Type species *Amm. tenuilobatus* Oppel, 1862.

Streblites? cf. *S. taimyrensis* Mesezhnikov, 1976 (m)

Fig. 7 [page 22]

1976 *Streblites taimyrensis* Mesezhnikov, pl. 17, fig. 3 (M).
1980 *Streblites? (Oxydiscites?)* cf. *taimyrensis* Mesezhnikov: Callomon & Birkelund, p. 223, pl. 3, figs 5a, b.
cf. 1983 *Ochetoceras elgense* Khudoley & Kalacheva, p. 66, pl. 3, figs 1–6 (m), 7 (M?).

Material. One specimen (MGUH 14348) from section 32, Cardioceraskløft Member, beds with fauna 19, Mutabilis Zone.

Description. The specimen is crushed almost flat. Maximum diameter 45 mm; discoidal; involute, umbilical ratio less than 10%, umbilical seam uncoiling slightly on the last half-whorl. Inner whorls almost smooth; primary ribbing as traces only, in the form of striae, with falcate inflection at mid whorl-height but without lateral groove; falcate secondary ribbing appearing on the last half-whorl, then fading again. Ribbing markedly projected mid-laterally towards the adapertural margin of the preserved shell with what appears to be part of a terminal constriction, suggesting the former presence of lateral lappets typical of many adult microconchiate Oppeliidae. Venter carinate with finely crenulate keel. No sutures visible, but the general impression is that of a microconch with complete adult bodychamber preserved.

Comparisons. The holotype and only figured specimen of *S. taimyrense* resembles the Milne Land specimen in most respects but is bigger, maximum diameter 120 mm, and most probably a macroconch. It marks a Zone of *S. taimyrensis* in northern Siberia, above beds with *Amoeboceras* of the Eudoxus Zone, but still associated with *A. (Nannocardioceras)* and hence at latest equivalent to the lower Autissiodorensis Zone. It is therefore somewhat younger than the Milne Land specimen. Closer comparisons must await more detailed descriptions of the Siberian fauna. (Technically, even the name *S. taimyrensis* is still only a *nomen nudum* under Art. 13(a) of the Rules of Nomenclature).

Resemblance between the Milne Land specimen and *O. elgense* from the peri-Pacific Far East is also close: similar size, involution, crenulate keel, falcate secondary ribbing and peristome. The age is, however, rather uncertain, said to be Late Oxfordian – Kimmeridgian, older than *Amoeboceras* cf. *A. kitchini* and associated with *Buchia* cf. *B. concentrica (bronni)*. It could therefore be an *Ochetoceras* as claimed.

Comparison with European forms is of little help. No oppelids are known from the Kimmeridgian of Britain. The nearest analogues might be expected in the Sub-Mediterranean faunas of the Rhodano-Franconian Mutabilis Zone of south Germany, Switzerland and south-east France, White Jura δ_1–δ_2 in the Swabian classification. The forms found at this level belong predominantly to the group of *Streblites tenuilobatus* (Oppel) and specifically to *S. levipictus* (Fontannes) (Ziegler, 1958, p. 177). This group differs consistently both from the Milne Land and Siberian forms in having dense tertiary ribbing between the more widely-spaced falcate secondaries and sub-tuberculate ridges at the mid-lateral points of inflection of primaries and secondaries.

The relationships between the Boreal and Sub-Mediterranean Oppeliidae are thus unclear. The northerly forms may represent a group that colonized a Boreal habitat and then evolved independently, as happened previously in the Bathonian.

APPENDIX

Descriptions of some key sections

Abbreviations: (M) and (m) refer to ammonite macro- and microconchs. (VR): very rare. (R): rare, (O): occasional, (C): common, (VC): very common.

Section M6: Cardioceraskløft

Section at the first major fork in the gorge upstream *c.* 1 km from the coast (see figs 1, 4)

From below: base at 68 m

		Thickness (metres)
	Kap Leslie Formation, Aldinger Elv Member	
1	Sands, fine-grained, quartzose, structureless, yellow to white. Upper boundary sharp, slightly undulating, burrowed and penetrated by flecks of glauconitic clay, seen	5
	Sharp boundary	
	Bays Elv Member (20.0 m)	
2	(a) Clay, micaceous, glauconitic, 1–3 cm, passing into (b) silts and fine-grained sands, variable, glauconitic, bioturbated, with small rusty concretions. Scattered belemnites, carbonized plant remains	0.20
3	Shales, black, silty, coarsely micaceous, bioturbated; carbonized plant remains, scattered belemnites. Beds 2–3, *Ringsteadia* – ? *Pictonia* sp. indet., *Amoeboceras* cf. or aff. *A. simplex* Spath. The ammonites are too poorly preserved to make the identifications at all certain, and cannot be assigned to a numbered fauna	0.20
4	Shales, black, silty, coarsely micaceous, carbonaceous, bioturbated, as below but harder. *Limatula consobrina* (d'Orbigny)	0.35
5	Shales, dark grey, silty, bioturbated, softer	0.20
6	Shales, as below but pyritic, hardened by gypsum	0.25
7	Shales, silty, soft, micaceous, pyritic, olive-grey, bioturbated; uniform but for occasional very thin harder beds; becoming sandy upwards, passing into fine-grained sandstone	10
	Sharp boundary	
8	Micaceous shale, soft, consisting predominantly of large mica flakes giving the bed a greasy, shimmering appearance	0.03
9	Sandstone, very fine-grained, strongly glauconitic, greenish; strongly bioturbated, burrows of *Diplocraterion habichi* concentrating to give a veined appearance	0.60
10	Sandstone, fine-grained, hard, glauconitic, weathering brown; marker; strongly burrowed, the burrows filled with glauconite from above	0.05–0.10
11	Sandstone, fine-grained, micaceous, strongly but variably glauconitic, greenish; occasional concretions, bioturbated; carbonized wood	1

12	Sandstone, fine-grained, non-micaceous, light-coloured, glauconitic in burrows; *Pholadomya* sp.	0.10
	Sharp boundary	
13	Shales, sandy, fine-grained, micaceous, soft, non-glauconitic, light grey; becoming indurated at the top into a soft, fissile, concretionary sandstone; bioturbated	6.70
	Sharp boundary	
14	Shales or soft sandstone, fine-grained, glauconitic, the lower part rich in coarse-flaked mica	0.30
	Sharp boundary	

Cardioceraskløft Member

15	Shales, silty micaceous, soft, non-glauconitic, light grey	3
16	Sandstone, prominent, fine- to very fine-grained, concretionary, hard, grey-hearted weathering yellow, doggery, breaking into large flat-edged fissile blocks or slabs; bioturbated, with many large burrows of *Thalassinoides, Curvolithus.* Highly fossiliferous; this, the lowest of the doggery horizons containing *Rasenia,* probably accounted for most of the 'concretions δ' of Aldinger, and can be recognized all over Milne Land, making a most reliable marker. It may be labelled δI. Fauna 15: *Rasenia inconstans* Spath (VC), *Amoeboceras subkitchini* Spath (VC). *Camptonectes* sp., large (C); myaceans in life-position, at times in layers; belemnites (VC); fossil wood	0.50
17	Shales, soft, micaceous, grey, as below, to top of the section; scattered, medium-sized round concretions with *Ostrea* sp. 1 m up, seen	*c.* 3

Section M7: Cardioceraskløft

Section at a small waterfall in the bend of the gorge where it turns from north to east, 2 km upstream from the coast, 1 km west of section M6. The succession overlaps with the top of section M6, so the same numbering is carried through. The boundary beds from Bays Elv to Cardioceraskløft Members are also well exposed on the south slopes of Cardioceraskløft between sections M6 and M7.

Kap Leslie Formation, Cardioceraskløft Member. Type section (25.5 m)

15	Shales, silty, micaceous, soft, non-glauconitic, grey.	
16	*R. inconstans* Bed, δI: sandstone, fine-grained, hard, concretionary, the doggers here fused into a continuous bed up to 1 m thick forming the lip of the waterfall. Prominent burrows: *Thalassinoides, Curvolithus;* many belemnites, myacean bivalves, fossil wood. Ammonites, fauna 15: *Rasenia inconstans* Spath, *Amoeboceras subkitchini* Spath	
17	Shales, silty, micaceous, as below	*c.* 2
18	Second layer of doggers, δII: sandstone, fine-grained locally cemented into well-separated large hard doggers up to 1 m in diameter, weathering light brown-yellow. Extensively bioturbated with *Thalassinoides* and other burrows. Fossils sparse: *Limatula* sp., *Pholadomya* and *Pleuromya* in life-position. Belemnites: *Cylindroteuthis* sp., *Hibolithes* cf. *H. hastatus* Blainville. Ammonites, fauna 16: *Rasenia inconstans* Spath (M) & (m) (R), *Rasenia (?Pachypictonia) simplex* sp. nov. (M) & (m), *Amoeboceras* aff. *A. subkitchini* Spath (M) & (m) (R)	*c.* 0.50
19	Shales, silty, micaceous, as below: belemnites common at the top	*c.* 3
	Sharp boundary	

20 Third layer of doggers, δIII: shales, sandy and micaceous, somewhat glauconitic, indurated, enclosing very large ellipsoidal concretionary doggers up to 3 m across resembling those in bed 16, δI, but much more widely separated. Moderately to highly fossiliferous, particularly in the shales between concretions: *Pleuromya uniformis* (J. Sowerby), *Limatula consobrina* (d'Orbigny), *Buchia lindstroemi* (Sokolov); *Orbiculoidea latissima* (J. Sowerby). Ammonites, fauna 17: *Rasenia cymodoce* (d'Orbigny) (M) & (m) (C), *Amoeboceras* aff. *A. subkitchini* Spath (m) *c.* 1

21 Shales, silty, micaceous, as below *c.* 7

22 Layer of small to medium-sized flat concretions, well spaced, very hard, somewhat pyritic and glauconitic, weathering a characteristic purple colour: Aldinger's concretions γ. Sparsely fossiliferous: small bivalves as calcitic casts in nests (*Grammatodon* sp.?); fossil wood, some concretions formed round pieces of large tree-trunk. Ammonites, fauna 19: *Rasenia borealis* Spath (M)

23 Shales, silty, micaceous, as below; further sparse small to medium-sized flat, purple concretions in 2–3 layers over some 6 m above bed 22; very few fossils *c.* 8

Gråkløft Member

– Shales, silty, black, carbonaceous, laminated, seen up-valley to a prominent basalt dyke running east–west, seen 20

Section M29: Bays Elv

Ridge rising to west from junction in the stream, 2 km west of Aldinger Elv.

Kap Leslie Formation, Aldinger Elv Member

1 Sandstones, quartzose, fine-grained, yellow, more or less consolidated, in cross-bedded courses, some highly shelly: *Camptonectes broenlundi* (Ravn) (VC), *Unicardium aceste* d'Orbigny, *Liostrea* sp. Ammonites in the top 2 m at a nearby locality, Fauna 11: *Amoeboceras glosense* (Bigot & Brasil), *A. damoni* Spath (cf. Sykes & Callomon, 1979, pl. 116) seen 5

2 Sands, yellow 6

Bays Elv Member. Type section (17.2 m)

3 Sands, fine-grained, glauconitic, olive-coloured, with lenticles of dark red sandstone in the upper part. Moderately fossiliferous, *Camptonectes* sp., *Buchia lindstroemi.* Ammonites, faunas 13–14: *Ringsteadia* aff. *R. pseudocordata* (Hudleston) (C), *Pictonia* cf. *P. baylei* Tornquist (section M31), *Amoeboceras bayi* sp. nov., *Amoeboceras* cf. *A. ernesti* (Fischer) *c.* 4

4 Sands, fine-grained, grey 1.3

5 Sands, glauconitic, brown 0.8

6 Sands, moderately glauconitic, grey-green, a few hard red concretions 2

7 Sands, glauconitic, with dark red lenticles of fine-grained sandstone 2.5

8 Sand, highly glauconitic, with slabs of dark red fine-grained sandstone; *Limatula consobrina* (d'Orbigny) (C), belemnites (VC); *Amoeboceras* sp. indet. 3

9 Sands, fine-grained, moderately glauconitic, with highly fissile but bioturbated light brown concretionary sandstone or doggers; *Curvolithus* 3

10 Greensand *c.* 0.6

Cardioceraskløft Member

11 Sands, micaceous, fine-grained, non-glauconitic, grey, capped by large flat doggers of the *Rasenia inconstans* Bed, δI, top section 3

This succession crops out again in a number of side-gullies running into the gorge of Bays Elv 1 km upstream, but exposures are poor and beds cannot be individually identified. Numerous fossils, notably in section 31, came, however, from the lower levels here as in section 29, bed 3. The composition of these collections suggests that they may be from more than one faunal horizon, spanning both faunas 13 and 14, but it was not possible to determine levels more closely within the range of the 4 m of bed 3.

Section M30

Stream-cuttings in the pass between peaks 350 and 470 m, south of Bays Elv.

Kap Leslie Formation, Cardioceraskløft Member (59.5 m)

1	*Rasenia inconstans* bed, δI: sandstone, discontinuous, fine-grained, micaceous, weathering into large, flat yellowish doggers that lie widespread over the ground; fossiliferous. Ammonites, fauna 15: *Rasenia inconstans* Spath, *Amoeboceras subkitchini* Spath	*c.* 0.5
2	(a) Shales, silty, micaceous, soft, grey (4.0 m), passing up into and terminating with (b) shales, hard, indurated fissile (0.15 m)	4.15
3	Silts, shaly, micaceous	9
4	*Rasenia cymodoce* bed, δIII: sandstone, very fine-grained, concretionary, discontinuous, micaceous, fissile, slightly glauconitic, weathering into very dark red paving-stone slabs. Heavily bioturbated; *Buchia* sp., *Pholamomya* sp., *Goniomya literata* (Sowerby), *Liostrea* sp. Ammonites profuse; complete adults but crushed, fauna 17: *Rasenia cymodoce* (d'Orbigny) (M) & (m) (VC), *Amoeboceras* cf. *A. rasenense* Spath (R)	0.15
5	Silts or shaly very fine-grained sands, micaceous, grey	18
6	Third layer of concretions, δIV: layer of giant fine-grained sandstone doggers up to 1 m across, very hard, septarian, breaking with angular fracture, weathering light brown to dark red; completely and finely bioturbated, but without recognizable traces. Very sparsely fossiliferous: belemnites, fossil wood. Ammonites, fauna 18: *Rasenia evoluta* Spath (M) & (m), *Amoeboceras* aff. *A. subkitchini* Spath (R)	
7	Silts or shaly sandstones, fine-grained, micaceous, as below; belemnites	12
8	Layer of flat, small to medium-sized concretions or slabs of indurated shale, weathering dark red: Aldinger's concretions γ. *Grammatodon* sp. in nests. Ammonites, fauna 19: *Rasenia borealis* Spath, *Amoeboceras* cf. *A. beaugrandi* (Sauvage)	0.15
9	Shales, micaceous, and fine-grained sands, as before, with occasional small to medium-sized lenticles of indurated shale or slabby, red concretions, as bed 8, in the lower part	*c.* 12

Gråkløft Member

10	Layer of laminated, indurated shales with some small grey concretions	0.15
11	Shales, micaceous, soft	2
12	Shales, indurated, as bed 10	0.15
13	Shales, micaceous, soft	2

14	Shales, indurated, pyritic; *Amoeboceras* sp.	0.60
15	Shales, silty, soft, pyritic, with indurated lenticles; belemnites. Ammonites, fauna 20: *Amoeboceras kochi* Spath	3
16	Shales, hard, ferruginous	0.15
17	Shales, micaceous, dark, weathered to mica-sands	seen *c.* 10

The boundary between Cardioceraskløft and Gråkløft Members is uncertain. Because of weathering it is not easy to tell how much of the shales in the higher beds were once in the black laminated facies that characterizes the Gråkløft Member.

Section M39

Stream gorge 1 km south-south-east of peak 620, east of Visdal, 5 km north of Mudderbugt.

Charcot Bugt Formation, Visdal Member

–	Sandstone, coarse, quartzose, light, in mega-cross-sets. Sharp boundary: slightly undulating surface, channelled, covered with a ferruginous crust	

Mudderbugt Member (5.9 m)

1a	Sandstone, very coarse-grained, fairly well sorted, mica free, weathering light grey. Trough cross-bedded at high angles in sets 0.3–0.5 m thick. Trace-fossils include *Planolites* and vertical burrows locally. Varied bivalve fauna: *Meleagrinella* sp., (VC), unbroken; large thick-shelled *Astarte; Pleuromya* sp., *Protocardia* sp., *Camptonectes* sp., *C. (Boreionectes)* cf. *C. (B.) broenlundi* (Ravn); *Liostrea* sp. and *Exogyra* sp., locally concentrated on bedding-planes; belemnites. (In section 38, 2 km south-east, this level yielded ammonites of the group of *Perisphinctes plicatilis,* fauna 7, Middle Oxfordian)	3.2
1b	Sands, poorly sorted, medium-grained in lower part, coarse-grained in the upper with scattered pebbles of quartzite and kaolinized gneiss up to 2 cm diameter, weathering greyish to white; terminated by a thin layer of yellow-brown sandstone, somewhat concretionary, with scattered lenses of consolidated sandstone which is then trough cross-bedded with trace-fossils as in 1a. Few fossils except oyster fragments	2.7
	Sharp boundary	

Kap Leslie Formation, ?Kosmoceraskløft – Aldinger Elv Members (17.5 m)

2	Silt, fine, soft, dark	1.5
3	Silts, variably glauconitic, with chips of light brown coarse siltstone (3a, 3c), poorly exposed; and a marker layer (3b) of indurated silty shale, highly bioturbated and weathering brown in slabs, 2 m below the top	13.5
4	Sandstone (4a), very fine-grained, heavily bioturbated, weathering light grey; terminated by a layer of light brown, medium-sized, fissile ('pot-lid') concretions (4b), also heavily bioturbated, easily recognized also in adjacent exposures. Ammonites, fauna 12: *Ringsteadia* cf. *R. pseudocordata* (Hudleston) (M), *Amoeboceras regulare* Spath (m)	2.5

Bays Elv Member (16 m)

5	Sand, very fine-grained, micaceous, loose, grey	3.5
6	Silt or sands, very fine-grained, moderately glauconitic (6a), terminated by a layer of reddish-weathering concretions (6b). Moderately fossiliferous: *Buchia* sp., *Goniomya* sp.; *'Turritella'* sp.; belemnites. Ammonites, fauna 13a: *Amoeboceras rosenkrantzi* Spath (M) & (m) (Sykes & Callomon 1979, pl. 120, figs 4–6)	3
7	Silt, clean, non-glauconitic, grey (7a); terminated by a layer of large, bioturbated concretions (7b), weathering brown. Patellid gastropods; pine cones. Ammonites, fauna 13b: *Ringsteadia* aff. *R. pseudocordata* (Hudleston) (M), *R. ('Microbiplices') anglica* Arkell (*non* Salfeld), *Amoeboceras* cf. *A. regulare* or *A. rosenkrantzi* Spath	3
8	Silt or silty shales, as below, with grey siltstone concretions	4.5
9	Siltstone or sandstone, very fine-grained, glauconitic, with reddish weathering highly bioturbated concretions. Ammonites, beds 8 or 9, fauna 13c: *Amoeboceras* cf. *A. rosenkrantzi* (Spath) (m)	1
10	Greensand, silty or very fine-grained sand, dark green (10a); terminating with a layer of concretionary ironstone, very hard, basalt-like, weathering into brown chips (10b); belemnites. Ammonites, fauna 14: *Pictonia* cf. *P. normandiana* Tornquist (M) & (m), *Amoeboceras bayi* sp. nov.	1
	Sharp boundary	

Cardioceraskløft Member

–	Silt or shales, soft, micaceous, light grey; gentle slope, soon overgrown and poorly exposed. Doggers of the *Rasenia inconstans* sandstone (δI) not far above the base.	

The lower boundary of the Bays Elv Member is drawn arbitrarily, for the Aldinger Elv Member in its typical facies has completely disappeared. Neither have its ammonites, of fauna 11, been found. Instead, fauna 12 appears, unknown further east, and fauna 13 is at its best development.

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ABBREVIATIONS

GGU: Geological Survey of Greenland
JHC: J. H. Callomon collection
MGUH: Geological Museum of the University of Copenhagen
SMNS: Staatliches Museum für Naturkunde, Stuttgart
BM: British Museum

Small black triangles at the sides of figures indicate the positions of the last septa and the onset of bodychambers.

Figures natural size unless specified otherwise

Photographs: J. Aagaard

Plate 1

Amoeboceras (Amoebites) bayi sp. nov. (M)
Bays Elv Member, fauna 14, Baylei Zone

Fig. 1. Large variant, typical, complete adult with part of the final peristome. MGUH 16654 from JHC 823; Bays Elv, section 31, beds equivalent to section 29, bed 3.

Fig. 2. Slightly more involute variant. MGUH 16655 from JHC 825; same level and locality.

Fig. 3. Final part of the bodychamber of a crushed mature adult, showing the projected ventral rostrum. MGUH 16656 from JHC 834; same level and locality.

Figs 4a–b. Another large but typical variant (4a), crushed but for the final bodychamber (4b). Note the slight modification and crowding of the ribbing at the aperture. MGUH 16657 from JHC 821; same level and locality.

Fig. 5. Somewhat more coarsely-ribbed variant. MGUH 16658 from JHC 832; same level and locality.

Fig. 6. Holotype. MGUH 16659 from JHC 836 (Sykes & Callomon, 1979, pl. 121, fig. 2); same level and locality.

Fig. 7. Involute variant with some looping of the secondary ribbing. MGUH 16660 from JHC 835; same level and locality.

Fig. 8. MGUH 16661 from JHC 822; same level and locality.

Fig. 9. Very evolute, densely-ribbed variant. MGUH 16662 from JHC 636 (Sykes & Callomon, 1979, pl. 121, fig. 3); section 29, bed 3 (see Appendix).

Fig. 10. MGUH 16663 from GGU 234071; section 39, bed 10b (see Appendix).

Fig. 11. Very densely-ribbed, involute, compressed variant. MGUH 16664 from GGU 234071; same level and locality.

Fig. 12. MGUH 16665 from JHC 829; same level and locality as figs 1–8.

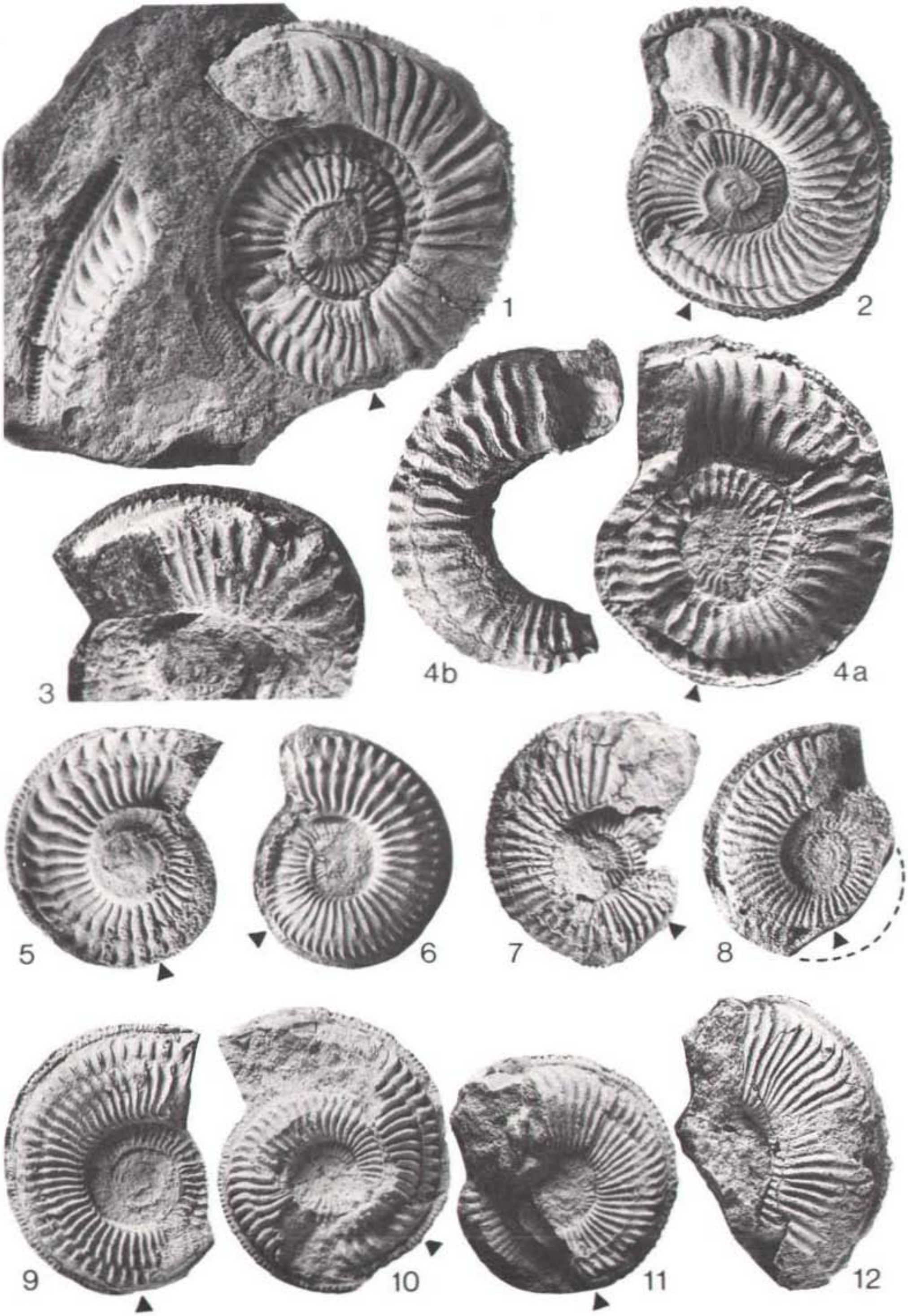
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Plate 2

Amoeboceras (Amoebites) subkitchini Spath (M)

Cardioceraskløft Member, faunas 15 and 17, Cymodoce Zone

Fig. 1. Apparently only phragmocone preserved (no sutures visible). MGUH 16666 from GGU 234089; Visdal, section 47, bed 19, fauna 17.

Fig. 2. Final part of mature bodychamber, showing the transition from strongly differentiated, tuberculate ribbing back to simple ribbing at the aperture. MGUH 16667 from GGU 137770; 300 m southeast of point 990, loose.

Fig. 3. Wholly septate (M) before the onset of modified ribbing on the adult bodychamber. MGUH 16668 from GGU 137739; Visdal, section 47, bed 17, fauna 15.

Figs 4–7. Four mature specimens showing the variability of ribbing on the bodychambers and its simplification near the aperture. 4: MGUH 16669 from GGU 234301; section 7, bed 16, fauna 15 (see Appendix). 5: MGUH 16670 from GGU 234057; Visdal, section 45, fauna 15. 6: MGUH 16671 from GGU 137763. 7: MGUH 16672 from GGU 234057;Visdal, section 45, fauna 15.

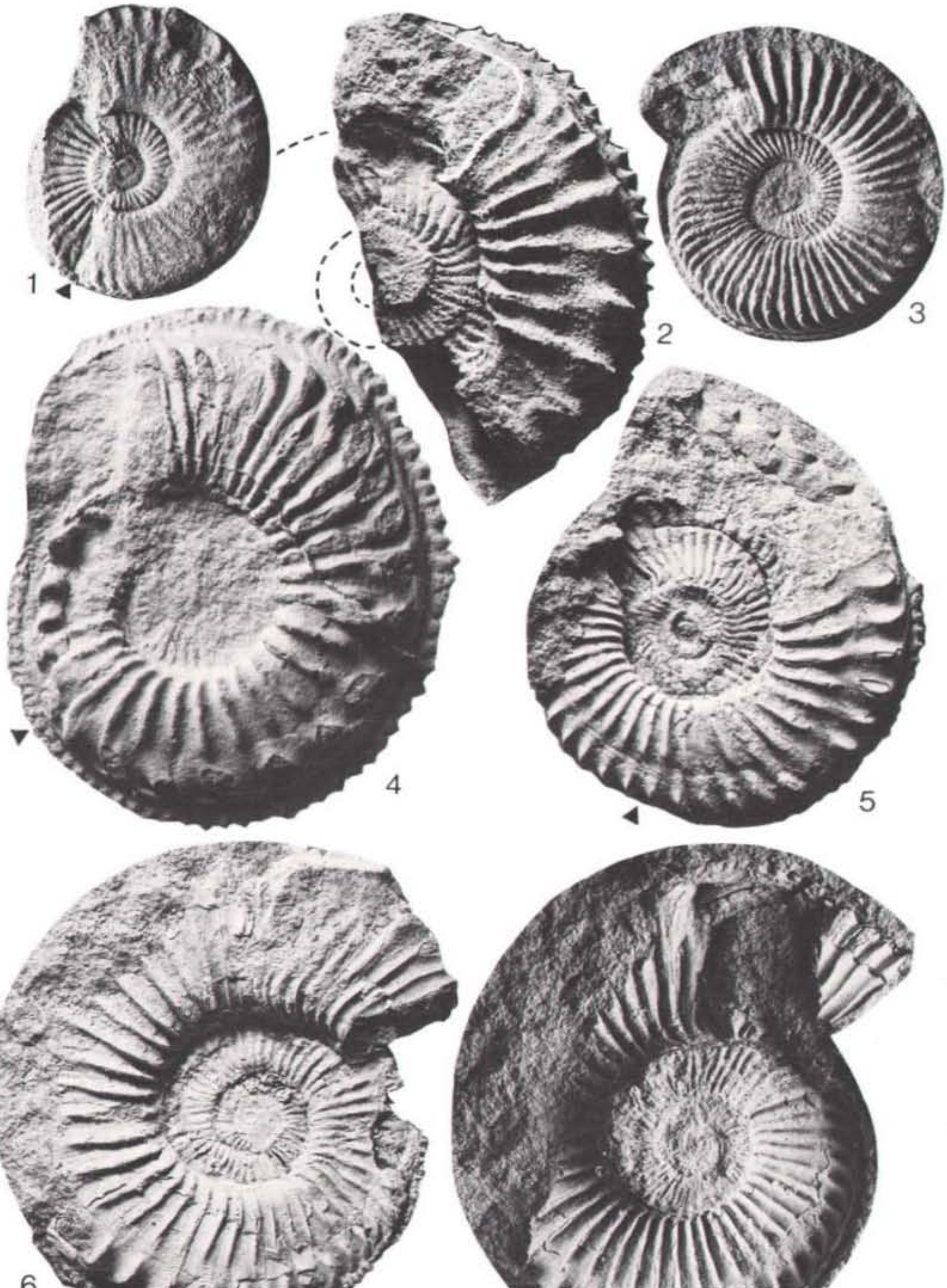
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Plate 3

Amoeboceras (Amoebites) subkitchini Spath
Cardioceraskløft Member, faunas 15 and 17, Cymodoce Zone

Fig. 1. Complete adult (M) showing some looping of secondaries. MGUH 16673 from GGU 234089; Visdal, section 47, bed 19, fauna 17.

Fig. 2. Incomplete adult (M). MGUH 16674 from GGU 234028; section 7, bed 20, fauna 17 (see Appendix).

Fig. 3. Incomplete imprint of (M) showing resimplification of the ribbing at maturity. MGUH 16675 from GGU 234084; west of section 39, fauna 17.

Fig. 4. Bodychamber of (m). MGUH 16676 from GGU 137739; Visdal, section 47, bed 17, fauna 15.

Fig. 5. Complete adult (M) with dense, single but differentiated ribbing. MGUH 16677 from GGU 234057; Visdal, section 45, fauna 15.

Fig. 6. Wholly septate phragmocone. MGUH 16678 from GGU 137687; section 7, bed 16, fauna 15 (see Appendix).

Fig. 7. Incomplete (m); note uncoiling of umbilical seam. MGUH 16679 from GGU 234028; section 7, bed 20, fauna 17 (see Appendix).

Fig. 8. Nearly complete (m). MGUH 16680 from GGU 234058; Visdal, section 45, fauna 15?

Fig. 9. Nearly complete (m); note the prominent uncoiling. MGUH 16681 from GGU 137739; Visdal, section 47, bed 17, fauna 15.

Fig. 10. Wholly septate (M) before the onset of modified ribbing on the adult bodychamber. MGUH 16682 from GGU 137763; at section 35, loose.

Fig. 11. Nearly complete (m). MGUH 16683 from GGU 234028; section 7, bed 20, fauna 17 (see Appendix).

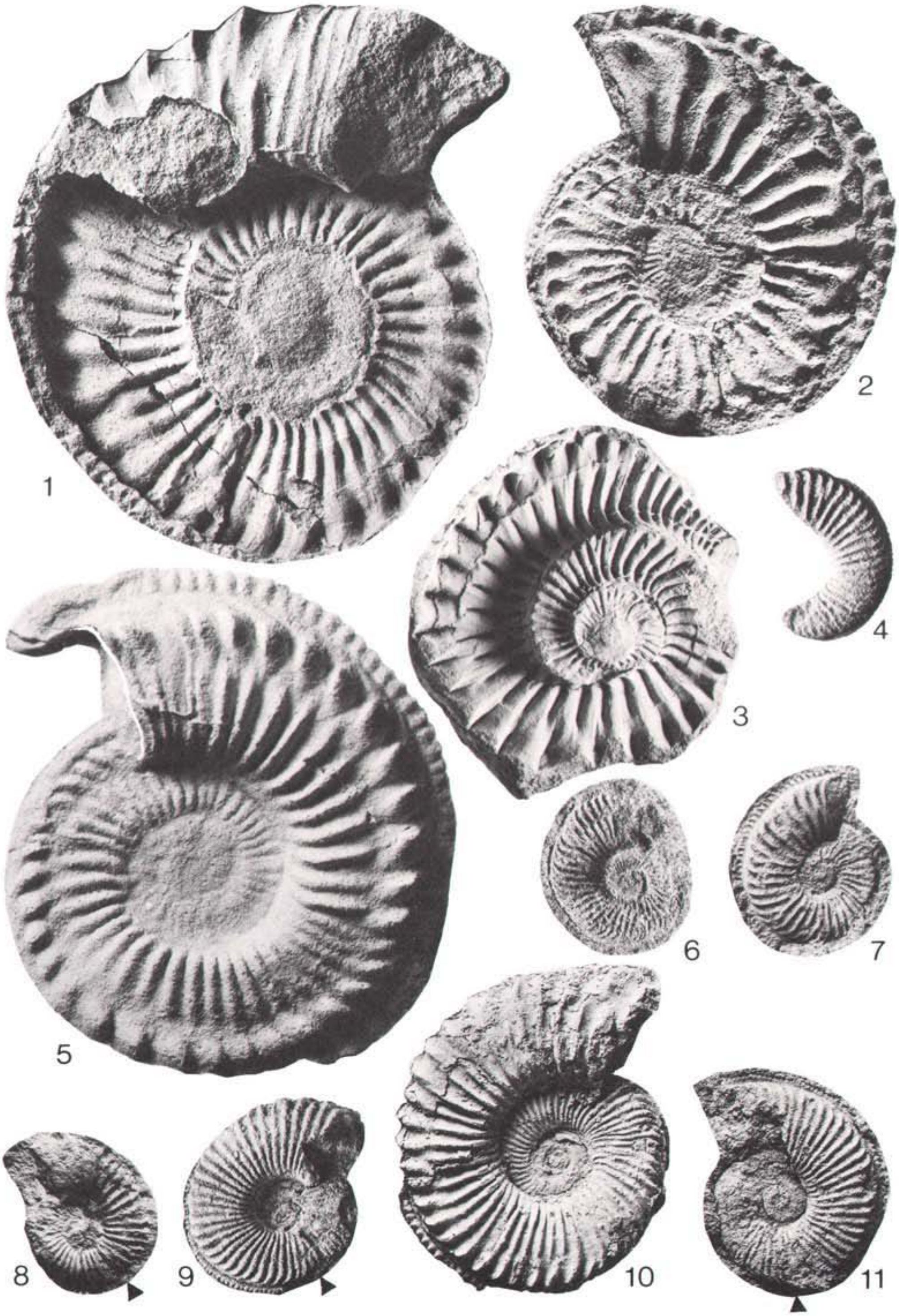
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Plate 4

Amoeboceras (Amoebites) aff. *A. (A.) shulginae* Mesezhnikov

Bays Elv Member, fauna 14, Baylei Zone

Figs 1a–b. Complete adult (M). MGUH 16684 from JHC 820; Bays Elv, section 31 in beds equivalent to section 29, bed 3 (see Appendix), associated with *A. bayi* sp. nov.

Fig. 2. Slightly less coarsely-ribbed (M). MGUH 16685 from JHC 636; section 29, bed 3 (see Appendix).

Figs 3a–b. Fragment of bodychamber. MGUH 16686 from GGU 234070; section 39, bed 10b *in situ* (see Appendix).

Amoeboceras (Amoebites) bayi sp. nov. (m)

Bays Elv Member, fauna 14, Baylei Zone

Fig. 4. Mature bodychamber with uncoiling umbilical seam. MGUH 16687 from JHC 830; same level and locality as fig. 1.

Fig. 5. Nearly complete adult, note uncoiling of umbilical seam. MGUH 16688 from JHC 830; same level and locality as fig. 1.

Amoeboceras (Amoebites) aff. *A. (A.) beaugrandi* (Sauvage) (m)

Cardioceraskløft Member, fauna 19, Mutabilis Zone

Fig. 6. Bedding plane covered with microconchs. MGUH 16689 from GGU 234024; section 8, equivalent to section 7, bed 22 (see Appendix).

Fig. 7 MGUH 16690 from JHC 597; section 32, bed 8, equivalent to section 30, bed 8 (see Appendix).

Fig. 8. From same sample as fig. 6. MGUH 16691 from GGU 234024.

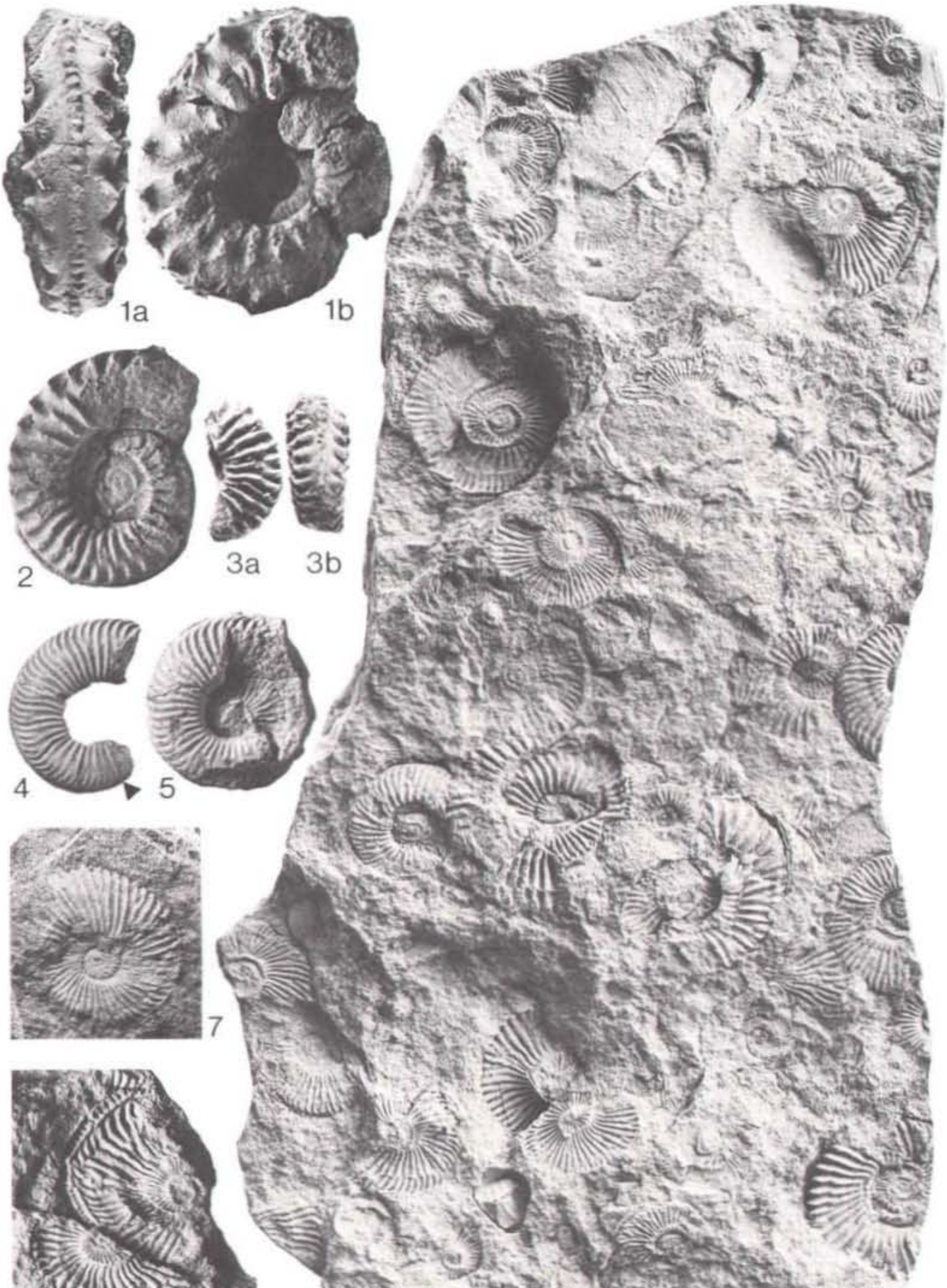
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Plate 5

Amoeboceras (Amoebites) elegans Spath (M)
Gråkløft Member, fauna 22, Eudoxus Zone

Fig. 1. Fragment of large adult. MGUH 16692 from GGU 234303; Sønderelv, section 21.

Fig. 2. Wholly septate nucleus. MGUH 16693 from GGU 234303; same level and locality.

Fig. 3. Fragment of large adult. MGUH 16694 from GGU 234303; same level and locality.

Fig. 4. MGUH 16695 from GGU 234303; same level and locality.

Fig. 5. Wholly septate nucleus. MGUH 16696 from GGU 234303; same level and locality.

Fig. 6. MGUH 16697 from GGU 234303; same level and locality.

Fig. 7. MGUH 16698 from GGU 137427; same level and locality.

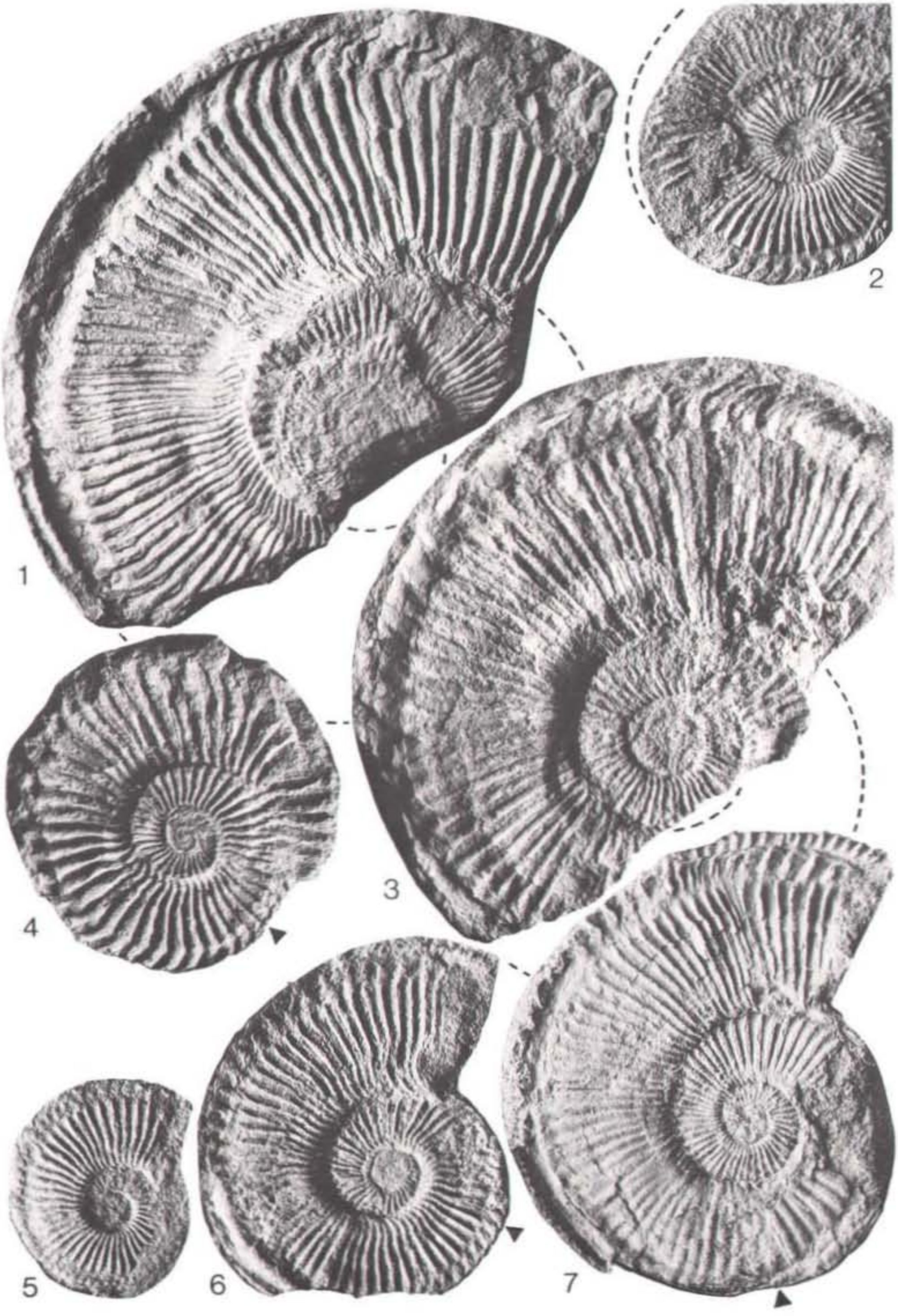
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Plate 6

Amoeboceras (Amoebites) elegans Spath

Gråkløft Member, fauna 22, Eudoxus Zone

Fig. 1. (M) MGUH 16699 from GGU 234303; Sønderelv, section 21.

Fig. 2. (M) MGUH 16700 from GGU 234303; same level and locality.

Fig. 3. (M) MGUH 16701 from GGU 234303; same level and locality.

Fig. 4. (M) MGUH 16702 from GGU 234303; same level and locality.

Fig. 5. (M) MGUH 16703 from GGU 137427; same level and locality.

Fig. 6. (M) MGUH 16704 from GGU 234303; same level and locality.

Fig. 7. Apparently (m), showing uncoiling of the last whorl. MGUH 16705 from GGU 137428; same level and locality, ×2.

Fig. 8. Apparently (m) as fig. 7. MGUH 16706 from GGU 137428; same level and locality, ×2.

Amoeboceras cf. *A. ernesti* (Fischer)

Bays Elv Member, fauna 14, Baylei Zone

Fig. 9. Complete adult with the adult bodychamber preserved, only partly crushed. MGUH 16707 from JHC 831; section 31, in beds equivalent to section 29, bed 3 (see Appendix), associated with *A. bayi* sp. nov.

Figs 10a–b. External mould of the complete but crushed shell (10a), and the partly crushed bodychamber (10b). MGUH 16708 from JHC 824; same level and locality as above.

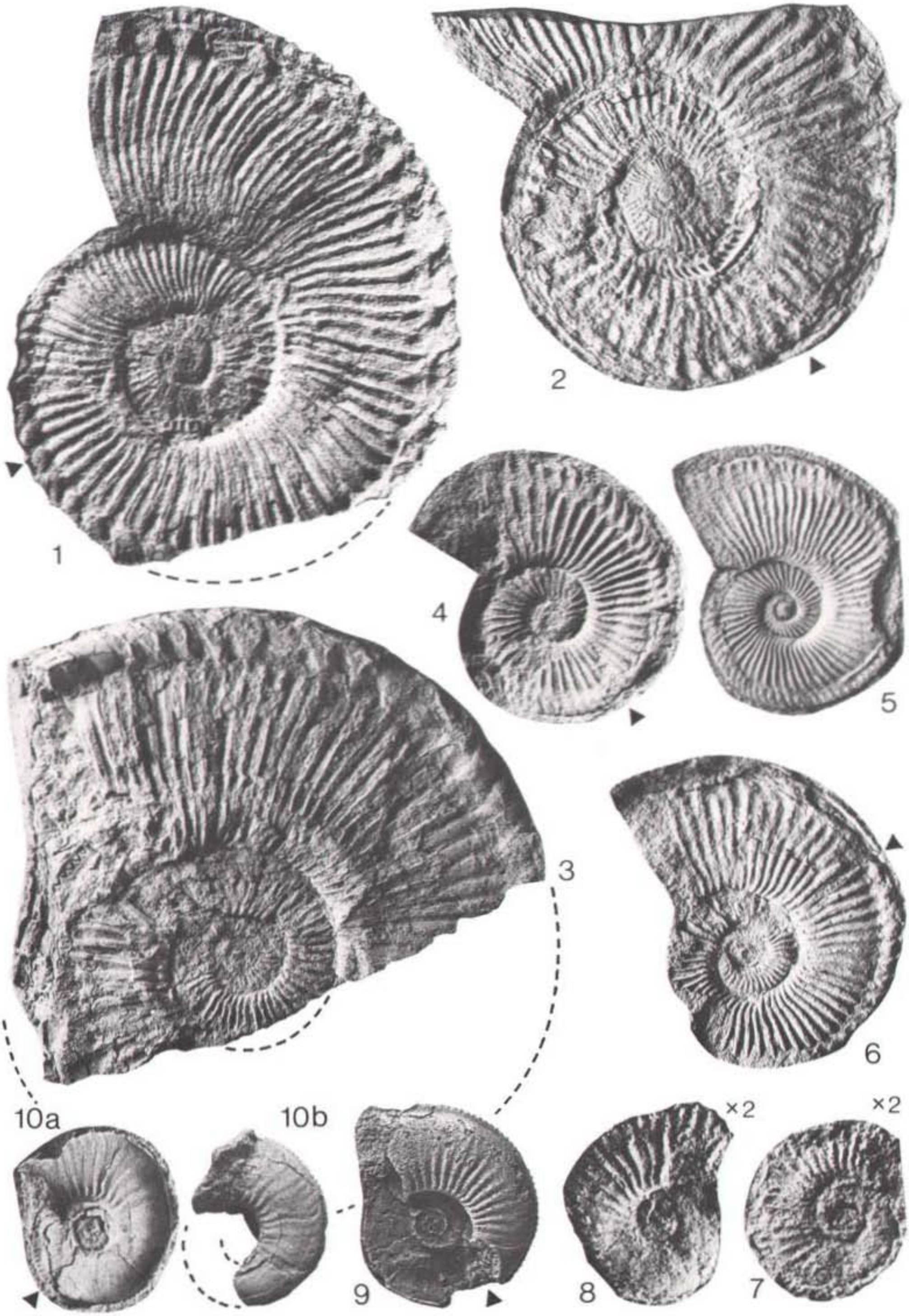
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Plate 7

Amoeboceras (Euprionoceras) kochi Spath (M)
Gråkløft Member, fauna 20, Mutabilis or Eudoxus Zone

All adults, but no sutures visible.

Fig. 1. MGUH 16709 from JHC 1669A; Kiderlen Kløft, section 10.

Fig. 2. MGUH 16710 from JHC 1669; Gråkløft, section 8, bed 6.

Fig. 3. MGUH 16711 from JHC 1668; same level and locality.

Fig. 4. MGUH 16712 from JHC 1669; same level and locality.

Fig. 5. MGUH 16713 from JHC 1668; same level and locality.

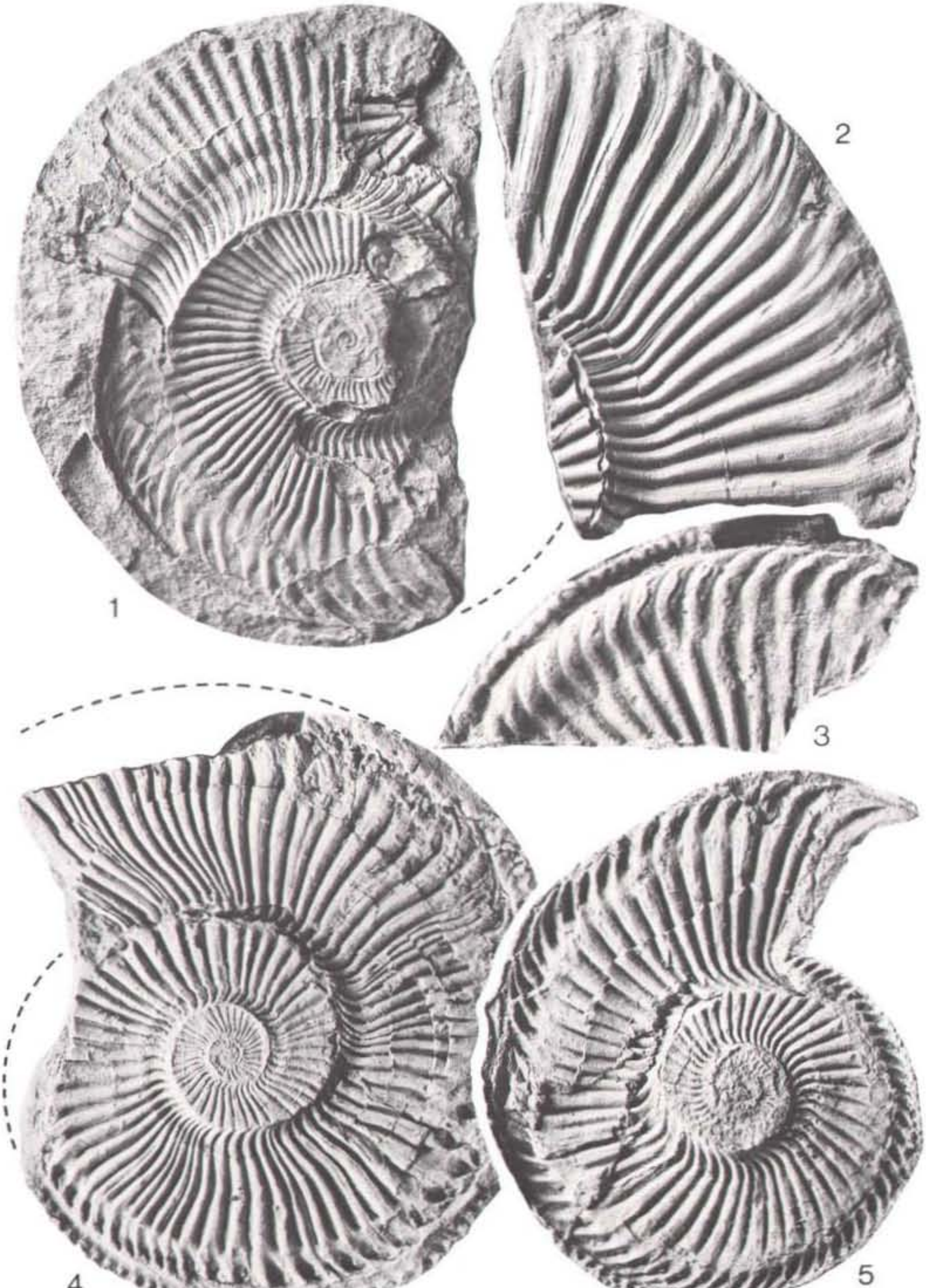
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Plate 8

Amoeboceras (Euprinoceras) kochi Spath
Gråkløft Member, fauna 20, Mutabilis or Eudoxus Zone

Fig. 1. Complete adult (M). MGUH 16714 from JHC 1669; Gråkløft, section 8, bed 6.

Fig. 2. Complete adult (M). MGUH 16715 from JHC 1668; same level and locality.

Fig. 3. Complete adult (M). MGUH 16716 from JHC 1669; same level and locality.

Fig. 4. Adult (M). MGUH 16717 from JHC 1668; same level and locality.

Figs 5–7. (m), but no sutures visible. 5: MGUH 16718. 6: MGUH 16719. 7: MGUH 16720. All from JHC 1668; same level and locality.

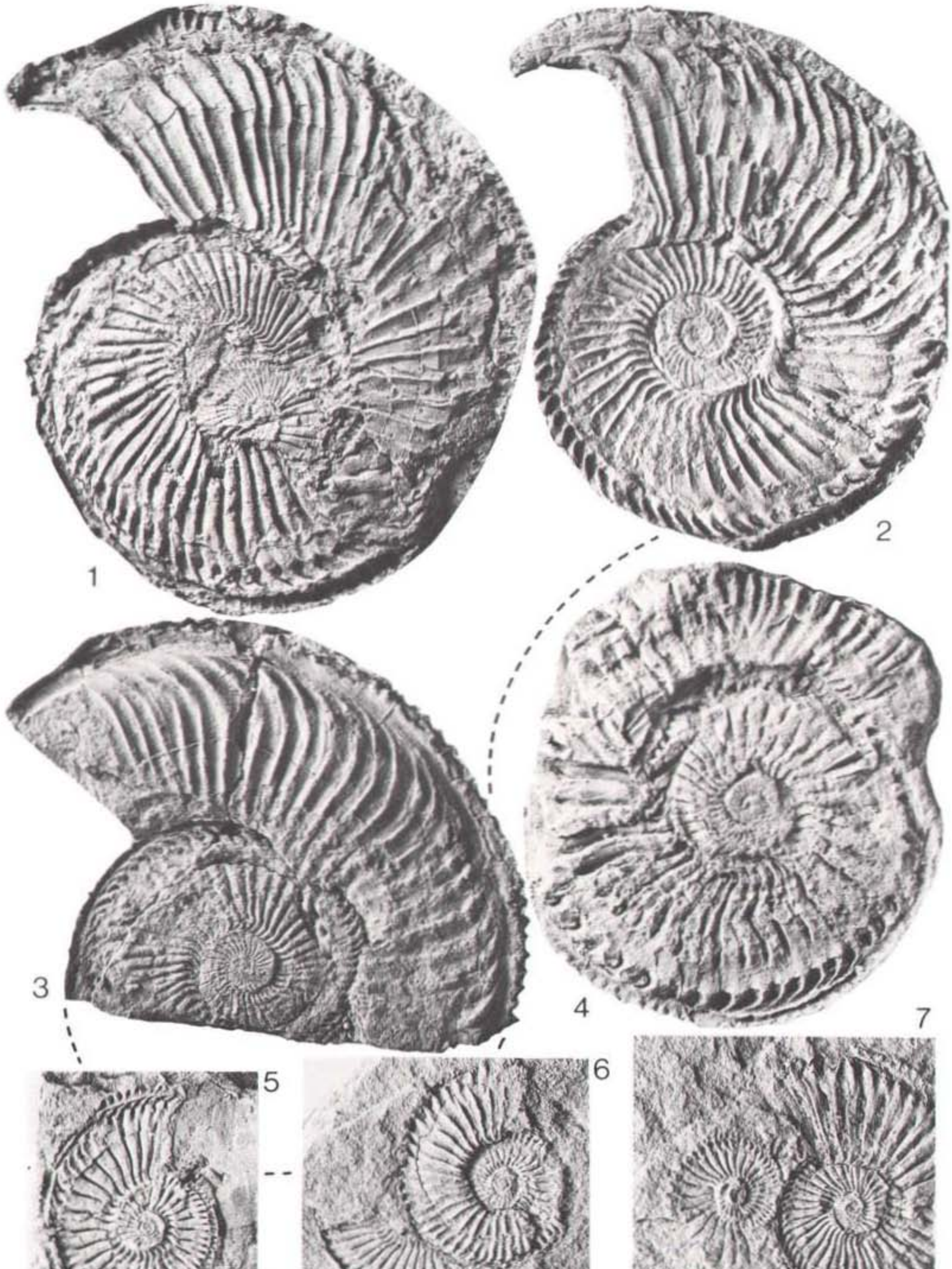
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Plate 9

Amoeboceras (Hoplocardioceras) decipiens Spath
Gråkløft Member, fauna 21, Eudoxus Zone

Fig. 1. Extremely nodate (M). MGUH 16721 from GGU 234048; Kiderlen Kløft, section 10.

Fig. 2. Large (M) with well preserved keel. MGUH 16722 from GGU 137438; Sønderelv, section 21.

Fig. 3. (M) with outer row of very large tubercles. MGUH 16723 from GGU 234304; Sønderelv, section 21.

Fig. 4. (M) with outer row of very large tubercles. MGUH 16724 from GGU 234043; north of section 5, loose.

Fig. 5. (M) with well preserved inner whorls. MGUH 16725 from GGU 137638; south of section 23, loose.

Fig. 6. Incomplete (m). MGUH 16726 from GGU 137446; Sønderelv, section 21.

Fig. 7. (m) showing uncoiling of umbilical seam. MGUH 16727 from GGU 234304; Sønderelv, section 21.

Amoeboceras (Amoebites) bauhini (Oppel)

Figs 8a–c. Complete adult with peristome. SMNS 26936.1; Planula Zone, Galar Subzone, region of Mühlheim ?, Swabia.

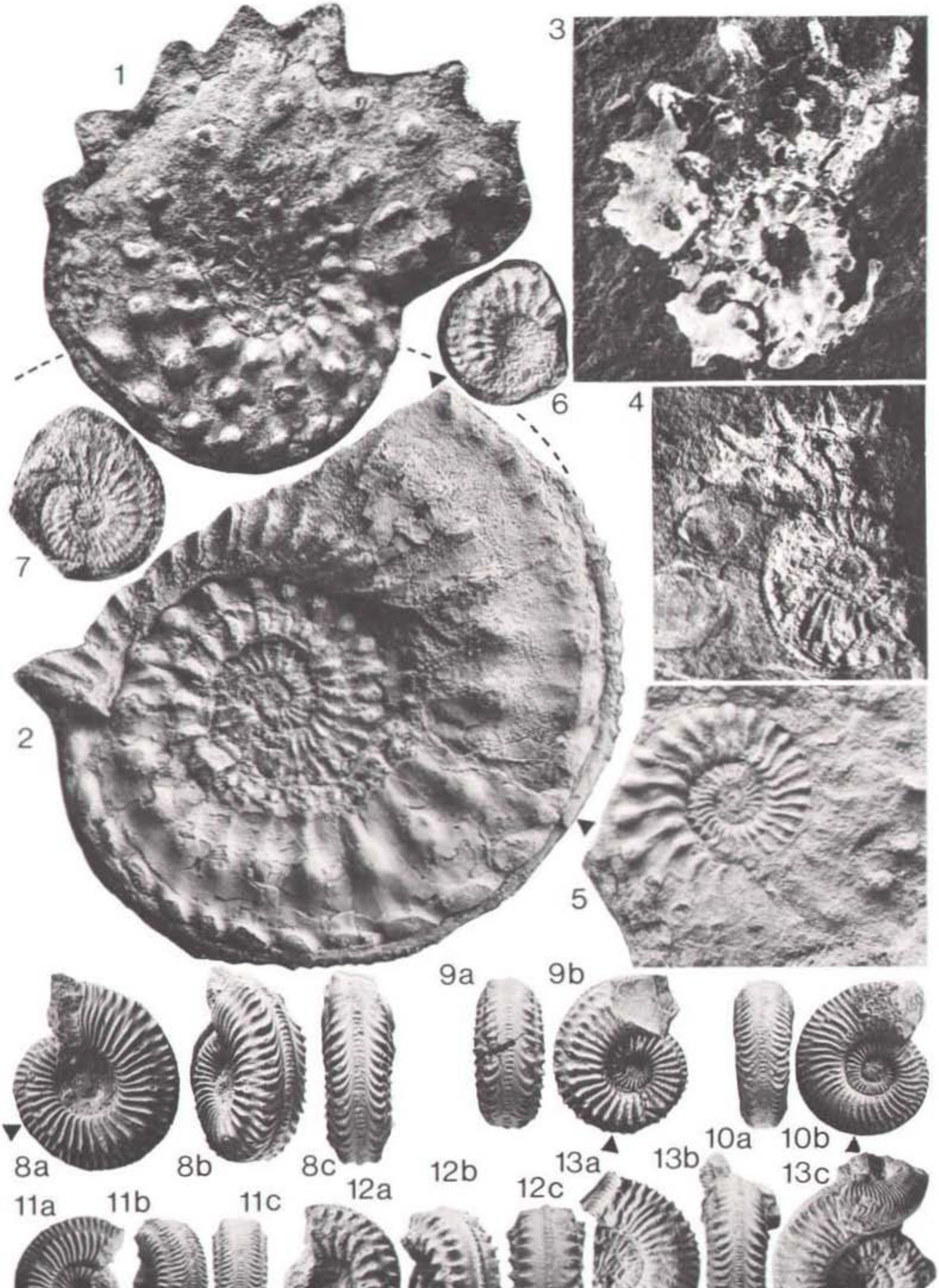
Figs 9a–b. More coarsely-ribbed specimen. SMNS 26935.1, near Esbach, Swabia.

Figs 10a–b. Complete adult. SMNS 26938.2; near Mühlheim, Swabia.

Figs 11a–c. Fine-ribbed variant. SMNS 26939.2; same locality.

Figs 12a–c. Extremely coarse-ribbed variant. SMNS 26937.2; Lochen, Swabia.

Figs 13a–c. Complete adult. JHC coll.; South Ferriby, Humberside, England, bed 10a; with, attached, part of the bodychamber of the presumed (m), *A.* aff. *A. cricki* or cf. *A. schlosseri*.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9b
10a
10b
11a
11b
11c
12a
12b
12c
13a
13b
13c

Plate 10

Pictonia sp. nov. *A*. aff. *P. normandiana* Tornquist
Bays Elv Member, fauna 14, Baylei Zone

Fig. 1. Part of a mature (M), MGUH 16728 from JHC 577; section 27, glauconites with fauna 14.

Figs 2a–b. Juvenile (M). MGUH 16729 from GGU 234071; section 39, bed 10b *ex situ* (see Appendix).

Figs 3a–b. Juvenile (M?). The whole of the last whorl is bodychamber. MGUH 16730 from JHC 828; section 31, level equivalent to section 29, bed 3, fauna 14.

Figs 4a–c. Juvenile (M). The whole of the last whorl is bodychamber. MGUH 16731 from GGU 234071; same level and locality as fig. 2.

Figs 5a–b. A presumed (m). MGUH 16732 from GGU 234082; west of section 39, loose, assumed to be the same level as that of figs 2 and 4.

Fig. 6. A presumed (m). MGUH 16733 from JHC 575; same level and locality as fig. 1.

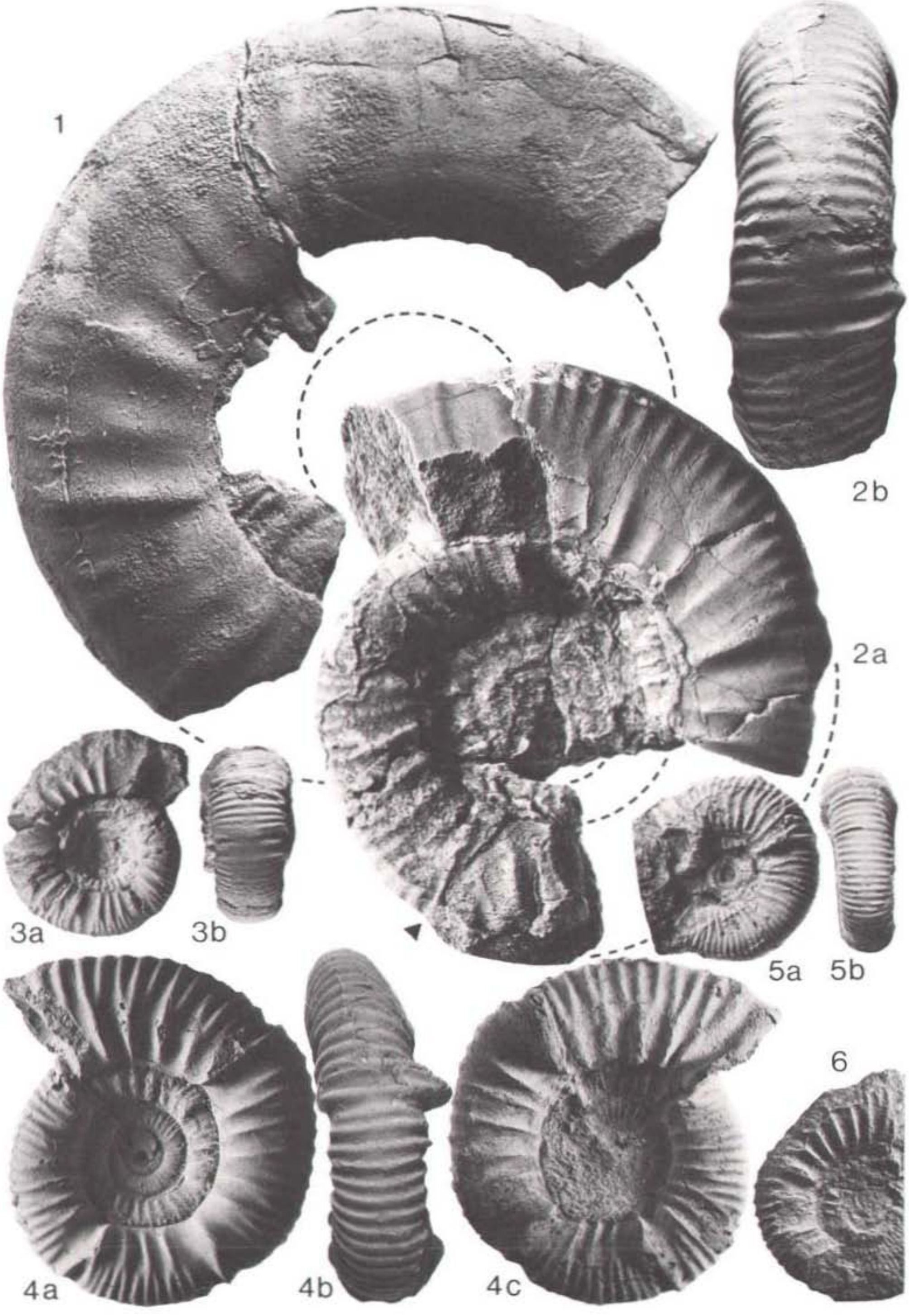

1
2a
2b
3a
3b
4a
4b
4c
5a
5b
6

Plate 11

Pictonia sp. nov. *A.* aff. *P. normandiana*

Bays Elv Member, fauna 14, Baylei Zone

Fig. 1. External mould of what appears to have been a not quite mature (M), photographed in the field. Close to, and at the same level as section 39, bed 10b (see Appendix).

Fig. 2. A not quite fully grown (M): note the absence of any serious crowding or degeneration of the last septal sutures, normally a marked feature of adult *Pictonia* or *Rasenia.* MGUH 16734 from JHC 826; section 31, at the same level as section 29, bed 3 (see Appendix).

Figs 3a–b. A complete adult (m). MGUH 16735 from JHC 573; section 27, glauconites with fauna 14, same level and locality as plate 10, fig. 1.

Pictonia? sp. indet. B

Bays Elv Member, fauna 14, Baylei Zone

Fig. 4. Probably an immature (M), the whole of the last whorl is bodychamber. MGUH 16736 from JHC 638; section 29, bed 3 (see Appendix), associated with *A. bayi.* Close to, and at the same level as section 39, bed 10b (see Appendix).

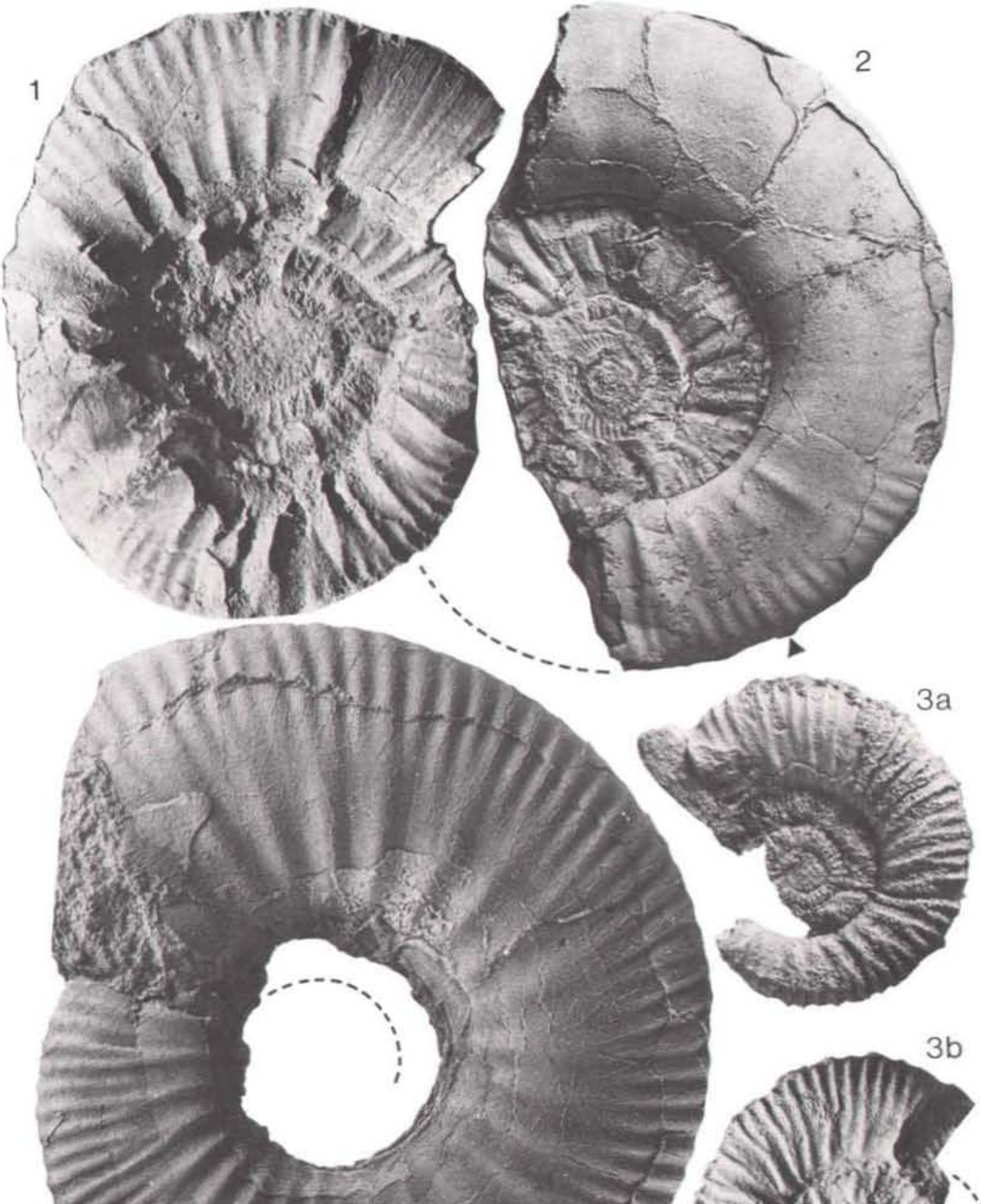

1
2
3a
3b
4

Plate 12

Rasenia inconstans Spath
Cardioceraskløft Member, fauna 15, Cymodoce Zone

Fig. 1. Adult (M) with crowding of the last sutures. MGUH 16737 from GGU 137739; Visdal, section 47, bed 17.

Fig. 2. Internal mould of (M), no sutures visible. MGUH 16738 from GGU 137687; section 7, bed 16 (see Appendix).

Fig. 3. Internal mould without visible sutures. MGUH 16739 from GGU 234027; same level and locality.

Fig. 4. Nearly complete (m) with biplicate ribs on bodychamber. MGUH 16740 from GGU 137687; section 7, bed 16 (see Appendix).

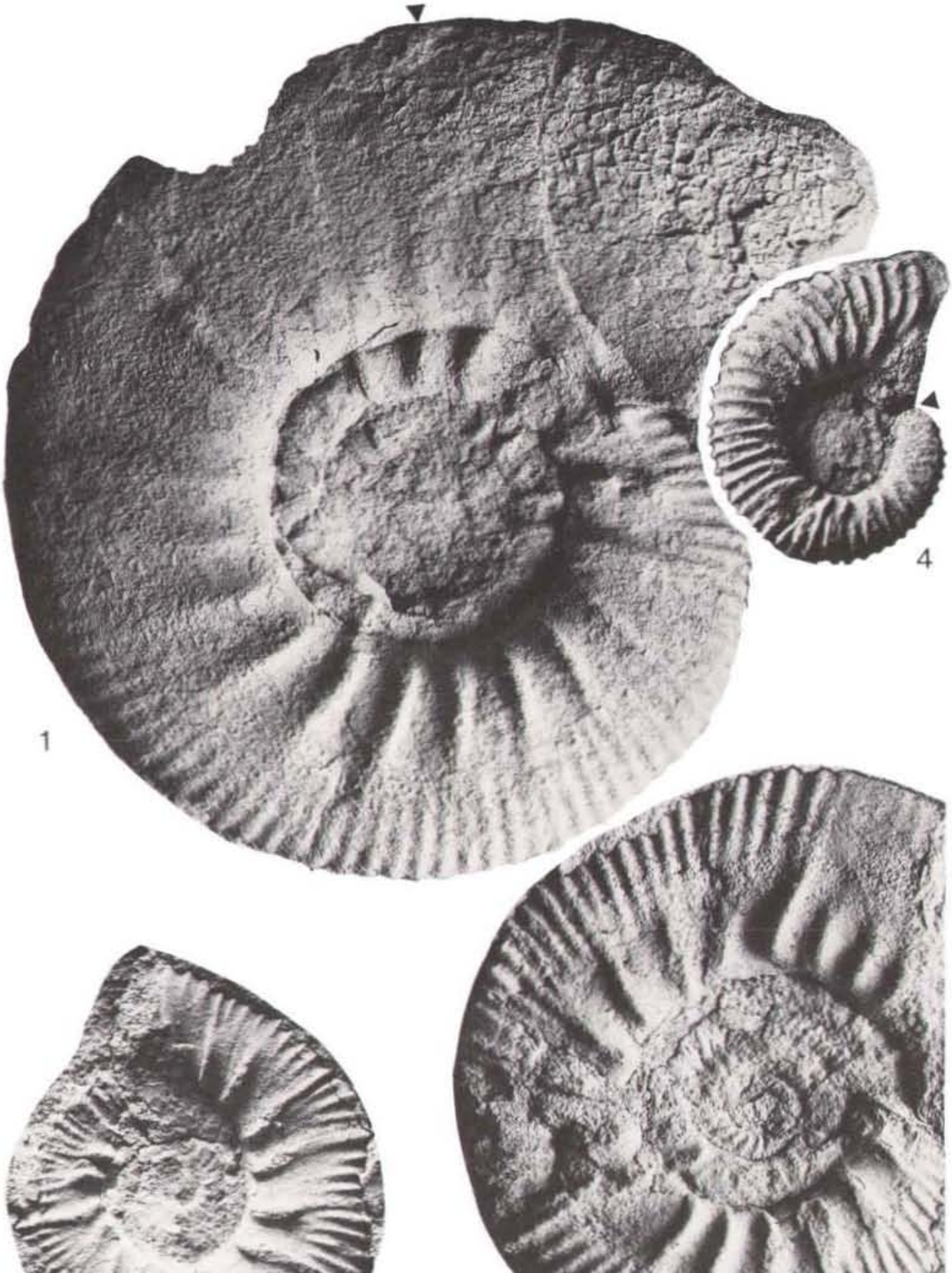

1
4
3
2

Plate 13

Rasenia inconstans Spath
Cardioceraskløft Member, fauna 15 and 16, Cymodoce Zone

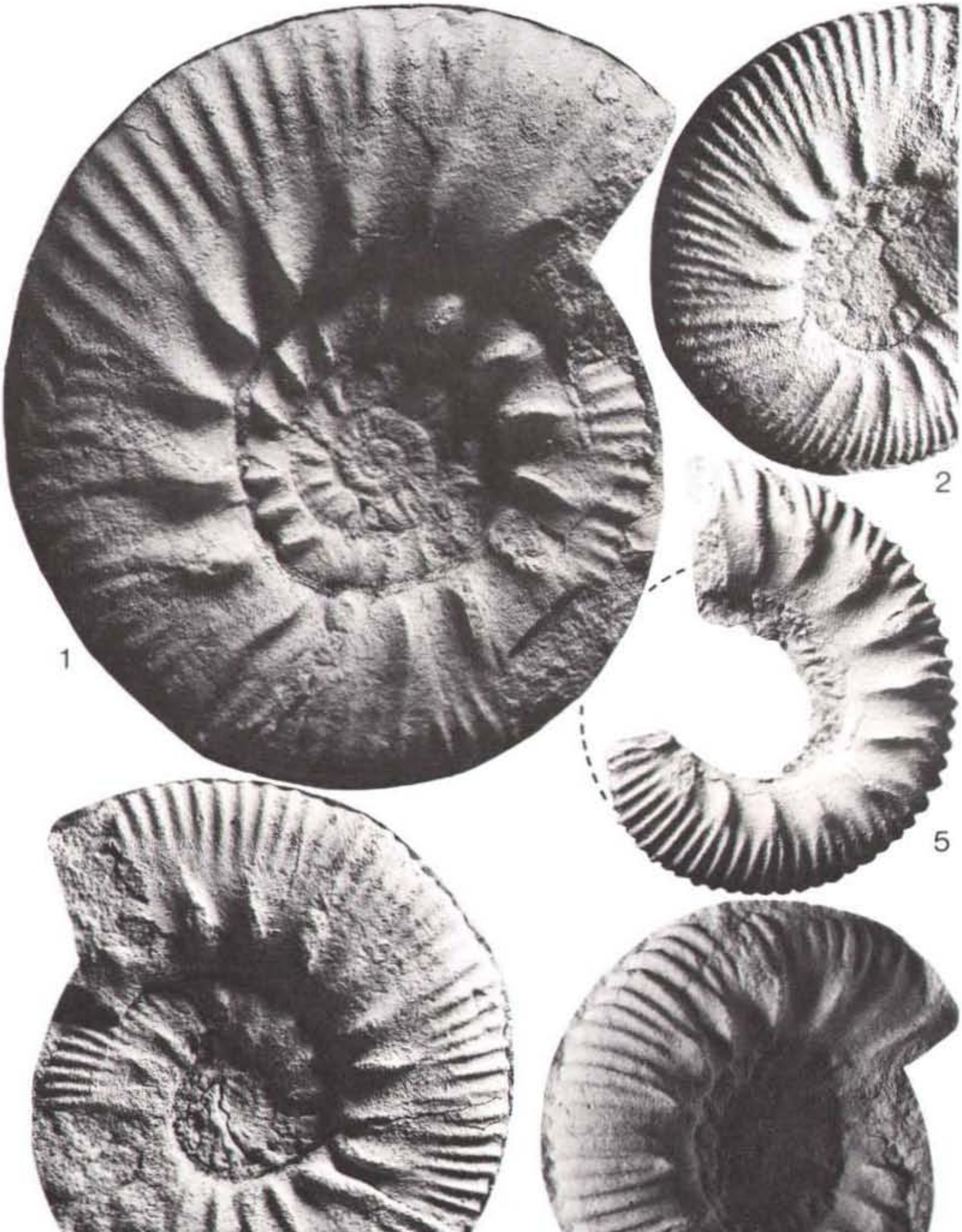
Fig. 1. Wholly septate phragmocone of (M). MGUH 16741 from GGU 137615; section 7, bed 16, fauna 15 (see Appendix).

Fig. 2. Internal mould of (M), no sutures visible. MGUH 16742 from GGU 137687; same level and locality.

Fig. 3. Wholly septate phragmocone of (M). MGUH 16743 from GGU 137687; same level and locality.

Fig. 4. Cast of external mould, apparently of (m). MGUH 16744 from GGU 234302; section 7, bed 18, fauna 16 (see Appendix).

Fig. 5. Internal mould, apparently a bodychamber of (m). MGUH 16745 from GGU 234302; same level and locality.



1
2
5
3
4

Plate 14

Rasenia inconstans Spath

Cardioceraskløft Member, fauna 15, Cymodoce Zone

Fig. 1. Juvenile (M), the whole of the last whorl is bodychamber. MGUH 16746 from GGU 234057; Visdal, section 45.

Fig. 2. A presumed (m), no sutures visible; MGUH 16747 from GGU 137739; Visdal, section 47, bed 17.

Fig. 3. Wholly septate (M). MGUH 16748 from GGU 137739; same level and locality.

Fig. 4. Bodychamber, apparently of (m). MGUH 16749 from GGU 234057; same level and locality as fig. 1.

? *Pachypictonia* sp. nov. C

Cardioceraskløft Member, fauna 16, Cymodoce Zone

Fig. 5. Fragment of bodychamber of (m). MGUH 16750 from GGU 234302; section 7, bed 18 (see Appendix).

Fig. 6. Fragment of (m). MGUH 16751 from GGU 234302. Same level and locality.

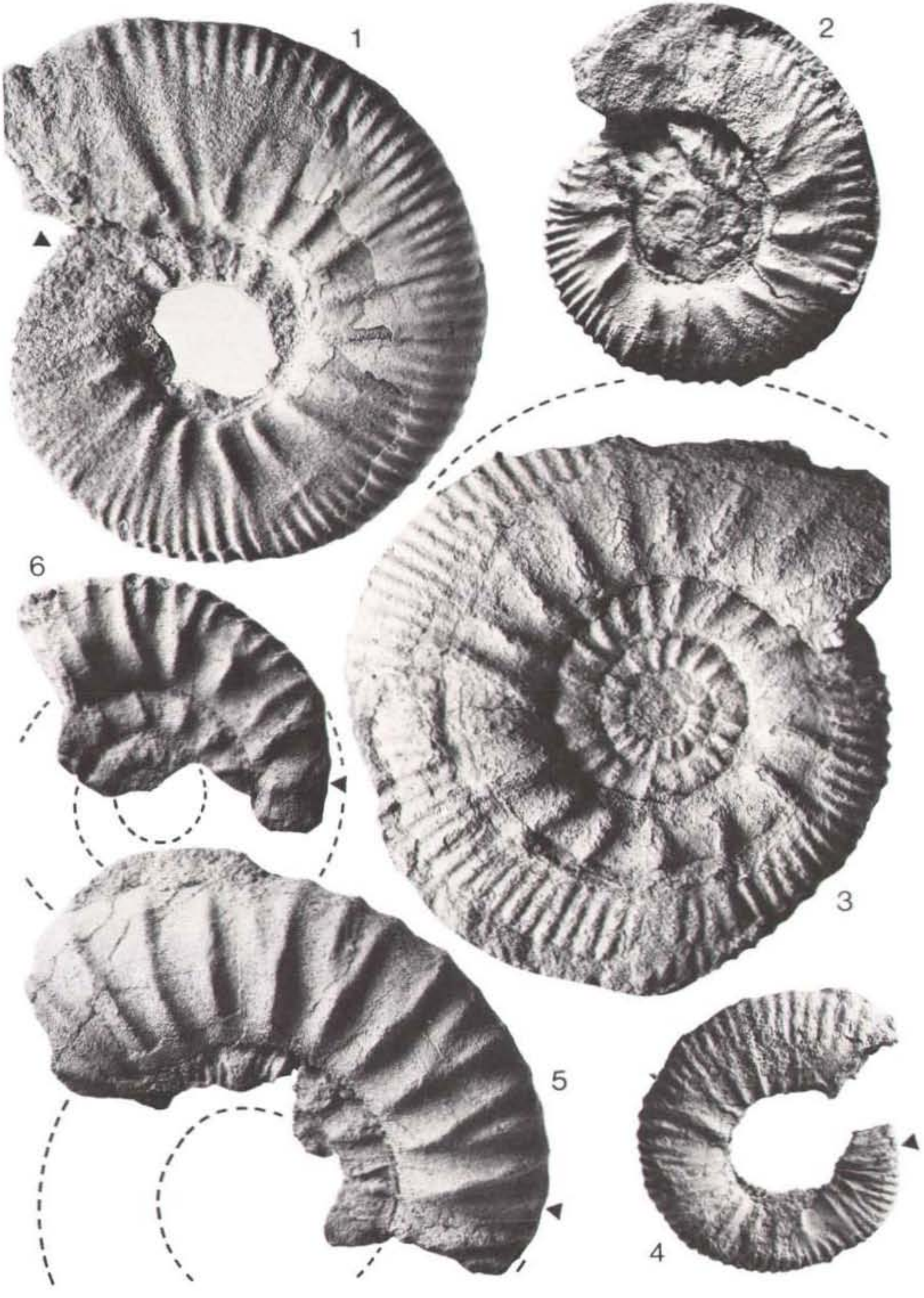

1
2
3
4
5
6

Plate 15

? Pachypictonia sp. nov. C
Cardioceraskløft Member, fauna 16, Cymodoce Zone

Fig. 1. Wholly septate (M). MGUH 16752 from GGU 234302; section 7, bed 18 (see Appendix).

Rasenia borealis Spath
Cardioceraskløft Member, fauna 19, Mutabilis Zone

Fig. 2. Large (M) with most of bodychamber preserved. MGUH 16753 from JHC 499; section 30, bed 8. $\times\frac{1}{2}$.

1

2

$\times \frac{1}{2}$

Plate 16

? Pachypictonia sp. nov. C
Cardioceraskløft Member, fauna 16, Cymodoce Zone

Figs 1a–b. Large adult (M) with most of bodychamber preserved. MGUH 16754 from GGU 234075; section 31. $\times\frac{1}{2}$.

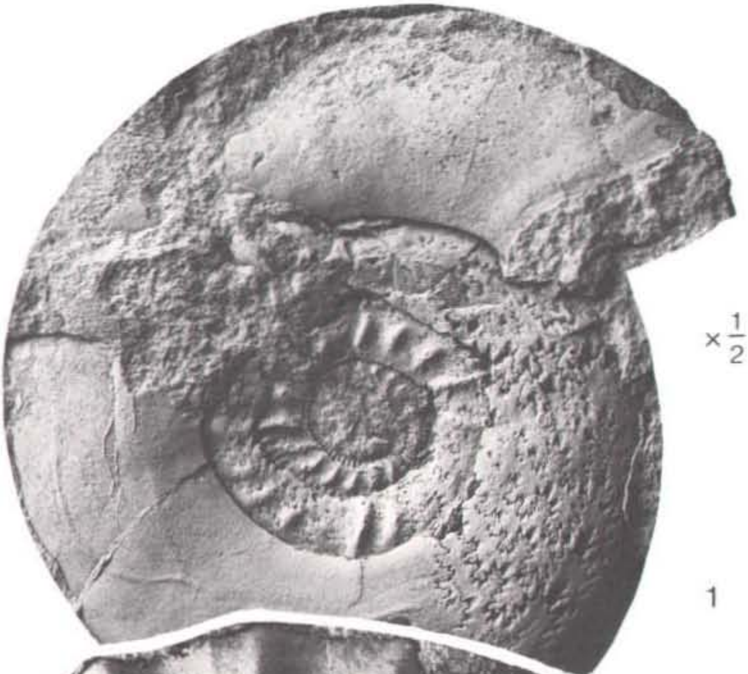
1a ×$\frac{1}{2}$ 1b

Plate 17

Rasenia cymodoce (d'Orbigny)
Cardioceraskløft Member, fauna 17, Cymodoce Zone

Fig. 1. Complete (M) showing the peristome. MGUH 16755 from GGU 234072; section 30, bed 4 (see Appendix). $\times\frac{1}{2}$.

Fig. 2. (M) with strongly ribbed bodychamber. MGUH 16756 from GGU 234072; same level and locality.



× $\frac{1}{2}$

1

2

Plate 18

Rasenia cymodoce (d'Orbigny)

Cardioceraskløft Member, fauna 17, Cymodoce Zone

Fig. 1. Large (M) with smooth bodychamber. MGUH 16757 from GGU 234072; section 30, bed 4 (see Appendix). $\times\frac{1}{2}$.

Fig. 2. Large (M) with better preserved sculpture on inner whorls. MGUH 16758 from GGU 234072; same level and locality.

Fig. 3. A presumed (m), no sutures visible. MGUH 16759 from GGU 234089; Visdal, section 47, bed 19.

Fig. 4. External mould of (m), no sutures visible. MGUH 16760 from GGU 234077; between section 30 and 32.

Fig. 5. A presumed (m), no sutures visible. MGUH 16761 from GGU 234072; section 30, bed 4 (see Appendix).

Fig. 6. A presumed (m), no sutures visible. MGUH 16762 from GGU 234028; section 7, bed 20 (see Appendix).


1
×1/2
2
×1/2
3
4
5
6

Plate 19

Rasenia evoluta Spath
Cardioceraskløft Member, fauna 18, Cymodoce Zone

Fig. 1. Field photograph of very large (M). The cross marks the onset of the bodychamber. Section 30, bed 6.

Plate 20

Rasenia evoluta Spath

Cardioceraskløft Member, fauna 18, Cymodoce Zone

Fig. 1. Complete (M) with peristome, the whole of the last whorl is bodychamber. MGUH 16763 from GGU 234078; section 32.

Fig. 2. Fragment of septate whorl of (M). MGUH 16764 from GGU 234078; section 32.

Fig. 3. Wholly septate nucleus. MGUH 16765 from GGU 234078; section 32.

Fig. 4. Wholly septate nucleus. MGUH 16766 from GGU 234078; section 32.

Fig. 5. Cast of complete (m) with lappet. MGUH 16767 from GGU 137785; section 41, bed 6.

Fig. 6. Cast of juvenile? (m). MGUH 16768 from GGU 234076; section 30, bed 6.

Fig. 7. Cast of nearly complete (m), final peristome not preserved. MGUH 16769 from GGU 234076; same level and locality.

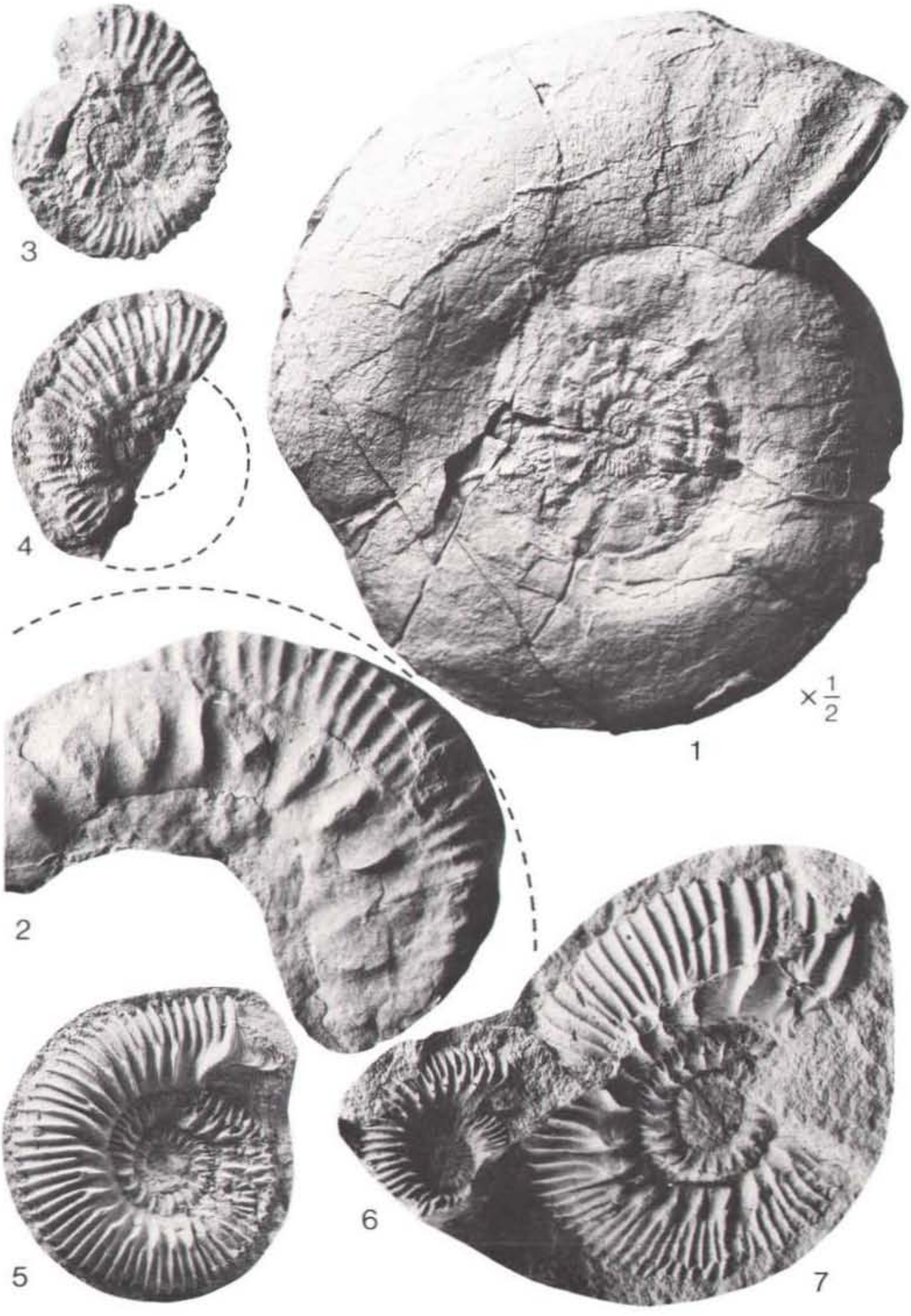

3
4
× 1/2
1
2
5
6
7

Plate 21

Aulacostephanus (?)groenlandicus Ravn

Figs 1a–b. Holotype, figured by Ravn, 1911, pl. 37, figs 3a–c. MGUH 791; Store Koldewey.

Rasenia borealis Spath

Cardioceraskløft Member, fauna 19, Mutabilis Zone

Fig. 2. Cast of septate (M). MGUH 16770 from GGU 234024; section 8, beds equivalent to section 7, bed 22. $\times\frac{1}{2}$.

Fig. 3. Nearly complete septate (M) with exposed inner whorls. MGUH 16771 from GGU 234024; same level and locality.

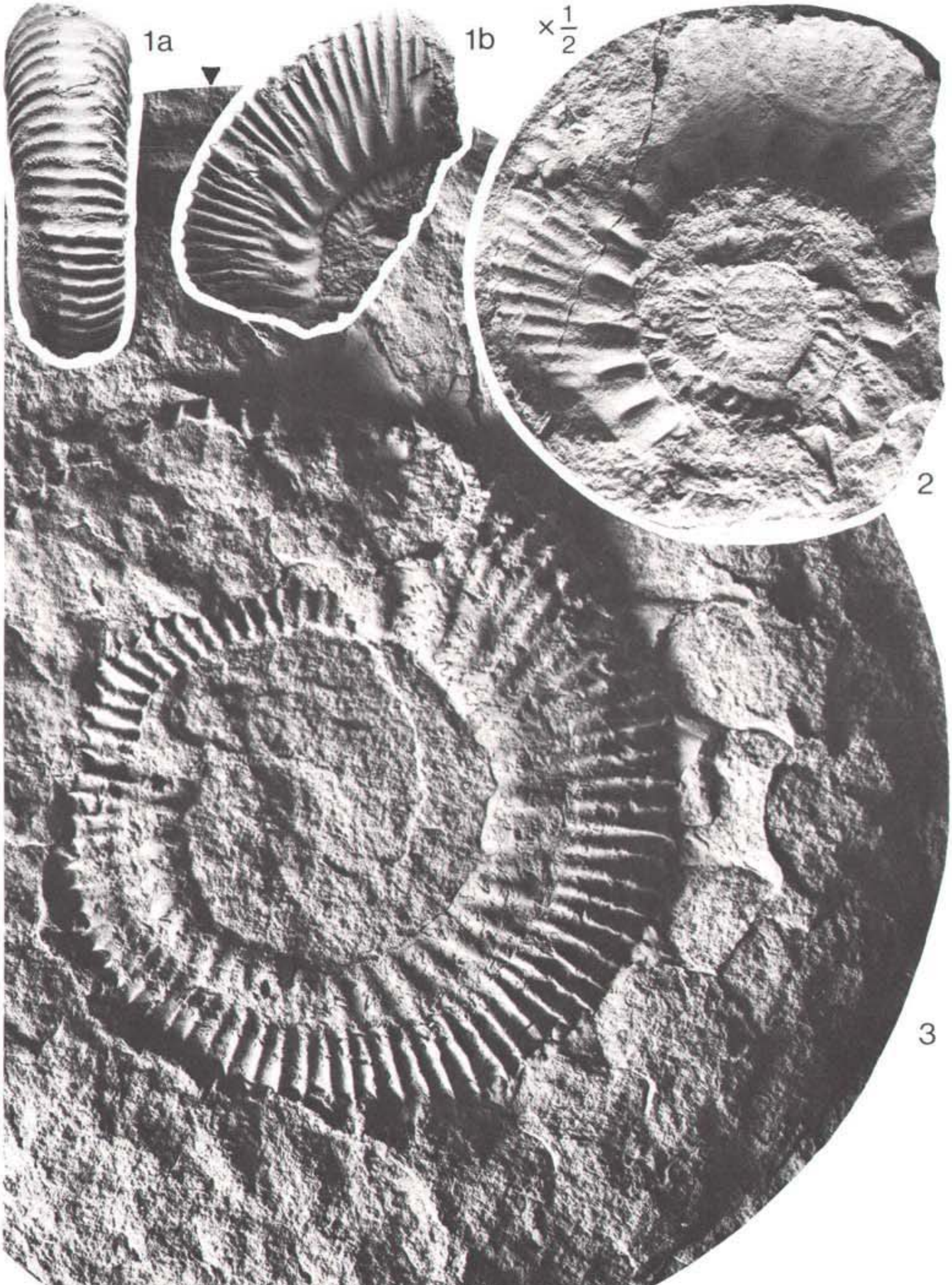

1a
1b
×$\frac{1}{2}$
2
3

Plate 22

Aulacostephanoides mutabilis (Sowerby)
Cardioceraskløft Member, fauna 19, Mutabilis Zone

Fig. 1. Fragment of large (M). MGUH 16772 from JHC 499; section 32, from a level equivalent to section 30, bed 8 (see Appendix).

Fig. 2. Cast of external mould. Apparently a (m), tentatively referred to *A. (Aulacostephanites) eulepidus* (Schneid). MGUH 16773 from GGU 234024; section 8, beds equivalent to section 7, bed 22.

1

2

Plate 23

Aulacostephanus eudoxus (d'Orbigny)
Gråkløft Member, fauna 21, Eudoxus Zone

Fig. 1. Coarse-ribbed specimen. No sutures visible. MGUH 16774 from GGU 137426; Sønderelv, section 21.

Fig. 2. Fragment showing the smooth venter. MGUH 16775 from GGU 137426. Same level and locality.

Fig. 3. Fine-ribbed specimen showing final peristome. MGUH 16776 from GGU 234026; section 7.

Aulacostephanus sp. cf. aff. *Au. kirghisensis* (d'Orbigny)
Gråkløft Member, fauna 23, Autissiodorensis Zone

Fig. 4. Large (M) with part of bodychamber preserved. MGUH 16777 from GGU 137684; Kiderlen Kløft, 135 m above sea-level, loose.

1

3

2

4