# Brachiopods of the Holm Dal Formation (late Middle Cambrian), central North Greenland

MARY G. ZELL and ALBERT J. ROWELL

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Brachiopods from the Holm Dal Formation are all inarticulates and some 70 percent belong to genera that had an intercontinental Cambrian distribution. The majority of the genera have relatively long stratigraphic ranges; because they are only moderately eurytopic, their chronostratigraphic resolution is modest. The species, however, are more strongly endemic than the genera and consist largely of forms that are known only from North Greenland or are referred to taxa whose distribution is limited to platforms around Cambrian Laurentia; only one species is known from another continent. The fauna consists of 14 species referred to 11 genera of which none of the latter are new. Six of the species are retained in open nomenclature because of limited material or inadequate information. Three of the species are new: *Canthylotreta grada, Dactylotreta patriella,* and *Anabolotreta groenlandica.*

*M. G. Zell, Department of Geology, University of Kansas, Lawrence, Kansas 66045, U. S. A.*
*A. J. Rowell, Department of Geology and Museum of Invertebrate Paleontology, University of Kansas, Lawrence, Kansas 66045, U. S. A.*

The Holm Dal Formation of central North Greenland is defined in an accompanying paper by Ineson (this volume; see also Fig. 1) who provides stratigraphic data and locality information for the brachiopods that are discussed here. Ineson also describes the depositional setting of the unit, which accumulated on an open shelf and associated slope during late Middle Cambrian time.

The Holm Dal Formation is a very fossiliferous segment of the stratigraphic column, although the upper approximately 30 m of the formation have only yielded trace fossils (Bergström & Ineson this volume). Brachiopods, all of which are inarticulates, form only a minor part of its fauna. The 14 recognised species are distributed among three orders (Table 1). Molluscs are a small but significant component of the benthos, and these are described by Peel (this volume). The preserved fauna is dominated by trilobites whose 58 species are documented by Robison (this volume). They include the cosmopolitan agnostoids and the more endemic polymeroids. The agnostoids demonstrate that the fossiliferous part of the Holm Dal Formation lies within the upper *Lejopyge laevigata* Interval zone and although the polymeroids include taxa that are found in three North American biozones, they are most similar to the faunas of the lower and middle *Cedaria* Zone (Robison this volume).

The brachiopods show stratigraphic and geographic distribution patterns that are intermediate between those of the agnostoids and those of polymeroid trilobites. At the generic level, the brachiopods are much more cosmopolitan than polymeroids because 8 of 11 brachiopod genera are not restricted to shelves around Cambrian Laurentia (in the sense of Bambach et al. (1980) to include most of North America and Greenland, together with part of Scotland). Nevertheless, the genera have limited biostratigraphic utility for intercontinental correlation: seemingly they were only moderately eurytopic and other aspects of larval distribution also may have slowed their dispersion across world oceans. Indeed, three genera, *Curticia* Walcott 1905, *Canthylotreta* Rowell 1966, and *Rhondellina* Rowell 1986, are known only from North America and Greenland. At the species level, the endemism of inarticulate brachiopods is broadly comparable with that of polymeroid trilobites. Only one species, *Linnarssonia tumida* Henderson & MacKinnon 1981, is known to have an intercontinental distribution. The remaining species are either restricted to North Greenland or have been recorded only from shelf and slope deposits around Laurentia.

Inarticulate brachiopods are difficult to study unless they can be etched free from their carbonate matrix by dilute formic or acetic acid. The technique is capable of yielding superb examples, unfortunately the majority of the specimens recovered from the insoluble residues of the North Greenland collections consist of only fragments of the more robust part of the valves. A few of the fragments are obviously worn and the valves were probably broken before they were entombed. Most valves, however, are not severely abraded and may

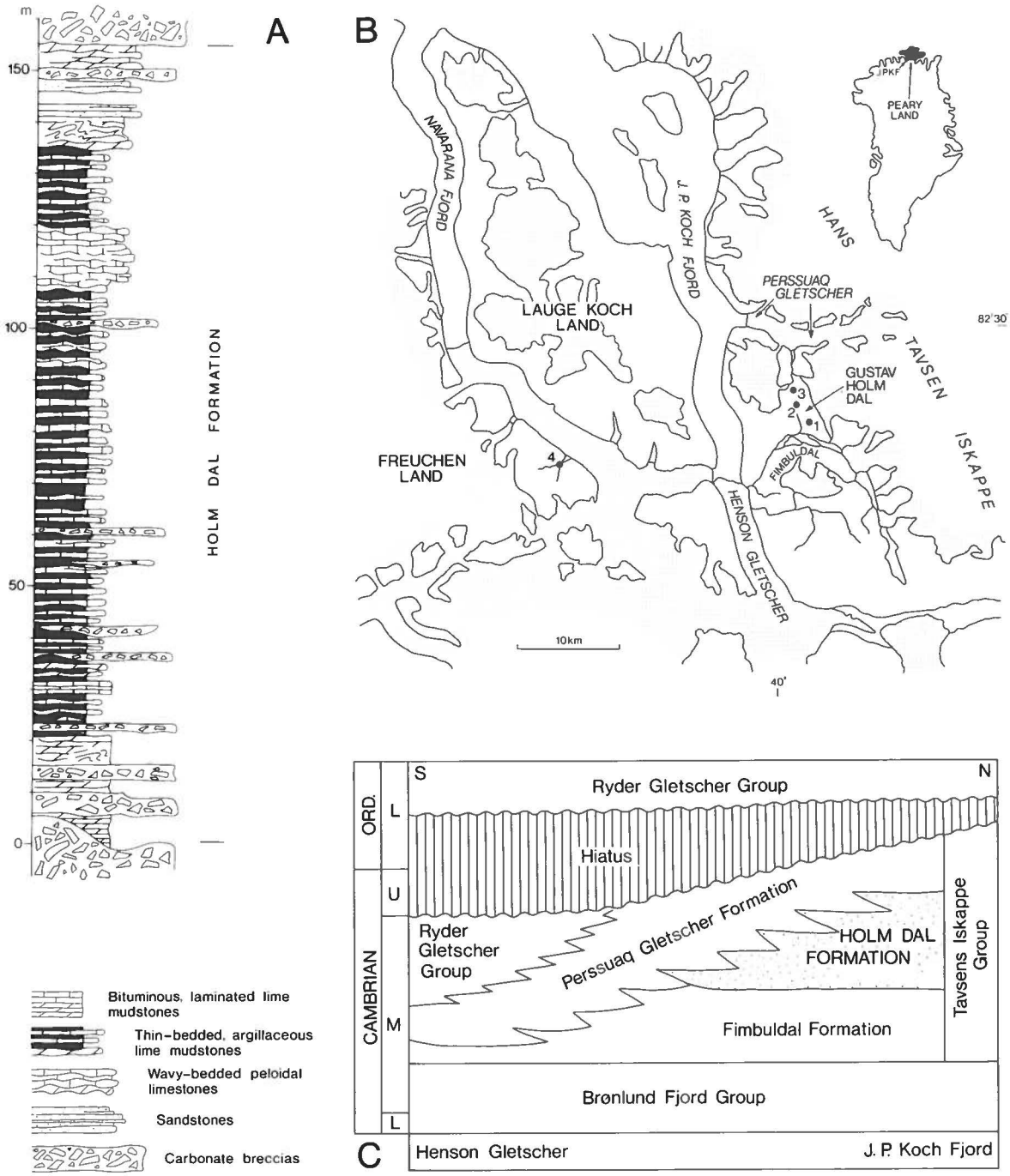



Fig. 1. Derivation of inarticulate brachiopods from the Holm Dal Formation, central North Greenland. A, Stratigraphic section through the Holm Dal Formation at its type locality (locality 1 in Fig. 1B; from Ineson, this volume). B, map of the area around Gustav Holm Dal, westernmost Peary Land, central North Greenland. Peary Land and J. P. Koch Fjord (JPKF) are indicated on the small inset of Greenland. Collection localities within the Holm Dal Formation are numbered 1 to 4: 1, the type section (Fig. 1A) and adjacent area, GGU collections in the sequence 225528–225567; 2, east side of Gustav Holm Dal, GGU collections 225586, 271403, 271404, 271408, 271414, 271417; 3, east side of Gustav Holm Dal, GGU collections 225592–225595; 4, south-east Freuchen Land, GGU collections 315007, 315009, 315011–315013. C, stratigraphic relationship of the Holm Dal Formation (from Ineson, this volume).

Table 1. The brachiopod fauna of the Holm Dal Formation.

| |
|---|
| Class Inarticulata |
| Order Acrotretida |
| Superfamily Acrotretacea |
| Family Acrothelidae |
| *Orbithele* sp. |
| Family Acrotretidae |
| Subfamily Acrotretinae |
| *Canthylotreta marjumensis* (Walcott) |
| *Canthylotreta grada* n. sp. |
| *Prototreta* sp. |
| *Dactylotreta patriella* n. sp. |
| Subfamily Linnarssoniinae |
| *Linnarssonia tumida* Henderson & MacKinnon |
| *Anabolotreta groenlandica* n. sp. |
| *Picnotreta* sp. |
| Subfamily unassigned |
| *Rhondellina dorei* Rowell |
| Family Curticidae |
| *Curticia minuta* Bell |
| Order Paterinida |
| Superfamily Paterinacea |
| Family Paterinidae |
| *Micromitra* cf. *M. modesta* (Lochman) |
| Order Lingulida |
| Superfamily Lingulacea |
| Family Obolidae |
| *Lingulella* sp. 1 |
| *Lingulella* sp. 2 |
| *Lingulella* sp. 3 |

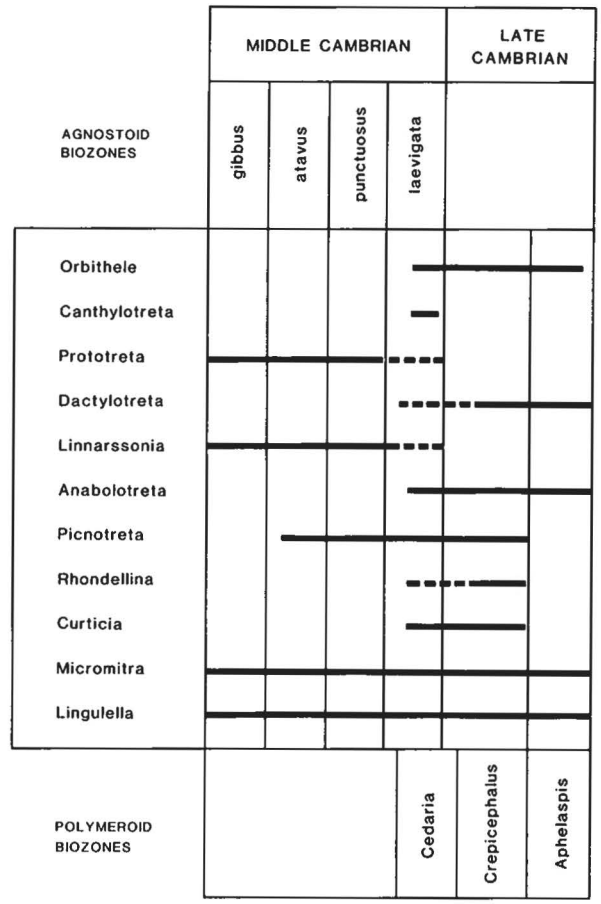



Fig. 2. Diagrammatic representation of the stratigraphic distribution of inarticulate brachiopod genera that occur in the Holm Dal Formation. Ranges are plotted on a sequence of biostratigraphic zones that are interpreted as informal chronozones for the purpose of the figure. Extension of previously known ranges shown by broken lines.

have been cracked after burial by diagentic compaction.

The new distributional data from North Greenland are interesting because several genera occur in associations that are presently unknown elsewhere in the world. Fig. 2 shows diagrammatically the previously known stratigraphic ranges of genera that occur in the Holm Dal Formation. The brachiopod fauna is consistent with the formation being of late Middle Cambrian age. Indeed, this age is the most parsimonious interpretation of the data (Fig. 2); with it, the stratigraphic ranges of two genera are lowered and those of two others are raised.

# Systematic descriptions

Terminology. – The terminology used for morphological features is largely that employed in the Treatise on Invertebrate Paleontology Part H (Moore 1965). We also use some terms, particularly for features of the Acrotretacea, that were defined by Krause & Rowell (1975).

Stratigraphic distribution. – The distribution of brachiopods and accompanying trilobites and molluscs is shown in Figs 3–7.

It should be noted that with the exception of the trace fossils described by Bergström & Ineson (this volume), no fossils were collected from the upper 30 m of the Holm Dal Formation in Peary Land (localities 1–3 in Fig. 1B; Figs 3–6). Fossiliferous collections from locality 4 in Freuchen Land are derived from the lowest 50 m of the formation (Fig. 7).

Depositories. – Collection sample numbers for all Geological Survey of Greenland (Grønlands Geologiske Undersøgelse) material used in this study are prefixed by GGU. Figured and type specimens bear additionally a specimen number prefixed by MGUH; they are housed in the Geologisk Museum (formerly the Mineralogisk Museum), Copenhagen. The remaining non-illustrated specimens are deposited in the collections of the Geological Survey of Greenland, Copenhagen.

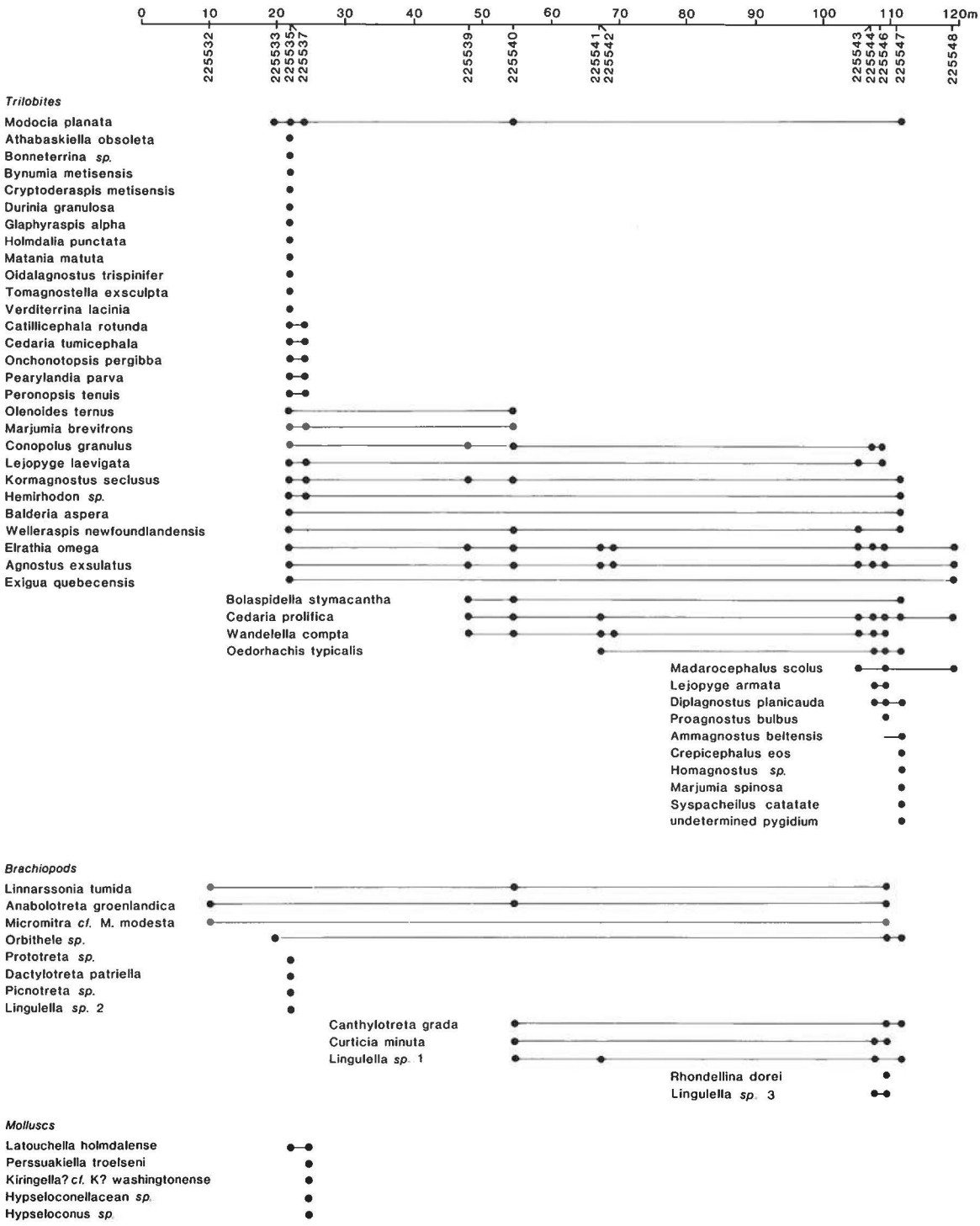
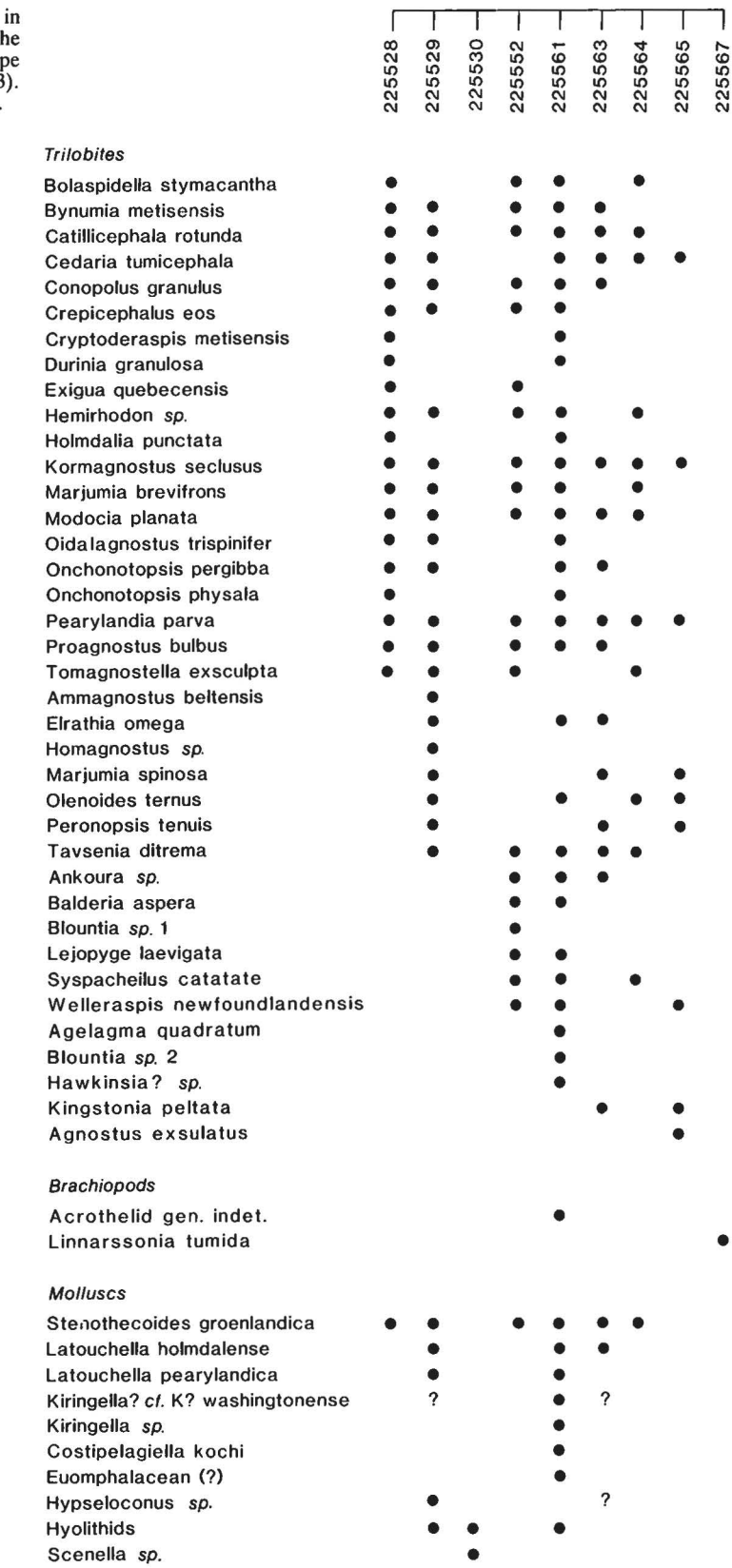



Fig. 3. Stratigraphic distribution of trilobites, brachiopods and molluscs from the type section of the Holm Dal Formation (Fig. 1A, locality 1 in Fig. 1B). Six-digit numbers are GGU collection numbers. The formation is almost 155 m thick in its type section; scale indicates height above the base of the formation.

Fig. 4. Trilobites, brachiopods and molluscs in GGU collections from the lowest part of the Holm Dal Formation in the vicinity of its type locality, exclusive of its type section (see Fig. 3). Collections are not in stratigraphic sequence.



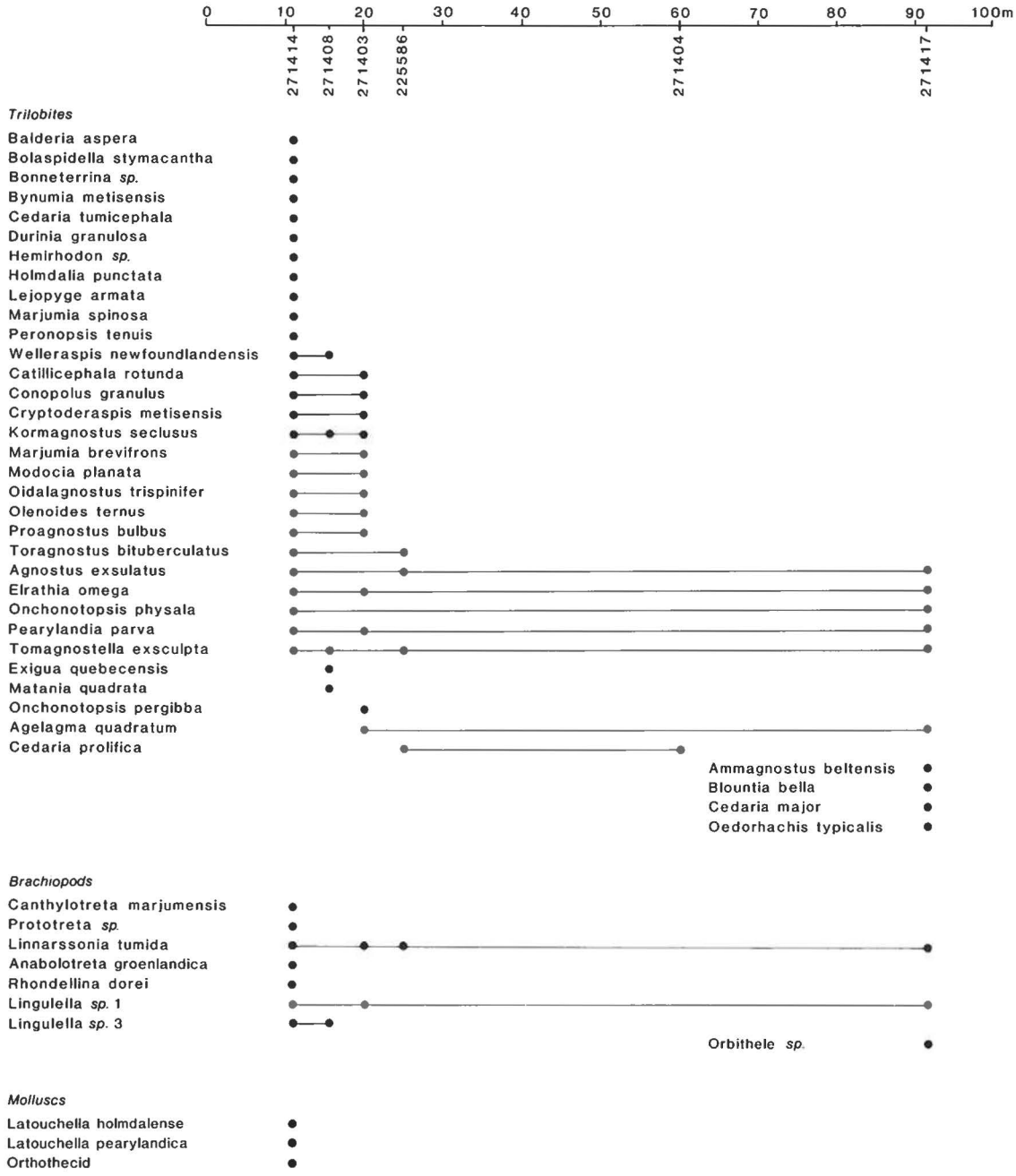



Fig. 5. Stratigraphic distribution of trilobites, brachiopods and molluscs in GGU collections (six-digit numbers) from locality 2 (Fig. 1B) of the Holm Dal Formation. Scale indicates height above the base of the formation.

Order Acrotretida
Superfamily Acrotretacea
Family Acrothelidae

## Genus Orbithele Sdzuy 1955

Type species. – *Discina contraria* Barrande 1868, p. 104, fig. 72; by original designation.

Remarks. – *Orbithele* and *Acrothele* Linnarsson 1876 are two phenetically similar genera that are judged to be closely related following cladistic analysis. *Acrothele* is a common Middle Cambrian genus; *Orbithele*, whose known stratigraphic range slightly overlaps that of *Acrothele*, is more common in the Upper Cambrian, but occurs also in the Lower Ordovician of Czechoslovakia (Mergl 1981). The principal morphological difference between the two is that *Orbithele* possesses a ventral internal pedicle tube. Seemingly, spines developed differently on the larval valves (Rowell 1980), but this merits further investigation. In the few species of *Orbithele* that have been examined at the appropriate magnification, the dorsal larval valve bears four relatively long spines that are arranged symmetrically. In contrast, the type species of *Acrothele*, *A. coriacea* Linnarsson 1876, and the common Great Basin species, *A. subsidua* (White 1874), have at least the anterior pair of projections as low nodes (Rowell 1980).

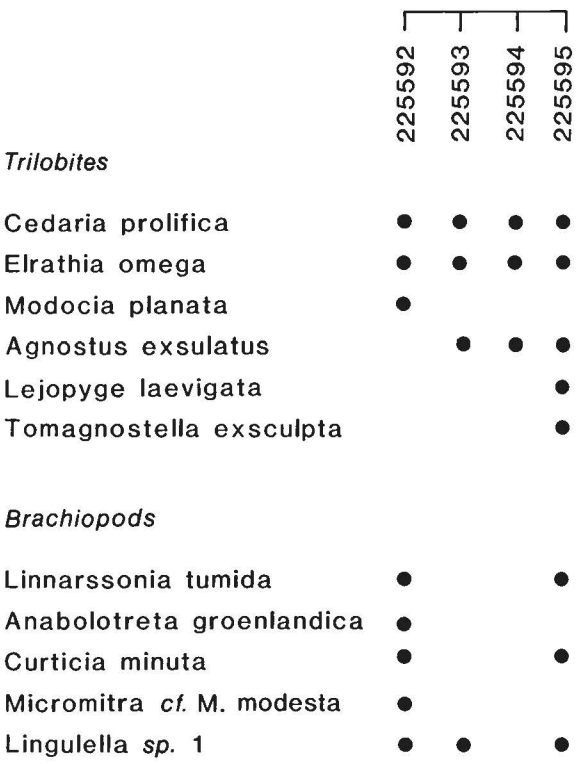



Fig. 6. Trilobites and brachiopods in GGU collections (six-digit numbers) from locality 3 (Fig. 1B) of the Holm Dal Formation. Collections are only placed relative to each other within about the lowest 100 m of the formation. GGU 225592 and 225593 are from near the middle of this interval, GGU 225594 and 225595 are from near the top of this fossiliferous interval.

## *Orbithele* sp.

Fig. 8.1–3

Material. – Five ventral and two dorsal valve fragments, together with one articulated juvenile shell from GGU samples 225533, 225546, 225547 and 271417. Unidentifiable acrothelids were also found in GGU sample 225561.

Remarks. – Because the available material is fragmentary and poorly preserved, or is juvenile, these specimens are left in open nomenclature. Three of the ventral valves retain indications of the pedicle tube, but it is intact in only one of them. The larval shells possess the coarse pitting characteristic of all known acrothelids (Figs 8.1d-f; see also Rowell 1980). The distribution of spines in these larval valves is consistent with the material being *Orbithele*, but the spines are all broken near their tip.

Occurrence. – Rare in the basal part of the Holm Dal Formation, and near the top of the fossiliferous sequence at localities 1 and 2 (Figs 1, 3, 5).

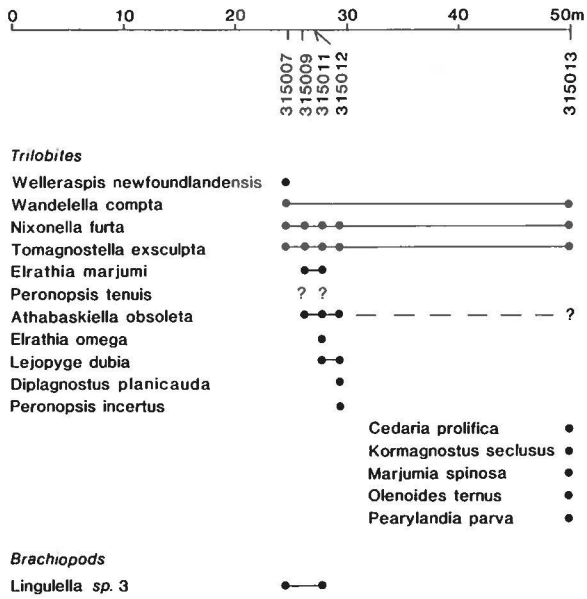


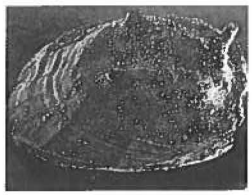

Fig. 7. Stratigraphic distribution of trilobites and brachiopods from locality 4 (Fig. 1B) of the Holm Dal Formation in GGU collections (six-digit numbers) from south-east Freuchen Land. Scale indicates height above the base of the formation.

1a

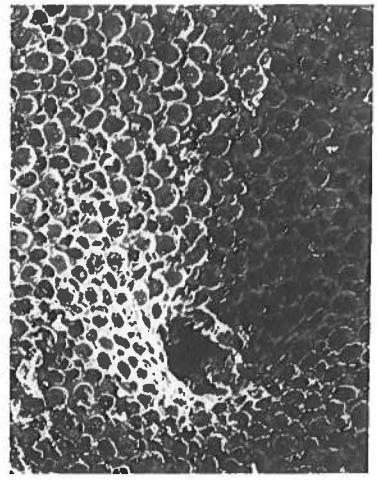
2a

1b

2b



1c

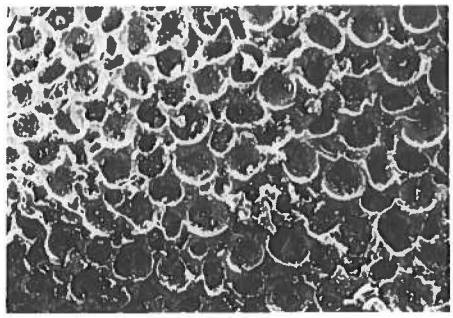


1d

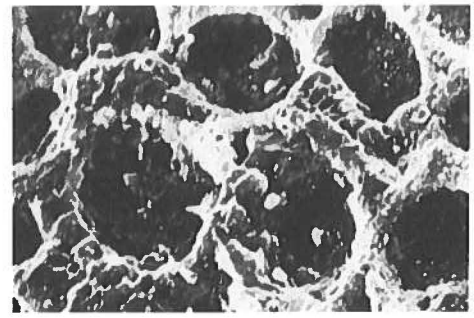
2c

3a

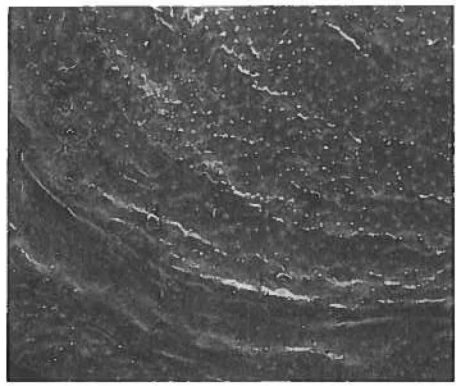
3b



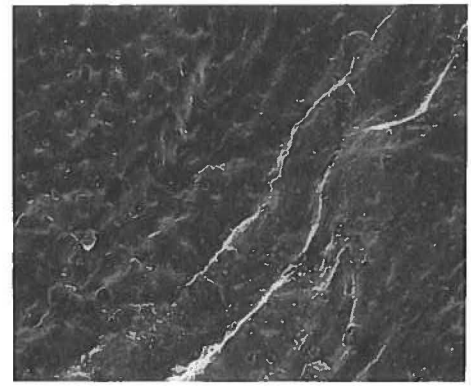
1e



1f



3c



3d

Family Acrotretidae
Subfamily Acrotretinae

## Genus *Canthylotreta* Rowell 1966

Type species. – *Acrotreta marjumensis* Walcott 1908, pp. 94–95, pl. 9, figs 2, 2a; by original designation.

Remarks. – The genus was known previously only from its type species, *C. marjumensis* (Walcott 1908), from the Great Basin of Utah and Nevada. In the western United States, this species occurs in the middle part of the *Cedaria* Zone. The new material from North Greenland does not extend the stratigraphic range of the genus but is referred to two species, *C. marjumensis* and the new species added here, *C. grada*.

Dorsal valves of *Canthylotreta* are similar to those of *Angulotreta* Palmer 1955, and *Apsotreta* Palmer 1955, but the dorsal median septum of *Canthylotreta* extends farther forward than it typically does in species of either of the other two genera. Furthermore, the outer surface of the dorsal valve has a noticeable sulcus in both species of *Canthylotreta,* a feature that is missing in species of *Angulotreta* and *Apsotreta.*

The ventral valve of *Canthylotreta* is not conical, as it typically is in *Angulotreta,* but it does resemble that of *Apsotreta* externally. The internal differences between these two genera, discussed previously in Rowell (1966), focus on the relationship of the internal pedicle opening to the apical process. In *Canthylotreta,* the opening lies entirely dorsal of the apical process; in *Apsotreta,* the pedicle passed through the thickened apex of the valve and emerged from a foramen within the apical process. The apical process of *Apsotreta* typically extends to near the middle of the valve and is much longer than that of *Canthylotreta.* It is possible that cladistic analysis would demonstrate that the two stocks are related and that a species of *Canthylotreta* is ancestral to the *Apsotreta* complex.

## *Canthylotreta marjumensis* (Walcott 1908)

Fig. 10.7–10

1908 *Acrotreta marjumensis* – Walcott: 94–95, pl. 9: 2, 2a
1912 *Acrotreta marjumensis* (in part) – Walcott: 693, pl. 78: 2, 2b, 2c
1908 *Acrotreta ophirensis descendens* – Walcott: 95: pl. 9: 1 1a
1912 *Acrotreta ophirensis descendens* – Walcott: 698–699, pl. 78: 1, 1a-1c
1966 *Canthylotreta marjumensis* (Walcott) – Rowell: 5–9, pl. 1: 13–34

Material. – Nine ventral valves and 18 dorsal valves from GGU sample 271414. Approximately half of the valves are complete.

Remarks. – *Canthylotreta marjumensis* is a moderately variable species in the Great Basin of the western United States. The Greenland material is closely comparable to topotypic specimens from Utah, but differs in having a relatively higher ventral valve with an apex less strongly incurved over the ventral pseudointerarea. These differences are judged subjectively to be minor and the Greenland specimens are included in the taxon. Scanning electron microscope (SEM) examination showed that the circular, posteriorly directed pedicle foramen is confined entirely to the larval shell in the thickened beak (Fig. 10.8). The foramen caps the triangular, slightly concave pseudointerarea. Interiorly, the apical process is spatulate and prominent with thickened lateral margins. The internal pedicle opening is posterior and dorsal of the apical process and is flanked by two conspicuous apical pits. Anteriorly diverging *vascula lateralia* separate large, elliptical cardinal muscle scars from the apical process.

The triangular blade-like median septum in the dorsal valve reaches its maximum height at approximately 70 percent of the valve length. Posteriorly it buttresses a large, triangular, concave median plate that separates two anacline propareas along the posterior margin of the valve.

Occurrence. – *Canthylotreta marjumensis* is found in a single very fossiliferous sample (GGU 271414) of the Holm Dal Formation, 13 m from its base (Fig. 5).

## *Canthylotreta grada* n. sp.

Fig. 9.1–5, 9

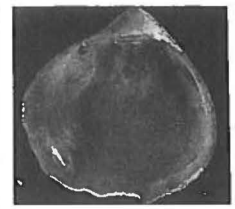
Holotype. – Ventral valve MGUH 18.024 from GGU sample 225547.

Fig. 8. *Orbithele* sp.

1–3. *Orbithele* sp. 1, juvenile dorsal valve exterior, in stereo view (a, b, X 27.5), and lateral oblique view (c; X 38.5); d, spine base on dorsal larval shell X 330; e, f, pitted ornament on larval shell (e, X 550; f, X 2200). MGUH 18.021 from GGU sample 225546. 2, ventral valve exterior, in stereo view (a, b) and lateral oblique view (c), all X 24.2. MGUH 18.022 from GGU sample 225546. 3, exterior of dorsal valve, larval valve with spines (a, X 44); b, ontogenetic change in shape shown by growth lines outside larval valve, X 19.8; c, d, detail of postlarval shell ornament (c, X 88; d, X 165). MGUH 18.023 from GGU sample 225547.

1a

2a

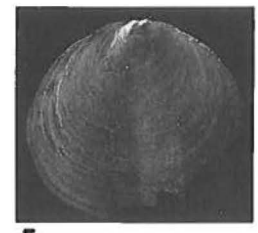


1b

2b

3

4



5

6a

7a

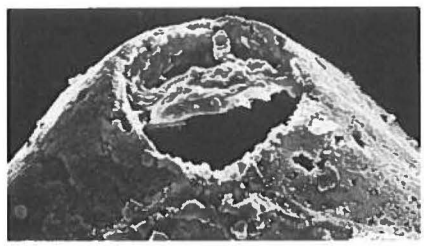
6b

7b

8a

8b

1c



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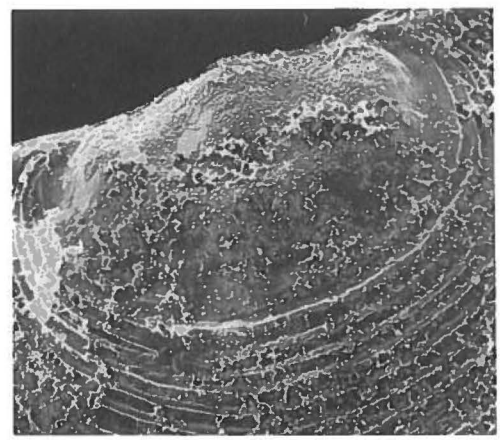

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Additional figured material. – MGUH 18.025, 18.027, 18.028 from GGU sample 225547; MGUH 18.026, 18.029 from GGU sample 225540.

Material. – In all, 76 ventral and 60 dorsal valves from GGU samples 225540, 225546 and 225547. One broken but still articulated specimen was obtained from 225546. Most valves are fragmentary, but a few of the more robust dorsal and ventral valves are complete.

Diagnosis. – *Canthylotreta* with ventral valves that are catacline to gently apsacline and with thickening in apex not strongly developed.

Description. – Ventral valve catacline to apsacline, having convex lateral profile, only gently incurved beak. Foramen posteriorly directed, confined to larval shell (Fig. 9.1c), overhanging pseudointerarea with dorsally directed growth lines. Length and width of valve subequal; commissural outline rounded subtriangular, essentially straight posteriorly. Maximum height of valve about half length occurring near midlength of valve. Internally, cardinal muscle scars large, oval and anterolaterally directed. *Vascula lateralia* deeply incised (Fig. 9.1a, b). Internal pedicle opening small, circular, flanked by slightly larger apical pits.

Dorsal valve transversely subtriangular to suboval in outline. Median sulcus extending back nearly to beak (Fig. 9.5). Concave median plate ornamented by fine growth lines separating small anacline propareas. Lateral commissural margin flattened in front of propareas. Median septum high, blade-like and subtriangular, extending forward almost to front of valve, maximum height of septum occurring about three quarters of valve length in front of beak, small median buttress at its posterior end. Short *vascula lateralia* diverging anterolaterally from front of buttress. Lobate cardinal muscle scars well developed, their posterior region beneath propareas (Fig. 9.2).

Remarks. – Although there is considerable variation within populations, *C. grada* may be distinguished from *C. marjumensis* by its more convex, less strongly apsacline ventral valve. Additionally, the beak of *C. grada* is less strongly incurved and its internal thickening, which is characteristic of *C. marjumensis*, is relatively weakly developed.

Occurrence. – The species occurs in the middle of the Holm Dal Formation (Fig. 3).

## Genus *Prototreta* Bell 1938

*Prototreta* Bell 1938: 405; Bell 1941: 221–223; Shimer & Shrock 1944: 289; Goryanskij 1960: 178–179; Robison 1964: 559; Rowell 1965: 276–277; Aksarina in Aksarina & Pelman 1978: 60–61; Koneva 1979: 37–38
*Homotreta* Bell 1941: 230; Shimer & Shrock 1944: 289; Pelman 1977: 24

Type species. – *Prototreta trapeza* Bell 1938, p. 405, pl. 1, figs 1–6; by original designation.

Remarks. – *Prototreta* and *Homotreta* are regarded here as subjective synonyms. Their ventral valves are essentially identical and the principal difference between the two genera is in the presence of a digitate septum in *Prototreta* in contrast to a simple, blade-like form in *Homotreta*. The two genera were established on mechanically prepared material and neither type species has been reinvestigated using acetic or formic acid treatment. Bell (1941) recognised that their two type species were isochronous homeomorphs and later considered that they should probably be regarded as synonyms (Bell & Ellinwood 1962). In at least two species of the related genus *Angulotreta* there are two phena, one with a simple septum, the other with a digitate structure (Palmer 1955, Bell & Ellinwood 1962). The significance of the digitation is unknown. It is unlikely to be an example of sexual dimorphism because both types of septa are not present in all populations.

The genus *Prototreta* is known from the lower Middle Cambrian of North America and Rowell's unpublished data show it to range through the *Ptychagnostus punctuosus* Zone. Its presence in the Holm Dal Formation thus extends its range significantly. The majority of the North Greenland material is very fragmentary; only one species is described and even that is left in open nomen-

Fig. 9. *Canthylotreta grada* n. sp. and *Micromitra* cf. *M. modesta* (Lochman 1940)

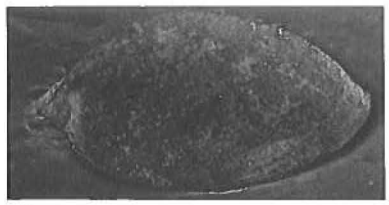
1–5, 9. *Canthylotreta grada* n. sp. 1, holotype ventral valve, stereo view of interior (a, b, X 16.5) and posterior view of foramen and ventral pseudo-interarea (c, X 220). MGUH 18.024 from GGU sample 225547. 2, dorsal valve, stereo view of interior, (a, b, X 22). MGUH 18.025 from GGU sample 225547. 3, oblique lateral view of dorsal valve and septum, X 22. MGUH 18.026 from GGU sample 225540. 4, oblique lateral view of apsacline ventral valve, X 27.5. MGUH 18.027 from GGU sample 225547. 5, dorsal valve exterior with sulcus and noded beak, X 22. MGUH 18.028 from GGU sample 225547. 9, ventral valve foramen enclosed by larval valve, X 550. MGUH 18.029 from GGU sample 225540.
6–8, 10. *Micromitra* cf. *M. modesta* (Lochman 1940) 6, broken ventral valve exterior in stereo (a, b, X 22). MGUH 18.030 from GGU sample 225532. 7, dorsal valve exterior in stereo (a, b, X 27.5). MGUH 18.031 from GGU sample 225592. 8, detail of posterior margin of dorsal valve with thickened notothyrial margins and lack of homeochilidium (a, X 33) and featureless dorsal valve interior (b, X 17.5). MGUH 18.032 from GGU sample 225546. 10, detail of larval dorsal valve and immediately adjacent postlarval valve; note poorly defined nodes in larval valve and pitted micro-ornament, X 110. MGUH 18.033 from GGU sample 225592.

1a

2a

1b

2b



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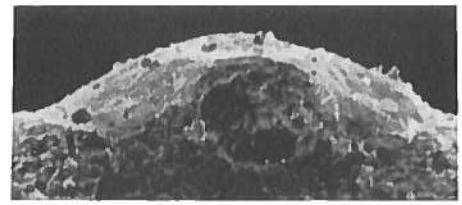

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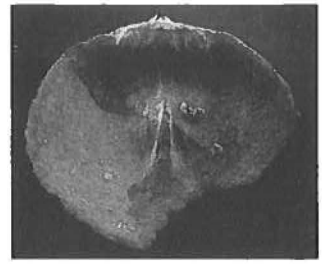

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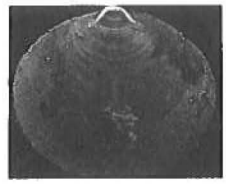
7a

9



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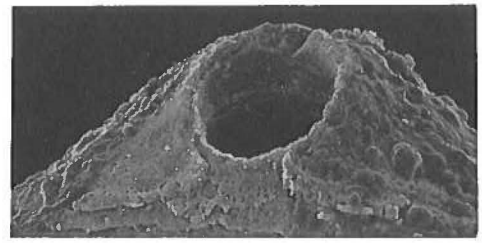

8a

8b

7b

8c

7c

clature. It is probable, however, that the genus is more widely distributed in the formation, for broken material, questionably referrable to *Prototreta*, occurs at several stratigraphic levels.

## *Prototreta* sp.

Fig. 12.9–13

Material. – Twelve fragmentary ventral valves and 16 dorsal valves, only one complete, from GGU samples 225535 and 271414.

Description. – Low conical procline ventral valve; height averages 1.05 mm. Growth lines indicate valve transversely oval in commissural outline, posterior commissural margin straight. Well-defined intertrough on straight to slightly concave pseudointerarea capped by circular, posteriorly-directed foramen (Fig. 12.9). Anterior slope variable; straight to slightly concave or convex in lateral profile. Large internal pedicle opening on dorsal surface of apical process (Fig. 12.12b); bordered posterolaterally by apical pits. Deeply incised *vascula lateralia* diverge anterolaterally from pits (Fig. 12.12a). Cardinal muscle scars large, circular, lateral to apical pits.

Dorsal valve flat to gently convex and strongly sulcate; about 15 percent wider than long. Blade-like median septum triangular in lateral profile (Fig. 12.13). Long pseudointerarea (Fig. 12.10) with broad, triangular, depressed median plate flanked by smaller anacline propareas. Oval cardinal muscle scars extend anterolaterally from beneath pseudointerarea. Anterior and lateral portions of valve flattened to form brim that merges with propareas.

Remarks. – The material most closely resembles *Prototreta gorjanskii* (Pelman 1973). The principal difference is that the dorsal valve of the latter is much more strongly convex and lacks the conspicuous sulcus that is characteristic of the Greenland material. *Prototreta interupta* (Bell 1941) resembles specimens from the Holm Dal Formation in having a simple median septum, but the posterior margin of its dorsal valve is straight, rather than pointed and, furthermore, it has an unusual, beaded, fine ornament.

Occurrence. – *Prototreta* sp. was obtained from samples from the lower part of the Holm Dal Formation (Figs 3, 5).

## Genus *Dactylotreta* Rowell & Henderson 1978

Type species. – *Dactylotreta redunca* Rowell & Henderson 1978, pp. 4–5, pl. 1, figs 1–8; by original designation.

Remarks. – *Dactylotreta* is characterised by its high procline to catacline ventral valve with the apical third or more of the valve occluded by an apical process. Within the genus, some species have a median dorsal septum, others lack one. In all known species, the median part of the dorsal pseudointerarea is buttressed.

*Dactylotreta* is a relatively widespread genus and is currently known from Australia, Antarctica and North America. In Australia, it ranges throughout much of the Upper Cambrian (Rowell & Henderson 1978), but in North America, Rowell's unpublished data show its first occurrence is in the upper part of the *Crepicephalus* Zone. The Holm Dal record thus extends the range of the genus slightly downward in this faunal province.

## *Dactylotreta patriella* n. sp.

Fig. 11.1–5

Holotype. – Ventral valve MGUH 18.044 from GGU sample 225535.

Other figured material. – MGUH 18.045–18.048 from GGU sample 225535

Material. – A total of 11 ventral valves and 5 dorsal valves from GGU sample 225535, all of which are abraded to some degree.

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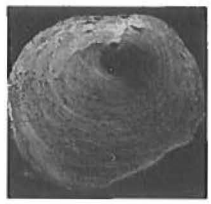
Fig. 10. *Linnarssonia tumida* Henderson & MacKinnon 1981 and *Canthylotreta marjumensis* (Walcott 1908)

1–6. *Linnarssonia tumida* Henderson & MacKinnon 1981. 1, ventral valve interior, in stereo (a, b, X 13.2). MGUH 18.034 from GGU sample 225586. 2, dorsal valve interior, in stereo (a, b, X 18.7). MGUH 18.035 from GGU sample 271414. 3, oblique lateral view of exterior of ventral valve X 16.5. MGUH 18.036 from GGU sample 225586. 4, ventral valve, posterior view of foramen and larval valve (a, X 275), and ventral interior with boss-like apical process (b, X 16.5). MGUH 18.037 from GGU sample 271414. 5, incomplete dorsal valve interior with large raised cardinal muscle scars X 16.5. MGUH 18.038 from GGU sample 271414. 6, dorsal valve interior X 11. MGUH 18.039 from GGU sample 271414.
7–10. *Canthylotreta marjumensis* (Walcott 1908). 7, dorsal valve interior, oblique lateral view (a, X 22) and in stereo (b, c, X 16.5). MGUH 18.040 from GGU sample 271414. 8, ventral valve, detail of foramen enclosed in larval valve (a, X 550) and interior view in stereo (b, c, X 27.5). MGUH 18.041 from GGU sample 271414. 9, ventral valve exterior, X 22. MGUH 18.042 from GGU sample 271414. 10, dorsal valve exterior, X 22. MGUH 18.043 from GGU sample 271414.

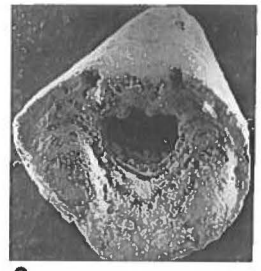


1a

2

1b

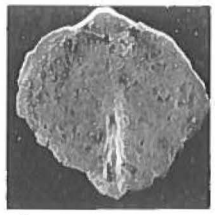
1c



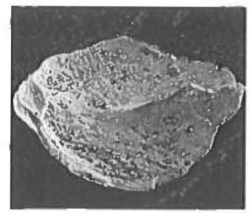
3a

1d

3b



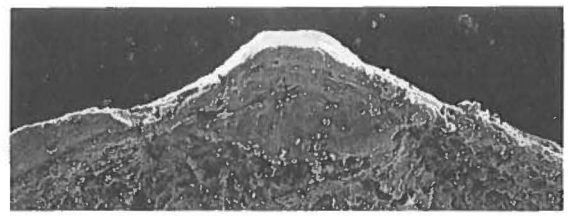
4a



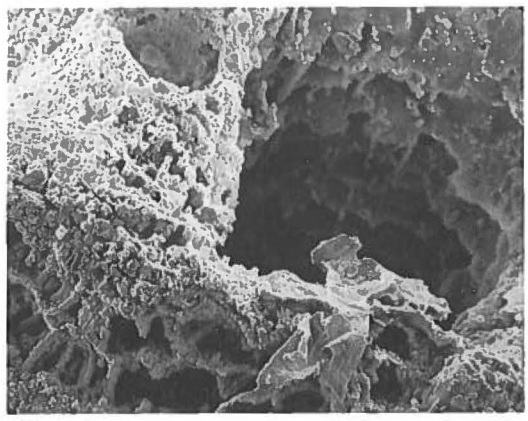
4c

4b

4d



4e



5

1e

Diagnosis. – *Dactylotreta* with ventral anterior slope planar to concave in lateral profile. Ventral pseudointerarea broad. Dorsal valve with low median septum and faint shallow sulcus.

Description. – Catacline ventral valve high conical, commissural outline slightly transversely oval. In lateral profile (Fig. 11.1c, d) anterior slope nearly straight apically, becoming markedly concave with growth. Fine growth lines present from base of larval shell to valve margin. Rounded beak with small circular, posteriorly directed foramen (Fig. 11.1e). Broad, well-defined, externally concave pseudointerarea, up to 50 percent of valve width. Internally, apical process occupies up to one third of valve height. Two small apical pits behind internal pedicle opening (Fig. 11.3a, b). Baculate *vascula lateralia* may be deeply incised.

Dorsal valve transversely oval; externally more convex posteriorly than anteriorly. Very shallow sulcus on anterior half of valve. Beak low, adjacent to commissural margin. Median septum low, maximum height approximately 100 µm immediately behind anterior terminous (Fig. 11.4c, d). Median plate small, concave, and triangular in outline, separating minute propareas that adjoin brim along posterolateral valve margin. Elliptical cardinal muscle scars extend anterolaterally from propareas.

Remarks. – *D. patriella* differs from both described species that have been referred to the genus in the slope of the anterior sector of the ventral valve. In the new species it is noticeably concave, whereas in both *D. redunca* (Rowell & Henderson 1978) and *D. solitaria* (Solov'ev et al. 1984), it is convex. The dorsal median plate of *D. patriella* is relatively shorter than that of *D. redunca*, and *D. solitaria* has a more prominent median buttress supporting this plate.

Occurrence. – The sample containing *Dactylotreta patriella* was taken 22 m above the base of the Holm Dal Formation (Fig. 3).

Subfamily Linnarssoniinae

## Genus *Linnarssonia* Walcott 1885

Type species. – *Obolella transversa* Hartt in Dawson 1868, p. 644; by original designation.

Remarks. – The concept of the genus has had a rather checkered history. We are using it in the sense of Rowell & Henderson (1978) for a group of biconvex acrotretids whose apical processes are dominated by a high, subconical boss.

## *Linnarssonia tumida* Henderson & MacKinnon 1981

Fig. 10.1–6

1981 *Linnarssonia tumida* – Henderson & MacKinnon: 301, figs 7K-P

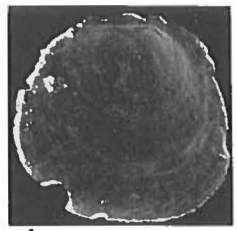
Material. – More than 800 specimens, most of which are fragmentary, from GGU samples 225532, 225540, 225546, 225567, 225586, 225592, 225595, 271403, 271414, and 271417.

Remarks. – Many of the species of *Linnarssonia* are in need of reexamination and revision. It is probable that there are many more available names than there are valid taxa. This topic and the potential synonomies involved are being investigated by our colleague, R. D. White.

The Greenland material is moderately variable but variability appears to be continuous and the collections are regarded as being samples of one species, *Linnarssonia tumida*. This species was discriminated by its authors from the common western North American taxon *Linnarssonia ophirensis* Walcott 1902, by its convexity and the relative height of its ventral pseudointerarea. *L.*

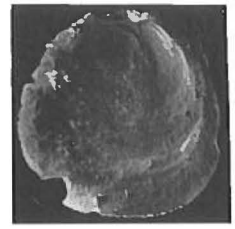
Fig. 11. *Dactylotreta patriella* n. sp.

1–5. *Dactylotreta patriella* n. sp. 1, holotype ventral valve in exterior stereo view (a, b, X 27.5, posterolateral view (c, X 27.5), oblique lateral view (d, X 22); e, posterior view of foramen, X 330. MGUH 18.044 from GGU sample 225535. 2, posterior view of ventral pseudointerarea, X 27.5. MGUH 18.045 from GGU sample 225535. 3, oblique view of fragmentary ventral valve apex showing posterior apical pits and extensive apical process, X 44. MGUH 18.046 from GGU sample 225535. 4, incomplete dorsal valve interior in stereo (a, b, X 24. 2); c, d, lateral view in stereo, X 27.5; e, detail of pseudointerarea, X 110. MGUH 18.047 from GGU sample 225535. 5, detail of shell ultrastructure in apical process, X 330. MGUH 18.048 from GGU sample 225535.



1a

2a



1b

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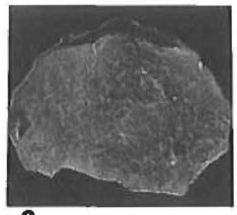
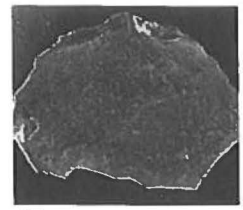


3a

4



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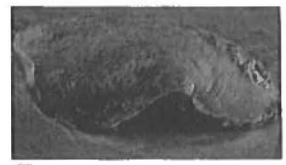


7

8

9a

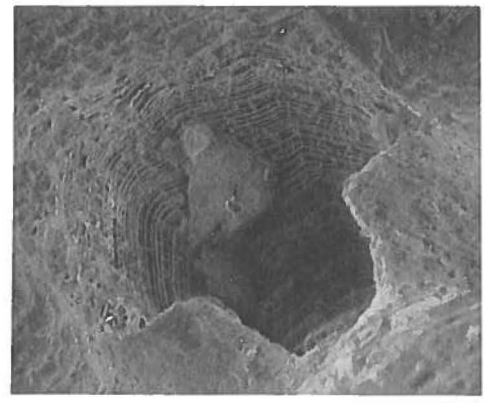
10a

9b

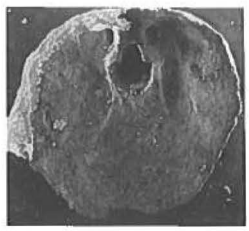
10b

13

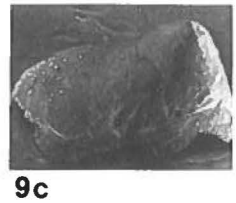
11



12b



12a



9c

*ophirensis* tends to have a more catacline ventral outline with maximum valve height near the beak. In contrast, *L. tumida* has a more rounded ventral lateral profile and the height of the pseudointerarea is about half the height of the valve. Comparison of topotypic material of these two species suggests that their dorsal valves are virtually indistinguishable.

Material from the Holm Dal Formation is closely comparable with topotypic specimens of *Linnarssonia tumida*. The most obvious difference is that the height of the ventral pseudointerarea of the Greenland material is higher in some specimens and varies between half and three-quarters of the valve height (Fig. 10.3). The Greenland specimens have a procline ventral valve whose pseudointerarea is externally slightly concave and bears a narrow intertrough. The external pedicle foramen is circular and posteriorly directed. SEM examination reveals that the foramen is not totally encircled by the larval shell (Fig. 10.4a), which bears the typical pitted ornament of the family. The ventral valve interior contains a prominent boss just anterior of the confluence of deeply-incised, baculate *vascula lateralia*. Two small ridges may diverge anterolaterally from the boss. The internal pedicle foramen is located posterior of the apical process and between large, subcircular cardinal muscle scars that are elevated above the valve floor.

The dorsal valve externally is more convex posteriorly than anteriorly. A small beak abuts the straight posterior margin. The interior of the dorsal valve also contains large, elevated, subcircular cardinal muscle scars; between them lies a short triangular median plate that in rare cases adjoins minute propareas. A low median ridge dominates the anterior slope of the valve and typically it extends forward between 60 and 70 percent of the valve length. Near the centre of the valve, a pair of small, elliptically bowed muscle scars are separated from it by *vascula media*.

Occurrence. – *Linnarssonia tumida* is rare to abundant in platy, mottled and brecciated limestones throughout the fossiliferous portion of the Holm Dal Formation.

## Genus *Anabolotreta* Rowell & Henderson 1978

Type species. – *Anabolotreta tegula* Rowell & Henderson 1978, pp. 9–10, pl. 2, figs. 7–14.

Emended diagnosis. – Subequally biconvex shells, with procline, more rarely catacline ventral pseudointerarea. Apical process low, elongate, subtriangular in outline, grooved from crest to internal pedicle opening. Dorsal valve typically with short pseudointerarea, median ridge present, absent, or expanded as a median septum.

Remarks. – When the genus was erected, the only species known to belong to it had relatively simple dorsal valves that had either a very low median ridge or lacked one entirely. Subsequently, Rowell has collected specimens that belong to two, presently unnamed, taxa from the western United States. These forms have ventral valves closely similar to that of the type species, but their dorsal valves differ significantly from that of *A. tegula*. One of the groups has a dorsal valve with a well-developed median septum, that of the other bears a conspicuous median ridge. The emended diagnosis is needed to include them within the concept of the genus.

## *Anabolotreta groenlandica* n.sp.

Fig. 13.1–7

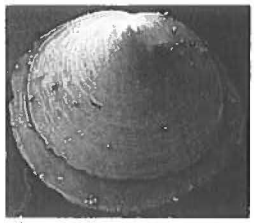
Holotype. – Ventral valve, MGUH 18.062 from GGU sample 225592.

Other figured material. – MGUH 18.063–18.065, MGUH 18.067 from GGU sample 271414; MGUH 18.066, MGUH 18.068 from GGU sample 225540.

Material. – A total of 44 ventral and 27 dorsal valves from GGU samples 225532, 225540, 225546, 225592 and

Fig. 12. *Curticia minuta* Bell 1944 and *Prototreta* sp.

1–8. *Curticia minuta* Bell 1938. 1, dorsal valve interior showing narrow propareas and median plate, in stereo (a, b, X 22). MGUH 18.049 from GGU sample 225592. 2, dorsal valve interior with faint impresions of cardinal muscle scars lateral of low median ridge, in stereo (a, b, X 22). MGUH 18.050 from GGU sample 225592. 3, ventral valve interior with gently apsacline propareas connected by collar, in stereo (a, b, X 33). MGUH 18.051 from GGU sample 225592. 4, ventral valve interior with well-developed propareas and collar, X 22. MGUH 18.052 from GGU sample 225592. 5, dorsal valve interior with weakly developed propareas and median plate, X 33. MGUH 18.053 from GGU sample 225592. 6, ventral valve fragment with very strongly developed triangular propareas, oblique interior view, X 44. MGUH 18.054 from GGU sample 225592. 7, oblique posterior view of ventral valve exterior with well-developed propareas that are scarcely visible from the outside, X 33. MGUH 18.055 from GGU sample 225592. 8, ventral propareas linked by strong collar, X 55. MGUH 18.056 from GGU sample 225592.
9–13. *Prototreta* sp. 9, ventral valve exterior, in stereo (a, b, X 16.5) and in oblique lateral profile (c, X 16.5). MGUH 18.057 from GGU sample 225535. 10, dorsal valve interior, stereo view (a, b, X 16.5). MGUH 18.058 from GGU sample 271414. 11, dorsal valve exterior, X 16.5. MGUH 18.059 from GGU sample 271414. 12, interior view of apical fragment of ventral valve showing pedicle opening, apical pits, and vascula lateralia (a, X 15.4), and detail of shell ultrastructure around apical process (b, X 110). MGUH 18.60 from GGU sample 225535. 13, oblique view into dorsal valve showing triangular profile of dorsal septum, X 16.5. MGUH 18.061 from GGU sample 271414.



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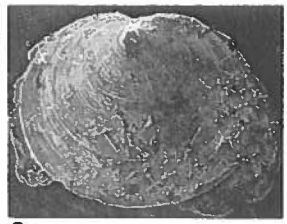
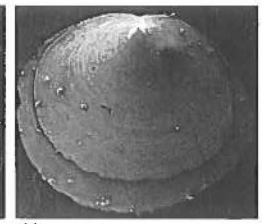


2a



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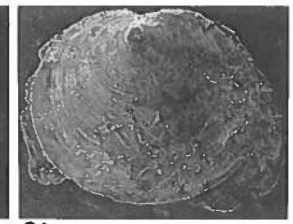

2b

3a

4a

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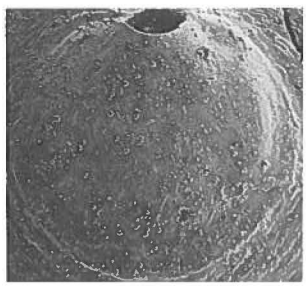
4b



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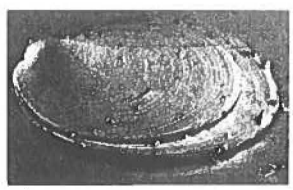

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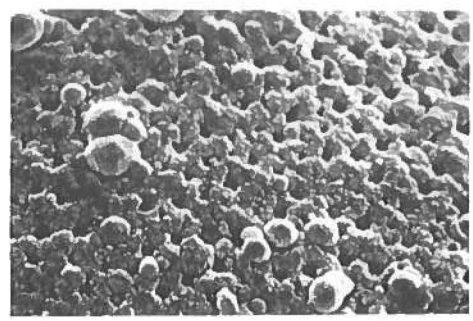

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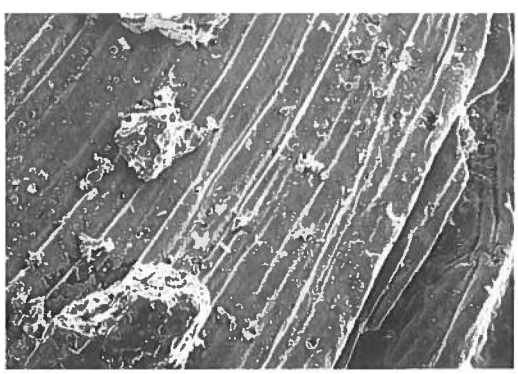
7



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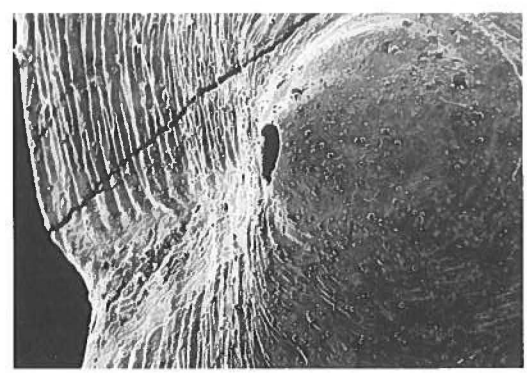

1g

271414. Very few of the valves are complete and unbroken.

Diagnosis. – *Anabolotreta* with subdued ornamentation. Ventral valve profile externally convex near beak, with concave anterior and lateral slopes. Dorsal valve with a variable low median ridge.

Description. – Shells about 20 percent wider than long, maximum width anterior of midline. Ornament of concentric growth lines and pronounced growth halts.

Ventral valve exterior convex near beak; anterior sector concave. Lateral portions of valve externally concave in anterior profile. Intertrough in procline pseudointerarea typically shallow, more rarely conspicuous. Beak with large circular, posteriorly-directed foramen. Ventral valve interior with low, anteriorly-broadening subtriangular apical process, grooved for approximately 60 percent of its length. Anterior margin of process well-defined; indistinct posterior margin abuts circular pedicle opening. Weakly impressed apical pits posterior to process. *Vascula media* between lobate cardinal muscle scars and apical process.

Dorsal valve predominantly convex, but posterolaterally flat to externally concave. Small triangular median plate, separating nearly imperceptible propareas. Subdued median ridge typically extends forward some 70 percent. Cardinal muscle scars suboval, in front of propareas. Anterior scars rarely preserved, but located anterolateral of median septum on low ridges.

Discussion. – *Anabolotreta groenlandica* differs from *Anabolotreta tegula* in its ventral exterior profile and also in the type of valve ornamentation. *A. tegula* is characterised by straight to slightly convex ventral anterior slopes, whereas the anterior and lateral slopes of *A. groenlandica* are decidedly concave. The well-developed exfoliation-type lamellae of *A. tegula* are not present in the new species, although shells of *A. groenlandica* may exhibit growth halts that resemble lamellae except that they are not undercut.

Occurrence. – *A. groenlandica* was obtained from limestones and limestone breccias throughout the fossiliferous part of the Holm Dal Formation.

## Genus *Picnotreta* Henderson & MacKinnon 1981

Type species. – *Picnotreta debilis* Henderson & MacKinnon 1981, pp. 304–305, fig. 9H-P; by original designation.

Remarks. – *Picnotreta* is a biconvex acrotretid genus characterised by having a strongly apsacline ventral valve with a pseudointerarea divided by a broadly triangular, externally concave median depression. The ventral beak is infilled with lamellose shell layers that are traversed by a very narrow pedicle tube. The apical process is variably developed and is typically more conspicuous in the type species than it is in undescribed North American forms that we would refer to the genus. The dorsal valve is morphologically less variable. The median plate of its pseudointerarea is weakly developed or absent, and is never supported by a median buttress. The median septum is a low triangular blade.

*Picnotreta* is most likely to be confused with *Acrothyra* Matthew 1901. Their dorsal valves are rather similar, but their ventral valves reveal clear differences; that of *Acrothyra* is linguloid in outline, and lacks the apical thickening found in *Picnotreta*. Because of the dorsal valve morphology, Henderson & MacKinnon (1981) referred *Picnotreta* to the Linnarssoniinae. We have followed them in the assignment, but with some reservations. If the genus is correctly placed, it is a relatively derived form and its lamellose apical thickening is seemingly an autapomorph.

*Picnotreta* has a wide geographical distribution. It occurs in Australia and New Zealand (Henderson & MacKinnon 1981) and has been questionably identified in northern Victoria Land, Antarctica, (Rowell et al. 1984). In North America, presently undescribed specimens in Rowell's collections show that it ranges from the middle Middle Cambrian to within a few metres of the base of the Upper Cambrian *Aphelaspis* Zone.

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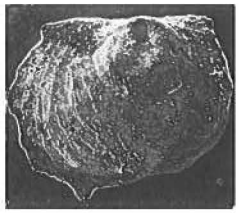
Fig. 13. *Anabolotreta groenlandica* n. sp.

1–7. *Anabolotreta groenlandica* n. sp. 1, holotype ventral valve exterior showing prominent lamellae, in stereo (a, b, X 11); c, ventral larval valve X 110; d, oblique lateral view X 13.2; e, corroded pits in ventral larval valve, X 2750; f, detail of valve ornament, X 330; g, oblique view of larval valve and intertrough, X 110. MGUH 18.062 from GGU sample 225592. 2, ventral valve exterior, in stereo (a, b, X 22). MGUH 18.063 from GGU sample 271414. 3, dorsal valve interior, in stereo (a, b, X 13.2). MGUH 18.064 from GGU sample 271414. 4, broken dorsal valve exterior, in stereo (a, b, X 11). MGUH 18.065 from GGU sample 271414. 5, oblique lateral view of ventral valve exterior, X 66. MGUH 18.066 from GGU sample 225540. 6, oblique view into apex of ventral valve fragment showing apical process and form of internal pedicle opening, X 44. MGUH 18.067 from GGU sample 271414. 7, *vascula lateralia* in ventral valve interior, X 11. MGUH 18.068 from GGU sample 225540.



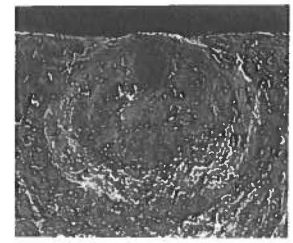
1a

2a

1b

2b

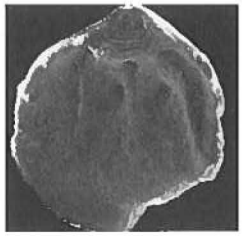
3



1c

4

5a

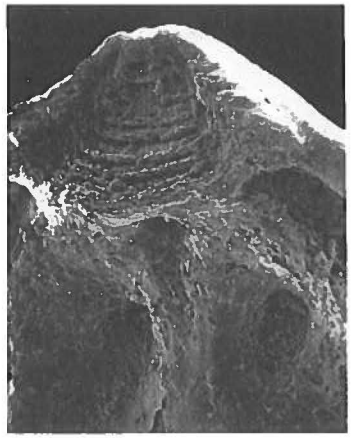


6a

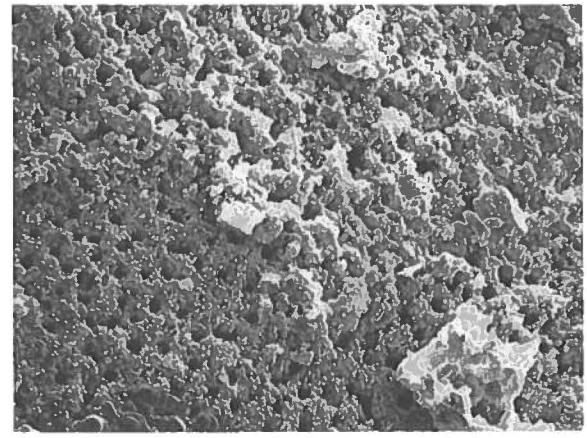
7a

6b

7b



6c



5b

## *Picnotreta* sp.

Fig. 14.4–7

Material. – Thirteen ventral valves and 3 dorsal valves from GGU sample 225535. Most of the specimens are fragmentary.

Remarks. – The Holm Dal material is very similar to specimens from the lower Upper Cambrian of the Great Basin of the western United States. It is not as well preserved, however, and consequently we are not creating a new taxon based upon it. The lamellose thickening of the beak is well developed and the thickening is traversed by a pedicle tube, whose internal opening lies immediately dorsal of the apical process (Fig. 14.6c). The apical process is considerably more subdued than that of *P. debilis*.

Occurrence. – *Picnotreta* sp. occurs near the base of the the Holm Dal Formation (Fig. 3). Three dorsal valves that are questionably referred to the genus were collected from near the top of the fossiliferous sequence.

Subfamily unassigned

## Genus *Rhondellina* Rowell 1986

Type species. – *Rhondellina dorei* Rowell 1986, pp. 1061–1063, figs 1–5; by original designation.

Remarks. – A dorsibiconvex shell, lanceolate apical process, and exceedingly short ventral pseudointerarea make this acrotretid morphologically very distinctive. Features of the dorsal valve suggest that the genus is a very derived member of the Linnarssoniinae. The unusual shell microstructure is clearly different from that of other acrotretids, but is seemingly an autapomorph. In the absence of more information on the distribution of the type of shell ultrastructure, we prefer to leave the genus without formal subfamilial allocation.

## *Rhondellina dorei* Rowell 1986

Fig. 14.1–3

1986 *Rhondellina dorei* – Rowell: 1061–1063, figs 1–5

Material. – Two ventral valves from GGU samples 225546 and 271414.

Remarks. – Although neither of the two known ventral valves is complete, they are almost identical to topotypic material from Nevada. The larval valve is slightly inflated and stands above the adjacent shell material. It completely encloses the pedicle foramen, which is continued anteriorly by a low groove (Fig. 14.1c). Internally, the lanceolate apical process extends forward from the internal pedicle opening as a low ridge. The shell microstructure is well preserved and shows the fine irregular ridges between inner shell lamellae that is characteristic of the taxon.

Occurrence. – *Rhondellina dorei* is very rare in limestones of the Holm Dal Formation (Figs 3, 5). In the United States, the species occurs in the *Crepicephalus* Zone, much higher stratigraphically than in Peary Land. Its presence in the Holm Dal Formation represents a significant downward extension of its range.

Family Curticiidae

## Genus *Curticia* Walcott 1905

Type species. – *Curticia elegantula* Walcott 1905, pp. 319–320; by original designation.

Remarks. – We are following Rowell & Bell's (1961) concept of the genus, which was strongly influenced by their work on *Curticia minuta* Bell 1944. The stratigraphic range of the type species is seemingly limited, but *C. minuta* occurs through the *Cedaria* and *Crepicephalus* zones of the western United States.

Fig. 14. *Rhondellina dorei* Rowell 1986 and *Picnotreta* sp.

1–3. *Rhondellina dorei* Rowell 1986. 1, ventral valve exterior, in stereo (a, b, X 38.5); c, larval valve with elongate foramen, X 88. MGUH 18.069 from GGU sample 225546. 2, incomplete ventral valve, stereo of interior view showing elongate apical process (a, b, X 24.2). MGUH 18.070 from GGU sample 271414. 3, ultrastructure of ventral valve showing fibrous radial lamellae, X 440. MGUH 18.070 from GGU sample 271414.
4–7. *Picnotreta* sp. 4, dorsal valve interior X 33. MGUH 18.071 from GGU sample 225535. 5, ventral valve exterior view, X 18.7, and corroded larval valve surface, X 1100. MGUH 18.072 from GGU sample 225535. 6, incomplete ventral valve, interior view in stereo (a, b, X 33); c, pseudointerarea, internal pedicle opening and apical pits, X 110. MGUH 18.073 from GGU sample 225535. 7, ventral valve interior, stereo view (a, b, X 22). MGUH 18.074 from GGU sample 225535.

## *Curticia minuta* Bell 1944

Fig. 12.1–8

1944 *Curticia minuta* – Bell in Lochman & Duncan: 145–146, pl. 18: 21–32
1961 *Curticia minuta* – Rowell & Bell: 928–929, pl. 104: 1–20

Material. – The species is abundant in GGU sample 225592 and also occurs in samples 225540, 225544, 225546, and 225595. The collections include about 200 specimens, but the majority are broken valves.

Remarks. – *Curticia minuta* is a small, ventribiconvex species of the genus; typically, it is only a third or less of the maximum size of the type species. In external shape, the Greenland material agrees closely with *C. minuta* described from its type area in Montana (Bell 1944, Rowell & Bell 1961). The species is unusually variable in its internal features. Rowell & Bell (1961) illustrated differences in development of the dorsal pseudointerarea from a single sample and discussed changes in the shape of the pedicle opening both during ontogeny and among comparably sized adults. The Greenland specimens differ from those in the Montana collections by having much smaller dorsal pseudointerarea: that shown in Fig. 12.1 is typical. The dorsal propareas are short, and although the intervening median plate is wide, it does not extend forward very far. The ventral propareas of the Holm Dal material are less variable than those from Montana but, nevertheless, there is a considerable diversity in them and in the shape of the pedicle opening. The external lateral margin of the pseudointerarea, and thus of the propareas, is well defined by an abrupt flexure of the shall material (Fig. 12.6). These margins intersect just below the beak of the ventral valve and bound an angle typically of about 120 degrees. The angle varies considerably between individuals, having an approximate range of 90 to 150 degrees. When viewed externally, the pedicle opening is triangular and bounded by these margins (Fig. 12.7); because of the apsacline inclination of the posterior margin, the propareas are scarcely visible in such a view. In commissural view, however, the propareas are seen to be basically triangular plates, inset in front of the pedicle opening and joined apically by a variably developed collar (Fig. 12.3, 6, 8). The plates are apsacline and typically ornamented by growth lines parallel to their dorsal margin.

Occurrence. – *C. minuta* occurs in limestones in the middle of the Holm Dal Formation (Figs 3, 6). These occurrences are among the oldest known for the taxon.

Order Paterinida
Superfamily Paterinacea
Family Paterinidae

## Genus *Micromitra* Meek 1873

Type species. – *Iphidea sculptilis* Meek 1873, p. 479; by original designation.

Remarks. – Systematic relations among the paterinids are still poorly understood and the group is in need of monographic treatment. We are using the concept of *Micromitra* in the sense of Rowell (1965) for relatively thick-shelled paterinids with strong concentric fila, with or without the development of a reticulate pattern formed by intersection of the fila with radial costellae. The genus ranges through much of the Middle and Upper Cambrian.

## *Micromitra* cf. *M. modesta* (Lochman 1940)

Fig. 9.6–8, 10

1940 *Paterina modesta* – Lochman: 14, pl. 1: 20–21
1940 *Micromitra paucicostellae* – Lochman: 14–15, p. 1: 23–24
1944 *Micromitra modesta* (Lochman) – Bell in Lochman & Duncan 1944: 144–145, pl. 18: 1–8, 18, 19
1960 *Micromitra modesta* (Lochman) – Lochman & Hu: 820, pl. 95: 37–40
1964 *Micromitra modesta* (Lochman) – Robison: 56, pl. 92: 1–4
1965 *Micromitra modesta* (Lochman) – Grant: 96, pl. 8: 3–4

Material. – The material consists of 10 small valves and several fragments from GGU samples 225532, 225546, and 225592.

Remarks. – The type material consists of valves that were mechanically extracted from the enclosing matrix and which are about twice the size of the Greenland specimens. The largest individuals from the Holm Dal Formation are just over 1 mm in length and are probably juveniles. In their gross shape and in the strong development of concentric ornament they resemble *M. modesta*, but differ from it in lacking a homeochilidium. Absence of this structure is characteristic of early developmental stages in other paterinids. The etched material reveals little of internal features except the pronounced shell thickening along the margins of the notothyrium (Fig. 9, 8). The early-formed larval shell bears two poorly defined nodes and is ornamented by a microreticulation that defines small shallow pits in the valve surface (Fig. 9.10). The latter feature has not been observed previously in paterinids and consequently its distribution within the order is unknown.

Occurrence. – *Micromitra* cf. *M. modesta* occurs sporadically throughout the fossiliferous part of the Holm Dal Formation (Figs 3, 6).

Order Lingulida
Superfamily Lingulacea
Family Obolidae

## Genus *Lingulella* Salter 1866

Type species. – *Lingula davisii* M'Coy 1851, pp. 405–406; by subsequent designation, Dall 1870, p. 159.

Remarks. – Although the number of available names for lingulacean genera has more than doubled since the last summary of the superfamily (Rowell 1965), the genus *Lingulella* remains a 'catch-all' name for elongate obolids. As Krause & Rowell (1975) have observed previously, it is relatively easy to see how the situation has arisen. With few exceptions, lingulaceans are externally rather featureless and only rarely do their shells possess complex internal structures. The type species of *Lingulella,* however, differs from many species that have been referred to the genus because the visceral area of both valves is strongly pitted (e.g. Rowell 1965, fig. 161: 3a,c,d). The functional significance of this pitting, if any, is unknown. It is developed in one of the three species found in the Holm Dal Formation. The most abundant species in the formation, here termed *Lingulella* sp. 1, lacks these pits and also differs in the structure of its pseudointerareas from typical *Lingulella.* It can be referred to the genus only by using a very broad generic concept. The available material, however, does not merit creation of a new taxon to receive it.

### *Lingulella* sp. 1

Fig. 15.1, 2, 5, 7

Material. – Approximately 200 specimens belonging to this form have been collected. The majority are from GGU sample 225592, but it occurs also in GGU samples 225540, 225542, 225544, 225547, 225593, 225595, 271403, 271414, and 271417.

Remarks. – This is the common lingulacean in the Holm Dal Formation. Individuals are moderately large with a maximum observed length of about 7 mm. When juvenile, shells are elongate suboval in commissural outline, but as adults they become subacuminate with rounded anterior margins. The shells are unusual in the family in that they are strongly biconvex and the ventral valve is only slightly longer than the dorsal one. Internally, the valves are rather featureless except for their pseudointerareas; these differ rather markedly from typical *Lingulella* but, to our knowledge, are unlike those of any described obolid. The dorsal propareas are narrowly triangular and are connected by a median plate that is approximately orthocline but lies slightly dorsal of the commissural margin and projects forward as a shelf (Fig. 15.2). Their ventral propareas are also approximately orthocline but, in the few specimens that preserve this part of the valve, they seemingly differ from typical *Lingulella* in that they are not connected by a pedicle groove (Fig. 15.5). This form occurs throughout the formation.

### *Lingulella* sp. 2

Fig. 15.4

Material. – Three incomplete valves from GGU sample 225535.

Remarks. – The preserved features of the valves are consistent with the material being *Lingulella* in its restricted usage. The visceral area of each valve is strongly pitted (Fig. 15.4); the dorsal propareas are approximately orthocline and are joined by a median plate that is depressed and adnate to the posterior inner surface of the dorsal valve.

### *Lingulella* sp. 3

Fig. 15.3, 6, 8.

Material. – Fourteen valves from GGU samples 225544, 225546, 271408, 271414, 315007, 315011, including the figured specimens.

Remarks. – In commissural outline, these valves are similar to those of *Lingulella* sp. 1 except that they are slightly wider and considerably less convex. The ventral pseudointerarea is unknown, but the dorsal pseudointerarea differs from that of *Lingulella* sp. 1 in possessing propareas and an adnate median plate; it is thus comparable to that of *Lingulella* in a restricted sense. The visceral areas of *Lingulella* sp. 3, however, lack pits. The species ranges throughout the Holm Dal Formation.

Acknowledgements
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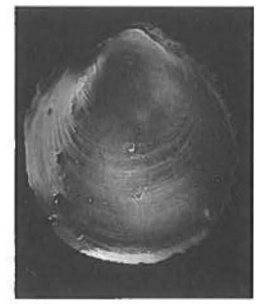
1a

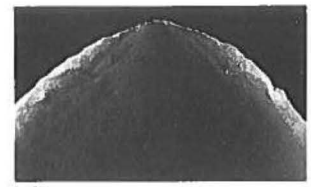
2a



1b

2b

3a

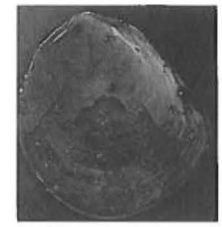


3b

4a

5a

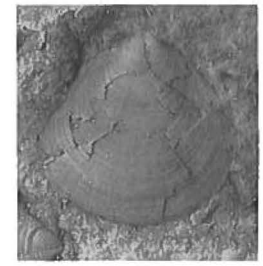
4b



5b

6

7a



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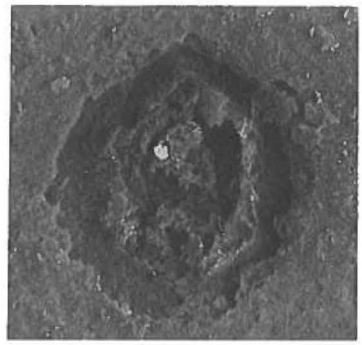

4c

7b

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Fig. 15. *Lingulella* spp. 1–3

1, 2, 5, 7. *Lingulella* sp. 1. 1, stereo view of articulated valves, dorsal valve uppermost (a, b, X 13.2). MGUH 18.075 from GGU sample 225592. 2, dorsal valve interior with shelf-like pseudointerarea, stereo view (a, b, X 11). MGUH 18.076 from GGU sample 225592. 5, ventral valve interior, stereo view (a, b, X 7.7). MGUH 18.077 from GGU sample 225592. 7, ventral valve exterior (a, X 13.2) and detail of valve ornament (b, X 88). MGUH 18.078 from GGU sample 225592.

4. *Lingulella* sp. 2. 4, interior of dorsal valve fragment, stereo view (a, b, X 12.1); c, detail of internal pit on visceral area X 220. MGUH 18.079 from GGU sample 225535.

3, 6, 8. *Lingulella* sp. 3. 3, dorsal valve propareas and low median ridge, stereo view (a, b, X 12.1). MGUH 18.080 from GGU sample 225544. 6, dorsal valve exterior, X 4.4. MGUH 18.081 from GGU sample 225594. 8, ventral valve exterior, X 3.9. MGUH 18.082 from GGU sample 225594.

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