Scale histology. The scales of *Thulolepis striaspina* gen. et sp. nov. have a typical thelodontid histology with straight or slightly curved dentine tubules passing directly into a central or slightly anterior pulp cavity (Fig. 18D–F). Some of the dentine tubules also radiate from each of the pulp canals which extend from the pulp cavity towards the postero-lateral crown spines. The converging tubules join and increase in thickness one or two times before they open into the pulp cavity. The outer layer of the crown, representing the initial cap, is proportionally thick with quite dense structure. In the neck area, towards the base, a few thicker longitudinal tubules are visible. The abundant growth lines are most clearly visible in central parts of the scales. The basal tissue is distinct with only a weak indication of tubules of Sharpey's fibres.

Scale dimensions. Length 0.1–0.4 mm; width 0.2–0.3 mm; height 0.1–0.2 mm.

Remarks. The small sample of scales of *Thulolepis striaspina* gen. et sp. nov. does not give a true picture of the proportion of scale types. Very few of the larger, presumed trunk, scales are found and there is not enough information to interpret the true squamation. The crown ornamentation of head and transitional scales is equivalent to *Thelodus admirabilis*, described by Märss (1982). *Thulolepis striaspina* gen. et sp. nov. differs notably by having a lateral wing or area on a slightly lower level and branched pulp canal.

Occurrence. Lochkovian, Monument, Hall Land, North Greenland.

Thelodontida indet.
Fig. 21B, C

Figured material. MGUH VP 3520 from GGU sample 319264 and MGUH VP 3521 from GGU sample 82737.

Locality and age. The Halls Grav and Monument localities, Hall Land, North Greenland, Chester Bjerg Formation, Late Silurian – Early Devonion (Pridoli–Lochkovian).

Remarks. These problematic scales show typical thelodontid characters, including a high distinct neck, robust base and a central pulp cavity. The rhomboidal or oval crown is flat and smooth, often with up to three pairs of smooth and wide lateral ridges and furrows running posteriorly with a steep angle from the neck. Scales of this type have been found growing together in pairs (Fig. 21C). They have a turiniid appearance but more material is required before their affinity can be assessed.

Occurrence. Pridoli–Lochkovian, Hall Land, North Greenland.

Heterostraci

Cyathaspidiformes indet.
Fig. 22A–F

1976 *Poraspis* sp.; Bendix-Almgreen, Fig. 443F.

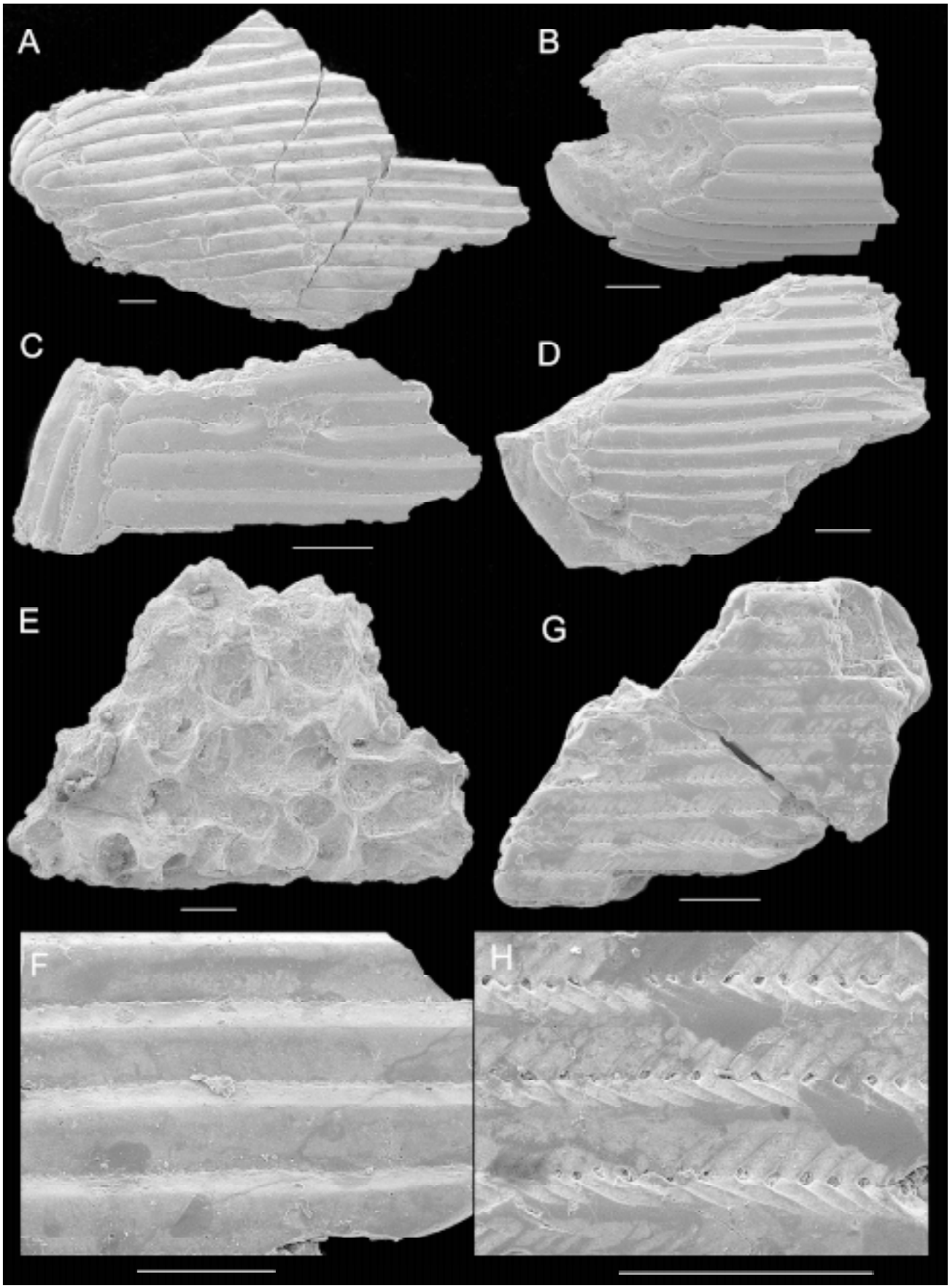
Figured material. MGUH VP 3522 from GGU sample 82737, MGUH VP 3523, 3524 from GGU sample 82738, MGUH VP 3525, 3526 from GGU sample 298937.

Other material. About 20 fragments of variable size and preservation from GGU samples 82736, 82737, 82738, 298937.

Locality and age. The Halls Grav locality, Hall Land, North Greenland, Chester Bjerg Formation, Late Silurian (Pridoli).

Description. Fragments of Cyathaspidiformes indet. are

Fig. 22. Indeterminate Cyathaspidiformes and Pteraspidiformes. SEM photomicrographs. Scale bars equal 0.2 mm.
A–**F**. Cyathaspidiformes indet. **A**: Fragment of antero-lateral part of head shield or branchial plate in upper view, MGUH VP 3522. **B**: Median dorsal trunk scale in upper view, MGUH VP 3523. **C**: Fragment of anterior part of head shield in upper view, MGUH VP 3524. **D**: Ventro-lateral? trunk scale in upper view, MGUH VP 3525. **E**: Fragment in visceral view, MGUH VP 3526. **F**: Fragment of antero-lateral part of head shield or branchial plate, close up of tubercles in upper view, MGUH VP 3522.
G, **H**. Pteraspidiformes indet. **G**: Fragment in upper view, MGUH VP 3527. **H**: Fragment in upper view, close up of tubercles, MGUH VP 3527.
MGUH VP 3522 from GGU sample 82737, Halls Grav; MGUH VP 3523, 3524 from GGU sample 82738, Halls Grav; MGUH VP 3525, 3526 from GGU sample 298937, Halls Grav; MGUH VP 3527 from GGU sample 319264, Monument.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relatively common and make up most of the larger fragments found in the processed samples. Several larger specimens from different broken parts of the main shield are found together with a few almost complete trunk scales. They show typical cyathaspidiform ornamentation with fine, about 7–10 per mm, tightly packed longitudinally arranged dentine ridges with a smooth upper surface and lateral margins (Fig. 22F). The dentine ridges are flat, round or even triangular in cross section, which may reflect from which part of the body they are derived or simple variation. In basal view, when the basal layer is broken, it is possible to see the cancellous layer with aspidine around large honeycomb-shaped cavities (Fig. 22E).

One specimen, MGUH VP 3522, is a fragment of the antero-lateral part of the ventral or dorsal shield, or the anterior of a branchial plate (Fig. 22A). The elongated dentine ridges bend inwards and meet anteriorly. They are tightly packed and are almost triangular in cross section, which gives the appearance of a median crest.

MGUH VP 3524 (Fig. 22C) is a small fragmental specimen from the rostral part of a dorsal shield or the anterior part of a ventral shield. It shows one group of fine longitudinal dentine ridges with two pores of the lateral line system disturbing their arrangement. The dentine ridges are smooth with flat, rounded or almost triangular cross section. Perpendicular at their anterior end are three transverse broken ridges with smooth, flat or slightly convex upper surfaces.

Trunk scales are found as median and ventro-lateral scales. One poorly preserved median dorsal scale is symmetrical and strongly curved, almost semicircular in cross section (Fig. 22B). It is about 1 mm long, but the posterior part is broken. On the outside, the scale is ornamented by fine, about 9 per mm, parallel longitudinal dentine ridges. They have a flat or rounded upper surface. Anteriorly, and closest to the midline, the ridges end earlier than the more lateral ones, forming a poorly preserved, anterior, triangular area free of longitudinal ridges. Smaller tubercles fill up at least the posterior part of this area. The most anterior part of the scale is rounded and free from dentine ornamentation. In basal view, the dorsal median scale is strongly concave.

One flat trunk scale of a probable ventro-lateral scale is broken, but indicates a rhomboidal outline. Anteriorly a narrow overlapping brim of basal tissue is free of dentine ornamentation (Fig. 22D). The main part of the scale has longitudinally arranged dentine ridges which are tightly packed and strongly parallel. Few, small, short or almost round transverse ridges or tubercles run between the overlapping brim and the longitudinal ridges, which are slightly rounded in cross section.

Remarks. These fragments show typical cyathaspidiform characters and can be compared with the exoskeleton of *Poraspis* Kiær 1930 and other poraspidids (Denison 1964; Blieck 1982), as also noted by Bendix-Almgreen (1976). The variation in ridge cross section, round, flat and V-shaped, may reflect both positional and taxonomical differences.

Occurrence. Pridoli, Halls Grav, Hall Land, North Greenland.

Pteraspidiformes indet.
Fig. 22G, H

Figured material. MGUH VP 3527 from GGU sample 319264.

Other material. One poorly preserved fragment from GGU sample 319264.

Locality and age. The top of Monument, Hall Land, North Greenland, Chester Bjerg Formation, Early Devonian (Lochkovian).

Description. Pteraspidiformes indet. is known from very few fragments found in the residues of the Chester Bjerg Formation, showing finely serrated ridge margins. They are best represented by a single specimen having a superficial layer of tightly packed, long, narrow dentine ridges and a thick layer of basal and middle tissue. The ridges are narrow, about 0.1 mm in width, but their total length is unknown since no fragments with complete ridges are found (Fig. 22F, H). They are longer, however, than 1 mm and probably extend along a large part of the not preserved full length of the head shields. The upper surface is flat and smooth except for some marginal ornamentation. Many small notches frequently disturb the lateral margins and bend dorso-posteriorly towards the median part. They are flanked by tiny processes or lobes which have short narrow ribs running parallel with anteriorly facing notches. Each tubercle is parallel with the next, forming pore-like holes where the notches, respectively the lobes, meet.

The rarity of material prohibited preparation of thin

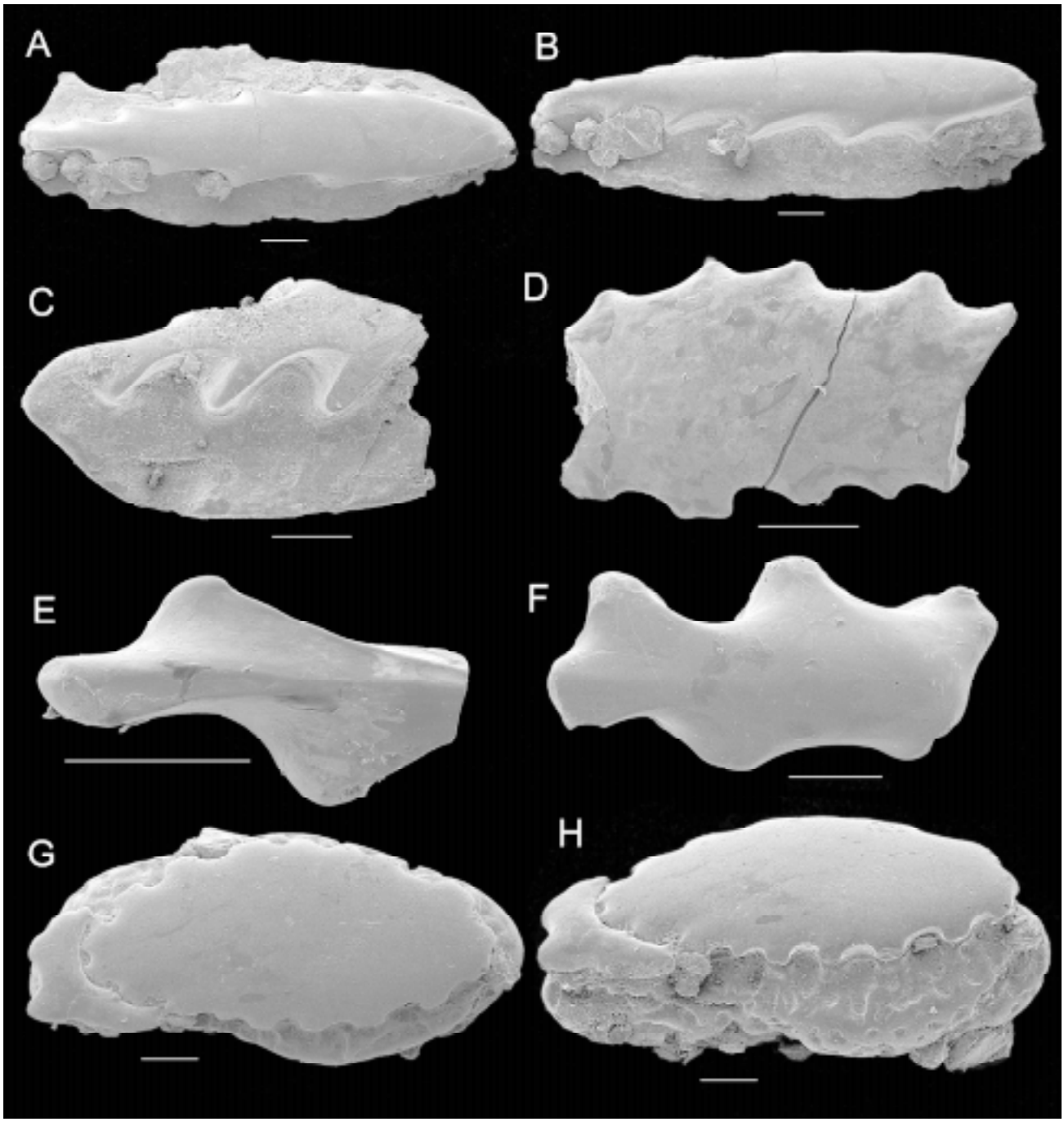

Fig. 23. Heterostraci indet. SEM photomicrographs. Scale bars equal 0.2 mm.

A–**C**. Heterostraci indet., type A. **A**: Fragment in upper view, MGUH VP 3528. **B**: Fragment in oblique upper view, MGUH VP 3528. **C**: Fragment in oblique upper view, MGUH VP 3529.

D: Heterostraci indet., type C. Tubercle in upper view, MGUH VP 3532.

E, **F**. Heterostraci indet., type B. **E**: Tubercle in upper view, MGUH VP 3530. **F**: Tubercle in upper view, MGUH VP 3531.

G, **H**. Heterostraci indet., type D. **G**: Fragment in upper view, MGUH VP 3533. **H**: Fragment in oblique upper view, MGUH VP 3533. MGUH VP 3528 from GGU sample 82738, Halls Grav; MGUH VP 3529, 3533 from GGU sample 82736, Halls Grav; MGUH VP 3530–3532 from GGU sample 319264, Monument.

sections, but available material shows a cancellar middle layer with large cavities.

Remarks. There are few detailed studies of pteraspidiform tubercles and the only figured form similar to the material under discussion is *Protopteraspis* Leriche 1924 (Blieck 1982).

Occurrence. Lochkovian, Monument, Hall Land, North Greenland.

Heterostraci indet., type A
Fig. 23A–C

Figured material. MGUH VP 3528 from GGU sample 82738, MGUH VP 3529 from GGU sample 82736.

Other material. A few fragments in bits and pieces from GGU samples 82736, 82737, 82738.

Locality and age. The Halls Grav locality, Hall Land, North Greenland, Chester Bjerg Formation, Late Silurian (Pridoli).

Description. This rare type is best known from MGUH VP 3528 which may represent a scale-like unit with a basal plate and a large elongated ridge (Fig. 23A, B). The basal plate is oval, more than 2 mm long and almost 1 mm maximum width. It has slightly uneven basal margins and edges, and no pores are visible, neither on the upper nor lower surface of the basal plate. The dentine ridges are almost as long as the base, having an elongated almost lacrymiform shape with its widest part posteriorly. The ridge is serrated with notches and intermediate rib-like barbs or processes. They all face anteriorly with a low angle, bending dorso-posteriorly towards the smooth, slightly convex median surface. Some units are much smaller, not exceeding 1 mm in length (Fig. 23C). Their ridges are usually narrower, higher and have more deeply serrated margins. The basal plate seems to be quite dense, but thin sections were not prepared.

Remarks. The main type of elongated, slightly lacrymiform, serrated ridges is similar to those described by Dineley & Loeffler (1976) within the family Traquairaspidae, part of the group of tessellated taxa which also includes *Weigeltaspis* Brotzen, 1933 and the Psammosteidae; all have serrated dentine ridges with anterior directed lateral processes (Tarlo 1964, 1965; Dineley & Loeffler 1976). The ridges differ, however, by having less pronounced lateral projections and notably by the indication of being part of a scale-like unit, represented by an oval basal plate. Such scale-like units and serrated margins are typical for *Lepidaspis* Dineley & Loeffler 1976 known from the Lower Devonian of the Canadian Arctic (Dineley & Loeffler 1976) and Spitsbergen (Blieck 1982). However, *Lepidaspis* differs by having deeper notches and most importantly, by having pore openings on the upper surfaces of the basal plate. Moreover, the shape of the ridges of *Lepidaspis* is usually not lacrymiform. The second, smaller, type is morphologically more similar to *Lepidaspis* but its rarity and poor preservation preclude further taxonomic treatment.

Occurrence. Pridoli, Halls Grav, Hall Land, North Greenland.

Heterostraci indet., type B
Fig. 23E, F

Figured material. MGUH VP 3530, 3531 from GGU sample 319264.

Other material. A few badly preserved specimens from the same collection.

Locality and age. The top of Monument, Hall Land, North Greenland, Chester Bjerg Formation, Early Devonian (Lochkovian).

Description. These fragments of large elongated oak leaf-like dentine ridges are never longer than 1 mm. Although the dentine is well preserved, complete ridges of full length have not been found. They usually lack all traces of the basal tissue, but when present this shows a complicated spongy tissue in the middle layer. The ridge is dark and very shiny with a high, very convex upper surface. They are slightly wider posteriorly and have smooth rounded indentations or notches in the lateral margins which bend smoothly up towards an imaginary midline on the convex upper surface. They, as well as the intermediate processes, are all oriented to face with a low angle to the anterior. This angle is larger for the notches in the posterior part and decreases towards the anterior. At the narrower end the last indentation, flanked by one pair of semiparallel processes, faces anteriorly.

A few very small and badly preserved ridges with

similar morphology are also found. They may represent different stage of development or may be interstitial ridges.

Remarks. The tubercles and the spongy middle parts of Heterostraci indet. type B resemble fragments described and referred to as *Traquairaspis* sp. indet. by Gross (1961). The U-shaped indentations of Heterostraci indet., type B are oriented, however, to face more to the anterior than those of *Traquairaspis* sp. indet. Such orientation is also more common among *Weigeltaspis*, *Lepidaspis*, *Tesseraspis* Wills 1935 and other traquairaspids different from Gross' (1961) *Traquairaspis* sp. indet. All these taxa can easily be confused with each other in fragmentary condition. Gross (1961) did not report any interstitial ridges like those found in traquairaspids from the Canadian Arctic by Dineley & Loeffler (1976). The presence of interstitial ridges in Heterostraci indet., type B is only speculative and based on the presence of a few smaller fragments of similar type.

Occurrence. Lochkovian, Monument, Hall Land, North Greenland.

Heterostraci indet., type C
Fig. 23D

Figured material. MGUH VP 3532 from GGU sample 319264.

Other material. A few badly preserved specimens from GGU samples 82736, 82738 and 319264.

Locality and age. The Halls Grav and Monument localities, Hall Land, North Greenland, Chester Bjerg Formation, Late Silurian – Early Devonian (Pridoli–Lochkovian).

Description. This rare type of low and wide ridge has a smooth flat or weakly convex upper surface. This type is only found as small isolated broken pieces which do not exceed 1 mm in length. These ridges are almost 0.5 mm wide and the lateral margins are serrated, with shallow U-shaped indentations of variable width between small sharp lateral processes which, in the central regions, have no clear orientation. The processes are sometimes weakly bi-lobed. Basal tissue is not preserved, but some fragments indicate a spongy middle layer.

Remarks. In size and state of preservation this type resembles Heterostraci indet., type B. In type C, however, the ridges are much lower, flatter and with less well oriented lateral processes and notches. Traquairaspids from the Canadian Arctic show considerable variability of tubercles within the same taxon (Dineley & Loeffler 1976), suggesting a close relation between Heterostraci indet., types B and C. Also *Strosipherus* may have ridges of this type (Märss 1986a).

Occurrence. Pridoli–Lochkovian, Hall Land, North Greenland.

Heterostraci indet., type D
Fig. 23G, H

Figured material. MGUH VP 3533 from GGU sample 82736.

Other material. About ten fragments of variable size and preservation from GGU samples 82736 and 82738.

Locality and age. The Halls Grav locality, Hall Land, North Greenland, Chester Bjerg Formation, Late Silurian (Pridoli).

Description. This type is best represented by specimen MGUH VP 3533, which has a large oval main ridge with serrated margins and small irregular ridges draping the anterior margin. The characteristic main ridge is about 1.5 mm long and 1 mm wide and it has a smooth, flat or slightly convex upper surface. Along the lateral margins are notches, with shallow indentations separated by lateral processes, the latter with slightly radial orientation. The preserved basal tissue is quite thick, approximately 70% of the thickness of the whole fragment, and it exposes a spongy middle layer. Anteriorly, a much smaller irregular ridge has a smooth flat upper surface. Its posterior margin follows the anterior outline of the main ridge and has a smoothly irregular or notched anterior margin.

Remarks. This type of oval and irregular interstitial ridges resembles those found on the central areas of the ventral shield of ?*Traquairaspis* cf. *T. postulata* and related taxa from the Late Silurian of the North West Territories, Canada (Dineley & Loeffler 1976). The flat upper surface is also similar to Heterostraci indet., type C, a comparison supported by some variability among both types.

Occurrence. Priodi, Halls Grav, Hall Land, North Greenland.

Heterostraci indet., type E
Fig. 24

1976 *Oniscolepis*? sp. – Bendix-Almgreen, fig. 443 B–E.

Figured material. MGUH VP 3534, 3539, 3540 from GGU sample 319264, MGUH VP 3535–3537 from GGU sample 82738, MGUH VP 3538 from GGU sample 82736.

Other material. About 100 fragments of variable size and preservation from GGU samples 82734, 82736, 82737, 82738, 298937, 298953 and 319264.

Locality and age. The Halls Grav and Monument localities, Hall Land, North Greenland, Chester Bjerg Formation, Late Silurian – Early Devonian (Pridoli–Lochkovian).

Description. The most common type of heterostracan fragment in the fauna of the Chester Bjerg Formation is included here. No complete head shields have been found, but ridges and several almost complete trunk scales indicate a pteraspidiform or related form. Although the characteristic ridges sometimes are notably different they are kept within the same taxa by their similar general morphology and because they sometimes are attached to the same basal plate. Another important character, common for all forms within this type, is the basal tissue which is composed of spongy aspidine.

One small, isolated ridge has very little of the spongy basal tissue preserved. It has a flat upper surface and deep sub-circular marginal notches, and apparent alignment of the intervening processes (Fig. 24A). The intervening processes are angular, irregular and sometimes weakly bi-lobed. This type of ridge is usually curved, suggesting an anterior position where it drapes the anterior end of more longitudinal ridges.

A larger ridge type with a smooth upper surface also has a slightly curved outline and less pronounced notches. This type of ridge is probably from the marginal part of the main shields; it is less curved than the previous one and sometimes flanks longer and more ornamented ridges (Fig. 24D, H). Similar shorter, but irregular, ridges with a smooth upper surface and marginal notches, clearly drape the anterior part of the longitudinal ridges, indicating that smoother intermediate forms are found in the marginal and anterior parts of the head shield (Fig. 24C, D). These ridges are commonly more curved and irregular than the longitudinal ridges and serve to fill up the space between the straight and more ornamented ridges.

Ridges with more pronounced ornamentation may reach about 1 mm in length and are characterized by having a median crest or rib running longitudinally along the whole length (Fig. 24B–G). The lateral notches bend up towards the upper surface with a more hydrodynamic and posterior orientation. An intervening smooth process or lobe is developed between each notch and a narrow rib extends dorsoposteriorly from the process towards the median part of the tubercle. The anterior end of the ridge is rounded and flanked by a pair of posteriorly pointing notches. Together with the more pointed posterior end this contrives to give the ridge an oak-leaf appearance.

The more sculptured types of ridges with a median crest and oriented lateral serration, vary both in size and the expression of ornamentation. One of these types, which is often flanked by the more elongated smooth ridges (Fig. 24B, D), is slender and relatively smoother while another with the same proportions has a quite sharp median crest and deeper lateral notches (Fig. 24F). The variation among the intervening processes and their ribs, usually follows the expression and the orientation of the notches. Sometimes the small ribs of the lateral lobes almost meet and merge with the upper median crest.

Larger fragments representing trunk scales have proportionally wider ridges with well pronounced sculpture, emphasizing the oak-leaf appearance (Fig. 24E, G). In these, the notches and intervening processes

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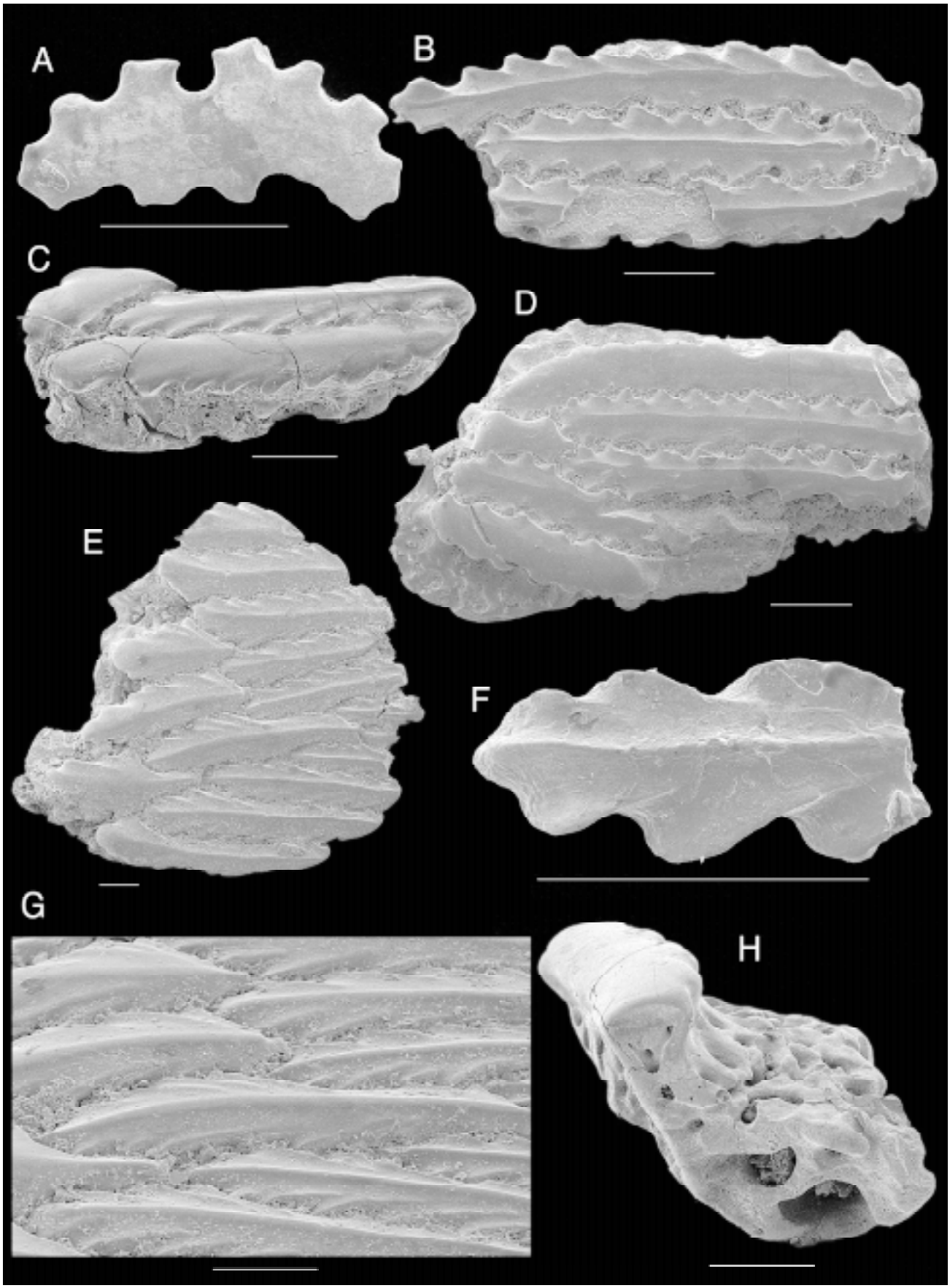
Fig. 24. Heterostraci indet., type E. SEM photomicrographs. Scale bars equal 0.2 mm.
A: Tubercle in upper view, MGUH VP 3534. **B**: Fragment in upper view, MGUH VP 3535. **C**: Fragment in oblique upper view, MGUH VP 3536. **D**: Fragment in upper view, MGUH VP 3537. **E**: Trunk scale in upper view, MGUH VP 3538. **F**: Tubercle in upper view, MGUH VP 3539. **G**: Trunk scale in oblique crown view, close up of tubercles, MGUH VP 3538. **H**: Fragment seen from the broken edge, MGUH VP 3540.
MGUH VP 3534, 3539, 3540 from GGU sample 319264, Monument; MGUH VP 3535–3537 from GGU sample 82738, Halls Grav; MGUH VP 3538 from GGU sample 82736, Halls Grav.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with ribs extend quite far posteriorly towards the upper surface and its rounded median crest.

Remarks. Bendix-Almgreen (1976, fig. 443B–E) figured as *Oniscolepis*? sp. specimens of this type from samples at the Halls Grav locality; they are similar to *Oniscolepis* sp. indet. of Gross (1961). Fragments of this type from the Baltic region were originally described by Pander (1856) as several different species, but they have been grouped into two genera, *Oniscolepis* and *Strosipherus* (Rohon 1893; Gross 1947, 1961; Tarlo 1965; Märss 1986a). Although the variation within these forms is quite large, they have been regarded as synonyms. The European and the North Greenland forms have similar leaf-like ridges and a spongy middle layer of the basal tissue. However, they are not identical since the ridge ornamentation is more pronounced in the North Greenland forms. Variation in this type of ridge from the Chester Bjerg Formation may reflect both positional and taxonomical differences, but this cannot be verified on the basis of available material. The first type of ridge found within Heterostraci indet., type E is similar to the much larger secondary ridges of *Lepidaspis serrata* from the North West Territories, Canada, described by Dineley & Loeffler (1976), but the difference in size and the other types of tubercle clearly exclude this group from *Lepidaspis*.

Also *Miltaspis* Blieck 1981 and *Corvaspis* Woodward 1934 sometimes show similarities with the material under discussion (Blieck 1982).

Occurrence. Pridoli–Lochkovian, Hall Land, North Greenland.

Anaspida

Anaspida indet.

Figs 25, 26

Figured material. MGUH VP 3541–3543 from GGU sample 319264, MGUH VP 3544 from GGU sample 82736, MGUH VP 3545, 3546 from GGU sample 82738.

Other material. About 50 fragments of variable preservation and size from GGU samples 82734, 82736, 82738, 298937 and 319264.

Locality and age. The Halls Grav and Monument localities, Hall Land, North Greenland, Chester Bjerg Formation, Late Silurian – Early Devonian (Pridoli–Lochkovian).

Description. Anaspid fragments are represented within the Chester Bjerg Formation by fragments of small elongate trunk scales with similar sculpture (Fig. 25). Most scales are broken, with a maximum preserved size of about 1.5 mm in width and 1 mm in length (Fig. 25B). They are characterized in crown view by coarse elongated tubercles, some of which are almost drop-shaped and clearly separated from each other. Some specimens also have small round tubercles between the larger elongated ones (Fig. 25B). The sculptured area covers more than half of the posterior scale part, and lies on a higher level than the smooth anterior. The slightly concave anterior region bends up towards the posterior sculptured part. This anterior region is overlapped by the posterior part of the previous scale when the scales are articulated. Circular pores occur on the upper surface between the tubercles. The whole scale is almost rectangular with one end slightly narrower having an extension or process for attachment when articulated. In basal view, the scales are characterized by one large smooth longitudinal median rib which is almost square in cross section (Fig. 25E). The rib widens and becomes lower before merging with the main visceral surface at the end opposite to the attachment process. At the other end the rib becomes narrower, forming the main part of the process for attachment.

A second scale type has a smoother transition from the anterior overlapping area to the posterior sculptured part. A wide and low longitudinal median rib is developed in the junction between these two areas (Fig. 25A). This type lacks the pores on the upper surface seen in the first type, but the sculpture is otherwise almost identical.

A fragment of a scale or most likely a plate, differs from the previous one by having tubercles that are almost grown together, forming long irregularly shaped ridges (Fig. 25C). It also has a flatter and smoother visceral side.

Due to the poor preservation and the lack of material, only remnants of tubules of Sharpey's fibres and radial fibres in the basal central rib have been observed (Fig. 26).

Remarks. Articulated material of anaspids from Scotland and Norway rarely shows the microscopic ornamentation of the scales and the plates (Kiær 1924; Stetson 1928). This ornamentation could be a good basis for scale taxonomy, but detailed studies of anaspid exoskeletal elements and their sculpture have previously only been made by Gross (1938, 1958, 1968), Märss (1986a) and Fredholm (1988, 1990). The forms

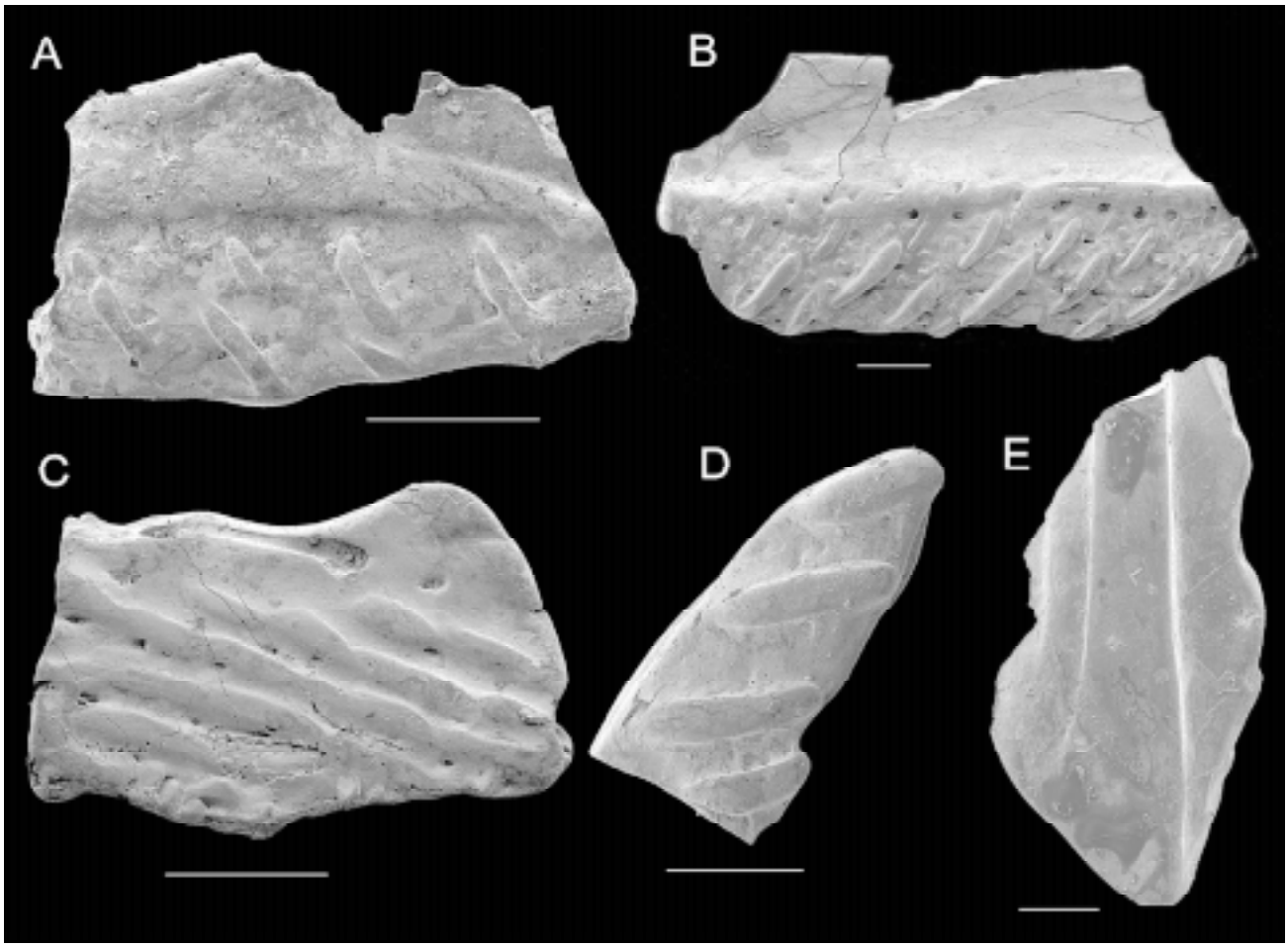


Fig. 25. Anaspida indet. SEM photomicrographs. Scale bars equal 0.2 mm.
A: Scale fragment in upper view, MGUH VP 3544. **B**: Scale fragment in upper view, MGUH VP 3541. **C**: Plate fragment in upper view, MGUH VP 3542. **D**: Scale fragment in upper view, MGUH VP 3545. **E**: Scale fragment in visceral view, MGUH VP 3543. MGUH VP 3541–3543 from GGU sample 319264, Monument; MGUH VP 3544 from GGU sample 82736, Halls Grav; MGUH VP 3545 from GGU sample 82738, Halls Grav.

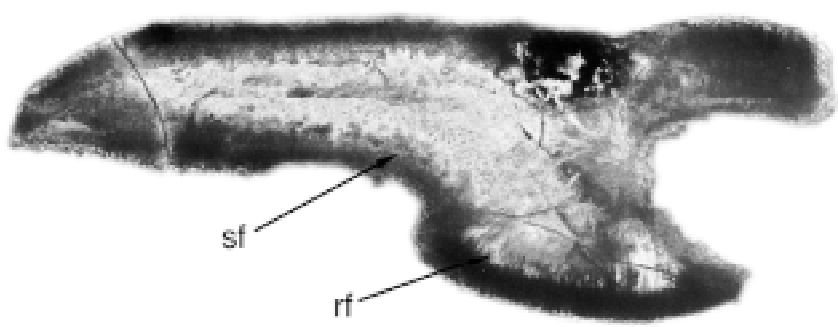


Fig. 26. Anaspida indet. Vertical antero-posterior thin section, MGUH VP 3546 from GGU sample 82738, Halls Grav, × 221.
rf: tubules for radial fibres; **sf**: tubules for Sharpey's fibres.

recovered from the Chester Bjerg Formation bear little resemblance to these Baltic forms.

Occurrence. Pridoli–Lochkovian, Hall Land, North Greenland.

Osteostraci

Osteostraci indet.

Fig. 27A, B, D–J

Figured material. MGUH VP 3548 from GGU sample 319264, MGUH VP 3549 from GGU sample 82736, MGUH VP 3550–3553 from GGU sample 82738.

Locality and age. The Halls Grav and Monument localities, Hall Land, North Greenland, Chester Bjerg Formation, Late Silurian – Early Devonian (Pridoli–Lochkovian).

Other material. About 50 fragments from GGU sample 82736 and 82738.

Description. A few shield fragments and trunk scales show similar ornamental features without any elevated tubercles. Shield fragments are poorly preserved and only reach a size of about 1 mm (Fig. 27E–J). Better preserved trunk scales reach about 1.5 mm in length (Fig. 27A, B, D). The upper surface of the shield fragments is flat and smooth with predominantly regular rows of large pore openings. Some specimens show that this surface is composed of welded individual elongated units of the superficial layer, separated by pores and combining superficial tissue (Fig. 27I). Cavities of the vascular system are visible at the broken edges.

The scales are also poorly preserved, but show the same general crown morphology with a smooth upper surface perforated by large pore openings (Fig. 27A, B). In crown view, the scales are rhomboidal. The surface is concave and bends down anteriorly towards the distinct base. A distinct neck is visible anteriorly as a shallow furrow, both on the lateral crown wall and the base. The base is low with a broad rounded brim and projects out anteriorly.

In basal view, the visceral surface of the scales and shield varies from smooth to bumpy and concave to convex, with a few round openings (Fig. 27D). The tissue often has a reticulate structure in visceral view, which is common in osteostracans.

Visible morphological structures at the broken edges may indicate a superficial layer of dentine-like tissue, a middle layer of spongy bone and a basal layer of laminar bone.

Remarks. Dermal ornamentation of osteostracans is little studied and the material under discussion can only be compared with fragments that Gross (1961) referred to as *Zenaspis* ? sp. indet. from erratics in north Germany. Several specimens of the latter differ by showing clear individual elongated units rather than a continuous smooth upper surface. However, this ornamentation, composed of a smooth superficial layer pierced by pores, is found in many different groups of osteostracans and it is not diagnostic of *Zenaspis*. Osteostraci indet. may be more similar to the non-cornuate osteostracan *Hemicyclaspis* (P. Janvier, personal communication 1999).

Occurrence. Pridoli–Lochkovian, Hall Land, North Greenland.

Osteostraci? indet.

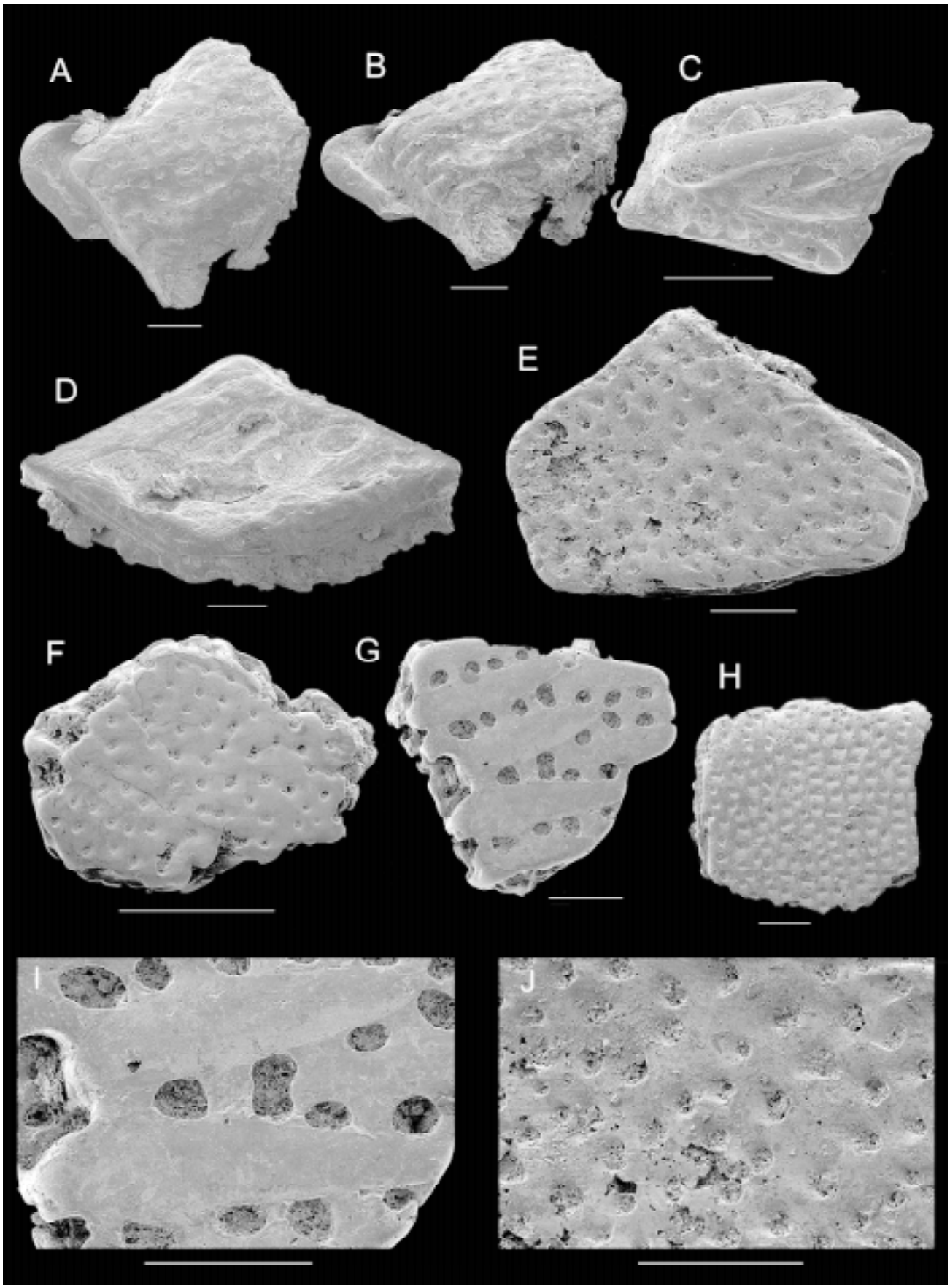
Fig. 27C

Figured material. MGUH VP 3547 from GGU sample 319264.

Other material. One specimen from GGU sample 82738.

Locality and age. The Halls Grav and Monument lo-

Fig. 27. Osteostraci indet. and Osteostraci? indet. SEM photomicrographs. Scale bars equal 0.2 mm.
A, **B**, **D**–**J**. Osteostraci indet. **A**: Trunk scale in crown view, MGUH VP 3550. **B**: Trunk scale in oblique crown view, MGUH VP 3550. **D**: Trunk scale in basal view, MGUH VP 3551. **E**: Shield fragment in external view, MGUH VP 3549. **F**: Shield fragment in external view, MGUH VP 3548. **G**: Shield fragment in external view, MGUH VP 3552. **H**: Shield fragment in external view, MGUH VP 3553. **I**: Shield fragment in external view, close up on surface, MGUH VP 3552. **J**: Shield fragment in external view, close up on surface, MGUH VP 3549.
C: Osteostraci? indet. Trunk scale in oblique crown view, MGUH VP 3547.
MGUH VP 3547, 3548 from GGU sample 319264, Monument; MGUH VP 3549 from GGU sample 82736, Halls Grav; MGUH VP 3550–3553 from GGU sample 82738, Halls Grav.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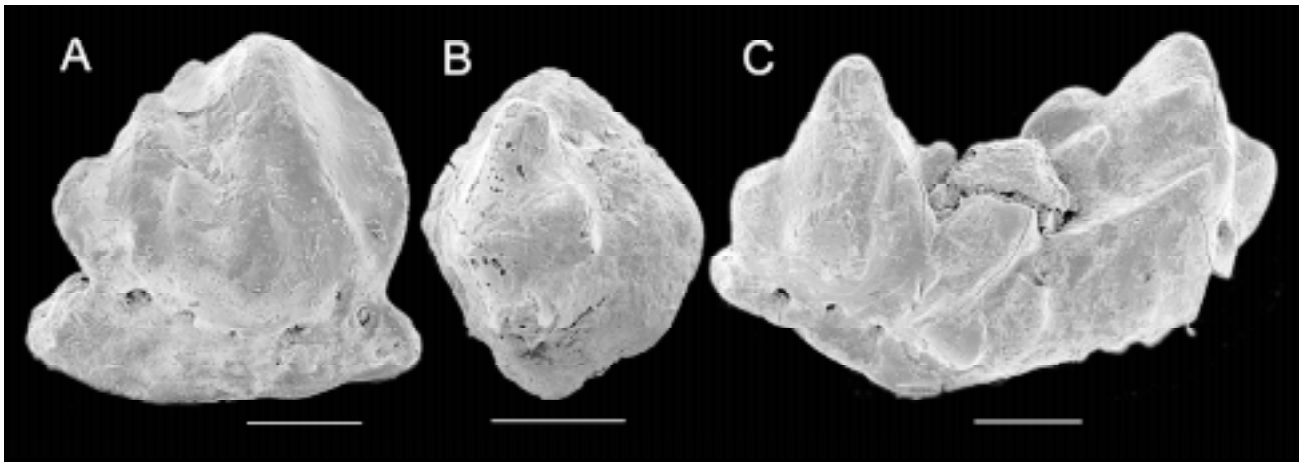


Fig. 28. Chondrichthyes indet. SEM photomicrographs. Scale bars equal 0.1 mm.
A: Unit with three odontodes in anterior view, MGUH VP 3554. **B**: Single odontode in crown view, MGUH VP 3555. **C**: Unit with many odontodes in oblique crown view, MGUH VP 3556.
All specimens from GGU sample 319264, Monument.

calities, Hall Land, North Greenland, Chester Bjerg Formation, Late Silurian – Early Devonian, (Pridoli–Lochkovian).

Description. This second type is completely different from the more common Osteostraci indet. and is only represented by two rhomboidal scales with elevated elongated tubercles, which are slightly wider in the anterior part (Fig. 27C). Each scale has three tubercles, one longer median and two shorter lateral. The basal part follows the general morphology of the scale and does not show any specialization. No clear neck is developed, but in crown view the anteriorly attached scale has a tubercle-free anterior area for overlap by the previous scale. In basal view the scale is concave with a bumpy surface.

The scarcity of present material prohibits histological investigation.

Occurrence. Pridoli–Lochkovian, Hall Land, North Greenland.

Chondrichthyes

Chondrichthyes indet.

Fig. 28

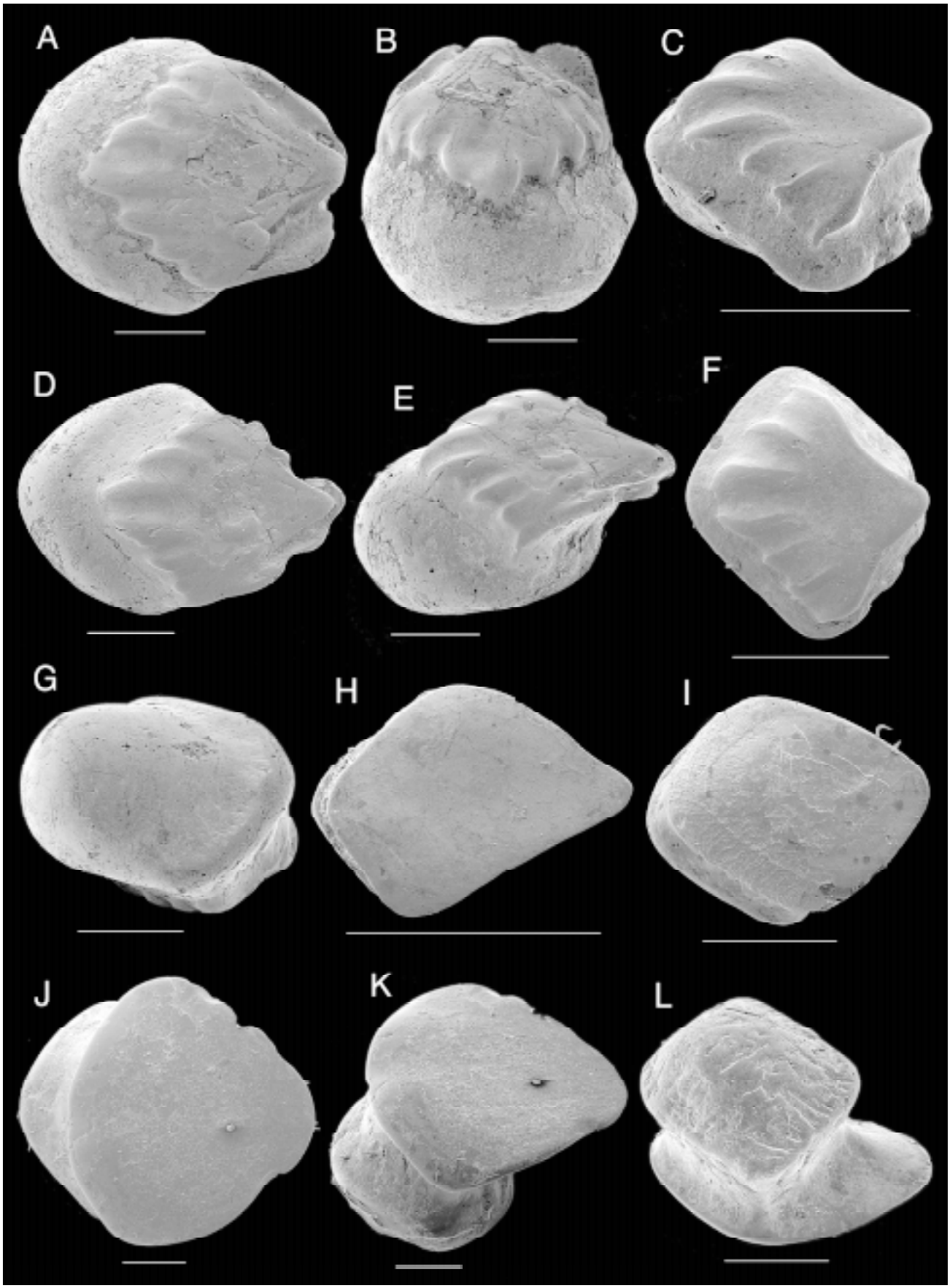
Figured material. MGUH VP 3554–3556 from GGU sample 319264.

Other material. Few poorly preserved specimens from GGU sample 319264.

Locality and age. The top of Monument, Hall Land, North Greenland, Chester Bjerg Formation, Early Devonian (Lochkovian).

Description. Chondrichthyes indet. includes odontodes which are found isolated or grown together to larger units (Fig. 28). Each odontode is very small and the largest unit, including about 5 variable sized scales, does not exceed 0.5 mm. Isolated odontodes have a round or slightly rhomboidal base (Fig. 28B). The base is low and in basal view either flat, concave or convex, sometimes exposing a tiny pulp opening. A high

Fig. 29. *Nostolepis* and *Gomphonchus*. SEM photomicrographs. Scale bars equal 0.2 mm.
A–**G**. *Nostolepis halli* sp. nov. **A**: Scale in crown view, holotype, MGUH VP 3567. **B**: Scale in anterior view, holotype, MGUH VP 3567. **C**: Scale in oblique crown view, MGUH VP 3568. **D**: Scale in crown view, MGUH VP 3569. **E**: Scale in oblique crown view, MGUH VP 3569. **F**: Scale in crown view, MGUH VP 3568. **G**: Scale in oblique basal view, MGUH VP 3570.
H–**L**. *Gomphonchus* cf. *G. sandelensis*. **H**: Scale in crown view, MGUH VP 3563. **I**: Scale in crown view, MGUH VP 3562. **J**: Scale in crown view, MGUH VP 3564. **K**: Scale in oblique crown view, MGUH VP 3564. **L**: Scale in oblique basal view, MGUH VP 3565.
MGUH VP 3562 from GGU sample 319264, Monument; MGUH VP 3563–3565, 3567–3570 from GGU sample 82738, Halls Grav.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inclination characterizes the tri-partite crown, which has the shape of a three-cusped tooth. A narrow and smooth median section is flanked by two wide, but shorter, lateral wings. The crown narrows towards the base, forming a short but pronounced neck. Several large canal openings perforate the neck on both sides. When the scales are grown together, differentiation of the base is not visible, and only the different crown units are seen. One well preserved specimen shows a group of three scales with welded bases (Fig. 28A). The main part is formed by a large scale, with two smaller scales growing on the anterior part. Another specimen shows a row of overlapping scales of different sizes with several large neck canal openings on both the anterior and posterior side (Fig. 28C).

Remarks. Since few scales were available, histological investigations were not made. Chondrichthyes indet. may be a growing polyodontodia of *Ctenacanthus* type in the scheme of Karatajute-Talimaa (1992).

Some vertebrate remains of unknown origin, treated under Incertae Sedis may also be comparable with true chondrichthyans (Fig. 43D, H, J).

Occurrence. Lochkovian, Monument, Hall Land, North Greenland.

Acanthodii

Order Climatiida Berg 1940
Family Climatiidae Berg 1940

Genus *Nostolepis* Pander 1856

Type species. *Nostolepis striata* Pander 1856, Late Silurian (Pridoli), Ohesaare Formation, Saaremaa, Estonia.

Diagnosis. Small and large scales with smoothly downbent anterior part of crown; neck less pronounced in anterior part; crown anteriorly ornamented by posteriorly converging or parallel strongly expressed ridges and ribs; superpositional growth with simple mesodentine in crown and irregular branching tubules rising from radial, circular and ascending vascular canals; cellular bone in base usually with numerous cell cavities.

Species content. *Nostolepis striata* Pander 1856; *N. alta* Märss 1986a; *N. applicata* Vieth 1980; *N. arctica* Vieth 1980; *N. athleta* Valiukevicius 1994; *N. costata* Goujet 1976; *N. curiosa* Valiukevicius 1994; *N. curta* Valiukevicius 1994; *N. gaujensis* Valiukevicius 1998; *N. gracilis* Gross 1947; *N. guangxiensis* Wang Nian-zhong 1992; *N. infida* Valiukevicius 1994; *N. kernavensis* Valiukevicius 1985; *N. lacrima* Valiukevicius 1994; *N. laticristata* Valiukevicius 1994; *N. matukhini* Valiukevicius 1994; *N. minima* Valiukevicius 1994; *N. multangula* Valiukevicius 1994; *N. multicostata* Vieth 1980; *N. robusta* (Brotzen 1934); *N. spina* Valiukevicius 1994; *N. taimyrica* Valiukevicius 1994; *N. tareyensis* Valiukevicius 1994; *N. tcherkesovae* Valiukevicius 1994.

Range. Early Silurian (Wenlock) – Middle Devonian (Eifelian).

Nostolepis halli sp. nov.

Fig. 29A–G; Fig. 30

Derivation of name. In honour of Charles Francis Hall, the leader of the U.S. North Polar Expedition 1871–73, who died and was buried in Hall Land. Also referring to the main fossil locality close to his grave.

Holotype. MGUH VP 3567 from GGU sample 82738 (Fig. 29A, B).

Figured material. MGUH VP 3567–3571, 3631 from GGU sample 82738.

Other material. About 60 scales from GGU samples 82734, 82736, 82737, 82738 and 298937.

Locality and age. The Halls Grav locality, Hall Land, North Greenland, Chester Bjerg Formation, Late Silurian (Pridoli).

Diagnosis. Homogeneous set of medium-sized scales, about 1 mm, with low rhomboidal crown, bent down anteriorly towards base and anteriorly diffuse neck; crown smoothly ridged anteriorly with intermediate furrows; lateral wings folded up; large convex base, displaced anteriorly, with lower posterior part; mesodentine tissue in crown with irregular branching tubules; cellular bone in base with few osteocyte cavities and process tubules.

Scale morphology. Like the other acanthodians, the scales of *Nostolepis halli* sp. nov. are quite poorly preserved. They are brown-yellow to dark brown, medium sized and vary in length from about 0.5–1 mm.