Silurian trilobites from the G. B. Schley Fjord region, eastern Peary Land, North Greenland

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A trilobite fauna of *Pterospathodus celloni* Biozone age (late Llandovery) is described from a horizon near the top of the Odins Fjord Formation. The commonest trilobite is the phacopid *Acernaspis* sp., with which are associated the proetid *Cyphoproetus*? cf. *C. alyo*, the harpetid *Scotoharpes*?, a second phacopid (*Ananaspis*?), the encrinurid *Briania* and an undetermined encrinurid. The trilobite species compare closely with others already described from various localities in the mid-late Llandovery of Greenland and Canada. The overall composition of the trilobite fauna, however, contrasts with that previously known from the Odins Fjord Formation; this may partly reflect the more offshore position of the Schley Fjord fauna on the Peary Land shelf. However, drowning of the shelf produced a possibly diachronous decrease in faunal content and diversity as deepening and muddying progressed southwards over time. Thus, faunal contrasts may simply reflect sampling of different levels within this muddying-upwards succession.

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The small collection of trilobites described here was obtained by R. L. Christie and J. R. Ineson in 1978 when they were engaged in the reconnaissance field mapping programme of the Peary Land region. These fossils are the most northerly Silurian trilobites discovered. The section from which the trilobites (GGU 197562; Fig. 1) were collected spans the boundary between the carbonates of the Odins Fjord Formation (of Hurst, 1984; the former un-named Silurian Limestone Formation of Christie & Peel, 1977), and the overlying shaly mudstones (Thors Fjord Member) and sandstone turbidites of the Wulff Land Formation (Christie & Ineson 1979, p. 69). The upper 30–40 m of the Odins Fjord Formation limestones at this locality show a progressive facies change upwards, becoming darker, more argillaceous, thinly bedded and nodular. The fossils were collected from the uppermost beds of the Odins Fjord Formation, some 2–3 m below the top. The rock type is a thinly bedded, sparsely fossiliferous, silty wackestone which is grey to dark grey on fresh surfaces and weathers brown. In thin section the limestone is seen to be bioturbated, and stylolitic surfaces occur.

In the early Silurian, Peary Land lay near to the eastern exposed end of a large carbonate platform, which extended some 800 km E-W and 100 km N-S (Surlyk & Ineson, 1992; Higgins *et al.*, 1991; Sønderholm & Harland, 1989; Sønderholm *et al.*, 1987). The northern boundary of the platform was marked by the Navarana Fjord Lineament. As the platform foundered in the late Llandovery, the active carbonate margin back-stepped to the south (Surlyk & Ineson, 1992, p. 401). Hurst (1984, p. 44) interpreted the upper part of the Odins Fjord Formation in this region to have been deposited under low energy conditions, possibly below the photic zone. If this interpretation is correct, the trilobites are unlikely to have suffered significant transport. A depositional environment situated at the transition from the mid to outer shelf may be suggested by the association of conodont genera which occurs (see below; Armstrong 1990, fig. 26, p. 36).

Silurian trilobites from northern Greenland have become much better known over the last twenty years (Lane, 1972, 1979, 1984, 1988; Lane & Owens, 1982; Lane & Siveter, 1991), though much material remains to be described. The Odins Fjord Formation fauna dealt with by Lane (1988) is also from the *celloni* Biozone, and therefore is at least approximately coeval with that described here. Lane's fauna, which was collected about 100 km SW of GGU 197562, contains the styginid *Opoa*, the encrinurids *Perryus* (= *Enrinuroides palasso* Lane; see Edgecombe & Chatterton 1992, p. 68) and *Distyrax*, the pterygometopid *Podowrinella* and the odontopleurid

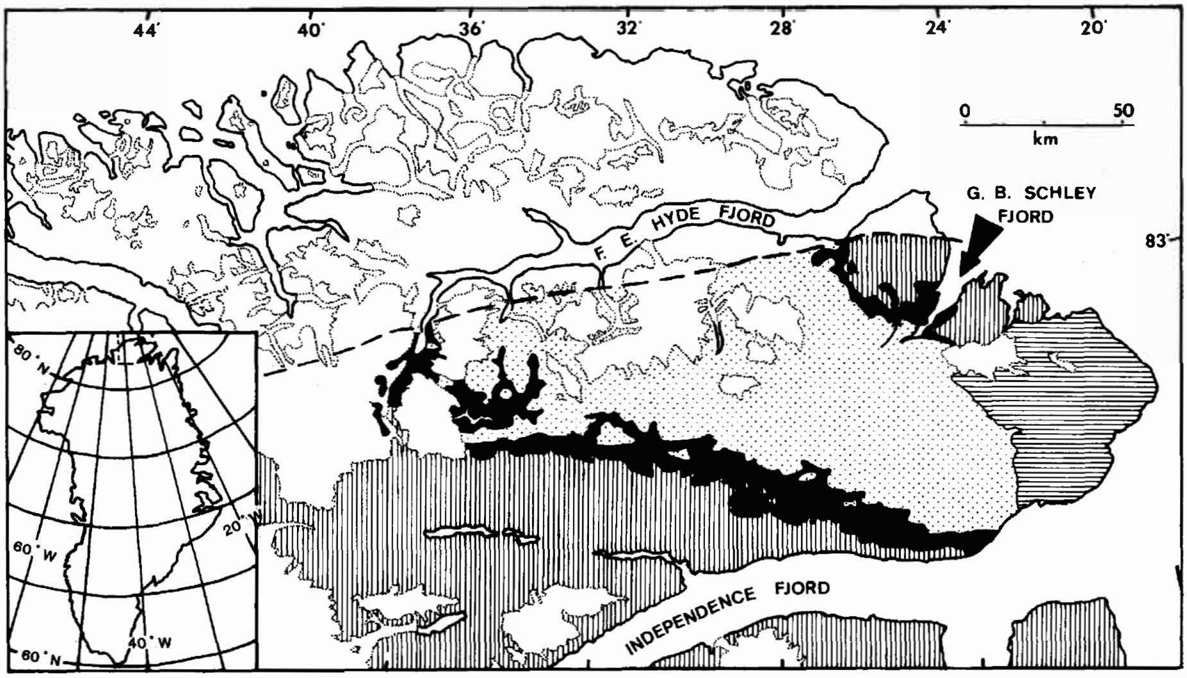

Fig. 1. Peary Land region, showing the geographical position of GGU 197562 (marked with a small arrow). Dashed line running E-W to the south of Frederick E. Hyde Fjord marks the early Silurian shelf edge (Navarana Fjord Lineament). Silurian carbonate formations are shown in black. Vertical shading marks the underlying Proterozoic to Ordovician units; stippling indicates younger Silurian rocks. Wandel Sea Basin (Upper Carboniferous to Lower Tertiary) is shaded horizontally. The Inland Ice is marked by finely broken lines. Inset map of Greenland shows area of enlarged map.

Gaotania. Associated with these are abundant brachiopods, pelmatozoan debris and (mainly smooth) ostracodes, with some gastropods, bivalves, and rugose and tabulate corals. The aspect of the fauna as a whole, and the trilobite component in particular, is thus rather different from that described here. Such contrasts in the composition of coeval Silurian trilobite associations are known elsewhere (Thomas, 1980, p. 450; Thomas *et al.*, 1984, p. 50). In this case they could reflect the more offshore position of GGU 197562 on the Peary Land shelf (Hurst, 1984, fig. 66D, p. 63; fig. 70, p. 67). However, the fossils were collected only 2–3 m below the the top of the Odins Fjord Formation, in a transitional, nodular, argillaceous wackestone lithofacies. This lithofacies reflects the gradual deepening and muddying of the outer part of the Peary Land shelf which took place as foundering occurred. On a regional scale, this lithofacies is probably slightly diachronous, extending southwards with time. The trilobite fauna described by Lane (1988) from the Odins Fjord Formation was collected about 20 m below the top: that fauna was therefore from a different level in the sequence, which deepens and becomes more argillaceous upwards. This palaeoenvironmental contrast may provide a sufficient explanation of the differences in composition between the two faunas.

Composition, preservation and age of the fauna

R. L. Christie and J. R. Ineson were primarily engaged in field mapping when they collected this fauna, and the size of the sample is therefore small (47 macrofossils, excluding brachiopods). Disassociated trilobites are the commonest macrofossils (31 specimens), next most common are orthoconic and cyrtoconic cephalopods (13 specimens) and articulate brachiopods (currently being studied by M. G. Bassett), with two high-spired gastropods (*Loxonema*? sp.) and a single thlipsuracean? ostracode. The limestone which encloses the fossils is highly indurated and adheres to the trilobites with great tenacity: generally the exoskeleton clings to the external mould. Preparing the fossils from the matrix is consequently exceedingly difficult. Some of the phacopid cranidia were therefore only partly prepared, in order to avoid causing an unacceptable level of damage to the specimens.

Surplus limestone was trimmed from the blocks which contained macrofossils. In this way, approximately 2.4 kg of rock was separated and kindly processed for conodonts by R. J. Aldridge. The sample yielded a rich fauna of conodonts (1767 elements) and acrocretacean brachiopods. Some of Aldridge's identifications are provisional, but the biostratigraphically important species are unequivocal. *Pseudolonchodina fluegeli* dominates the assemblage (1379 elements). The *celloni* Biozone age is indicated by the presence of the nominate species (39 elements), and the occurrence of *Astropentagnathus irregularis* (97 elements) is indicative of the lower part of that biozone. Associated with these are (element numbers given in brackets): *Panderodus* spp. (117), *Carniodus* (25), *Ozarkodina* spp. (20), *Decoriconus fragilis* (10), *Dentacodina*? (6), *Belodella* (5) and *Pseudooneotodus* (1).

Systematic palaeontology

Family Proetidae Salter, 1864
Subfamily Proetinae Salter, 1864
Genus *Cyphoproetus* Kegel, 1928

Type species. Cyph. depressa Barrande, 1846, p. 60, from the Liteň Formation (Wenlock) of Lištice, Prague district, Czechoslovakia.

Cyphoproetus? cf. *C. alyo* Lane, 1979
Fig. 2H

Material. MGUH 22161 from GGU 197562, GGU 197562.1, free cheeks.

Discussion. This specimen compares very closely with the specimen figured by Lane (1979, pl. 3, fig. 7) and agrees in all respects with his description (1979, p. 21). In view of the fragmentary nature of the present specimen, the identification is inevitably equivocal. *C? alyo* was originally described from rocks of *Coronograptus gregarius* Biozone age (lower Aeronian).

Family Harpetidae Hawle & Corda, 1847
Genus *Scotoharpes* Lamont, 1948

Type species. Scotoharpes domina Lamont 1948, p. 535, pl. 1, fig. 2, from the upper Llandovery of the North Esk Inlier, Scotland.

Scotoharpes? sp.
Figs 2A, G

Material. MGUH 22162a, b from GGU 197562, brim fragment and counterpart.

Discussion. This fragment is provisionally assigned to *Scotoharpes*, a widespread genus common in the Llandovery of northern Greenland, on account of its overall similarity to specimens such as that figured by Lane (1979, pl. 5, fig. 3). In the absence of the axial part of the cephalon, however, the identification is provisional. One character which distinguishes species of *Scotoharpes* is the number of small pits in the width of the brim. These pits are difficult to count properly in the present specimen for preservational reasons: there seem to be about 24. In *S. loma*, from the upper Llandovery or Wenlock of Kronprins Christian Land, this number is about 40 (Lane 1972, p. 353). *Scotoharpes* sp. of Lane (1979, p. 24), from the Llandovery (Idwian, now lower Aeronian, B1, or slightly older) of Washington Land, has 20–22 pits.

Family Phacopidae Hawle & Corda, 1847
Subfamily Phacopinae Hawle & Corda, 1847
Genus *Acernaspis* Campbell, 1967

Type species. Phacops orestes Billings, 1860, from the Jupiter and Gun River formations (Llandovery), of Anticosti Island, Canada.

Acernaspis sp.
Figs 3A–J

Material. MGUH 22163–6 from GGU 197562.2–9, cranidia; MGUH 22167 from GGU 197562.10, free cheeks; MGUH 22168, thoracic segment; MGUH 22169–70 from GGU 197562.11, 12, pygidia: all MGUH specimens from GGU 197562. One poorly preserved pygidium (GGU 197562.13) may also belong to this species.

Discussion. In cephalic morphology, this species compares closely with the type species (Campbell, 1967, pl. 12 figs 1–3; pl. 13, fig. 8). Comparison is limited, however, because the present species is known mainly from internal moulds. Pygidia of *Acernaspis* sp. differ from these of *A. orestes* in being wider and shorter. *Acernaspis* species are typical of the Llandovery, but the genus ranges up into the Wenlock.

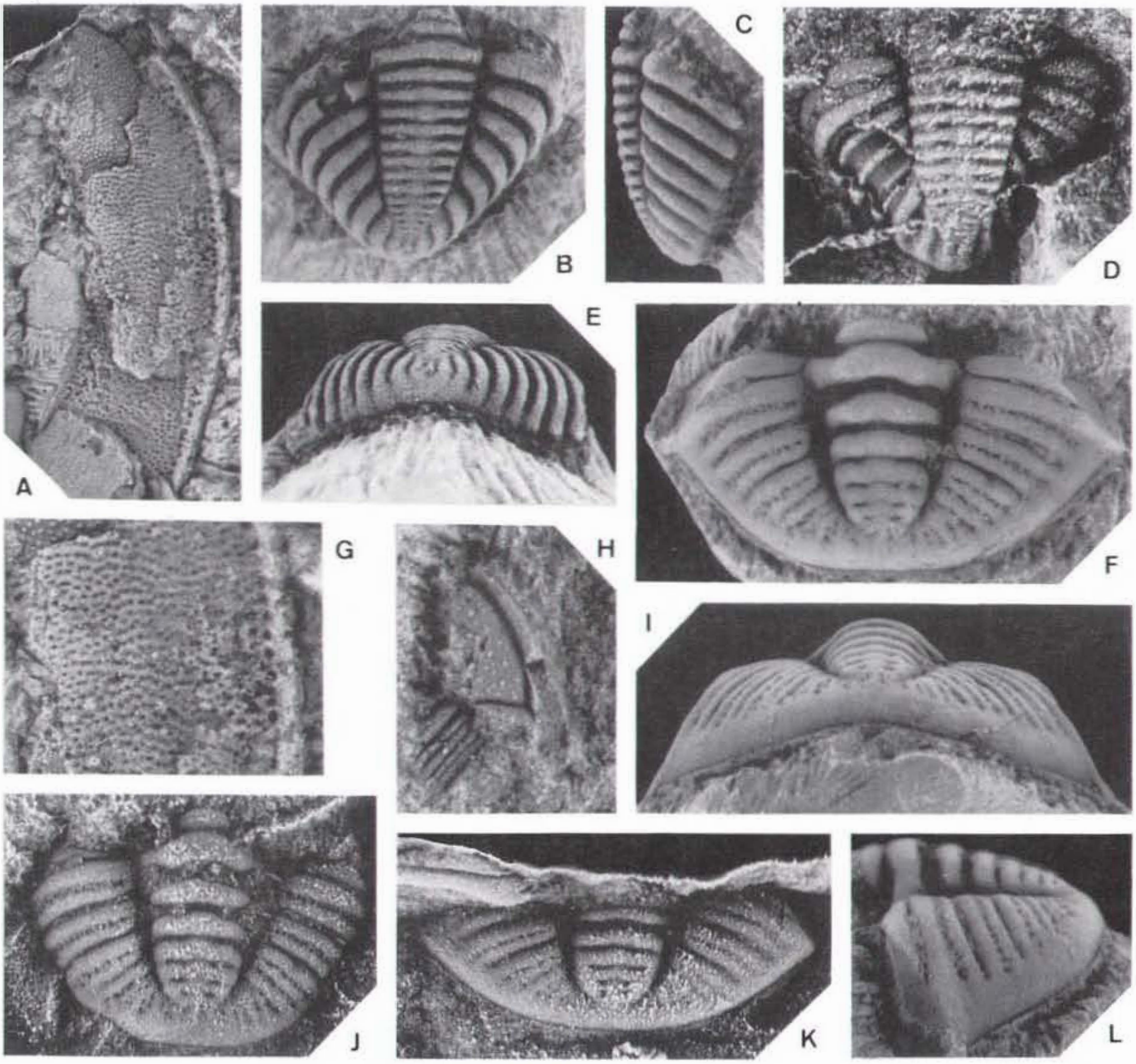

Fig. 2. A, G *Scotoharpes*? sp., MGUH 22162, latex cast from counterpart of brim fragment, dorsal view, ×2.5 and ×5. B, C, E. *Brianía* sp., MGUH 22174, pygidum, dorsal, lateral and posterior views, ×10. D, MGUH 22175, encrinurine gen. and sp. indet., latex cast from external mould of pygidium, dorsal view, ×10. F, I, J-L, *Ananaspis*? sp. F, I, L, MGUH 22171, pygidium, dorsal, posterior and lateral views, ×8. J, MGUH 22172, latex cast from counterpart of pygidium, dorsal view, ×6. K, MGUH 22173, latex cast from counterpart of pygidium, dorsal view, ×8. H, *Cyphoproetus*? cf. *C. alyo* Lane, MGUH 22161, free cheek, dorsal view, ×10.

Genus *Ananaspis* Campbell, 1967

Type species. *Phacops fecundus* Barrande, 1846, p. 46, from the Kopanina Formation (Ludlow), Koledník, near Beroun, Czechoslovakia.

Ananaspis? sp.

Figs 2F, I-L.

Material. MGUH 22171-3 from GGU 197562, pygidia.

Description. Pygidium almost twice as wide as long, with distinct border. Axis slightly more than one third maximum pygidial width anteriorly. Five complete axial rings, but fourth and fifth defined posteriorly by furrows which are very shallow sagittally; sixth axial ring defined only by apodemal pits. Pleural area with six pleural furrows; anterior four of these distinct, posterior two consist of aligned pits. Six interpleural furrows, all consisting of aligned pits. Anterior and posterior pleural bands of similar length (exsag.).

Discussion. This species is known only from internal surfaces: in the two specimens preserved as counterparts, the recrystallized exoskeleton is visible as a slightly paler layer which grades into the limestone matrix. On first inspection, one specimen (Fig. 2J) appears to be transitory pygidium. However, the deep furrow which posteriorly bounds the anterior two "segments" is a pleural, not an interpleural, furrow.

The specimens are questionably assigned to *Ananaspis* on the basis of the well-developed segmentation (Chlupáč, 1977, p. 77). *Ananaspis*? sp. has fewer axial rings and pairs of pleural ribs than species unequivocally assigned to that genus, but it is stratigraphically older than any of them. Pygidia of *Acernaspis* are much less strongly segmented. The pitted nature of the interpleural furrow is matched in a number of *Ananaspis* species (Chlupáč, 1977, pl. 4, figs 12–15; pl. 5, figs 23) and in some other phacopids.

Family Encrinuridae Angelin, 1854
Subfamily Encrinurinae Angelin, 1854
Genus *Briania* Edgecombe, 1994

Type species. Briania jeffersoni Edgecombe 1994, p. 827, figs 2.1–2.16, 3.1–3.4?, 3.5–3.22, from upper Telychian part of Whittaker Formation, east of Avalanche Lake, District of Mackenzie, Canada.

Briania sp.
Figs 2B, C, E

Material. MGUH 22174 from GGU 197526, pygidium.

Discussion. This specimen shows general similarities to a number of stratigraphically younger encrinurines such as *Fragiscutum glebale* (Campbell, 1967, pl. 8, figs 3, 9, 18) and *Struszia obtusa* (see Ramsköld, 1986, pl. 48, figs 2c, 7–10). It is closest, however, to the monotypic *Briania* Edgecombe (1994, figs 3.8–3.22). Similarities include the pygidial length:width proportions, the anterior width of the axis relative to total pygidial width, axial shape and pattern of segmentation, the very shallow sagittal band with subdued tubercles, and the pleural inter-rib furrow and rib morphology. Anteriorly the latter terminate in blunt, subquadrate tips, whereas posteriorly the inter-rib furrows are almost effaced distally (Figs 2C, E), though this is not a character unique to *Briania* (e.g. see Thomas & Narbonne, 1979, pl. 3, fig. 6). The present specimen differs from *B. jeffersoni* is having 15 (not 16–19) distinct axial rings, only 8 (not 10–11 pleural ribs) and a slightly lower R/P (Ramsköld, 1986, p. 529) ratio (1.66 rather than 1.78). These differences are unlikely to be of more than specific significance. Many of the diagnostic characters of *Briania* are cephalic, however, so a full comparison with the type species is not possible.

Briania jeffersoni was described from late Telychian strata (*Pterospathodus amorphognathoides* Biozone; though graptolite/trilobite correlations suggest a slightly older age, Edgecombe, 1994, p. 824), rocks a little younger than those dealt with here. Nevertheless, the new record reinforces the general biostratigraphical utility of some Silurian encrinurid taxa which has been noted previously (Edgecombe, 1994, p. 826; Thomas *et al.*, 1984, p. 51).

Encrinurine gen. and sp. indet.
Fig. 2D

Material. MGUH 22175 from GGU 197562, external mould of incomplete pygidium.

Discussion. This specimen clearly represents a different taxon from *Briania* sp., differing most obviously in the wide axis and shorter (exsag.) pleural ribs which are separated by much broader inter-rib furrows. It cannot be assigned to any of the seven named encrinurine genera recorded from Telychian rocks by Edgecombe (1994, fig. 1, p. 825), and instead probably belongs to what he described as the group of *variolaris*-plexus plesiomorphs. Except for the less rapidly tapering axis, the present specimen is similar in most respects to a pygidium from the late Llandovery of the North Yukon described by Ludvigsen & Tripp (1990, p. 24, pl. 9, fig. 6) as *Encrinuraspis* sp. G. D. Edgecombe (personal communication, November 1993) informs me that a related species from the *amorphognathoides* Biozone in the Mackenzie Mountains indicates placement in the *variolaris*-plexus, related to *Balizoma*, *Struszia*, and other post-Llandovery genera.

The only other encrinurid specimen found in the sample is a small librigenal? fragment (GGU 197562.14). Given its fragmentary nature, it cannot be further identified.

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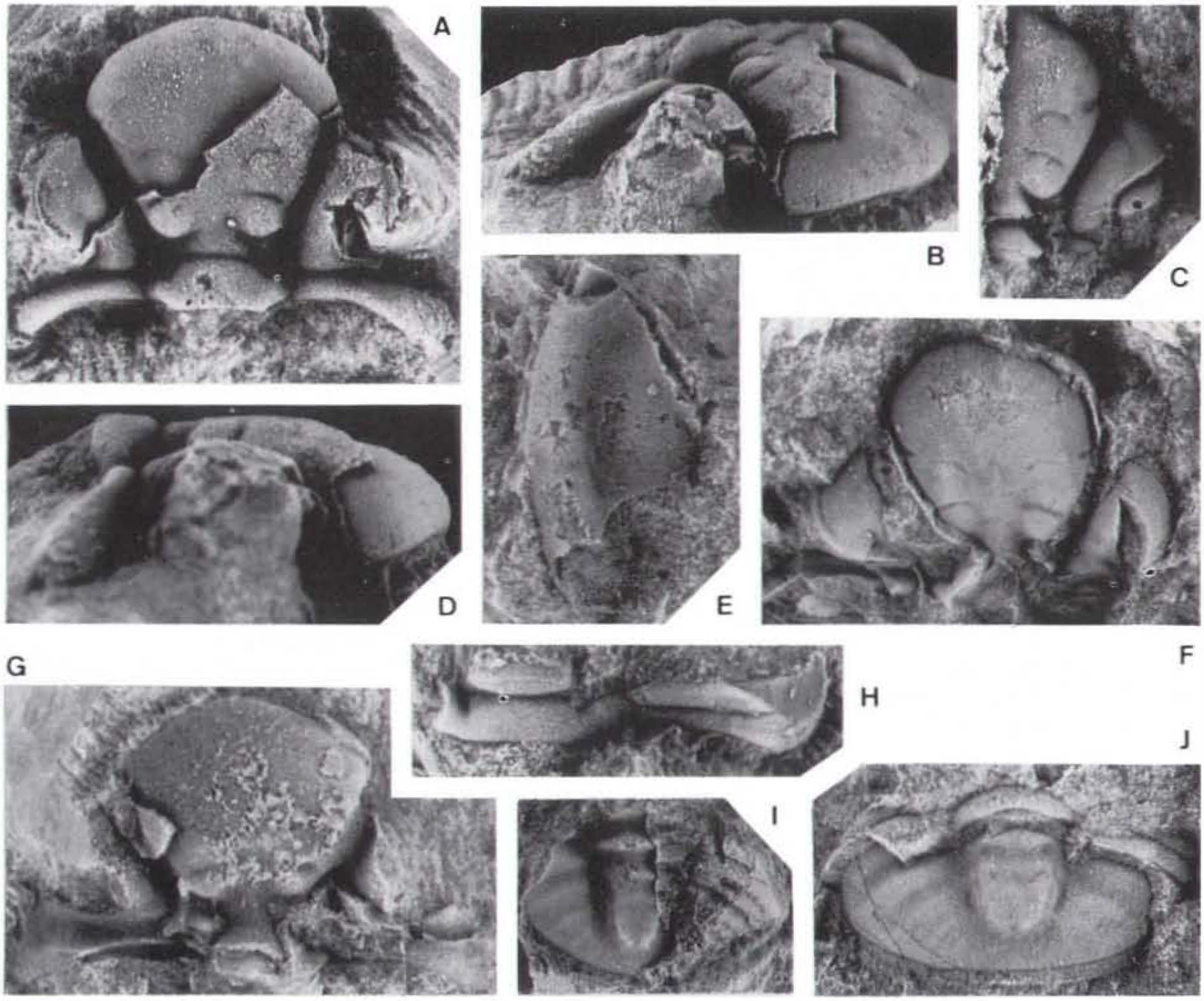

Fig. 3. *Acernaspis* sp. A, B, D, MGUH 22163, partly exfoliated cranidium, palpebral and oblique anterolateral views, ×8, lateral view, ×10. C, MGUH 22164, latex cast from external mould of incomplete cranidium, ×7. E, MGUH 22167, free cheek, exterior view, ×6. F, MGUH 22165, incomplete cranidium, palpebral view, ×5. G, MGUH 22166, internal mould of cranidium, dorsal view, ×5. H, MGUH 22168, incomplete thoracic segment, dorsal view, ×6. I, MGUH 22169, pygidium, dorsal view, ×6. J, MGUH 22170, largely exfoliated pygidum, dorsal view, ×8.

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