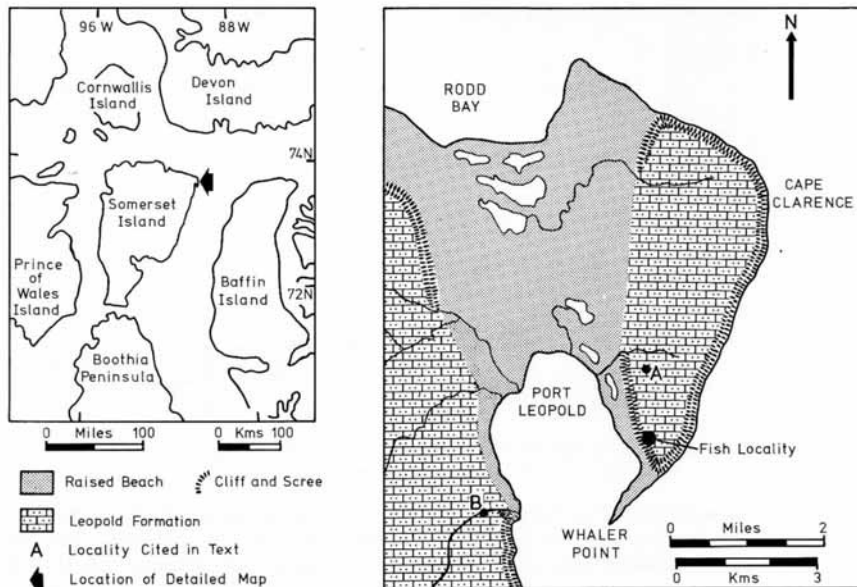


AN OSTRACODERM FAUNA FROM THE LEOPOLD FORMATION (SILURIAN TO DEVONIAN) OF SOMERSET ISLAND, NORTH-WEST TERRITORIES, CANADA

by E. J. LOEFFLER and B. JONES

ABSTRACT. An ostracoderm fauna, comprising *Archegonaspis* cf. *A. schmidti* (Geinitz), *Homalaspidella* cf. *H. borealis* Denison, Cyathaspididae indet., and Heterostraci indet., occurs in the Leopold Formation on north-eastern Somerset Island. The associated invertebrate faunas indicate a Pridolian (upper Silurian) or Gedinnian (lower Devonian) age for the ostracoderm horizon; this is the youngest substantiated report of *Archegonaspis*.

THE ostracoderms described in this paper were collected from a unit near the top of the cliffs at the southern end of the peninsula at Port Leopold, Somerset Island (text-fig. 1). This locality was discovered by one of the authors (B. J.) during a detailed study of the carbonate rocks of the area. The collection made at that time (1971) was sufficiently interesting to warrant further collecting; this, by both authors, took



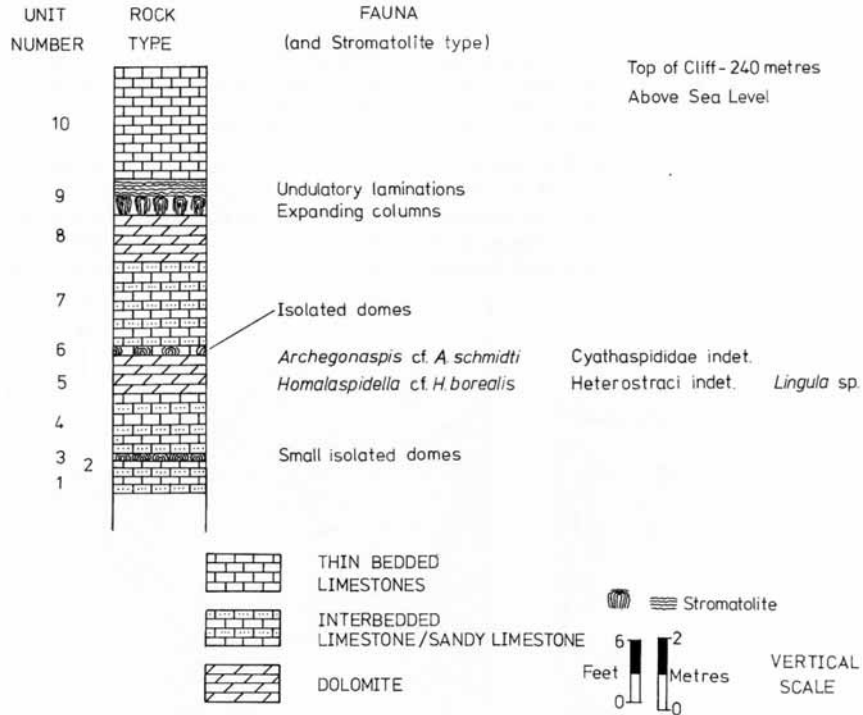
TEXT-FIG. 1. Locality map.

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place in 1973. In the following discussion the stratigraphic and sedimentological information and age assessments were prepared by Jones; Loeffler described the vertebrates and discussed their significance.

STRATIGRAPHIC LOCATION

The ostracoderms occur in a one-metre-thick unit of dolomite approximately 240 m (800 ft) above sea level, 8 m (26 ft) below the top of the cliff (text-fig. 2) and approximately 220 m (670 ft) above the base of the Leopold Formation. From the southern extremity of the peninsula, the unit can be traced northwards for about 60 m (190 ft)



TEXT-FIG. 2. Section measured on cliffs on the east side of the bay at Port Leopold, showing lithological subdivisions and the position of the ostracoderm horizon.

before the exposure ends. Indeterminate ostracoderm fragments, in a similar lithology, were also found in the scree to the north (locality A, text-fig. 1) suggesting that the unit continues northward beneath the scree. Another ostracoderm fauna, which will form the subject of a separate paper, has been found on the west side of the bay at Port Leopold (locality B, text-fig. 1).

McMillan (in Fortier *et al.* 1963, p. 130) assigned the strata of this area to the Read Bay Formation. However, detailed sedimentological study of the area (Jones 1974; Jones and Dixon 1975) has shown that the strata cannot be assigned to the Read Bay Formation since the lithologies and fauna do not correspond to the definition of the formation given by Thorsteinsson (1958, p. 47). Jones and Dixon (1975) have, consequently, assigned the strata to the Leopold Formation.

DEPOSITIONAL ENVIRONMENTS

The dolomite unit which contains the ostracoderms occurs in a succession in which stromatolitic units are common (text-fig. 2). Although the stromatolites have various forms (text-fig. 2), they collectively suggest intertidal environments (Logan *et al.* 1964). The textural relationship of the dolomite to small patches of micritic calcite in the rock suggests that the dolomite is of secondary origin and that it formed at an early stage. Such dolomite formation in Recent environments is most commonly associated with high intertidal and supratidal environments (Illing *et al.* 1965; Deffeyes *et al.* 1964). The presence of the brachiopod *Lingula* in unit 5 (text-fig. 2) also suggests shallow water. Craig (1952) noted that this brachiopod is commonly associated with tidal flat areas.

Based on the evidence outlined above and on evidence obtained from other sections in the area, the depositional environment has been interpreted as a tidal flat area with a seaward margin occupied by stromatolites (Jones and Dixon 1975).

The vertebrate remains in unit 5 comprise isolated dorsal and ventral shields, together with isolated scales. The ostracoderms probably did not live in the tidal-flat environment, since it is doubtful that they could have survived under such conditions. They may well have been washed on to the tidal flat during a period of strong current action, possibly during a storm. With decay of the soft tissues under aerobic conditions, the various elements of the skeleton would have become separated and subsequently incorporated in the sediment as isolated shields and scales.

AGE OF THE OSTRACODERM HORIZON

While the macrofauna of rare brachiopods (*Lingula*, *Kirkidium?*, and *Howellella*), rare coral fragments (*Coenites*), and abundant eurypterids (of *Eurypterus remipes* group) suggests an upper Silurian age for the strata, it does not permit distinction of the Ludlovian or Pridolian series (Jones and Dixon 1975). The ostracods (*Bairdicypris*, *Beyrichia* (*Beyrichia*) aff. *arctigena*, *Leperditia jonesi*) suggest correlation with the upper part of the Read Bay Formation and/or the lower part of the Peel Sound Formation (Copeland 1973, pers. comm.). Elsewhere on Somerset Island the upper part of the Read Bay Formation and the lower part of the Peel Sound Formation are of Pridolian age (Jones 1974). The conodonts, *Ozarkodina confluens* (Branson and Mehl) (late form) and '*Ozarkodina*' *ortuformis* Walliser, from the basal 20 m (63 ft) of the Leopold Formation indicate a Pridolian age (*eosteinhornensis* Zone) (Uyeno 1974, pers. comm.).

Since the ostracoderm unit is approximately 220 m (670 ft) above the base of the

Leopold Formation, a Pridolian or younger age is indicated for the ostracoderm fauna.

SYSTEMATIC PALAEOLOGY

The ostracoderms described in this paper are the property of the National Museum of Canada and bear their catalogue numbers (prefixed NMC); they will eventually be housed in that institution.

Order HETEROSTRACI Lankester, 1868
 Family CYATHASPIDIDAE Kiaer, 1932
 Subfamily CYATHASPIDINAE Denison, 1964
 Genus ARCHEGONASPIS Jaekel, 1927
Archegonaspis cf. *A. schmidti* (Geinitz, 1884)

Plate 1, figs. 1, 2, 3; Plate 2, fig. 1

Material. Sixteen dorsal shields (NMC 21574–21587, 21589, 21590, 21595) and three ventral shields (NMC 21597–21599).

Occurrence. Approximately 220 m above the base of the Leopold Formation, on the east side of the bay at Port Leopold, Somerset Island, North-west Territories, Canada (text-fig. 1).

Dimensions. Ranges are based on the measurement of ten dorsal and three ventral shields, few of which are complete; parameters selected for measurement are the same as those used by Denison (1964, fig. 93).

	Range	Mean	No. measured
Dorsal Shield:			
Median length	32.2–38.0 mm	33.9 mm	10
Maximum width	20.0–23.0 mm	21.2 mm	10
Orbital width	15.0–17.0 mm	15.9 mm	8
Orbital length	5.0–6.3 mm	5.9 mm	9
Pineal length	8.4–10.0 mm	9.3 mm	10
Postbranchial length	8.5–10.3 mm	9.2 mm	7
Width ratio	0.58–0.64	0.62	10
Orbital width ratio	0.44–0.48	0.46	7
Orbital length ratio	0.15–0.19	0.17	8
Pineal length ratio	0.25–0.29	0.27	10
Postbranchial length ratio	0.24–0.30	0.27	7
Ventral Shield:			
Median length	25.8–28.6 mm	27.0 mm	3
Maximum width	16.6–18.1 mm	17.3 mm	3
Width ratio	0.63–0.67	0.64	3

EXPLANATION OF PLATE I

Archegonaspis cf. *A. schmidti* (Geinitz)

Fig. 1. Latex cast of external moulds of three dorsal shields; NMC 21582 (left), NMC 21581 (bottom centre), NMC 21583 (top right). Magnification $\times 2$.

Fig. 2. Ventral shield, NMC 21598A, partly preserved as an internal mould. Magnification $\times 3$.

Fig. 3. Latex cast of external mould of ventral shield, NMC 21598B. Magnification $\times 3$.



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Remarks. Division of the dorsal shield into distinct epitega, the presence of transverse ridges on the rostral epitegum, the short, irregular ridges of the postrostral field, and the absence of a median rostral process suggest that these specimens belong to the genus *Archegonaspis* Jaekel. Comparison of size and proportions with those of established species of *Archegonaspis* (see Novitskaya 1970) shows that the specimens from Port Leopold are generally rather smaller, but of similar proportions. Dimensions are closest to those of *A. schmidtii* (Geinitz), the width ratio and orbital width and length ratios of the holotype falling within the range of values calculated for the specimens from Port Leopold; the pineal length ratio of the holotype of *A. schmidtii* is larger (0.31) and the postbranchial length ratio is not known.

Since the holotype is the only specimen of *A. schmidtii*, and since it is not readily available for comparison, it is considered more valid to refer the Canadian specimens to *Archegonaspis* cf. *A. schmidtii* (Geinitz) than to establish a new species for their reception.

Dorsal ornamentation comprises uniformly high, round-crested dentine ridges with a density of approximately four per mm. Their arrangement is typically transverse on the rostral epitegum, showing a gradation from continuous ridges anteriorly to short ridges and tubercles adjacent to the boundary with the postrostral field. On the postrostral field, ornamentation is mainly of short ridges with a fanned or irregular arrangement, but this is replaced anteriorly by small tubercles (text-fig. 3); dentine ridges on the rest of the central epitegum are long and longitudinal, although short ridges are commonly present toward the posterior margin. The single, median, scale-like area of short ridges, which is present on the posterior margin of the dorsal shield (Pl. 2, fig. 1), may represent a ridge scale which has been incorporated into the shield.

The three ventral shields ascribed to *Archegonaspis* cf. *A. schmidtii* (Geinitz) are relatively slender, with a conspicuous median notch in the anterior margin (Pl. 1, fig. 3). The lateral margins are convex and the posterior margin slightly drawn out. Dentine ridges, which have a density of four per mm, are long and longitudinal over much of the ventral shield, but short and fanned anteriorly. Both the dorsal and the ventral shields are vaulted, the ventral more than the dorsal.

The lateral line system of *Archegonaspis* is known only from the holotype of *A. bimarisi* Novitskaya, where the pattern of canals was deduced from the distribution of sensory pores (Novitskaya 1970). Although sensory pores are not conspicuous in the specimens from Port Leopold, the canals can be made visible through the somewhat transparent shields by immersion in glycerol. Viewed in this way the lateral line system of the dorsal shield is seen to consist of short segments of canal (text-fig. 4a, b) arranged in a simple network which includes medial dorsal canals, supraorbital canals,

EXPLANATION OF PLATE 2

Fig. 1. *Archegonaspis* cf. *A. schmidtii*. Latex cast of external mould of dorsal shield, NMC 21580. Magnification $\times 3$.

Fig. 2. *Homalaspidea* cf. *H. borealis*. Incomplete dorsal shield. NMC 21596. Magnification $\times 3$.

Fig. 3. Cyathaspididae indet. Dorsal shield. NMC 21588. Magnification $\times 3$.

Fig. 4. Heterostraci indet. Indeterminate shield fragment. NMC 21571. Magnification $\times 2$.



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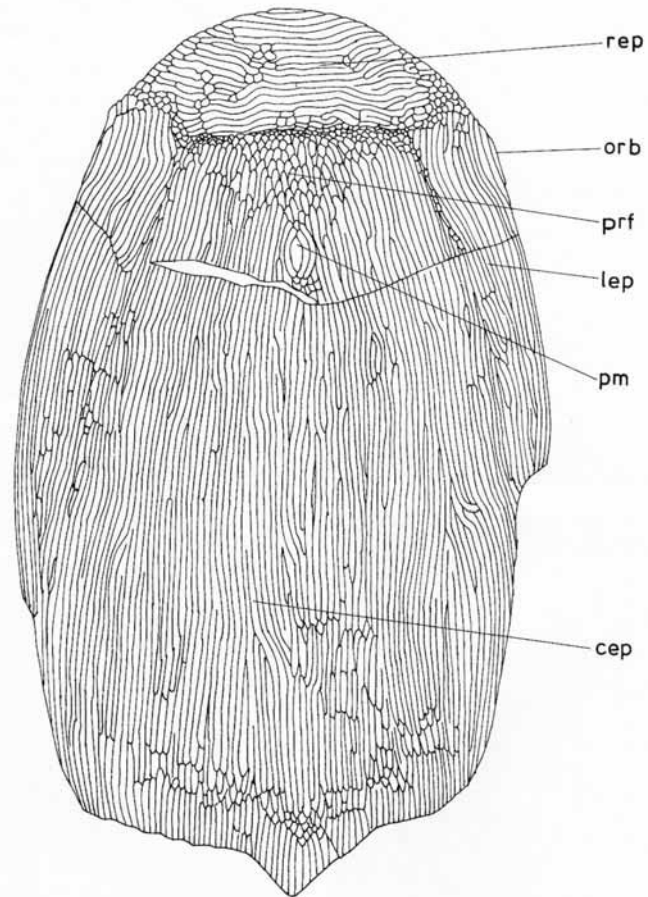
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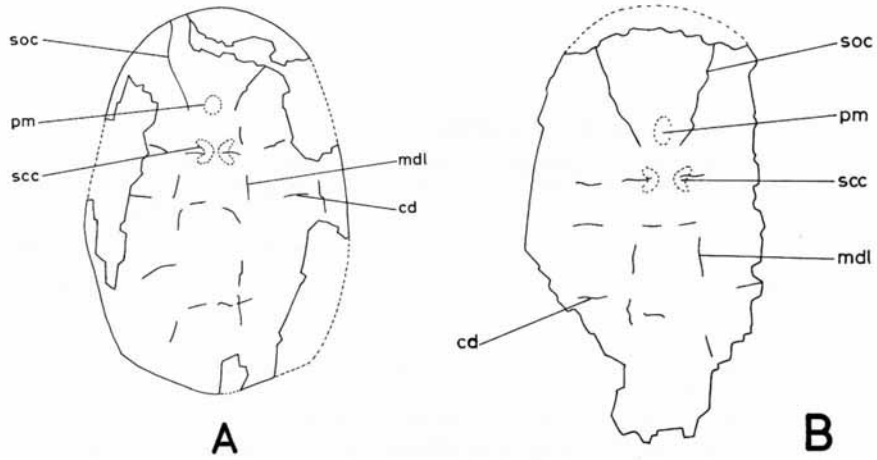
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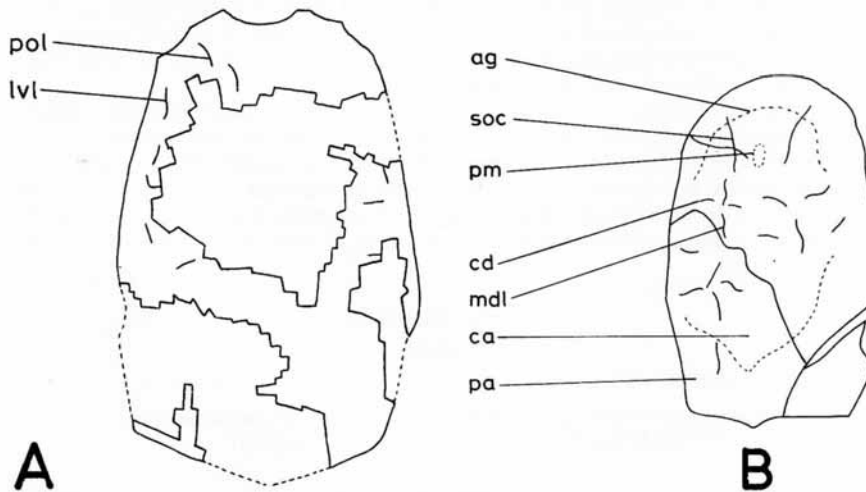
and transverse commissures. The lateral line canals of the ventral shield are also divided into segments (text-fig. 5a). Segmented lateral line canals, which are also known in *Tolypelepis* and *Americaspis*, were regarded by Denison (1964) as the primitive condition in the Heterostraci.



TEXT-FIG. 3. *Archegonaspis* cf. *A. schmidtii*, dorsal shield, NMC 21580. *cep*, central epitegum; *lep*, lateral epitegum; *orb*, orbital notch; *pm*, pineal macula; *prf*, postrostral field; *rep*, rostral epitegum. Magnification approximately $\times 4$.



TEXT-FIG. 4. Dorsal lateral line system in *Archegonaspis* cf. *A. schmidtii*. A, NMC 21581. Magnification approximately $\times 2$. B, NMC 21590. Magnification approximately $\times 2.5$. *cd*, dorsal transverse commissure; *mdl*, medial dorsal canal; *pm*, pineal macula; *scc*, semicircular canal; *soc*, supraorbital canal.



TEXT-FIG. 5. Lateral line systems. A, *Archegonaspis* cf. *A. schmidtii*, ventral shield, NMC 21598. Magnification approximately $\times 3$. B, *Cyathaspidae* indet., dorsal shield, NMC 21588. Magnification approximately $\times 2.5$. *ag*, anterior groove; *ca*, central area; *cd*, dorsal transverse commissure; *lvi*, lateral ventral canal; *mdl*, medial dorsal canal; *pa*, peripheral area; *pm*, pineal macula; *pol*, postoral canal; *soc*, supraorbital canal.

Subfamily PORASPIDINAE Denison, 1964
 Genus HOMALASPIDELLA Strand, 1934
Homalaspidella cf. *H. borealis* Denison, 1963

Plate 2, fig. 2

Material. An incomplete dorsal shield (NMC 21596).

Occurrence. Approximately 220 m above the base of the Leopold Formation, on the east side of the bay at Port Leopold, Somerset Island, North-west Territories, Canada (text-fig. 1).

Dimensions.

Median length	26.0 mm	Postbranchial length	6.6 mm
Maximum width	—	Orbital length ratio	0.15
Orbital width	—	Pineal length ratio	0.26
Orbital length	3.8 mm	Postbranchial length ratio	0.26
Pineal length	6.7 mm		

Remarks. Reference of this specimen to *Homalaspidella* Strand is suggested by the rather narrow proportions of the shield, the lack of epitega, the shallowness of the orbital notches, and the absence of a median rostral process. The size of the shield, together with the size and pattern of the dentine ridges, implies a closer affinity with *H. borealis* Denison than with *H. nitida* (Kiaer).

Although there are some differences between the specimen from Port Leopold and *H. borealis* (Denison 1963), it is regarded as inappropriate to erect a new species for the reception of a single incomplete specimen. The most noticeable differences are in the smaller size of the shield and the coarseness (4–5 per mm) and simplicity of the dentine ridges of the specimen from Port Leopold. Although the orbital notches are rather more posteriorly placed than in *H. borealis* (orbital length ratio = 0.10–0.12), the position of the pineal region is similar.

The pattern of ornamentation of the specimen from Port Leopold is very simple; the uniformly high dentine ridges are long and longitudinal posteriorly but converge anteriorly to form a broad curve in front of the pineal macula (Pl. 2, fig. 2; text-fig. 6).

Of the lateral line system, only the supraorbital canal and several short segments of transverse commissure are distinguishable. The supraorbital canal is marked by a slight discordance of the dentine ridges (text-fig. 6), but lateral line pores are not readily visible.

CYATHASPIDIDAE indet.

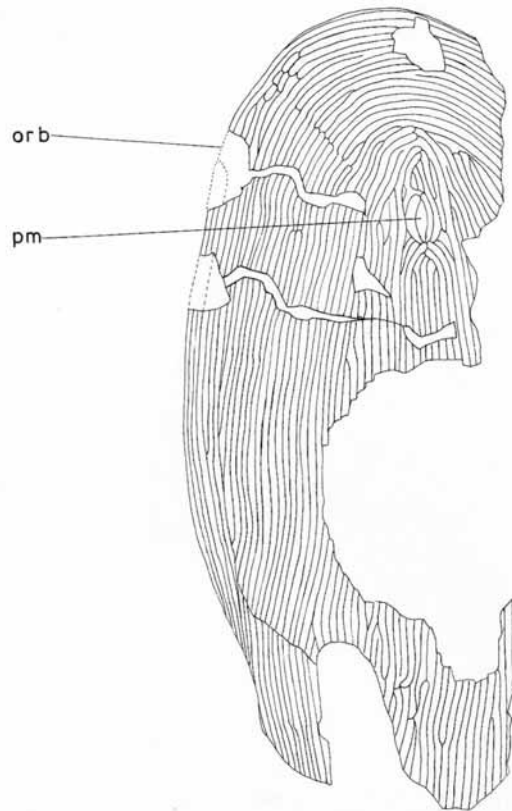
Plate 2, fig. 3

Material. A dorsal shield (NMC 21588).

Occurrence. Approximately 220 m above the base of the Leopold Formation, on the east side of the bay at Port Leopold, Somerset Island, North-west Territories, Canada (text-fig. 1).

Dimensions.

Median length	24.3 mm	Width ratio	0.58
Maximum width	14.0 mm	Orbital width ratio	0.45
Orbital width	11.0 mm	Orbital length ratio	0.10
Orbital length	2.5 mm	Pineal length ratio	0.26
Pineal length	6.2 mm	Postbranchial length ratio	0.24
Postbranchial length	5.8 mm		



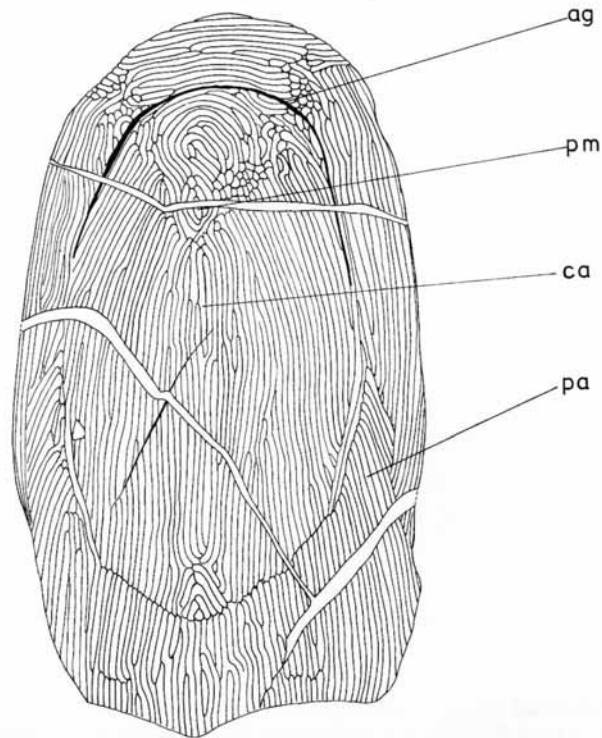
TEXT-FIG. 6. *Homalaspidella* cf. *H. borealis*, dorsal shield, NMC 21596. *orb*, orbital notch; *pm*, pineal macula. Magnification approximately $\times 5$.

Remarks. The small dorsal shield lacks a median rostral process, has moderately well-developed branchial lobes and, although the pineal macula occupies a posterior position, the orbital notches are unusually far forward. The posterior margin of the shield is transverse, except for a small median lobe.

The dorsal shield exhibits an unusual subdivision into an oval central area and a peripheral area (text-fig. 7). The anterior and anterolateral margins of the central area coincide with the normal position of the anterior boundary of the central epitegum in a typical cythaspidinid, and are marked by a distinct groove and a discontinuity of ornamentation; the posterior and posterolateral margins of the central area are delimited by a discordance of ornamentation only. The peripheral area includes those parts of the shield that would normally form the rostral and lateral

epitega but, in this specimen, there is no boundary between the rostral and lateral epitega, nor between the latter and the posterior part of the shield.

Ornamentation consists of uniformly high, flat-topped dentine ridges with a density of five ridges per mm. Within the oval central area the ridges are whorled in front of the pineal macula but largely longitudinal elsewhere. In the mid-line of the posterior margin, the ridges are arranged in an anteriorly pointing V. In the peripheral area the ridges are transverse on the rostrum, parallel to the lateral margins of the shield laterally, and longitudinal posteriorly (text-fig. 7).



TEXT-FIG. 7. *Cyathaspididae* indet., dorsal shield, NMC 21588. *ag*, anterior groove; *ca*, central area; *pa*, peripheral area; *pm*, pineal macula. Magnification approximately $\times 5$.

Although lateral line pores are not distinguishable, canals are visible under glycerol. Both the medial dorsal canals and the transverse commissures are made up of short segments of canal (text-fig. 5*b*); no lateral dorsal canals are distinguishable.

Since this specimen is unique, it is difficult to determine whether or not it is an example of an abnormal individual and, if it is, whether it belongs to a new or an established taxon.

Similar anomalous subdivision of the shield has been recognized in *Americaspis* (Denison 1964), *Arhegonaspis* (Novitskaya 1970), *Vernonaspis* (Broad and Lenz 1972), and *Pionaspis* (undescribed material from Arctic Canada). Although Denison (1964) considered the superficial subdivision of the shield of his specimen to be the result of injury prior to mineralization, both Novitskaya (1970) and Broad and Lenz (1972) established new species for their material which they considered to differ in ontogenetic development from closely related forms. Studies on cyathaspidids from the Delorme Formation of Western Canada (Loeffler 1974) indicate that the superficial layer of the shield underwent incremental growth which, if interrupted by disease or adverse conditions, could have resulted in the formation of anomalous areas. The variation in relative size of these anomalous areas in the specimens ascribed to *V. epitegosa* (Broad and Lenz 1972) supports this interpretation.

Unfortunately, since the border between the central and peripheral subdivisions obscures the region where epitegal subdivisions would be apparent, it is not possible to refer this specimen to a smaller taxonomic unit than Cyathaspididae indet.

HETEROSTRACI indet.

Plate 2, fig. 4

Material. Four shield fragments (NMC 21571-21573, 21594).

Occurrence. Approximately 220 m above the base of the Leopold Formation, on the east side of the bay at Port Leopold, Somerset Island, North-west Territories, Canada (text-fig. 1).

Remarks. Four shield fragments bearing similar ornamentation of coarse elevated ridges and finer interstitial ridges are referred to the Heterostraci, but cannot be ascribed with certainty to a smaller taxonomic unit.

The largest of the specimens, NMC 21571 (Pl. 2, fig. 4), appears to be part of a large median plate. Near its lateral margin, ornamentation is of long coarse ridges (0.2 mm wide) separated by interspaces (0.4 mm wide) occupied by up to five narrow ridges. Toward the centre of the plate there is a gradual change in ornamentation; the coarse ridges become broader (up to 0.4 mm), flatter, and more closely spaced, while the interstitial ridges become progressively fewer in number and are completely absent from the central region of the plate. The dentine ridges have an over-all longitudinal arrangement, but fan out anteriorly.

The three remaining plate fragments bear similar ornamentation to that of the lateral margins of the large plate fragment (NMC 21571). In these specimens, however, the elevated ridges are no wider than 0.2 mm and the interspaces, which are from 0.4 to 0.8 mm wide, contain 5-12 interstitial ridges. Although most of the coarse ridges are long, all of the fragments have at least some short ridges, around which the interstitial ridges are curved. Both the coarse and the fine ridges are minutely serrated along their lateral margins.

From the similarity of ornamentation of these specimens it is probable that the single median plate is a ventral shield and that the smaller fragments are parts of the dorsal armour of the same species; the coarse medial ornamentation of the ventral shield may be an adaptation to continued abrasion.

Similarity in ornamentation to the cyathaspidid genus *Cyathaspis* Lankester is

probably not indicative of a close relationship; *Cyathaspis* is much smaller and does not have coarse ventral ridges.

SIGNIFICANCE OF THE VERTEBRATE FAUNAS

The discovery of *Archegonaspis* in Pridolian or Gedinnian strata at Port Leopold is the first reliable evidence for extension of the range of the genus beyond the lower and middle Ludlovian. Although Denison (1964) recorded an occurrence of *Archegonaspis* sp. in the ?early Devonian of Wales, Novitskaya (1970) questioned the identification of the specimen, which was originally listed as a Ludlovian occurrence (White 1958, p. 218). *A. schmidtii* is known only from an erratic of the Graptolithengestein, which is of early Ludlovian age (Denison 1964).

This is not the first record of *Archegonaspis* from Canada; Thorsteinsson (1967) has reported the genus from the early Ludlovian and possibly the late Wenlockian intervals of the Cape Phillips Formation of Cornwallis Island, but the material has not been figured or described.

Two species of *Homalaspidella* are known; *H. nitida* occurs in the early Devonian of Spitsbergen (Kiaer 1932) and *H. borealis* in the upper Silurian of south-eastern Yukon (Denison 1964). At the type locality of the latter species, the ostracoderm horizon is overlain by strata containing the graptolite, *Monograptus dubius* (Hovedebo *et al.*, in Denison 1963), which is considered by Broad and Lenz (1972) to range from Wenlockian to Pridolian; that the ostracoderm horizon is of upper Silurian age is suggested by the presence of *Conchidium?* in the same beds (Hovedebo *et al.*, in Denison 1963).

Homalaspidella, or forms closely resembling it, have been reported from the late Wenlockian and early Ludlovian intervals of the Cape Phillips Formation on Cornwallis Island (Thorsteinsson 1967).

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