LATE MIDDLE CAMBRIAN TRILOBITES FROM TRIAL RIDGE, SOUTHWESTERN TASMANIA

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(with one table, one text-figure and three plates)

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The first Middle Cambrian trilobites to be described from southwestern Tasmania come from two localities within siltstone in the Trial Ridge area on the HUNTLEY 1:50 000 sheet. Sixteen trilobite taxa are described. The 11 agnostoid species include one new species, *Hypagnostus trali*. *Lisogoragnostus* is recorded for the first time in Tasmania. The faunas of both localities are of a very similar late Middle Cambrian age, probably high in the *Lejopyge laevigata* Zone on the northern Australian biostratigraphic scale. One fauna is dominated by complete specimens of *Goniagnostus nathorsti* but has very few polymeroids. In the other fauna, there are no complete agnostoids, *G. nathorsti* is absent, and the most common trilobite is a member of the Proasaphiscidae, thus suggesting that the former fauna is of deeper water origin than the latter

Key Words: **Middle Cambrian, trilobites, Trial Ridge, southwestern Tasmania.**

INTRODUCTION

During the mapping of the *HUNTLEY 1:50 000 Geological Atlas Map Sheet* (Brown *et al.* 1982) new fossil faunas were found in two localities on Trial Ridge. The southern locality (no.1, fig.1), yielded a fauna with abundant agnostoid trilobites, numerous phosphatic brachiopods as well as polymeroids and trilobite tracks. The northern locality (no.2, fig.1) contains a similar but more restricted fauna. The trilobites described in this paper allow their horizon to be dated as late Middle Cambrian, the first of that age to be described from southwestern Tasmania.

Geological Setting

The term "Trial Ridge Beds" was introduced by Corbett (1970) for the succession of sedimentary rocks on Trial Ridge. In the course of mapping the Huntley Quadrangle the sequence on Trial Ridge was re-mapped in greater detail than previously, allowing the rocks within the area to be subdivided into three members. The lowest member (Cml, fig.1) comprises thickly bedded, siliceous, granule to cobble conglomerate and siliceous sandstone. The fossiliferous middle member (Cmm, fig.1) consists of thinly and monotonously interbedded light to dark-grey sandstone and siltstone. Some siltstone units contain abundant muscovite whereas, in other places, siltstone beds contain a sand-grade component. Most of the siltstone beds contain multiple truncated cross-bedding, with some of the interbedded sandstone units having silt-grade basal flame structures. The highest member (Cmh, fig.1) consists of an irregularly interbedded sequence of granule to cobble conglomerate, siliceous pebbly sandstone and siltstone. A detailed description of this succession is contained in Brown *et al.* (1989: 40–45).

Composition and Age of the Faunas

Locality 1 contains the following agnostoid trilobites: *Goniagnostus nathorsti* (Brøgger), *Lejopyge laevigata* (Dalman), *Hypagnostus trali* sp. nov., *Lisogoragnostus* sp., *Oidalagnostus changi* Lu, *Clavagnostus* cf. *repandus* (Westergård), *Glaberagnostus* sp., *Valenagnostus* sp. and Agnostoid gen. et sp. indet. Polymeroid trilobites present are *Amphoton* sp. and Papyriaspididae gen. et sp. indet. Trace fossils, probably formed by polymeroid trilobites, are also present.

The following agnostoid trilobites are present at Locality 2: *Lejopyge laevigata* (Dalman), *Hypagnostus trali* sp. nov., *H. brevifrons* (Angelin), *Ammagnostus laiwuensis* (Lorenz), *Oidalagnostus changi* Lu and Agnostoid gen. et sp. indet. Polymeroid trilobites present are *Fuchouia* sp., *Bathyuriscus(?)* sp. and Proasaphiscidae gen. et sp. indet.

The overlap in the faunal compositions suggests that the two faunas are of similar, if not identical, age. The combination of *Lejopyge laevigata, Goniagnostus nathorsti, Hypagnostus brevifrons, Ammagnostus laiwuensis, Clavagnostus* cf. *repandus* and *Oidalagnostus changi* suggests correlation with the *L. laevigata* Zone on the northern Australian biostratigraphic scale. *Amphoton* and *Fuchouia* are well-known late Middle Cambrian genera from China and Australia. The specimens described herein as Proasaphiscidae gen. et sp. indet. belong in a genus known from several localities elsewhere in Tasmania. These include Native Track Tier and St Valentines Peak (see Laurie *et al.*, 1995, for details of these localities), where the faunas are both of very late Middle Cambrian age (Bao 1995). The combination of the above species suggests an age high in the *L. laevigata* Zone on the northern Australian biostratigraphic scale or near the boundary of the *L. laevigata* and *Proagnostus bulbus* Zones of the late Middle Cambrian of China (Peng & Robison 2000).

The composition of the agnostoid component of both localities (table 1) shows that, while there are similarities in the composition of the faunas from the two localities, there

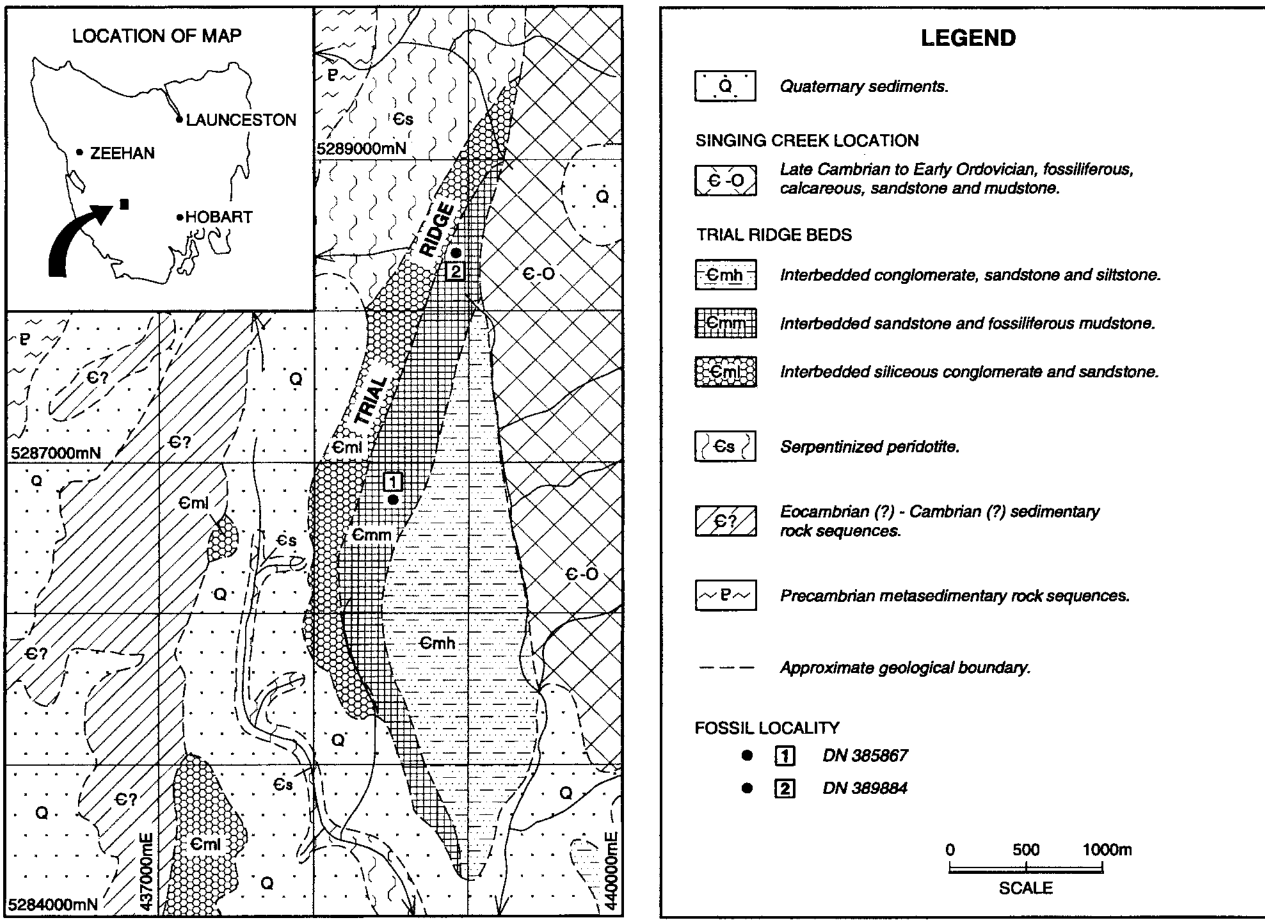

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FIG. 1 — Geology of the Trial Ridge area showing fossil localities: (1) southern, (2) northern.

are also some differences. At Locality 1, 59.77% of the known agnostoid cephala and pygidia are found in complete specimens (table 1); *Goniagnostus nathorsti* makes up 67.82% of the agnostoid fauna and only three polymeroid specimens are known.

In contrast to Locality 1, there are no known complete agnostoids from Locality 2, *G. nathorsti* is not present, and polymeroid trilobites make up about 50% of the trilobite fauna. Of the polymeroids, Proasaphiscidae gen. et sp. indet. is the most common trilobite at Locality 2. As noted above, this species is also common in faunas of similar age at Native Track Tier and St Valentines Peak in northern Tasmania. The abundance of complete agnostoids, particularly *G. nathorsti*, at Locality 1 and the absence of *G. nathorsti* and the presence of abundant Proasaphiscidae gen. et sp. indet. at Locality 2 all suggest that the faunas of Localities 1 and 2 respectively fit into Faunas 2 and 3 of Jago (1973), with the Locality 1 fauna being a deeper water fauna than that of Locality 2.

SYSTEMATIC PALAEONTOLOGY

All specimens described occur as internal and external moulds in weathered siltstone. For description, silicone rubber casts of the external moulds were prepared and then photographed after whitening with magnesium oxide. The terminology used for agnostoid trilobites is essentially that of Shergold *et al.* (1990). Specimens are housed in the collection of the School of Earth Sciences, University of Tasmania.

DESCRIPTIONS

Order AGNOSTIDA Salter, 1864
Superfamily AGNOSTOIDEA M'Coy, 1849
Family PTYCHAGNOSTIDAE Kobayashi, 1939
Genus *Goniagnostus* Howell, 1935b

Synonymy

See Lu & Lin 1989: 97. To this should be added Laurie 1989: 176; Shergold *et al.* 1990: 39; Peng & Robison 2000: 71.

Type species

Agnostus nathorsti Brøgger 1878: 68, pl. 5, fig. 1.

Remarks

The generic and subgeneric classification of *Ptychagnostus*, *Goniagnostus* and related taxa has long been problematic (e.g. Öpik 1961, 1979, Robison 1964, 1982, 1984, Laurie 1988, 1989, Westrop *et al.* 1996, Peng & Robison 2000). We follow Peng & Robison in rejecting the subgeneric subdivisions of the genus as proposed by Öpik (1979).

TABLE 1
Analysis of agnostoid trilobites from Trial Ridge*

LOCALITY ONE	Complete specimens	Separate cephala	Separate pygidia	Total no. of specimens	Total cephala and pygidia
Goniagnostus nathorsti	21	10	7	38	59
Lejopyge laevigata	2	2	2	6	8
Hypagnostus trali	1		1	2	3
Lisogoragnostus sp.	1		1	2	3
Oidalagnostus changi		6	1	7	7
Clavagnostus cf. *repandus*			2	2	2
Glaberagnostus sp.	1			1	2
Valenagnostus sp.			2	2	2
Agnostoid gen. et sp. indet.		1		1	1

Total number of cephala and pygidia = 87. Number of cephala and pygidia in complete specimens = 52. Percentage of cephala and pygidia in complete specimens = 59.77%.

LOCALITY TWO	Complete specimens	Separate cephala	Separate pygidia	Total no. of specimens	Total cephala and pygidia
Lejopyge laevigata		3	2	5	5
Hypagnostus trali			1	1	1
H. brevifrons		1		1	1
Ammagnostus laiwuensis		3	1	4	4
Oidalagnostus changi		3	3	6	6
Agnostoid gen. et sp. indet.		4		4	4

* Every available agnostoid cephalon and pygidium is shown on this table. Each individual cephalon and pygidium is counted as one unit; thus a complete agnostoid comprises two units.

Goniagnostus nathorsti (Brøgger, 1878) Pl. 1A–K

Synonymy
See Peng & Robison (2000: 72)

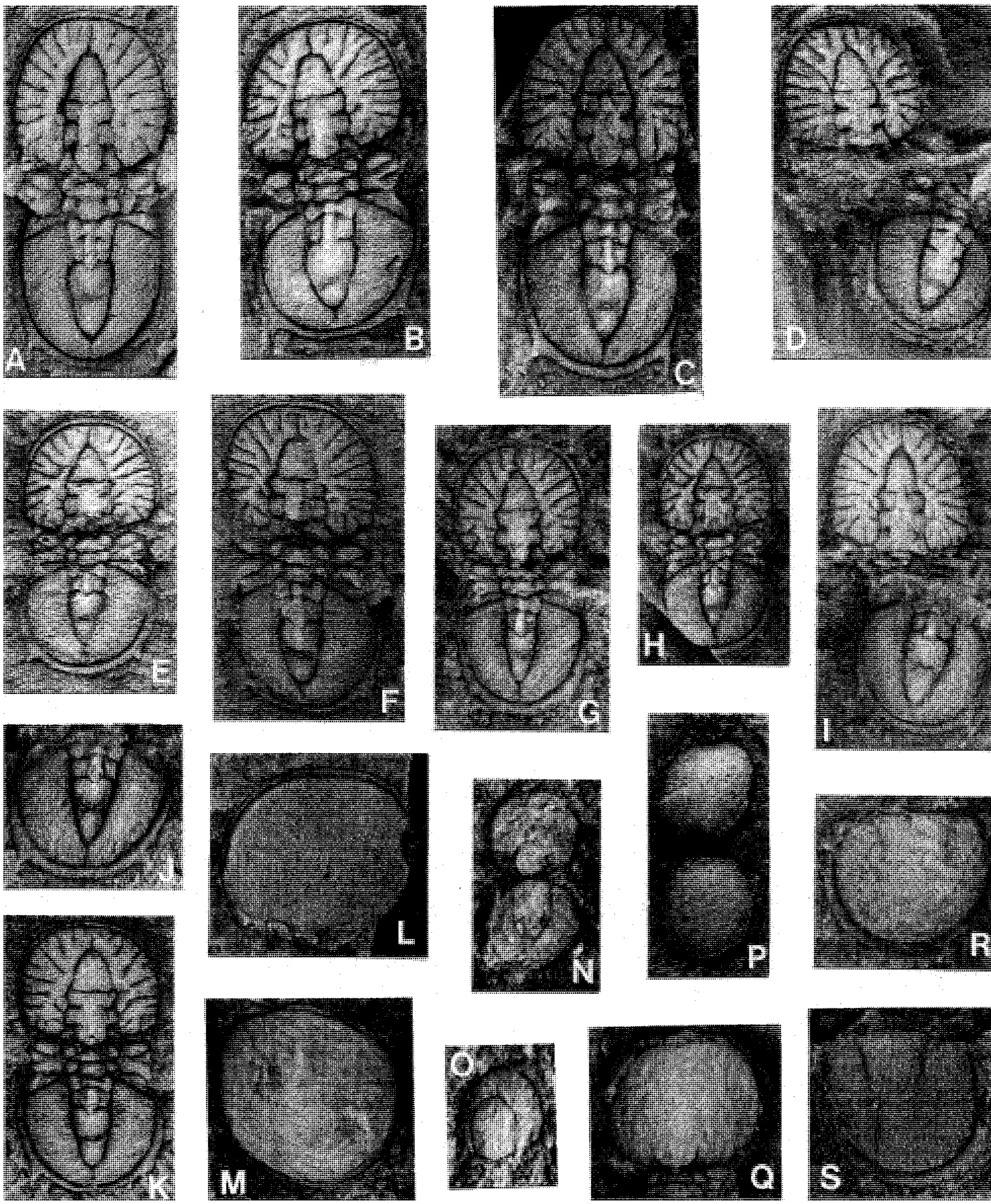
Material
Twenty-one complete, or nearly complete, specimens, plus ten separate cephala and seven separate pygidia. Specimens UTGD 125320a, b, 125321a, b, 125322–125324, 125325a, b, 125326a, b, 125328–125330.

Diagnosis
See Laurie (1989: 177).

Description
Cephalon slightly larger than pygidium, with weakly and finely pustulose surface; cephalon slightly wider than long. Well-developed radial scrobicules. Narrow border; narrow, shallow border furrow. Very short cephalic fulcral spines. Unconstricted acrolobe. Well-developed preglabellar median furrow. Well-defined axial furrows. Glabella length 0.75–0.8 that of cephalon; width about one-third of cephalon. Subtriangular anteroglabella has length about 0.4 that of glabella. F3 well developed; deflected slightly forwards centrally. F1, F2 well developed, extend about one-third of distance into glabella from either side; central part of posteroglabella raised well above lateral parts of glabella. Some specimens (e.g. pl. 1A) have shallow longitudinal furrows that separate the central and lateral parts of the glabella. Central part of glabella increases in height posteriorly. Small subtrapezoidal basal lobes.

Pygidium slightly wider than long. Low pustules on pleural areas coalesce to form a reticulate prosopon. Narrow, shallow border furrow; border widens posteriorly. Short posterolateral spines placed behind axial termination. Large shoulders and facets. Shallow postaxial median furrow shallows posteriorly to border furrow. Pygidial axis outlined by well-developed axial furrows. Axis about 0.7–0.8 length of pygidium; well-developed rosette with node. Axis constricted at M2 and at rosette. F1, F2 well developed. Central part of M1 and particularly M2 separated from lateral parts of axis by shallow longitudinal furrows that are more clearly developed on M2. Central part of M2 extends into a node that continues on to posteroaxis.

Discussion
These specimens fit into *Goniagnostus nathorsti* as discussed by Laurie (1989) and Peng & Robison (2000). *G. nathorsti,* as figured by Westergård (1946: pl. 12, figs 12-16), Öpik (1979: pl. 47, fig.6; pl.60, figs 1–5; pl.61, figs 1, 3–6), Xiang & Zhang (1985: pl. 20, figs 1–3, 6–10), Laurie (1989: fig. 1) and Peng & Robison (2000: fig. 56), shows considerable morphological variation. Variable features include the length of the glabella, the length and width of the pygidial axis and the position and length of the pygidial posterolateral spines. The Trial Ridge specimens show a similar variation, with some of the differences in appearance of the Tasmanian specimens, when compared to the specimens figured in the above papers, being due to the fact that the Trial Ridge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specimens are preserved in a siltstone rather than a limestone. The pygidial spines of the Trial Ridge specimens are longer than most of those shown in the specimens figured by Westergård (1946), Öpik (1979), Xiang & Zhang (1985), Laurie (1989) and Peng & Robison (2000). However, the pygidium figured by Laurie (1989: fig. 1B) has spines of similar length.

The pattern of scrobicules on *G. nathorsti* as figured herein is very similar to that of *G. spiniger* (Laurie 1989: figs 5, 6; Lu & Lin 1989: pl.8, figs 9–12), even down to the small scrobicules arising from the axial furrows just behind F_2. The fact that the only real difference between *spiniger* and *nathorsti* is the length of the cephalic and pygidial spines raises the question as to whether there should be a single species covering specimens normally described under *G. nathorsti* and *G. spiniger*. This is supported when it is noted that the spines in the specimens described from northwestern Tasmania by Jago (1976a) as *Ptychagnostus buckleyi* and placed in synonymy with *spiniger* by Laurie (1989) are intermediate in size between those of *spiniger* illustrated by Laurie and those of *nathorsti* illustrated herein. It could be argued that *spiniger* from Queensland, *buckleyi* from northwestern Tasmania and *nathorsti* from Trial Ridge are simply geographic variants of a single species. However, the difference in the spines of *spiniger* and *nathorsti* is so marked that the writers feel the continued separation into two species is warranted.

Genus *Lejopyge* Hawle & Corda, 1847

Type species

Battus laevigatus Dalman 1828: 136.

Remarks

The concept of *Lejopyge* has been discussed at some length by Daily & Jago (1975), Öpik (1979), Robison (1984, 1994), Laurie (1989), Westrop *et al.* (1996) and Peng & Robison (2000). On the basis of cladistic analysis Robison (1994) placed *Onymagnostus* in synonymy with *Lejopyge*. However, also on the basis of cladistic analysis, Westrop *et al.* (1996) placed *Onymagnostus* in synonymy with *Ptychagnostus*. Peng & Robison (2000) dispute the work of Westrop *et al.* and return *Onymagnostus* to *Lejopyge*. Shergold & Laurie (1997) maintained *Onymagnostus* as a separate genus. A detailed analysis of this matter is outside the scope of this paper, but we would suggest that *Onymagnostus* does not belong in *Lejopyge*. We would prefer to retain *Onymagnostus* as a separate genus.

Lejopyge laevigata (Dalman, 1828)
Pl. 1L–M,P–S; Pl. 2C

Synonymy

See Peng & Robison (2000).

Material

Two poorly preserved complete agnostoids, five poorly preserved cephala and four reasonably well-preserved pygidia are available. Specimens UTGD 125331, 125332a, b, 125335a, b, 125336–125338, 125441.

Remarks

The available cephala are poorly preserved. The very posterior of the glabella is outlined by shallow axial furrows; the basal lobes are very small. The pygidia, which are better preserved, have a narrow, shallow border furrow and a narrow, flat border. The anterior part of the axis is outlined by shallow furrows which fade posteriorly, becoming effaced about the position of the F2 furrow. There is a low node on M2; posterolateral spines are absent.

These specimens are assigned to *Lejopyge* based on the narrow pygidial border, the lack of pygidial spines and the high degree of effacement, suggesting affiliation with either *L. laevigata* or *L. calva*, with the former being preferred.

Family SPINAGNOSTIDAE Howell, 1935a
Genus *Hypagnostus* Jaekel, 1909

Hypagnostus Jaekel 1909: 399; Kobayashi 1939: 122; Lermontova 1940: 129; Westergård 1946: 43 (part); Ivshin 1953: 17; Howell 1959: 184; Öpik 1961:57; Robison 1964: 529 (part); Lu *et al.* 1965: 44; Öpik 1967: 82; Palmer 1968: 31 (part); Jago 1976a: 140 (part); Öpik 1979: 65; Lu & Lin 1989: 105; Shergold *et al.* 1990: 43; Jago & Webers 1992: 106; Westrop *et al.* 1996: 822; Shergold & Laurie 1997: 356; Peng & Robison 2000: 60.

Cotalagnostus Whitehouse 1936: 92; Kobayashi 1939: 129; Lermontova 1940: 129; Westergård 1946: 53; Howell 1959: 184; Robison 1964: 528; Shergold *et al.* 1990: 43; Shergold & Laurie 1997: 356.

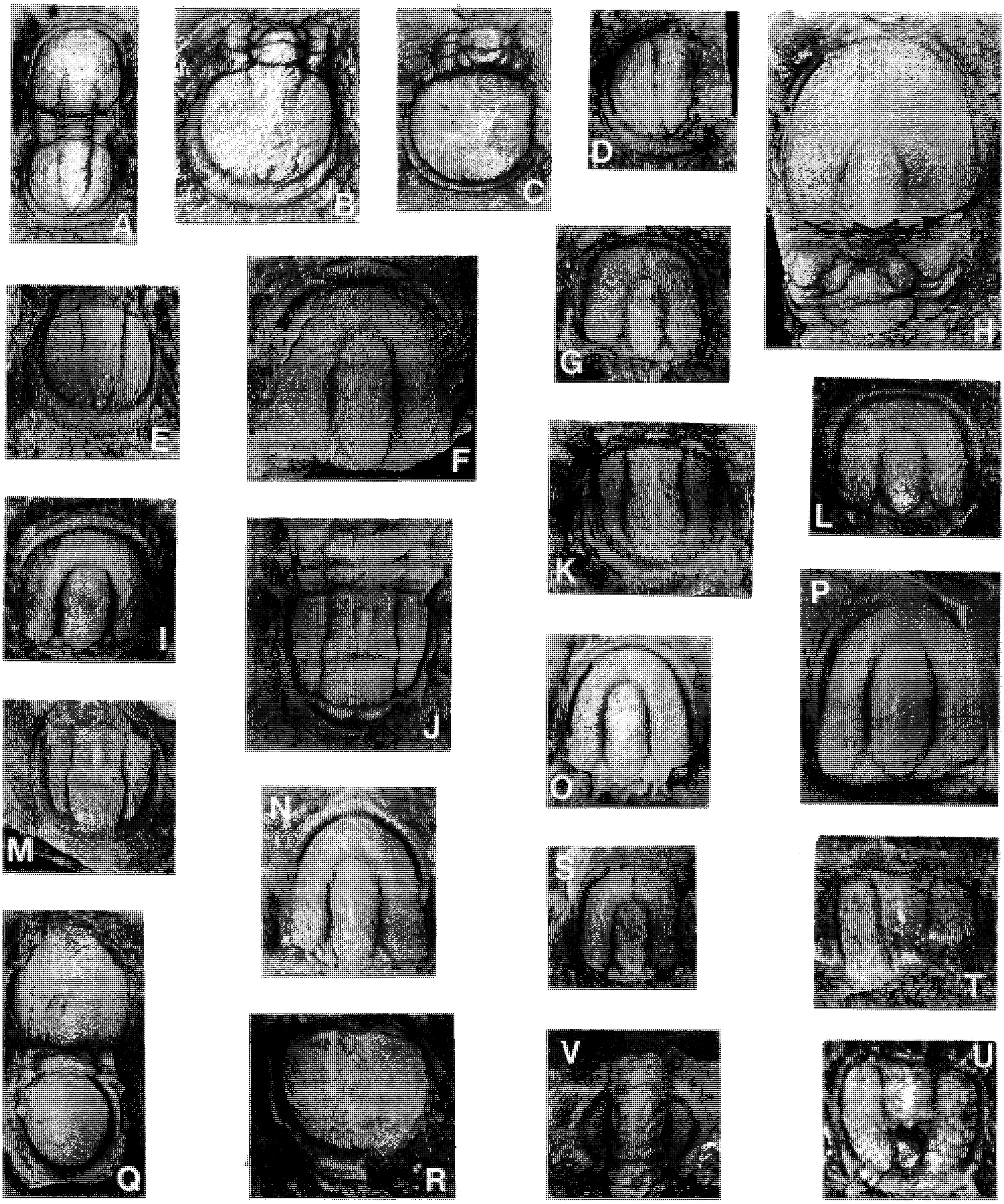
PLATE 1

(A–K) Goniagnostus nathorsti *(Brøgger 1878): (A) UTGD125320a complete specimen, holotype, silicone rubber cast of external mould, ×8; (B) UTGD125321b complete specimen, internal mould, ×8; (C) UTGD125322 complete specimen, internal mould, ×5; (D) UTGD125323 complete specimen, internal mould, ×8; (E) UTGD125324 complete specimen, silicone rubber cast of external mould, ×10; (F) UTGD125325a complete specimen, silicone rubber cast of external mould, ×8; (G) UTGD125326b complete specimen, internal mould, ×10; (H) UTGD125327 complete specimen, internal mould, ×10; (I) UTGD125328 disarticulated cephalon and pygidium, internal mould, ×6; (J) UTGD125329 pygidium, internal mould, X6; (K) UTGD125330 complete specimen, silicone rubber cast of external mould, ×8.*

(L–M, P–S) Lejopyge laevigata *(Dalman 1828): (L) UTGD125331 cephalon, internal mould, ×6; (M) UTGD125332b pygidium, internal mould, ×10; (P) UTGD125335b poorly preserved complete specimen, internal mould, ×10; (Q) UTGD125336 cephalon with thoracic segments, internal mould, ×15; (R) UTGD125337 pygidium, internal mould, ×15; (S) UTGD125338 pygidium, internal mould, ×7.*

(N,O) Lisogoragnostus *sp.: (N) UTGD125333 complete specimen, internal mould, ×20; (O) UTGD 125334 partial pygidium, silicone rubber cast of external mould, ×15.*

Specimens figured in L and S come from Locality 2; all others come from Locality 1.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Type species
Agnostus parvifrons Linnarsson 1869: 82, pl.2, figs 56, 57.

Diagnosis
See Shergold & Laurie (1997: 356), with the amendment that the F3 glabellar furrow may be effaced as may be the posterior parts of the axial furrows of the pygidium.

Discussion
Öpik (1979: 71) stated that although many authors had followed Westergård (1946: 44) in placing *Tomagnostella* in synonymy with *Hypagnostus*, he regarded *Tomagnostella* as a separate genus, a move supported by Robison (1988: 57), Lu & Lin (1989: 108), Shergold *et al.* (1990: 44), Jago & Webers (1992: 106), Shergold & Laurie (1997: 358) and herein.

The generally accepted concept of *Cotalagnostus* is that it is similar to *Hypagnostus* except that the F3 glabella furrow is effaced, as may be the posterior parts of the pygidial axial furrows. Many of the pygidia of *Cotalagnostus lens* and *C. lens claudicus* as illustrated by Westergård 1946 (pls 6, 7) and Hutchinson 1962 (pl. 6) are indistinguishable from those of *Hypagnostus.* Westergård (1946) and Robison (1964) considered *Cotalagnostus* evolved from *Hypagnostus* by effacement of furrows. Westrop *et al.* (1996) concluded that the difference between the two genera, i.e. the presence of a distinct F3 furrow on the cephalon of *Hypagnostus*, was arbitrary and regarded *Cotalagnostus* as a junior synonym of *Hypagnostus.* Shergold & Laurie (1997) maintained the separation of the two genera. Peng & Robison (2000) disputed the placement of *Cotalagnostus* in synonymy with *Hypagnostus*, on the grounds that *Cotalagnostus* is differentiated by the effacement of F3 and the greater effacement of its axial furrows on both the cephalon and pygidium. We accept *Cotalagnostus* as a junior synonym of *Hypagnostus* on the grounds given by Westrop *et al.* (1996) and because, as noted above, it is difficult to distinguish the pygidia of the two genera.

Hypagnostus trali sp. nov.
Pl. 2A, B, D, E

Derivation of name
Anagram of Trial.

Material
The holotype, a complete specimen (UTGD125339), a pygidium with thorax attached (UTGD 125340) and two pygidia (UTGD 125342–43) are assigned to this species.

Holotype
Complete specimen UTGD125339 (Pl. 2A) is selected as holotype.

Diagnosis
Both cephalon and pygidium have unconstricted acrolobes, narrow borders and narrow, shallow border burrows. Posterior part of glabella outlined by shallow axial furrows. Narrow pygidial axis extends almost full length of acrolobe; F1 and F2 effaced. Terminal axial node present.

Description
Complete specimen 3.5 mm long. Acrolobes unconstricted. Cephalon about as wide as long. Narrow, shallow border furrow; narrow convex border. Small basal lobes. Broadly rounded glabellar posterior. Posterior part of glabella outlined by shallow axial furrows which extend almost 0.4 length of cephalon to a position just short of where F3 would be. Pygidium about as wide as long. Narrow, shallow border furrow; narrow, convex border widens posteriorly. Narrow pygidial axis extends almost full length of acrolobe; slight constriction at position of M2. F1, F2 effaced. Terminal axial node present.

Discussion
The pygidial axis of *trali* is narrower and extends further to the posterior than in *H. lens* or the subspecies *H. lens claudicans* (Westergård 1946). The pygidium of *H. confusus* is more effaced than that of *trali*, and where the outline of the axis of *confusus* can be seen (Westergård 1946: pl.7, figs14, 16, 19), it is shorter than that of *trali*. *H. laevus* is

PLATE 2

(A,B,D,E) Hypagnostus trali *sp. nov.: (A) UTGD125339 complete specimen, holotype, internal mould, ×10; (B) UTGD125340a pygidium with thorax attached, silcone rubber cast of external mould, ×12; (D) UTGD125342 small pygidium, silicone rubber cast of external mould, ×20; (E) UTGD125343 pygidium, internal mould, ×7.*
(C) Lejopyge laevigata *(Dalman 1828). UTGD125341 pygidium and thoracic segments, silicone rubber cast of external mould, ×10.*
(F,I,J,M–P) Oidalagnostus changi *Lu 1964: (F) UTGD125344 cephalon internal mould, ×8; (I) UTGD125347 cephalon, internal mould, ×6; (J) UTGD125348 pygidium and thoracic segments, internal mould, ×7; (M) UTGD125351 pygidium, internal mould, ×5; (N) UTGD125352 cephalon, internal mould, ×10; (O) UTGD125353 cephalon, internal mould, ×8; (P) UTGD125354 cephalon, silicone rubber cast of external mould, ×10.*
(G,K,L) Ammagnostus laiwuensis *(Lorenz 1906): (G) UTGD125345 cephalon, internal mould, ×5; (K) UTGD125349 pygidium, internal mould, ×6; (L) UTGD 125350 cephalon, internal mould.*
(H) Hypagnostus brevifrons *(Angelin 1851) UTGD125346 cephalon and thoracic segments, internal mould, ×8.*
(Q) Glaberagnostus *sp. UTGD125355b complete specimen, internal mould, ×6.*
(R) Valenagnostus *sp. UTGD125356 partial pygidium, internal mould, ×15.*
(S) Agnostoid gen. et sp. indet. UTGD125357 cephalon, internal mould, ×15.
(T, U) Clavagnostus *cf.* repandus *(Westergård in Holm & Westergård 1930): (T) UTGD125358 partial pygidium, internal mould, ×8; UTGD125359 pygidium, internal mould, ×10.*
(V) Bathyuriscus *(?) sp. UTGD125360 partial cranidium, internal mould, ×10.*
Specimens figured in A–D, I,J, N–R, T and U come from Locality 1; those figured in E–H, K–M, S and V come from Locality 2.

much more effaced than *trali* (Robison 1964: pl.80, figs 17–28). The pygididial axis of *Cotalagnostus* sp.1 of Egorova *et al.* (1982: pl.14, fig. 14) extends to the posterior of the acrolobe as in *trali* but is wider than that of *trali*. The pygidium of *trali* is similar to that of *H. hippalus* Öpik 1961; however, the cephalon of *hippalus* is quite different.

Hypagnostus brevifrons (Angelin, 1851) Pl. 2H

Synonymy
See Peng & Robison (2000).

Material
One cephalon with attached thoracic segments (UTGD 125346).

Remarks
As noted by Peng & Robison (2000) and other authors, cephala of *H. brevifrons* and *H. parvifrons* are difficult to distinguish. However, when compared with previously illustrated material, this cephalon appears to fit better into *H. brevifrons.*

Genus *Lisogoragnostus* Rozova in Lisogor, Rozov & Rozova, 1988

Synonymy
See Peng & Robison (2000).

Type species
Lisogoragnostus kalisae Rozova in Lisogor *et al.* (1988: 64, pl. 5, fig. 9).

Diagnosis
See Peng & Robison (2000: 64) with the amendment that the pygidium may have a narrow border.

Remarks
Peng & Robison (2000) discussed the genus comprehensively. The pygidium described by Jago (1976a: pl. 26, fig. 15) as Agnostid, gen. et sp. indet. no. 1 figured from St Valentines Peak, Tasmania, should be included in *Lisogoragnostus.* The explanation for plate 26, figure 15 in Jago (1976a) is incorrect in that it states that the specimen is Agnostid, gen. et sp. indet. no. 2.

Lisogoragnostus sp. Pl. 1N,O

Material
One almost complete specimen (UTGD 125333) and a partial pygidium (UTGD 125334). Neither specimen is well preserved.

Description
Both available specimens small. Complete specimen (pl. 1N) length of 1.5 mm. Acrolobes unconstricted. Cephalon about as wide as long. Very narrow, shallow border furrow; very narrow border. Very small basal lobes. Shallow axial furrow effaced forwards of F3. F3 very shallow; concave anteriorly. Posteroglabella has length about 0.4–0.45 of glabella. Pygidium about as wide as long. Narrow, shallow border furrow; narrow, flat border. Narrow, shallow axial furrow. Axis has length about 0.6–0.65 and width about 0.5 of pygidium. Axis parallel-sided for about 0.75 of length from where it narrows to angulate posterior. F1, F2 effaced. Smooth pleural fields.

Remarks
These specimens differ from previously described species of *Lisogoragnostus* by the presence of a distinct pygidial border. However, the preservarion is not good enough to justify the erection of a new species. The Trial Ridge specimens are probably closest to *L. hybus* Peng & Robison (2000: fig.47). However, the cephalon of *L. hybus* is more elongated than the Trial Ridge specimens. The pygidial axis of the Trial Ridge species appears to be angulate in a manner similar to the pygidia described and figured by Rasetti (1967: 38, pl. 10, figs 22–26) as Agnostida, pygidium no. 1, which belong in *Lisogoragnostus* (Peng & Robison 2000). However, preservation of our specimens makes it difficult to be certain about this matter. The anteroaxis of the Trial Ridge specimens is more parallel-sided than in the specimen of *Lisogoragnostus* illustrated by Jago (1976a: pl. 26, fig. 15) as Agnostid gen. et sp. indet. no. 1.

Family AMMAGNOSTUS Öpik, 1967 Genus *Ammagnostus* Öpik, 1967

Synonymy
See Peng & Robison (2000: 25).

Type species
Ammagnostus psammius Öpik 1967: 139, pl. 55, fig. 3; pl. 66, figs 1–4; text fig. 40.

Diagnosis
See Peng &Robison (2000: 25).

Ammagnostus laiwuensis (Lorenz, 1906) Pl. 2G, K, L

Synonymy
See Peng & Robison (2000: 27).

Material
Three cephala and one pygidium. Specimens UTGD 125345, 125349, 125350.

Diagnosis
See Peng & Robison (2000: 29).

Remarks
These specimens fit *Peronopsis ekip* of Jago (1976a), which was placed in synonymy with *Ammagnostus laiwuensis* (Lorenz, 1906) by Peng & Robison (2000). This synonymy is accepted herein.

Family DIPLAGNOSTIDAE Whitehouse, 1936
Subfamily OIDALAGNOSTINAE Öpik, 1967
Genus *Oidalagnostus* Westergård, 1946

Synonymy
See Peng & Robison (2000).

Type species
Oidalagnostus trispinifer Westergård (1946: 65, pl. 9, figs 4–7).

Diagnosis
See Peng & Robison (2000).

Discussion
Robison (1988: 37) discussed *Oidalagnostus* and related genera in some detail and concluded that *Ovalagnostus* Lu 1974 (type species, *O. changi* Lu *in* Lu *et al.* 1974) and *Tasagnostus* Jago 1976 (type species, *T. debori*) are junior synonyms of *Oidalagnostus* Westergård 1946. Lu & Lin (1989: 81) placed *Tasagnostus* in synonymy with *Ovalagnostus,* which they retained as a separate genus from *Oidalagnostus*. Peng & Robison (2000) included *Ovalagnostus* as a junior synonym of *Oidalagnostus,* as did Shergold *et al.* (1990), Shergold & Laurie (1997) and the present authors. Peng & Robison (2000) place *Tasagnostus compani* of Jago (1976a) questionably in synonymy with *Oidalagnostus changi.* Certainly *compani* and *changi* are quite close and belong in the same genus, *Oidalagnostus,* but better specimens of both species are required before a final assessment is made. Peng & Robison (2000) included *Tasagnostus* as a junior synonym of *Diplagnostus.* However, the two genera are clearly differentated on the basis of the structure of the pygidial axis and the glabellar anterior. Rushton (1978: 264) pointed out that genera such as *Oidalagnostus, Tasagnostus, Cristagnostus, Oedorhachis, Linguagnostus* and *Dolichagnostus* are best distinguished in the features of the pygidial axis.

Shergold *et al.* (1990) placed *Tasagnostus* in the Diplagnostinae along with *Diplagnostus, Baltagnostus, Dolichagnostus, Linguagnostus* and *Oedorhachis,* with *Iniospheniscus* being included questionably in the Diplagnostinae. They suggested that *Diplagnostus, Linguagnostus, Dolichagnostus* and *Tasagnostus* fit into a tight morphological group characterised by a zonate pygidium in combination with an axiolobate or only slightly modified axiolobate condition, frequently with a transverse depression on the anterior of the posterior pygidial lobe and an often sulcate anterior glabellar lobe. Shergold & Laurie (1997) added *Acadagnostus* to the Diplagnostinae.

Shergold *et al.* (1990) and Shergold & Laurie (1997) placed *Oidalagnostus,* along with *Cristagnostus,* in the Oidalagnostinae and characterised the subfamily as having a zonate pygidium, but with a gap in the pygidial collar. They stated that the anteroaxis of the pygidium comprises three segments, that the posterior lobe is subquadrate and extends to the pygidial collar, and that a third, centrally placed marginal spine is present. They suggested that the major features in the phylogeny of *Oidalagnostus* and *Cristagnostus* are the separation of the anterior portion of the posterior lobe of the axis as the third segment of the anteroaxis and the presence of lateral bosses as appendages of this third segment.

As revised above, the only two species of *Tasagnostus* are *T. debori* Jago 1976a and *Tasagnostus* sp. Jago 1976b (pl. 2, fig.18). It is possible that *Tasagnostus* is ancestral to *Oidalagnostus,* with the best known species, *T. debori,* occurring in either the *L. laevigata* I or II Zones on the northern Australian biochronological scale. *O. compani* from St Valentines Peak, Tasmania, is from the *L. laevigata* III Zone or the *Damesella torosa-Ascionepea janitrix* Zone. However, in Queensland *Oidalagnostus* ranges from the *L. laevigata* II Zone through to the lower part of the *Acmarhachis quasivespa* Zone (Öpik 1967: table 4). Öpik (1967: 134) suggested that *O. trispinifer* is found in the *Glyptagnostus stolidotus* Zone of Tasmania. However, to the best of the authors' knowledge, the youngest known *Oidalagnostus* from Tasmania is from the Brewery Junction Formation at Dundas, where it is in either the *Erediaspis eretes* or *Acmarhachis quasivespa* Zone (Jago 1972).

Oidalagnostus changi Lu, 1964
Pl. 2F, I, J, M–P

Synonymy
See Peng & Robison (2000: 56).

Material
Nine cranidia and four pygidia, three of which have attached thoracic segments. Illustrated specimens UTGD 125344, 125347–125348, 125351–125354.

Diagnosis
See Peng & Robison (2000: 57).

Remarks
These specimens are similar to *Oidalagnostus changi* as illustrated by Peng & Robison (2000: fig. 43). The cranidia show some variation. The anterior margin may show a distinct anterior angularity (pl. 2O), may be quite smooth (pl. 2I) or have a slight angularity (pl. 2F, N). The depth of the transverse glabellar furrow is variable, as is the shape of the glabellar posterior. In the pygidium the pleural fields are slightly pitted. The collar is separated from the axis by a shallow, narrow furrow; the knobs on the collar are well developed. There is a well-developed furrow between the collar and the pygidial border.

Family CLAVAGNOSTIDAE Howell, 1937
Subfamily CLAVAGNOSTINAE Howell, 1937
Genus *Clavagnostus* Howell, 1937

Type species
Agnostus repandus Westergård in Holm & Westergård, (1930:13, pl.4, figs 11, 12 only).

Diagnosis
See Jago & Daily (1974: 97).

Clavagnostus cf. *repandus* (Westergård *in* Holm & Westergård 1930)
Pl. 2T, U

Material
Two small, poorly preserved pygidia, UTGD 125358–59.

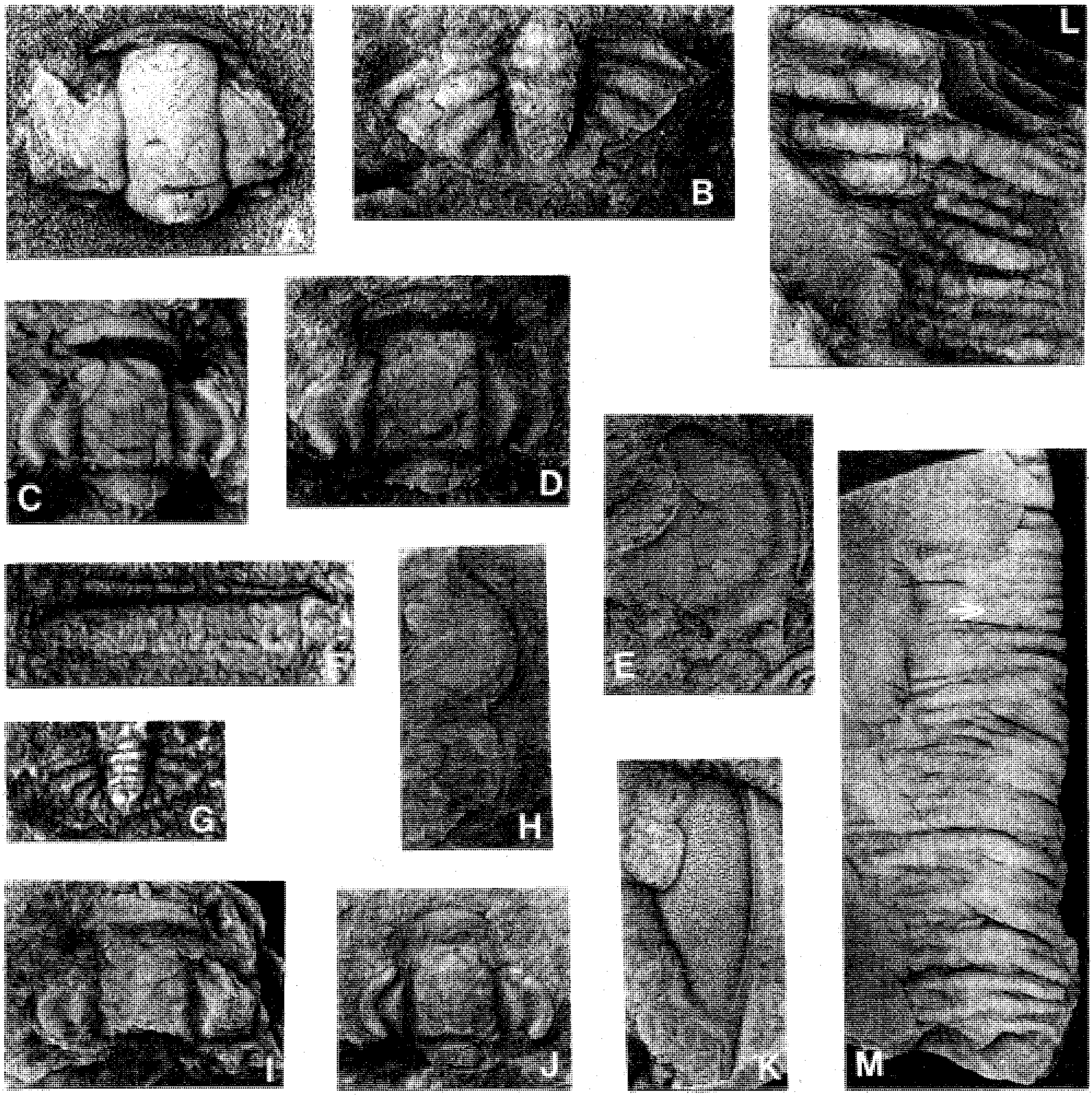

PLATE 3

(A, G) Amphoton *sp.: (A) UTGD125361a cranidium, silicone rubber cast of external mould, ×4; (G) UTGD125367 pygidium, internal mould, ×10.*
(B) Fuchouia *sp. UTGD125362 pygidium, silicone rubber cast of external mould, ×5.*
(C–E, H–J) Proasaphiscidae gen. et sp. indet.: (C) UTGD125363 cranidium, internal mould, ×4; (D) UTGD125364 cranidium, internal mould, ×6; (E) UTGD125365 right librigena, silicone rubber cast of external mould, ×8; (H) UTGD125368 right librigena, internal mould, ×5; (I) UTGD125369 partial cranidium, internal mould, ×3; (J) UTGD125370 cranidium, internal mould, ×6.
(F, K) Papyriaspidae gen. et sp. indet.: (F) UTGD125366 partial thoracic segment, silicone rubber cast of external mould, ×10; (K) UTGD125371 right librigena, silicone rubber cast of external mould, ×5.
(L, M) Trace fossils: (L) UTGD125372 internal mould, ×2; (M) UTGD125373b internal mould, ×1. The arrow points to a small complete specimen of Goniagnostus nathorsti *resting on the tracks.*
Specimens figured in A, F, G, and K–M come from Locality 1; those figured in B–E and H–J come from Locality 2.

Remarks
These pygidia are similar to *C. repandus* as described and illustrated by Westergård (1946), and in particular to the pygidium figured by Westergård (1946: pl.4, fig.22) and refigured by Jago & Daily (1974: 11, fig.4).

Family INCERTAE SEDIS
Genus *Glaberagnostus* Romanenko, 1985

Type species
Glaberagnostus altaicus Romanenko 1985: 57, pl. 5, figs 5–7.

Diagnosis
See Peng & Robison (2000: 90).

Glaberagnostus sp.
Pl. 2Q

Material
One almost complete specimen, UTGD125355a, b.

Description
Specimen length, 7.0 mm. Cephalon almost completely effaced; only very posterior of glabella distinguished. Border appears absent. Position of any glabellar node indeterminate due to preservation. Pygidium with wide border and border furrow; low centrally placed node about 0.2 of distance from anterior to posterior of acrolobe.

Genus *Valenagnostus* Jago, 1976a

Type species
Agnostus nudus Beyrich var. *marginata* Brøgger 1878: 73, pl. 6, fig. 3.

Diagnosis
See Jago (1976a: 142).

Valenagnostus sp.
Pl. 2R

Material
Two small, poorly preserved pygidia. Illustrated specimen, UTGD 125356.

Remarks
The effaced acrolobe, wide pygidial border and suggestion of a terminal axial node suggest affiliation with *Valenagnostus*.

Agnostoid gen. et sp. indet.
Pl. 2S

Material
Five cephala. Illustrated specimen, UTGD 125357.

Description
Narrow border; border furrow of moderate width. Glabella 0.6–0.7 length of cephalon. F1, F2 short, shallow; F3 shallow, straight. Posteroglabella length about 0.7 that of glabella. Glabellar posterior broadly rounded. Shallow preglabellar median furrow extends to anterior border. Small basal lobes confluent behind glabella. Smooth cheeks.

Remarks
These small cephala are not assigned to any particular genus. They may belong in *Agnostus* or a related genus.

Family DOLICHOMETOPIDAE Walcott, 1916
Genus *Amphoton* Lorenz, 1906

Synonymy
See Zhang & Jell (1987: 62).

Type species
Amphoton steinmanni Lorenz (1906: 89, pl. 4, figs 15–17).

Amphoton sp.
Pl. 3A,G

Material
One well-preserved cranidium is available both as the internal and external mould (UTGD 125361a, b); a small pygidium (UTGD 125367) may belong in the same species.

Description
Amphoton with shallow occipital furrow; base of what appears to have been a strong occipital spine preserved. Lateral glabellar furrows entirely effaced. Shallow axial furrows. Glabellar anterior almost straight. Anterior border of moderate width; shallow anterior border furrow. Palpebral areas of fixigenae gently convex. Shallow palpebral furrows. Narrow posterolateral limbs; well-developed posterior border furrow. Pygidial axis stops just short of posterior margin. Axis of four annulations plus terminus; four pairs of pleural furrows. No distinct border.

Remarks
The cranidium shows some similarities with *Amphoton deois*, although the anterior border of *deois* is a little wider, the palpebral areas of the fixed cheeks are a little narrower, and the anterior sections of the facial suture of *deois* do not diverge as much as those of the Trial Ridge form.

The characters of the pygidium, including the absence of a distinct border, suggest affiliation with *Fuchouia* rather than *Amphoton* (e.g. Zhang & Jell 1987: 67). Although it is quite possible that the two specimens described here under *Amphoton* sp. belong in separate species or even separate, but related genera, they are placed together in open nomenclature until more material is obtained.

Genus *Fuchouia* Resser & Endo *in* Kobayashi 1935

Synonymy
See Zhang & Jell (1987: 66).

Type species
Bathyuriscus manchuriensis Walcott (1911: 97, pl. 16, fig. 4).

Fuchouia sp.
Pl. 3B

Material
One pygidium, UTGD 125362

Description
Although posterior of axis is poorly preserved there appear to be four axial annulations plus a terminus. Four pairs of pleural furrows, plus at least two pairs of faintly developed interpleural furrows. Very narrow border.

Remarks
The presence of the interpleural furrows and a very narrow border indicates that this pygidium belongs in *Fuchouia* rather than *Amphoton* (Zhang & Jell 1987: 67).

Genus *Bathyuriscus* Meek, 1873

Type species
Bathyurus(?) haydeni Meek (1873: 484).

Diagnosis
See Robison (1964: 534).

Bathyuriscus (?) sp.
Pl. 2V

Material
One partial cranidium, UTGD125360.

Remarks
This specimen is questionably assigned to *Bathyuriscus* as defined by Robison (1964: 534). In *Bathyuriscus* the glabella expands anteriorly, but this feature is not clear on the available specimen. Robison's diagnosis stated that the palpebral lobes have a length one-third that of the cranidium. However, although a complete cranidium is not available, it is probable that the palpebral lobes of the Tasmanian specimens are considerably longer. When compared with *Bathyuriscus fimbriatus* Robison 1964, *Bathyuriscus (?)* sp. has wider fixigenae.

Family PROASAPHISCIDAE Chang,1963
Proasaphiscidae, gen. et sp. indet.
Pl. 3C–E, H–J

Material
Six partial cranidia and several librigenae. Illustrated specimens, UTGD 125363–125365; 125368–125370.

Description
Large, convex subrectangular glabella about 0.75–0.8 cephalic length and about 0.43 cranidial length. Glabella tapers slightly forwards to a truncated front at anterior border furrow. Deep axial furrows. Lateral glabellar furrows very poorly defined. Shallow occipital furrow; occipital ring narrows abaxially. Long, crescentic palpebral lobes extend from just forwards of occipital furrow to about three-quarters length of glabella. Anterior ends of palpebral lobes close to axial furrows. Wide palpebral furrows. Palpebral areas of fixigenae gently convex. Gently convex anterior border furrow. Anterior sections of facial suture diverge slightly; posterior sections diverge markedly. Wide posterior border furrow. Gently convex librigena with shallow border furrow. Moderately wide border widens posteriorly and extends into long genal spine.

Remarks
These specimens belong to a new genus of the Proasaphiscidae that is also found in other late Middle Cambrian faunas from Tasmania, at Riana, Native Track Tier and St Valentines Peak (Laurie *et al.* 1995). Much better preserved, and more complete specimens, are known from these localities (Bao 1995).

Family PAPYRIASPIDIDAE Whitehouse, 1939

Papyriaspididae gen. et sp. indet.
Pl. 3F, K

Remarks
A single well-preserved partial librigena (UTGD 125371) and a partial thoracic segment (UTGD 125366) may belong in a single genus of the Papyriaspididae. It has a narrow border and part of a well-developed genal spine. A very well-developed and prominent caecal pattern radiates out from the shallow palpebral furrow. The librigena is similar to that figured by Öpik (1961: pl.15, fig. 6) for *Pianaspis sors* (Öpik).

Trace Fossils
Pl. 3L, M

Remarks
Two sets of what appear to be trilobite resting places occur at Locality 1. The larger one (Pl. 3M) has a length of almost 100 mm, while the smaller one (Pl. 3L) has a length of almost 30 mm. Both are incomplete. Given that only two specimens are available, it is difficult to assign these specimens to any particular ichnogenus, but they appear to be related to *Rusophycus*. One of the specimens (Pl. 3M) has a small specimen of *Goniagnostus nathorsti* resting on it.

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