**Supplementary Table 1.** Results of CA-ID-TIMS U-Pb analyses for zircons analysed in this study.

**Supplementary Figure 1.** Optical photomicrographs of zircon crystals subjected to CA-IDTIMS geochronology. Crystals are arranged from left to right and top to bottom in order of the ‘z#’ labels in Supplementary Table 1. The zircon crystals of sample SPBr-105.75 and SPCB-4.4 were photographed after chemical abrasion, while all other samples are illustrated prior to chemical abrasion. All images are presented at the same magnification.

**Supplementary Appendix 1. Cambrian tuff sample localities in SE Newfoundland**

**Branch Cove (Bn)**

Chamberlain’s Brook Formation, Easter Cove Member, sample BrC-CB-114, 6 cm K-bentonite 114 m from base of measured section and 11 m above unconformable base of Chamberlain’s Brook, Middle Cambrian, base Wuliuan, *Kiskinella* Zone of Fletcher (2006; section in Landing & Westrop, 1998, fig.b 14) (no zircons)

Brigus Formation, upper Jigging Cove Member, BRC-91.0, *Morocconus-Condylopyge eli* Assemblage, sample ca. 10 m below unconformable top of Brigus Formation (section in Landing & Westrop, 1998b, fig. 14) (no zircons)

**Duck Point (DP)**

Bonavista Group, Cuslett Formation, lower Stage 3, sample DP-69.85, Lower Cambrian, upper Fortunian, 69.85 m above unconformity with Chapel Island Formation, 5 cm. calcareous volcaniclastic sandstone (section in Landing & Benus, 1988, p. 62, fig. 36, discussion) (no zircons)

**Foster’s Point (FP)**

Manuels River Formation, base of formation, sample FPMR-0.00, 2 cm K-bentonite, middle Middle Cambrian (section in Landing & Westrop, 1998b, fig. 17) (no zircons)

**Highland Cove (HC)**

MacLean Brook Group, top of Cavendish Formation, sample HC-41 from black volcaniclastic sandstone 40.85–41.15 m from base of section, Middle Cambrian, possibly Guzhangian, post-*Paradoxides davidis* fauna? (no zircons)

**Hopeall Head (Ho)**

Manuels River Formation, basalt-granule to -pebble debris flows and channelized sandstones forming lower member 1, lenticular (to 5.5 m) interval mistakenly assigned to upper Chamberlain’s Brook Formation by Hutchinson (1962, beds 28–32), see Landing, Westrop & Geyer (2023, fig. 7 and text), samples HoMr-5.0 and HoMr-5.4 (no zircons)

**Manuels River (MR)**

Manuels River Formation, K-bentonites, samples (in metres) from base of formation (Landing & Westrop, 1998, fig. 7). Middle Cambrian; lower 2 samples probably Wuliuan, upper sample Drumian?, see Landing, Westrop & Geyer (2023) on problematical Drumian definition in Avalonia

Member 3 (lower): MRMr-14.2 (2–6 cm K-bentonite, no zircons)

Member 2 (top): MRMR-5.9 (2–4 cm K-bentonite, no zircons)

Member 1: MRMR-0.0 (to 7 cm K-bentonite; reworked Ediacaran zircons; G. Dunning *in* Landing, 1996)

**Red Bridge Road (RB)**

Chamberlain’s Brook Formation, Braintree Member: RBCB-1.2, Middle Cambrian, lower Wuliuan (5 cm K-bentonite 1.2 m from base of formation, Figure 3), 506.25 ± 0.07 Ma (this report).

Brigus Formation, St. Mary’s Member: RBBR-26.5, upper Lower Cambrian, *Callavia broeggeri* Zone (6 cm K-bentonite 26.5 m from base of formation, Figure 3), 507.91 ± 0.07 Ma (this report).

**Redland Cove (Re)**

Brigus Formation, Jigging Cove Member, sample ReBr-118.5, upper Lower Cambrian, probably correlative with uppermost Brigus at Fosters Point (above), 118.5 m above base of Brigus (see Fletcher, 2006) and 6 m below top of Brigus Formation (Figure 6); 507.21 ± 0.13 Ma (this report).

**Smith Point (SP)**

Chamberlain’s Brook Formation, lower Easter Cove Member, sample SPCB-4.4 (Figure 5), lower Middle Cambrian, *Kiskinella cristata* Zone (2 cm K-Bentonite 4.4 m from base formation), 506.34 ± 0.21 Ma (this report).

Brigus Formation, Jigging Cove Member, sample SPBr-105.75 (Figure 5), upper Lower Cambrian (3 cm K-bentonite 105.75 m from base Brigus, 507.67 ± 0.08 Ma (this report)

**SUPPLEMENTARY APPENDIX 2. SYSTEMATIC PALAEONTOLOGY**

A Systematic Palaeontology is appended to this report to discuss the taxonomic and biostratigraphic significance of newly recovered trilobites and agnostid arthropods in the context of U-Pd dates on associated tuffs. Cite this Supplementary Appendix as SR Westrop (*in* Landing *et al*., this report). Illustrated specimens are reposited in the New Brunswick Museum, Saint John (NBMG). The specimens were coated with ammonium chloride prior to photography. Depth of field was maximised by rendering digital images from stacks of images focused at 100 µm intervals using Helicon Focus 4.0 for the Macintosh <http://www.heliconsoft.com>. Measurements were made on digital images to the nearest 0.1 mm using the Measure Tool of Adobe Photoshop™.

Genus *Mallagnostus* Howell, 1935

*Type species*. *Agnostus* *desideratus* Walcott, 1890a, from Hatch Hill Formation, Salem, Washington County, New York (by original designation).

*Discussion*. A flattened pygidium from collection SPBr-40.45 resembles *Eodiscus* *llarenai* Richter & Richter, 1941, in having a relatively long border (compare Figure 9f with Collantes *et al.*, 2022, fig. 9L). This species has a tangled nomenclatural history, and its classification and relationships (and hence the specimen from SPBr-40.45) are uncertain. Examination of the sclerites of the type and other species of *Eodiscus* Hartt *in* Walcott, 1884 (Westrop *et al*., 2018, figs. 2–14) shows *E.* *llarenai* was misassigned by Richter & Richter (1941). Rushton (1966) suggested that the Spanish topotypes and additional specimens from Avalonian England belong to *Ladadiscus* Pokrovskaya, 1959, but Blaker & Peel (1997) transferred *E.* *llarenai* to *Serrodiscus* Richter & Richter, 1941. Jell (1997; *in* Jell & Adrain, 2002) included the species in *Mallagnostus* Howell, 1935, which they considered the senior synonym of *Ladadiscus* and, possibly, *Jinghediscus* Xiang & Zhang *in* Wang *et al*. (1985). Recently, Collantes *et al*. (2022) treated *E*. *llarenai* as a synonym of *Serrodiscus* *bellimarginatus* (Shaler & Foreste, 1888), and interpreted the differences between these species, including the much shorter pygidial border and presence of robust, spinose pygidial axial nodes in the latter (e.g., Westrop & Landing, 2011, figs. 6A–C, 10A–C), to reflect taphonomic deformation in the latter.

In assigning *Eodiscus* *llarenai* to *Ladadiscus*, Rushton (1966) recognised it lacked the distinctive transverse furrows on the cephalon of the type species, *L*. *limbatus* Pokrovskaya, 1959. These furrows (e.g., Pokrovskaya, 1959, pl. 11, figs. 7, 8, 11, 12, 15), which are clearly distinct from the border furrow, intersect the preglabellar furrow and isolate a preglabellar platform from the rest of the cephalon. Rushton (1966, p. 24) proposed these furrows were ‘of specific importance only,’ but this interpretation cannot be evaluated without a broader phylogenetic analysis. It is also worth noting that the pygidial border of *L*. *limbatus* is a narrow (sag., exsag.), convex rim (e.g., Pokrovskaya, 1959, pl. 11, figs. 5, 10, 14) that is much shorter than in *E*. *llarenai* (e.g., Collantes *et al*., 2022, fig. 9L; see also Rushton, 1966, pl. 3, figs. 19, 20). These differences cast doubt on assignment of *E*. *llarenai* to *Ladadiscus*.

The type species of *Jinghediscus*, *J*. *nummularius* Xiang & Zhang *in* Wang *et al*. (1985) also has a long pygidial border comparable to *E*. *llarenai* and, as the specimen from SPBr-40.45, the pygidial axis ends short of the border furrow and has well-defined segments on the internal mould (Xiang & Zhang *in* Wang *et al*., 1985, pl. 1, fig. 6; Jell, 1997, fig. 246.4b). However, segmentation of the pygidial axis is only expressed on the visceral side of the exoskeleton, and the external surface is smooth (Xiang & Zhang *in* Wang *et al*., 1985, pl. 1, figs. 10, 11). The *J*. *nummularius* cephalon has an anterior transverse furrow that seems identical to the furrow on *L*. *limbatus*. It is best defined on smaller specimens (e.g., Xiang & Zhang *in* Wang *et al*., 1985, pl. 1, figs. 2, 5) and becomes shallower in larger individuals (e.g., Xiang & Zhang *in* Wang *et al*., 1985, pl. 1, figs. 3, 7). However, there is uncertainty whether these remarkably similar furrows are actually homologous as the glabellar morphologies of *J*. *nummularius* and *L*. *limbatus* are dramatically different. *Jinghediscus* *nummularius* has a tapered glabella that is unequally divided by a firmly impressed furrow into a posterior and shorter anterior lobes. This bilobed configuration recalls *Tannudiscus* Pokrovskaya, 1959, as do the effaced axial rings on the pygidium (e.g., Rushton, 1966, pl. 3, figs. 8–14), although the large glabella of this genus is nearly parallel-sided and dominates the cephalon. In contrast, *Ladadiscus* has a narrow, parallel-sided to gently-tapered glabella that, as far as can be determined from Pokrovskaya’s (1959, pl. 11, figs. 6–8, 11) photographs, lacks furrows on the pre-occipital glabella. The glabella structure of *E*. *llarenai* (including specimens brought to the species by Rushton [1966]) is also unlike the configuration of *J*. *nummularius* (e.g., Richter & Richter, 1941, pl. 2, fig. 25; Rushton, 1966, pl. 3, figs. 16–18) and an assignment to *Jinghediscus* seems unlikely.

Jell (1997) suppressed *Ladadiscus* as a junior synonym of *Mallagnostus* Howell, 1935, but the type species of the latter, *M*. *desideratus* (Walcott, 1890a), is known only from one figured cephalon (Rasetti & Theokritoff, 1967, pl. 20, fig. 31) that lacks the transverse furrows of *L*. *limbatus*. Further collecting in the type area failed to provide any additional information (e.g., Rasetti, 1967). The glabellar outline of *M*. *desideratus* is broadly similar to *L*. *limbatus*, but, instead of a transverse furrow and convex preglabellar platform, it has a broad, apparently gently concave region between the glabella and border furrow. Walcott (1890a, p. 39; Walcott, 1890b, p. 629, repeats the 1890a text) mentioned a pygidium ‘associated with the head on the same piece of rock,’ but it has not been illustrated nor mentioned by Rasetti & Theokritoff (1967). Jell (1997, fig. 248.1a, 1b) illustrated the *M*. *desideratus* cephalon but used the holotype of *E*. *llarenai* as a proxy for the pygidium. Walcott's (1890a) brief description notes this specimen has a prominent, unfurrowed axis that terminates near the border and refers to ‘an elongate median tubercle.’ However, this description does not cast light on the potential relationships of *Mallagnostus*.

Rasetti & Theokritoff (1967, p. 190) proposed that *Mallagnostus* should be restricted to the holotype of *M*. *desideratus*, and this is followed herein. This leaves *E*. *llarenai* in taxonomic limbo, but at the current state of knowledge, establishment of a new genus seems unwarranted. As an interim step, *E*. *llarenai* is assigned to ‘*Mallagnostus,*’ with quotation marks (Wiley, 1979) to indicate the uncertainty about the status of the genus, and relationship of *M*. *desideratus* and ‘*M*.’ *llarenai*.

Collantes *et al*. (2022) proposed synonymy of *E*. *llarenai* and some species of *Serrodiscus* with *S*. *bellimarginatus* (Shaler & Foerste, 1888). They made use of new material (Collantes *et al*., 2022, figs. 5–8) from Lower Cambrian strata of Spain that comprises variably compacted and distorted sclerites preserved mostly as internal moulds. Unfortunately, Collantes *et al*.’s (2022) interpretation of *S*. *bellimarginatus* is limited by the nature of their specimens. As they note, taphonomic deformation has introduced morphologic variability, so that some characters may be unreliable for systematic work. However, at the risk of stating the obvious, these issues apply only to poorly preserved material. Collantes *et al*. (2022, p. 300) assign a wide range of material to *S. bellimarginatus*:pygidia with small axial nodes on most of what are well-defined axial rings (e.g., Collantes *et al*., 2022, fig. 7I, M), specimens with nodes present only posteriorly (e.g., Collantes *et al*., 2022, fig. 7J, L), and specimens with weak axial rings that lack nodes entirely (e.g., Collantes *et al*., 2022, fig. 8A–C). They interpret this spectrum of morphotypes as recording loss of nodes and weakening of axial rings due to differences in taphonomic overprint. However, Collantes *et al*. (2022, p. 308) also followed Westrop & Landing (2011) in using the expression of the axial rings and nodes as characters to separate *S*. *bellimarginatus* and *S.* *speciosus* (Ford, 1873). Well-preserved, undeformed specimens demonstrate the utility of characters of the pygidial axis. *Serrodiscus* (*s.l*.) ‘*bellimarginatus*’ from SE Newfoundland (see Westrop & Landing, 2011, pp. 227, 229 for the rationale for using quotation marks for this species) has well defined axial rings and ring furrows with at least the first five rings having large, spinose axial nodes (e.g., Westrop & Landing, 2011, figs. 8–10). In contrast, *Serrodiscus* (*s.l*.) *speciosus* (Ford, 1873) from New York has shallow axial ring furrows and weakly convex rings, none of which carry axial nodes (e.g., Westrop & Landing, 2011, fig. 14).

Collantes *et al*. (2022) may be correct, and taphonomic deformation of their material from Spain effectively mimics biological differences that can be observed in well-preserved sclerites from other regions. However, it is impossible to be sure about this, and in any event, it does allow wholesale synonymy of species. Pygidia with poorly defined axial rings that lack nodes (e.g., Collantes *et al*., 2022, fig. 7A) and those with better differentiated rings that carry nodes (Collantes *et al*., 2022, fig. 9O) could reflect real biological differences as in *S*. (*s.l.*) ‘*bellimarginatus*’ and *S.* (*s.l*.) *speciosus*, respectively, even if overprinted by the effects of compaction. Moreover, where present, axial nodes on axial rings from Spain are uniformly small (Collantes *et al*., 2022, fig. 7B, I, J, M–O, P, S, U), whereas it is clear that those of *S*. (*s.l.*) ‘*bellimarginatus*’ from SE Newfoundland are larger, more robust features, even when broken (e.g., Westrop & Landing, 2011, figs. 6A, B, 10A, B). It is possible that the smaller nodes in the Spanish material are entirely due to taphonomic distortion, but well-preserved specimens demonstrate that there are species with genuinely small nodes (e.g., *S*. *mackenziensis* Fritz; see Fritz, 1973, pl. 3, figs. 3–8). Thus, separating taphonomic overprint and real biological character variation is not straightforward. Given these uncertainties, it is difficult to identify Collantes *et al*.’s (2022) new material confidently to the species level, and use of open nomenclature would be preferable (i.e., as *Serrodiscus* cf. *S*. *serratus* Richter & Richter, 1941).

The problems discussed above underscore the pitfalls of basing revisionary systematics on poorly preserved material. Collantes *et al*. (2022) certainly identified problems with the diagnosis of some *Serrodiscus* species, including the type species *S*. *serratus*. However, it is a cautionary tale about the utility of compacted, deformed sclerites, rather than a justification for sprawling synonymy lists. A different approach would recognise the limitations of deformed sclerites, and restrict species based on compacted specimens to the type material.

*Serrodiscus* *daedalus* Öpik, 1975, has a pygidium with a long border and well-segmented axis (e.g., Öpik, 1975, pl. 3, fig. 9) that resembles *E*. *llarenai*. However, the cephalon (e.g., Öpik, 1975, pl. 3, figs. 5–7) has a border that is much longer than in *E*. *llarenai*, with well-developed tubercles, and the glabella has conspicuous lateral and transglabellar furrows that contrast with the unfurrowed glabella of *E*. *llarenai*. A relationship between *E*. *llarenai* and *S*. *daedalus* lacks strong character support. It is worth noting that the independent phylogenetic analyses of Cotton & Fortey (2005, fig. 3) and Westrop & Landing (2011, fig. 3) indicate *Serrodiscus* is paraphyletic, and there is some evidence that *S*. *daedalus* may be more closely related to species of *Meniscuchus* Öpik, 1975 (Cotton & Fortey, 2005, fig. 3) than to species such as *S*. *speciosus*.

‘*Mallagnostus*’ cf. ‘*M*.’ *llarenai* (Richter & Richter, 1941)

Figure 9f

cf*.* 1941 *Eodiscus* (*Eodiscus*) *llarenai* Richter & Richter, p. 23, pl. 2, figs. 25, 26, pl. 4, fig. 58.

cf. 1966 *Ladadiscus* *llarenai* (Richter & Richter); Rushton, p. 24, pl. 3, figs. 16–20, text-fig. 9a.

cf. 1975 *Serrodiscus* *llarenai* (Richter & Richter); Öpik, p. 27.

cf. 1997 *Serrodiscus* *llarenai* (Richter & Richter); Blaker & Peel, p. 46.

cf. 1997 *Mallagnostus* *llarenai* (Richter & Richter); Jell, p. 397, fig. 248.1a, 1b.

cf. 2006 *Mallagnostus* *llarenai* (Richter & Richter); Fletcher, p. 52, fig. 27.

cf. 2022 ‘*Eodiscus* *llarenai*’Richter & Richter; Collantes *et al*., fig. 9I.

*Occurrence*. Jigging Cove Member, Brigus Formation, Smith Point, western Trinity Bay, collection SPBr-40.45 (Figure 5).

*Discussion*. The type material of ‘*M*.’ *llarenai* (Richter & Richter, 1941) is of internal moulds of a pygdium and cephalon from the Herrerías beds, Minas de Cala, Huelva, Spain. The paratype cephalon (Richter & Richter, 1941, pl. 2, fig. 25; misnumbered ‘fig. 26’ in the caption) has a wide border with at least four tubercles on the lateral portion. The holotype pygidium (Richter & Richter, 1941, pl. 2, fig. 26, misnumbered ‘fig. 25’ in the caption; see Collantes *et al*., 2022, fig. 9I for a newer image) has an even wider border than the cephalon and a well-segmented axis that ends close to the border. Axial nodes are not evident in Collantes *et al*.’s (2022) figure. In arguing for synonymy of ‘*M*.’ *llarenai* with *Serrodiscus* (*s.l.*) *bellimarginatus*, Collantes *et al*. (2022, p. 306) considered these character states to result from deformation. However, the convexity of the axis of the holotype (Collantes *et al*., 2022, fig. 9I) of ‘*M*.’ *llarenai* suggests minimal flattening has taken place and the absence of nodes may be an original biological feature. Moreover, none of the deformed pygidia that Collantes *et al*. (2022, fig. 7) used to evaluate taphonomic variability of *Serrodiscus* resembles the holotype of ‘*M*.’ *llarenai* in border morphology. Indeed, the short pygidial borders of undistorted specimens of *S*. (*s.l.*) *bellimarginatus* and related species (e.g., Westrop & Landing, 2011, figs. 6–10, 14, 16A–C) would take substantial sagittal stretching to produce a border comparable to ‘*M*.’ *llarenai*. This should be reflected in deformation of the entire sclerite. It seems more likely that the elongate border has not been modified significantly in the holotype.

The holotype pygidium of ‘*M*.’ *llarenai* has a relatively long axis whose tip lies close to the border furrow (Collantes *et al*., 2022, fig. 9I), whereas the axis of the single flattened specimen from SPBr-40.45 (Figure 9f) terminates well short of that point. Other pygidia attributed to “*M*.” *llarenai* by Rushton (1966, pl. 3, figs. 19–20) and Fletcher (2006, pl. 27, fig. 27) also have relatively longer axes than ‘*M*.’ cf. ‘*M*.’ *llarenai.*

In the absence of an associated cephalon, assignment of ‘*M*.’ cf. ‘*M*.’ *llarenai* to *Jinghediscus* cannot be ruled out. The most complete pygidium of *J*. *nummularius* Xiang & Zhang *in* Wang *et al*. (1985 (pl. 1, fig. 6) shows that it has a relatively longer axis than ‘*M*.’ cf. ‘*M*.’ *llarenai*, and it appears more strongly segmented.

Family Ellipsocephalidae Matthew, 1887

Genus *Strenuella* Matthew, 1887

*Type species*. *Agraulos strenuus* Billings, 1872, from the St. Mary's Member, Brigus Formation, Conception Bay, Newfoundland (by original designation).

*Strenuella strenua* (Billings, 1872)

Figure 7

1872 *Agraulos strenuus* Billings, p. 473, fig. 10.

2006 *Strenuella strenua* (Billings); Fletcher, p. 52, fig. 26.

2008 *Strenuella strenua* (Billings); Fletcher & Theokritoff, p. 324, fig. 6.11 [only; identification of fig. 6.4–6.10 is questionable].

*Lectotype*. A cranidium (GSC 269A; Figure 7a–c) from the Brigus Formation, Brigus Head, Conception Bay, eastern Newfoundland (designated by Fletcher & Theokritoff, 2006, p. 324).

*Material and occurrence*. *Strenuella strenua* is known with certainty only from the Brigus Formation of eastern Newfoundland. Other reports are based upon limited and/or poorly preserved material that cannot be identified with confidence (see below). Figured specimens include the lectotype and paralectotype (Figure 7a–f), as well as cranida from the Brigus at the Brigus South section of Landing & Westrop (2010, p. 252) that can be treated as topotypes (Figure 7g–j).

*Discussion*. *Strenuella* *strenua* has been reported widely from Avalonia, including the Boston area, eastern Massachusetts (Shaw, 1950; Fletcher & Theokritoff, 2006); Cape Breton Island, Nova Scotia (Hutchinson, 1952); the Avalon Peninsula, SE Newfoundland (Hutchinson, 1962; Landing & Westrop, 1998; Fletcher, 2006); and Shropshire, England (Lake, 1932). A full revision of this species will be presented elsewhere using extensive collections from the Brigus Formation at several localities (e.g., Landing & Westrop, 2010, appendices 1–4) on the Avalon Peninsula, but it is included in this paper for comparison with *Myopsostrenua* cf. *M*. *sabulosa* Rushton, 1966.

The synonymy only includes specimens that can be assigned to *S*. *strenua* with confidence, and a full assessment of the literature will be part of future work. However, it is already clear that many putative occurrences of the species will not withstand critical scrutiny. For example, cranidia attributed to the species by Shaw (1950) include specimens with very short (e.g., Shaw, 1950, pl. 79, fig. 2) and longer (e.g., Shaw, 1950, pl. 79, fig. 8) anterior borders. Specimens with longer borders are much closer to *S. strenua* than those with short borders, but a wide-bordered librigena has a very stout genal spine (Shaw, 1950, pl. 79, fig. 3) that contrasts with more slender spines of librigenae in our collections (Westrop & Landing, unpubl.).

Cranidia from Massachusetts assigned to *S*. *strenua* by Fletcher & Theokritoff (2006) include specimens that differ from those from the Brigus Formation in having shorter, well-defined, and apparently strongly convex anterior borders (e.g., Fletcher & Theokritoff, 2006, fig. 6.7, 6.8) and shorter palpebral lobes (e.g., Fletcher & Theokritoff, 2006, fig. 6.6). Fletcher & Theokritoff (2006, p. 324) included only two of the twelve figured specimens from Shropshire that Lake (1932) identified as *S. strenua* in their species synonymy. However, one of these (Lake, 1932, pl. 21, fig. 6) has a long, stout occipital spine that is at least half of the length of the rest of the glabella, and sharply contrasts with the short, slender spines of the Brigus cranidia (e.g., Figure 7h, i). Hupé (1953, p. 238) proposed *Strenuella lakei* for this specimen and named *S. comleyensis* for the other specimen (Lake, 1932, pl. 21, fig. 7) that Fletcher & Theokritoff (2006) referred to *S*. *strenua*. The *S. comleyensis* occipital ring is incomplete, but that species appears to have much larger palpebral lobes than the Brigus specimens. One sclerite is a poor basis for the establishment of new species, but Hupé (1953) correctly recognised that Lake's (1932) specimens do not record *S*. *strenua* in Avalonian Britain. Finally, Fletcher & Theokritoff (2006, p. 325) suggested that only one of the four strongly deformed cranidia from the MacCodrum Formation of Cape Breton Island, Nova Scotia (i.e., junior synonym of Brigus Formation; Landing, 1991; Landing *et al*., 2022; Landing & Geyer, 2023) illustrated by Hutchinson (1952, pl. 3, fig. 4a–c) resembles *S. strenua*. However, that specimen is too incomplete for a confident evaluation. However, another cranidium (Hutchinson, 1952, pl. 3, fig. 3) has a very large occipital spine, which places it closer to *S*. *lakei*. At the current state of knowledge, it is not possible to identify *S. strenua* confidently outside of SE Newfoundland.

Genus *Myopsostrenua* Rushton, 1966

*Type species*. *Strenuella* (*Myopsostrenua*) *sabulosa* Rushton, 1966, from the Purley Shales of the Nuneaton area, Warwickshire, England (by original designation).

*Discussion*. Rushton (1966, pl. 5, figs. 1–9) proposed *Myopsostrenua* as a subgenus of *Strenuella* characterised by a small palpebral lobe, with *M*. *sabulosa* as the type species. Comparison of Rushton's figured specimens of *M*. *sabulosa* with type (Figure 9a–f) and topotype (Figure 9g–j) cranidia of the type species of *Strenuella*, *S*. *strenua*, confirm the small size of the palpebral lobe, which is equal to about 30% of preoccipital glabellar length in the former species, versus a little more than half of the preoccipital glabellar length in the latter (53%; 46%–59%, with higher values in smaller specimens, Figure 9g–j). The anterior border of *M. sabulosa* seems more convex than in *S. strenua*, and the lateral glabellar furrows more firmly impressed, but both of these apparent differences could be influenced by preservation of the former as internal moulds. In any event, separation of these taxa as subgenera is arbitrary, and in this report they are treated as distinct genera, pending a broader phylogenetic analysis of Ellipsocephalidae. Synonymy of *Myopsostrenua* and *Strenuella*, as proposed by Fletcher (2006), is premature.

*Myposostrenua* cf. *M*. *sabulosa* Rushton, 1966

Figure 9a–e

cf*.* 1966 *Strenuella* (*Myopsostrenua*) *sabulosa* Rushton, p. 38, pl. 5, figs. 1–9, text-fig. 14.

? 2006 *Strenuella* *sabulosa* Rushton; Fletcher, p. 52, figs. 28, 29.

? 2008 *Strenuella* (*Myopsostrenua*) *sabulosa* Rushton: Fletcher & Theokritoff, fig. 6.13.

*Occurrence*. Jigging Cove Mbr, Brigus Formation, Smith Point, western Trinity Bay, collection SPBr-24 (Figure 5) and Redland Cove, St. Mary's Bay (Figure 1, lower Redland Cove section not illustrated in this report), collection ReBr-61.7 (Westrop and Landing, 2011, p. 261).

*Discussion*. Specimens from SPBr-24 are badly flattened, and the two best specimens are illustrated here (Figure 9a, b). They seem to be comparable in frontal area proportions and expression of the glabellar furrows to Rushton’s (1966) types, and have the granulose sculpture that Rushton (1966, p. 38) highlighted in the species’ name. However, they have larger palpebral lobes (36% of preoccipital glabella length in the most completely preserved specimen) than the types, although still smaller than those of *Strenuella* *strenua*. Two cranidia from St. Mary's Bay attributed to *M. sabulosa* by Fletcher (2006, figs. 28, 29; Fletcher & Theokritoff, 2008, reproduce fig. 28 as their fig. 6.13) were illustrated with very small photographs and cannot be interpreted easily. However, two cranidia (Figure 9a–e) from the same general locality at Redland Cove (Westrop and Landing, 2011, section ReBr, appendix 4) allow a more complete assessment to be made. They have longer palpebral lobes than Rushton’s (1966) types and may belong to the same species as the specimens of *M*. cf. *M*. *sabulosa* from SPBr. There are some differences the specimens from ReBr including a coarser texture to the surface of the internal mould that obscures any sculpture, a more curved anterior border, and more strongly deflected palpebral ridges. They provide a biostratigraphic tie-point in the lower part of the Jigging Cove Member.

Family Solenopleuridae Angelin, 1854

Genus *Parasolenopleura* Westergård, 1953

*Type species*. *Calymene* *aculeata* Angelin, 1851, from the Exsulans Limestone of Sweden (by original designation).

*Discussion*. Published diagnoses of *Parasolenopleura* are essentially phenetic (e.g., Geyer, 1998; Fletcher, 2005). In establishing the genus, Westergård (1953, p. 21) emphasised that it was defined by a combination of characters, of which ‘none of them alone is a reliable distinctive criterion.’ In modern terms, this implies that there may not be any unambiguous synapomorphies on which to base the genus, although this need not mean that the taxon is not monophyletic— characters that originate more than once in a given phylogenetic tree can still be informative, and the retention index is a measure of this. However, the comprehensive phylogenetic analysis needed to evaluate *Parasolenopleura* and related genera (see also Esteve, 2015) is beyond the scope of this appendix.

New illustrations (Esteve, 2015, figs. 3A–I, 4A–F) of the lectotype and other specimens of the type species of *Solenopleura* Angelin, 1854, *S*. *holometopa* (Angelin, 1854), help evaluate the type species of *Parasolenopleura*, *P*. *aculeata* (Angelin, 1851). It is unfortunate that Westergård's (1953, pl. 5, figs. 6–10, pl. 6, figs. 1–4) figures remain the best source of information on the latter species. Compared to *Solenopleura*, the combination of characters that Westergård (1953, p. 21) highlighted as diagnostic of *Parasolenopleura* included a less steeply sloping frontal area and less convex anterior border (e.g., compare Esteve, 2015, figs. 3A–I, 4A–F with Westergård, 1953, pl. 6, fig. 3a–c). Lateral views of *P*. *aculeata* indicate that the border slopes upward from the border furrow (Westergård, 1953, pl. 6, figs. 1b, 3b) instead of being convex. He also indicated that the cheeks are less inflated than in *Solenopleura*, although anterior views of *P*. *aculeata* (e.g., Westergård, 1953, pl. 6, figs. 1c, 3c) indicate that the palpebral areas are as arched as those of *S*. *holometopa* in anterior view (e.g., Esteve, 2015, figs. 3B, E, I, 4B, E), with the palpebral lobes of the latter upturned rather than nearly flat. Westergård (1953, p. 21) also commented on the external surface of the exoskeleton, which he described as ‘smooth to the naked eye but under the microscope [....] finely granulate.’ *Solenopleura* *holometopa* has a well developed sculpture of coarse granules to fine tubercles on small cranidia (e.g., Esteve, 2015, fig. 3D–F), but it is subdued on other, mostly larger specimens (e.g., Esteve, 2015, figs. 3A–C, 4A–C). As far as the pygidia are concerned, Westergård separated *P*. *aculeata* from *S*. *holometopa* by a more strongly furrowed pleural field in the former species. Esteve's (2015, fig. 4G, H) photographs also show that the pygidium of *S*. *holometopa* is dominated by a broad, strongly convex axis that occupies more than a third of maximum pygidial width, whereas the *P*. *aculeata* axis is noticeably narrower (e.g., Westergård, 1953, pl. 6, fig. 4).

Esteve (2015) assigned *Calymene* *canaliculata* Angelin, 1851, the type species of *Gonzaloia* Geyer, 1998, questionably to *Solenopleura*. He considered *Gonzaloia* to be inappropriately erected, apparently because some characters were ‘not properly quantified’ (see also Rushton & Berg-Madsen, 2002, p. 341), the holotype of the type species was not illustrated, and no diagnosis was provided for the type species. However, the proposal of the name clearly meets the requirements of ICZN Article 13 as Geyer (1998, p. 392) provided a genus diagnosis and the type species is designated. Nothing else is required. Complaints about some of the characters do not change the fact that *Gonzaloia* is a valid, available name, and there is no requirement that the type species be illustrated. Moreover, Esteve (2015, p. 191) identified two potential apomorphic states in *G*. *canaliculata*—a well-developed plectrum on the anterior border of the cranidium and a very wide pleural field on the pygidium. Other potentially apomorphic character states of *Gonzaloia* could include a broad cranidium with a wide palpebral area that is similar in width to the glabella at S1 and the narrow, multisegmented pygidial axis that is strikingly different from the axis in *S*. *holometopa* (compare Esteve, 2015, fig. 4G, H with 4O–Q). These characters do, however, support removal of *S*. *conifrons* Westergård, 1953, from *Gonzaloia*, as proposed by Esteve (2015), so that the genus is currently monotypic.

Traditional classifications of *Solenopleura* (e.g., Westergård, 1953; Rushton & Berg-Madsen, 2002) likely mask considerable phylogenetic structure and attempts to establish additional genera (e.g., Rudolph, 1994; Geyer, 1998) are likely premature. A broader review of the family, based on new material from Avalonian Canada, will be presented elsewhere. The species illustrated herein would meet current diagnoses of *Parasolenopleura*, which is used with reservation here, and the quotation marks indicate uncertainty about monophyly.

*‘Parasolenopleura*’ cf. ‘*P*.’ *ouangondiana* (Hartt *in* Dawson, 1868)

Figure 8

cf. 1868 *Conocephalites* *ouangondianus* Hartt *in* Dawson. p. 651, fig. 226.

1998 *Braintreella* cf. *ouangondiana* (Hartt *in* Dawson, 1868); Landing & Westrop, fig. 5.

cf. 2005 *Parasolenopleura* *ouangondiana* (Hartt *in* Dawson, 1868); Fletcher, fig. 5K, L, O.

*Occurrence*. Braintree Member, Chamberlain's Brook Formation, Red Bridge Road quarry, Conception Bay, collection RBCB-38 (Figure 3)

*Discussion*. Hartt's material of *‘Parasolenopleura*’ *ouangondiana* needs restudy. The frontal area proportions of the original illustration (Dawson, 1868, fig. 266) match those of two cranidia from RBCB-38, but it shows the occipital ring without an occipital spine while Hartt's description (*in* Dawson, p. 652) indicates a short, conical spine. Fletcher (2005, fig. 5O) illustrated a New Brunswick specimen with an occipital spine, but with a shorter frontal area than either specimen from RBCB-38. With these uncertainties, an open nomenclature is used.

Chirivella *et al*. (2022) assigned poorly preserved sclerites from north-east Spain to ‘*P*.’ *aculeata*, andconsidered this species a senior synonym of ‘*P*.’ *ouangondiana*. However, these specimens are simply inadequate for a revisionary systematics, and it is debatable as to whether they should be identified to the species level.

One cranidium of ‘*P*.’ cf. ‘*P*.’ *ouangondiana* (Figure 8a–c) has small gently inflated muscle scars that correspond to S1–S4. The palpebral lobe, which is longer than in ‘*P*.’ *aculeata* (e.g., Westergård, 1953, pl. 6, figs. 1a, 3a) is centred near S2, and in front of the mid-length of the pre-occipital glabella. As in ‘*P*.’ *aculeata* (e.g., Westergård, 1953, pl. 6, figs. 1b, 3b), the anterior border is upturned (Figure 8c, f) but is relatively longer. Cranidia attributed to ‘*P*.’ *ouangondiana* by Fletcher (2005, fig. 5K, L, O) from the Chamberlain’s Brook Formation in Newfoundland also have a shorter border than ‘*P*.’ cf. ‘*P*.’ *ouangondiana* and, consequently, a shorter frontal area. One of these specimens (Fletcher, 2005, fig. 5K) has an inflated fixigena that apparently represents post-depositional deformation. It remains to be seen whether this inflation represents an end-member in a style of deformation that Fletcher (2005, p. 1086, fig. 5M, N, P) suggested was also responsible for very narrow (tr.) fixigenal ridges, strong palpebral ridges and upturned borders in *Badulesia* *tenera* (Hartt *in* Dawson, 1868). However, the wide geographic distribution of *B*. *tenera* (e.g., Skehan *et al*., 1978, fig. 3a–c), as well as a range of configurations of fixigenal ridges in other species (e.g., Sdzuy, 1961, pl. 24, figs.12–16) suggests that these features record biological structures (see also Álvaro & Vizcaïno, 2001, who interpreted these and other ridges in evolutionary terms), even if accentuated by deformation.

Fletcher's (2005) interpretation of ‘*P*.’ *gregaria* (Billings) as a highly variable species is also relevant to the identity of the RBCB-38 species. Most cranidia of the type series of ‘*P*.’ *gregaria* show a more strongly curved anterior border and gently tapered, well rounded glabella (Fletcher, 2005, pl. 1, figs. 14, 15, 24 [paralectotypes], pl. 2, fig. 21 [lectotype]). These characters are maintained through ontogeny from small to what Fletcher describes as a medium-sized cranidium. The largest specimen among the paralectotypes (Fletcher, 2005, pl. 1, fig. 23) has a more weakly curved, broader border, which is a consequence of relatively wider fixigenae. Large cranidia from Fletcher's collections from Bed 2 of the Big Gully Marl Member (i.e., this is a junior synonym of the Braintree Member of Landing and Westrop, 1988) at Wester Cove, St. Mary's Bay also show the weakly curved, broad border of the largest paralectotype (e.g., Fletcher, 2005, pl. 1, figs. 25, pl. 2, fig. 1). While it is possible to interpret this as ontogenetic variation in a single species, other figured specimens raise doubts. There are relatively small cranidia with the weakly curved border (Fletcher, 2005, pl. 1, figs. 20, 22) and a relatively large, slightly distorted cranidium (Fletcher, 2005, pl. 2, fig. 3) retains the strongly curved anterior border of the lectotype and smaller paralectotypes. It is equally possible to view the cranidia illustrated by Fletcher as recording two co-occurring species, and the limits of ‘*P*.’ *gregaria* are not yet settled. More material, particularly of intermediate sizes is needed.

Compared to the lectotype and smaller paralectotypes of ‘*P*.’ *gregaria*, the borders of the cranidia from RBCB-38 are more strongly upturned in lateral view (e.g., compare Fletcher, 2005, pl. 1, fig. 15) and less strongly curved in dorsal view. Fletcher (e.g., 2005, pl. 1, figs. 23, 25, pl. 2, fig. 1) illustrated large cranidia attributed to ‘*P*.’ *gregaria* in dorsal view only, limiting comparison with our specimens. At a minimum, they have wider palpebral areas of the fixigenae. Cranidia of both morphotypes that are similar in size to ‘*P*.’ cf. ‘*P*.’ *ouangondiana* (e.g., Fletcher, 2005, pl. 1, figs. 20, 24) have smaller palpebral lobes that are located a little farther forward on the cranidium, and glabellas that terminate closer to the anterior border, so that the preglabellar furrow merges with the border furrow.

**SUPPLEMENTARY FIGURE 1.** Optical photomicrographs of zircon crystals subjected to CA-IDTIMS geochronology. Crystals are arranged from left to right and top to bottom in order of the ‘z#’ labels in Supplementary Table 1. The zircon crystals of sample SPBr-105.75 and SPCB-4.4 were photographed after chemical abrasion, while all other samples are illustrated prior to chemical abrasion. All images are presented at the same magnification.