A new Cambrian catillicephalid trilobite from the Shallow Bay Formation of western Newfoundland, Canada

STEPHEN R. WESTROP and ALYCE A. DENGLER

Westrop, S.R and Dengler, A.A. 2022. A new Cambrian catillicephalid trilobite from the Shallow Bay Formation of western Newfoundland, Canada. *Acta Palaeontologica Polonica* 67 (1): 27–33.

Species of *Catillicephala* are known from sites around the mid-Cambrian margin of Laurentian North America, including Vermont, Quebec, Newfoundland and North Greenland. *Catillicephala cifellii* sp. nov. is from the Downes Point Member of the Shallow Bay Formation (Cow Head Group) in western Newfoundland. It occurs in three shelf margin-derived boulders in debris flow conglomerates that accumulated in a continental slope setting. The associated trilobites and agnostoid arthropods, including *Ptychagnostus aculeatus* and *Megagnostus glandiformis*, indicate a correlation with the *Lejopyge laevigata* Zone. As such, *C. cifellii* is among the oldest representatives of the genus, and is early Guzhangian in age.

Key words: Trilobita, *Catillicephala*, Cambrian, Laurentia, North America.

Stephen R. Westrop [swestrop@ou.edu], Oklahoma Museum of Natural History and School of Geosciences, University of Oklahoma, Norman, OK 73072, USA. Correspondence address: 103 Melita Street, Ingersoll, Ontario N5C 3W3, Canada.
Alyce A. Dengler [sandydengler2@yahoo.com], Oklahoma Museum of Natural History, University of Oklahoma, Norman, OK 73072, USA.

Received 29 June 2021, accepted 6 October 2021, available online 30 March 2022.

Introduction

The Cow Head Group of western Newfoundland (James and Stevens 1986) is a succession of Cambrian to Lower Ordovician continental slope strata that includes debris flow conglomerates (assigned to the Shallow Bay Formation) containing carbonate boulders that yield abundant trilobites (Kindle and Whittington 1958; Kindle 1982). Along with fossiliferous boulders from Quebec (e.g., Rasetti 1946, 1948), the conglomerates provide a record of the faunas of a Laurentian shelf-margin that was destroyed during the Taconic orogeny, and have been characterized as the remnants of a "lost faunal realm" (Pohler et al. 1987).

We are engaged in a long-term project to document the mid–upper Cambrian (Drumian–Stage 10; Miaolingian–Furongian) trilobite faunas of the Cecil H. Kindle Collection (Kindle 1982) from the Cow Head Group. Work on the Sunwaptan (Jiangshanian–Stage 10) faunas was completed some time ago (Ludvigsen et al. 1989), but study of the older Marjuman–Steptoean (Drumian–Paibian; Miaolingian–Furongian) trilobites is in progress (e.g., Westrop and Eoff 2012; Westrop and Dengler 2017; Westrop et al. 2018). We completed a revision of late Guzhangian (*Crepicephalus* Zone; Miaolingian) species of *Catillicephala* Raymond, 1938 from Quebec and Newfoundland (Westrop and Dengler 2014a) but a species from an older Guzhangian boulder from the Cow Head Group was overlooked. It is described in this paper as a contribution to the special volume honouring our colleague, Richard Cifelli, on his retirement.

Nomenclatural acts.—This published work and the nomenclatural acts it contains have been registered in ZooBank: urn:lsid:zoobank.org:pub:C7D78F31-469B-409A-A8A3-575D8AB42B4D

Institutional abbreviations.—GSC, Geological Survey of Canada, Ottawa.

Other abbreviations.—BPS, Broom Point South, Newfoundland (Westrop et al. 1996: fig. 4); exsag., exsagittal; LO, lobus occipitalis (occipital ring); L1–L3, lateral glabellar lobes, numbered from posterior to anterior; SO, sulcus occipitalis (occipital furrow); S1–S3, lateral glabellar furrows, numbered from posterior to anterior; tr, transverse.

Geological setting

The study area lies in the Cow Head region of western Newfoundland. The trilobites were collected from three boulders (BPS 458, 467, 468) in a 20-m-thick interval of amalgamated debris flow conglomerates exposed along the shore to the south of Broom Point (Broom Point South section of James and Stevens 1986). Westrop et al. (1996: fig. 4) provided a locality map and stratigraphic column that shows where the boulders were collected. The conglomerate beds are part of the oldest Downes Point Member of the Shallow Bay Formation (see James and Stevens 1986, for an exhaustive account of the stratigraphy and sedimentology of the Cow Head Group, including the Shallow Bay Formation).

The boulders that yielded *Catillicephala cifellii* sp. nov. also contain agnostoid arthropods (Westrop et al. 1996) that provide a constraint on the age of the species. It is associated with *Ptychagnostus aculeatus* (Angelin, 1851), in BPS 458, with *Megagnostus glandiformis* (Angelin, 1851), in BPS 468, and with *Kormagnostus* cf. *K. seclusus* (Walcott, 1884), in BPS 467 and BPS 468. These indicate a correlation with the *Lejopyge laevigata* Zone (Westrop et al. 1996), which is the oldest zone (Peng et al. 2009) of the Guzhangian (Miaolingian; Zhao et al. 2019). Associated trilobites that have been named in recent papers include *Hysteropleura* (*Verditerrina*) *adraini* Westrop and Ludvigsen, 2000, in BPS 468, and *Holmdalia lata* Westrop and Dengler, 2017, in boulders BPS 458, 467, 468. Numerous other trilobites remain to be documented from these boulders, including undescribed species of *Bynumia* Walcott, 1924, *Prolonchocephalus* Palmer in Palmer and Peel, 1981, and *Onchonotopsis* Rasetti, 1946.

The other records of *Catillicephala* comes from material from shelf margin sites of Laurentia, including boulders in conglomerate beds in Vermont (Shaw 1952), Quebec (Rasetti 1946; Westrop and Dengler 2014a) and Newfoundland (Westrop and Dengler 2014a), as well as in situ specimens from Greenland in shallow (Palmer in Palmer and Peel 1981) and deep subtidal (Robison 1988) settings. *Catillicephala cifellii* sp. nov. is most likely the oldest known species from shelf-margin derived boulders, and an indeterminate species from deep subtidal facies in Greenland (= *C. rotundata* of Robison 1988; see Westrop and Dengler 2014a: 97) is also from the *Lejopyge laevigata* Zone.

Material and methods

Illustrated material is housed at the Geological Survey of Canada, Ottawa (GSC). Depth of field was maximized by rendering digital images from stacks of images focused at 200 micron intervals using Helicon Focus 4.0 for the Macintosh.

Proportions expressed in percentages in descriptions and diagnoses are means, with the following pair of numbers indicating the range of values. All measurements were made on digital images of specimens in Figs. 1–3 to the nearest tenth of a millimetre using the Measure Tool of Adobe Photoshop ™.

Systematic palaeontology

Class Trilobita Walch, 1771

Order uncertain

Family Catillicephalidae Raymond, 1937

Genus *Catillicephala* Raymond, 1938

Type species: *Cephalocoelia ovoides* Raymond, 1937 from the Rockledge Conglomerate of Vermont, USA (by original designation).

Remarks.—*Catillicephala* was revised by Westrop and Dengler (2014a) and their diagnosis is followed here.

Catillicephala cifellii sp. nov.

Figs. 1–3.

Zoobank LCID: urn:lsid:zoobank.org:act:4B4919F0-DFB7-4569-B8B1-1A2DE79BACFD

Etymology: In honour of Richard Cifelli upon his retirement and in recognition of his studies of Cretaceous mammals.

Type material: Holotype: GSC 142512, well preserved cranidium (Fig. 1A). Paratypes: five cranidia (GSC 142513–142515, Fig. 1; GSC 142517, Fig. 2B; GSC 142519, Fig. 2D), five pygidia (GSC 142520–142524, Fig. 3) from boulder BPS 467; one cranidium (GSC 142516, Fig. 2A) from boulder BPS 468; one cranidium (GSC 142518, Fig. 2C) from boulder BPS 458. All from the type locality.

Type locality: Broom Point South, western Newfoundland, Canada.

Type horizon: Boulder BPS 467, Downes Point Member, Shallow Bay Formation, Guzhangian, Miaolingian, Cambrian.

Material.—The type material and two pygidia from boulder BPS 467; two cranidia and two pygidia from boulder BPS 458. All from the type locality.

Diagnosis.—*Catillicephala* with ovoid glabella, occipital ring subtriangular, drawn out posteriorly into stout spine, and short, narrow anterior border tapered laterally.

Description.—Strongly convex cranidium subtrapezoidal in outline (excluding LO), with curved anterior margin; preoccipital glabella length 54% (51–58%) maximum cranidial width across posterolateral projections. Frontal area represented only by very narrow, rim-like anterior border. Anterior border furrow finely etched, merges with preglabellar furrow; axial furrows shallow but clearly defined grooves, bowed gently outwards. Glabella barrel-shaped in outline, with outwardly curved flanks and gently rounded anteriorly; inflated, standing well above adjacent fixigenae in anterior view (e.g., Figs. $1A_3$, $2B_1$); width at anterior tip of S1 equal to 89% (81–94%; lower values in smaller specimens) preoccipital length. LO extended into stout, upwardly curved, triangular occipital spine in larger individuals (e.g., Figs. $1A_1$, 2D). SO curved gently backwards, shallow, defined in part by break in slope between LO and preoccipital

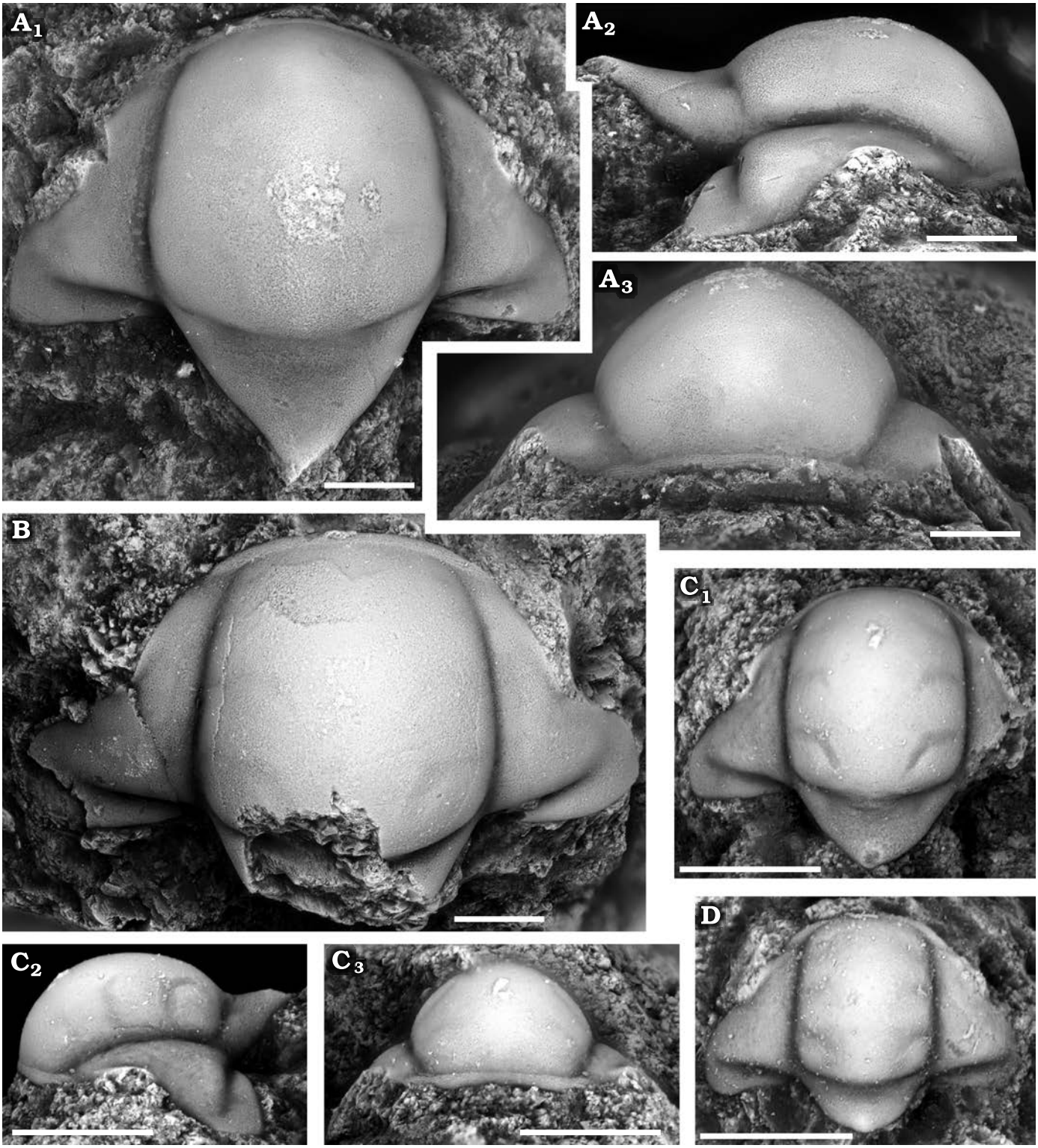


Fig 1. Cranidia of catillicephalid trilobite *Catillicephala cifellii* sp. nov. from the Downes Point Member, Shallow Bay Formation, Guzhangian, Miaolingian, Cambrian; boulder BPS 467, Broom Point South, western Newfoundland, Canada. **A**. GSC 142512, holotype; dorsal (A_1), lateral (A_2), and anterior (A_3) views. **B**. GSC 142513, paratype; dorsal view. **C**. GSC 142514, paratype; dorsal (C_1), lateral (C_2), and anterior (C_3) views. **D**. GSC 142515, paratype; dorsal view. Scale bars 1 mm.

glabella, particularly on larger specimens (e.g., Fig. 1A). Lateral glabellar furrows barely perceptible on all but the smallest specimens (e.g., Figs. $1A_1$, B, $2B_3$, D). S1 geniculate, termination short of LO; S2 curved gently forward; S3 straight, directed obliquely forward from axial furrow. L1–L3 without independent convexity, maximum lengths (exsag.) roughly equal. Palpebral area of fixigenae narrow, equal to 25% (21–32%; higher values in smaller specimens)

of glabellar width at anterior tip of S1, curved downwards in anterior view (e.g., Figs. 1A$_3$, 2B$_1$). Palpebral lobe narrow (tr.), gently curved, length equal to 20% (16–24%) of preoccipital glabella length and centred opposite S2; palpebral furrow shallow, defined in part by break in slope between lobe and adjacent palpebral area. Palpebral ridge weakly convex, extends obliquely forward to intersect axial furrow near anterior end of glabella. Anterior branches of facial suture short, convergent; posterior branches divergent before curving backward at posterior border furrow to become subparallel. Postocular fixigenae broadly triangular in outline, cranidial width at palpebral lobe 77% (74–80%) maximum width of cranidium; posterolateral projection flexed sharply downward in anterior view (e.g., Fig. 1A$_3$). Posterior border furrow narrow, oblique, deep groove adaxially, shallowing abruptly abaxially and curving forward. Posterior

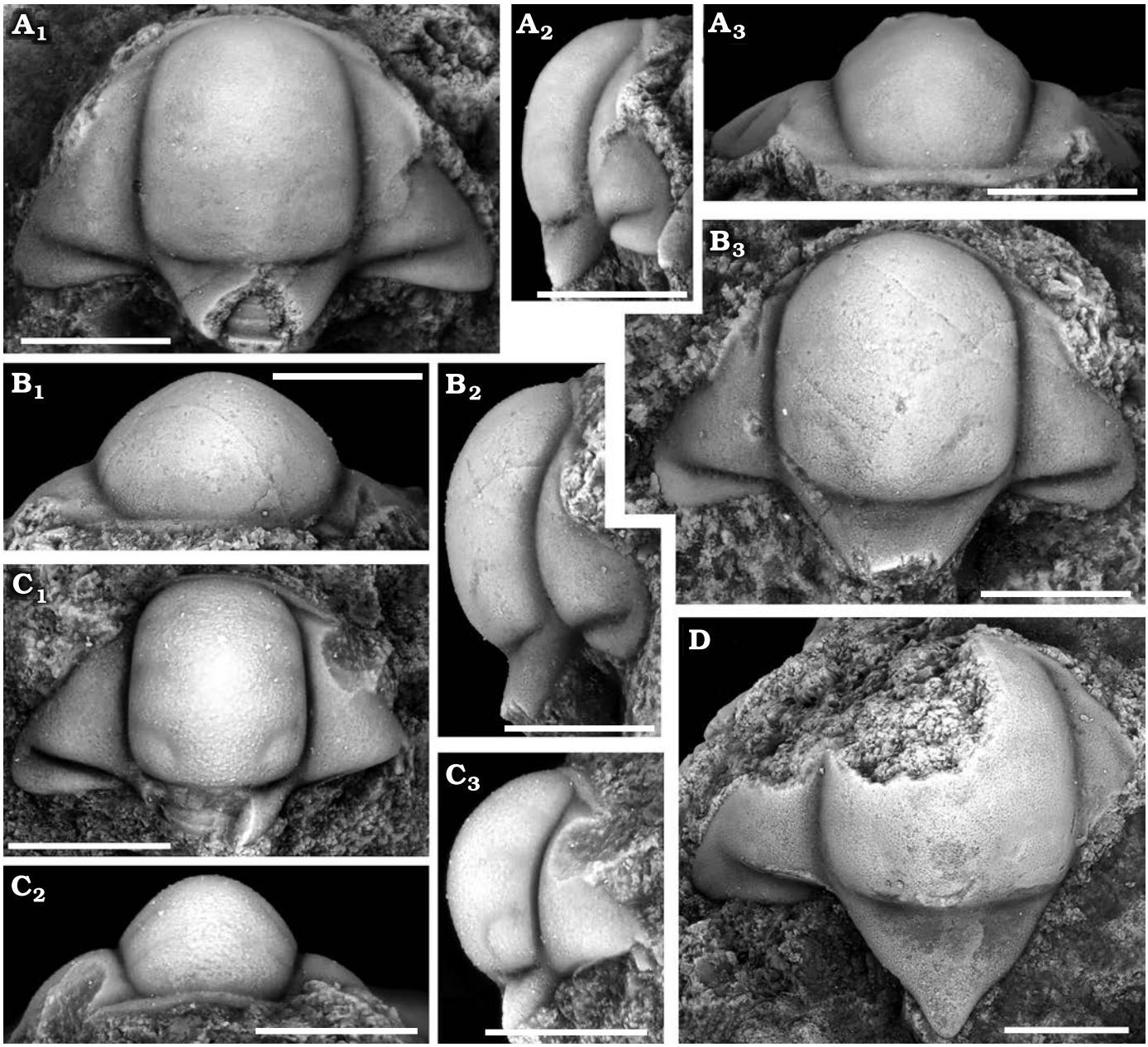
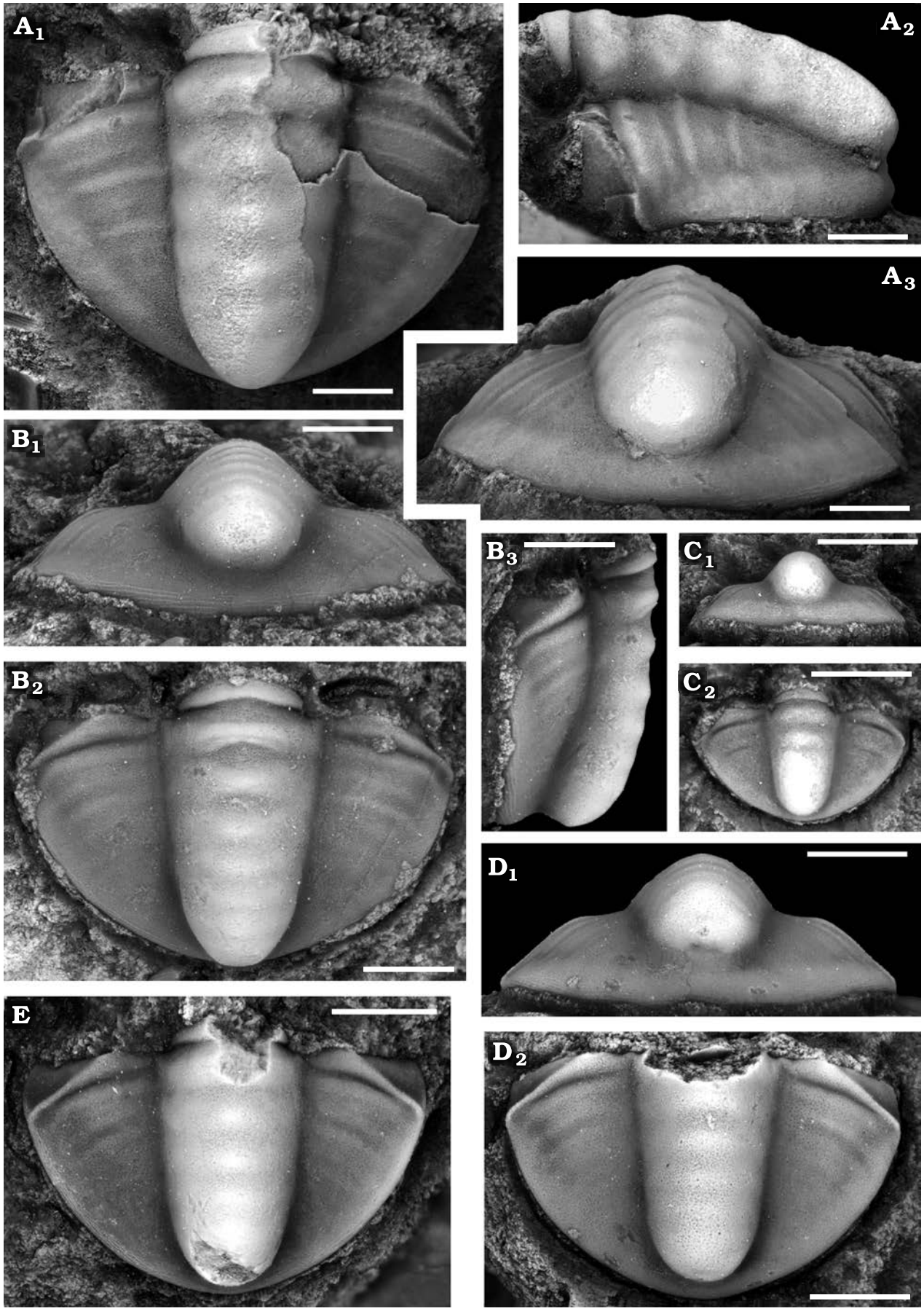


Fig. 2. Cranidia of catillicephalid trilobite *Catillicephala cifellii* sp. nov. from the Downes Point Member, Shallow Bay Formation, Guzhangian, Miaolingian, Cambrian; boulders BPS 468 (A), BPS 467 (B, D), BPS 458 (C), Broom Point South, western Newfoundland, Canada. **A**. GSC 142516, paratype; dorsal (A_1), lateral (A_2), and anterior (A_3) views. **B**. GSC 142517, paratype; anterior (B_1), lateral (B_2), and dorsal (B_3) views. **C**. GSC 142518, paratype; dorsal (C_1), anterior (C_2), and lateral (C_3) views. **D**. GSC 142519, paratype; dorsal view. Scale bars 1 mm.

Fig. 3. Pygidia of catillicephalid trilobite *Catillicephala cifellii* sp. nov. from the Downes Point Member, Shallow Bay Formation, Guzhangian, Miaolingian, Cambrian; boulder BPS 467, Broom Point South, western Newfoundland, Canada. **A**. GSC 142520, paratype; dorsal (A_1), lateral (A_2), and posterior (A_3) views. **B**. GSC 142521, paratype; posterior (B_1), dorsal (B_2), and lateral (B_3) views. **C**. GSC 142522, paratype; posterior (C_1) and dorsal (C_2) views. **D**. GSC 142523, paratype; posterior (D_1) and dorsal (D_2) views. **E**. GSC 142524, paratype; dorsal view. Scale bars 1 mm. →


A1
A2
A3
B1
B2
B3
C1
C2
D1
D2
E

weakly convex, expanding abaxially, with minimum length near axial furrow 28% (22–33%) of length at point where border furrow shallows. External surface other than furrows finely pitted, augmented with coarse granules on smaller specimens (e.g., Fig. $2C_1$).

Pygidium strongly arched, semicircular in outline, length equal to 70% (65–78%) of maximum width, with anterior margin angled back, and conspicuous articulating facet at anterior corner. Axis inflated, rising well above pleural field; gently tapered and well-rounded posteriorly; long, overhanging posterior margin slightly on largest specimens (e.g., Fig. $3A_1$, B_2), with width at anteriormost axial ring equal to 37% (34–40%) of maximum pygidial width. Articulating half-ring conspicuous, roughly semielliptical in outline; articulating furrow broad, roughly equal in length to half-ring. Broad, transverse ring furrows generally faint. Up to four rings and a terminal piece comprising at least two segments evident (e.g., Fig. $3A_1$, B_2). Pleural field flexed downward; one well-defined pleural furrow expressed on external surface, remainder faint, although better defined on internal moulds. Border furrow faint but clearly defined; border downsloping. External surface save for furrows finely pitted; posterior edge of border with terrace ridges (e.g., Fig. $3B_1$).

Ontogeny.—A series of differently sized cranidia show that the occipital spine develops during holaspid ontogeny. The smallest cranidium (Fig. 1D) has a short, aspinous LO that occupies only 21% of glabellar length, although there is an ill-defined node present. LO becomes longer (occupying 24% of glabellar length) and more triangular in outline in a somewhat larger specimen (Fig. $1C_1$) but, although a node may be present, it is not yet spinose. By the time a distinct spine appears, LO accounts for 32% of glabellar length (Fig. 2D), and the incompletely preserved spine of the larger holotype is also part of a very long LO (Fig. $1A_1$). The axial furrows become increasingly bowed outwards, producing a distinctly barrel-shaped glabellar outline (compare Fig. $1A_1$, B, C_1, D). Smaller individuals have better defined lateral glabellar furrows (Fig. $1C_1$, D). The pygidial axis is very long in all specimens. It terminates just short of the pygidial margin in smaller specimens (e.g., Fig. $3C_2$) but extends to overhang the margin slightly in larger individuals (Fig. $3A_1$, B_2).

Remarks.—The conspicuous glabella that overhangs a very short anterior border and pygidium with a strongly convex, gently tapered axis ally *Catillicephala cifellii* sp. nov. with the other members of the genus that were revised by Westrop and Dengler (2014a). The spinous, triangular occipital ring of larger individuals (Figs. 1A, 2D) is unique. *Catillicephala cifellii* sp. nov. is most like *C. rotunda* (Rasetti, 1946) from the Grosses-Roches Formation, Métis-sur-Mer area, Quebec. The latter species has a tapered occipital ring with a rounded to bluntly pointed terminus (e.g., Westrop and Dengler 2014a: figs. 3D, 4B, G) that resembles the condition in small specimens of *C. cifellii* (Fig. 1D), albeit without an occipital node. Unlike *C. cifellii*, the occipital ring of *C. rotunda* does not develop a spine, even in the largest individuals. In addition, *C. rotunda* has a more bulbous glabella that is well-rounded anteriorly, and has narrower (tr.) posterior area of the fixigena. In the largest pygidia of *C. rotunda*, the axis terminates short of the posterior margin (e.g., Westrop and Dengler 2014a: fig. 5A–C), whereas similarly sized pygidia of *C. cifellii* have longer axes that overhang the pygidial margin (e.g., Fig. 3A, B)

Compared to *C. cifellii*, *C. impressa* (Rasetti, 1946) has a far more rounded preoccipital region of the glabella that is subcircular in outline and usually has a medial backward expansion that constricts the occipital furrow (e.g., Westrop and Dengler 2014a: figs. 7A, I, 8E, 9B). The anterior border furrow of *C. impressa* is effaced medially across almost the entire width of the glabella (e.g., Westrop and Dengler 2014a: figs. 7D, 8F, I, 9C, F, I), whereas *C. cifellii* has a shallow but complete border furrow (Figs. $1A_3$, C_3, $2A_3$).

Catillicephala shawi Westrop and Dengler, 2014a, differs from *C. cifellii* in having a subquadrate glabella that expands gently forward, an occipital furrow that shallows medially, and, as in *C. impressa*, the anterior border furrow is effaced in front of the glabella (e.g., Westrop and Dengler 2014a: figs. 14, 15). Like *C. cifellii*, the pygidium of *C. calva* Westrop and Dengler, 2014a, has a convex axis that overhangs the posterior margin. The cranidia of these two species are differentiated readily. In addition to lacking an occipital spine, *C. calva* has a relatively narrow, forwardly expanding glabella that contrasts with the barrel-shaped glabella of *C. cifellii* (compare Fig. 1A, B with Westrop and Dengler 2014a: fig. 19).

Stratigraphic and geographic range.—Type locality and horizon only.

Concluding remarks

Studies of the faunas of the Cow Head Group of western Newfoundland continue to expand the diversity of trilobites known from mid- to upper Cambrian paleoenvironments at the edge of the continental shelf of Laurentian North America (e.g., Westrop and Dengler 2014a, b, 2017). *Catillicephala cifellii* sp. nov. is the oldest member of Family Catillicephalidae, which may be a large clade with representatives that range throughout the upper Cambrian (e.g., Ludvigsen et al. 1989).

Acknowledgements

We thank Rich Cifelli for his role as a member of the advisory committees of numerous graduate students conducting thesis and dissertation research on trilobites at the University of Oklahoma, including AD. Michelle Coyne (Geological Survey of Canada, Ottawa, Canada) provided type numbers. Brian Pratt (University of Saskatchewan, Saskatoon, Canada) and Fred Sundberg (Museum of Northern Arizona, Flagstaff, USA) provided helpful reviews of the manuscript. Research

on the Cambrian faunas of the Cow Head Group was supported in part by a succession of grants to SRW from the Natural Sciences and Engineering Research Council of Canada and the National Science Foundation (USA).

References

Angelin, N.P. 1851. *Palaeontologia Suecica, Pars 1: Iconographia crustaceorum formationis transitionis*. 24 pp. Weigel, Lund.

James, N.P. and Stevens, R.K. 1986. Stratigraphy and correlation of the Cambro-Ordovician Cow Head Group, Western Newfoundland. *Geological Survey of Canada Bulletin* 366: 1–143.

Ludvigsen, R., Westrop, S.R., and Kindle, C.H. 1989. Sunwaptan (Upper Cambrian) trilobites of the Cow Head Group, Western Newfoundland, Canada. *Palaeontographica Canadiana* 6: 1–175.

Kindle, C.H. 1982. The C.H. Kindle collection: middle Cambrian to Lower Ordovician trilobites from the Cow Head Group, western Newfoundland. *Current Research, Geological Survey of Canada* 82-1C: 1–17.

Kindle, C.H. and Whittington, H.B. 1958. Stratigraphy of the Cow Head region, western Newfoundland. *Geological Society of America Bulletin* 69: 315–342.

Palmer, A.R. and Peel, J.S. 1981. Dresbachian trilobites and stratigraphy of the Cass Fjord Formation, western North Greenland. *Grønlands Geologiske Undersøgelse Bulletin* 141: 1–46.

Peng, S., Babcock, L.E., Zuo, J., Lin, H., Zhu, X., Yang, X., Robison, R.A., Qi, Y., Bagnoli, G., and Chen, Y. 2009. The Global boundary Stratotype Section and Point (GSSP) of the Guzhangian Stage (Cambrian) in the Wuling Mountains, northwestern Hunan, China. *Episodes* 32: 41–55.

Pohler, S.L., Barnes, C.R., and James, N.P. 1987. Reconstructing a lost faunal realm: conodonts from the Ordovician Cow Head Group, western Newfoundland. *In*: R. Austin (ed.), *Conodonts: Investigative Techniques and Applications*, 314–362. Ellis Horwood, Chichester.

Rasetti, F. 1946. Early upper Cambrian trilobites from western Gaspé. *Journal of Paleontology* 20: 442–446.

Rasetti, F. 1948. Middle Cambrian trilobites from the conglomerates of Quebec (exclusive of the Ptychopariidea). *Journal of Paleontology* 22: 315–339.

Raymond, P.E. 1937. Upper Cambrian and Lower Ordovician Trilobita and Ostracoda from Vermont. *Geological Society of America Bulletin* 48: 1079–1146.

Raymond, P.E. 1938. Nomenclatural notes. *Geological Society of America Bulletin* 48 (Supplement): xv.

Robison, R.A. 1988. Trilobite of the Holm Dal Formation (late middle Cambrian), central North Greenland. *Meddelelser om Grønland, Geoscience* 20: 23–103.

Shaw, A.B. 1952. Paleontology of Northwestern Vermont: II. Fauna of the upper Cambrian Rockledge Conglomerate near St. Albans. *Journal of Paleontology* 26: 458–483.

Walch, J.E.I. 1771. *Die Naturgeschichte der versteinerungen zur erläuterung der Knorrischen Sammlung von Merkwürdigkeiten der Natur. Vol. 3*. 235 pp. Felbecker, Nürnberg.

Walcott, C.D. 1884. Palaeontology of the Eureka District. *U.S. Geological Survey Monograph* 8: 1–298.

Walcott, C.D. 1924. Cambrian Geology and Paleontology V. *Smithsonian Miscellaneous Collections* 75 (2): 53–60.

Westrop, S.R. and Dengler, A.A. 2014a. The mid-Cambrian (Guzhangian; Marjuman) trilobite genus *Catillicephala* Raymond 1938 (Catillicephalidae) from the Cow Head Group and correlatives in eastern Canada. *Memoirs of the Association of Australasian Palaeontologists* 45: 89–116.

Westrop, S.R. and Dengler, A.A. 2014b. The mid-Cambrian (Series 3, Guzhangian; Marjuman) trilobite *Deiracephalus* Resser, 1935, from western Newfoundland. *Canadian Journal of Earth Sciences* 51: 682–700.

Westrop, S.R. and Dengler, A.A. 2017. The mid-Cambrian (Series 3, Drumian–Guzhangian; Marjuman) trilobite *Holmdalia* Robison, 1988, in western Newfoundland and its biostratigraphic significance. *Canadian Journal of Earth Sciences* 54: 113–128.

Westrop, S.R. and Eoff, J.D. 2012. Late Cambrian (Furongian; Paibian, Steptoean) agnostoid arthropods from the Cow Head Group, Western Newfoundland. *Journal of Paleontology* 86: 201–237.

Westrop, S.R. and Ludvigsen, R. 2000. The late Cambrian (Marjuman) trilobite genus *Hysteropleura* Raymond from the Cow Head Group, western Newfoundland. *Journal of Paleontology* 74: 1020–1030.

Westrop, S.R., Landing, E., and Dengler, A.A. 2018. Pseudocryptic species of the middle Cambrian trilobite *Eodiscus* Hartt, in Walcott, 1884, from Avalonian and Laurentian Newfoundland. *Canadian Journal of Earth Sciences* 55: 997–1019.

Westrop, S.R., Ludvigsen, R., and Kindle, C.H. 1996. Marjuman (Cambrian) agnostoid trilobites of the Cow Head Group, western Newfoundland. *Journal of Paleontology* 70: 804–829.

Zhao, Y., Yuan, J., Babcock, L.E., Guo, Q., Peng, J., Yin, L., Yang, X., Peng, S., Wang, C., Gaines, R.R., Esteve, J., Tai, T., Yang, R., Wang, Y., Sun, H., and Yang, Y. 2019. Global Standard Stratotype-Section and Point (GSSP) for the conterminous base of the Miaolingian Series and Wuliuan Stage (Cambrian) at Balang, Jianhe, Guizhou, China. *Episodes* 42: 165–184.