

BATHYURUS PERPLEXUS BILLINGS, 1865: DISTRIBUTION AND BIOSTRATIGRAPHIC SIGNIFICANCE

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ABSTRACT

The type specimen of Bathyrus perplexus Billings is a pygidium (GSC 632) from faulted limestone exposed in East Arm, Bonne Bay, Gros Morne National Park (Gros Morne – NTS 12H/12). Some workers have regarded it as a junior subjective synonym of B. extans (Hall); others have compared it to Acidiphorus pseudobathyrus Ross. The discovery of additional sclerites (cranidia, librigenae, thoracic segments, pygidia) confirms its distinctness. Bathyrus perplexus is widespread in western Newfoundland; it has a restricted stratigraphic range and is the nominate species of the Bathyrus perplexus Biozone. It occurs in dolostones or dolomitic lime mudstones of the uppermost Aguathuna Formation (St. George Group) at Table Point (Bellburns – NTS 12I/06 and 12I/05); in Back Arm, Port au Choix (Port Saunders – NTS 12I/11); Big Spring Inlet (St. Julien's – NTS 02M/04); and on the Radar Tower Road, Table Mountain (Stephenville – NTS 12B/10). It also occurs in the immediately overlying Spring Inlet Member of the basal Table Point Formation (Table Head Group) in the Phillips Brook Anticline (Harrys River – NTS 12B/09); and at Table Point (Bellburns – NTS 12I/06 and 12I/05). Bathyrus perplexus is associated with conodont Assemblage VII of Stait and Barnes, which indicates a correlation with the Anomalorthis (brachiopod) Biozone of the Whiterockian, Kanoshian Stage, i.e., early Middle Ordovician, Darriwilian. Typically, it is associated with shallow-water (littoral) Midcontinent Province conodonts and leperditicopid ostracodes (Bivia), an assemblage characteristic of the long-ranging, low-diversity, nearshore Bathyrus Biofacies.

INTRODUCTION

The type specimen of *Bathyrus perplexus* Billings, 1865 is a pygidium (GSC 632) from faulted limestone exposed in East Arm, Bonne Bay, Gros Morne National Park (Gros Morne – NTS 12H/12). Because of the historic lack of other sclerites, some workers (Walcott, 1886; Raymond, 1913; Ludvigsen, 1978a; and Tremblay and Westrop, 1991, page 809) have regarded it as a junior subjective synonym of *B. extans* (Hall, 1847); others have compared it to *Acidiphorus pseudobathyrus* Ross, 1967 (Knight and James, 1987, 1988; Ross and James, 1987; Williams *et al.*, 1987). The discovery of additional sclerites (cranidia, librigenae, thoracic segments, pygidia) confirms its distinctness. Some material collected by Stouge and Boyce from Table Point (TP) and Back Arm (BA), respectively (*see* Figure 1), was loaned to Hofmann and Bolton (1998), who were the first to illustrate the cranidium, librigena and other pygidia; these they designated as hypotypes. Because *Bathyrus perplexus* is widespread in western Newfoundland, the author felt it was time to describe the material in a unified study.

DISTRIBUTION

Klappa *et al.* (1980), Stouge (1984), Knight and James (1987, 1988), Ross and James (1987), Stenzel *et al.* (1990)

and Stait and Barnes (1991) have detailed lithostratigraphic accounts of the upper St. George Group and the Table Head Group. In this report, the study localities are shown in Figure 1, and detailed information in Appendix 1.

EA – EAST ARM, BONNE BAY, GROS MORNE NATIONAL PARK (NTS 12H/12 – GROS MORNE)

The type specimen of *Bathyrus perplexus* Billings, 1865 is a pygidium (GSC 632) from faulted limestone exposed in East Arm, Bonne Bay.

Lower Cambrian Divisions A (605 ft) and B (483 ft) of Logan *et al.* (1863) were measured “on the flank of a range of hills of Laurentian gneiss, 2,000 or 3,000 feet in height”, between “one and two miles inland from the northeast side of the East Arm of Bonne Bay”. From Bed 1 of Division B (“Light grey yellow-weathering limestone, in beds of from one to three inches thick, interstratified with blackish-blue slightly calcareous slate”), Richardson in Logan *et al.* (1863, page 866) reported “the pygidium of a species so closely resembling *B. extans* of the Birdseye and Black River formation”, i.e., Middle Ordovician (Blackriveran age), “that it can scarcely be distinguished from it, and may possibly be the same”. The pygidium was named *Bathyrus perplexus* by Billings (1865, page 364; Figure 350), probably because

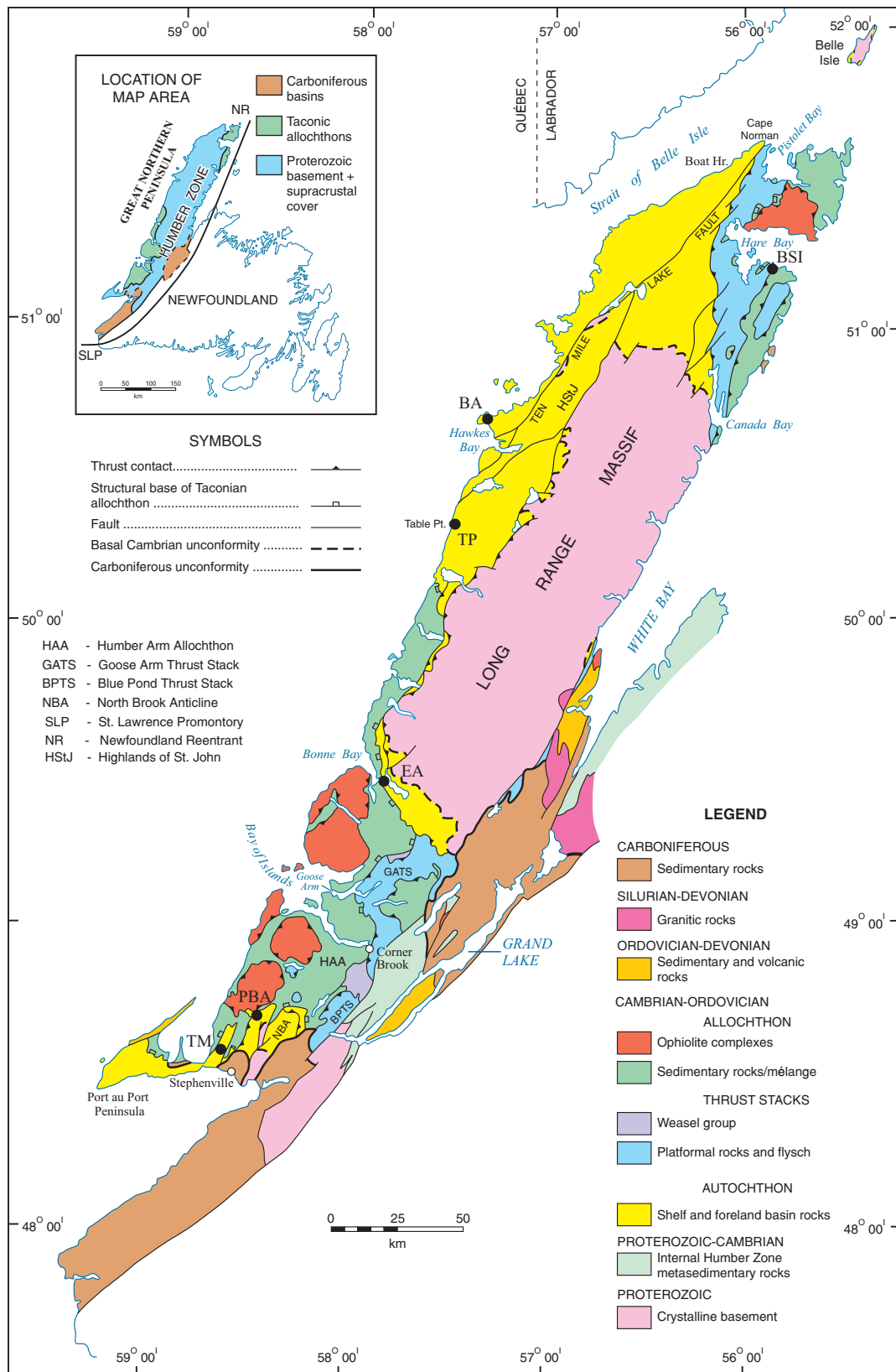


Figure 1. Regional geological map of western Newfoundland showing the major geologic terranes and *Bathyrus perplexus* localities (dots) from south to north: TM – Table Mountain, PBA – Phillips Brook Anticline, EA – East Arm of Bonne Bay, TP – Table Point, BA – Back Arm, Port au Choix, and BSI – Big Spring Inlet, Hare Bay. Map based on Knight (2007).

of its apparent puzzling occurrence with “*Paradoxides (Olenellus) Vermontana*” (Richardson in Logan *et al.*, 1863, page 866), *i.e.*, *Mesonacis vermontanus*, a Cambrian (Dyeran) trilobite species. Some of the material must have been from talus; assuming the Cambrian trilobite identifications were correct, the present author suspects that the *B. perplexus* material tumbled down from a higher level. Thus, for a hundred and eleven years, *B. perplexus* was known only from the pygidium, which was re-illustrated by Hofmann and Bolton (1998, page 80; Plate 1, figure 8; Plate 2, figures 6, 10).

For many years, western Newfoundland has been an important target for Pb–Zn exploration (Cumming, 1968; Collins, 1971, 1972; Collins and Smith, 1972, 1975; Lane, 1990); the Daniel’s Harbour Mine was a consequence of this interest. Given its restricted occurrence (*see below*), *B. perplexus* is an excellent regional stratigraphic marker.

TP – TABLE POINT (NTS 12I/06 AND 12I/05 – BELLBURNS)

The first comprehensive collection of *B. perplexus* sclerites (cranidia, librigenae, thoracic segments, additional pygidia), was made by Svend Stouge (*see* Stouge, 1980, page 9). He obtained “a restricted fauna of gastropods (*Hormotoma* sp.) and leperditiid ostracodes” (Stouge, 1980, page 24; 1984, page 97) and trilobite specimens (*Bathyurus* sp.) from Unit A1 – the basal bed of the Table Point Formation (Stouge, 1984, page 97). The trilobites subsequently were identified in 1976 as *B. perplexus*.

In 1983, a thorax and pygidium of *B. perplexus* were retrieved from the uppermost bed of the Aguathuna Formation (*see* Plate 10C–D, Appendix 1).

Fortey (personal communication, 1984 in Ross and James (1987, page 72) identified *Acidiphorus* cf. *A. pseudobathyurus* Ross from collection 80-RJ-25. According to Ross and James (1987, Appendix 3, page 94) the collection (UTM 5579380N, 4619190E) was obtained 1 m below the base of the Table Point Formation’s Spring Inlet Member in dolomitic laminite of the uppermost Aguathuna Formation and contained “cf. *Acidiphorus? pseudobathyurus* Ross” and two undetermined ostracode species.

BA – BACK ARM, PORT AU CHOIX (NTS 12I/11 – PORT SAUNDERS)

The second comprehensive collection of *B. perplexus* Billings, 1865 was made from the uppermost bed of the Aguathuna Formation, exposed in the Port au Choix dump, 0.6 km north of the community (Boyce, 1983, page 13; Knight, 1983, page 7; 1991, pages 64, 130; Stait, 1989, page

86; Lane 1990, page 38). The section was previously investigated by Stouge (1980), who reported ostracodes from fossiliferous micrite, dolomitic micrite, calcareous dolostone, and laminated dolostone in the lower 5 m of his Back Arm East Section VII (Stouge, 1980, page 34); he also obtained *Leptochirognathus prima* Branson and Mehl, 1943 (Stouge, 1980, page 248) and *Trigonodus rectus* n. sp. (Stouge, 1980, page 194). The Back Arm section was also studied by Stait (1989) and Stait and Barnes (1991).

BSI – BIG SPRING INLET, HARE BAY (NTS 02M/04 – ST. JULIEN’S)

The Spring Inlet Member of the Table Point Formation was proposed by Ross and James (1987, page 72) for a 10–40-m-thick succession of limestone, dolomitic limestone and dolomite with distinctive sedimentary textures indicating peritidal environments. According to Ross and James (1987, page 73), the Spring Inlet Member “is 40 m thick at its type locality east of Hare Bay along the western shore of Big Spring Inlet, directly west of Chevaliers Point (long. 55°51’W, lat. 51°13’N; St. Julien’s quadrangle UTM grid: Zone 21, 5773960N, 580595E). They indicated that the fauna comprised “a low diversity assemblage of leperditiid ostracodes and high spired gastropods” (Ross and James, 1987, page 73).

Ross and James (1987, Appendix 3, page 93) identified *Acidiphorus? cf. A.? pseudobathyurus* Ross in collection N-RJ-4 from the uppermost Aguathuna Formation, 3 m below the base of mud-cracked laminate of the Spring Inlet Member on the western shore across from Chevaliers Point Section (5773960N, 580595E). Williams *et al.* (1987, page 466) identified *Acidiphorus pseudobathyurus* Ross, whereas Knight and James (1987, page 1942) reported *Acidiphorus* sp. cf. *A. pseudobathyurus* Ross and *Bathyurus perplexus* Billings.

Bathyurus perplexus was collected in 1987 (Boyce *et al.*, 1988, page 82) from Knight’s Section K-1987-058 (*see* Plate 9, Appendix 1), on the north shore of Big Spring Inlet, west of the tickle (5774975N, 580600E). This presumably is the same monospecific trilobite locality reported by Ross and James (1987, pages 72, 93), one containing a trilobite “thorax of nine segments is still attached to pygidium” and detached cranidia, similar to that reported later by Boyce *et al.* (1988).

TM – TABLE MOUNTAIN (NTS 12B/10 – STEPHENVILLE)

In July, 1996 (as part of National Geographic Grant 6110-98 field work with Drs. D.M. Rohr and E.A. Measures, Sul Ross State University, Alpine, Texas), a small

amount of *B. perplexus* material was collected from the Aguathuna Formation along the Radar Tower Road Section, east of the Port au Port Peninsula (see Plate 10, Appendix 1).

PBA – PHILLIPS BROOK ANTICLINE (NTS 12B/09 – HARRYS RIVER)

The most recent collections of *B. perplexus* were made in 1999. *Bathyurus perplexus*, *Bivia bivia* and an indeterminate articulate brachiopod were obtained from a roadside exposure of the 9.3-m-thick Spring Inlet Member along the Phillips Brook Anticline, northeast of Stephenville (Knight and Boyce, 2000, page 208; – see Plate 11A–C, Appendix 1).

BIOSTRATIGRAPHY

TRILOBITES

The basal stage of the Whiterockian Series of Ross and Ethington (1991) – the Rangerian (Ross *et al.*, 1997, page

21) – comprises the *Paralenorthis*–*Orthidiella* (brachiopod) Zone (=Zone L of Ross, 1951=*Orthis subalata* Zone of Hintze, 1953). The overlying Kanoshian Stage (Ross *et al.*, 1997, page 21) comprises the *Anomalorthis* (brachiopod) Zone (Zones M and N of Hintze, 1953) and *Lichenaria*–*Oepikina* Zone (Zone O).

Bathyurus perplexus Billings, 1865 is the nominate species of the *Bathyurus perplexus* Biozone (Boyce, 1996, 1997; see Figure 2). It has a restricted range, from the uppermost Aguathuna Formation (St. George Group) to the immediately overlying Spring Inlet Member of the basal Table Point Formation (Table Head Group) – see Appendix 1. Boyce in Williams *et al.* (1987, page 466) erroneously regarded the *B. perplexus*-bearing beds to be indicative of the Ross (1951, 1970) – Hintze (1953) early Whiterockian *Orthidiella* Biozone (Zone L), *i.e.*, the Rangerian Stage of Ross and Ethington (1991), correlative with the global Dapingian Stage. However, later information shows that conodont Assemblage VII of Stait and Barnes (1991) is Darriwilian rather than Dapingian (*e.g.*, Johnston and

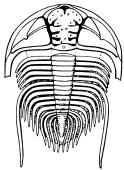


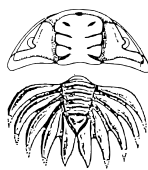


GLOBAL	NA	UK	LITHOSTRATIGRAPHY	TRILOBITE ZONES	CONODONT ZONES
Middle Ordovician Series	Darriwilian Stage	Whiterockian Series	TABLE HEAD GROUP	 <i>Cybelurus mirus</i>	 <i>Histiodella bellburnensis</i>
					 <i>Histiodella kristinae</i>
				 <i>Pseudomera barrandei</i>	 <i>Histiodella holodentata</i>
			ST. GEORGE GROUP	 <i>Bathyurus perplexus</i>	Assemblage VII of Stait & Barnes (1991)

Figure 2. Lithostratigraphy and trilobite and conodont biostratigraphy of the uppermost St. George Group and the Table Head Group within the Table Point Ecological Reserve (after Rohr *et al.*, 2004, 2008, 2019; Boyce and Knight, 2009; Stouge *et al.*, 2017). The left side of the chart is based on Bauer (2010, page 3, figure 2). NA=North America. UK=United Kingdom. The trilobite and conodont zonations follow Boyce (1997), Stouge (1984) and Stouge *et al.* (2017). The base of each zone is the FAD (First Appearance Datum) of the nominate species. The black triangles indicate the chert horizons.

Barnes, 1999, page 31, Figure 6; Stouge, 2012), which is not older than Kanoshian. Consequently, *B. perplexus* is also Kanoshian (see below).

Pseudomera barrandei Billings, 1865 characterizes the immediately overlying *Pseudomera barandei* Biozone. It is also present in the Kanoshian *Anomalorthis* Zone (Ross and Ethington, 1991, page 160, Table 1), and Kanoshian-correlative strata in Nevada and Oklahoma (Whittington, 1953; Shaw, 1974).

CONODONTS

Conodont Assemblage VII of Stait and Barnes (1991, page 130, Figure 5; page 132, Table 1; see Figure 2) characterizes the uppermost 15 m of the Aguathuna Formation and the basal Table Point Formation; it comprises the following taxa: *Neomultioistodus angulatus* Bauer, 2010 (formerly “*Multioistodus auritus*” (Harris and Harris, 1965) *sensu* Ethington and Clark, 1981 in Stait and Barnes, 1991, *Drepanoistodus angulensis* (Harris, 1962), *Erismodus asymmetricus* (Branson and Mehl, 1933), *Leptochirognathus quadratus* Branson and Mehl, 1943, *Multioistodus subdentatus* Cullison, 1938, *Paraprioniodus costatus* (Mound, 1965), *Protopanderodus strigatus* Barnes and Poplawski, 1973, and *Apteracontiodus sinuosus* (Mound, 1965) (= *Scandodus sinuosus* Mound in Stait and Barnes, 1991).

Stouge (1980, page 34) earlier obtained *Leptochirognathus prima* Branson and Mehl, 1943 (Stouge, 1980, page 248) and *Trigonodus rectus* (Stouge, 1984) in Stouge (1984, page 194) from the same interval.

Stait and Barnes (1991, page 131, Table 1) correlated Assemblage VII with the upper Kanosh Formation and the overlying Lehman Formation of Utah, *i.e.*, the Kanoshian Stage of Ross *et al.* (1997, page 21), which comprises the *Anomalorthis* (brachiopod) Biozone (Zones M and N of Hintze, 1953).

The *Paraprionodus neocostatus* Biozone occurs in the upper *Anomalorthis* subbiozone of the Kanoshian Stage (Bauer, 2010), *i.e.*, Zone N of Hintze, 1953.

BIOFACIES SIGNIFICANCE

The *Bathyurus* (nearshore) Biofacies originally was recognized by Walker (1972) in New York State, and subsequently documented by Ludvigsen (1978a, b, 1979) from other areas. Boyce *et al.* (2000, page 117, Figure 4) presented and demonstrated the temporal distribution of the informal Lower to lower Middle Ordovician ‘bathyrud biofacies’ in western Newfoundland, which occupied slightly

deeper water inshore depositional environments. Typically, *Bathyurus* is the only trilobite present; leperditicoid ostracodes commonly form the other faunal component. In western Newfoundland, *Bathyurus perplexus* Billings, 1865 commonly occurs with possible *Bivia bivia* (White, 1874) – see Appendix 1, Plates 6E, F; Plate 8E, F; Plate 11D–F, a widespread species studied by White (1874, 1877); Copeland (1974); Berdan (1976); Pitman (1991). According to Berdan (1981, 1984) and Pitman (1991), leperditids (leperditicoids) like *Bivia bivia* are good indicators of very shallow-water conditions.

Conodont Assemblage is VII of Midcontinent Province affinity, and generally is of shallow, warm-water depositional environs. (see Barnes and Fåhræus, 1975, page 136, Figure 1; Stouge, 1984, Figure 23).

CONCLUSIONS

Bathyurus perplexus is a significant and precise biostratigraphic marker, both in a regional and interregional scale. The *Bathyurus perplexus* Biozone occupies the narrow stratigraphic interval between the uppermost Aguathuna Formation (St. George Group) and the Spring Inlet Member, *i.e.*, the lowermost strata of the Table Point Formation (Table Head Group), probably correlating with the mid Whiterockian, *i.e.*, Darriwilian (Dw2, mid Middle Ordovician; see Figure 2). The *B. perplexus* Biozone corresponds to conodont Assemblage VII of Stait and Barnes (1991) and is followed by the *Uromystrum validum* Biozone of the Table Head Group (Figure 2). The occurrence of *B. perplexus* and conodont Assemblage VII below, and immediately above, the St. George–Table Head boundary indicates a conformable contact at the Table Point and Spring Inlet sections. The genus is the defining paleoenvironmental marker for the long-lived nearshore *Bathyurus* Biofacies.

SYSTEMATIC PALEONTOLOGY

Uncoated specimens were photographed in the Paleontology Lab at The Rooms Natural History Annex, St. John’s. The smaller specimens were photographed using a 10.0 MP OMAX A35100U digital microscope camera (<http://omaxmicroscope.com/a35100u-omax-10-0mp-usb-digital-camera-for-microscope-with-0-01mm-calibration-slide-windows-mac-linux.html>). The larger specimens were photographed using the author’s personal Canon or Panasonic bridge cameras. Multiple images were taken of each specimen at varying distances; these images subsequently were stitched together using Alan Hadley’s freeware vertical image stacking program CombineZP for Windows. The material is housed at The Rooms Natural History Annex, Provincial Museum Division, The Rooms Corporation of Newfoundland and Labrador, prefixed by ‘NFM F-’.

Note: In this study, an ‘original cast’ is the original fossil specimen positively preserved in the rock. A ‘latex cast’ is a replica made from the original fossil impression (negative or mold) in the rock.

Phylum ARTHROPODA Siebold and Stannius, 1845
 Class TRILOBITA Walch, 1771
 Order PROETIDA Fortey and Owens, 1975
 Superfamily BATHYURACEA Walcott, 1886
 Family BATHURIDAE Walcott, 1886
 Subfamily BATHYURINAE Walcott, 1886
 Genus *Bathyrurus* Billings, 1859

Type species. *Asaphus? extans* Hall, 1847, from the Lowville Formation (Black River Group), Mohawk Valley, New York State, USA (by monotypy).

Diagnosis from Ludvigsen (1979, page 13). “A genus of Bathyuridae with inflated glabella that expands slightly forward and two pairs of faint to firm, obliquely disposed lateral glabellar furrows. Palpebral areas large. Genal spines long and tapering with flattened borders. Hypostome quadrate with narrow convex borders, firm border furrows, distinct maculae, and high anterior wings. Rostral plate thinly crescentic; strongly flexed (sag.) and markedly waisted by connective sutures. Pygidium semi-circular to sub-triangular with deep axial furrows, four (or rarely five) interpleural furrows, and flattened borders.”

Other species. According to Billings (1865), Ludvigsen (1979), Ross (1967) and Tremblay and Westrop (1991), *Bathyrurus* also includes: *B. acutus* Raymond, 1913; *B. angelini* Billings, 1859; *B. angustus* Ross, 1970; *B. esbataottinensis* Ludvigsen, 1979; *B. granulosus* Ludvigsen, 1979; *B. mackenziensis* Tremblay and Westrop, 1991; *B. margareti* Tremblay and Westrop, 1991; *B. nevadensis* Ross, 1967; *B. platyparius* Ludvigsen, 1979; *B. sunbloodensis* Tremblay and Westrop, 1991; *B. superbus* Raymond, 1910; and *B. ulu* Ludvigsen, 1979.

Remarks. Swisher *et al.* (2015) treated *Raymondites* as a subgenus of *Bathyrurus* and assigned to *Bathyrurus* (*Raymondites*) the following taxa: *Acidaspis spiniger* Hall, 1847; *Bathyrurus* (*Raymondites*) *bandifer* Sinclair, 1944; *B. (R.)* cf. *B. (R.) ingalli* (Raymond, 1913) of Swisher *et al.* (2015, page 131; Figures 11.1–11.4 and 13.1–13.6); *B. (R.) clochensis* Swisher, Westrop and Amati, 2015; *B. (R.) missouriensis* Swisher, Westrop and Amati, 2015; *Bathyrurus ingalli* Raymond, 1913; *B. longispinus* Walcott, 1876; and *B. trispinosus* Wilson, 1947. Swisher *et al.* (2015, page 121) assigned the traditional *Bathyrurus* species above to *Bathyrurus sensu lato*. This is not followed here because the author regards *Bathyrurus* and *Raymondites* as two separate and distinct genera.

Bathyrurus perplexus Billings, 1865
 Plate 1A–F; Plate 2A–F; Plate 3A–F; Plate 4A–F;
 Plate 5A–F; Plate 6A–D; Plate 7A–F; Plate 8A–D;
 Plate 9A–F; Plate 10A–D; Plate 11A–C

- 1865 *Bathyrurus perplexus* (n sp.) – Billings, pages 364–365; Figure 350.
 ?1865 *Bathyrurus vetulus* (n sp.) – Billings, page 365.
 1886 **non** *Bathyrurus extans* (Hall) – Walcott, page 20.
 1913 **non** *Bathyrurus perplexus* Billings – Raymond, page 52.
 ?1915 *Bathyrurus? vetulus* Billings – Bassler, page 107.
 1978a **non** *Bathyrurus extans* (Hall) – Ludvigsen, page 12.
 1988 *Acidiphorus pseudobathyrurus* Ross – Knight and James, page 46.
 1991 **non** *Bathyrurus extans* (Hall) – Tremblay and Westrop, page 809.
 ?1991 ?*Bathyrurus* sp. – Tremblay and Westrop, page 814; Figure 15.1–15.4.
 1998 *Bathyrurus perplexus* Billings – Hofmann and Bolton, pages 78, 80, 81; Plate 1, figures 1–3, 5, 8; Plate 2, figures 6–8, 10, 11, 15.
 2013 *Bathyrurus perplexus* Billings, 1865 – Boyce, page 72.
 2014 *Bathyrurus perplexus* Billings, 1865 – Boyce, page 93.
 2019 *Bathyrurus perplexus* Billings, 1865 – Boyce; Plate 1A–C, E.

Diagnosis. Glabella straight-sided, anteriorly gently expanding. Prosopon consists of fine, reticulate terrace-lines; axially it also includes fine, dense granules/pustules.

Remarks. The cranidia and librigenae of *B. perplexus* previously were unknown until the study of Hofmann and Bolton (1998) who illustrated material loaned to them by the author – two cranidia, two left librigenae, one right librigena and three pygidia; these they designated as hypotypes (*see below*).

Stratigraphic range. Spring Inlet Member (Ross and James, 1987), basal Table Point Formation, Table Head Group (Klappa *et al.*, 1980; Stenzel *et al.*, 1990).

Section K-1999-032 of Knight, Phillips Brook Anticline, northeast of Stephenville (5397287N, 392298E, NTS 12B/09 – Harrys River) – *see* Figure 1, Appendix 1 1999F141

Section I of Stouge (1984), Table Point (5579250N, 461800E, NTS 12I/06 and 12I/05 – Bellburns) – *see* Figure 1, Appendix 1

TP3 of Stouge (1980, page 50, Figure 3.2; 1984, page 97)

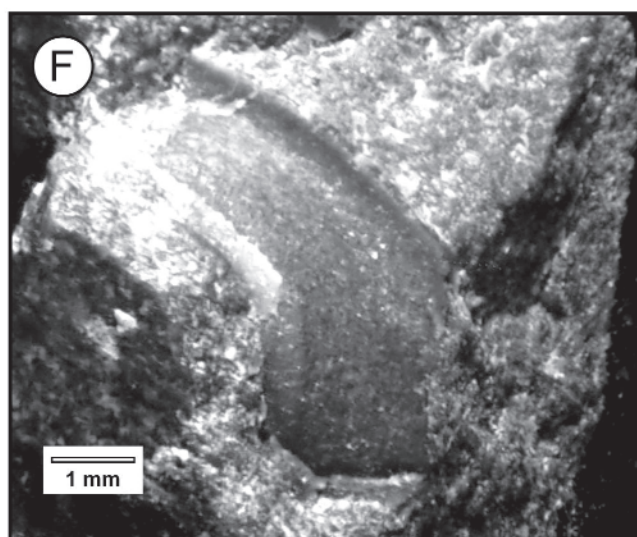
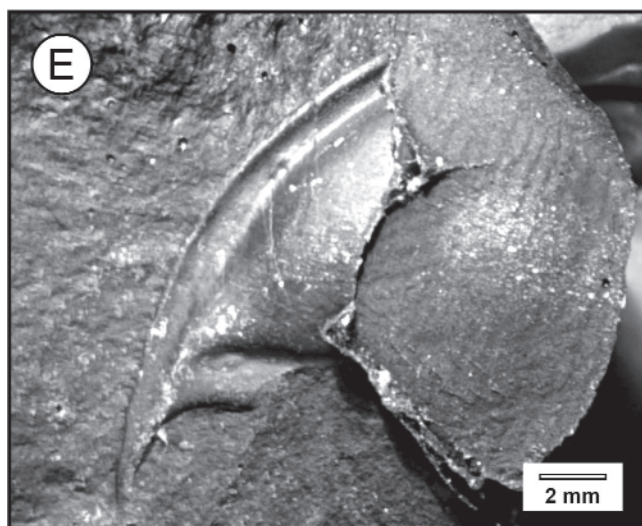
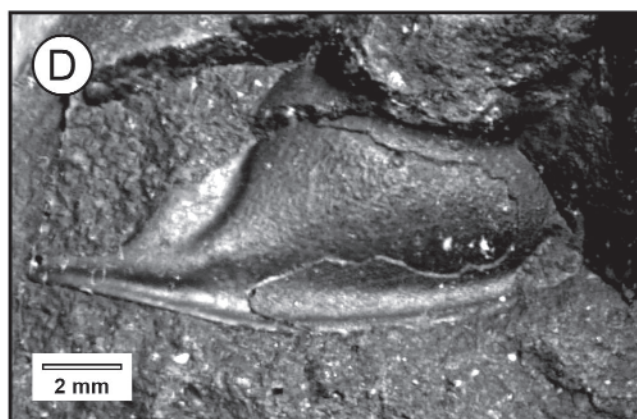
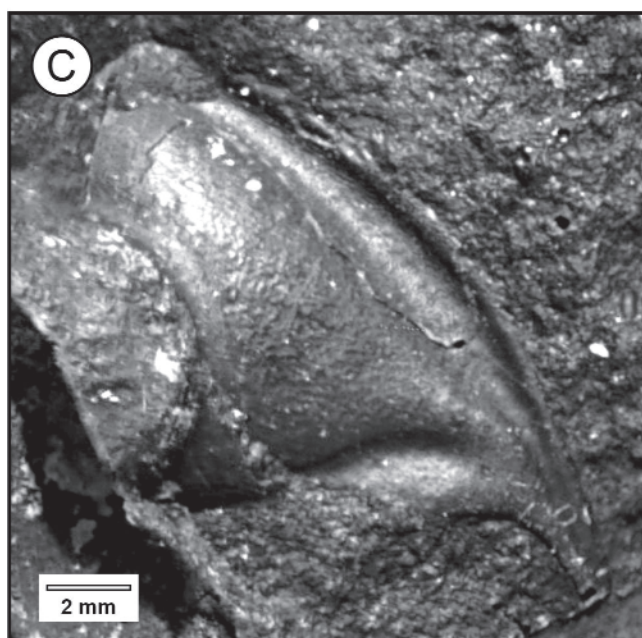
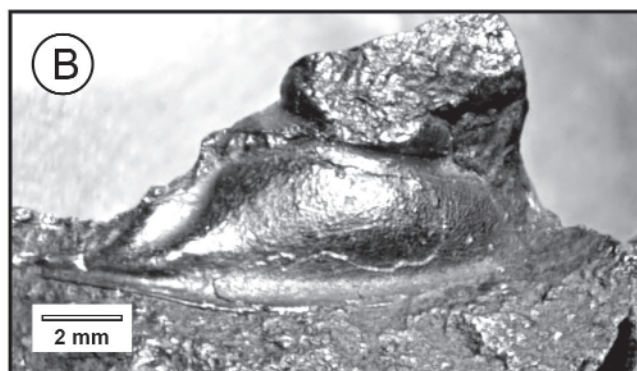
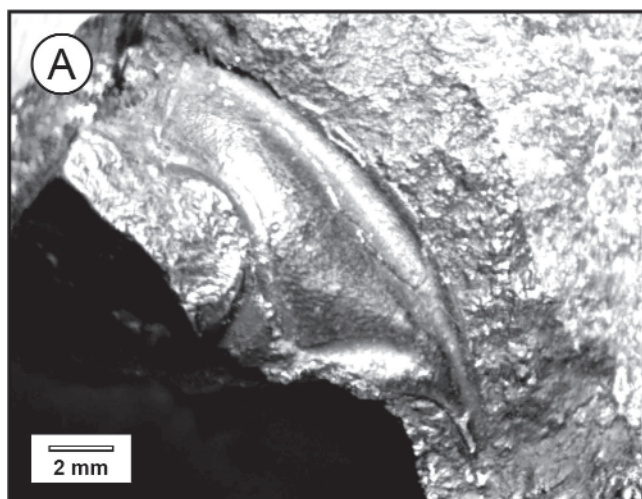


Plate 1. *Bathyrurus perplexus* Billings, 1865, Table Point Formation, base of Spring Inlet Member, TP3 of Stouge (1984, page 97), Table Point. A, B) Hypotype right librigena, original cast (NFM F-308.1), dorsal and lateral (right) views; C, D) Hypotype right librigena, latex cast (NFM F-308.2), dorsal and lateral (right) views; E) Hypotype left librigena, latex cast (NFM F-2712), dorsal view; F) Right librigena (NFM F-2715.1), dorsal view.

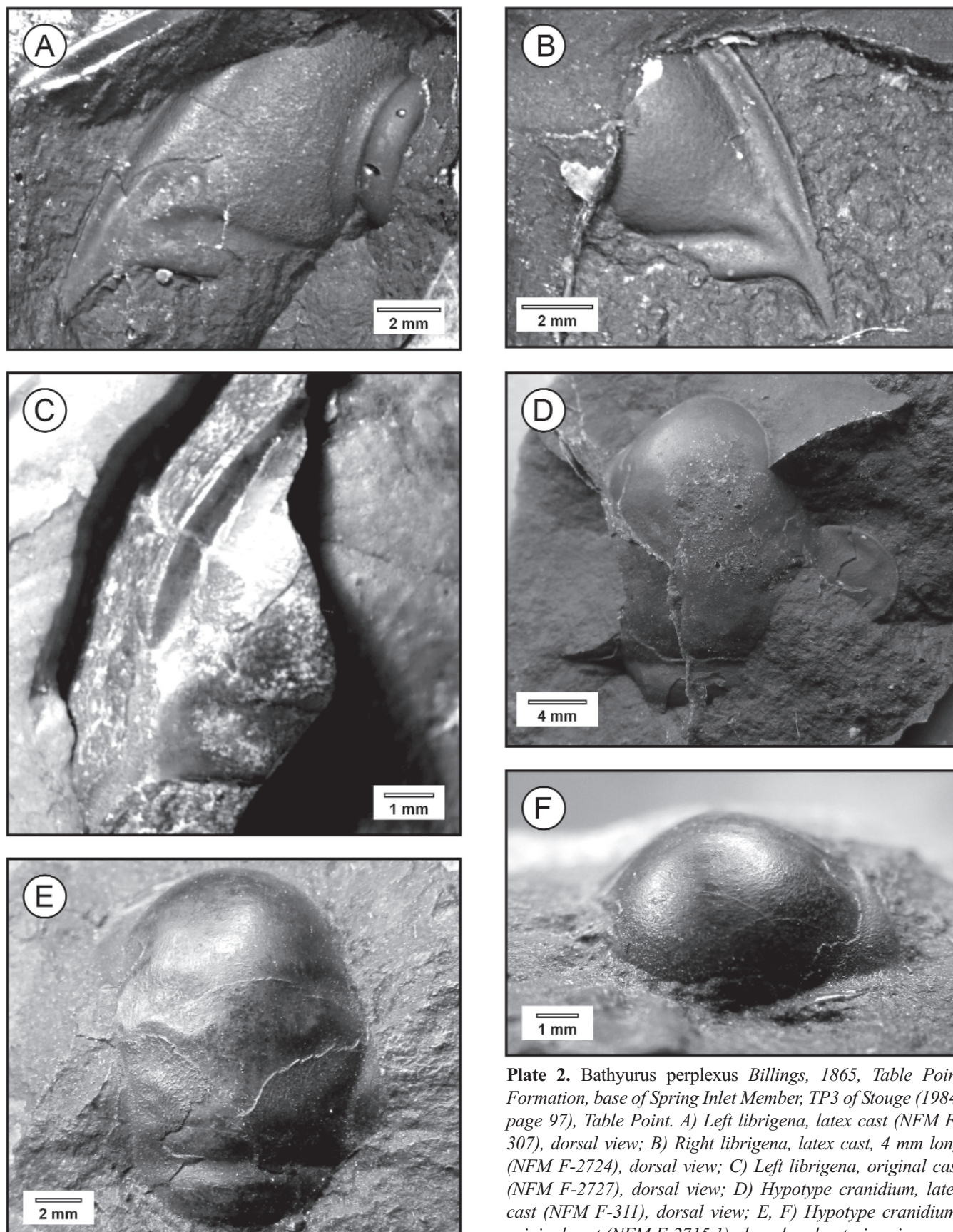


Plate 2. *Bathyrus perplexus* Billings, 1865, Table Point Formation, base of Spring Inlet Member, TP3 of Stouge (1984, page 97), Table Point. A) Left librigena, latex cast (NFM F-307), dorsal view; B) Right librigena, latex cast, 4 mm long (NFM F-2724), dorsal view; C) Left librigena, original cast (NFM F-2727), dorsal view; D) Hypotype cranidium, latex cast (NFM F-311), dorsal view; E, F) Hypotype cranidium, original cast (NFM F-2715.1), dorsal and anterior views.

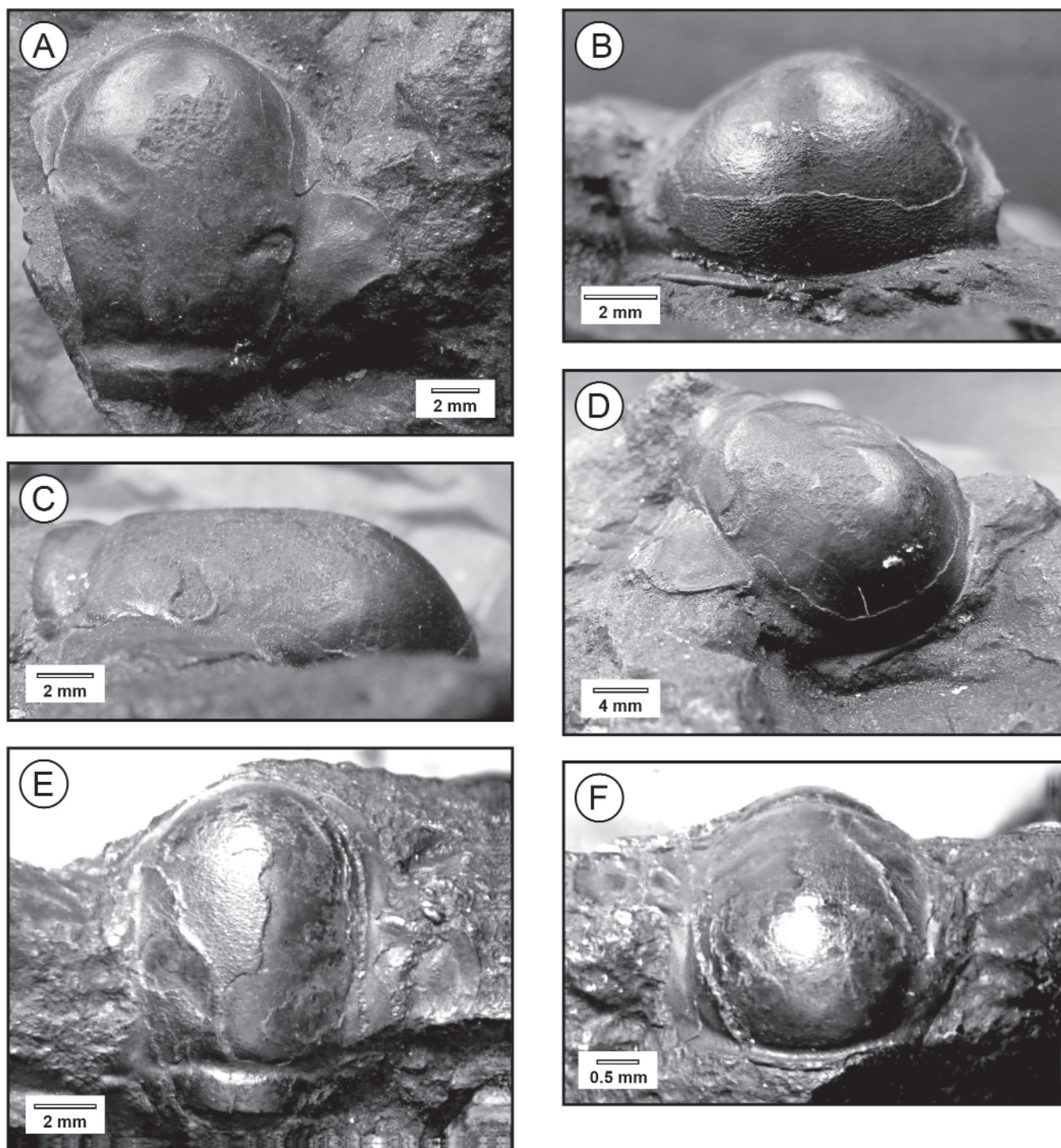


Plate 3. *Bathyrurus perplexus* Billings, 1865, Table Point Formation, base of Spring Inlet Member, TP3 of Stouge (1984, page 97), Table Point. A, B, C, D) Hypotype (partially testate) cranidium, original cast (NFM F-2719), dorsal, anterior, lateral (right), and oblique anterior (right) views; E, F) Hypotype (testate) cranidium, original cast (NFM F-2720), dorsal and anterior views.

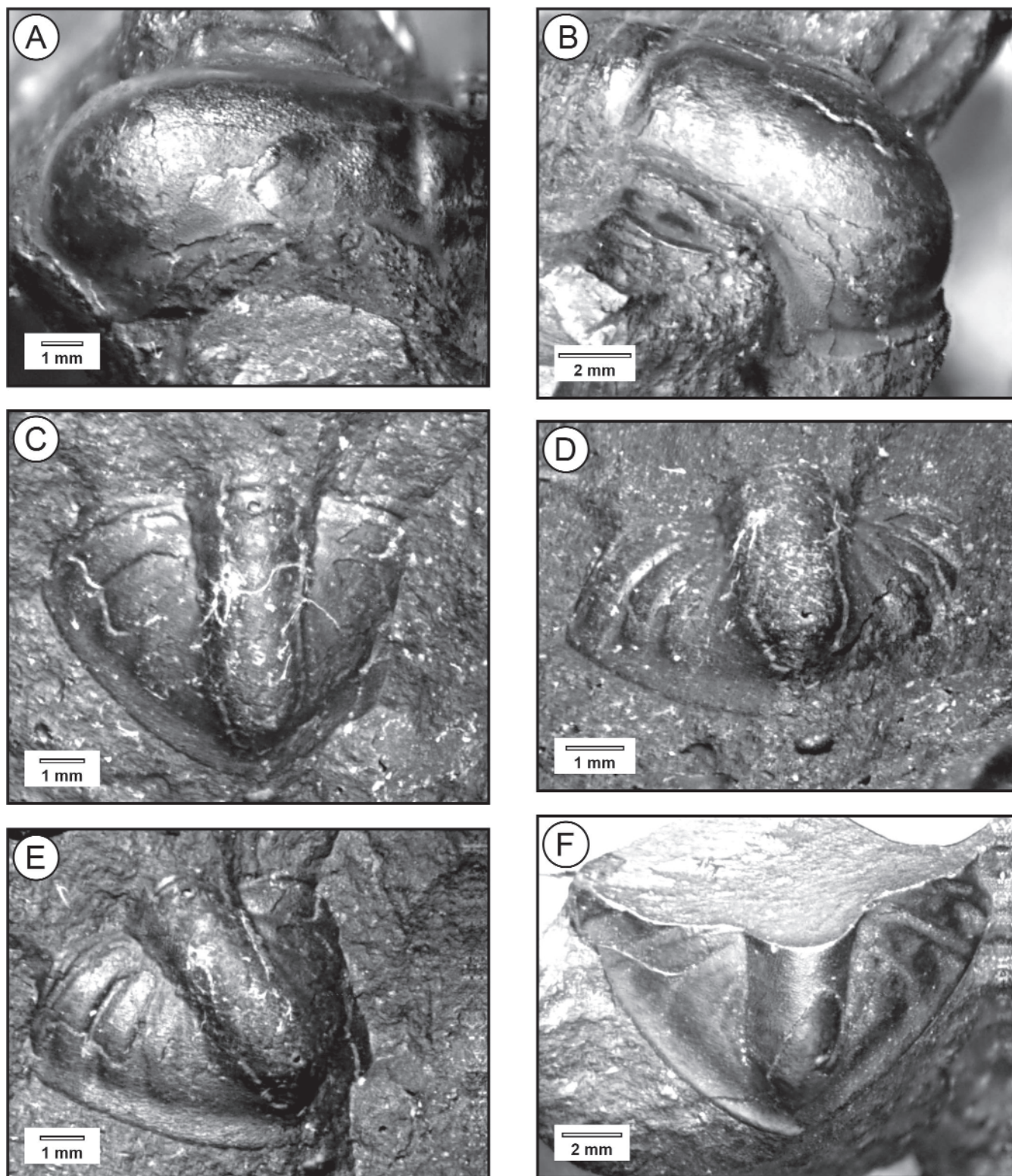


Plate 4. *Bathyrurus perplexus* Billings, 1865, Table Point Formation, base of Spring Inlet Member, TP3 of Stouge (1984, page 97), Table Point. A, B) Hypotype (testate) cranidium, original cast (NFM F-2720), inclined lateral (left) and oblique (right) views; C, D, E) Hypotype pygidium, original cast (NFM F-310), dorsal, posterior, and oblique (left) views; F) Hypotype pygidium, original cast (NFM F-309.1), dorsal view.

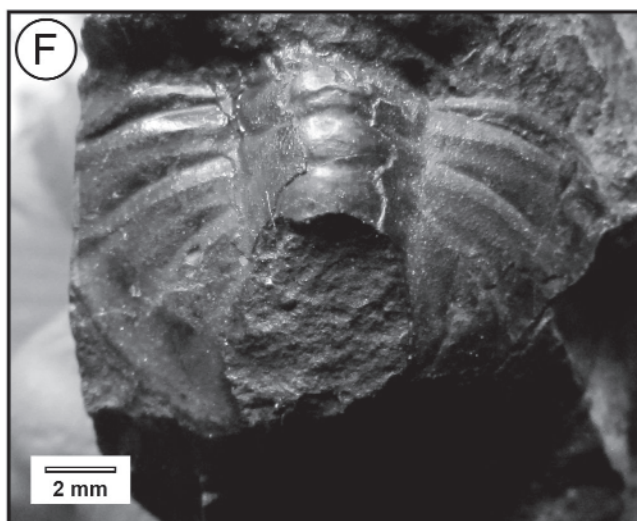
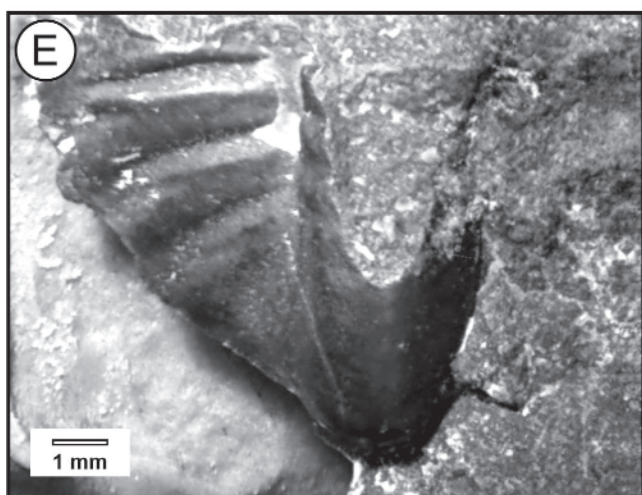
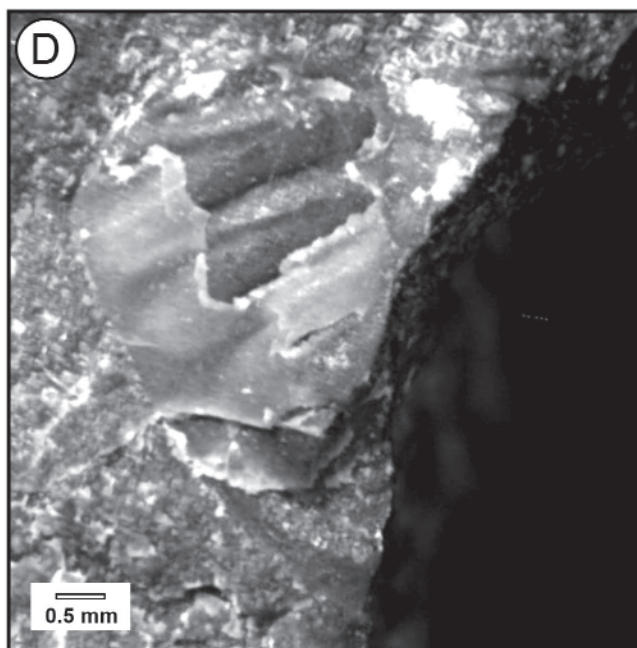
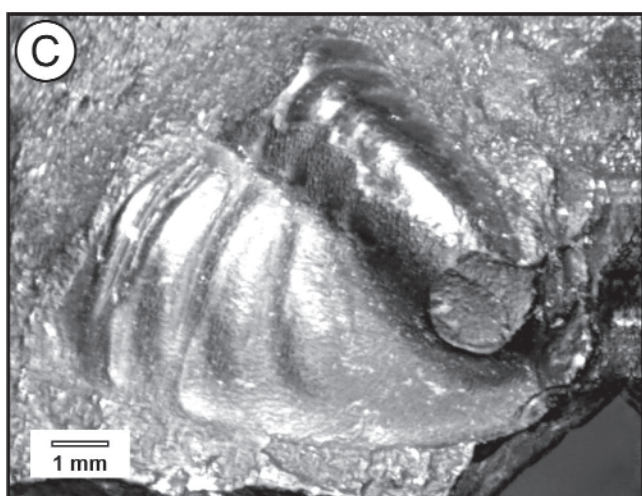
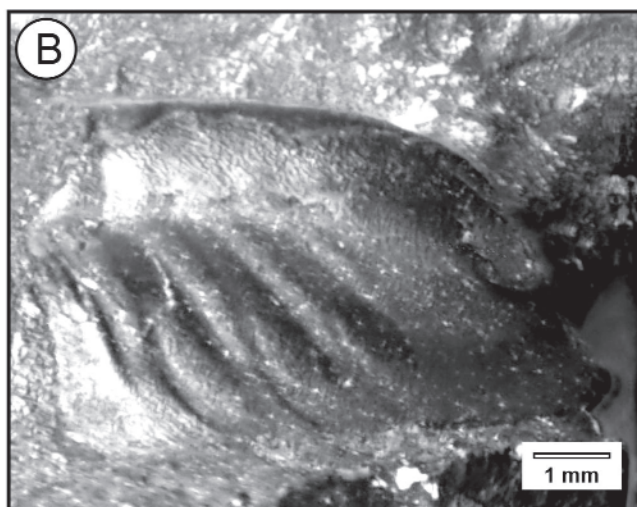
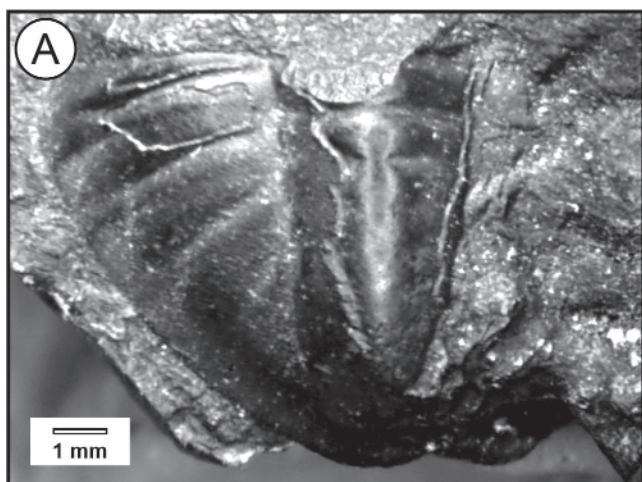


Plate 5. *Bathyrurus perplexus* Billings, 1865, Table Point Formation, base of Spring Inlet Member; TP3 of Stouge (1984, page 97), Table Point. A, B, C) Hypotype pygidium, original cast (NFM F-2726), dorsal, lateral (left), and oblique (left) views; D) Fragmentary pygidium, original cast (NFM F-2717), dorsal view; E) Fragmentary pygidium, original cast (NFM F-2718), dorsal view; F) Incomplete pygidium, original cast (NFM F-2728), dorsal view.

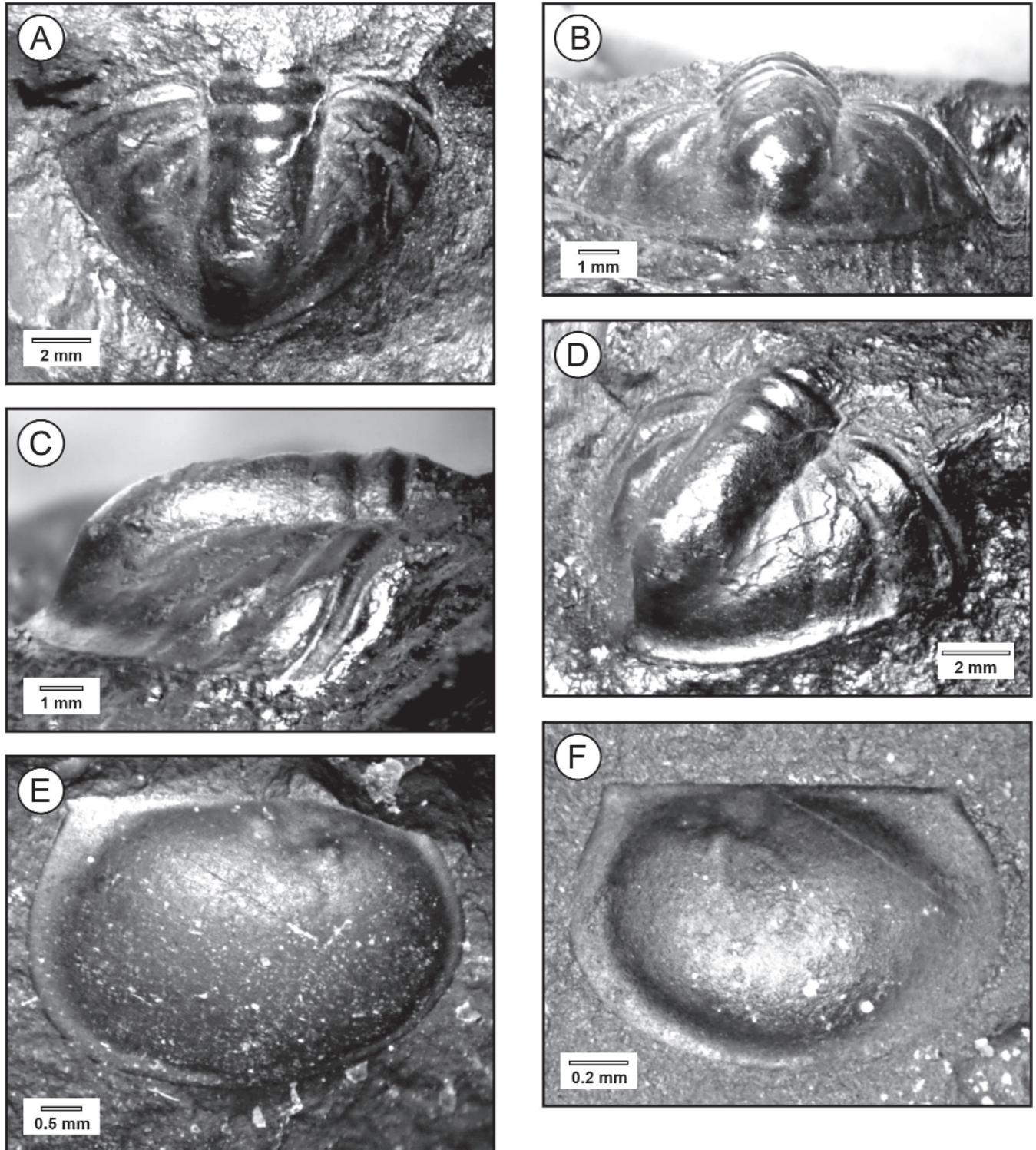


Plate 6. *Bathyrus perplexus* Billings, 1865, Table Point Formation, base of Spring Inlet Member, TP3 of Stouge (1984, page 97), Table Point. A, B, C, D) Hypotype (partially testate) pygidium, original cast (NFM F-2730), dorsal, posterior; lateral (right), and oblique (right) view; E, F) Ostracode *Bivia bivia* (White, 1874), Table Point Formation, base of Spring Inlet Member, TP3 of Stouge (1984, page 97), Table Point; E) "Large" specimen, original cast (NFM F-2713), lateral view; F) "Small" specimen, original cast (NFM F-2739), lateral view.

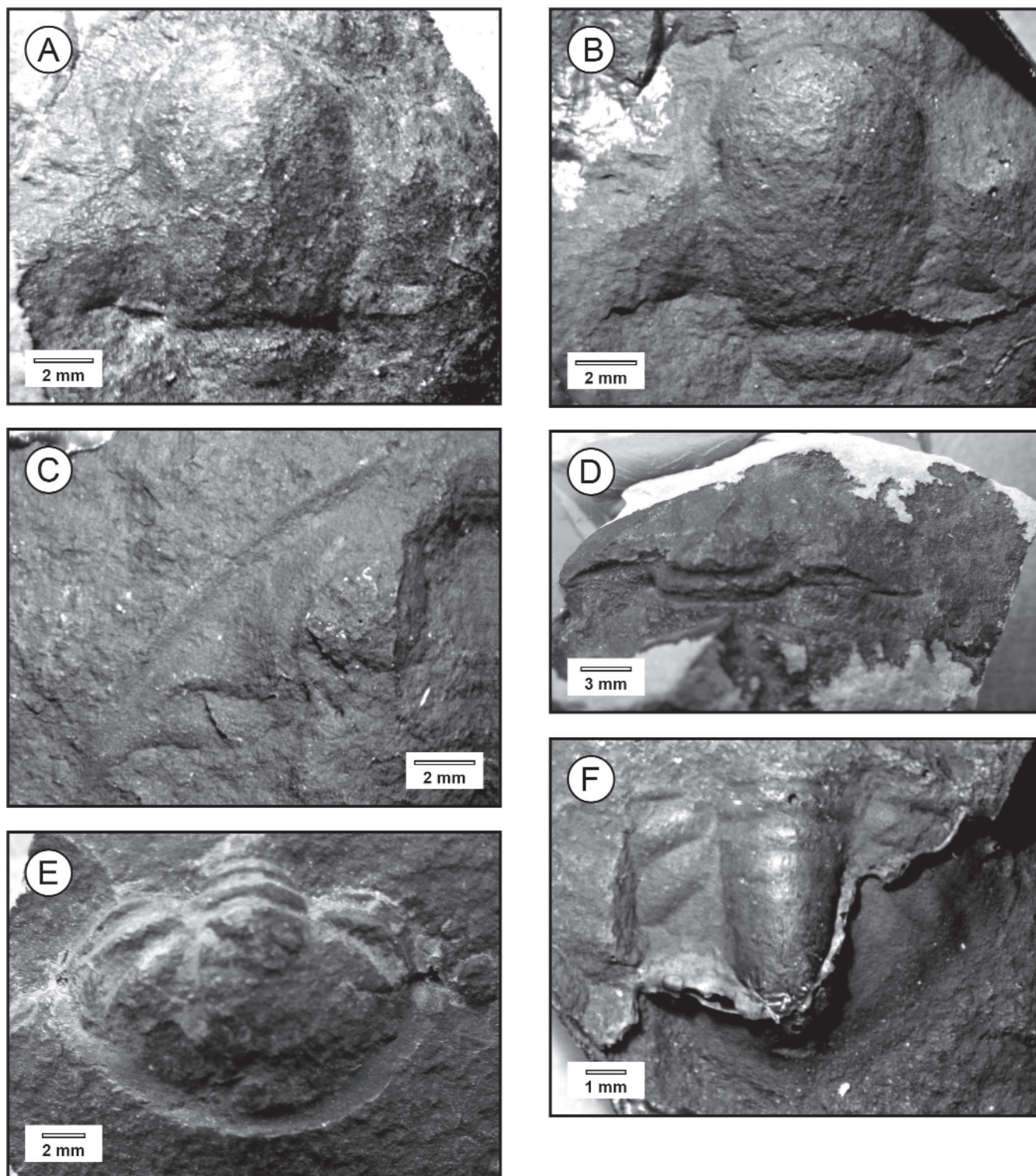


Plate 7. *Bathyrurus perplexus* Billings, 1865, uppermost Aguathuna Formation (St. George Group), ECW-097=1982F058 of Boyce, Back Arm, Port au Choix (see Boyce, 1983, page 13; Knight, 1991, page 130). A) Cranidium, original cast (NFM F-304.1), dorsal view; B) Cranidium, latex cast (NFM F-304.2), dorsal view; C) Left librigena, latex cast (NFM F-305), dorsal view; D) Thoracic segment, original cast (NFM F-2711); E) Pygidium, original cast (NFM F-2701); F) Pygidium, latex cast (NFM F-2703), dorsal view.

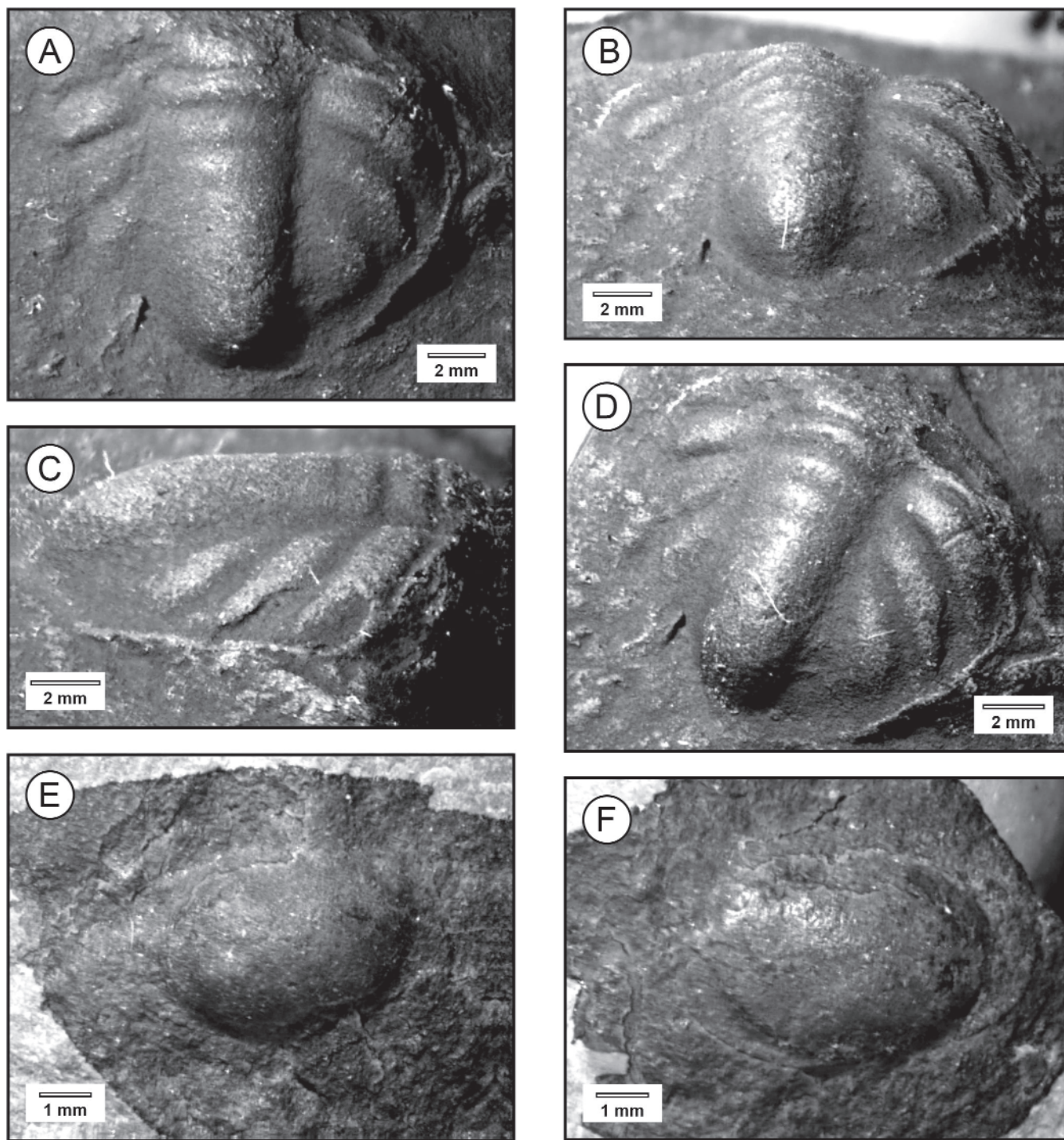


Plate 8. *Bathyrus perplexus* Billings, 1865, uppermost Aguathuna Formation (St. George Group), ECW-097=1982F058 of Boyce, Back Arm, Port au Choix (see Boyce 1983, page 13; Knight, 1991, page 130). A, B, C, D) Pygidium, latex cast (NFM F-306), dorsal, posterior, lateral (right), and oblique (right) views; E, F) Ostracode *Bivia bivia* (White, 1874)?, uppermost Aguathuna Formation (St. George Group), ECW-097=1982F058 of Boyce, Back Arm, Port au Choix (see Boyce 1983, page 13; Knight, 1991, page 130); E) Poorly preserved original cast (NFM F-2709), lateral view. F) Poorly preserved original cast (NFM F-2710), lateral view.

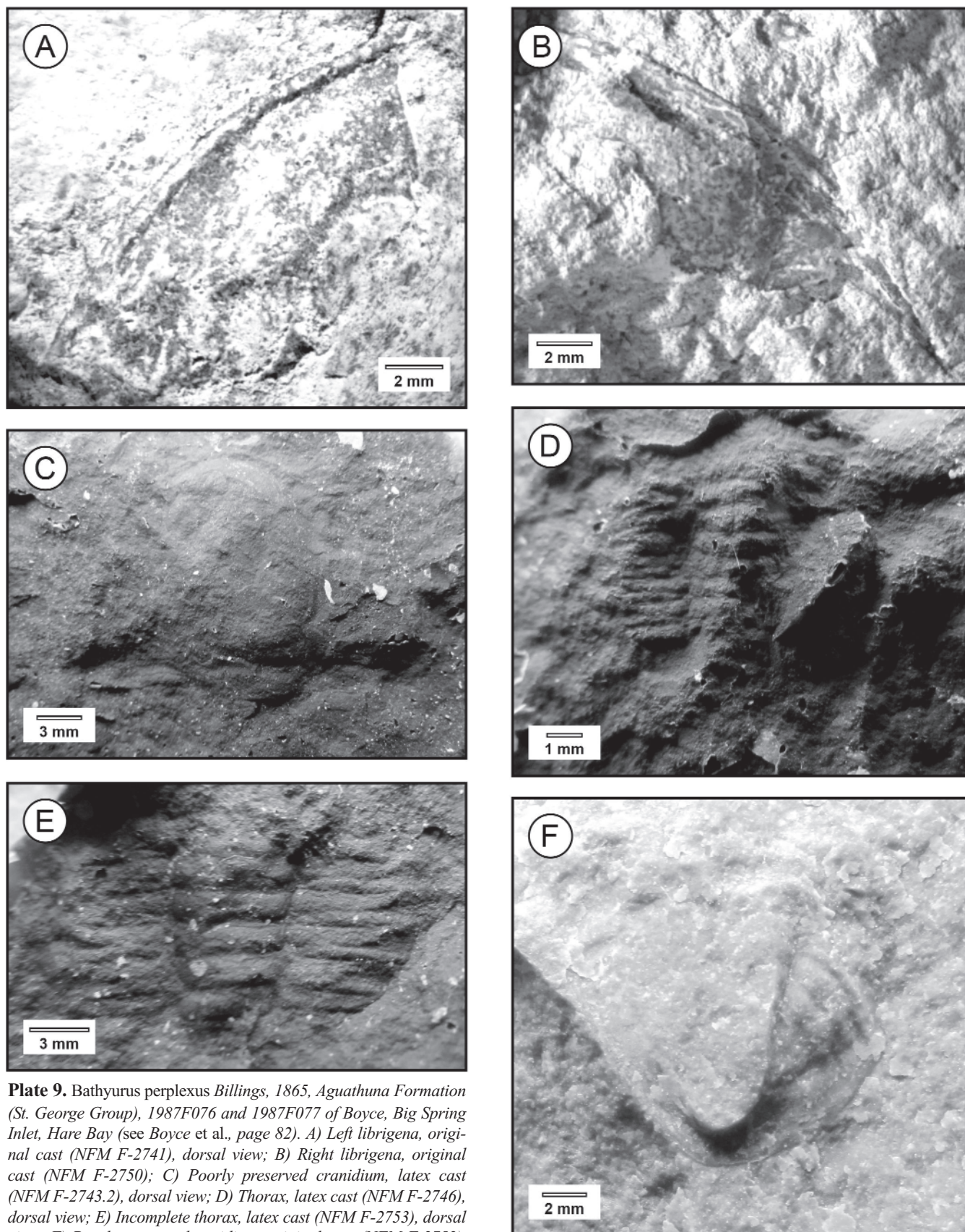


Plate 9. *Bathyrurus perplexus* Billings, 1865, *Aguathuna* Formation (St. George Group), 1987F076 and 1987F077 of Boyce, Big Spring Inlet, Hare Bay (see Boyce et al., page 82). A) Left librigena, original cast (NFM F-2741), dorsal view; B) Right librigena, original cast (NFM F-2750); C) Poorly preserved cranidium, latex cast (NFM F-2743.2), dorsal view; D) Thorax, latex cast (NFM F-2746), dorsal view; E) Incomplete thorax, latex cast (NFM F-2753), dorsal view; F) Poorly preserved pygidium, original cast (NFM F-2752), dorsal view.

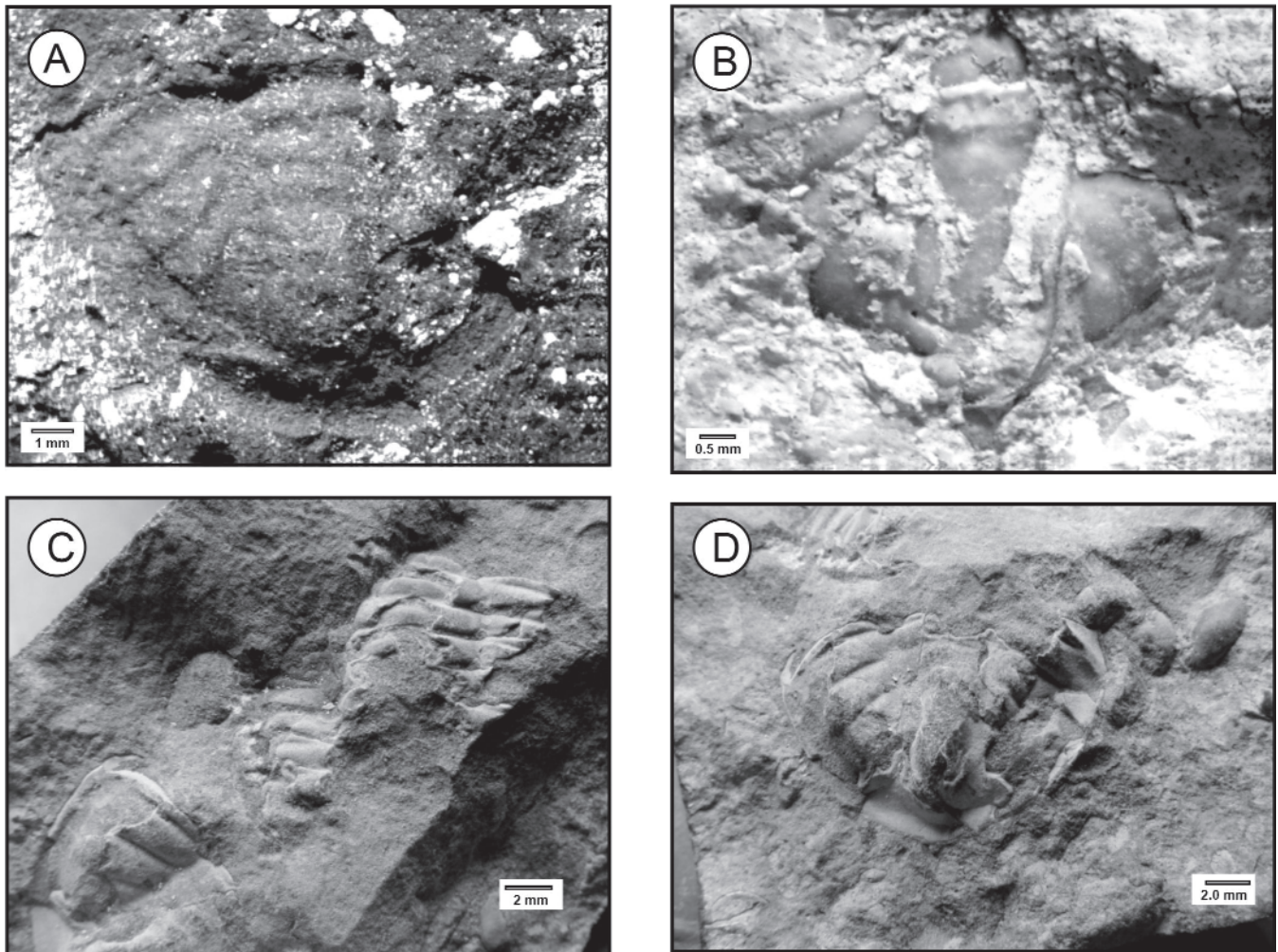


Plate 10. *Bathyrurus perplexus* Billings, 1865, Aguathuna Formation (St. George Group), 1996F005 of Boyce, Radar Tower Road, Table Mountain. A) Pygidium, latex cast (NFM F-2760), dorsal view; B) Pygidium, original cast (NFM F-2761), dorsal view; C, D) *Bathyrurus perplexus* Billings, 1865, Aguathuna Formation (St. George Group), 1983F004 of Boyce, Table Point; C) Thorax, original cast (NFM F-2768.1), dorsal view; D) Pygidium, original cast (NFM F-2768.2), dorsal view.

Plate 11. (Page 17) *Bathyrurus perplexus* Billings, 1865, Table Point Formation, Spring Inlet Member, 1999F141, Phillips Brook Anticline of Knight and Boyce (2000, page 208). A) Right librigena, latex cast (NFM F-2763), dorsal view; B) Small, cracked pygidium, original cast (NFM F-2762), dorsal view; C) Larger flattened pygidium, latex cast (NFM F-2764), dorsal view; D, E, F) *Ostracode Bivia bivia* (White, 1874), Table Point Formation, Spring Inlet Member, 1999F141, Phillips Brook Anticline of Knight and Boyce (2000, page 208); D) strongly convex specimen, original cast (NFM F-2765), lateral view; E) Broken specimen, original cast (NFM F-2766), lateral view; F) Well preserved specimen, original cast (NFM F-2767), lateral view.

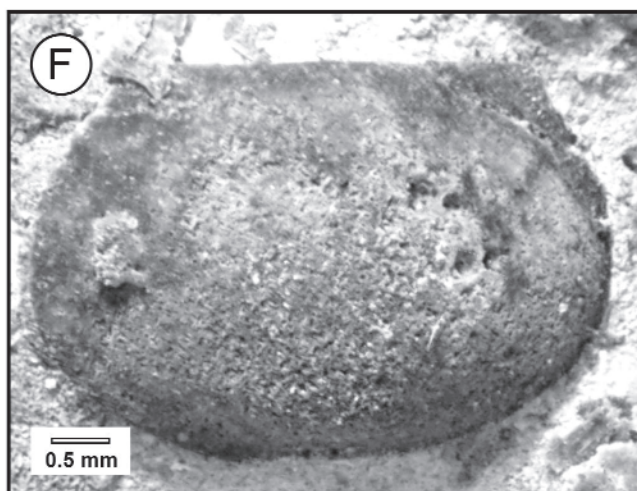
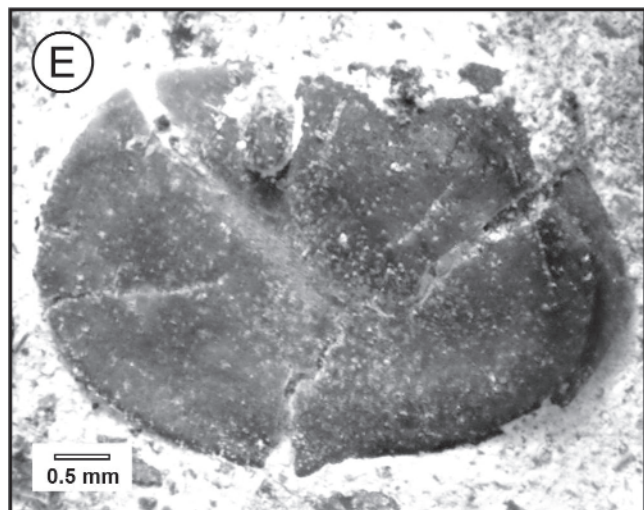
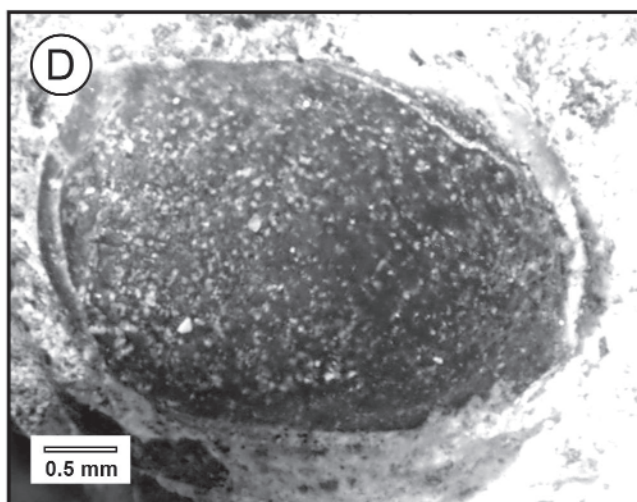
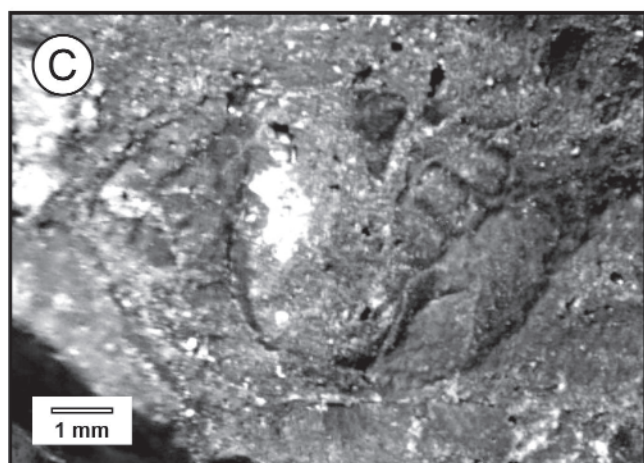
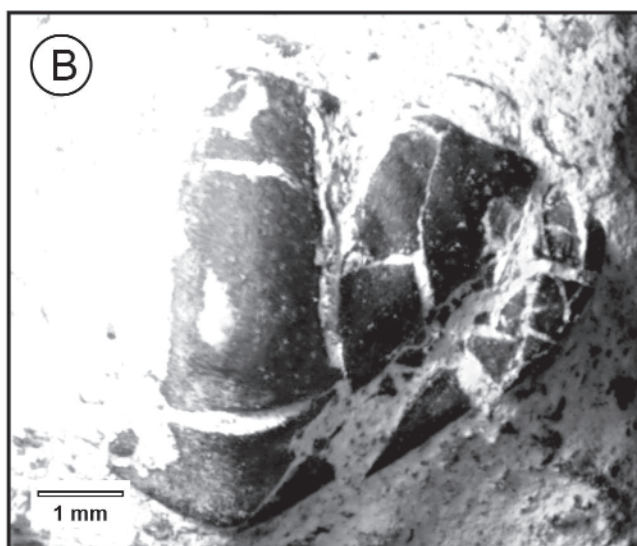
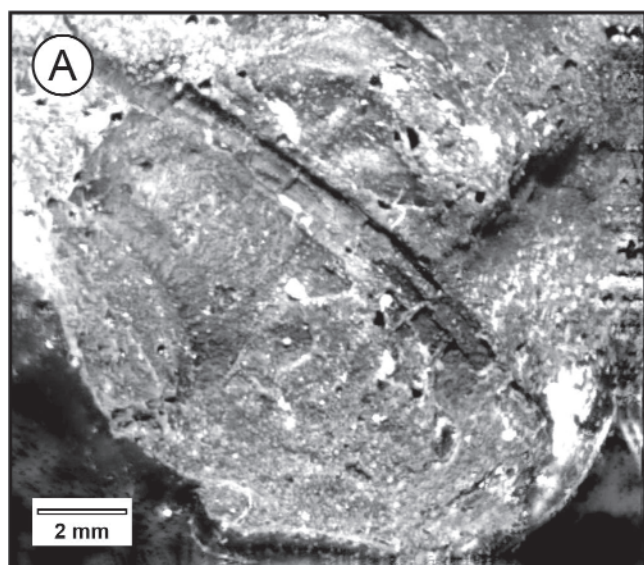


Plate 11. Caption on page 16.

Aguathuna Formation, St. George Group (Knight and James, 1987, 1988)

Section I of Stouge (1984), Table Point (5579250N, 461800E, NTS 12I/06 and 12I/05 – Bellburns) – *see* Figure 1, Appendix 1
1983F004

Section 10 of Knight (1991, page 130), Back Arm, 0.6 km north of Port au Choix (5617800N, 475800E, NTS 12I/11 – Port Saunders) – *see* Figure 1, Appendix 1
ECW-097=1982F058= K-1982-63 of Knight, 1982

Section K-1987-058 of Knight, Big Spring Inlet, north shore, west of tickle, Hare Bay (5674975N, 580600E, NTS 02M/04 – St. Julien's) – *see* Figure 1, Appendix 1
1987F077= K-1987-058-17
1987F076= K-1987-058-17

Radar Tower Road Section, Table Mountain, east of the Port au Port Peninsula, (5382600N, 375625E, NTS 12B/10 – Stephenville) – *see* Figure 1, Appendix 1
1996F005

Holotype. Pygidium, GSC 632, from limestones exposed in East Arm, Bonne Bay, western Newfoundland, Canada (the original of Billings, 1865; Figure 350 – by monotypy).

Hypotypes designated by Hofmann and Bolton (1998, page 80). From 1982F058 of Boyce in Back Arm – *see* Appendix 1: one cranidium (NFM F-304.1 and 2); one left librigena (NFM F-305); one pygidium (NFM F-306). From Unit A1, sample TP3 of Stouge (1984, page 97) at Table Point – *see* Appendix 1: one cranidium (NFM F-311); one left librigena (NFM F-307); one right librigena (NFM F-308.1 and 2); two pygidia (NFM F-309.1 and 2, NFM F-310).

Additional hypotypes designated herein. Three cranidia (NFM F-2716, NFM F-2719, NFM F-2720); one left librigena (NFM F-2712); two pygidia (NFM F-2726, NFM F-2730), also from TP3 of Stouge (1984, page 97). One thorax (NFM F-2768.1); one pygidium (NFM F-2768.2), from 1983F004 of Boyce – *see* Appendix 1.

Other figured material. One cranidium (NFM F-2743.2); two left librigenae (NFM F-2727, NFM F-2741); four right librigenae (NFM F-2715.1, NFM F-2724; NFM F-2750; NFM F-2764); one thoracic segment (NFM F-2711); two partial thoraxes (NFM F-2746, NFM F-2753); twelve pygidia (NFM F-306, NFM F-2701, NFM F-2703; NFM F-309.1, NFM F-2717, NFM F-2718, NFM F-2728; NFM F-2752; NFM F-2760, NFM F-2761; NFM F-2762, NFM F-2765).

Unfigured material. Six cranidia (NFM F-2699, NFM F-2714, NFM F-2721, NFM F-2729, NFM F-2743.1, NFM F-2744); one left librigena (NFM F-2747); two right librigenae (NFM F-2742, NFM F-2757); four thoraxes and pygidia (NFM F-2745, NFM F-2754, NFM F-2756, NFM F-2759); fifteen pygidia (NFM F-2698.1 and 2, NFM F-2702, NFM F-2704, NFM F-2705, NFM F-2706, NFM F-2707, NFM F-2708, NFM F-2722, NFM F-2731, NFM F-2732, NFM F-2748, NFM F-2749, NFM F-2751, NFM F-2752, NFM F-2758); one unknown, poorly preserved sclerite, possibly a hypostoma (NFM F-2755).

Description. Glabella highly convex, transversely strongly vaulted, sagittally long, straight-sided, anteriorly gently expanding and abruptly rounded, forward protruding – it overhangs anterior border. Forward glabellar outline subtriangular. Occipital ring sagittally narrow, rectangular. Preglabellar, occipital and axial furrows well defined, wide, shallow. Two pairs of lateral glabellar furrows; these are well defined, broad, shallow, oblique, elliptical and subparallel; they extend adaxially and posteriorly at an angle of 55 to 60° to sagittal line – the posterior pair are more distinct, longer, deeper. Preglabellar field not developed. Preglabellar portion of anterior border furrow well defined, narrow, shallow; abaxially it becomes less distinct, wider. Anterior border transversely long, extremely narrow, weakly convex, smooth – in anterior view it appears horizontal. Preglabellar portion of anterior margin convex-forward, abaxial portion straight to gently concave-forward. Anterior fixigenal areas narrow, weakly convex, anteriorly steeply downsloping. Anterior portions of facial suture strongly divergent, gamma approximately 90°. Palpebral fixigenal areas about three times wider than anterior fixigenal areas, abaxially and sagittally horizontal to very gently upsloping. Palpebral lobes large, long – exsagittal length about one-third sagittal glabellar length, wide, crescentic, generally poorly defined but more distinct in smaller individuals. Palpebral furrow indistinct, narrow, shallow. Line through centers of palpebral lobes crosses glabellar line about four-tenths of glabellar length from posterior end of occipital ring. Posterior fixigenal areas incompletely preserved on the author's specimens but from outline of librigenal sutures appear to be short, weakly convex, posteriorly steeply downsloping. Posterior border furrow incompletely preserved on author's specimens but well defined, wide, shallow. Prosopon consists of fine, reticulate terrace-lines; axially it also includes fine, dense granules/pustules.

Hypostoma unknown.

Librigena with genal field moderately convex. Lateral border and lateral border furrow are of constant width except posteriorly tapering from posterior border to tip of

genal spine. Lateral border extremely narrow, weakly convex; lateral border furrow distinct, wide, shallow. Genal spine continuous with lateral border, short, weakly convex; it projects from the posterolateral corner of the librigenal field. Posterior border distinct, transversely long, weakly convex. Posterior border furrow well defined, wide, shallow; it does not intersect lateral border furrow but shallows and is deflected posteriorly just short of genal angle where it then parallels posterior margin. Visual surface of eye strongly curved, sub-semicircular in horizontal plane, relatively narrow, outward-bulging in vertical plane, covered by numerous extremely small lenses. Prosopon consists of fine, reticulate terrace-lines.

Thorax comprises eight or nine segments, strongly convex, transversely long, sagittally wide – all of equal length and width. Pleural furrows well defined, wide, deep. Axial furrows distinct, narrow, shallow.

Pygidium strongly convex, subelliptical to subtriangular, length about three-quarters maximum width at posterior end of articulating facets. Axial lobe highly convex, cylindrical-conical, transversely strongly arched, posteriorly gently tapering and abruptly rounded; it extends about nine-tenths total pygidial length to posterior border, in profile gently downsloping. Three to four variably defined axial rings of even sagittal width. Axial furrows well defined, narrow, shallow. Four pairs of pleural furrows wider, deeper; they slope backwards posteriorly and stop at posterior border. Posterior border well defined, narrow, flat to concave-upward, posteriorly gently downsloping. Two or three pairs of interpleural furrows variably developed, indistinct, narrow, shallow, except abaxially from posterior border furrow where they widen, deepen and extend to posterior margin. Posterior border furrow indistinct, narrow, shallow. Prosopon consists of fine, reticulate terrace-lines; axially it also includes fine, dense granules/pustules. On internal molds a faint median carina extends from the posterior end of the axial lobe to the posterior margin.

Remarks. Fortey in Fortey and Droser (1996, page 83) assigned *Acidiphorus pseudobathyurus* Ross, 1967 to *Psephosthenaspis* Whittington, 1953; the glabellar prosopon of *A. pseudobathyurus* is coarsely tuberculate in comparison to that of *B. perplexus*.

Walcott (1886), Raymond (1913), Ludvigsen (1978a) and Tremblay and Westrop (1991, page 809) incorrectly regarded *Bathyurus perplexus* Billings as a junior subjective synonym of *B. extans* (Hall). This is because, until the collections herein were obtained, *B. perplexus* was known only from the holotype pygidium. However, the anteriorly expanding glabella, the markedly shorter genal spines and the distinctive prosopon readily distinguish this species

from *B. extans*. *Bathyurus perplexus* closely resembles: (1) *Bathyurus sunbloodensis* Tremblay and Westrop, 1991 = *Bathyurus* sp. cf. *B. extans* (Hall) of Ross (1970, page 85; Plate 13, figure 12; Plate 15, figures 16–19), from the Kanosh Shale of Ibex, Utah, the Antelope Valley Formation of Nevada, and the Sunblood Formation of the Southern Mackenzie Mountains; and (2) *Bathyurus margareti* Tremblay and Westrop, 1991 = “*Bathyurus*” sp. of Ludvigsen (1975, pages 677–679; Plate 1, figures 15, 16), from the Sunblood Formation of the Southern Mackenzie Mountains.

The prosopon of fine, reticulate terrace-lines and fine, dense granules/pustules readily distinguishes *B. perplexus* from the above two species. Of the two, *B. margareti* is morphologically the closest to *B. perplexus*. This species also has an anteriorly expanding glabella; however, the palpebral lobes are substantially larger and more distinct and the posterior pygidial border is wider. This strong resemblance suggests to the author that the two species are close evolutionary relations.

Bathyurus vetulus Billings, 1865 was collected in East Arm along with *B. perplexus* Billings, 1865. Billings did not illustrate *B. vetulus*, but from his description, it may be a junior synonym of *B. perplexus*; the pygidial proportions are comparable, and the prosopon comprises fine pustules. The type of *B. vetulus* appears to be lost, however. According to Ms Michelle Coyne: “The specimen is not in the type collection, neither is it listed in Tom’s (Dr. T.E. Bolton) Catalogue nor Alice Wilson’s log books which means that a number was not assigned. This specimen may have been ignored and downgraded without publication” (personal communication, October 16, 2019). She also wrote: “I’ve found nothing so far. I will keep my eyes out but it was never given a number in the log book and so I don’t think it has been in the collection for over 100 years. Logbook was started in 1920s” (personal communication, February 1, 2020).

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timate version of the manuscript was reviewed by Ms Nathalie Djan-Chekar (Natural History Collections Manager, Provincial Museum Division, The Rooms Corporation of Newfoundland and Labrador) and Drs. Elliott Burden (Department of Earth Sciences, Memorial University, St. John's), Lucy McCobb (National Museum of Wales, Cardiff), and Svend Stouge (Natural History Museum, University of Copenhagen). Ms Nathalie Djan-Chekar provided the specimen numbers.

REFERENCES

- Barnes, C.R. and F  hraeus, L.E.
1975: Provinces, communities and the proposed nekto-benthic habit of Ordovician conodontophorids. *Lethaia*, Volume 8, pages 133-149.
- Barnes, C.R. and Poplawski, M.L.S.
1973: Lower and Middle Ordovician conodonts from the Mystic Formation, Quebec, Canada. *Journal of Paleontology*, Volume 47, pages 760-790.
- Bassler, R.S.
1915: Bibliographic index of American Ordovician and Silurian fossils. Volume 1. United States National Museum, Bulletin 9, 718 pages.
- Bauer, J.A.
2010: Conodonts and conodont biostratigraphy of the Joins and Oil Creek formations, Arbuckle Mountains, south-central Oklahoma. Oklahoma Geological Survey, Bulletin 150, 44 pages.
- Berdan, J.M.
1976: Middle Ordovician Leperditicopid ostracodes from the Ibex area, Millard County, western Utah. Brigham Young University Geology Studies, Volume, Part 3, pages 37-56.

1981: Facies control of Ordovician Leperditicopid ostracodes from Kentucky. Geological Society of America, Abstracts with Programs, Volume 13, Number 7, page 407.

1984: Leperditicopid ostracodes from Ordovician rocks of Kentucky and nearby states and characteristic features of the Order Leperditicopida. United States Geological Survey, Professional Paper 1066-J, 40 pages.
- Billings, E.
1859: Descriptions of some new species of trilobites from the Lower and Middle Silurian rocks of Canada. *Canadian Naturalist* (Ottawa), Volume 4, pages 367-383.

1865: Palaeozoic Fossils. Volume I. Containing descriptions and figures of new or little known species of organic remains from the Silurian rocks. 1861-1865. Dawson Brothers, Montreal. Geological Survey of Canada, Separate Report, 426 pages.
- Boyce, W.D.
1983: Preliminary Ordovician trilobite biostratigraphy of the Eddies Cove West-Port au Choix area, western Newfoundland. In *Current Research*. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 83-1, pages 11-15.

1985: Cambrian-Ordovician biostratigraphic investigations, Great Northern Peninsula, western Newfoundland. In *Current Research*. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 85-1, pages 60-70.

1990: Table Point Ecological Reserve. Government of Newfoundland and Labrador, Department of Environment and Lands, Parks Division, Management Plan (October, 1990), 26 pages.

1996: Revised Ordovician trilobite biostratigraphy of the autochthon/parautochthon, western Newfoundland. In *Report of Activities*. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, page 8.

1997: Early to Middle Ordovician trilobite-based biostratigraphic zonation of the Autochthon and Parautochthon, western Newfoundland, Canada. Second International Trilobite Conference, Brock University, St. Catharines, Ontario, August 22-25, 1997, Abstracts with Program, page 10.

2013: *Bathyurus perplexus* Billings, 1865, not so perplexing. In *Winnipeg 2013: At The Centre Of The Continent*. Geological Association of Canada-Mineralogical Association of Canada (GAC-MAC) Joint Annual Meeting, Abstracts, Volume 36, page 72.

2014: *Bathyurus perplexus* Billings, 1865, not so perplexing. In *Geological Association of Canada, Newfoundland and Labrador Section, Abstracts, 2014 Spring Technical Meeting, February 17-18, 2014 and Atlantic Geology*, Volume 50, page 93.

- 2019: *Bathyrus perplexus* Billings, 1865 (Middle Ordovician): Distribution and significance. Government of Newfoundland and Labrador, Department of Natural Resources, 2019 Mineral Resources Review poster.
- Boyce, W.D., Ash, J.S. and Knight, I.
1988: Biostratigraphic studies of Ordovician carbonate rocks in western Newfoundland, 1987. *In* Current Research. Government of Newfoundland and Labrador, Department of Mines, Mineral Development Division, Report 88-1, pages 75-83.
- Boyce, W.D. and Knight, I.
2009: New fossil localities in the Middle Ordovician Table Point Formation, Bonne Bay Little Pond area, western Newfoundland. *In* Current Research. Government of Newfoundland Labrador, Department of Natural Resources, Geological Survey, Report 09-1, pages 123-129.
- Boyce, W.D., Knight, I., Rohr, D.M., Williams, S.H. and Measures, E.A.
2000: The Upper St. George Group, western Port au Port Peninsula: Lithostratigraphy, biostratigraphy, depositional environments and regional implications. *In* Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 2000-1, pages 101-125.
- Boyce, W.D. and Stouge, S.
1997: Trilobite and conodont biostratigraphy of the St. George Group at Eddies Cove West, western Newfoundland. *In* Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 97-1, pages 183-200.
- Branson, E.B. and Mehl, M.G.
1933: Conodont studies, numbers 1 and 2. University of Missouri Studies, Volume 8, Numbers 1,3, pages 1-167.
- 1943: Ordovician conodont faunas from Oklahoma. *Journal of Paleontology*, Volume 17, pages 89-92.
- Chatterton, B.D.E. and Ludvigsen, R.
1976: Silicified Middle Ordovician trilobites from the South Nahanni River area, District of Mackenzie, Canada. *Palaeontographica*, Part A, Volume 154, pages 1-106.
- Collins, J.A.
1971: Carbonate lithofacies and diagenesis related to sphalerite mineralization near Daniel's Harbour, western Newfoundland. Unpublished M.Sc. thesis, Queen's University, 184 pages.
- 1972: Sphalerite as related to the tectonic movements, deposition, diagenesis and karstification of a carbonate platform. *Proceedings of the 24th International Geological Congress*, Montreal, Section 6, page 208.
- Collins, J.A. and Smith, L.
1972: Lithostratigraphic controls of some Ordovician sphalerite. *In* Ores in Sediments. *Edited by* G.C. Amstutz and A.J. Bernard. Springer Verlag, Heidelberg, pages 79-91.
- 1975: Zinc deposits related to diagenesis and intrakarstic sedimentation in the Lower Ordovician St. George Formation, western Newfoundland. *Bulletin of Canadian Petroleum Geology*, Volume 23, pages 393-427.
- Copeland, M.J.
1974: Middle Ordovician Ostracoda from the southwestern District of Mackenzie. *Geological Survey of Canada*, Bulletin 244, 55 pages.
- Cullison, J.S.
1938: Dutchtown fauna of southeastern Missouri. *Journal of Paleontology*, Volume 12, pages 219-228.
- Cumming, L.M.
1968: St. George-Table Head disconformity and zinc mineralization, western Newfoundland. *Canadian Mining and Metallurgical Bulletin*, Volume 61, pages 721-725.
- Ethington, R.L., and Clark, D.L.
1981: Lower and Middle Ordovician conodonts from the Ibex area, western Millard County, Utah. *Brigham Young University Geology Studies*, Volume 28, Number 2, pages 1-155.
- Fortey, R.A. and Droser, M.L.
1996: Trilobites at the base of the Middle Ordovician, western United States. *Journal of Paleontology*, Volume 70, pages 73-99.
- Fortey, R.A. and Owens, R.M.
1975: Proetida: a new order of trilobites. *Fossils and Strata*, Number 4, pages 227-239.
- Hall, J.
1847: *Palaeontology of New York*, Volume 1. Albany, New York.

- Harris, R.W.
1962: New conodonts from the Joins (Ordovician) Formation of Oklahoma. Oklahoma Geology Notes, Volume 22, pages 199-211.
- Harris, R.W. and Harris, B.
1965: Some West Spring Creek (Ordovician Arbuckle) conodonts from Oklahoma. Oklahoma Geology Notes, Volume 25, pages 34-47.
- Hintze, L.F.
1953: Lower Ordovician trilobites from western Utah and eastern Nevada. Utah Geological and Mineralogical Survey Bulletin 48, 249 pages.
- Hofmann, H.J. and Bolton, T.E.
1998: Middle Ordovician (Whiterockian) trilobite *Bathyurus angelini* Billings 1859 from the Carillon Formation (uppermost Beekmantown Group) at Kahnawake, Quebec, and correlative trilobites from eastern Canada. Canadian Journal of Earth Sciences, Volume 35, pages 76-87.
- Johnston, D.I. and Barnes, C.R.
1999: Early and Middle Ordovician (Arenig) conodonts from St. Pauls Inlet and Martin Point, Cow Head Group, western Newfoundland, Canada. 1. Biostratigraphy and Paleoecology. *Geologica et Paleontologica*, Volume 33, pages 21-70.
- Klappa, C.F., Opalinski, P.R. and James, N.P.
1980: Middle Ordovician Table Head Group of western Newfoundland: A revised stratigraphy. Canadian Journal of Earth Sciences, Volume 17, pages 1007-1019.
- Knight, I.
1983: Geology of Cambro-Ordovician rocks in parts of the Castors River, St. John Island and Port Saunders map sheets. In Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 83-1, pages 1-10.

1991: Geology of Cambro-Ordovician rocks in the Port Saunders (NTS 12I/11), Castors River (NTS 12I/15), St. John Island (NTS 12I/14), and Torrent River (NTS 12I/10) map areas. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey Branch, Report 91-4, 138 pages.

2007: Geological studies in the Lomond (NTS12H/5) and adjacent map areas of the eastern part of the Goose Arm thrust stack, western Newfoundland. In Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 07-01, pages 45-54.
- Knight, I. and Boyce, W.D.
2000: Geological notes on the Cambro-Ordovician rocks of the Phillips Brook Anticline, north of Stephenville. In Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 2000-1, pages 197-215.
- Knight, I. and James, N.P.
1987: The stratigraphy of the Lower Ordovician St. George Group, western Newfoundland: The interaction between eustasy and tectonics. Canadian Journal of Earth Sciences, Volume 24, pages 1927-1951.

1988: Stratigraphy of the Lower to lower Middle Ordovician St. George Group, western Newfoundland. Government of Newfoundland and Labrador, Department of Mines, Mineral Development Division, Report 88-4, 48 pages.
- Lane, T.E.
1990: Dolomitization, brecciation and zinc mineralization and their paragenetic, stratigraphic and structural relationships in the upper St. George Group (Ordovician) at Daniel's Harbour, western Newfoundland. Unpublished Ph.D. thesis, Memorial University of Newfoundland, St. John's, 565 pages.
- Logan, W.E., Murray, A., Hunt, T.S. and Billings, E.
1863: Geology of Canada. Geological Survey of Canada. Report of Progress from its Commencement to 1863; illustrated by 498 wood cuts in the text, and accompanied by an atlas of maps and sections. Dawson Brothers, Montreal, 983 pages.
- Ludvigsen, R.
1975: Ordovician formations and faunas, southern Mackenzie Mountains. Canadian Journal of Earth Sciences, Volume 12, pages 663-697.

1978a: The trilobites *Bathyurus* and *Eomonorachus* from the Middle Ordovician of Oklahoma and their biofacies significance. Royal Ontario Museum, Life Sciences Contributions 114, 18 pages.

1978b: Middle Ordovician trilobite biofacies, southern Mackenzie Mountains. In Western and Arctic Canadian Biostratigraphy. Edited by C.R. Stelck and B.D.E. Chatterton. Geological Association of Canada, Special Paper Number 18, pages 1-37.

- 1979: A trilobite zonation of Middle Ordovician rocks, southwestern District of Mackenzie. Geological Survey of Canada Bulletin 312, 99 pages.
- Moore, R.C. (Editor)
1959: Treatise on Invertebrate Paleontology. Part O, Arthropoda 1. Geological Society of America and University of Kansas Press, New York and Lawrence, Kansas, 560 pages.
- Mound, M.C.
1965: A conodont fauna from the Joins Formation (Ordovician), Oklahoma. Tulane Studies in Geology, Volume 4, Number 1, 46 pages.
- Pitman, D.J.
1991: Taxonomy of Ordovician ostracodes from western Newfoundland, Anticosti Island and the St. Lawrence Lowlands of Québec. Unpublished Ph.D. thesis, Memorial University of Newfoundland, St. John's., 337 pages.
- Poulsen, C.
1927: The Cambrian, Ozarkian and Canadian faunas of northwest Greenland. Meddelelser om Grønland, Volume 70, number 2, pages 233-343.
- Raymond, P.E.
1910: On two new trilobites from the Chazy near Ottawa. Ottawa Naturalist, Volume 24, pages 129-134.

1913: Revision of the species which have been referred to the genus *Bathyurus*. Geological Survey of Canada, Victoria Memorial Museum Bulletin, Volume 1, pages 51-69.
- Richter, R. and Richter, E.
1949: Die Trilobiten der Erdbach Zone (Kulm) im Rhenischen Schiefergebirge and im Harz, I. Die Gattung *Phillibole*. Senckenbergiana, Volume 30, pages 63-94.
- Rohr, D.M., Boyce, W.D. and Measures, E.A.
2008: The Middle Ordovician mollusc *Archinacella* from the Table Point Formation (Table Head Group), western Newfoundland. In Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 08-1, pages 93-99.
- Rohr, D.M., Measures, E.A. and Boyce, W.D.
2004: Middle Ordovician (Whiterockian) gastropods from the Table Point Formation, western Newfoundland. In Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 04-1, pages 225-234.
- 2019: New Early and Middle Ordovician gastropods from western Newfoundland. In Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 19-1, pages 175-186.
- Ross, R.J., Jr.
1951: Stratigraphy of the Garden City Formation in northeastern Utah and its trilobite faunas. Yale University, Peabody Museum of Natural History, Bulletin 6, 161 pages.

1967: Some Middle Ordovician brachiopods and trilobites from the Basin Ranges, western United States. United States Geological Survey, Professional Paper 523-C, 44 pages.

1970: Ordovician brachiopods, trilobites and stratigraphy in eastern and central Nevada. United States Geological Survey, Professional Paper 639, 103 pages.
- Ross, R.J., Jr. and Ethington, R. L.
1991. Stratotype of Ordovician Whiterock Series. *Palaios*, Volume 6, pages 156-173.

1992: North American Whiterock Series suited for global correlation. In Global Perspectives on Ordovician Geology. Edited by B.D. Webby and J.R. Laurie. Balkema, pages 135-152.
- Ross, R.J., Jr., Hintze, L.F., Ethington, R.L., Miller, J.F., Taylor, M.E. and Repetski, J.E.
1993: The Ibexian Series (Lower Ordovician), a replacement for "Canadian Series" in North American chronostratigraphy. In Paleozoic Biochronology of the Great Basin, western United States. Edited by M.E. Taylor. United States Geological Survey, Open-File Report 93-598, pages 1-75.

1997: A. The Ibexian, Lowermost Series in the North American Ordovician. In Early Paleozoic Biochronology of the Great Basin, Western United States. Edited by M.E. Taylor. United States Geological Survey, Professional Paper 1579, pages 1-50.
- Ross, R.J., Jr. and James, N.P.
1987: Brachiopod biostratigraphy of the Middle Ordovician Cow Head and Table Head groups, western Newfoundland. Canadian Journal of Earth Sciences, Volume 24, pages 70-95.

- Shaw, F.C.
1974: Simpson Group (Middle Ordovician) trilobites of Oklahoma. Paleontological Society, Memoir 6, 54 pages.
- Stait, K.A.
1989: Upper Canadian to Whiterockian (Ordovician) conodont biostratigraphy of the Upper St. George Group, western Newfoundland. Unpublished M.Sc. thesis, Memorial University of Newfoundland, St. John's, 493 pages.
- Stait, K.A. and Barnes, C.R.
1991: Conodont biostratigraphy of the Upper St. George Group (Canadian to Whiterockian), western Newfoundland. In *Advances in Ordovician Geology. Edited by C.R. Barnes and S.H. Williams*. Geological Survey of Canada, Paper 90-9, pages 125-134.
- Stenzel, S.R., Knight, I. and James, N.P.
1990: Carbonate platform to foreland basin: revised stratigraphy of the Table Head Group (Middle Ordovician), western Newfoundland. *Canadian Journal of Earth Sciences*, Volume 27, pages 14-26.
- Stouge, S.
1980: Conodonts of the Table Head Formation (Middle Ordovician) western Newfoundland. Unpublished Ph.D. thesis, Memorial University of Newfoundland, St. John's, Newfoundland, 413 pages. [NFLD/1296]

1982: Preliminary conodont biostratigraphy and correlation of Lower and Middle Ordovician carbonates of the St. George Group, Great Northern Peninsula, Newfoundland. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 82-3, 63 pages.

1983: Notes on the geology of the St. Julien's map area (2M/4), Great Northern Peninsula, Newfoundland. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Map 82-68, 16 pages.

1984: Conodonts of the Middle Ordovician Table Head Formation, western Newfoundland. *Fossils and Strata*, Number 16, 145 pages.

2012: Middle Ordovician (late Dapingian–Darriwilian) conodonts from the Cow Head Group and Lower Head Formation, western Newfoundland, Canada. *Canadian Journal of Earth Sciences*, Volume 49, pages 59-90.
- Stouge, S, Bagnoli, G., and McIlroy, D. (with contributions by Maletz, J., Boyce, W.D., Knight, I., and Scorrer, S.)
2017: Cambrian–Middle Ordovician platform-slope stratigraphy, palaeontology and geochemistry of western Newfoundland. *International Symposium on the Ediacaran–Cambrian Transition 2017, Field Trip Guide. Edited by D. McIlroy*. The International Subcommission on Ediacaran Stratigraphy (ICES) and The International Subcommission on Cambrian Stratigraphy (ISCS), 119 pages.
- Swisher, R.E., Westrop, S.R. and Amati, L.
2015: The Upper Ordovician trilobite *Raymondites* Sinclair, 1944 in North America. *Journal of Paleontology*, Volume 89, pages 110-134.
- Tremblay, J.V. and Westrop, S.R.
1991: Middle Ordovician (Whiterockian) trilobites from the Sunblood Formation, District of Mackenzie. *Journal of Paleontology*, Volume 65, pages 801-824.
- Walcott, C.D.
1886: Second contribution to the studies on the Cambrian faunas. United States Geological Survey, Bulletin 30, 369 pages.
- Walker, K.R.
1972: Community ecology of the Middle Ordovician Black River Group of New York State. *Geological Society of America Bulletin*, Volume 83, pages 2499-2524.
- Wang, X., Stouge, S., Erdtmann, B.-D., Chen, X., Li, Z., Wang, C., Zeng, Q., Zhou, Z. and Chen, H.
2005: A proposed GSSP for the base of the Middle Ordovician Series: the Huanghuachang section, Yichang, China, *Episodes*, Volume 28, pages 105-117.
- White, C.A.
1874: Preliminary Report Upon Invertebrate Fossils Collected by the Expeditions of 1871, 1872, and 1873, with Descriptions of New Species. *Geographical and Geological Explorations and Surveys West of the One Hundredth Meridian*. United States Army Engineers Department, 27 pages.

1877: Report Upon the Invertebrate Fossils Collected in Portions of Nevada, Utah, Colorado, New Mexico, and Arizona, by Parties of the Expeditions of 1871, 1872, 1873, and 1874. Report upon United States Geographical Surveys West of the One Hundredth Meridian. United States Army Engineers Department, Volume 4, Paleontology, 216 pages.

Whittington, H.B.

1953: North American Bathyruridae and Leiostegiidae (Trilobita). *Journal of Paleontology*, Volume 27, pages 647-678.

1961: Middle Ordovician Pliomeridae (Trilobita) from Nevada, New York, Quebec, Newfoundland. *Journal of Paleontology*, Volume 35, pages 911-922.

Whittington, H.B. and Kindle, C.H.

1963: Middle Ordovician Table Head Formation, western Newfoundland. *Geological Society of America Bulletin*, Volume 74, pages 745-758.

Williams, S.H., Boyce, W.D. and James, N.P.

1987: Graptolites from the Lower–Middle Ordovician St. George and Table Head groups, western Newfoundland, and their correlation with trilobite, graptolite, brachiopod and conodont zones. *Canadian Journal of Earth Sciences*, Volume 24, pages 456-470.

APPENDIX 1

Location of Illustrated Specimens (All Coordinates are NAD27, UTM Zone 21)

TABLE HEAD GROUP
TABLE POINT FORMATION
SPRING INLET MEMBERTABLE POINT ECOLOGICAL RESERVE (5579250N,
461800E, NTS 12I/06 and 12I/05 – Bellburns)Section I of Stouge (1984)
TP3 of Stouge (1984, page 97)

– Unit A₁ of Stouge (1984, page 97), 0.00 to 0.10 m above the base of the Table Point Formation. According to Stouge (1984, page 97): “Micrite, grey to dark-grey, mottled weathering, argillaceous. Bioclasts are trilobites (*Bathyurus* sp.), orthocones, brachiopods, ostracodes, gastropods (*Hormotoma* sp.)”.

Arthropoda–Ostracoda
Bivia bivia (White, 1874) – nine valves (NFM F-2723, NFM F-2733 to NFM F-2740)

Arthropoda–Trilobita
Bathyurus perplexus Billings, 1865 – four cranidia (NFM F-311, NFM F-2716, NFM F-2719, NFM F-2720); three left librigenae (NFM F-307, NFM F-2712, NFM F-2727); three right librigenae (NFM F-308.1 and 2, NFM F-2715.1 and 2, NFM F-2724); seven pygidia (NFM F-309.1 and 2, NFM F-310, NFM F-2717, NFM F-2718, NFM F-2726, NFM F-2728, NFM F-2730)

Note: The material was collected by Dr. Svend Stouge in June, 1976.

PHILLIPS BROOK ANTICLINE, NORTHEAST OF
STEPHENVILLE (5397287N, 392298E, NTS 12B/09 –
HARRYS RIVER)Section K-1999-032 of Knight
1999F141

– Lime mudstone/wackestone. Stratigraphically above 1999F140.

Arthropoda–Ostracoda
Bivia bivia (White, 1874) – three valves (NFM F-2765 to NFM F-2767) – erroneously attributed to “(White, 1877)” by Knight and Boyce (2006, page 208).

Arthropoda–Trilobita
Bathyurus perplexus Billings, 1865 – one right librigena (NFM F-2763); two pygidia (NFM F-2762, NFM F-2764)

Brachiopoda–Articulata
Gen. et sp. undet.

ST. GEORGE GROUP
AGUATHUNA FORMATIONTABLE POINT ECOLOGICAL RESERVE (5579250N,
461800E, NTS 12I/06 and 12I/05 – Bellburns)Section I of Stouge (1984)
1983F004 of Boyce=TP2 of Stouge (1984, page 97)?

Arthropoda–Ostracoda
Bivia bivia (White, 1874)

Arthropoda–Trilobita
Bathyurus perplexus Billings, 1865 – one thorax (NFM F-2768.1); one pygidium (NFM F-2768.2)

Note: This may be the same bed as collection 80-RJ-25 of Ross and James (1987, page 94), in which Fortey (personal communication, 1984 in Ross and James, 1987, page 72) identified *Acidiphorus* cf. *A. pseudobathyurus* Ross, 1 m below the base of the Table Point Formation.

BACK ARM, 0.6 KM NORTH OF PORT AU CHOIX
(5617800N, 475800E, NTS 12I/11 – Port Saunders)Section 10 of Knight (1991, page 130)
ECW-097=1982F058=K-1982-63 of Knight, 1982

– Unit 4 of Knight (1991, page 130): “Argillaceous, dolomitic lime mudstone and dolostone: dolostone in basal 50 cm only, dolostone and lime mudstone mottles, hackly to blocky weathering, bioturbation sparse, trilobites (*Bathyurus perplexus* Billings), ostracods and brachiopods, suture-like, uneven solution pitted upper bedding surface.” Fossils only collected from uppermost 40 cm of 90 cm-thick unit.

Arthropoda–Ostracoda
Bivia bivia (White, 1874) – three valves (NFM F-2700, NFM F-2709, NFM F-2710)

Arthropoda–Trilobita
Bathyurus perplexus Billings, 1865 – one cranidium (NFM F-304.1 and 2); one left librigena (NFM F-305); one thoracic segment (NFM F-2711); pygidia (NFM F-306, NFM F-2698.1 and 2, NFM F-2701, NFM F-2703).

Brachiopoda–Articulata
Gen. et sp. undet.

**BIG SPRING INLET, NORTH SHORE, WEST OF
TICKLE, HARE BAY (5674975N, 580600E, NTS
02M/04 – ST. JULIEN’S)**

**Section K-1987-058 of Knight
1987F077=K-1987-058-17**

Arthropoda–Trilobita

Bathyrurus perplexus Billings, 1865 – one cranidium (NFM F-2743.1 and 2); one right librigena (NFM F-2750); two partial thoraxes (NFM F-2746, NFM F-2753); one pygidium (NFM F-2752)

1987F076=K-1987-058-17

– Light grey weathering, thin, planar bedded, dark grey dolostone.

Arthropoda–Trilobita

Bathyrurus perplexus Billings, 1865 – one left librigena (NFM F-2741)

**TABLE MOUNTAIN, EAST OF THE PORT AU PORT
PENINSULA (5382600N, 375625E, NTS 12B/10 –
STEPHENVILLE)**

Radar Tower Road Section

1996F005=“B” collection

– Outcrop on east side of radar tower road (294 or 394 dps = 441.00 or 591.00 metres, entry in field notebook). White weathering, thin bedded, intraclastic, light grey dolomitic limestone/limy dolostone.

Arthropoda–Trilobita

Bathyrurus perplexus Billings, 1865 – one articulated thorax and pygidium (NFM F-2759; two pygidia (NFM F-2760, NFM F-2761)

Note: The locality was visited with Drs. D.M. Rohr and E.A. Measures (Sul Ross State University, Alpine, Texas) on July 10, 1996, supported by National Geographic Grants 6110-98 and 6550-99 to Rohr.

