

NEW EARLY AND MIDDLE ORDOVICIAN GASTROPODS FROM WESTERN NEWFOUNDLAND

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ABSTRACT

Two gastropod genera (*Bucania?* and *Pterotheca*) are reported for the first time from the early Middle Ordovician Table Point Formation (Table Head Group) of western Newfoundland. In addition, the stratigraphic range of *Ceratopea unguis* is extended downward into the lower part of the Early Ordovician Catoche Formation (St. George Group) – the operculum found there being the largest known *Ceratopea*.

INTRODUCTION

Early and Middle Ordovician gastropods from western Newfoundland were first described by Billings (1865) from strata now assigned to the St. George and Table Head groups. Many of the taxa subsequently were re-studied and/or revised by Rohr *et al.* (2000, 2001, 2002, 2003, 2004b), Rohr and Measures (2001) and Boyce and Knight (2010). Additional species are described here:

- 1) *The disconformity-bounded Floian megacycle of the upper St. George Group on the Port au Port Peninsula and at Bonne Bay.* The Floian megacycle overlies the Boat Harbour Disconformity, and comprises the Barbace Cove Member of the Boat Harbour Formation, the Catoche Formation, and the Aguathuna Formation; it terminates at the St. George Unconformity (Knight *et al.*, 1991).
- 2) *The Table Point Formation (Table Head Group) in the Table Point Ecological Reserve (TP – see Figure 1; Appendix 1).* The Table Point locality lies within the Dapingian–Darriwilian *Uromystrum validum* trilobite zone, the *Anomalorthis* brachiopod zone (Ross and James, 1987) and the *Histiodellella tableheadensis* conodont zone (Stouge, 1982, 1984) – see Figure 2.

The illustrated specimens are deposited with the Provincial Museum Division, The Rooms Corporation of Newfoundland and Labrador (NFM) in St. John's and the Yale Peabody Museum, Department of Invertebrate Paleontology (YPM IP).

PALEOBIOGEOGRAPHIC SETTING OF FAUNAS

This report documents the gastropods *Bucania* and *Pterotheca*, which are new to western Newfoundland, and re-examines old material of *Ceratopea unguis* Yochelson and Bridge, 1957, adding new information about the operculum of this previously known species.

Bucania, a cosmopolitan Ordovician–Silurian genus, has not previously been found in Newfoundland. Ordovician occurrences of the genus are known mostly from eastern North America (Wahlman, 1992), but also Scandinavia (Yochelson, 1963), Korea (Kobayashi, 1934, 1958), and possibly Australia (Yu, 1993) and South America (Aceñolaza, 1968).

Pterotheca, known from the Ordovician and Silurian of Canada, the United States, Europe (Britain, Spain and Czech Republic) – see Wahlman (1992), Clarkson *et al.* (1995) and Ebbestad *et al.* (2013) – has not been described before from western Newfoundland.

Ceratopea is known mostly from eastern North America (see Yochelson and Bridge, 1957), as well as Greenland (Rohr *et al.*, 2015) and Scotland (Yochelson, 1964). It was already well known in western Newfoundland (Walthier, 1949; Yochelson, 1964; Yochelson and Jones, 1968; Yochelson, 1990, 1992; Whittington, 1968; Whittington and Kindle, 1969; Rohr *et al.*, 2000; Boyce and Knight, 2010).

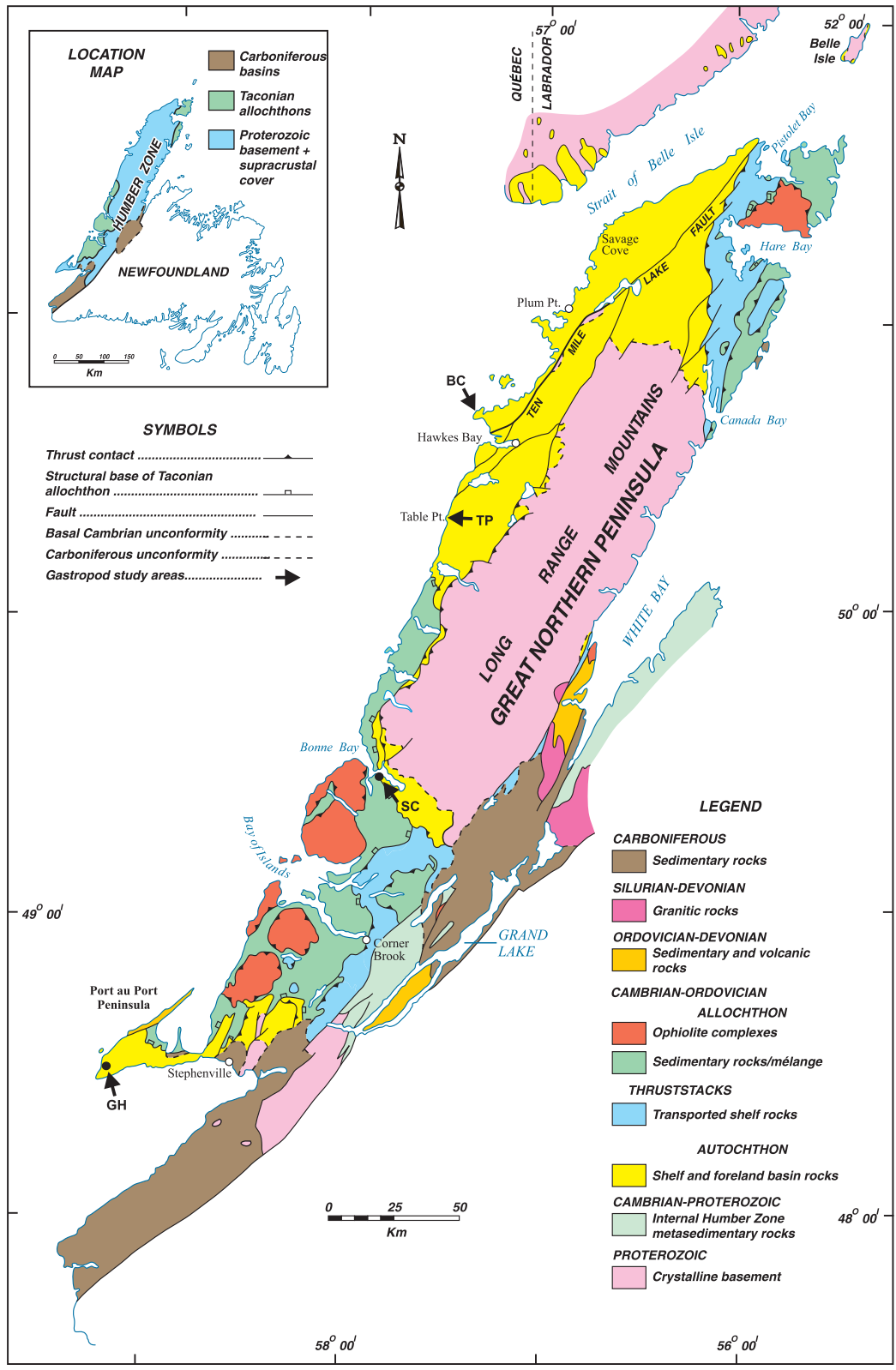


Figure 1. Geology map of western Newfoundland showing the main geological terranes and the location of study areas (arrows). BC – Barbace Cove, Port au Choix Peninsula, TP – Table Point, SC – Shag Cliff, East Arm of Bonne Bay (Gros Morne National Park), and GH – Garden Hill, Port au Port Peninsula (Hunt–Pan Canadian Petroleum No. 1 well head).

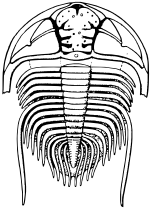


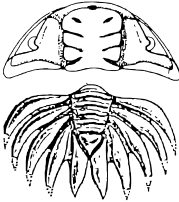
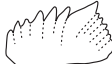


LITHOSTRATIGRAPHY		TRILOBITE ZONES		CONODONT ZONES	
TABLE HEAD GROUP	Table Cove Formation		<i>Cybelurus mirus</i>		<i>Histiodella bellburnensis</i>
					<i>Histiodella kristinae</i>
	Table Point Formation	▲ 	<i>Pseudomera barrandei</i>		<i>Histiodella tableheadensis</i>
		▲ 	<i>Uromystrum validum</i>		
ST. GEORGE GROUP	Aguathuna Formation		<i>Bathyrurus perplexus</i>		

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; Boyce and Knight, 2009; Stouge *et al.*, 2017). The trilobite and conodont zonations follow Boyce (1997) and Stouge (1984), respectively. The base of each zone is the FAD (First Appearance Datum) of the nominate species. The black triangles indicate the chert horizons. *Bucania? sp.* and *Pterotheca sp.* were obtained from 96R-3, in the lowest chert horizon.

GEOLOGICAL SETTING

During the Cambrian–Ordovician, western Newfoundland was part of the equatorial southern margin of the paleocontinent of Laurentia. The Early Ordovician carbonate succession of the St. George Group (Watts Bight, Boat Harbour, Catoche and Aguathuna formations) was deposited during the later stages of passive margin buildup that began in the late Early Cambrian (Cooper *et al.*, 2001) and culminated at the St. George Unconformity (Knight *et al.*, 1991). The subsequent Middle Ordovician mixed carbonate-clastic foreland basin succession of the Table Head Group (Table Point and Table Cove formations) and the Goose Tickle Group (Black Cove and American Tickle formations),

records the ongoing collapse of the margin and evolution of a foreland basin, as a consequence of the closing of the Iapetus Ocean and obduction of Taconic allochthons (Stenzel *et al.*, 1990; Stenzel, 1991; Cooper *et al.*, 2001).

TAXA PRESENT

The gastropod shells and opercula treated herein are from the Catoche, Aguathuna and Table Point formations. They are described in systematic, rather than stratigraphic order.

Kingdom ANIMALIA Linnaeus, 1758
Phylum MOLLUSCA Linnaeus, 1758
Class GASTROPODA Cuvier, 1795

Order BELLEROPHONTIDA Ulrich and Scofield, 1897
 Suborder BELLEROPHONTINA Ulrich and Scofield, 1897
 Superfamily BELLEROPHONTOIDEA McCoy, 1851
 Family BELLEROPHONTIDAE McCoy, 1852
 Genus *Pterotheca* Salter, 1853

Type species. – *Atrypa expansa* Portlock, 1843 (by original designation of Salter, 1853), probably from the Caradoc Bardahessiagh Formation of Desertcreat, County Tyrone, Northern Ireland (see Clarkson *et al.*, 1995, page 110).

Remarks. – The bellerophontid gastropod *Pterotheca* is distinguished by its lack of coiling, its dorsal median angulation and a well-developed plate within the aperture forming a triangular visceral chamber. Its shape is analogous to the extant gastropod *Crepidula*. *Pterotheca* is the only member of the Pterothecidae known from the Ordovician, and has not been previously reported from Newfoundland. Wahlman (1992) noted that the genus is, “in need of complete re-study”, because of its commonly poor preservation, descriptions and illustrations.

Pterotheca sp.
 Plate 1, figures 1–7

Remarks. – Two fragmentary, silicified shells were found from the lowest chert horizon in the Table Point Formation at Table Point, from the same locality (96R-3) that yielded *Bucania?* sp. – see Figure 2; Appendix 1).

Wahlman (1992) concluded the most useful method for differentiating species within the genus is the angle at which the lateral septal margins diverge from the apex. In our two fragmentary specimens, the angle is between 40 and 50°. This is half that exhibited by *P. saffordi* (Hall, 1861), *P. expansa* (Emmons, 1842) and *P. harviei* Foerste, 1924. It is closer to *P. angusta* Raymond, 1921 but the Newfoundland shells lack other diagnostic features to allow a more certain identification.

Family BUCANIIDAE Ulrich and Scofield, 1897
 Subfamily BUCANIINAE Ulrich and Scofield, 1897
 Genus *Bucania* Hall, 1847

Type species. – *Bellerophon sulcatinus* Emmons, 1842 (designated by Waagen, 1880, page 130), from the Chazy Formation of Chazy, New York State, USA.

Bucania? sp.
 Plate 2, figures 1–4

Remarks. – A single silicified specimen was recovered from the lowest chert horizon in the Table Point Formation at Table Point, from the same locality (96R-3) that yielded

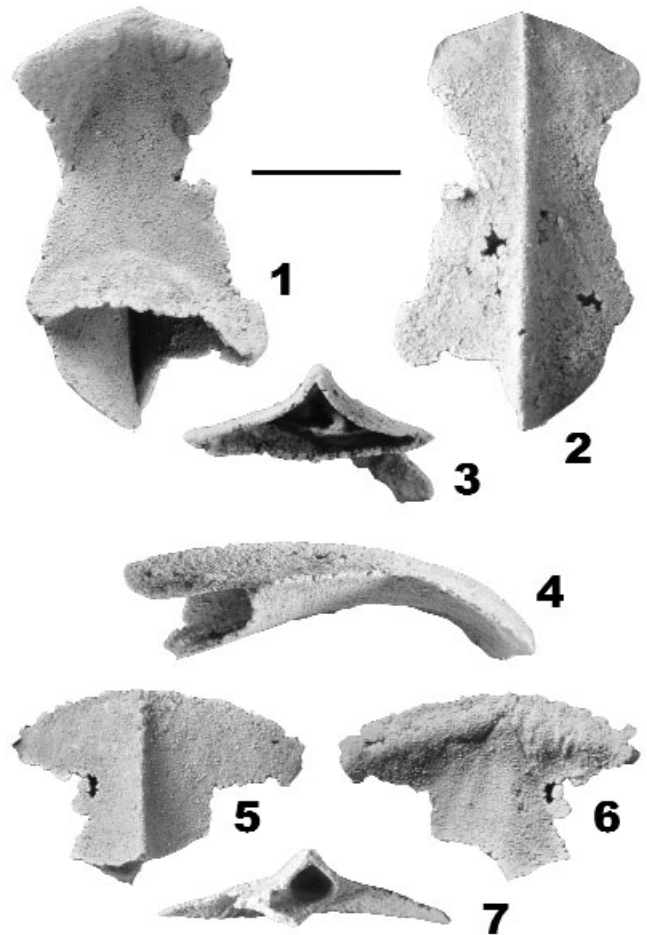


Plate 1. *Pterotheca* sp. 1-3, interior, dorsal and side views (NFM F-2583). 4-7, side dorsal, interior and side views (NFM F-2584). Locality Rohr 96R-3. Black bar is 1 cm.

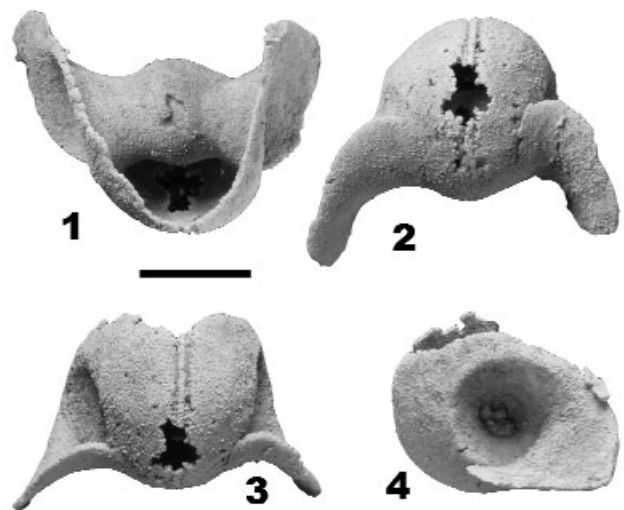


Plate 2. *Bucania?* sp. 1-4, dorsal, apertural, posterior and umbilical views (NFM F-2585). Locality Rohr 96R-3. Black bar is 1 cm.

Pterotheca – see Figure 2; Appendix 1. The aperture, except for the flaring margin, is not preserved, so the presence of a sinus or slit is not certain. The narrow dorsal band (Plate 2, figures 2, 3) suggests the presence of a slit. The rounded dorsal shell and smooth surface are similar to *Bellerophon* Montfort, 1808, but the large umbilicus is much more characteristic of the more primitive Bucaniidae. The family Bucaniidae is characterized by spiral and collabral lines in most species, but the earliest bucaniid, *Eobucania* Kobayashi, 1955, has spiral threads only bordering the selenizone (Wahlman, 1992). The moderately wide umbilici are a primitive character that are closed in the more advanced shells such as *Bellerophon* (Wahlman, 1992). The bucaniid genus *Salpingostoma* Roemer, 1876, has an umbilical shoulder, but its diagnostic closed-off anterior slit is not present on the incomplete Newfoundland specimen. In conclusion, because only one incomplete specimen was recovered, and diagnostic features are missing, the shell is tentatively assigned to the family Bucaniidae. It may be a more primitive species of *Bucania*, or less likely a species of *Salpingostoma*.

Subclass EOGASTROPODA Ponder and Lindberg, 1996
 Order EUOMPHALINA de Koninck, 1881
 Superfamily EUOMPHALOIDEA de Koninck, 1881
 Family RAPHISTOMATIDAE Koken, 1896
 Genus *Ceratopea* Ulrich, 1911

Type species. – *Ceratopea keithi* Ulrich, 1911 (by original designation¹), from the Beekmantown Group at Wytheville, Virginia, USA.

Remarks. – Opercula and shells of several species of *Ceratopea* are present in the St. George Group. At Hunters Point, near Eddies Cove West, opercula of *Ceratopea* cf. *capuliformis* Oder, 1932 occur in the Barbace Cove Member of the Boat Harbour Formation (Rohr *et al.*, 2000, pages 246, 250); they lie within the *Strigigenalis brevicaudata* trilobite zone of Boyce (1989, 1997) and Boyce and Stouge (1997), and indicate the lowest part of the *Ceratopea* Zone of Yochelson and Bridge (1957). Opercula of *Ceratopea billingsi* Yochelson, 1964 are found throughout the Catoche Formation – within the *Strigigenalis brevicaudata* to *Benthamaspis gibberula* trilobite zones of Boyce (1989, 1997) and Boyce and Stouge (1997) – they initially were documented by Yochelson (1964) from the formation at Cape Norman and the Croisaphuill Formation (Durness Group) of Scotland (Yochelson, 1964; Rohr *et al.*, 2000, page 246; Raine, 2009, page 14). Poorly preserved shells of other *Ceratopea* occur throughout the Catoche Formation,

some of which may belong to *Ceratopea canadensis* (Billings, 1865).

In western Newfoundland, *Ceratopea unguis* Yochelson and Bridge, 1957 previously was known only from the Aguathuna Formation; Yochelson (1990, 1992) and Boyce and Knight (2010) illustrated it from the East Bay section, north of The Gravels, eastern Port au Port Peninsula. Other Aguathuna Formation occurrences were documented by Rohr *et al.* (2000, pages 246, 250) from exposures along Route 463, western Port au Port Peninsula; an outcrop along the radar tower road on Table Mountain, east of the Port au Port Peninsula; and a logging road north of Stephenville. It is newly recognized at Garden Hill (GH – see Figure 1), western Port au Port Peninsula (Appendix 1). This extends the stratigraphic range of *C. unguis* considerably downward into the lower Catoche Formation.

Ceratopea unguis Yochelson and Bridge, 1957
 Plate 3, figures 1–13

2010 *Ceratopea unguis* Yochelson and Bridge, 1957 – Boyce and Knight, pages 219, 235, 238, 240; Plate 4, figures B, D.

2015 Operculum of *Ceratopea unguis* Yochelson and Bridge, 1957 – Rohr in Rohr *et al.*, page 802; Figure 3I–N (synonymy to date).

Remarks. – Silicified opercula are abundant in the Garden Hill area on the Port au Port Peninsula. Yochelson and Bridge (1957) noted that locally, bedding planes may be covered with opercula, and were probably winnowed after death and left as lag, after the shells were transported. The specimens are large and oval in mature cross section, and have more curvature in the early whorls producing a hook-like appearance (Plate 3, figures 5, 8, 9). The attachment surface has a deep pit (Plate 3, figures 4, 10). The operculum is weakly torted, has a weak dorsal ridge in early growth only, a weak umbilical (ventral) ridge (Plate 3, figure 7), and lacks the carina present on other species. Growth lines on later stages show no major re-entrants. The largest complete specimen from Garden Hill is 5.5 cm long, 2.0 cm wide, and 1.5 cm high. The specimen from Bonne Bay is 8.7 cm long, 2.0 cm wide, and 1.5 cm high.

The Newfoundland specimens are long and are similar to *C. unguis* Yochelson and Bridge, 1957 and *C. buttsi* Yochelson and Bridge, 1957. *Ceratopea keithi* Ulrich, 1911, is shorter and has a strong carina. Both *C. unguis* and *C. buttsi* have an attachment with a deep pit. Yochelson and

¹From Ulrich (1911, page 665): “As genotype, I have selected the species figured by Bassler (1909) without description in Bulletin No II-A, Virginia Geological Survey, 1909, plate 20, figure 3. The specific name *keithi* is here applied to the genotype, Mr. Arthur Keith of the U. S. Geological Survey, having collected at Trundles Crossroads east of Knoxville, Tennessee, some of the best specimens seen.”

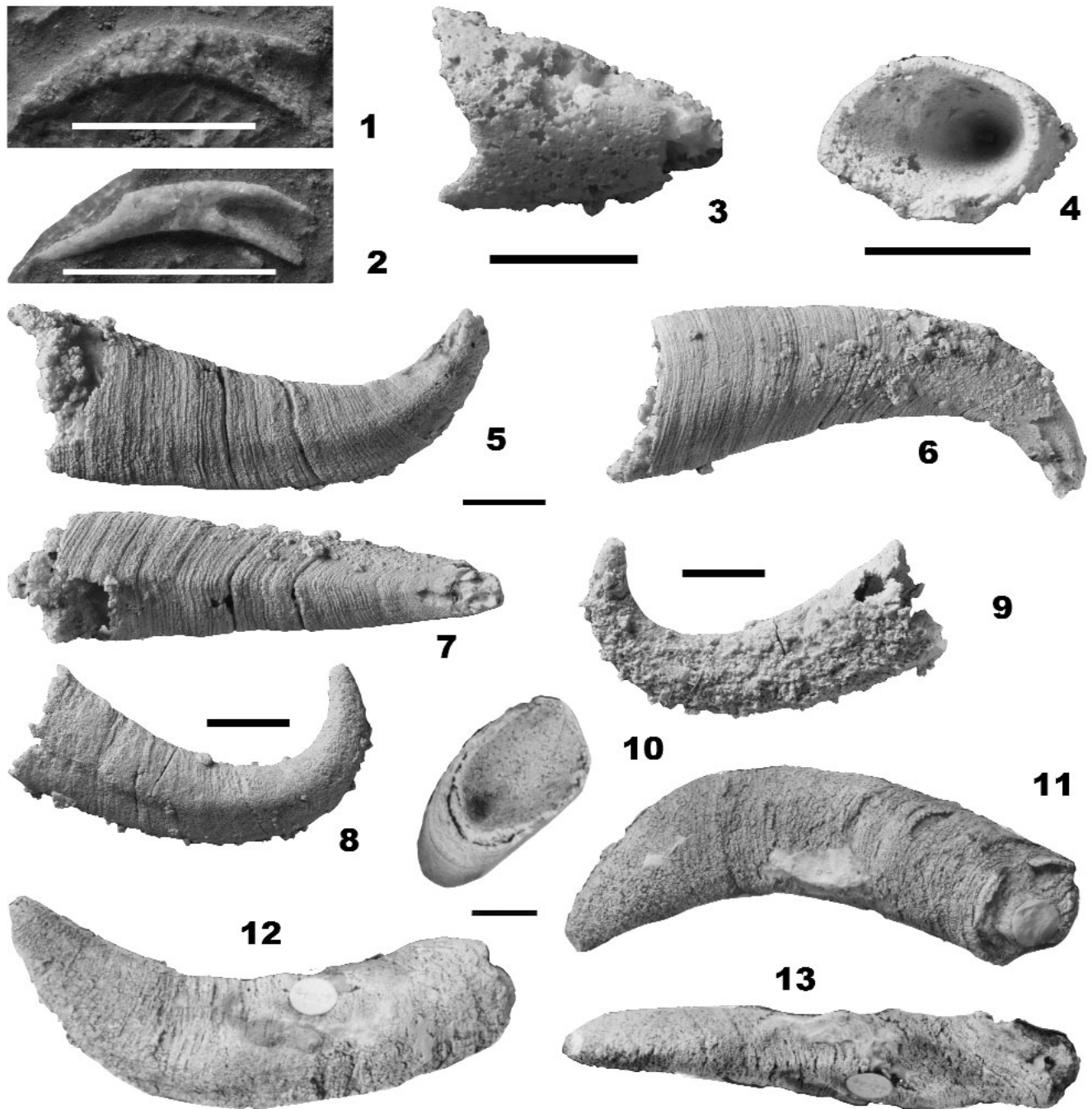


Plate 2. *Operculum of Ceratopea unguis* Yochelson and Bridge, 1957. Black bars are 1 cm. 1-2, cross sectional view of small, non-silicified specimens in matrix with deep pit (NFM F-2578, NFM F-2579). Catoche Formation, Locality Rohr 2000R-2. 3-4, side and attachment surface views of broken specimen (NFM F-2581). Catoche Formation, Locality Rohr 96R-16. 5-7, ventral, dorsal and parietal views (NFM F-2580). Catoche Formation, Locality Rohr 96R-16. 8-9, dorsal and ventral views showing hook-like curvature (NFM F-2582). Catoche Formation, Locality Rohr 96R-16. 10, attachment surface with deep pit (YPM IP 034955). Probable Aguathuna Formation, Locality YPM IPB.03855. 11-13, parietal, dorsal and side views (YPM IP 034027). Probable Aguathuna Formation, Locality YPM IPB.04002.

Bridge (1957) noted that *C. buttsi* is less strongly curved than *C. unguis*; and that *C. unguis* is the most common and most variable of the species. Along the paleo-southern margin of Laurentia it is widespread in the latest Ibexian (late Early Ordovician) – see Rohr *et al.* (2004a, page 218), Boyce and Knight (2010, page 238), and Rohr *et al.* (2015, pages 797, 802); along the paleo-northern margin of Laurentia, it is restricted to the Whiterockian (early Middle Ordovician) – see Rohr *et al.* (1995, 2004b).

Charles Schuchert supervised four geological expeditions to western Newfoundland (1910, 1918, 1920 and 1933), and was accompanied by William H. Twenhofel in 1910. In 1918, Carl O. Dunbar and photographer and collector Wayne Edwards were his companions. In 1920, Dunbar and Thomas Lovering conducted the third expedition. The final (1933) expedition was led by Dunbar, and assisted by F.E. Ingerson, E.I. Leith and Percy A. Morris. These expeditions culminated in the publication of Memoir 1 of the Geological Society of America: *Stratigraphy of Western Newfoundland* (Schuchert and Dunbar, 1934).

The fossils collected during the expeditions are reposit-ed in the Yale Peabody Museum Invertebrate Paleontology collection, but the bulk of the material has remained unde-scribed. However, three opercula (YPM IP 034954, YPM IP 034955 and YPM IP 034027) are described for the first time, and assigned to *C. unguis* (Plate 3, figures 10–13). Specimens YPM IP 034954 and YPM IP 034955 were col-lected by C. Schuchert and W.H. Twenhofel on August 18, 1910, during the first expedition from the “upper St. George, upper Beekmantown, promontory opposite Neddys Harbor², Bonne Bay, western Newfoundland” (YPM Locality B3855), according to Rohr and Yochelson (unpublished, 1996) – see Appendix 1. Although the YPM collections’ website, lists the specimens as being from longitude - 57.877637, and latitude 49.5211³ (WGS84), *i.e.*, Neddy Hill, Williams (1985) and Williams and Cawood (1989) indicate that Neddy Hill comprises the Rocky Harbour mélange⁴ and the Goose Tickle Formation – the YPM coor-dinates therefore are regarded as incorrect. The specimens most probably are from Shag Cliff (SC – see Figure 1; Appendix 1), which is a major promontory opposite Neddy Harbour, and are believed to come from the 150.50-m⁵-thick Division V recognized there by Troelsen (1947, pages 31-33) and Johnson (1949, pages 19-21).

According to Rohr and Yochelson (unpublished, 1996), specimen YPM IP 034027 “was collected July 27, 1918⁶ by Charles Schuchert and Carl Dunbar from YPM Locality B4002, considered by them to be Upper Beekmantown. The original label reads Headland opposite Neddys Harbour⁷, Bonne Bay, *Ceratopea* bed”.

Ellis Yochelson photographed the YPM *Ceratopea* specimens, but never published them, and gave Rohr his original plate. Yochelson observed (written communication 25 July 1996): “none of the previously illustrated specimens of this species or any other species of the operculum of *Ceratopea* are as large as those”. Because of Dr. Yochelson’s familiarity with *Ceratopea*, we believe this remains a valid observation.

ACKNOWLEDGMENTS

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REFERENCES

- Aceñolaza, F.G.
1968: Geología estratigráfica de la region de la Sierra de Cajas, Departamento de Humahuaca (Provincia de Jujuy). *Revista de la Asociación Geológica Argentina*, Volume 23, Number 3, pages 207-222.

² Neddy Harbour of modern usage

³ 5485757N, 436480E

⁴ “grey to black and red scaly shale with mainly sedimentary blocks derived from low structural slices at the top of the autochthon”

⁵ 494 feet (Johnson, 1949, page 21)

⁶ on the second Schuchert-led expedition

⁷ Neddy Harbour of modern usage

- Bassler, R.S.
1909: The cement resources of Virginia west of the Blue Ridge. Virginia Geological Survey, Bulletin 2-A, 309 pages.
- Billings, E.
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.
1989: Early Ordovician trilobite faunas of the Boat Harbour and Catoche formations (St. George Group) in the Boat Harbour-Cape Norman area, Great Northern Peninsula, western Newfoundland. Government of Newfoundland and Labrador, Department of Mines, Geological Survey, Report 89-2, 175 pages.

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.
- 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.

2010: Macropaleontological investigation of the upper St. George Group, West Isthmus Bay to East Bay section, Port au Port Peninsula, western Newfoundland. *In* Current Research. Government of Newfoundland Labrador, Department of Natural Resources, Geological Survey, Report 10-1, pages 219-244; A1-A18.
- 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.
- Clarkson, E.N.K., Harper, D.A.T. and Peel, J.S.
1995: Taxonomy and palaeoecology of the mollusc *Pterotheca* from the Ordovician and Silurian of Scotland. *Lethaia*, Volume 28, pages 101-114, Oslo, ISSN 0024-1164.
- Cooper, M., Weissenberger, J., Knight, I., Hostad, D., Gillespie, D., Williams, S.H., Burden, E.T., Porter-Chaudhry, J., Rae, D. and Clark, E.
2001: Basin evolution in western Newfoundland: New insights from hydrocarbon exploration. American Association of Petroleum Geologists Bulletin, Volume 85, pages 393-418.
- Ebbestad, J.O.R., Frýda, J., Wagner, P.J., Horný, R.J., Isakar, M., Stewart, S., Percival, I.G., Bertero, V., Rohr, D.M., Peel, J.S., Blodgett, R.B. and Högström, A.E.S.
2013: Chapter 15—Biogeography of Ordovician and Silurian gastropods, monoplacophorans and mimospirids. *In* Early Palaeozoic Biogeography and Palaeogeography. Edited by D.A.T. Harper and T. Servais. Geological Society, London, Memoir 38, pages 199-220.
- Emmons, E.
1842: Geology of New York; Part II, Comprising The Survey of the Second Geological District, United States. W. and A. White and J. Visscher, Albany, New York, 437 pages.
- Foerste, A.F.
1924: Upper Ordovician faunas of Ontario and Quebec., Geological Survey Canada Memoir 138, 255 pages.
- Hall, J.
1861: Note on the genera *Bellerophon*, *Bucania*, *Carinaropsis*, and *Cyrtolites*. New York State Cabinet, Annual Report 14, pages 93-98.
- Johnson, H.
1949: Excerpts from “Geology of Western Newfoundland”. Unpublished manuscript, Newfoundland Geological Survey, 48 pages. [NFLD/0188]
- Knight, I.
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.
- 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.
- Knight, I., James, N.P. and Lane, T.
1991: The Ordovician St. George Unconformity, northern Appalachians: The relationship of plate convergence at the St. Lawrence Promontory to the Sauk/Tippecanoe sequence boundary. *Geological Society of America Bulletin*, Volume 103, pages 1200-1225.
- Kobayashi, T.
1934: The Cambro-Ordovician formations and faunas of south Chosen. *Palaeontology*. Part I. Middle Ordovician faunas. *Journal of the Faculty of Science, Imperial University of Tokyo, Section II, Volume 3, Part 8*, pages 329-519.
- 1955: The Ordovician fossils from the McKay group in British Columbia, western Canada, with a note on the early Ordovician palaeogeography. *Journal of the Faculty of Science, Imperial University of Tokyo, Section II, Volume 9, Part 3*, pages 355-492.
- 1958: Some Ordovician gastropods from the Mun'gyong or Bunkei district, South Korea. *Journal of the Faculty of Science, the Imperial University of Tokyo, Section II, Volume 11*, pages 85-90.
- Montfort, P.H. de
1801: *Conchlioge systématique, et classification méthodique des coquilles, offrant leurs figures, leur noms; ainsi que leur synonymie en plusieurs langues: Tome 1, Coquilles univalves, cloisonées*, Paris.
- Oder, C.R.L.
1932: Fossil opercula from the Knox dolomite. *American Midland Naturalist*, Volume 13, Number 3, pages 133-153.
- Raine, R.J.
2009: The Durness Group of NW Scotland: a stratigraphical and sedimentological study of a Cambro-Ordovician passive margin succession. Unpublished Ph.D. thesis, The University of Birmingham, 239 pages.
- Raymond, P.E.
1921: A contribution to the description of the fauna of the Trenton group. *Geological Survey of Canada, Museum Bulletin 31*, 64 pages.
- Rohr, D.M., Boyce, W.D. and Knight, I.
2003: Ordovician gastropods from western Newfoundland. *In Current Research*. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 03-1, pages 127-136.
- 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 Labrador, Department of Natural Resources, Geological Survey, Report 08-1, pages 93-99.
- Rohr, D.M., Fix, M.F. and Darrough, G.
2004a: Life association of shell and operculum of *Ceratopea* Ulrich, 1911 (Ordovician; Gastropoda). *Journal of Paleontology*, Volume 78, pages 218-220.
- Rohr, D.M., Harper, D.A.T, Stouge, S. and Christiansen, J.L.
2015. Ordovician Gastropoda from Northeast Greenland. *Bulletin of Geosciences*, Volume 90, Number 4, pages 795-805. Czech Geological Survey, Prague. ISSN 1214-1119.
- Rohr, D.M. and Measures, E.A.
2001: Middle Ordovician (Whiterockian) gastropods of western Newfoundland: Macluritoidea and Euomphaloidea. *Journal of Paleontology*, Volume 75, pages 284-294.
- Rohr, D.M., Measures, E.A. and Boyce, W.D.
2004b: 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.
- Rohr, D.M., Measures, E.A., Boyce, W.D. and Knight, I.
2000: Ongoing studies of Late Cambrian and Early Ordovician gastropods of western Newfoundland. *In Current Research*. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 2000-1, pages 241-250.
- 2001: Early Ordovician gastropods of the Barbace Cove Member (Boat Harbour Formation) and Catoche Formation, western Newfoundland. *In Current Research*. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 01-1, pages 113-126.

- 2002: *Euomphalopsis* and *Polhemia* (Gastropoda) from the Lower Ordovician Catoche Formation, western Newfoundland. *In* Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 02-1, pages 265-275.
- 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.
- Salter, J.W.
1853: On a few genera of Irish Silurian fossils. Report of the 22nd meeting of the British Association for the Advancement of Science 1852, pages 59-61.
- Schuchert, C. and Dunbar, C.O.
1934: Stratigraphy of western Newfoundland. *Geological Society of America, Memoir 1*, 123 pages.
- Stenzel, S.R.
1991: Carbonate sedimentation in an evolving Middle Ordovician foreland basin. Memorial University of Newfoundland, St. John's, Unpublished Ph.D. thesis, (<http://collections.mun.ca/u/?theses,92533>), 575 pages.
- 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.
1982: Preliminary conodont biostratigraphy and correlation of Lower to 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, 59 pages.

1984: Conodonts of the Middle Ordovician Table Head Formation, western Newfoundland. *Fossils and Strata*, Number 16, 145 pages.
- 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.
- Troelsen, J.C.
1947: Geology of the Bonne Bay area. Unpublished report, Geological Survey of Newfoundland, 90 pages. [012H/05/0065]
- Ulrich, E.O.
1911: Revision of the Paleozoic systems. *Geological Society of America Bulletin*, Volume 22, pages 281-680.
- Ulrich, E.O. and Scofield, W.H.
1897: The Lower Silurian Gastropoda of Minnesota. *The Geology of Minnesota, Paleontology. Final Report of the Geological Survey of Minnesota, Volume 3, Part 2. Harrison and Smith, Minneapolis*, pages 813-1081.
- Waagen, W.H.
1880: Productus limestone fossils. *Palaeontologica Indica, Series 13, Salt Range Fossils, Volume 1*, pages 73-183.
- Wahlman, G.P.
1992: Middle and Upper Ordovician Symmetrical Univalved Mollusks (Monoplacophora and Bellerophontina) of the Cincinnati Arch Region. *United States Geological Survey, Professional Paper 1066-O*, 203 pages.
- Walthier, T.N.
1949: Geology and mineral deposits of the area between Corner Brook and Stephenville, western Newfoundland. *Newfoundland Geological Survey, Bulletin 35, Part 1*, pages 9-54.
- Whittington, H.B.
1968: Zonation and correlation of Canadian and early Mohawkian series. *In Studies of Appalachian Geology: Northern and Maritime. Edited by E-an Zen, W.S. White, J.B. Hadley and J.B. Thompson, Jr. Wiley-Interscience, New York*, pages 49-60.
- Whittington, H.B. and Kindle, C.H.
1969: Cambrian and Ordovician stratigraphy of western Newfoundland. *In North Atlantic-Geology and Continental Drift. Edited by M. Kay. American Association of Petroleum Geologists, Memoir 12*, pages 655-664.

- Williams, H.
1985: Geology of Gros Morne area (12H/12, west half), western Newfoundland. Geological Survey of Canada, Open File 1134, 1:50 000 geology map.
- Williams, H. and Cawood, P.A.
1989: Geology, Humber Arm Allochthon, Newfoundland. Geological Survey of Canada, Map 1678A, scale 1:250 000.
- Yochelson, E.L.
1963: The Middle Ordovician of the Oslo Region, Norway. 15. Monoplacophora and Gastropoda. Norsk Geologisk Tidsskrift, Volume 43, Number 2, pages 133-213.

1964: The Early Ordovician gastropod *Ceratopea* from east Greenland. Meddelelser om Grønland. Volume 164, Number 7, 12 pages.

1990: Billings' second operculum: a late Early Ordovician *Maclurites* (Gastropoda) from western Newfoundland and the Canadian Arctic. Canadian Journal of Earth Sciences, Volume 27, pages 669-676.

1992: The late Early Ordovician gastropod *Teiichispira* at Port au Port, Newfoundland. Canadian Journal of Earth Sciences, Volume 29, pages 1334-1341.
- Yochelson, E.L. and Bridge, J.
1957: The Lower Ordovician gastropod *Ceratopea*. United States Geological Survey, Professional Paper 294-H, pages 281-304.
- Yochelson, E.L. and Jones, C.R.
1968: *Teiichispira*, a new Early Ordovician gastropod genus. United States Geological Survey, Professional Paper 613-B, 15 pages.
- Yu, W.
1993: Early Ordovician gastropods from the Canning Basin, Western Australia. Records of the Western Australian Museum, Volume 16, pages 437-438.

APPENDIX 1

Location of Illustrated Specimens (all from UTM Zone 21)

Note: The quoted text is from the original Yale Peabody Museum specimen labels, in a list provided by Dr. Susan H. Butts (Collections Manager, Division of Invertebrate Paleontology, Yale Peabody Museum).

96R-3

Lowest chert horizon, Table Point Formation, Table Point. (TP – see Figure 1; 5579522N, 461917E⁸, NTS 12I/06 – Bellburns). Collected by D.M. Rohr and E.A. Measures, 1996. See Rohr *et al.* (2008, page 95, Figure 2).

96R-15

Lower part of Catoche Formation, Garden Hill (GH – see Figure 1), western Port au Port Peninsula, roadcut 3.7 km north of Cape St. George, west of Hunt–Pan Canadian Petroleum Port au Port No. 1 well head. Well head location (335490E, 5372856N, NAD27, NTS12B/06 – Cape St. George).

96R-16

Lower part of the Catoche Formation, Garden Hill (GH – see Figure 1), western Port au Port Peninsula, Hunt–Pan Canadian Petroleum Port au Port No. 1 well head. Beds south of well head dip about 10°W. Well head location (335490E, 5372856N, NAD27, NTS12B/06 – Cape St. George).

2000R-2

Shoreline exposure of lowest Catoche Formation, Barbace Cove, Port au Choix Peninsula, bioclastic bed 4 of Knight (1991) (474700E, 5619410N, NAD83, NTS 12I/11 – Port Saunders).

Yale Peabody Museum (YPM) locality IPB.03855

“Upper St. George, upper Beekmantown, promontory opposite Neddys Harbor⁹, Bonne Bay, western Newfoundland¹⁰” probable Aguathuna Formation. (Longitude: -57.877637, Latitude: 49.5211, WGS84¹¹)

⁸ 50°21.9620'N 57°32.1282'W

⁹ Neddys Harbour of modern usage

¹⁰ collected by Charles Schuchert, William H. Twenhofel (1910-08-18)

¹¹ 5485757N, 436480E

Mollusca–Gastropoda

Ceratopea unguis Yochelson and Bridge,
1957 – YPM IP 034954, 034955

The probable locality is Shag Cliff (SC – see Figure 1). Troelsen (1947) subdivided the St. George Group of Bonne Bay into five divisions (I to V). Walthier's divisions were recognized by Johnson (1949, pages 19-21). According to Knight (personal communication, January, 2018), Division I (400 m) comprises Cambrian strata; Troelsen (1947, pages 29, 30) reported *Cryptozoon?* (cyanobacterial mounds) and an unidentified gastropod, respectively, from Beds 2 and 6. According to Knight (personal communication, January, 2018), Division II (15.25 m) includes a portion of the Berry Head Formation (Port au Port Group). However, the *Cryptozoon?* reported by Troelsen (1947, page 30), might instead indicate the Watts Bight Formation (St. George Group), as cyanobacterial mounds (stromatolites and thrombolites) are common in the unit. The presence of *Ecculiomphalus* and *Lecanospira* in the (44 m thick) Division III (Troelsen (1947, page 30) indicates a correlation with the middle member of the Boat Harbour Formation, specifically with the beds of the *Randaynia saundersi* trilobite zone, *i.e.*, below the Boat Harbour Disconformity (Knight and James, 1987, 1988; Boyce, 1997, 1989; Boyce and Stouge, 1997). *Cassinoceras* aff. *C. wortheni* and *Curtoceras?* (Troelsen (1947, page 31) indicate that Division IV (300.25 m of medium grey-weathering, thick-bedded dolostone) is probably equivalent to the Catoche Formation. *Cassinoceras* aff. *C. wortheni* was obtained “a few feet above the base of Division IV” (Troelsen (1947, page 34). Despite the sparse fossil evidence, Troelsen's (1947, page 34) correlations of Divisions III and IV with the “Middle Canadian” and “Upper

Canadian” were correct. Division V comprises 150.50 m of black, thin-bedded, sheared limestone with bands of massive, fractured grey dolostone. On the NW side of Shag Cliff, Troelsen (1947, page 31) reported “*Ceratopea* and poorly preserved cephalopods” from Bed 30 (sheared black limestones) and “*Ceratopea* and large gastropods” from Bed 34 (thin-bedded black limestones); these are probably the beds from which Schuchert and Twenhofel earlier obtained their *Ceratopea* specimens. West of Shag Cliff, the following taxa were collected by Johannes C. Troelsen in 1945 from the “Table Head Fm” (see Troelsen, 1947, page 38).

Arthropoda–Trilobita

Iliaenus consimilis Billings, 1865

Pseudomera barrandei (Billings, 1865)

Mollusca–Gastropoda

Maclurites? sp.

Maclurites cf. *crenulatus* (Billings, 1865)

These are firmly indicative of the *Pseudomera barrandei* trilobite zone (see Figure 2). The underlying Division V therefore probably belongs to the Aguathuna Formation.

Yale Peabody Museum (YPM) locality IPB.04002

“N of Neddys Harbor¹², Bonne Bay, western Newfoundland¹³” probable Aguathuna Formation.

Brachiopoda

Gen. et sp. undet. – YPM IP 122674

Mollusca– Cephalopoda

undet. Nautiloidea – YPM IP 086905

Mollusca– Gastropoda

Ceratopea unguis Yochelson and Bridge, 1957 – YPM IP 034027

¹² Nedly Harbour of modern usage

¹³ collected by Carl O. Dunbar (1918-07-27) from “Beekmantown Fm”. However, according to Rohr and Yochelson (unpublished, 1996), the locality was originally sampled on July 27, 1918 by Schuchert and Dunbar from “Headland opposite Nedly's Harbor, Bonne Bay, *Ceratopea* bed.”, so it may be equivalent to the earlier collected IPB.03855. See the discussion of Shag Cliff (NTS 12H/12 - Gros Morne) above