*Current Research (2000) Newfoundland Department of Mines and Energy Geological Survey, Report 2000-1, pages 241-250*

# ONGOING STUDIES OF LATE CAMBRIAN AND EARLY ORDOVICIAN GASTROPODS OF WESTERN NEWFOUNDLAND

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## ABSTRACT

*Gastropods are relatively common and diverse in the Lower Ordovician carbonate shelf rocks of western Newfoundland, but relatively few studies have been made of them since the 19th century. The present work attempts to recollect the known gastropod taxa, and document their ranges, as well as recovering taxa new to the area.* Sinuopea, *the oldest gastropod known from Newfoundland (Late Cambrian–Early Ordovician) is documented from several areas.* Lecanospira nerine *(Billings, 1865) has been found closely associated with algal mounds in the Boat Harbour Formation. The stratigraphic ranges of well-preserved, silicified gastropod opercula, including* Maclurites, Ceratopea *spp. and* Teiichispira *are being determined.*

## INTRODUCTION

Gastropods comprise a significant proportion of the earliest publication on fossils of western Newfoundland published in the 19th century by Billings (1865). In all, 45 species of gastropods collected by James Richardson were described and named by Billings (1865). Fossil collecting during the early years, however, was not pursued in any systematic fashion (Knight and James, 1988). Samples taken by Richardson were monographed by Billings (1865) and subsequent documentation was usually in the form of fossil lists, reported together with generalized stratigraphic sections. Since then, recent studies have dealt with only *Teiichispira* and "Billings second operculum" (Yochelson, 1990, 1992). The present study aims to resample many of Billings' (1865) localities with the goal of determining the age ranges of the gastropods by using established trilobite and graptolite biostratigraphy (Boyce, 1989; James *et al.*, 1988) within the detailed lithostratigraphic framework established throughout western Newfoundland (Knight and James, 1988; Knight, 1991, and unpublished data). In particular, Lower Ordovician carbonate shelf sections were examined from the Port au Port Peninsula, Bonne Bay and the Port au Choix area, as well as scattered localities near Stephenville, but gastropods from Late Cambrian carbonate rocks of the Port au Port Group on the Great Northern Peninsula and Stephenville area were also studied.

The Lower Ordovician shallow-water carbonate rocks of the St. George Group consist of 500 m of subtidal and peritidal limestone and dolostone divided into the Watts Bight, Boat Harbour, Catoche and Aguathuna formations (Knight and James, 1987). This sequence is broadly divided into two megacycles, unconformity-bound sequences of Tremadoc and Arenig age (Knight and James, 1987; James *et al.,* 1989). The Tremadocian sequence consists of rocks of the Watts Bight and the lower member of the Boat Harbour Formation, the Arenig sequence consists of the Barbace Cove Member, Boat Harbour Formation and the Catoche and Aguathuna formations. Detailed systematic collections of trilobites on the Great Northern Peninsula enabled Boyce (1989, 1997) to established 9 distinct trilobite zones within the Boat Harbour, Catoche, and Aguathuna formations. Graptolites are scattered within the Catoche and Aguathuna formations and allow correlation of much of the upper sequence to the *Tetragraptus approximatus, Didymograptus nitidus* and *D. bifidus* zones (Williams *et al.,* 1987, *this volume*).

Gastropods and other molluscs are locally abundant throughout the St. George Group. The Boat Harbour Formation gastropod fauna is relatively diverse, but is not silicified in the lower member. Gastropods from the Catoche and Aguathuna formations are also common and include many forms retrieved from silicified horizons. At least six species of gastropod opercula are also present. In addition, this paper addresses a number of scattered and stratigraphically orphaned collections of *Sinuopea* from Cambrian carbonates of the Port au Port Group.

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# TAXANOMY OF GASTROPODS FROM WESTERN NEWFOUNDLAND

### *Sinuopea* Ulrich, 1911

The oldest gastropod found in western Newfoundland is *Sinuopea*. It is recovered from Late Cambrian to possibly earliest Ordovician strata in three scattered localities. Two of the localities occur in undivided dolostones of the Petit Jardin and Berry Head formations in the neighbourhood of Plum Point and St. Barbe, Great Northern Peninsula (Figure 1). The third locality occurs in interbedded dolostone and limestone of the Berry Head Formation and was newly discovered in 1999 by I. Knight and D. Boyce north of Stephenville, along a skidder trail in the centre of the Phillips Brook anticline (Figure 2; *see* Knight and Boyce, *this volume*).

On the Great Northern Peninsula, the first discovery of *Sinuopea* sp. was made by D. Boyce at a road-cut along the north side of Route 432. The *Sinuopea* (Plate 1) occurs abundantly in a massive, tan-weathering, light-blue-grey, finely crystalline, sucrosic dolostone bed. The gastropod also occurs in a 30 to 40 cm bed of burrow-mottled, light and dark grey, finely crystalline dolostone that is intercalated with stromatolitic dolostone and mudcracked, shaly dolostone on the southwest side of Mutton Island, a kilometre southwest of the community of Forresters Point (Figure 1). These specimens of *Sinuopea* sp., which are silicified, are the only identifiable fossils so far discovered in the 250-m-thick dolostone sequence that forms the upper dolostone member of the Petit Jardin Formation (Port au Port Group) and the lower Berry Head Formation in this area. Dresbachian (early Late Cambrian) trilobites occur locally in the middle stromatolite member of the Petit Jardin Formation (Boyce, 1978, 1979; Knight, 1978; James *et al.*, 1988) at Deadmans Cove, 6 km north of St. Barbe, and no other fauna occurs in the sequence in this area of the Great Northern Peninsula until Early Ordovician age (early Canadian) gastropods and cephalopods of the Watts Bight Formation (Knight, 1977).

In the Phillips Brook anticline, *Sinuopea* (Plate 2) occurs in dark-grey, bioturbated and thrombolitic, dolomitic limestone beds, 20 to 30 cm thick, intercalated in a thick sequence of bioturbated and locally cherty dolostones and dololaminites of the upper member of the Berry Head Formation (Knight and Boyce, *this volume*). The steeply dipping, westward-younging sequence forms the hanging wall to a steeply southeastward-dipping, northeast-trending fault that separates the section from trilobite-rich Dresbachian ribbon carbonates of the Petit Jardin Formation to the west. Similar gastropods occur in similar cyclic peritidal limestones and dolostones in the upper Berry Head Formation section at Goose Arm (*see* Figure 3 of Knight and Boyce, 1991).

*Sinuopea* sp. of this study, range in height from 4 mm to nearly 2.5 cm and have a narrow, deep umbilicus. The apical angle of the holopeiform shell is about 90°, and the shell has a slightly concave band at midwhorl. Faint growth lines suggest a broad and deep sinus culminating at midwhorl. The shell differs from *Sinuopea sweeti*, which is anomphalous.

*Sinuopea* sp. is a common gastropod genus in the Upper Cambrian and Lower Ordovician strata of eastern and central North America and Greenland. It is known from the Cambrian of Wisconsin, Missouri, Oklahoma, and the southern Appalachians (Ulrich and Bridge *in* Ulrich *et al.*, 1931), and the Lower Ordovician of Missouri, central Texas, North Greenland (Fortey and Peel, 1990) and East Greenland (Poulsen, 1937). The type species of *Sinuopea, Holopea sweeti*, was described by Whitfield (1882) from the Upper Cambrian (Trempealeauan) of Wisconsin. The genus *Sinuopea* was established by Ulrich (1911), and later Ulrich and Bridge (*in* Ulrich *et al.*, 1931) erroneously designated *S. vera* as the type species (Knight, 1941). Ulrich and Bridge (*in* Ulrich *et al.*, 1931) named *Sinuopea vera, S. cingulata, S. umbilicata, S. basiplanata,* and reported *S. regalis* Ulrich (*in* Butts, 1926) from the Lower Ordovician (Gasconade) of Missouri. Cloud and Barnes (1948) illustrated *Sinuopea cingulata, S. typicalis, S. umbilicata*, and *S. vera* from the Tanyard Formation of the Ellenburger Group (mid Lower Ordovician) in central Texas. The genus is also illustrated from the Lower Ordovician (mid Canadian or upper Tremadoc) of North Greenland (Fortey and Peel, 1990).

*Sinuopea* sp. is differentiated from the Late Cambrian (Trempealeauan) genus *Taeniospira* Ulrich and Bridge (*in* Ulrich *et al.*, 1931), represented only by the species, *T. eminencensis*, by the presence of a slit (Ulrich *et al.*, 1931). It is uncertain however, if the slit actually exists (Knight, 1941), and this species may belong to the genus *Sinuopea*.

*Sinuopea* sp. in the younger Canadian strata of North Greenland occurs along with bathyurid trilobite biofacies. Fortey and Peel (1988) concluded that this biofacies is characteristic of inshore calcareous lithofacies of the Lower Ordovician platform that extends from Greenland through Newfoundland and eastern North America as far as New Mexico and into Laurentia's interior as far as Missouri and on to the western Laurentian margin in Utah. *Sinuopea* sp. has a similar distribution, although it is not known from Utah.

Lithofacies associated with the *Sinuopea* sp. in western Newfoundland suggest that the older genus occurs in

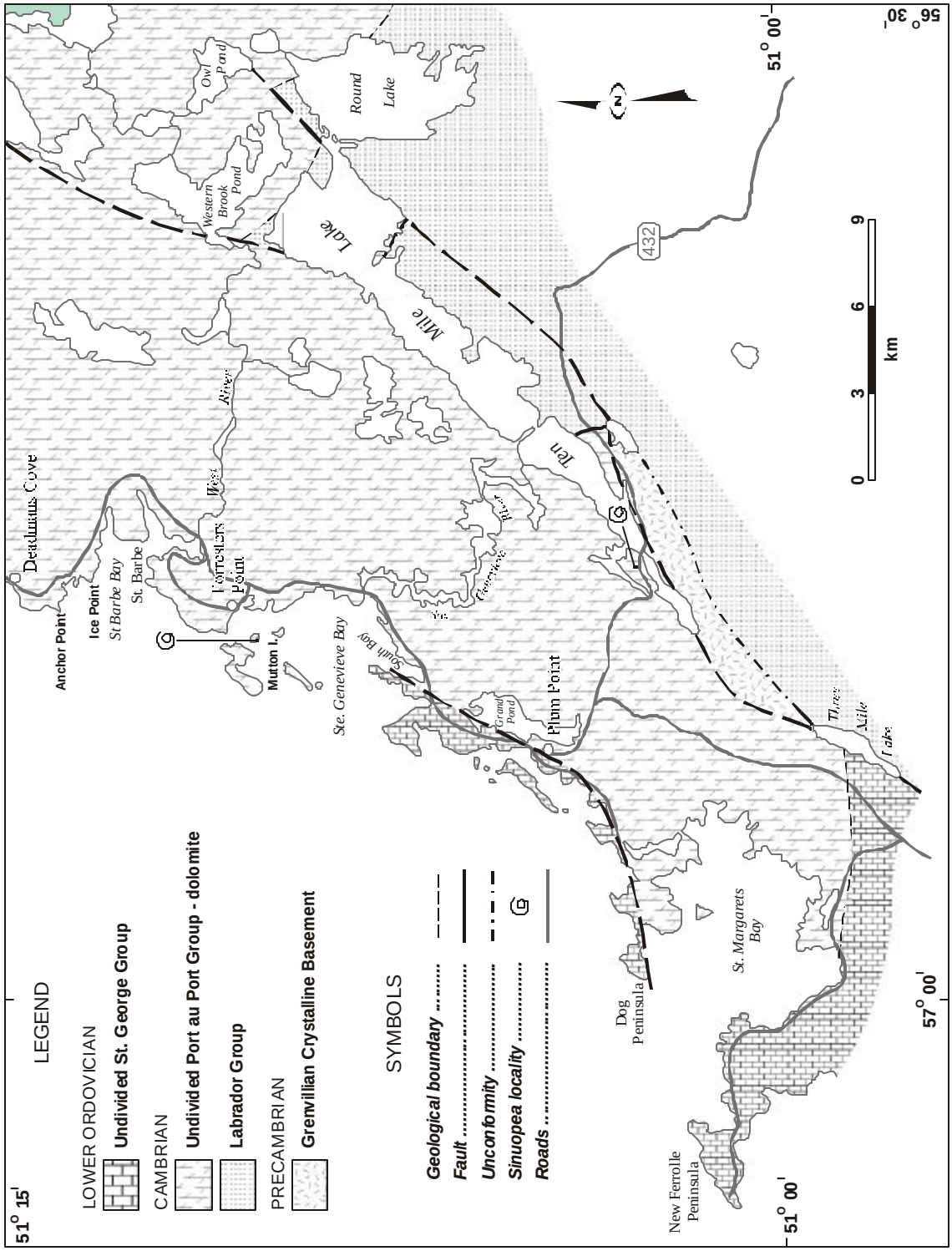


**Figure 1.** *Simplified geological map of the Plum Point and St. Barbe area, Great Northern Peninsula showing the location of Sinuopea. Map adapted from Snow and Knight, 1979.*

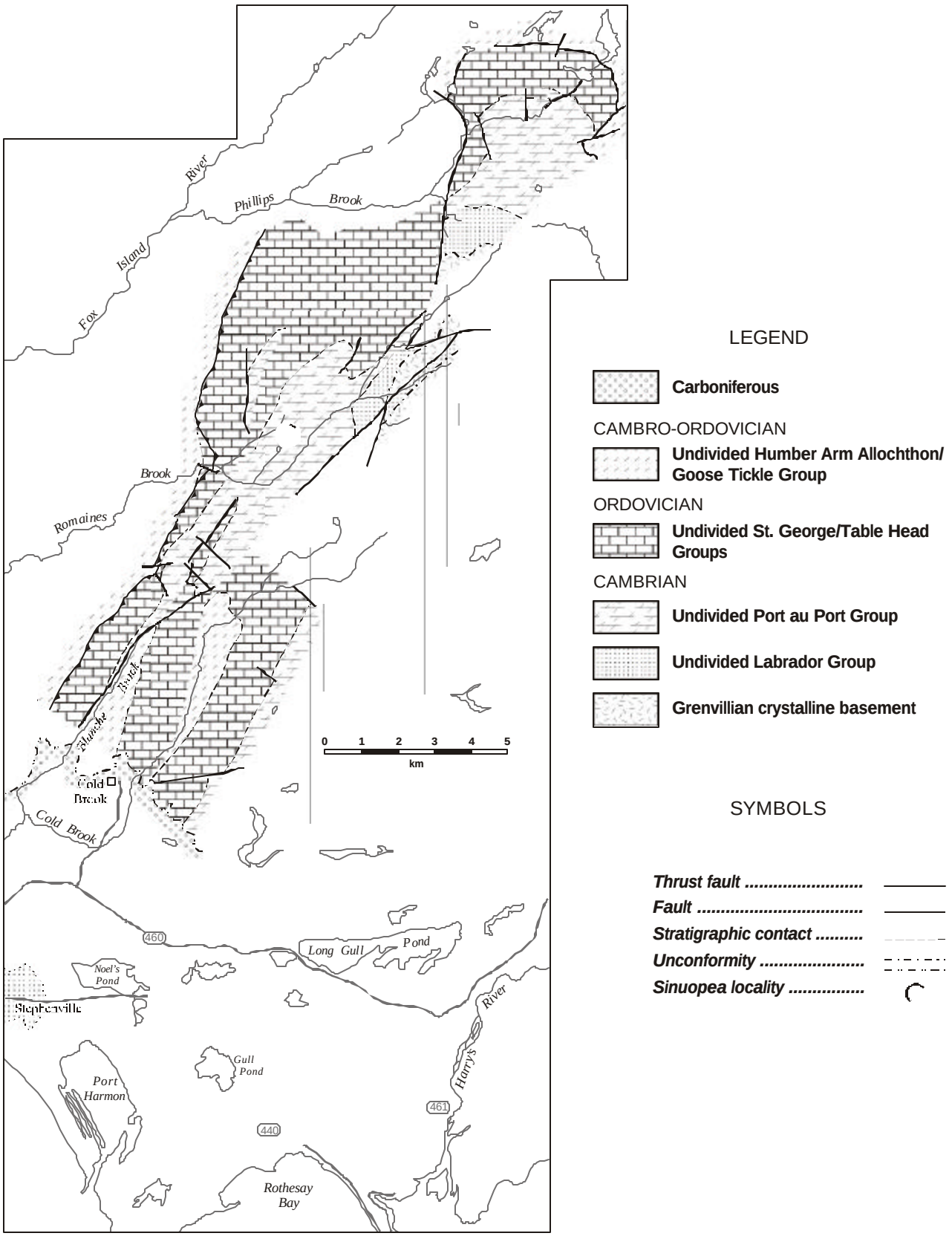


**Figure 2.** *Simplified geological map of the Cambro-Ordovician rocks north of Stephenville, showing the* Sinuopea *locality in the Romaines Brook valley. Map based on Knight and Boyce,* this volume.

restricted, probably hypersaline interior peritidal shelf settings of the Petit Jardin–Berry Head dolostones of the Great Northern Peninsula (*see* Knight, 1977; Cowan and James, 1993) and more open, perhaps near-normal-marine cyclic peritidal carbonates of the upper Berry Head Formation in a mid-shelf setting of the Stephenville and Goose Arm areas. The facies and cyclicity of the upper Berry Head Formation in both areas appear to prelude the early Tremadocian flooding of the Newfoundland shelf that controlled the deposition of the lower part of the St. George Group (**see** Knight and James, 1987; James *et al.*, 1989).

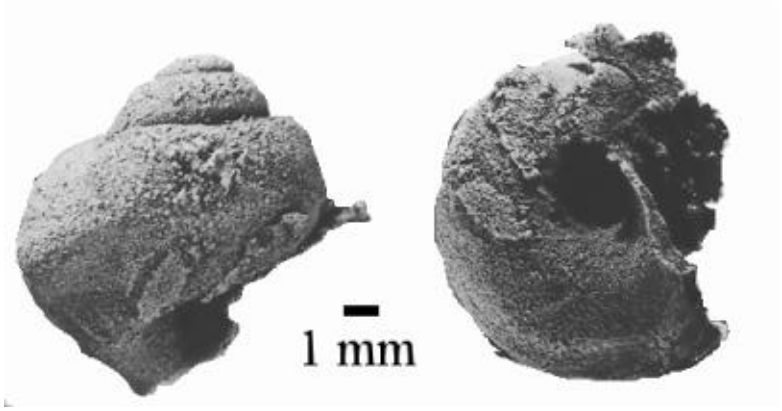


**Plate 1.** Sinuopea *sp. from undivided Petit Jardin–Berry Head formations dolostones, Roddickton road, Route 432 roadside outcrop.*

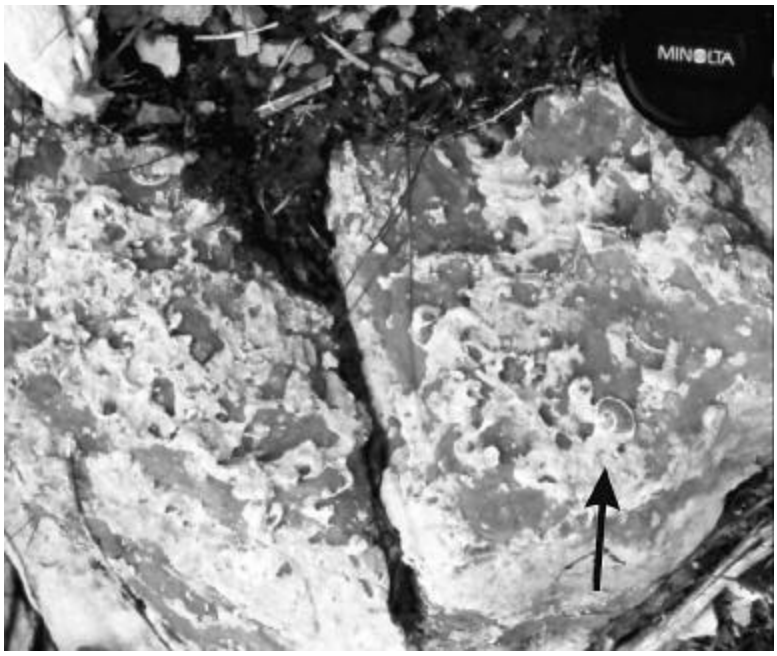


**Plate 2.** Sinuopea *sp. (arrow) in a dolomitic limestone of the Berry Head Formation, Romaines Brook valley, north of Stephenville.*

### *Lecanospira nerine* (Billings, 1865)

The Boat Harbour Formation comprises 105 m of metre-scale sequences of peritidal limestone and dolostone (Knight, 1991) that are divided into a lower member of Demingian (late Tremadoc) strata and a disconformably overlying upper member, the Barbace Cove Member, of late Jeffersonian–Cassinian (early Arenig) age. Near Eddies Cove West, the lower member of the formation is interspersed with six intervals of thrombolitic and stromatolitic boundstone mounds including large bun-shaped mounds at one interval (Unit 46 of Knight, 1991), which are notable for their abundant fauna of the gastropod *Lecanospira nerine* (Billings, 1865) (Plates 3 and 4). The mound unit, which occurs approximately 34 m above the base of the section (Knight, 1991), also hosts the trilobite *Hillyardina levis* Boyce, 1989, and the cephalopod *Bassleroceras* sp. undet. and belongs to the late *Leiostegium proprium* Zone (Boyce, 1989, 1997; Boyce and Stouge, 1997).

The boundstone mounds initially grew on a layer of intraclastic limestone. The mounds consist of two distinct zones, an inner core of digitate stromatolite separated by a thin chert layer from a clotted thrombolitic outer zone rich in *Renalcis*. The reef-like growth of the outer mound zone produced cavities that host larger skeletal material including gastropods and cephalopods. The gastropods, which are also very abundant in the intermound grainstones and packstones, are unique in western Newfoundland because of their exceptional preservation and lack of diagenesis, their 0.5 to 1.5 cm size, and their thriving living ecological association with the *Renalcis* sp. thrombolite. The small gastropods appear to represent a micromorphic (dwarfed) species of *Lecanospira* that is not found anywhere else in the formation.

The *Lecanospira nerine* location identified here is probably the type locality. Billings (1865, p. 246) noted that the small (6 to 17 mm or "3 to 8 lines wide") specimens were, "found in immense numbers."

Larger *Lecanospira* (probably *Lecanospira compacta* (Salter, 1859)) occur throughout most of the Lower Boat Harbour Formation, but the small *L. nerine*, are only seen in the mound and in intermound beds.

*Lecanospira* Butts, 1926, is a common genus in the Lower Ordovician of eastern North America (Texas, Missouri, Alabama, Virginia, Maryland, Pennsylvania, New York, Quebec and Newfoundland), and it has been used as a biostratigraphic zone within the upper half to third of the Canadian Series (Yochelson and Copeland, 1974).

### Gastropod Opercula

Lower Ordovician gastropod opercula are common in the upper St. George Group above the Boat Harbour disconformity ("pebble bed" of Knight, 1978; Boyce, 1978) where they occur in the Barbace Cove Member of the Boat Harbour Formation, Catoche Formation and Aguathuna Formation. During this study, opercula have been collected from sections that include western Port au Port Peninsula (*see* Boyce *et al., this volume*), Table Mountain east of the peninsula, the Phillips Brook anticline (*see* Knight and Boyce, *this volume*), and shoreline sections of Bonne Bay, Table Point and Port au Choix to Eddies Cove West.

**Plate 3.** *Large stromatolitic and Renalcis-thrombolite mounds that host abundant small* Lecanospira nerine, *shoreline north of Eddies Cove West, Great Northern Peninsula.*

**Plate 4.** *Internal structure of the boundstone mounds of Plate 3. A thin zone of chert (arrow) separates a core of stromatolite from an outer zone of* Renalcis*-rich thrombolite. The light coloured areas in the outer zone are fine grained sediments trapped in open space between thromboids. Numerous* Lecanospira nerine *gastropods, generally less than 1 cm in size occur throughout the thrombolite.*

At least six types of opercula occur silicified in the St. George Group. The opercula belong to *Maclurites* LeSueur, 1818, *Ceratopea* Ulrich, 1911; *Teiichispira* Yochelson and Jones, 1968; and possibly *Monitorella* Rohr, 1994. Yochelson (1990, 1992) illustrated *Teiichispira odenvillensis* (Butts, 1926) and *Ceratopea unguis* Yochelson and Bridge, 1957, from the Aguathuna Formation at the Gravels section, eastern Port au Port Peninsula, and "Billings' Second Operculum" (*Maclurites*) from the Catoche Formation at Cape Norman. We have collected additional *Ceratopea* and *Teiichispira* from the same horizons and from a new section exposed at the west end of Port au Port Peninsula (Plate 5) (*see* Boyce *et al., this volume*). Our collections indicate that "Billings Second Operculum" is restricted to the Catoche Formation.

Several species of *Ceratopea* are present in the St. George Group. *Ceratopea* cf. *capuliformis* Oder, 1932, is present in the uppermost Boat Harbour Formation (*Strigigenalis brevicaudata* trilobite zone) near Eddies Cove West in bioturbated packstone and wackestone beds below mud-cracked and laminated, lime mudstones at Hunters Point. This species indicates the lowest part of the *Ceratopea* Zone (Yochelson and Bridge, 1957). *Ceratopea billingsi* Yochelson, 1964, is found throughout the Catoche Formation, and has been previously reported by Yochelson (1964) from the St. George Group at Cape Norman and the Durness Group of Scotland. The shell of the gastropod *Ceratopea canadensis* (Billings, 1865) is found in the Catoche Formation, but which operculum belongs to it is not yet known.

*Maclurites* opercula including "Billings Second Operculum" are common throughout the Catoche Formation. There is, however, another opercula type that is characterized by a distinctive, plate-like form having concentric growth lines and by the lack of the muscle process on the interior surface exhibited by many other species of the genus. Shells of *Maclurites* such as *M. oceana* Billings, 1865, having a similar whorl profile, are common in the Catoche.

Opercula recovered from different sections of the upper St. George Group are listed by formation in Appendix 1.

## ACKNOWLEDGMENTS

Field work for this study was supported in part by grants 6110-98 and 6550-99 from the Committee for Research and Exploration, National Geographic Society, and the Sul Ross Faculty Research Fund to Rohr.

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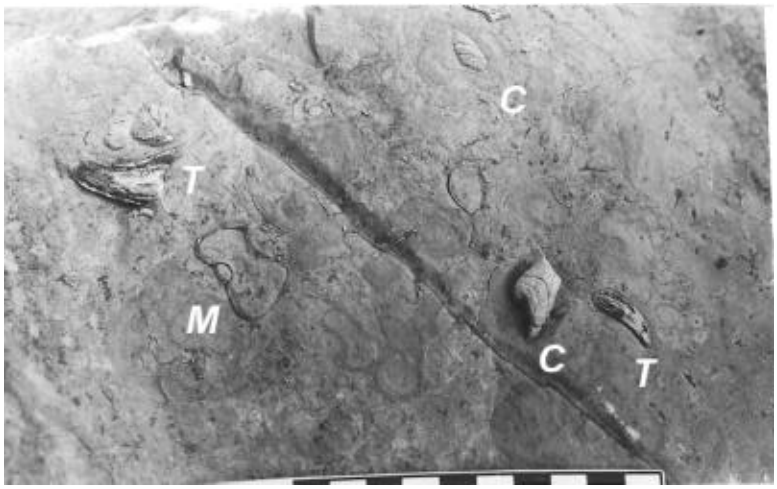


**Plate 5.** *Silicified opercula of* Teiichispira odenvillensis *(T),* Ceratopea unguis *(C), and an unidentified macluritid gastropod shell (M) exposed on a bedding plane of the Aguathuna Formation, western Port au Port Peninsula, east side of Route 463 highway south of Mainland.* Ceratopea *opercula form the cores of oncoids. Scale is in centimetres.*

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# APPENDIX 1

***Sinuopea* localities**

Roddickton road, Route 432, north side, dolostone outcrop, undivided Petit Jardin–Berry Head formations, UTM Zone 21, 515557E, 5655460N, Brig Bay map sheet, 12P2 & 12P/3; Rohr 98R-19 Boyce 98F-034.

Mutton Island, Ste Genevieve Bay, shoreline dolostone outcrop, UTM Zone 21, Brig Bay map sheet, 12P2 & 12P/3.

Tributary of Romaines Brook, small gully along a skidder trail, Knight field station K99-3Q, Boyce 99-F005, UTM Zone 21, 391230E, 5393400N Harry's River Map sheet, 12B/9.

***Lecanospira nerine* (Billings, 1865) locality**

Eddies Cove East, shore of Old Man Cove 1.3 km north of the village of Eddies Cove West. UTM Zone 21, 488700W, 5623290N, St. John Island map sheet 12I/14, Boyce fossil locality ECW-014; Rohr 98R9.

***Ceratopea* cf. *capuliformis* Oder, 1932 locality**

Boat Harbour Fm. (uppermost), Eddies Cove West, Hunters Point, Unit 119 of Knight (1991), UTM Zone 21, 484616E, 5622752N; Rohr 98R17.

***Ceratopea billingsi* Yochelson, 1964 localities, Western Port au Port Peninsula**

Port au Port No. 1 Well Head. Beds east of Hunt Oil Port au Port No. 1 Well, dipping about 10 W. UTM Zone 21, 335490E, 5372856N; Rohr 96R17.

Lower part of Catoche section (99R2), UTM Zone 21, 337336E, 5377594N.

***Ceratopea unguis* Yochelson and Bridge, 1957 localities in Aguathuna Formation**

The Gravels, eastern Port au Port Peninsula, UTM Zone 21, 372158E, 5380014N; Rohr 98R2.
Table Mountain east of the Port au Port Peninsula. Radar tower road cut.
Table Point, high-tide level, UTM Zone 21, 462258E, 5579974N.

Western part Port au Port Peninsula, east side of highway, UTM Zone 21, 337501E, 5378454N; Rohr 98R5, Boyce 98F-013.

Logging trail, north of Stephenville. UTM Zone 21, 390597E, 5394108N; Rohr 99R1, Boyce 98F-025.

***Ceratopea canadensis* (Billings, 1865) locality**

Hunters Point, Catoche Formation, Bed 2 of Knight (1991), UTM Zone 21, 484227E, 5622664N. ECW-037=98F032.

**Billings' Second Operculum localities in Catoche Formation**

Western Port au Port Peninsula, Port au Port No. 1 Well Head. Beds east of Hunt Oil Port au Port No. 1 Well, dipping about 10 W. UTM Zone 21, 335490E, 5372856N; Rohr 96R17.

Western Port au Port Peninsula, lower part of Catoche section on ridge east of highway.
99R2, UTM Zone 21, 337336E, 5377594N (lowest).
99R3, UTM Zone 21, 337409E, 5377628N
99R4, UTM Zone 21, 337330E, 5377725N

Hunters Point, east of Eddies Cove West, Bed 2 of Knight (1991) UTM Zone 21, 484227E, 5622664N. ECW-037=98F032.

***Teiichispira odenvillensis* Butts, 1926 localities in Aguathuna Formation**

Western part Port au Port Peninsula, east side of highway, UTM Zone 21, 337501E, 5378454N; Rohr 98R5, Boyce 98F-013.

The Gravels, eastern Port au Port Peninsula, UTM Zone 21, 372158E, 5380014N; Rohr 98R2.