New occurrence of Ostracodes used as indications of paleoecology and age for Scots Bay Formation, Bay of Fundy, Canada

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Abstract: Fossils in the Jurassic Scots Bay Formation are rare but silicified, species include ostracodes, small gastropods, small clams, fragments of charophyte stems, and freshwater stromatolites. The silicified ostracodes and algae are found in thin to thick beds of mixed carbonate and siliciclastic units deposited in erosional paleotopographic lows on the top of the Early Jurassic North Mountain Basalt (NMB).
Ostracodes are the most common type of fossil in the Scots Bay Formation, in this study nearly 800 specimens have been extracted. These ostracodes are moderately to well preserved, thin-shelled, and occur as whole silicified carapaces, separated valves, and internal molds. Three ostracodes genera have been identified: Darwinula, Timiriasevia, and Metacypris. Determining the exact age for this Formation has been a matter of mild dispute. The
recorded new occurrence of these ostracodes assemblage will help to revise age and provide enough knowledge about paleoecology of Scots Bay Formation

Keywords: Assignment problem, Fuzzy numbers, Robust ranking function, Hungarian method.

Introduction

The Triassic-Jurassic Fundy Group rocks are exposed along the south and north shores of the Bay of Fundy (Fig. 1). It consists of four nonmarine formations which, in ascending order, are the Wolfville, Blomidon, North Mountain Basalt, and the Scots Bay formations. At the top of the Fundy Group, the Scots Bay Formation along the south shore is believed to be time-equivalent to the McCoy Brook Formation along the north shore [21]. The little studied Scots Bay Formation is unique because it is a chert-bearing mixed carbonate and siliciclastic units.

In outcrop, the Scots Bay Formation reaches a maximum thickness of about 7 meters, being exposed in small coves from east of Baxters Harbour to west of Scots Bay, Nova Scotia The Scots Bay Formation is composed of different types of lithofacies of which siliciclastics dominate, including feldspathic

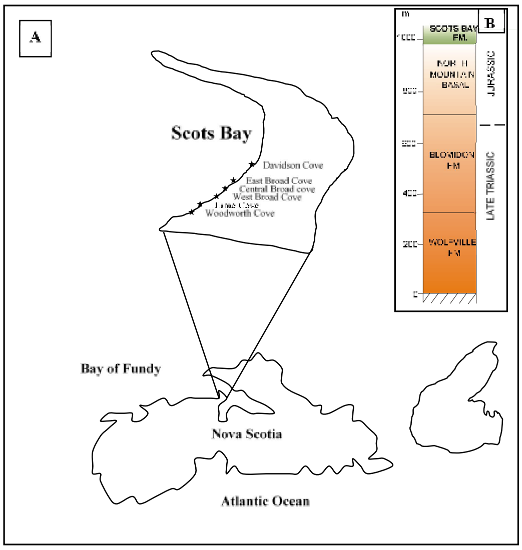


Figure 1. Location map of the study area. A, the Bay of Fundy in northern Nova Scotia and the main outcrops of Scots Bay Formation in the Scots Bay area. B, Stratigraphic section of the study area.

sandstones, conglomeratic sandstones, silty sandstones (Fig. 2). The carbonate rocks consist of calcareous sandstones, packstones, wackestones, and bioclastic limestones. Chert beds and jasperoid nodules are common ([17].

The Scots Bay Formation is characterized by small assemblage of silicified freshwater lacustrine ostracodes, micromollusks, algae, stromatolites, rare dinsour footprints, plant fragments and rare fish [4, 16,17]

Because there is a paucity of studies of Late Triassic-Early Jurassic nonmarine fossils available worldwide, there is insufficient knowledge about their biostratigraphy, paleoecology and evolution. This information is necessary to understand and interpret the depositional environments, age and paleoecology of the Scots Bay Formation as well as other Fundy Group formations along eastern North American margin.

Over 800 specimens of small Ostracodes were collected and prepared for identification and analysis during the study of my master degree at Acadia University in Nova Scotia, Canada. Ostracodes are the most common faunal element in the Scots Bay Formation, they are mostly silicified and common in bioclastic limestones at Woodworth Cove, Central Broad Cove and East Broad Cove (Fig 1). Three genera are identified and reported as new occurrence and published for first time in the Scots Bay Formation, these are *Timiriasevia, Darwinula* and *Metacypris* [17].

In this paper, the new identified Ostracode have been utilized for the study of the paleoecology of the Early Jurassic Scots Bay Formation.

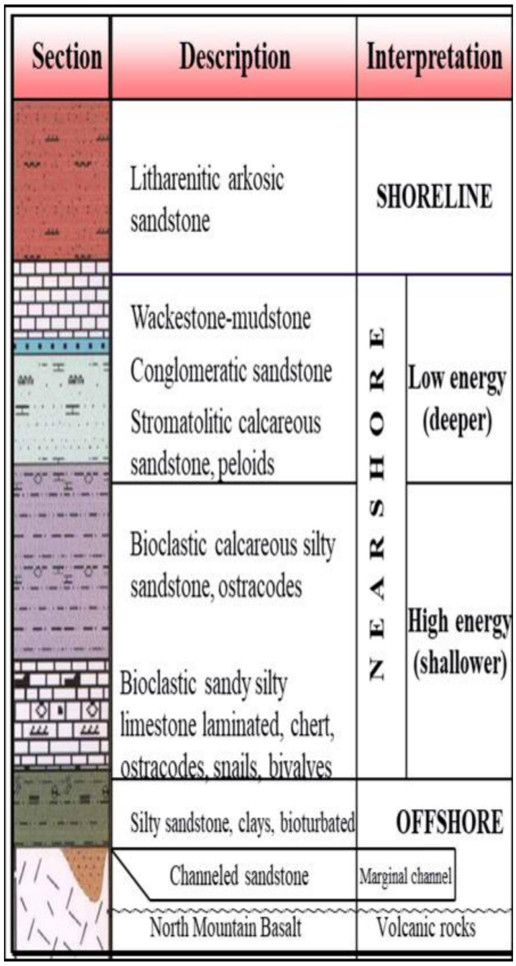


Figure 2, Stratigraphic section of the Scots Bay Formation with major characteristic features of the environmetnal facies

The Scots Bay Formation is at a crucial level just above the Triassic-Jurassic boundary over which there is currently a debate regarding the kind of late Triassic extinction event(s)[22]. Because there are very few well preserved early Jurassic freshwater fossil assemblages known worldwide, a thorough study of the Ostracodes of the Scots Bay Formation should be significant regionally along the eastern North America continent and possibly more broadly to correlations with northwest Africa [23] and elsewhere. The occurrence of these Ostracodes may led to better understanding of the genera age range for the Scots bay Formation.

Paleoecology

The study of the environmental requirements and water chemistry of ostracodes began early this century, so that paleoenvironmental reconstruction can be made from fossils ostracode assemblages. Ostracodes have been found almost in all environments: marine, rivers, lakes, springs, estuaries and brackish lagoons. The earliest known freshwater ostracodes inhabited shallow ponds, coal-forming swamps, and streams of Early Pennsylvanian time. Some ostracodes are most common in fresh water such as Darwinulidae, most of the Cypridae and a few Cytheridae. Carapace thickness indicated the alkalinity or acidity of the water. For example, Candona is intolerant of acid waters [1]. Carbonel [3] reported that the abundance and diversity of ostracodes can reflect a good food supply, low energy levels and an adequate oxygen supply. It should be noted that the Scots Bay Ostracodes are very silicified which made it impossible to examine and run isotopes analysis on their carapace.

Based on geochemistry studies for Scots Bay rocks, Thompson [26] concluded that the climate of Scots Bay lake was warm and humid with seasonal variation in precipitation. In this warm subtropical environment, ostracodes, microgastropoda and algae thieved in shallow well oxygenated waters of Scots Bay in eastern Canada.

Limestones and carbonate deposits in general are well-known in slightly alkaline environments and are more appropriate for ostracode faunas. The ostracode assemblages in the Scots Bay Formation have been found more in carbonate rocks rather than in the clastic rocks. Today, and probably since Jurassic, cyprid, Darwinulid, and limnocytherid ostracodes occur in all aqueous environments except those of low pH and very high alkalinity water [26]. They are found from deepest lakes to the shallowest temporary puddles. According to [20] Darwinula is essentially a freshwater form and occasionally is also encountered in oligomesohaline waters. Darwinula represents the largest part of the Scots Bay Ostracodes assemblage (Plate 1). It is smooth-shelled and mainly represented by isolated valves. However, the presence of freshwater fossils in limestone and silty sandy limestone and the absence of evaporite minerals are indicate aerobic freshwater condition for Scots Bay lake. The new occurrences of Timiriasevia and Metacypris (Plate 2) which have been found in Scots Bay Formation. are thought to be in brackish or freshwater strata. The salinity and temperature of the lake evidently did not reach extreme values even when lake levels fell as evidenced by the horizons of mudcracks. The high amount of closed carapaces that occur in the bioclastic limestone bed at Central Broad Cove may also indicate weak current activity. On the other hand, the large amount of the single valves that occur in the sandy limestone at Woodworth Cove may indicate relatively high current activity.

AGE OF THE SCOTS BAY FORMATION

The age interpretation of Scots Bay Formation has changed from Cretaceous to Triassic to Early Jurassic during this century. It has been matter of minor controversy to determine the precise age for this formation. Haycock [13] suggested a Cretaceous age, but later he found a head of a fish that was identified as a Triassic genus. Power [25] suggested a Triassic age for Scots Bay Formation based on the Triassic fish found [10,] suggested an Early Jurassic age. Cameron (1986) noted that the Scots Bay fauna resembles, at the generic level, the freshwater invertebrate faunas of the Late Jurassic Morrison Formation of North America and Purbeck Beds of Europe.

The stratigraphic position of the Scots Bay Formation on the top of the stratigraphic sequence in Bay of Fundy makes its age determination problematical. Knowing just the age of underlying North Mountain Basalt just provide a lower age limit. Hayatsu [19] dated the age of the underlying North Mountain Basalt (NMB) at 191 ± 2 Ma, which is Late-Early Jurassic. Deposition of the Scots Bay Formation occurred some time later, at the end of early Jurassic or early Middle Jurassic.
Ostracodes finds by [16] and published herein may hold the greatest promise for pinning down the exact age of the Scots Bay Formation. Darwinula lissica is known from Early Jurassic freshwater deposits, such as Bristol Horizon (Rhaetic assemblage) and Coal-bearing strata of south China. *Darwinula Sarytirmenensis* has been reported from the Middle Jurassic Kota Limestone of India also Late Early Jurassic of South China. *Metacypris* has been previously reported from younger Jurassic occurrences elsewhere in the world. The presence of darwinulid ostracodes may suggest that deposition of Scots Bay Formation started at the Early Jurassic time. This support its correlation by [10]. with the Early Jurassic McCoy Brook Formation along the north shore of the Bay of Fundy.

However, the Early to Middle Jurassic age uncertainty using biostratigraphic techniques may be resolved by further work on other elements of the Scots Bay fauna. The time range of several of these ostracode genera may extend back to Early Jurassic, but there are very few well-studied Early Jurassic freshwater microfossil assemblages known throughout the world for comparisons with the Scots Bay fauna. The genus *Timiriasevia* was originally reported from the Middle Jurassic of the former U.S.S.R. and from Bathonian (Middle Jurassic) beds of the Paris Basin.

It appears that there are more evidance that indicate that the age of Scots Bay Formation should be extended to Middle Jurassic. These include ostracode assemblage *(Timiriasevia* sp.) of Scots Bay Formation which is very similar to the ostracode assemblage of the Middle Jurassic-age Kota Limestone in India. Moreover, The evidence of weathering and erosion [16] on the irregular surface (nonconformity top of NMB, dated 191 ± 2 Ma) of which the sediments of Scots Bay Formation were deposited may suggest time gap (hiatus) between the two formations.

CONCLUSION

The Scots Bay Formation was deposited by a lake system that was generally shallow. Fossils in the Scots Bay Formation are rare and mostly silicified. They include a relatively low diversity of ostracodes, small gastropods, small clams. Ostracodes reported for the first time include *Darwinula sarytirmenensis*, *D.* aff. *liassica*, *D. acadiaensis* n. sp., *Darwinula* n. sp., *Metacypris ridgensis* n. sp., and *Timiriasevia aff. digitalis.* The presence of this ostracode assembly indicates freshwater lacustrine environment. The darwinulid ostracodes suggest an Early Jurassic age for the Scots Bay Formation. This suggests its age according to its stratigraphic position and dinosaur footprints which suggest its correlation with the Early Jurassic McCoy Brook Formation along the north shore of the Bay of Fundy. However, the recent recorded occurrence of ostracodes in Scots Bay Formation shows considerable similarities to other ostracode assemblage reported in Middle Jurassic-age formations elsewhere. Also, the presence of late early Jurassic nonconformity between Scots Bay Formation and underlain NMB Formation may indicate time gap (hiatus) between the two formations.

Explanation of plate 1

Darwinula aff. liassica

Fig. 1- Oblique view (X 77)
Fig. 2- Ventral view (X 66)

Darwinula sarytirmenensis

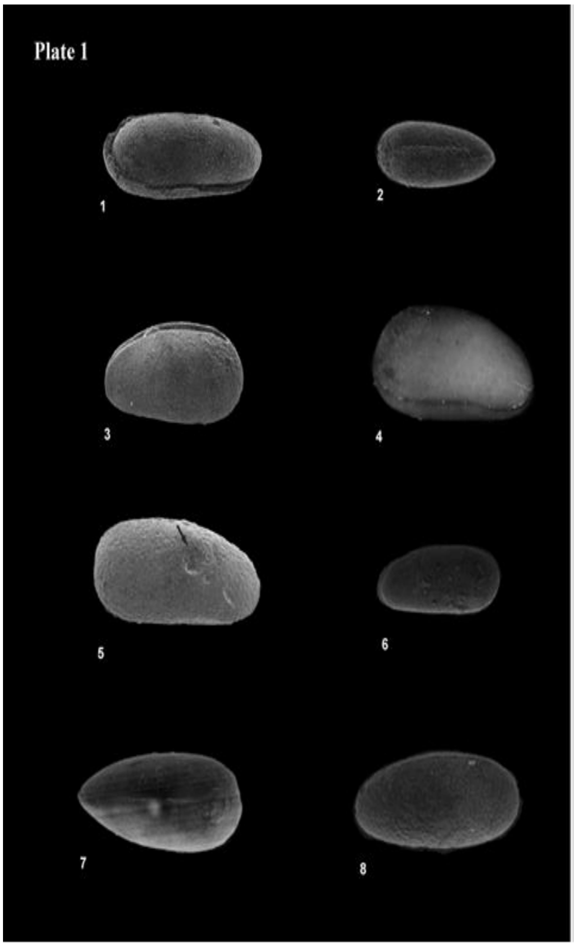
Fig. 3- Oblique view (X 43)
Fig. 4- Oblique view (X 60)
Fig. 7- Dorsal view (X 56)

Darwinula n. acadiaensis

Fig. 5- Lateral view, arrow indicates adductor muscle scar on internal silica mold (X 77)
Fig. 6- Lateral view of juvenile carapace (X 60)

Darwinula n. sp.

Fig. 8- Lateral view (X 105)



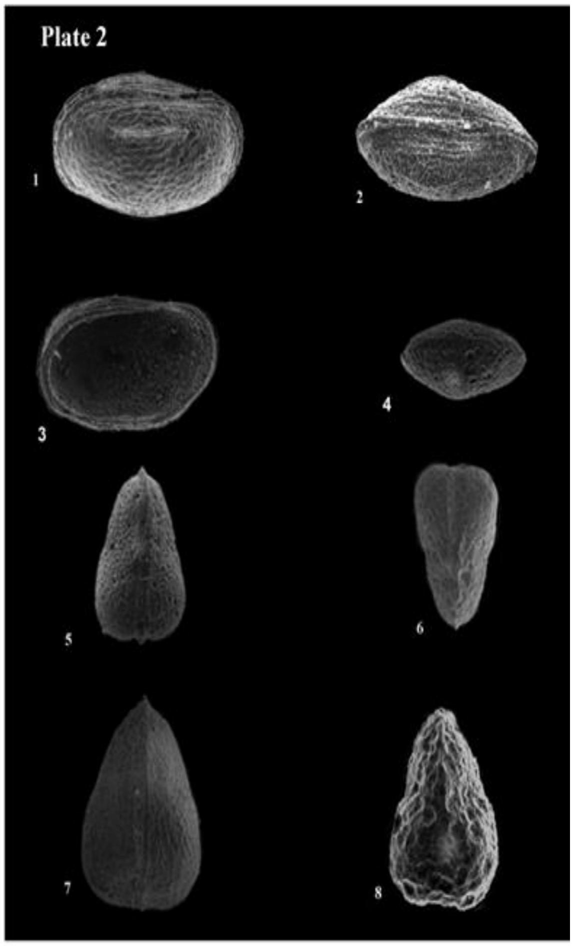
Explanation of plate 2

Metacypris ridgensis n. sp.

Fig. 1- Oblique view (X 100)
Fig. 2- Dorsal view (X 51)
Fig. 3- Internal view of single valve (X 74)
Fig. 4- Oblique view of juvenile internal mold (X 74)

Timiriasevia aff. digitalis.

Fig. 5- Dorsal view of male carapace (X 74)
Fig. 6- Ventral view of male carapace (X 63)
Fig. 7- Dorsal view of female carapace (X 70)
Fig. 8- Ventral view of female carapace of internal mold (X 102)



REFERENCES

1-Benson, R. H., 1961, Ecology of Ostracodes Assemblages. In Treatise on invertebrate paleontology. Edited by Raymond C.

Moore. The Geological Society of America, Inc. And the University of Kansas, p.56-63.
2-Birney, C. C., 1985, Sedimentology and petrology of the Scots Bay Formation (Lower Jurassic), Nova Scotia, Canada. Unpublished M.Sc. thesis; University of Massachusetts at Amherst, 325 pp.
3-Carbonel P., 1988, Ostracods and the transition between fresh and Saline waters. In: De Deckker P, Colin JP, Peypouquet JP (eds) Ostracoda in the earth sciences, Elsevier, Amsterdam, pp 157-174.
4-Cameron, B., 1985, Discovery of silicified lacustrine microfossils and stromatolites: Triassic-Jurassic Fundy Group, Nova Scotia. Geological Society of America, programs with Abstracts, V.17, No.7, p. 538.
5- Rogers, D., Grantham, R. and Jones, J. R., 1985, silicification and silicified microfossils and stromatolites from the Scots Bay Formation, Fundy Basin, Nova Scotia a progress report. Maritime sediments and Atlantic Geology, V. 21, No. 2. p. 41- 42.
6-Jurassic fossils from the Scots Bay Formation, 1986, in program and summaries, Tenth Annual open House and Review of Activities. Nova Scotia Department of Mines and Energy Information Series No. 12, p. 167- 169.
7- Jones J. R., 1987, Discovery of fossils and meandering stream deposits in the Late Triassic Blomidon Formation of Nova Scotia; in Mines and Minerals Branch, Report of Activities 1987, part A, eds. J. L. Bates and D. R. MacDonald. Nova Scotia Department of Mines and Energy, report 87-5, p.179-181.
8- Jones, J. R., 1988, plant fossils from the early Mesozoic Fundy Group of the Annapolis valley region of Nova Scotia; in Mines and Minerals Branch,
Report of Activities 1988, part A, eds. D. MacDonald and Y. Brown. Nova Scotia Department of Mines and Energy, Report 88-3, p. 173-177.
9-Jong, W., 1985, subsurface stratigraphy of the late Triassic Wolfville
sandstone and Blomidon shale of the Fundy Basin: Annapolis Valley, Nova Scotia; in Ninth Annual open House and Review of Activities. Nova Scotia Department of Mines and Energy, Information Series No. 9, p. 105-106.
10- Cameron and Jones, 1990, Non-marine fossils of Late Triassic-Early Jurassic Fundy
Group of the Annapolis Valley, Nova Scotia. Atlantic Geology, vol. 26, no. 2, p. 167.
11-Domanski, and Jones, 1990, Contributions to the vertbrate paleontology of the Late Triassic-Early Jurassic Fundy Group along the Scots Bay-Cape Blomidon coast. In program and summaries, Fourteenth Annual Open House and Review of Activities, Nova Scotia. Department of Mines and Energy, Report 90-3, p. 36.
12-Charles, R. W., and M. Dane, Picard, 1974, Petrology of carbonate rocks of the Green River Formation (Eocene). Jour. Sedi. Petro., v. 44, p. 738-759 .
Chester, R. Pelto, 1956, A study of Chalcedony. American Journal of Science, v. 254, p. 32-50.
13-Haycock, Ernest, 1900a, Records of post-Triassic changes in Kings County, Nova Scotia. Trans. of the Nova Scotia Inst. of Sci., 1899, V. 10, p. 287-302.
14-Hesse, Reinhard, 1990, Silica Diagensis: origin of inorganic and replacement cherts. In Diagensis, edited by Ian A. Mcillreath and David W. Morrow. Geological Association of Canada. Department of Earth Sciences, Memorial University of Newfoundland, p. 253-275.
15-Hassan, H.S. 2000. Sedimentology and paleontology of the Lower Jurassic Scots Bay Formation, Bay of Fundy, Nova Scotia, Canada. Unpublished M.Sc. thesis, Acadia University, Wolfville, Nova Scotia, 180 p.
16-Hassan, H. S., and Cameron, B., 1999, Lacustrine environmental facies of Scots Bay Formation, Nova Scotia, Canada. Atlantic Geoscience Society Colloquium

and Annual General Meeting, Amherst, Nova Scotia, Canada (Abstract).

17-Hassan, H. S., and Cameron, B., 1998 Sedimentology and Paleontology of the Lacustrine Early Jurassic Scots Bay Formation: Bay of Fundy, Nova Scotia, Canada. 5th International Symposium on the Jurassic System, Vancouver, Canada (Abstract).

18-Hassan S. Hassan and Barry Cameron, 1998 Nonmarine Silicified Ostracodes from the Jurassic Scots Bay Formation (Fundy Group) of Nova Scotia, Canada. Mining Matters for Nova Scotia 98, Halifax, Canada.

19-Hayatsu, A. 1979. K-Ar isochron age of the North Mountain Basalt, Nova Scotia. Canadian Journal of Earth Sciences, 16, pp. 973–975. http://dx.doi.org/10.1139/e79-085

20-Morkhoven, F. P. C. M. Van., 1963, Post-Paleozoic ostracoda. 1, Amsterdam. Elsevier. p. 29-31.

21-Olsen, P. E., 1987, Triassic and Jurassic Formations of the Newark Basin. In W.Manspeizer (editor), field studies of New Jersey Geology and guide to field trips. 52nd Ann. Mg. N. Y. State Geol. assoc. Newark College of Artsand Sciences, Rutgers University, Newark, New Jersey, p. 2-37.

22- Olsen, P. E and Shubin, N. H., and Anders, 1987, New Early Jurassic tetrapod assemblages constrain Triassic-Jurassic tetrapod extinction event. Science, vol. 273, p. 1025-1029.

23- Olsen, P. E and Hans, 1990, Triassic Vertbrates of Gondwanan aspects from the Richmond Basin of Virginia. Science, vol. 249, p. 1020-1022.

24-Oertli, H. J. (1957), Ostracodes du Jurassic superieur du Basin de Paris (Sondage Vernon 1). Revue de l'Institut Francais du Petrole, 12, 647-695.

25-Powers, S. 1916. The Acadian Triassic. Journal of Geology, 24, pp. 1–26, 105–122, 254–268

26-Thompson, J. P., 1974, Stratigraphy and geochemistry of the Scots Bay Formation, Nova Scotia. Unpublished M.Sc. thesis, Acadia University, Wolfville, Nova Scotia, p. 30-96.

27-Whatley, R. C., 1983, The application of ostracoda to paleoenvironmental analysis. In application of ostracoda. Edited by R.F. Maddocks. Houston, Tex: Dept. of Geosciences, University of Houston-University Park, p. 51-77.

28-White, J. F., and Corwin, J. F., 1961, Synthesis and origin of chalcedony. Amer. Min., v. 46, p. 112-119.