# PALEOECOLOGIC AND TAPHONOMIC CONTROLS ON THE BRYOZOAN-RICH FAUNA OF THE LOWER MOYDART FORMATION (SILURIAN), ARISAIG, NOVA SCOTIA

**ABIGAIL R. D'AMBROSIA**
Smith College
Sponsor: H. Allen Curran

## INTRODUCTION

Arisaig is a small coastal town in the county of Antigonish, located on the Northumberland Strait, at 45.45°N and 62.10°W. The Arisaig Group is the most complete section of Silurian sedimentary rocks in the Appalachian-Caledonian mountain system, with a total thickness of 1,500 to 1,750 meters (Melchin and MacRae, 2005). The depositional basin for the Arisaig Group was part of the microcontinent of Avalonia. Today the sedimentary rocks of this basin crop out along the coast near the town of Arisaig. The outcrop zone is cut by many faults that are the result of Middle and Late Paleozoic tectonic events. Latitudinal compression and folding have also caused slatey cleavages to form in some units, resulting in low-level metamorphism in some areas (Bambach, 1998). In spite of these deformations, it is still quite possible to decipher the general stratigraphic sequence of the section through the presence of fossils and marker sedimentation "event" beds. No major unconformities have been reported in this section (Bambach, 1998).

The Moydart Formation is about 115 meters thick, and is subdivided into the lower Green Member (marine) and the upper Red Member (terrestrial), both named for their actual color. These members are 105 meters thick, and 10 meters thick, respectively (Melchin and MacRae, 2005). The lower Moydart is dominated by greenish-grey, well-bioturbated mudstones, centimeter- to decimeter-scale laminated siltstones, and "silty bioclastic limestone beds"—or "silty coquinas." The mudstones are so heavily bioturbated that little, if any, layering or lamination remains. The overall environment for the Green Member has been interpreted as a marine shelf below fair-weather wave base (Melchin and MacRae, 2005), interrupted occasionally by storm events.

This project focused on the fossil-rich assemblages appearing throughout the lower Moydart Formation. Emphasis was placed on identification of the major faunal groups present and interpretation of the paleoenvironmental setting.

## METHODS

### Measurement and Data Collection

A 3-part composite stratigraphic section was centered around Moydart Point. A spot was chosen just northeast of Moydart Point where some excellent assemblages of bryozoans occur. From this point the section was measured using a Jacob's staff, marking every 1.5 meters and moving up through the section. Sixty-five total meters of section were measured. Corrections were made so that gaps in the measured section, where excessive faulting obscured the stratigraphy, could be correlated with Melchin and MacRae's "crinoid bed 3," as noted in their 2005 Arisaig field trip guide. In all cases, faults that were encountered had marker beds on either side, to provide stratigraphic control.

Beginning from the bottom of the composite stratigraphic section to the top, the occurrences of bryozoans and grainstone lenses were noted and plotted on the measured section. Each occurrence was described thoroughly, photographed, and samples collected where possible. As fossils were described, so was the surrounding rock matrix. GPS coordinates were also recorded for each major fossil occurrence.

**Laboratory and Statistical Methods**

Twenty-five thin sections were made from all fossiliferous rock samples. Each thin section was examined, and identifiable fossil fragments were counted and recorded. These data were then plotted in Microsoft Excel, and run through JMP statistical analysis software so that statistical trends between the groupings of taxa could be interpreted.

# RESULTS


**Figure 1. Example of the fossiliferous grainstone lenses that occur throughout the Moydart Formation.**

Throughout the lower Moydart section, lighter colored fossiliferous grainstone lenses and meter-long beds with mixed faunal assemblages of brachiopods, bryozoans, crinoids, trilobites, tentaculites, and gastropods were observed (Figure 1). These lenses and beds clearly incorporated broken fossil fragments, which can be observed best in photomicrographs (Figure 2A,B). Some fossils also occurred in situ, including well preserved articulated crinoids and beds of articulate brachiopods.

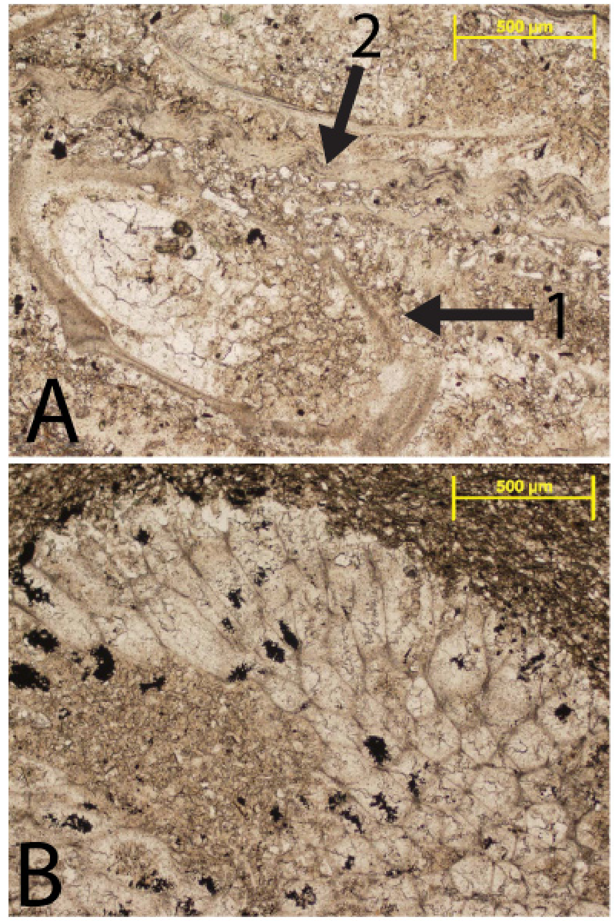


**Figure 2. A) Photomicrograph of a tentaculite in cross-section (1), and the edge of a brachiopod shell (2); B) photomicrograph of a trepostome bryozoan.**

Figure 3 is a bar chart showing the stratigraphic distribution of samples through time (youngest at top), which were divided into three assemblages on the basis of overall faunal composition. The chart also plots the position of the faunal assemblages recognized within the sections. Assemblage 1 exhibited few fossils compared to Assemblages 2 and 3. Assemblage 2 consists of a relatively rich and diverse fauna compared to Assemblages 1 and 3, with Assemblage 3 showing a decline in fossil content.

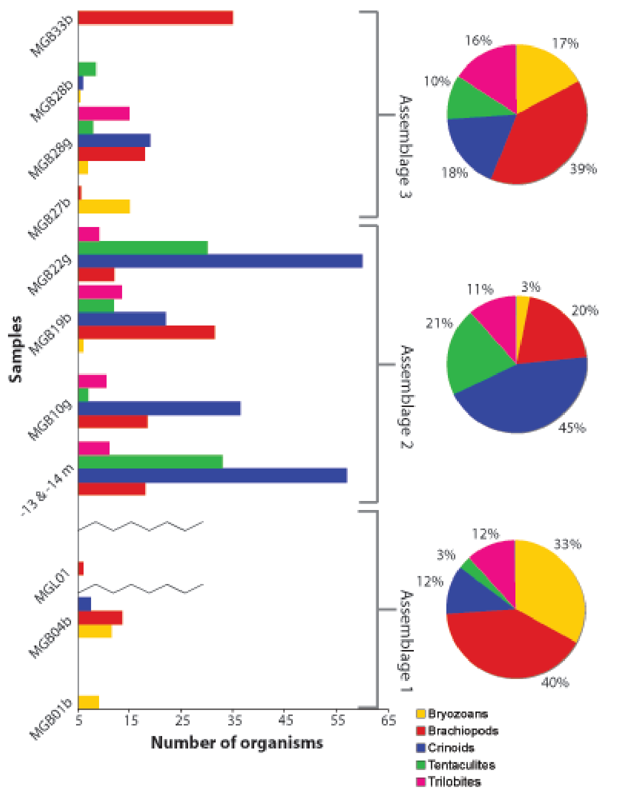


**Figure 3. Bar chart showing stratigraphic distribution of samples. Counts for the fossil groups are raw numbers. The pie charts are aligned with each assemblage to present better overview of fossil content. The beds of Assemblage 1 are seven meters thick, Assemblage 2 = 43 meters thick, and Assemblage 3 = 15 meters thick.**

Pie charts aligned with each of the three assemblages help to give a better overview of fossil composition and thin section counts. However, despite the clear visual difference in amounts of fossils throughout the three assemblages, especially the major fluctuation patterns between bryozoans, brachiopods, and crinoids, the only statistically significant results were for crinoids of Assemblages 1 and 2 ($p=0.0064$), and 2 and 3 ($p=0.0228$) using a "student's t" analysis (Figure 4).

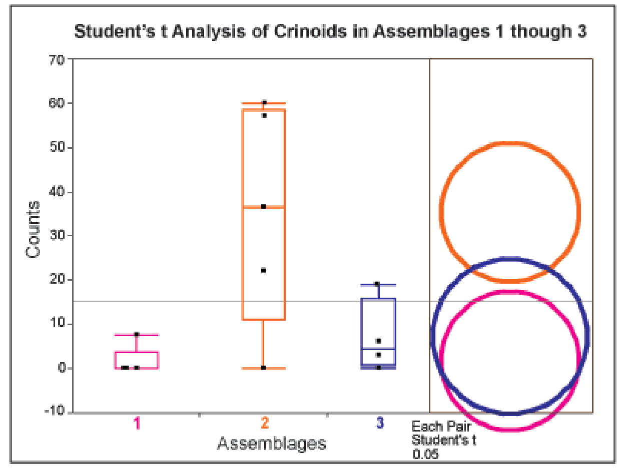


**Figure 4. "Student's t" analysis generated by the JMP software program. Box plots represent crinoid occurrences from Assemblages 1, 2, and 3. Circles on left coincide with the three box plots; greater statistical significance occurs at the beginning of the stratigraphic column where circles make the least contact.**

## DISCUSSION AND CONCLUSIONS

The three very distinct assemblages plotted on the bar chart suggest different conditions of deposition, as the content of fossil fragments changes so sharply between the first two assemblages, and then with Assemblage 3 reverts back to conditions more typical at the beginning of the stratigraphic column. Observing sediment grain size and composition yielded no striking changes in characteristics.

In his study of Silurian sea-level change, Bambach (1998) postulated that the lower Moydart Formation was deposited as sea level was rising over an open shelf (he referred to this as Arisaig's seventh highstand). Bambach also used the mixed faunal assemblages of the section as a guide for interpreting sea-level change. Then, following this highstand, the upper Lower Moydart began "shallowing." The samples of this study were collected from this part of the section, immediately following the sea-level highstand.

The data from this study generally agree with Bambach's observations and interpretations, as Assemblage 1 is relatively low in fossil abundance, reflecting deeper water conditions. As the shallowing sequence begins, more organisms, and therefore fossil remains were present (samples of Assemblage 2); and this assemblage is also where more *in situ* fauna occurred (brachiopods and crinoids). Moving upwards through the section, it also becomes clear that fossiliferous grainstone lenses and beds, observed so frequently in the field and interpreted by Melchin and MacRae (2005) to be tempestites, become more frequent. This too coincides with the shallowing conditions proposed by Bambach (1998).

The only statistically significant differences in faunal content between the assemblages, which occurred with respect to crinoids, may be explained by the fact that crinoids are dominantly deeper water creatures. The highstand represented in by Assemblage 1 may have been too deep for the survivorship of crinoids, but Assemblage 2 probably signifies ideal conditions and depth for crinoids. This may also explain why there is a rapid decrease of crinoids with the shallowing represented by Assemblage 3, and a rather distinct (but not statistically significant) increase of bryozoans, which tend to prefer shallower conditions.

Overall, it can be concluded that changing faunas of the lower Moydart section of the Arisaig group can be attributed to a period of shallowing following a sea-level highstand, supporting the conclusions of Bambach (1998). The increasing occurrence of "tempestite beds," or fossiliferous grainstone lenses observed as one moves upwards through the section is added evidence that regression during the time of formation of the lower Moydart green member is in fact the case.

## ACKNOWLEDGMENTS

I thank the Keck consortium for providing this incredibly valuable research experience. I also thank my project director, Hilary Sanders Lackey, and our two other faculty members, Jade Star Lackey and Carl Mendelson for all of their knowledge, ideas and help… as well as fun in the field! A big thank you to Professor H. Allen Curran for sponsoring me, and for all of his guidance and expertise. A special thanks must also go out to all of my project members who made Nova Scotia an unforgettable trip, and to Mr. Larry Keisler who allowed us direct access to the study area, and was so hospitable when the weather was not cooperating. An extra special thanks also goes out to whomever robbed our vans and taught me the very important lesson of how valuable all of my research materials and field equipment items were, are, and will be in the future.

## REFERENCES

Bambach, R.K., 1998, Silurian sea-level change at Arisaig, Nova Scotia: Comparison with the standard eustatic pattern, in E. Landing and M.E. Johnson (eds.), Silurian Cycles: Linkages of Dynamic Stratigraphy with Atmospheric, Oceanic and Tectonic Changes: Albany, New York State Museum Bulletin 491, James Hall Centennial Volume, p. 27-37.

Melchin, M.J., and MacRae, R.A., 2005, The Stratigraphy and Paleontology of the Ordovician-Silurian Arisaig Group, Nova Scotia: Field Trip Guide, North American Paleontology Convention, Halifax, NS, 33 p.