Stratigraphy, Petrography, and Evidence of an Upper Ordovician Rocky Shoreline on Heywood Island, Manitoulin Island Area, Ontario

Meriem GRIFI,
Patricia L. CORCORAN,
Cameron J. TSUJITA

Department of Earth Sciences, the University of Western Ontario, London, ON, N6A 5B7
mgrifi@uwo.ca, pcorcor@uwo.ca, ctsujita@uwo.ca

Introduction

Manitoulin and Heywood islands are located in northern Lake Huron in Ontario, Canada, and represent an ancient rocky shoreline setting (Johnson and Rong, 1989; Corcoran, 2007). Carbonate strata of the Middle Ordovician Lindsay Formation are separated from the underlying ca. 2.5 – 2.2 Ga (Krogh et al., 1984) Paleoproterozoic quartzites of the Bar River Formation by an unconformity representing a depositional hiatus of at least 1.7 billion years. This unconformity is exposed on eastern Manitoulin Island (Sheguiandah locality), and extends northeastward onto Heywood Island. Here, ridges of quartz arenite are oriented in an east – west direction through the centre of the island and represent high-relief paleoislands. Evidence of high relief comes from Paleozoic dolostone strata dipping away from the basement at steep angles, as well as large boulders of quartz arenite that were derived from the basement and incorporated into the overlying sedimentary rocks (e.g. Johnson and Rong, 1989; Corcoran, 2007). A rocky shoreline depositional setting developed during a Middle to Late Ordovician transgression occurring in two pulses, where organic-rich carbonate muds were deposited along quartz arenite inliers that acted as paleoislands during that time (Harland and Pickerill. 1984; Brookfield and Brett, 1988).

Stratigraphy

The carbonate strata on Heywood Island consist mainly of dolomitized limestone which is capped by organic rich shale towards the top of the succession. The strata are subdivided into six main units, based on their clastic/bioclastic content. From base to top these consist of: 1) quartzitic dolostone, 2) a lower crinoidal dolostone unit, 3) brachiopod-rich dolostone, 4) stromatoporoid-rich dolostone, 5) an upper crinoidal dolostone unit, and 6) fossiliferous black shale. These beds range from 0.1 to 3.5 m thick and are exposed intermittently along the shoreline of Heywood Island. Quartz boulders within the quartzitic dolostone are as large as 3.2 m in diameter with a decrease in quartz clast size up section, and nautiloids predominate the fossil assemblage. Fossils common in the overlying units include rugose corals, bivalves, bryozoans, stromatoporoids, and gastropods. Graptolites, orbiculoid brachiopods, conularids and rare trilobites occur in the black shale unit, which is considered to be part of the Collingwood member of the Lindsay Formation (Armstrong and Carter, 2006).

Petrography

Petrographic analysis of the units shows highly dolomitized limestones containing abundant quartz grains reworked from the underlying Precambrian basement. Comparison between dolostones from Heywood Island and those of the same age in the Sheguiandah area of

Manitoulin Island indicates much more dolomitization of limestones on Heywood. A comparison of kerogen rich Collingwood shale between the two locations shows higher silt content and common quartz grains at the latter locality. The silty laminae occur persistently throughout the shale unit, becoming thinner and less frequent upsection. Micro-flame structures are also observed occurring on Heywood Island. In contrast, the same unit exposed at Sheguiandah on Manitoulin Island lacks silt laminae as well as micro-flame structures.

Evidence Of High Energy

The above described units represent varying degrees of agitation attributed to wave energy. Due to the proximity of carbonate deposition to the quartz arenite basement on Heywood Island, granule to boulder sized quartz clasts were intermittently incorporated into the beds of the carbonate succession. High energy transport and wave/current-generated reworking along a high relief rocky shoreline are indicated by: 1) the presence of large (2.5 to 4.5m) subangular to subrounded boulders in the quartzitic dolostone unit at the base of the carbonate succession, 2) beds of granule to pebble sized quartzite clasts in the lower crinoidal dolostone unit, 3) 72-cm wavelength ripples in the brachiopod dolostone unit, and 4) a prevalence of disarticulated, highly fragmented and abraded shelly skeletal remains in the lower part of the succession.

Preliminary Conclusions

The highly disarticulated and fragmented nature of fossils preserved in some of the carbonate strata is interpreted to be the result of storm activity, followed by periods of little to no wave action, as indicated by the presence of micro-flame structures. The presence of silty laminae in this region may indicate increased localized erosion of the quartz arenite basement. It is possible that alternating high and low wave energy contributed to reworking of sediment along the sea floor, where fine muddy sediment was incorporated with the coarser grained quartz rich material.

Preliminary petrographic analysis indicates much more reworking of carbonates and dolomitization occurring post-deposition on Heywood Island than in the Sheguiandah area of Manitoulin Island. While it’s generally accepted that dolomitization occurred as the result of fracture related fluid migration in the Manitoulin Island area (Coniglio and Williams-Jones, 1992; Coniglio et al., 1994), this does not fully explain why Heywood Island shows higher amounts of dolomitization, which presents a current ongoing problem for the study area.

A preliminary depositional model for the area depicts the progressive onlap of Paleozoic sediments on the Precambrian basement highs as the paleoislands were submerged during two transgressive pulses occurring in the Middle Ordovician (Johnson and Rong, 1989). The first pulse resulted in the shoreline erosion of quartz arenite basement highs, and the shallow sea promoted carbonate deposition, while the second pulse promoted relatively deeper water conditions in which carbonate muds were deposited on limestone throughout the area (Corcoran, 2007).

Detailed sedimentological studies concerning ancient rocky shoreline settings are still lacking, and Heywood Island presents an excellent opportunity to further investigate the dynamics of rocky shorelines and onlapping sediments that occur on and/or adjacent to them.

References

Armstrong, D.K., Carter, T.R., 2006. An updated guide to the subsurface Paleozoic stratigraphy of southern Ontario. Ontario Geological Survey Open File Report. **6191**, 214 pp.

Brookfield, M.E., Brett, C.E., 1988. Paleoenvironments of the Mid-Ordovician (upper Caradocian) Trenton limestones of southern Ontario, Canada: storm sedimentation on a shoal basin shelf model. Sedimentary Geology. **57**, 75–105.

Corcoran, P.L., 2007. Ordovician paleotopography as evidenced from original dips and differential compaction of dolostone and shale unconformity overlying Precambrian basement on Manitoulin Island, Canada. Sedimentary Geology. **207**, 22-33.

Coniglio, M., Williams-Jones, A.E., 1992. Diagenesis of Ordovician carbonates from the north-east Michigan Basin, Manitoulin Island area, Ontario: evidence from petrography, stable isotopes and fluid inclusions. Sedimentology. **39**, 813–836.

Coniglio, M., Sherlock, R., Williams-Jones, A.E., Middleton, K., Frape, S.K., 1994. Burial and hydrothermal diagenesis of Ordovician carbonates from the Michigan Basin, Ontario, Canada. Special Publication International Association of Sedimentologists. **21**, 231–254.

Harland, T.L., Pickerill, R.K., 1984. Ordovician rocky shoreline deposits: the basal Trenton Group around Quebec City, Canada. Journal of Geology. **19**, 271–298.

Johnson, M.E., Rong, J.Y., 1989. Middle to Late Ordovician rocky bottoms and rocky shores from the Manitoulin Island area, Ontario. Canadian Journal of Earth Science. **26**, 642–653.

Krogh, T.E., Davis, D.W., Corfu, F., 1984. Precise U–Pb zircon and baddeleyite ages for the Sudbury area. Ontario Geological Survey Special Volume. **1**, 431–446.