Trends and architecture of Low Density Turbidites of the Lower Ordovician Meguma Supergroup, Nova Scotia

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Summary

This study investigates the distribution and architecture of low density turbidites in the Meguma Supergroup. Standard outcrop mapping and measured sections are combined with advanced techniques (LiDAR, high resolution photogrammetry, scintollmeter analysis) for visualization of the stratal geometries in 3D models. The results of this study demonstrate the depositional history of these outcrops and provide an analogue for fine grained turbidite reservoirs, particularly unconventional gas resources.

Introduction

In the Meguma Supergroup, a series of sandy and shaly intervals formed in a range of depositional environments from deltaic to deepwater and subsequently metamorphosed and deformed during the Acadian orogeny during the Devonian. The Lower Ordovician Bluestone Formation is part of the Halifax Group, outcropping in Point Pleasant Park, Nova Scotia (Figure 1). The formation comprises meta-siltstone and slates; however the formation lacks meta-sandstone, and sulphide minerals common to the underlying finer-grained Cunard Formation (Figure 2).

Figure 1: Images showing the location of Halifax in the red box, and Point Pleasant Park in the black box (Google Earth, 2009).

Harris and Schenk (1975) examined the structure and gross sedimentology of the Meguma Supergroup with focus on the Goldenville Formation, interpreted as coarser grained flysch deposits of a eugeosyncline, which can be today described as high density turbidites along a passive margin setting. This study examines the sedimentology of the finer grained deposits of the Bluestone Formation, the stratigraphic top of the Meguma Supergroup.

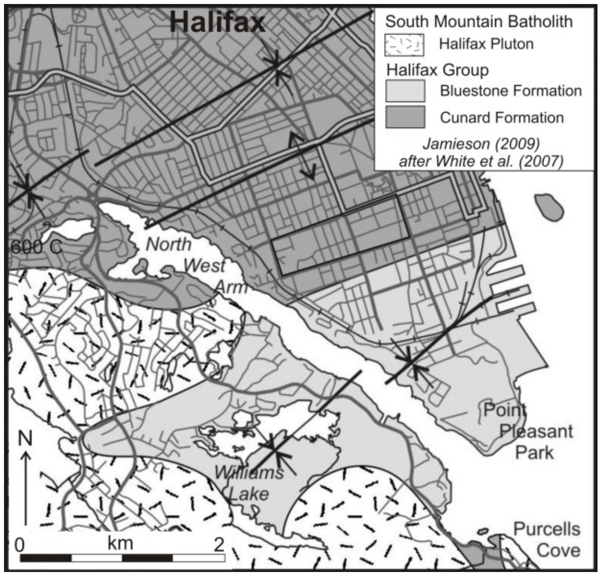


Figure 2: Geological map showing the Goldenville Group, Halifax Group (Cunard, and Bluestone), and the South Mountain Batholith (Jamieson, 2009 after White et al. 2007).

Methodology

Data collection included logging outcrop sections, paleocurrent measurements of tool marks and current ripples, scintillometer measurements (Figure 3) to create synthetic gamma logs, LiDAR measurements, high resolution photogrammetry from outcrops along the Northwest Arm, Black Rock Beach, the Battery, and Sailors' Memorial Road. Each outcrop was logged recording grain size, laminae, bed and bedset, thickness, lateral continuity of beds and bedsets and physical and biogenic sedimentary structures. The measured sections were digitally processed in ALT Well Cad and Core Cad software for analysis. For paleocurrent analysis structural deformation were unfolded using stereonets to resolve correct orientation of current ripple stratification, followed by plotting on a rose diagram to discern paleoflow direction. Petrographic analysis of representative thin sections were completed to determine compositions and the relationship between lithofacies, colour, grain size, and sedimentary structures. The scintillometer measures the amount of gamma ray particles that are emitted from the rock and can be plotted to represent a gamma ray curve. These curves can be used to correlate the outcrops in combination with the detailed measured sections in WellCAD. LiDAR data (scans of the outcrops) were processed to produce 3D images of the outcrops. LiDAR measures the time delay between laser pulses and the reflection signal from short wavelengths like UV, and infra-red waves. The LiDAR scans captured sedimentary structures, change in lithology, and penetrated outcrop surfaces covered in lichens and vegetation. The scans were used to develop 3D models in Petrel (Figure 4), to investigate the geometry and architecture of the studied sections.

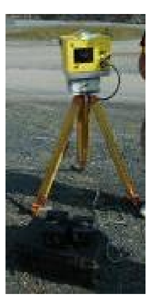
(a)  (b) 

Figure 3: The ILRIS LiDAR (a) and the AUSlog scintillometer (b)

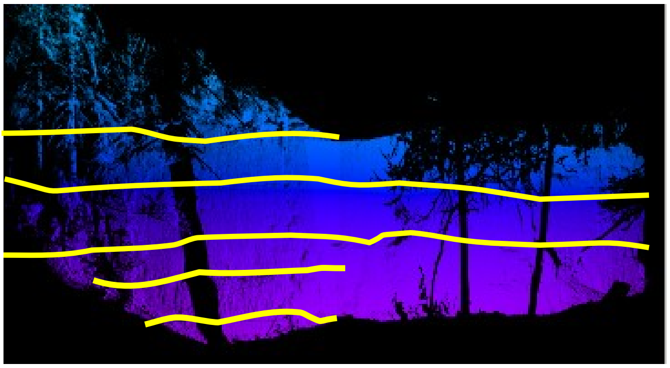


Figure 4: ILRIS scan of an outcrop in Point Pleasant Park. The yellow lines delineate bedset boundaries. The vertical scale of the outcrop is 4m.

Results

Results record the strata are made up of mainly quartz, mica, zircon, cordierite tourmaline, pyrrhotite and show five lithofacies. These lithofacies are 1) structureless meta fine-grained sandstone, 2) meta silty-sandstone laminae, 3) meta sandy-siltstone climbing ripples, 4) meta-siltstone laminae, and a 5) structureless silty slate to slate lithofacies and make up a cyclic lithofacies association which is separated by sharp or scoured contacts (Figure 5). The beds fine and become thinner towards the top of the outcrop and lithofacies like meta sandy-siltstone ripples, and structureless silty slate to slate become more dominant, due to the reduction of sediment supply, the distal nature of the deposits, or the basin topography at time of deposition controlling distribution of the deepwater fan lobes. Bulk composition is the same throughout the five lithofacies, however the ratio between mica and quartz decreases from meta fine grained sandstone to slate.

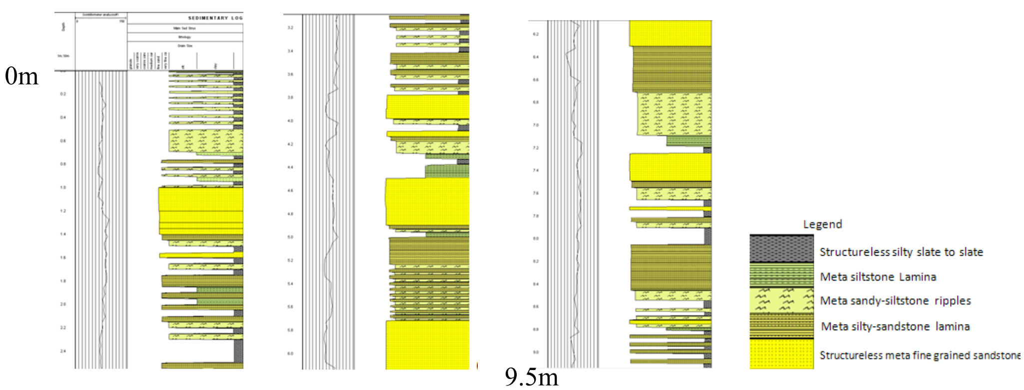


Figure 5: Type section with the five lithofacies and the synthetic gamma log from scintillometer measurements of the outcrop.

Scintillometer analysis (Figure 6) showed no apparent relationship to lithology, likely due to the moderate metamorphism throughout the Meguma Supergroup. Interpretations suggested the lithofacies association is characteristic of the Bouma Sequence. Current ripples on bedding planes indicate the paleoflow was towards the northwest (Figure 6).

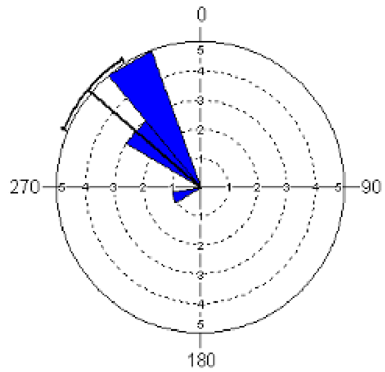


Figure 6: Rose diagram of the paleocurrent of current ripples (corrected on stereonets) of the outcrops in Point Pleasant Park. The average orientation is 310±22°.

Conclusions

The strata lacked lateral continuity as beds within the outcrops did not show correlatable beds over 1km on either side of the park. This is not uncommon as demonstrated in the De Gray Spillway of Arkansas. Metamorphism appeared to enhance the physical sedimentary structures, but made accurate grain size measurements difficult. Interpretations demonstrate these lithofacies are characteristic of the Bouma Sequence deposited during low density turbiditic flow at the distal edges of potentially higher density flows. Paleocurrents in this study area show similar trends to the Goldenville-Halifax transition in the Tancook Island area (Waldron et al., 1987; 2009), where the Goldenville Formation sands were deposited along a passive margin, indicating these low density turbidites were flowing north west as they were being deposited.

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Acknowledgements

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References

Google Earth, 2009. Satellite image of Nova Scotia and Halifax. Retrieved on February 1st 2010

Harris, I.M. and Schenk, P.E., 1975, The Meguma Group, Atlantic Geology. 11(1) p 25-46.

Waldron, J.W.F., Chris E. White, Sandra M. Barr, Antonio Simonetti, and Larry M. Heaman, 2009, Provenance of the Meguma terrane, Nova Scotia: rifted margin of early Paleozoic Gondwana, Can. J. Earth Sci. 46(1), p1–8.

Waldron J.W.F. (1987) Sedimentology of the Goldenville-Halifax transition in the Tancook Island area, South Shore, Nova Scotia. *Geological Survey of Canada Open File **1535***.

White, C.E, Bell J.A., Macleish, D.F., MacDonald, M.A., Goodwin, T.A., MacNeil, J.D., 2007. Geology of the Halifax Regional Municipality, Central Nova Scotia. Report of Activities, NSDNR, pp 125-139.