Reservoir Potential of the Bradore and Hawke Bay Formations, western Newfoundland: the integration of sedimentological and ichnological data.

The Lower Cambrian Bradore and Hawke Bay Formations outcrop extensively in the Humber Zone, western Newfoundland between Deer Lake and the southern coast of Labrador close to Forteau. The Bradore Formation is part of the Labrador Group, and forms part of the synrift megasequence deposited during rifting of the Iapetus Ocean (Cooper et al. 2001). The Bradore Formation unconformably overlies Precambrian gneiss and is overlain by fossiliferous carbonates of the Forteau Formation. This poorly fossiliferous, fluvial to shallow marine sandstone unit is remarkably similar to other sandstones deposited around the margins of north American craton during sea level rise (e.g. Potsdam sandstone of New York and Quebec and the Eriboll Formation of NW Scotland; see Hiscott et al. 1984) and the Hawke Bay Formation with which the Bradore Formation will be compared. Although body fossils are sparse, trace fossils are abundant in the upper two members of this unit, forming a distinctive “pipe-rock” ichnofabric. Such piperock fabrics are common in Lower Palaeozoic sandstones the world over (McIlroy & Garton 2004, 2010).

Detailed sedimentological work has constrained the depositional context of the Bradore Formation (Hiscott et al. 1984; Long & Yip 2009) and preliminary ichnological work has described the bioturbation and trace fossil assemblages from these rocks (Hiscott et al. 1984; Pemberton & Frey 1984). Given the potential for onshore petroleum plays, an integrated modern study investigating the architecture and properties of likely sandstone reservoir units in this area (including the Bradore and Hawke Bay Formations) is of great importance and relevance to petroleum exploration in western Newfoundland. Predictive conceptual models linking ichnofabric with colonization styles and sedimentation rate (McIlroy 2004a, 2004b), when integrated with the reservoir characterization-based approach proposed herein, will provide insights into bioturbation-enhanced reservoir quality.

We propose to integrate the ichnological and reservoir-characterization datasets within a sedimentological and sequence stratigraphic understanding to assess the potential extent of high porosity trace fossil fabrics within the Bradore and Hawke Bay Formations. These stratigraphic units are currently used by Memorial students taking field school EASC 3705 for two day-long training exercises which would be greatly augmented by the additional background and insights arising from this work. EASC 3705 typically runs with around 20 senior undergraduate students, many of whom are interested in careers in the oil and gas industry.

The principal objective of this study is to conduct an integrated study assessing trace fossil assemblages in different architectural elements of these fluvial, tidal and shallow shelf siliciclastic sediments. A particular interest will be investigating lateral variability of sedimentary and ichnological parameters within, and between different architectural elements. This will be supplemented by assessing the impact of these trace fossils on reservoir quality of these sediments (cf. Tonkin et al. 2010), and linking this to an overall

assessment of the significance of the Bradore and Hawke Bay Formations as a possible reservoir units.

This study is important for a number of reasons. Firstly we note the potential for bioturbation and trace fossils to increase permeability in otherwise well cemented, low permeability sandstones (McIlroy & Garton 2004). Secondly, we draw attention to the abundance of hydrocarbon reserves in similar facies in northern Africa, the Middle East, and peri-Gondwanan regions (McIlroy & Garton 2004). Thirdly, we highlight the application of trace fossil assemblages to reservoir and facies characterization in younger Phanerozoic successions (e.g. McIlroy 2004a, 2004b). Lastly, and most importantly we draw attention to the well known potential for onshore petroleum plays in western Newfoundland and the possible role of the Bradore and Hawke Bay Formations as reservoir units. In this case, we predict that bioturbation is likely to exert a significant control on reservoir quality (porosity and permeability). We therefore propose to undertake an integrated study involving facies characterization, ichnological analysis, and laboratory porosity-permeability investigations to refine the distribution of trace fossils in this system and to assess their potential impact on reservoir quality.

Expected Research Deliverables

- Description and quantification of bioturbation in different facies elements of the Bradore and Hawke Bay Formations.
- Assessment of sequence stratigraphic distribution of trace fossils.
- Determination of the possible use of trace fossil assemblages as predictive tools in refining reservoir models of Lower Cambrian shallow marine sandstones
- Assessment of lateral variability of sedimentological and ichnological parameters.
- Empirical determination of the impact of trace fossils on porosity and permeability and the effect on sandstone reservoir quality.
- Development of a predictive sequence stratigraphic framework to understand facies, ichnofabric and therefore reservoir quality.
- Assessment of potential of Bradore and Hawke Bay Formations.as reservoir rock in western Newfoundland.

Methods and Techniques

• Field logging of well exposed successions from different sedimentary facies.
• Sequence stratigraphic interpretation of well-exposed sections.
• Facies interpretation and depositional environment characterization.
• Ichnological analysis in the field, ichnofabric description, quantification of bioturbation, abundance, diversity.
• Inter-log correlation to constrain lateral variability of sedimentary structures and bioturbation on an inter-well scale.
• Sample collection for laboratory studies, to incorporate:
•Large thin slicing to examine ichnofabrics (see Garton & McIlroy 2006 and Figure 1).
•Serial grinding and 3-dimensional reconstructions of key trace fossils (Bednarz & McIlroy 2009).
• Production of petrographic thin sections to analyse effect of bioturbation on sediment properties.

• Dye impregnation of thin sections to assess porosity variations.
• Small plug porosity measurement to assess the impact of trace fossils on sandstone porosities.
•Permeability measurement and effects of trace fossils on permeability in 2 and 3 dimensions