Assessing the utility of stable isotope chemostratigraphy in Jurassic and Cretaceous strata on the eastern margin of Canada: refining correlations and the history of Atlantic rifting

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Summary

New elemental geochemistry (ICP-MS/ICP-OES) and stable isotope data ($\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$) is presented from Jurassic to Cretaceous strata from offshore, deepwater sections on the Grand Banks of Newfoundland. These are compared and integrated with published data compiled from the technical literature, and with results generated by *Chemostrat Ltd.* in earlier studies. This is used to produce refined chemostratigraphic correlations and a comprehensive look at depositional history in formerly adjacent basins in the proto-Atlantic ocean during the mid-Mesozoic rifting of Pangaea.

Introduction

Upper Jurassic and Lower Cretaceous sedimentary rock on the eastern margin of Canada record a pivotal moment in the shaping of the modern world: the breakup of Pangaea and the formation of the Atlantic Ocean (Manspeizer, 1988). However, diachronous rifting and the compartmentalization of depositional environments make it difficult to integrate this area with formerly adjacent provinces of Europe, west Africa, and the eastern seaboard of North America (Withjack and Schliesche, 2005). Many strata in these settings are also lucrative targets for hydrocarbon production (Sheppard et al., 2000). In such structurally and depositionally complex systems, a robust stratigraphic model is of the highest importance for effective development of natural resources.

Figure 1: A location map of the Grand Banks, showing the location of the Jeanne d'Arc Basin.

The principal target of investigation here are organic rich source rocks of the Rankin Formation in the Jeanne d'Arc and Flemish Pass basins on the Grand Banks of Newfoundland (Figure 1). Regularly spaced cutting samples from several wells have been processed for inorganic geochemistry and stable isotope chemostratigraphy. Data from these analyses are integrated with published biostratigraphy and geochronology to resolve depositional history, refine stratigraphic correlations, and characterize sediment sources.

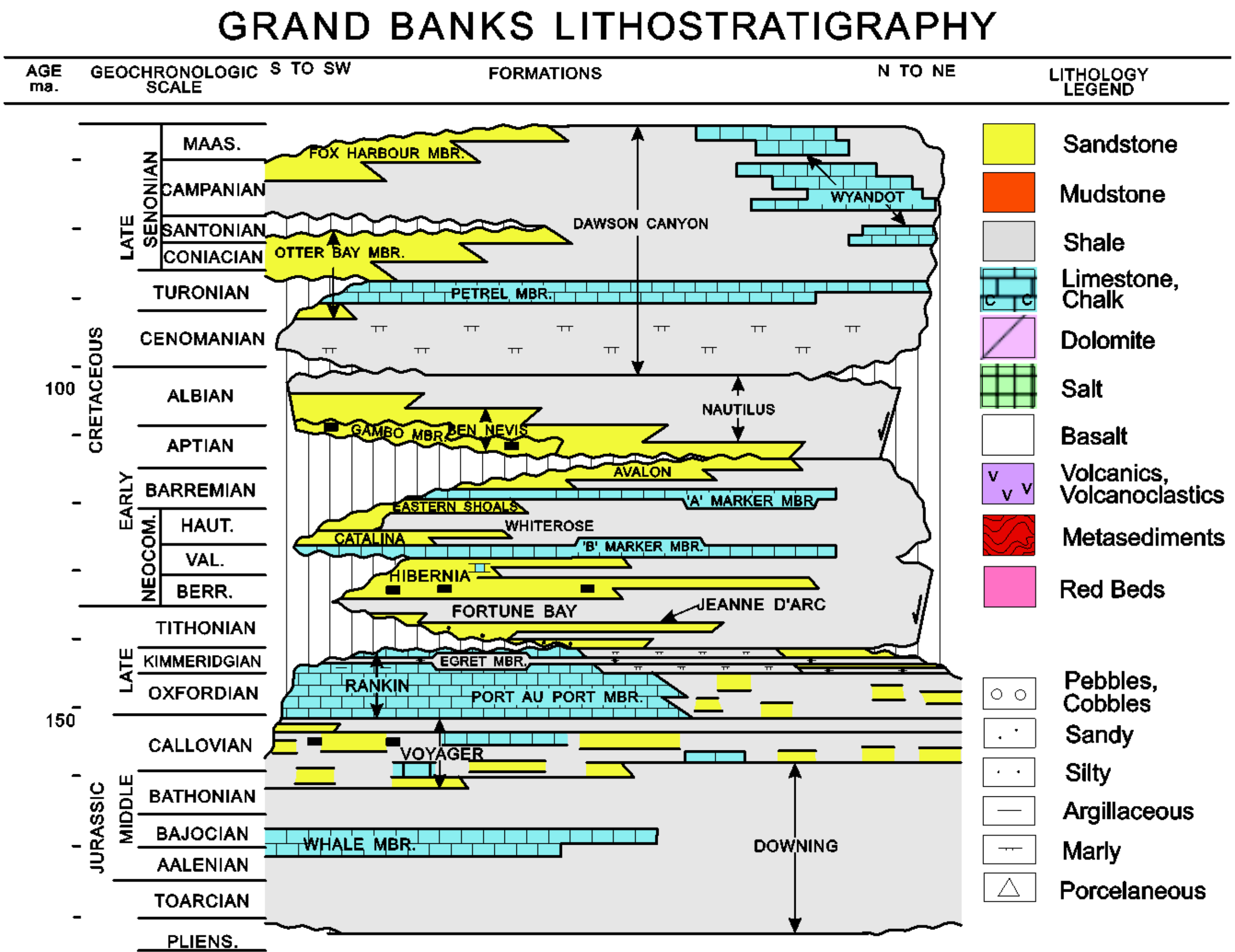

Figure 2: Summary of middle Mesozoic lithostratigraphic terminology in the Jeanne d'Arc Basin (from Sinclair, 1993; Enachescu, 2013). The principal target of this study are Jurassic to Cretaceous reservoir and source rocks.

Elemental Geochemistry

Elemental geochemistry data has been generated with coupled inductively coupled plasma mass spectrometry (ICP-MS) and optical emissions spectroscopy (ICP-OES). Element abundances and key ratios can be used to define chemostratigraphic packages that are useful for correlation within the Jeanne d'Arc Flemish Pass, Hopedale, and Carson basins. Many of these have probable controls in sediment provenance or redox conditions (Roach et al., 2014).

Stable Isotope Chronostratigraphy

Inorganic carbon ($\delta^{13}C_{carb}$) and oxygen ($\delta^{18}O_{carb}$) isotope data are generated here using element analyzer isotope ratio mass spectrometry (EA-IRMS) and plotted against stratigraphic depth. Diagnostic signals in the curve are compared to data from biostratigraphically well-constrained Jurassic/Cretaceous sections (Jenkyns and Clayton, 1997; Weissert et al., 1998; Katz et al., 2005) and from the composite global chronostratigraphic $\delta^{13}C_{carb}$ curve, tied to the geologic timescale (Figure 4; Saltzman and Thomas, 2012).

Conclusions

At least 13 distinct chemostratigraphic packages may be demarcated on the basis of key element abundances and ratios. Values of V/Al_2O_3, Ga/Cs, Y/Al_2O_3, Nb/Al_2O_3, TiO_2/Nb, U/Al_2O_3, and Zr/Th appear to have great utility for establishing element-based correlations within and between basins on the east coast of Canada. The overarching controls on these geochemical ratios are clastic sediment provenance and redox conditions.

Preliminary isotope findings suggest that inorganic carbonate $\delta^{13}C_{carb}$ values in these sections may have some utility for chronostratigraphic control. Diagnostic features of the global curve can be identified in sections, including a sharp negative shift near the Pleinsbachian/Toarcian Boundary (the Toarcian OAE *sensu* Jenkyns, 1988), a positive excursion near the Aalenian/Bajocian Boundary (Bartolini et al., 1999), and a long-term positive shift in values peaking in the Oxfordian before declining into the Tithonian (Katz et al., 2005). Recognition of signals such as these may be of great value for high-resolution chronostratigraphic models for Jurassic to Cretaceous strata in the proto-Atlantic ocean.

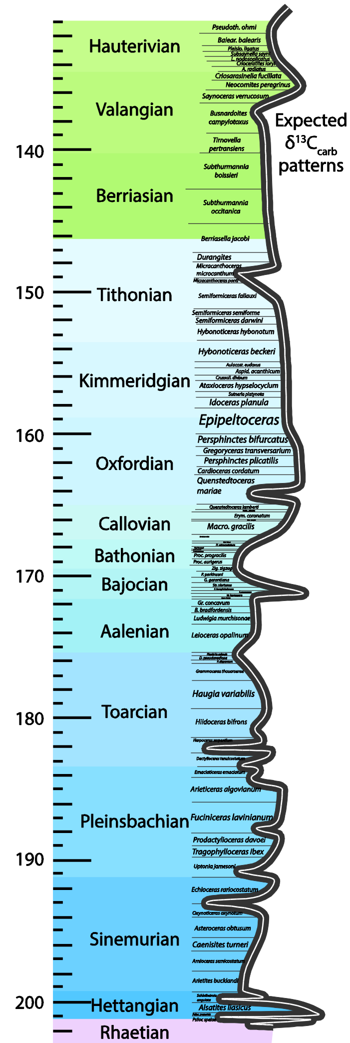

Figure 3: The composite global $\delta^{13}C_{carb}$ curve tied to ammonoid biozones and the most recent geologic timescale (modified from Saltzman and Thomas, 2012; Davydov et al., 2012).

Acknowledgements

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