Isotopic Composition, Provenance and Regional Correlation of the Upper Hornby Bay Group, NWT and Nunavut

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Summary

Late Paleoproterozoic continental basins including the Thelon, Athabasca and Hornby Bay can be broadly correlated based on similarities in age, sequence stratigraphy, paleocurrents and detrital zircon provenance results. Herein we present new stratigraphic information, including Sm-Nd isotopes from siliciclastic mudstones and C/O isotopes from carbonates, from the upper Hornby Bay Group (Hornby Bay Basin) in order to test possible correlations with its proposed epicontinental equivalent, the Wernecke Supergroup.

Introduction

Stratigraphy of the Hornby Bay Basin, located along the Nunavut-Northwest Territories border north of Great Bear Lake, consists of two siliciclastic to carbonate sequences (>4000m), the Hornby Bay and Dismal Lakes groups, which unconformably overly deformed magmatic and supracrustal rocks of the Wopmay Orogen. These are overlain by a thick succession of continental basalt flows and fluvial sandstones, the Coppermine River Group. Collectively these strata define four sequences: A1, consisting of the Big Bear and Fault River formations; A2, consisting of the Lady Nye, East River, and Kaertok formations; A3, consisting of the LeRoux Formation and Dismal Lakes Group and; A4, consisting of the Coppermine River Group. Broad correlation of these sequences with thick, dominantly fine-grained, deep-marine strata of the Wernecke Supergroup exposed in the northern Canadian Cordillera have been made with the aid of seismic data collected by the petroleum industry (MacLean and Cook 2004).

Stratigraphy and Sedimentology

Sedimentological studies focused on sequence A2 and its contact with sequence A3, a boundary which represents an important horizon for uranium mineralization. The Lady Nye Formation conformably to unconformably overlies the Fault River and Big Bear formations. It consists dominantly of arenites with minor conglomerates and siliciclastic mudstones and is up to 500 m thick in some sections. The vertical succession is generally cross-bedded fluvial sandstones at the base to shallow marine deltaic deposits at the top.

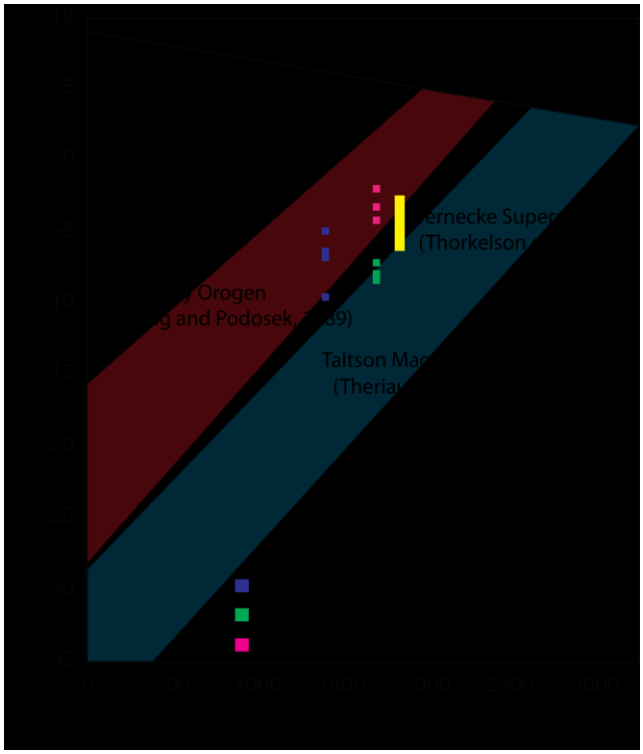
The conformably overlying East River Formation ranges in thickness from 100 to 200 m and records gradual development of a storm-dominated carbonate platform during marine transgression. Mudstone to cross-bedded arenite of the Kaertok Formation gradationally overlies the East River Formation and ranges in thickness from 0 to >400 m. It records development of a syntectonic delta as indicated by paleocurrents and geometry being largely controlled by movement along the Teshierpi uplift (Cook and Maclean, 1995). The LeRoux Formation unconformably to disconformably overlies the Kaertok Formation and other strata of the Hornby Bay Group, where an angular unconformity is present. It ranges in thickness from

10 to >150 m and is dominantly composed of cross-bedded, white quartz arenite. Sedimentology of the LeRoux Formation indicates that it was deposited in fluvial environments at its base and shallow marine settings towards its gradational upper contact with the Fort Confidence Formation. The Fort Confidence Formation (>130 m in thick) is composed of interbedded wavy- and lenticular-bedded sandstone and carbonaceous mudstone, which are interpreted to represent extensive tidal flat deposits.

Sedimentary Provenance

Sedimentary provenance was determined using Sm-Nd isotope analysis of mudrocks and this was compared to previously determined U-Pb detrital zircon ages from upper Hornby Bay Group sandstones. Bulk sample drill cores of siliciclastic mudstones were collected from the East River, Kaertok, and Fort Confidence formations and were analyzed on a mass spectrometer. The Nd isotope data point to several potential source regions based solely on ε_{Nd} values. The data were compared with published data from three potential source regions; the Trans Hudson Orogen, the Great Bear Magmatic Zone of the Wopmay Orogen (GMZ), and the Thelon-Taltson Tectonic Zone (TMZ). The isotopic evolution field of the Trans-Hudson orogen is wide and encompasses the Kaertok, East River, and Fort Confidence Formation data sets. However, our data sets comprise two distinct compositional groups; a more positive group, including the East River Formation and part of the Fort Confidence Formation, and a more negative group defined by the Kaertok Formation. By comparing these data sets to detrital zircon data from corresponding units sedimentary provenance is more tightly constrained.

All values for ε_{Nd} (-4.75 to -2.34 at 1600 Ma) of the East River Formation lie within the isotopic evolution field of the GMZ. The corresponding detrital zircon data identifies a prominent peak at 1.85 Ga (Rainbird and Davis, unpublished), which is the dominant age of the GMZ. The detrital zircon data identify a significant source at ca 1650 Ma (Rainbird and Davis, unpublished), the approximate age of syn-sedimentary volcanic rocks (e.g. Narakay Volcanic complex; Bowring and Ross, 1985) and a component of Archean material not apparent in the $\varepsilon_{Nd.}$. This could be attributed to the analysis of bulk samples, which yields a value that represents a mixture of both felsic and mafic sources, and juvenile and evolved material. The detrital zircon data are biased toward felsic sources (e.g. late Archean granites in the Slave craton that lie to the east of the Hornby Bay Basin). In this case, the GMZ dominates over other material that may be present.



The range of ε_{Nd} values (-8.24 to -7.73 at 1600 Ma) in the Kaertok Formation plot entirely within the isotopic evolution field of the TMZ; this is corroborated by the detrital zircons which identify a strong peak at 1.9 Ga, and thus supports the hypothesis that the TMZ contributed significant detritus to the Hornby Bay Basin. ε_{Nd} of the Fort Confidence Formation (-9.78 to -6.42 at 1400 Ma) plots within both the isotopic evolution fields of the GMZ and the TMZ. This suggests that there was no significant change in sediment

Figure 1: Isotopic evolution fields for different source regions with data points from the Hornby Bay Basin

provenance across the sequence A2-A3 boundary.

C/O Stable Isotope Analysis

Forty specimens of dolostone from the East River Formation were selected from drill cores at approximately 2 m stratigraphic intervals for C and O isotope analysis. The East River Formation is dominated by stromatolitic dolostdone, dololutite, ooid grainstone, and intraclastic dolarenite. Prior to analysis, standard petrographic and cathodoluminescence (CL) microscopy was completed on polished thin sections in order to determine least diagenetically altered zones. Micrite and micritic intraclasts were identified as the least altered components and were specifically drilled with care taken to avoid cross-cutting veins, late-stage meteoric cement, and recrystallized ooids.

$\delta^{13}C$ ranged from -2 $^{o}/_{oo}$ to +1 $^{o}/_{oo}$ with a mean of -0.5 $^{o}/_{oo}$. $\delta^{18}O$ ranged from -14 $^{o}/_{oo}$ to -6 $^{o}/_{oo}$(Figure 2). It is currently unknown whether these data represent a primary sea-water signal as major elements have not yet been analyzed. Our data compare well with $\delta^{13}C$ values for similar-age carbonates from the McArthur basin in Australia (Lindsay and Brasier, 2000), thereby supporting the hypothesis that they represent a primary global sea-water signature.

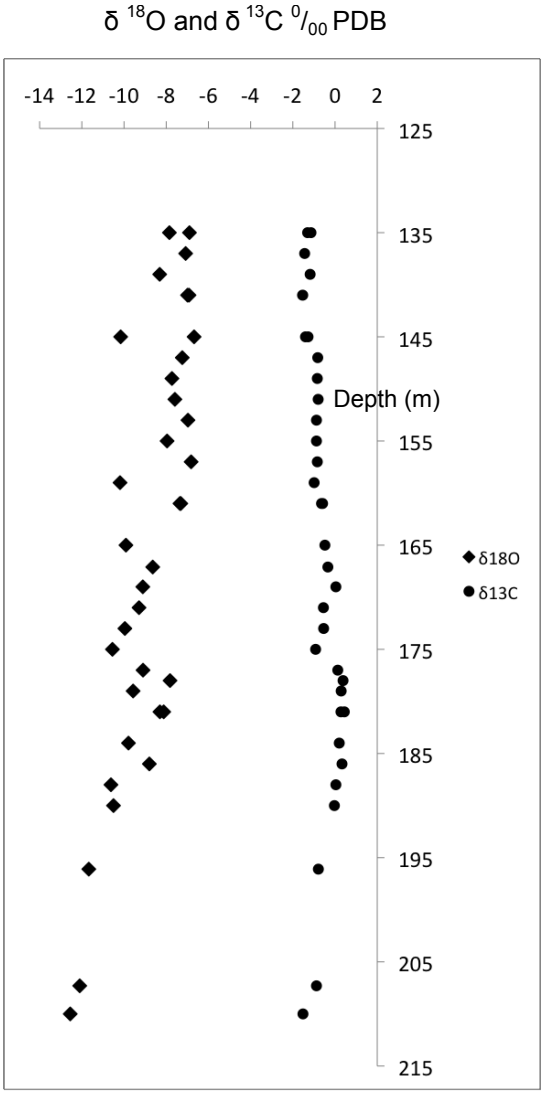


Figure 2. Stable C and O isotope stratigraphy of the East River Formation, plotted against depth (m) below surface

Regional Correlations

Recent detrital zircon studies of the Wernecke Supergroup in the northern Canadian Cordillera identified a suite of zircons ranging in age from 1660-1620 Ma (Furlanetto et al, 2009), which are approximately the same age as volcanic and epiclastic rocks in the East River Formation (Rainbird, personal comm.). These data support the hypothesis that the Wernecke Supergroup is the distal, deep-water, correlative to sequence A2, which differs from MacLean and Cook (2004), who suggested a correlation with sequence A1.

Sm-Nd values from sequence A2 are similar to a small data set from the Wernecke Supergroup (Figure 2), further supporting common provenance from the TMZ and GMZ. A thick platformal carbonate unit (Gillespie Lake Group) at the top of the Wernecke Supergroup may represent the lateral equivalent to the East River Formation. This correlation can be tested by comparing the stable isotope signatures of the two carbonate units.

Conclusions

1) Sm-Nd data and detrital zircon geochronology of the upper Hornby Bay Group indicates dominant sourcing from the Thelon-Taltson Tectonic Zone and Great Bear Magmatic Zone which is supported by regional paleocurrents. Similar studies in the Wernecke Supergroup show a strong correlation, which suggests a common sediment source.
2) There is good correspondence between global $\delta^{13}C$ values during the late Paleoproterozoic and the signature from the East River Formation carbonates, which may indicate that it represents a primary sea-water signal.

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