Sedimentology and Stratigraphy of Lower Cretaceous Sandstone in the Mackenzie Corridor, Northwest Territories, Canada

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Summary

The Lower Cretaceous (Albian) Martin House Formation in the Mackenzie Corridor represents a potential hydrocarbon exploration target relatively close to the Mackenzie River and the proposed Mackenzie pipeline. Outcrop sections, wire-line logs, core, palynology, seismic, and petrographic analyses are utilized to better constrain the paleogeographic setting. Martin House Formation lithofacies described and interpreted from core and outcrop vary significantly across the study area. Coal and rooted floodplain deposits and/or fluvial channels are associated with the Tukweye member. Deposits transitioning laterally and vertically from the Tukweye member are interpreted as marginal marine (e.g., tidal, deltaic) to marine (e.g., shoreface, offshore). Petrographic analysis is used to recognize trends in sandstone composition associated with particular geographical locations. Observations from wireline logs and seismic suggest that underlying topography on the sub-Cretaceous unconformity imparted a significant control on sedimentation.

Introduction

Lower Cretaceous strata in the Mackenzie Corridor are poorly understood and under-explored, yet form potential hydrocarbon exploration targets relatively proximal to the Mackenzie River and the proposed Mackenzie pipeline. This study interprets Lower Cretaceous sedimentology and stratigraphy from subsurface and field data-sets in the Mackenzie Corridor study area (Figure 1) in order to develop a paleoenvironmental model. Previous studies agree that there is widespread distribution of sandstone facies overlying the sub-Cretaceous unconformity; however there is less consensus on where the sand was sourced, the age of deposition, and stratigraphic correlations in the basin (Mountjoy and Chamney, 1969; Yorath and Cook, 1981; Dixon, 1999; Hadlari, 2009a, b). Zircon dating was interpreted to show an eastern source during the Albian and a western source during the Cenomanian-Turonian (Hadlari, 2009b). Previous work divided Lower Cretaceous strata (Figure 2) in the study area into the Albian-aged transgressive, heterolithic marine sandstones of the Martin House Formation and overlying conformable Arctic Red Formation marine shales. Maximum transgression is represented by the Cenomanian Slater River Formation shales which overlie the angular unconformity formed by Albian-aged strata (Mountjoy and Chamney, 1969; Yorath and Cook, 1981; Thomson et al. 2008). Our study supports the subdivision of the Martin House Formation into the Tukweye member (Hadlari, 2009) as the terrestrial facies association. The Tukweye member transitions both laterally and vertically to the marine facies of the Martin House Formation.

Figure 1. Map of the study area showing eleven cores (yellow circles), six measured outcrop sections (pink triangles), Norman Wells town and Tulita community (yellow house). The Keele Arch (green line) is a reactivated fault structure interpreted as a topographic high during the deposition of the Martin House Formation. The Cap Fault (purple line) was reactivated several times prior to the Cretaceous to form the Mahoney Arch. The base map is modified from the Department of Natural Resources Canada.

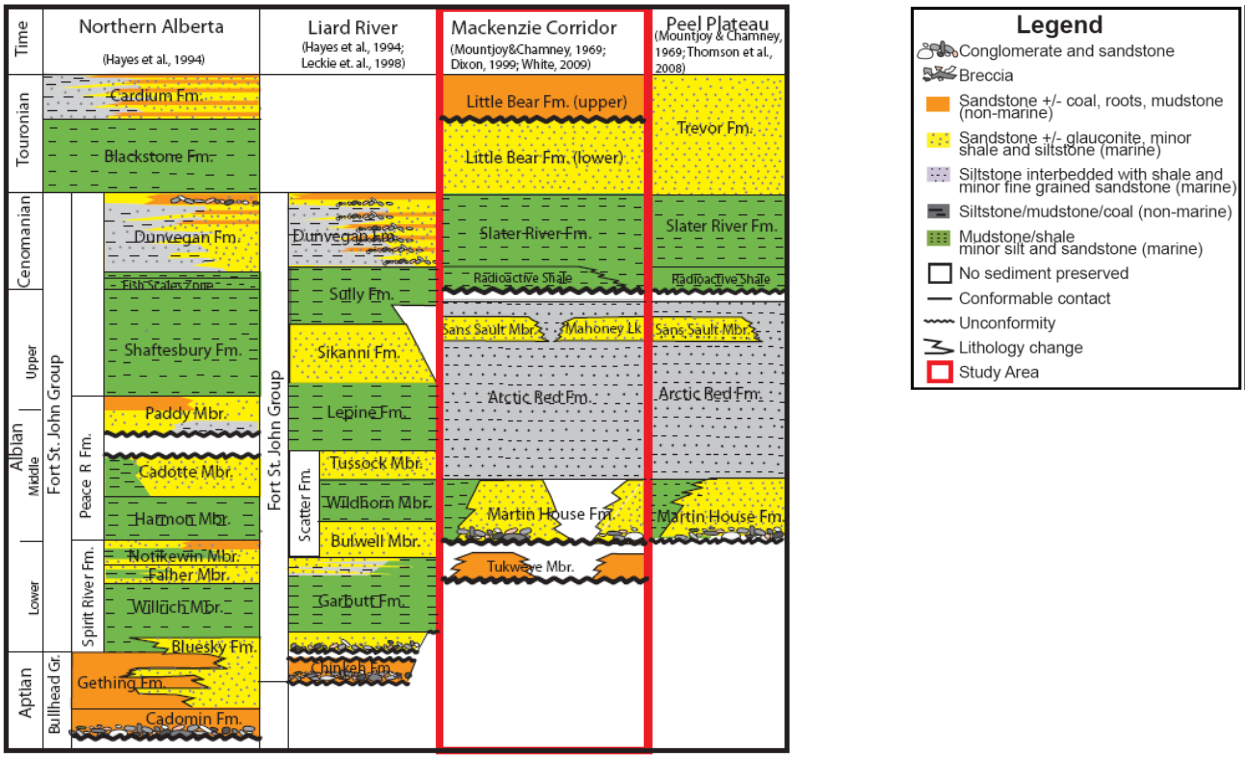

Figure 2. Chart of the stratigraphy of the Western Canada Sedimentary Basin, Liard Basin and the Mackenzie Corridor study area compiled from Dixon, 1999; Hayes et al., 1994; Mountjoy and Chamney, 1969; Thomson et al., 2008; and White, 2009.

Methods

A multidisciplinary approach was taken as data within any single data-set in the study area were relatively limited. Cross-sections were constructed from wireline logs (~110 wells) to understand the stratigraphy and lateral continuity of interpreted lithologies. A consistent flooding surface within the Martin House Formation was used as a datum. 2-D seismic over the study area was utilized to provide structural information and larger scale stratigraphic relationships. Eleven outcrop sections and twelve cores were analyzed for lithology, sedimentary structures, and ichnological characteristics. Thin sections were analyzed using the Gazzi-Dickinson point-counting method. Palynology samples were taken and evaluated by Geological Survey of Canada scientists (White, J. 2009).

Results

Seismic and wire-line log correlations indicate that: a) the study area is comprised of westerly dipping strata, with Cretaceous deposits forming a clastic wedge overlying progressively older strata eastward, and b) fault reactivation prior to the Cretaceous resulted in the development of two paleotopographic highs in the basin that persisted through deposition of the Martin House Formation: the Keele Arch and the Mahoney/Bulmer Arch (Dixon, 1999). The Martin House Formation is most sandstone-rich along the western margin of the study area near the present-day Mackenzie Mountains, and shales out to the south and to the northwest. Strata of Martin House Formation, and the overlying Arctic Red Formation, on-lap and pinch out over the Keele Arch on both its eastern and western flanks. A thinner accumulation of the basal sandstone to the east of the Mahoney Arch in the Great Bear Basin decreases in grain-size southward.

A series of outcrops of the sub-Cretaceous unconformity were assessed along a west-east transect from the edge of the Mackenzie Mountains to the edge of the Great Bear Basin (Figure1). Cretaceous strata in the western outcrops at Imperial River (IR) and north of Bear Rock (BR) were characterized by an overall upwards-fining succession of fine to medium-grained highly bioturbated, glauconitic, quartz sandstone interbedded with mud and locally rippled and stratified. These strata were interpreted as marine and assigned to the Martin House Formation. The Kelly Lake (KL) outcrop, located on the eastern flank of the Keele Arch, is characterized by trough-cross bedded, fine- to medium-grained cherty, quartz sandstone. Similarly, the eastern-most outcrop south of Mahoney Lake (ML) contains trough-cross-bedded, very coarse-grained, cherty lithic sandstone. Lacking a marine signature, both the KL and ML outcrops are interpreted as fluvial deposits and assigned to the Tukweye member. The St Charles Creek (SCC) outcrop is highly bioturbated, glauconitic, quartz sandstone interbedded with shale and siltstone in an overall fining upwards succession. Thick shale and siltstone beds outcropping upstream (and down-dip) of the SCC outcrop are assigned to the Arctic Red Formation. Stratigraphy in proximal wells supports this interpretation and places them within the Mahoney Lake member (Dixon, 1999) of the Arctic Red Formation.

The most westerly core from the Sainville D-08 well is characterized by a transgressive vertical succession from lower shoreface to offshore marine facies. Other westerly cores (I66, N58, N10) have terrestrial signatures with rooted sandstones, coals and incised channel deposits directly overlying Paleozoic strata. These in turn are overlain by bioturbated marine sandstones of the Martin House Formation. Strata in core from the Great Bear Basin (M04, H34, N30, G22) reflect fluvial, deltaic, submarine gravity flow and low-energy marine depositional settings. The terrestrial strata across the study area are assigned to the Tukweye member.

The oldest preserved Cretaceous strata are interpreted as continental in areas of the Great Bear Plain, the Peel Plateau and over the flanks of the Keele Arch. Strata of the Martin House Formation is interpreted as the product of several diachronous transgressive shorelines.

Conclusions

The range of lithofacies and stratigraphic relationships mapped across the Mackenzie Corridor study area show complicated vertical and lateral variation in Lower Cretaceous sandstones. Observations of stratigraphic relationships from wireline logs, seismic, core and outcrop suggest that basin topography imparted a significant control on the distribution and lateral continuity of units. The Lower Cretaceous Martin House Formation records an overall transgressive event with the oldest preserved deposits attributed to the Tukweye member.

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References

Dixon, J., 1999, Mesozoic-Cenozoic stratigraphy of the Northern Interior Plains and Plateaux, Northwest Territories: Geological Survey of Canada, **Bulletin 536**, 56 p.

Hadlari, T., 2009, Anatomy of a Transgressive Sandstone: Sequence Stratigraphy of the Martin House and Lower Arctic Red Formations (Albian), Peel Plateau and Plain, NWT: **CSPG CSEG CWLS** Convention, Program with Abstracts

Hadlari, T., 2009, in Regional Geoscience Studies and Petroleum Potential, Peel Plateau and Plain, Northwest Territories and Yukon: Project Volume, *edited by:**Pyle, L.J., & Jones, A.L.,*** Northwest Territories Geoscience Office, NWT **Open File 2009-02**, digital files.

Hayes, B.J.R. et al., 1994, Cretaceous Manville Group of the Western Canada Sedimentary Basin. In: Geological Atlas of the Western Canada Sedimentary Basin. G.D. Mossop and I. Shetsen (comps.). Calgary, **Canadian Society of Petroleum Geologists and Alberta Research Council**, chpt. 19.

Leckie, D. & Potocki, D.J.,1998,Sedimentology and petrography of marine shelf sandstones of the Cretaceous, Scatter and Garbutt formations, Liard Basin, northern Canada, ***Bulletin of Canadian Petroleum Geology*****,** Vol. 46, No. 1 (March, 1998), p. 30-50.

Mountjoy, E.W. and Chamney, T.P., 1969, Lower Cretaceous (Albian) of the Yukon: stratigraphy and foraminiferal subdivisions, Snake and Peel rivers: Geological Survey of Canada, **Paper 68-26**, 71 p.

The Atlas of Canada, (January 2, 2010) Department of Natural Resources Canada.: http://atlas.nrcan.gc.ca

Thomson, D., Schröder-Adams, C.J., and Hadlari, T., 2008, Foraminiferal biostratigraphic framework for the Cretaceous of the Peel Plateau region: **Yellowknife Geoscience Forum**, Program with Abstracts.

White, J.M. 2009. Palynological Report on 10 samples of probable Devonian and Cretaceous age, from NTS 96-C-13, 96-C-16, 96-F-03, 96-F-06, 96-E-04, 96-E-08, Northwest Territories, as requested by J.Davison, University of Calgary. Geological Survey of Canada**, Paleontological Report 2-JMW-2009**, 7p.

Yorath, C.J, and Cook, D.G., 1981, Cretaceous and Tertiary stratigraphy and paleogeography, northern interior plains, District of Mackenzie: Geological Survey of Canada, **Memoir 398**, 76 p.