Facies of Hume Formation and Horn River Group (Devonian, Mackenzie River Corridor) based on core studies

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Introduction

New regional data on the Middle Devonian succession of the Mackenzie River corridor and the adjacent cordillera are being rapidly accumulated, driven by recent exploration activity for shale hydrocarbons of the Horn River Group (Gal et al., 2009; Pyle & Gal, 2012, 2013; Gal & Pyle, 2012). In 2012, GSC office in Calgary resumed detailed examination of stratigraphic surfaces and facies in core within the frame of GEM Program (Kabanov, 2013). This paper reports on current results from several representative cored sections.

Methods and materials

The core studied to date (over 800 m in total) comes from 7 wells, drilled in the 1960s to 1990s. This core is housed at the NEB Core and Sample Repository at the Geological Survey of Canada in Calgary. The sub-mm scale structures were enhanced by finishing slabbed core surfaces with 400 grit sanding and subsequent etching by 10% HCl for 1-3 seconds. A range of analyses (Rock-Eval pyrolysis/combustion, $\delta^{13}C$- $\delta^{18}O$ of sedimentary and early diagenetic calcites, thin sections, and ICP-MS geochemistry) are being applied to obtain a more comprehensive understanding of the facies patterns, sequence surfaces and packages.

Results

Representative core from the Headless Member of the Hume Formation, including its top and base, was recovered from Kugaluk N-02 and Ebbutt C-50 wells. These are calcareous and dolomitic shales to argillaceous limestones recording moderate drowning from the peritidal settings of the underlying Landry Limestone into a lower ramp setting (Fig. 1B). New data support the Landry/Hume boundary as being conformable (Gal et al., 2009). The overlying Nahanni Limestone is exemplified by core from same wells. Its upper contact with the Bluefish Shale varies from a rapid but conformable shift from bioturbated limestone with brachiopod coquina to laminated black shale (Kugaluk N-02; Fig. 1A)) to an undulating cemented surface, probably representing a submarine hardground (Ebbutt C-50). The Ebbutt C-50 well provides a continuously cored, 31 m thick section of the undivided Horn River Group. Three facies are recognized in this section: (1) black, pyritic, laminated, very siliceous shale to porcellanite; (2) black, pyritic, laminated, less siliceous shale to siltstone; and (3) black to dark gray, sideritic, laminated shale. The last facies comprises the upper 4.8 m of the section. This core records a very gradual transition to the gray, progressively more bioturbated shale that has been put into the base of the Imperial Formation in previous studies. The two cores from the Norman Wells

Oilfield (Norman Wells P32X and Bear Island R34X) recover, repsectively, the base and the top of the producing Kee Scarp carbonate bank. The latter well also shows the details of basal portion of the Canol oil shale (Fig. 1C). Rock-Eval pyrolysis data reveal sharp changes in the character of organic matter across the Kee Scarp / Canol contact (Fig. 2). A conformable section of the Ramparts base with very gradational development of carbonate-bank features upwards from the Carcajou marker bed can be observed in Bear Island R34X. The core section with details of the Canol Shale onlapping the Ramparts Limestone in its platform facies can be observed in Maida Creek G-56 (Gal & Pyle, 2012).

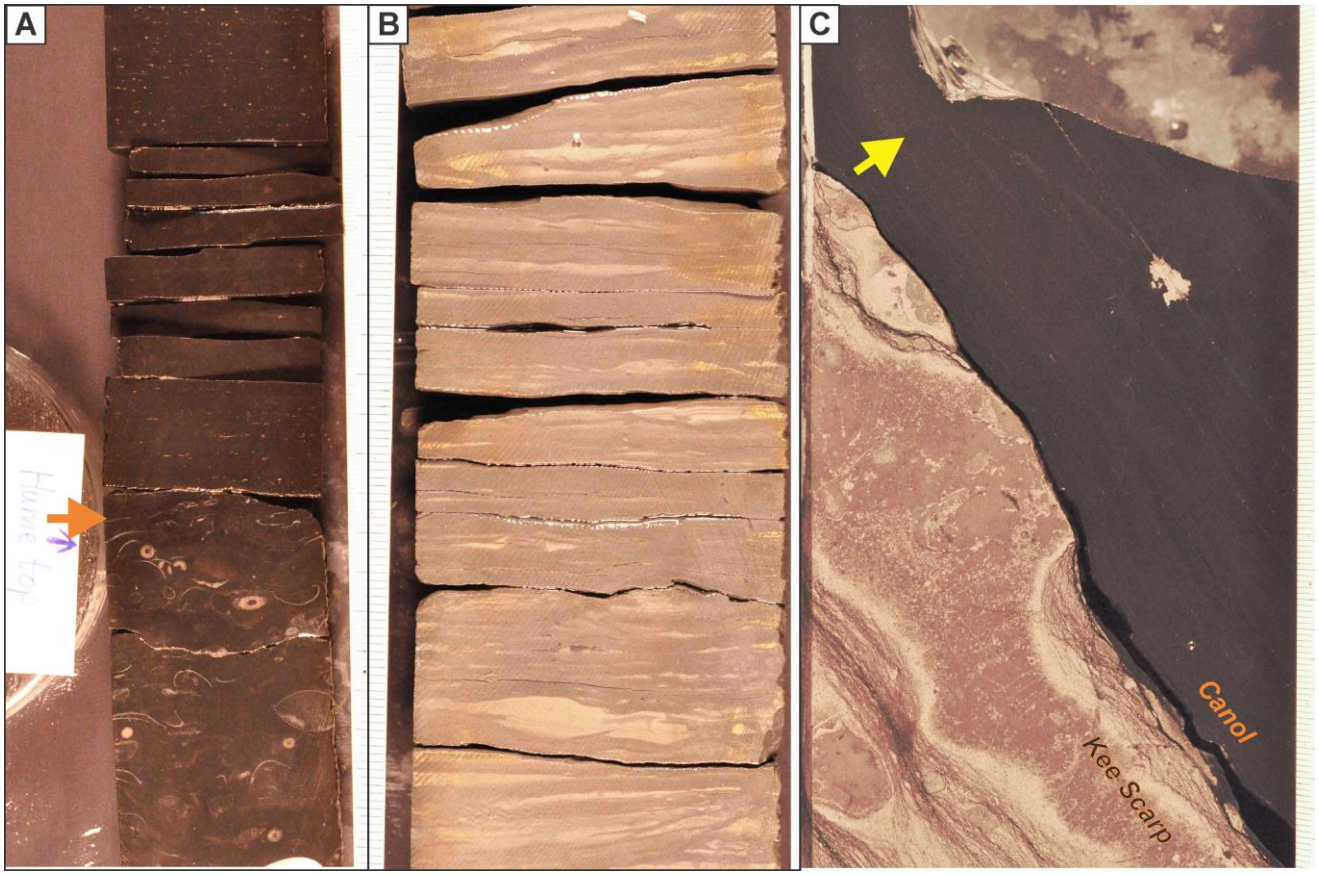

Figure 1: Shale units and their contacts with limestones: (A) Visually conformable contact of Hume limestone and Horn River black shale in Kugaluk N-02 (arrow at contact); (B) laminated calcareous shale of Headless Member (distal tempestite) deposited in lower ramp setting; (C) Kee Scarp - Canol contact in Norman Wells P32X directional well; yellow arrow shows stratigraphic up.

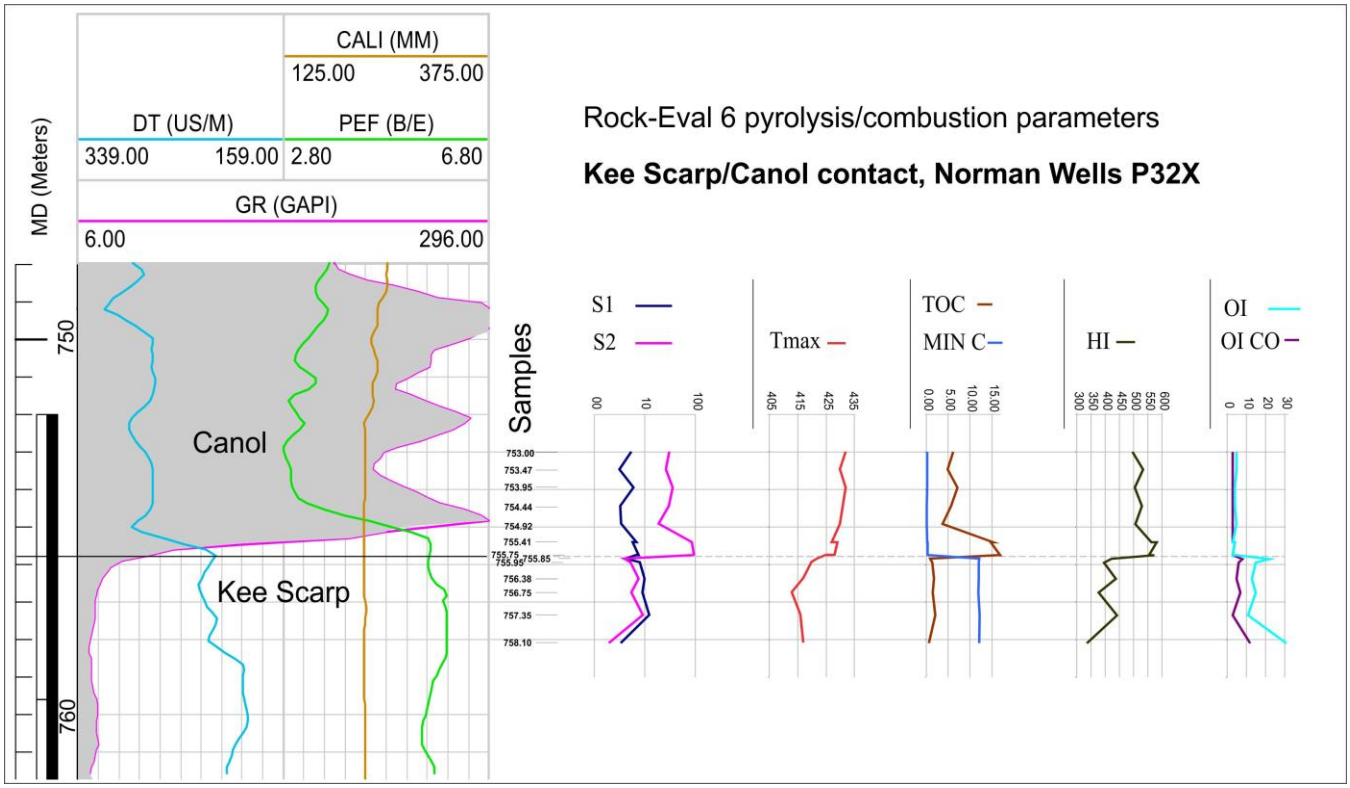

Figure 2: Norman Wells P32X: Expression of Kee Scarp / Canol contact (Fig. 1C) on borehole logs and Rock-Eval pyrolysis parameters

Discussion

Sm-Nd isotope signatures of Middle Devonian black shales across the drowned Mackenzie Platform indicate a juvenile source of clays, corroborating theearlier idea of the existence of a volcanic arc along the western Laurentian margin (Hadlari et al., 2010). The foreland character of Middle Devonian drownings thus finds several lines of support. Three pre-Imperial drowning events recognized in the Mackenzie region are represented by Headless, Bluefish, and Canol shales. The Headless event did not create conditions for economic-scale accumulation/preservation of organic matter. Possible reasons of this deficiency might have included insufficient eutrophication, high sedimentation rate, and maintenance of episodic bottom ventilation in the tempestite system. The Bluefish and Canol black-shale events are undoubtedly anoxic, yet the mechanisms of anoxia are not sufficiently understood. A variety of options include genuine drowning, coastal upwelling, and basin stratification due to convection slowdown and/or development of oceanographic seal(s). Protracted plankton blooms fed by westerly-sourced ashfalls might have also enhanced bottom anoxia. Further multiproxy facies study will help answer these questions.

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