# First-Time Characterization of Black Shaly Facies along a Full Montney Core: Lithofacies Controls on the Distribution of Primary Organic Matter

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## Summary

While the possibility of existing primary organic matter (OM) in the Montney Formation has been proposed previously (e.g. Beaton et al., 2010; Romero-Sarmiento et al., 2016; Crombez et al., 2017), the occurrence of primary-OM bearing shale facies, their nature, and characteristics, and the extent of their vertical and lateral distribution have not been evaluated in previous Montney studies.

This work presents results from an ongoing laboratory study documenting the presence of multiple organic-rich black shale beds along a complete Montney core (230 m) located in SW Alberta. The core covering the entire Montney Formation as wells as the contacts with the Doig and Belloy formations, provided a unique opportunity to thoroughly 1) document the presence and 2) characterize the geochemical, petrophysical and geomechanical properties of the observed black shale facies. Methods used for core characterization include programmed pyrolysis, extended slow-heating (ESH) programmed pyrolysis, organic petrography (OM type and thermal maturity), helium pycnometry (grain density, porosity); low-pressure gas ($N_2$, $CO_2$) adsorption (surface area, pore size distribution, pore volume); X-ray fluorescence (XRF; elemental composition), X-ray Diffraction (XRD; mineralogical composition), rate-of-adsorption (ROA; permeability/diffusivity), profile gas ($N_2$) permeability, mechanical (rebound) hardness, and scanning electron microscopy (SEM; rock fabric).

In total, approximately 300 black shale beds were counted with individual thicknesses ranging between 1 to 8 cm. While these beds are more abundant in the upper part of the Middle Montney [refer to Davis et al. (2018) for nomenclature], scattered beds are also present in the lower part of the Middle Montney. Organic petrography observations indicate that the Montney is in the early/peak oil window ($VRo_{eqv}$ ~0.85%) in the study area. Further, the presence of alginite macerals was confirmed, coexisting with disseminated and pore-filling solid bitumen. These observations call into question the nature and possible source(s) of the hydrocarbons/OM within the Montney Formation – a long-lasting baffling question for the Montney operators that has been discussed in detail in Ardakani et al., (2020). Detailed core observations (**Figure 1**) demonstrate that the black shales occur interbedded in sharp contacts with a wide variety of Montney siltstone facies (e.g. massive, rippled, bioturbated, laminated, heterolithic, soft-deformed), suggesting accumulation of the black shale facies as condensed intervals resulting from paucity in the background silty load.

Regardless of their stratigraphic position in the core, the organic-rich shale facies have unique characteristics which are highly contrasting with the primary Montney facies including: high organic content (up to 3.5 wt.% TOC), preserved primary organic matter (*alginite*), high clay minerals content (up to 70%), poorly sorted grains which sizes range from <2 to 50 µm, very low carbonate content (<5%), elevated pyrite contents (up to 13%), elevated grain density values (up to 2.78 g/cc), and elevated concentrations of elemental proxies such as S, U, Mo, Ni, Zn and V. Based on the low-pressure gas ($CO_2$, $N_2$) adsorption analysis, the organic-rich shale facies have higher surface area and pore volumes, and smaller pore diameters compared to the siltstone/sandstone facies. High-resolution (2 cm) rock hardness values measured along the full core (230 m) result in very low hardness values for the black shale facies (< 500 HLD) in comparison to siltstone facies (up to 900 HLD).

Understanding the geological, petrophysical and rock mechanical properties of the commonly 'overlooked' black shale facies within the Montney Formation might have significant implications for 1) evaluating hydrocarbon storage and transport properties along both vertical and horizontal wells and 2) optimizing hydraulic fracturing operations along multi-fractured horizontal wells. Most of the black shale beds identified herein display polished slip faces and/or cleavage – previously described by Davis et al. (2014) – causing these beds to potentially be "weak" interfaces which, in turn, could become preferred or undesirable targets in terms of future exploration (i.e. drilling) and completion (i.e. hydraulic fracturing) in order to enhance the propagation and connectivity of induced hydraulic fractures.

The identification of black shaly beds in the Montney further highlights the necessity of considering an unbiased sampling strategy for future laboratory-based analyses (e.g. mineralogy, Rock-Eval, organic petrography, etc) in order to increase the validity of interpretations. The findings of this study could be beneficial to operators developing Montney tight oil resources by allowing them to identify and target specific zones with reservoir quality and rock mechanical properties amenable to maximizing hydrocarbon production.

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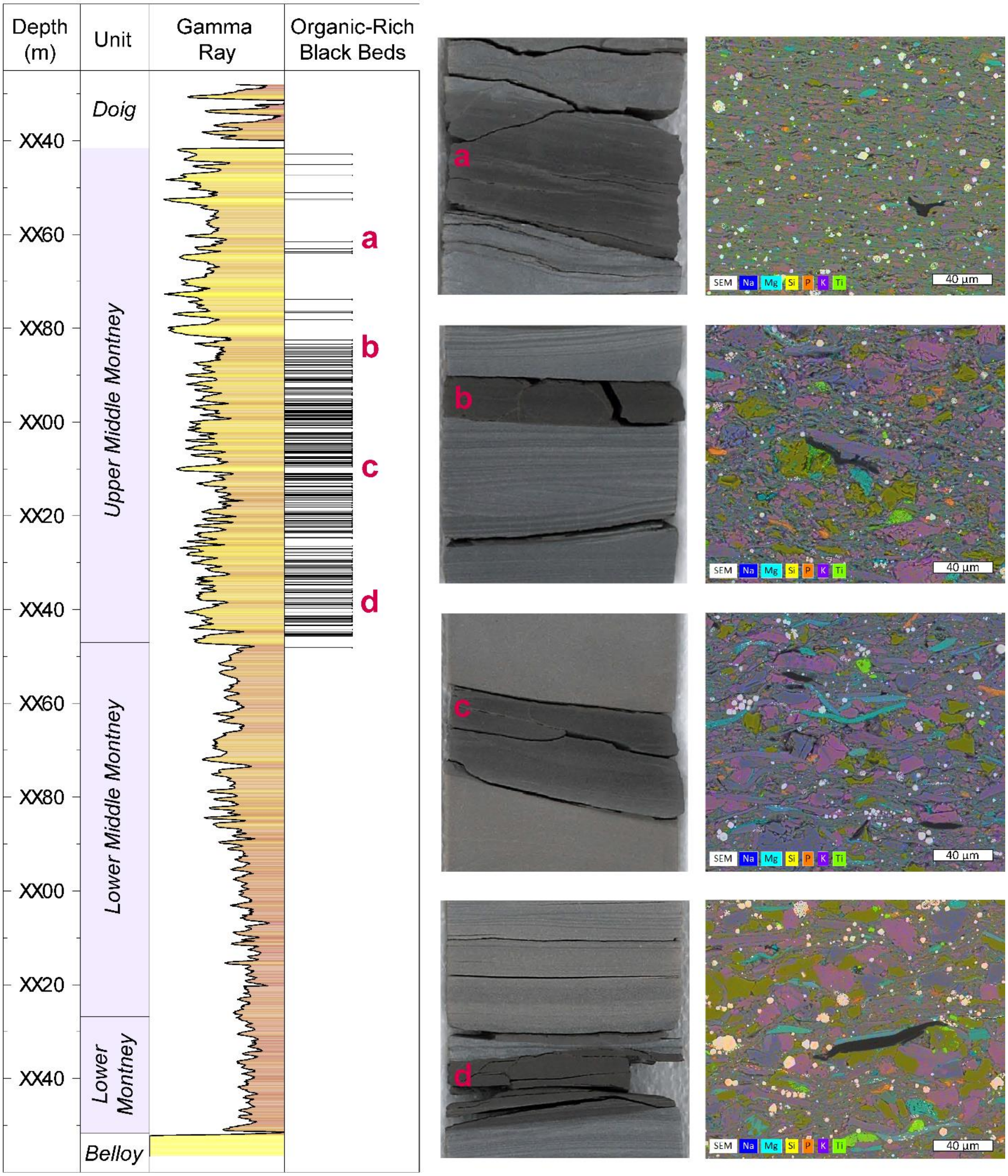


**Figure 1.** Stratigraphic location of primary-OM bearing shale facies identified in a full (230 m) Montney core located in SW Alberta. Core diameter: 8 cm.