# Upper Cretaceous (Cenomanian-Turonian) Organic-rich Source Rock Characterization through Organic Geochemistry and Petrology, Application for Paleo-condition Reconstruction

## Abstract

This study characterizes the organic matter composition of the Upper Cretaceous (Cenomanian-Turonian) Second White Specks Formation (2WS) from the south-western Manitoba to investigate the hydrocarbon potential and the paleo-depositional environment. This work includes core samples obtained from boreholes from locations along the eastern margin of the Canadian Cretaceous Interior Seaway. These samples are analysed through rock-eval pyrolysis, Flourcent light petrography and SEM.

The rock-eval result shows that the two groups of samples are immature (mean VRo=0.38%) and organicrich (mean TOC=7%) with predominantly liptinite-rich, marine kerogen. There is minor contribution of reworked vitrinite and inertinite macerals. Relatively higher input from land comprising vitrinite macerals was found within the samples from the 2WS overlying formation (Carlile), which is an indication of higher influence of land-derived material during deposition of these sediments. The percentage of organic matter ranges from 0-14% with a min of 7% which is considered high organic content. The high hydrogen index is representative of the great potential of these sediments for petroleum production. However, due to the immature nature of these sediments there has not been significant hydrocarbon generation.

## Paleogeography and Stratigraphy:



**a.** Paleo-map showing the position of the study area with respect to the position of paleo-shoreline and the current Cretaceous outcrop (Manitoba escarpment) (modified from Kauffman, 1969). c. Upper-Cretaceous stratigraphic chart representing Manitoba and Saskatchewan nomenclatures and eustatic sea-level curve with intermittent global anoxic events (after MacNail, 2009 and Dean et al. 1998). In this study, the upper part of the Belle-Fourche Member, Second White Speckled Formation including Keld and Assiniboine members as well as the lower part of Carlile Formation were analyzed.

## **Study Area and Core location:**



Regional Second White Specks thickness isopach map (modified from TGI, 2010) highlightin change of thickness from Study Area1 in Saskatchewan to Study Area 1 in Manitoba.







Outcrop views of the Second White Specks shale members in Manitoba (Faval Fm.). a. Showing the Lower member of Second White Specks . **b**. The Upper member of 2WS Formation. This interval is caped by a thick (up to 1.5 m) biogenic carbonate layer called "Marco Calcarenite". 2WS is overlain by the non-calcareous Carlile Formation. Note that thinning of the outcrops to the sides is due to photographing effect.

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#### **Rock-Eval**



Plots showing the results of Rock-Eval pyrolysis conducted on samples from 2WS Formation (Faval Fm) in Manitoba. a, b, c, d: crossplots of TOC, S2, HI, OI vs. depth. e, f: Van Krevelen Diagram indicating that 2WS is mostly containing organic matter type II with high hydrogen index. g, h: 2WS is an oil prone source rock with low level of organic matter conversion.

#### **Organic Petrography**



Photomicrographs in fluorescence mode showing marine organic matter from samples within upper and lower part of the Second White Specks Formation in southwestern Manitoba. Samples were taken from core 3-27-1-25W2. a. bituminite groundmass. b. Carbonate pallets containing organic matter (algae). c. Unidentified piece of organic matter. d. bituminite groundmass within the carbonate-rich facies, lower part of the 2WS. e. Carbonate pellet containing high amounts of algal fragments. **f**. marine dinoflagellate cyst.

#### Palynology



Pictures of marine acritarchs within the Second white Specks Formation (2WS) in Saskatchewan. All the samples are from core well 16-21-47-11W2. Presence of these specimens is an indication of strong marine influence during deposition of the upper member of the 2WS. *a*. Cleistosphaeridium sp. **b**. This particular specimen represents the chitinous inner test of foraminifer. **c**. Photograph of Veryhachium lairdi (?) from upper 2WS. **d**. Marine dinoflagellate cyst was recognized as *Palaeoperidinium cretaceum* was photographed from upper 2WS Fm.

Photograpgy by: Lorraine Bloom

#### **SEM/EDX**



Scanning electron micrographs (SEM/EDX) of 2WS Formation. a. Organic mater is present as organic-rich pellets within the carbonate matrix, as on the right is the EDX image representing carbon concentrations (organics) **b**. Carbonate-rich facies with clay and organic matter filling the spaces created among the carbonate grains and the carbon map. **c**. Marine algae surrounded by carbonate grains, pyrite and clay minerals. d. Accumulation of nano-fossils (coccolithophores) associated with organic particles. e. Carbonate pellet with high concentrations of organic matter, cabon map highlight the presence of organic matter. f. Organic matter filling the space created by carbonate grains. g. Pellet-rich facies followed by high magnification photo of a carbonate pellet consisting of coccolithophores fragments and organic matter. **h**. Carbonate pellet-rich facies with high magnification image of an organic pellet.

#### **Depositional Settings**



- land during deposition of this member.
- sediments as well as their insignificant diagenetic history in terms of tectonic events.
- degraded organic matter within the lower 2WS.
- ronment with high carbonate productivity and low sediment input.

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• Organic matter characterization through Rock Eval as well as flourcent microscopy indicates that the studied succession was deposited in a marine environment. The majority of organic matter within Second White Speckled Formation (Faval) is type II, which is oil-prone marine organic matter. The majority of samples have concentrations of organic in the range of 2 to 10%. This is considered as high and very high organic content. • Within the overlying Morden Member organic matter mainly consists of type II as well as type III kerogen. This is an indication of a higher influence of

• The maturity plot indicates that these sediments categorize as immature with the Tmax of about 410 Ic. This is due to the low depth of burial for these

• Based on flourcent microscopy of the organic matter, they are mainly occurring within pellets or evenly distributing in the matrix.

• Palynology studies show higher marine influence during the Upper 2WS with dominant amorphous organic consisting of bacterial remains as well as

• Based on the sedimentology studies and the characteristics of organic matter we suggest that these units were deposited in a shallow marine envi-







