

A new method for estimating source rock maturity from whole rock and extracted pyrolysis samples analysis

Macasty (Utica of Anticosti) Case Study

B. Granger, geol. Msc., Chief Geologist Petrolia,

F. Hamel, Ing., Petrolia

Summary

$R_{o\text{-evi-org}}$ (%) measured from the reflectance of organoclasts has been used for Macasty maturity evaluation. Based on these results, it is proposed to use the adapted version from Bertrand's $R_{o\text{-evi}}$ iso-curves overly on the cross plot of hydrogen index (HI) versus oxygen index (OI), from the modified Van Krevelen diagrams, in order to estimate the degree of maturation of the organic matter of source rocks ($R_{o\text{-evi}}$ (%)). This method is easy to use and give reliable results for the Macasty when compare to $R_{o\text{-evi}}$ from the reflectance of organoclasts.

Introduction

In organic rich shale play, thermal maturation is one of the key elements in resource estimation. R_o from vitrinite reflectance has been widely used and serve as a bench mark to calibrate other maturation index methods. With the lack of plants in Silurian and older sources rock as well as in younger marine source rock depraved of terrestrial input, the Tmax method from whole rock pyrolysis as well as other direct reflectance results made on maceral or on bitumen have been widely used as maturation index substitutes for maturity evaluation, sometime with mixed results.

Method

In 2012, 2014 and 2015, 15 cores holes were drilled to evaluate the Upper Ordovician Macasty source rock of Anticosti Island located in Gulf of Saint-Lawrence of the province of Quebec (Eastern Canada). $R_{o\text{-evi}}$ (%) measured from organoclasts reflectance was done in the all the new cores holes as well as in rock cuttings and / or cores samples of 15 old wells, at a sampling rate of 100 meters from surface down to the top of the Trenton.

For the recent core holes campaigns, Rock-Eval pyrolysis analysis has been done at high-resolution sampling rate, in other to get a representative number of source rock samples. Macasty Rock-Eval pyrolysis analysis has also been done on source rock cutting samples collected at wells sampling rate of 10 feet or 5 meters, in 15 of the old wells drilled on the island, including 4 Macasty continuous cored intervals in which high-resolution sampling rate has been applied. In 7 of the core holes, Rock-Eval pyrolysis analysis has been done on selected samples on which both whole rock and extracted samples were performed in order to compare results before and after extraction.

An original method is proposed to estimate of the maturity of the organic matter in the Macasty source rock. The method is based on an adapted version from Bertrand of $R_{o\text{-evi}}$ iso-lines overly on the hydrogen index (HI) and Oxygen Index (OI) cross plot (modified Van Krevelen diagram). For the Macasty, good to excellent relationships are obtained from linear regression lines when $R_{o\text{-evi}}$ estimated with the overly method are compared with $R_{o\text{-evi-org}}$ measured from organoclasts reflectance.

Results

For the Upper Ordovician Macasty source rock, the Tmax from the pyrolysis method applied on both whole rock and extracted samples indicates artificially elevated S2 peaks for whole rock samples as well as strongly suppressed T_{max} values compare to $R_{o-evi-org}$ from the reflectance of organoclasts resulting in unreliable maturation evaluations. Macasty whole rock analysis when compared to extracted values gives highly optimistic hydrogen index (HI) values. Moreover R_{o-Tmax} from both whole rock and extracted samples gives non-coherent R_{o-Tmax} results when compare with their respective HI values. $R_{o-evi-org}$ measured from the reflectance of organoclasts gives better estimates of the Macasty maturities and coherent HI values for a given R_{o-evi} .

Conclusions

A 2015 an economic evaluation study done by the Quebec government suggest a production scenario for Anticosti based on liquid to gas average production of the Point Pleasant (Utica of Ohio) which is considered an analog of the Macasty (Utica of Anticosti). There optimize scenario favor wet gas rather than oil as the main production in the prospective lands (22.5% oil and 77.5% gas).

A later resource evaluation study published in 2016 by the Geological Survey of Canada, essentially based on $T_{max}(^{\circ}C)$ done on whole rock samples and partly on R_{o-evi} (%) from the reflectance of organoclasts, concluded that oil production is favored instead of gas production on Anticosti prospective land.

The present study concluded that the southern part of Anticosti Island is essentially contained in the wet gas window where R_{o-evi} exceeds 1.0%. The present study support the optimize scenario proposed by the economic evaluation done by the Quebec government.

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