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Controlling Factors of the Organic Content in the Montney and Doig Formations (Alberta / British Columbia): Insights from Multi-Proxies Analysis and Sequence Stratigraphy

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Introduction and challenges

During the last decade, the shift of the oil and gas industry towards unconventional resources in North America has brought the focus on self-sourced reservoirs. The occurrence of hydrocarbons in these reservoirs is strongly associated with in situ organic content and maturation. On the other hand, the effective extraction of this resource depends on the brittleness of the reservoir, mainly controlled by the mineralogy of the matrix and by rock fabric (natural fractures, bedding…). Hence, understanding the distribution of organic heterogeneities and associated mineralogical variations is paramount to reduce the risk in exploration and development of unconventional resources. The Montney and the Doig Formations (Fms) are a suitable exemple to study the controlling factors of the organic heterogeneities. These formations are known from the petroleum industry since the early 60s. They present both conventional and unconventional plays (NEB, 2013) which allow to have data on the whole sedimentary system.

Case study

The deposition of the Montney and Doig Fms took place in early to middle Triassic on the western margin of Pangea before the orogen of the Canadian cordillera (Edwards *et al.,* 1994). Both Fms are composed of fine-grained sandstone, silt and shale (Golding *et al.,* 2014). In term of mineralogy, the Montney and Doig Fms are mainly composed of quartz, feldspars, carbonates and clay minerals (less than 25%). This makes them different from Utica and Eagle Ford shale plays which content more clays.

Organic content within the Montney and Doig Fms presents a singular heterogeneity: the lower Doig "Phosphate zone". In this layer, TOC can reach values up to 11wt. %, whereas in the rest of the Montney and Doig Fms the average TOC is around 1.5%.

Database, concepts and methods

This study is based on a 450km, SE-NW, cross sections of 40 wells and two outcrops. 106 cuttings samples from two wells, 138 samples from a 300m long core and 138 samples from two outcrops were analyzed with a Rock-Eval VI, an ICP-MS and an ICP-AES. 182 additional cutting samples from 4 other wells have been also sampled to be analyzed with a Rock-Eval VI.

Organic richness of sediment is controled by three main factors: the organic production, its dillution by non-organic particles and its preservation/destruction (Bohacs *et al.,* 2005).

In a first step, the well log correlation using sequence stratigraphy (Catuneanu *et al.,* 2009) provided the stratigraphic architecture and the time lines of the studied interval. In a second step, the analysis of the samples with a Rock-Eval VI (Behar *et al.,* 2001) and the study of palynomorphs (Tyson, 1995) on 24 samples allowed to study the organic matter distribution along the cross section and to compute the immature TOC (Jarvie, 2012). Lastly, the ICP-MS and AES analysis provided the quantification of major and trace elements that can be used as paleoredox and paleoproductivity proxies (Tribovilard *et al.,* 2006).

Thanks to these analyses it was possible to estimate the organic paleoproductivity though Phosphorus (P), Barium (Ba), Copper (Cu), Zinc (Zn) and Nickel (Ni). As sequence stratigraphy provided time line within the interval, it was possible to compute the mass-accumulation rates of non-organic sediments in order to approach the dillution factor. Lastly, it was possible to study preservation/destruction of organic matter using paleoredeox proxies : Uranium (U), Molybdenum (Mo) and Vanadium (V).

Results and first conclusion and ongoing studies

Sequence stratigraphy provided a high resolution stratigraphic architecture of the basin along a 2D section. The main result of this 2D study is that deposition of the Montney and Doig Fms does not seem to occur on a classical passive margin but that some bathymetric highs may affect the connections between the basin and the oceanic domain.

Palynomorph and Rock-Eval analysis show that the organic content comes mainly from marine sources. Immature HI should be expected to have reach between 400 and 600 mgHC/gTOC.

The ICP-MS and AES and the Rock-Eval analysis integrated in the stratigraphic architecture show that the organic content in the Montney and Doig Fms is controlled by different combinations of the three factors depending on the location along the depositional profile and on the systems tracts. For instance, the “Phosphate zone” is linked to high organic productivity, low oxygenation and moderate mass-accumulation rate.

This study allows to understand the influence of different controlling factors of the organic content at basin scale. The ultimate goal of this PhD is to model at basin scale, the deposition of the Montney and Doig Fms. Modeling the factors controlling the deposition and preservation of organic matter in sedimentary basins will help predicting high potential fairways in unconventional plays.

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