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Exshaw-Banff! petroleum systems in Southern Alberta

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Summary

There are three source rocks present at the Devonian to Mississippian transition in Southern Alberta. This study presents a new data on source rock geochemistry with implications for associated oils which may have been derived from them. This is a continuation of the review of the petroleum systems of Southern Alberta which was undertaken by the authors in 2015 (Mort *et al.*, 2015).

The Devonian to Mississippian transition in Southern Alberta was a period of global changes in sea level combined with periods of uplift associated with tectonism caused by the Antler Orogen in the United States (Johnston *et al.*, 2010). There are rapid transitions in lithology and interformational hiatuses and erosional events. The net result is a transition from the peritidal carbonates and evaporites of the Stettler to the shallow marine carbonates of the Big Valley and then a transition to the deep-water source rocks of the Exshaw, equivalent to the Lower Bakken. This is followed by a shallowing which led to the deposition of the siltstone, fine sand and carbonates of the upper Exshaw, which are equivalent to Middle Bakken. This was followed by another deepening which lead to the deposition of a Lower Banff black shale source rock succeeded by deposition of the lower ramp carbonates and shales of the Banff (Johnston *et al.*, 2010; Colborne et al, 2015, Hartel et al, 2014). There is likely another hiatus between the Lower Banff black shale and the overlying Banff sediments since the fine-grained silty Lodgepole Sand, which hosts the Ferguson “Alberta Bakken” oil pool appears to be of shallow marine origin and is under- and overlain by deep-water carbonates and clastics. In the overlying Lower Banff an additional source rock was observed to be present in the Torc HZ Leopard well, 15-27-9-20W4, which was cored and evaluated as part of this study.

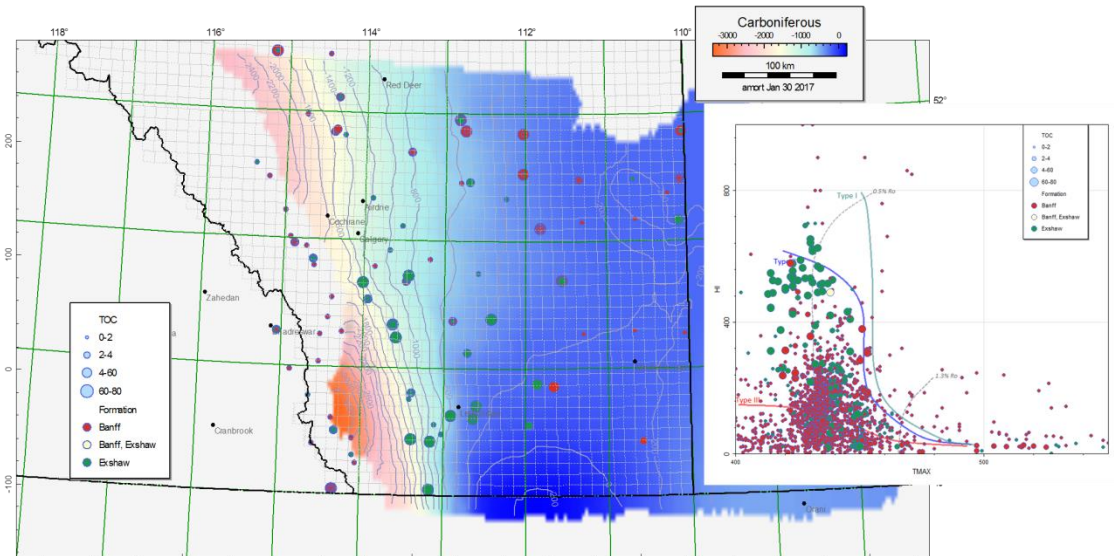

Figure 1. Exshaw-Banff source rock samples and Rock-Eval characteristics in Southern Alberta

A review of the data available for the Exshaw and Banff Formations (Figure 1) indicates that the Banff Formation in southern Alberta exhibits good to excellent source rock potential. While this is not a new

observation, there has not yet been a regional evaluation of the contribution of the Banff Shale to regional proven or potential petroleum systems. Manzano-Kareah et al (2004) identified a geochemically distinct group of oils, termed Family M, in the Manyberries and Black Butte fields of southern Alberta and Whitlash and Fred & George fields in northern Montana. The terpane distribution for this and the larger Exshaw-sourced Family E are shown in Figure 2 (m/z 191 ion chromatograms).

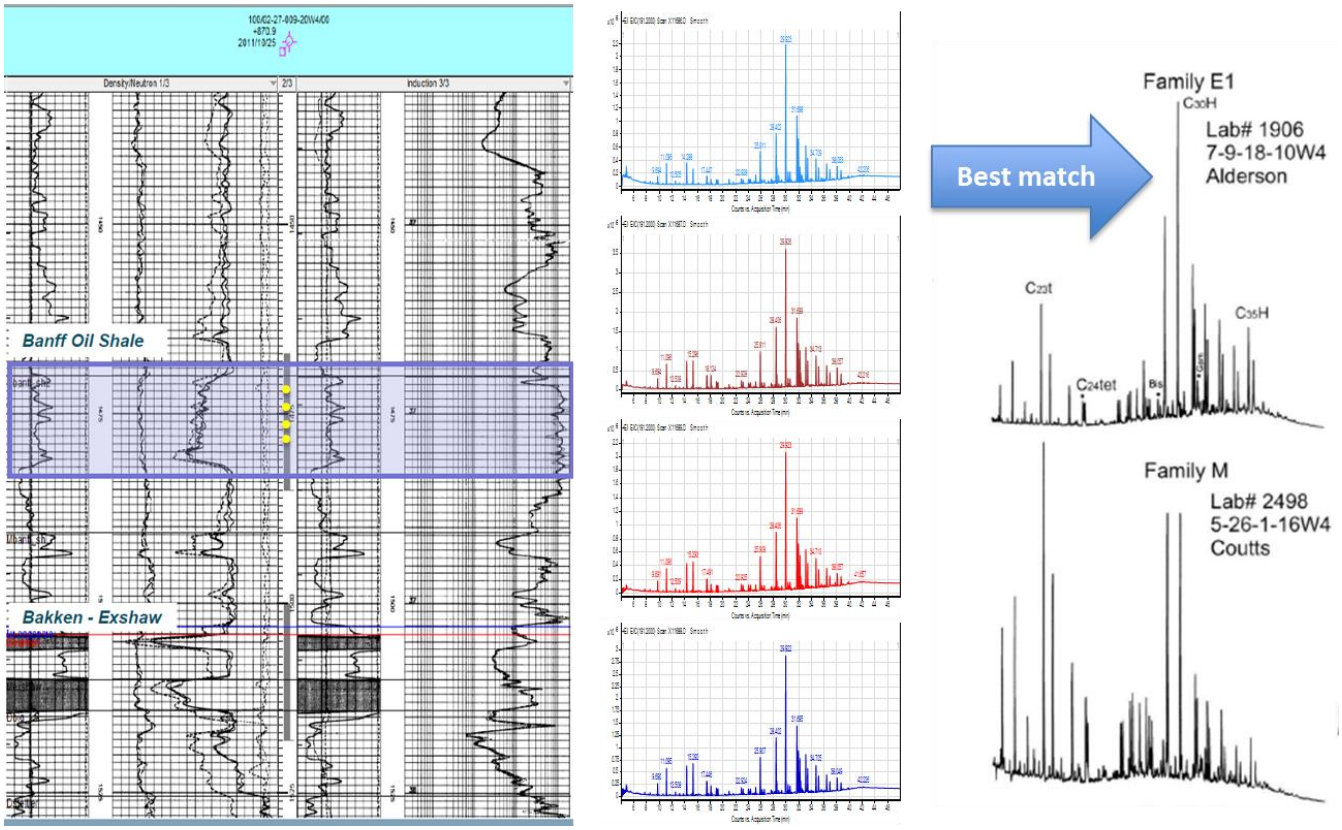

Figure 2.Type Log for 15-27-9-20W4 showing the three Devonian-Mississippian source rocks present

On the basis of molecular geochemical characteristics (e.g. dibenzothiophene content, norhopane-hopane parity, elevated pregnane and diasteranes) the source for Family M oils was postulated to be a Palaeozoic calcareous shale, and several workers have proposed that the Banff shale represents this missing piece of the puzzle. Samples were taken from the Torc HZ Leopard well 15-27-9-20W4 (see depths in Figure 2) and subjected to screening analysis by Rock-Eval pyrolysis, confirming the excellent potential of the younger of the two Banff Formation black shales. TOC values were up to 6.5% with HI values of up to 570, representing world class source potential. However, the subsequent high resolution analysis of the extracted hydrocarbons by GC-ToF-MS indicates that this zone most closely resembles the Exshaw family rather than providing the smoking gun for Family M oils that was anticipated.

These results nonetheless have important implications for the potential contribution of the Banff Formation organic rich shales to oil pools hitherto thought to be exclusively sourced by the Exshaw. Ongoing work will yield molecular geochemical information on the precise source(s) to some of the more recently discovered oil pools in Southern Alberta, and shed further light on the identifiy of oils in the so-called Alberta Bakken.

Acknowledgements

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