Investigation on natural bitumen occurrence in Birch Mountains kimberlite pipes in northern Alberta

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During diamond exploration from 1990 to 2010, kimberlitic rocks were discovered in three separate areas of northern Alberta; Mountain Lake cluster, Buffalo Head Hills and Birch Mountains fields, of Late Cretaceous and Paleocene [1]. These pipes comprise mainly lapilli-bearing olivine crystal tuff and volcaniclastic rocks, interpreted as pyroclastic crater facies. The Birch Mountains kimberlite cluster lies on the NW margin of the Athabasca oil sands. Radiometric age dates have been determined for the kimberlites, thus their spatial and temporal relationship to the bitumen provides key information on petroleum charge time and residence time of the Athabasca oil sands. These dates constrain basin modelling and charge history studies in the Alberta Basin. Bitumen is described for only three of the exploration drill holes in the Birch Mountains fields, the Phoenix, Valkyrie, and Legend kimberlites [2]. In all three cases, the drill hole descriptions suggest that the bitumen in the kimberlites is live and has not suffered thermal alteration. Radiometric ages for Phoenix, Valkyrie, and Legend kimberlites are 70.3 ± 1.6 Ma (U-Pb perovskite), 75.8 ± 2.7 Ma (U-Pb perovskite), and 77.6 ± 0.8 Ma (Rb-Sr phlogopite), respectively [2].

To investigate thermal alteration of the bitumen in the kimberlites, 30 bulk rock samples were collected from these kimberlites in the Birch Mountains fields. Bitumen was extracted and analyzed by gas chromatography - mass spectrometry (GC-MS) technique. Extractable Organic Matter (EOM) yield is very low for this suite of samples, with only a few detectable compounds by GC-MS. However, Legend samples show subtle traces of oil-like compounds. Average $\delta^{13}C$ values of whole oil in the studied suite vary in a narrow range from -30.3 to -28.3 ‰. The carbon isotope ratios are within the range of reported $\delta^{13}C$ values for Exshaw-sourced marine oil samples in the Athabasca oil sands.

We discuss further analyses conducted using ultrahigh resolution mass spectrometry to characterize the EOM from the kimberlite samples and examine any potential relationship of the bitumen with the Athabasca oil sands.

[1] Eccles, D. R., (2011). ERCB & AGS Bull., v. 65, 119 p.

[2] Tozer et al., (2014). AAPG Bull., v. 98, no. 3, 429–447.