Alberta Oil Sands Charge Allocation: Mapping Source Rock Contributions

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The sources of the oil sands bitumen remains controversial (Riediger et al. 2000 for review); however a clearer understanding of the source and charge timing may aide targeting of sweet spots and fluid property predictions and provide a quantitative framework for fundamental studies of petroleum system processes, e.g. biodegradation. The wide range of oil compositions are related to variable biodegradation levels driven by reservoir history and major gas leakage, superimposed on a mixed oil charge derived from at least two major source rocks. Oil maturity charge, source signal and biodegradation variability in each of the source oils, makes classic biomarker bitumen-source rock correlations ambiguous, especially for these heavy and severely biodegraded oils. Here, we use quantitative GCMS methods optimized for heavy oils, highly biodegradation resistant proxies (metal, S content) and analysis of source dependent high molecular weight multi-heteroatom compounds (HMWMH; often with N, S, O) enabled by advances in FTICRMS analysis of oils (Oldenburg et al. 2010). Molecular and elemental analyses are confirmed by S and N stable isotopic data to be highly conservative for source signals even in severely biodegraded oils (Marcano et al. 2010). Molecular and isotopic geochemical analysis of north-central Alberta Lower Cretaceous oils identify variable source contributions to the oil sands from the Exshaw, Gordondale and Duvernay source rocks. Cold Lake and southern Athabasca oils are most likely derived from the Exshaw with minor contributions from the Duvernay whereas west to east across the Peace River region, S content, isotopic composition, and biomarker and molecular marker geochemistry show a mixing zone of Gordondale (west) and Exshaw (east) sourced oils. Distributions of resistant HMWMH compounds with NS and NS2 functionality also very clearly differentiate oil source signatures for southern Athabasca and Peace River oil sands. Buffalo Head Hills and northern Athabasca bitumen chemistry shows a sole source from the northern Alberta Exshaw Formation. Using multivariate statistical analysis of quantitative geochemical data, the oil sands bitumens are de-mixed to map source contributions in Lower Cretaceous reservoirs. The significance of charge mixing and fluid property implications are discussed in the context of charge timing, initial oil composition and properties prior to biodegradation, biodegradation rates and total petroleum loss from these systems.