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Chemofacies and Provenance Analysis of the McMurray Formation, Telephone Lake, North-Eastern Alberta, Canada

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Summary

Chemofacies analysis involves the study of chemically- and mineralogically-related deposits in a rock succession. These chemofacies can be grouped into chemopackages reflecting distinct geochemical signals. These geochemically-distinct packages may be stratigraphically correlatable over local to expansive geographical regions. Such geochemical signals preserved in the rock record may indicate: a) subtle changes in the provenance of sands which source a reservoir; b) changes in palaeoclimate; or c) changes in marine influence. Furthermore, these mineralogical distinctions may permit more detailed and intricate intra-reservoir architectural analysis in high net-to-gross sand-rich settings.

The McMurray Formation at Telephone Lake in northeastern Alberta is a thick, sandy and high net-to-gross reservoir containing numerous geobodies of both fluvial and estuarine channel origin. The reservoir will be produced by the steam assisted gravity drainage (SAGD) process. The asset is located in an eastern tributary to the Main McMurray Fairway. Canadian Shield-derived sediment influx into this eastern tributary valley is thought to have been a significant contributor to the McMurray reservoir. Some of the questions that this study wanted to answer included the following: How much, if any, contribution was there from the Canadian Shield; If there was sediment sourced from the east, was there a distinct mineralogical signature; Could this mineralogical signature be used to define and subdivide McMurray stratigraphy and sand packages; and lastly, could any mineralogically different sediment packages alter the expected diagenetic reactions when the reservoir is exposed to SAGD pressure and temperature conditions? A geochemical study was initiated to answer these questions and some of the results are explained in this presentation.

Geochemical analysis of sand reservoirs can be easily and cheaply obtained by both X-Ray Fluorescence (XRF) and/or Quantitative Evaluation of Materials by Scanning Electron Microscopy (QEMSCAN). Although both methods were employed at Telephone Lake, this presentation focusses on the results of the latter method. Fifty-three samples were selected from three vertical cored delineation wells, covering lower and middle members of the McMurray Formation and the Wabiskaw Member of the Clearwater Formation. Samples were taken from various lithologies

(sands, muds and coals), various fluids (including bitumen, top and basal water intervals) and various channel belt packages. Eight channel belts have been recognised and mapped out at Telephone Lake, of which only four were encountered in the three wells of interest in this study. These channel belts were identified and mapped based on sedimentological, petrophysical and geophysical data. The three wells cover a wide geographical area of 15 km from northwest to southeast across the asset. QEMSCAN analysis resulted in recognition and quantification of dominant minerals, clay minerals and accessary (heavy) minerals. Thin-section petrographic analyses and selected XRD samples were run to confirm the mineral interpretations conducted by QEMSCAN. Mineral species were identified, quantified and distinct mineralogical packages recognized with the aid of statistical approaches (i.e., principal component analysis and hierarchical cluster analysis). This core presentation focusses on examining the sedimentology and geochemistry of the McMurray from one well within the Telephone Lake asset.

Although the mineralogy of McMurray sands is composed predominantly of quartz, there are noticeable differences in the secondary minerals, namely, potassium feldspar, kaolinite, smectite, illite and certain accessary minerals. There is a consistent difference in mineral composition between the lower and middle members of the McMurray Formation across the three studied wells. Furthermore, statistical analysis has permitted the recognition of finer-scale chemopackages that correspond to distinct channel belts within the McMurray Formation. Moreover, petrographic analysis of thin-sections has revealed further compositional differences between the lower and middle members. The lower member contains significantly more abundant chert, rock fragments, monocrystalline quartz, muscovite, kaolinite, mixed-layer clays (illite) and smectite, whereas the middle McMurray member contains higher abundance of potassium-feldspar, rutile, polycrystalline quartz and an absence of chert and other rock fragments. Grain-size is also noticeably coarser in the middle member than the lower member of the McMurray. Together with palaeocurrent interpretations (derived from formation microimager analyses), the lower McMurray is thought to have been sourced from distant, varied volcanic sources to the south, and deposited as a series of braided channel systems. In contrast, the middle McMurray appears to have been supplied both from a southern source, but more importantly, from a dominant, more locally-derived eastern cratonic meta-granitic source. These eastern-derived sediments are transported through tributary valley systems and can form point-sourced local alluvial fan accumulations within broad, structural low areas.

Future integration of multidisciplinary data as well as analysis of additional samples will allow for more refined lateral correlation and mapping of these chemopackages.