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Three-Dimensional Characterization of the Total Dissolved Solids Concentration and Stable Isotope Composition of Porewater Extracted from Athabasca Oil Sands Drill Core

Benjamin R. Cowie[1], Bruce James[2], Michael Nightingale[3], and Bernhard Mayer[3]

[1]Department of Earth and Planetary Sciences, Harvard University, Cambridge, Massachusetts, USA
[2]Suncor Energy Inc., Calgary, Alberta, Canada
[3]University of Calgary, Calgary, Alberta, Canada

Abstract

Total dissolved solids (TDS) concentrations in McMurray Formation waters range from 220 to 280 000 mg/L in the Athabasca Oil Sands Region (AOSR) (Cowie et al., 2014). The observed variability in TDS concentrations within a reservoir or across a lease area influences measurements of resistivity that are required for resource assessment. Here we present a robust, low-cost method to characterize the geochemical composition of reservoir pore fluids from drill core derived porewater. The methods reveal the heterogeneity of TDS concentrations and the stable isotope compositions (δ^2H, $\delta^{18}O$) of reservoir porewater, both vertically within a core, and laterally across a field. Analysis of water samples extracted directly from drill core provides a significant advance in the ability to characterize the properties of reservoir porewater, but requires corrections to account for drilling fluid contamination. Our new technique utilizes two end-member mixing relationships between the stable isotope compositions of drilling fluids and formation waters from multiple samples within a single reservoir, and does not require measurement of drilling fluids to calculate formation water properties. The new method revealed that water derived from drill cores in several preliminary reservoirs had significant variability in TDS (860 to 45 000 mg/L), δ^2H (−172 to −149‰) and $\delta^{18}O$ (−22.4 to −19.3‰). These values are consistent with regional trends in formation water salinity and stable isotope composition, and illustrate the wide range of TDS values that can be found in McMurray Formation waters. A detailed characterization of the Suncor-Firebag lease area revealed both lateral and vertical heterogeneity in TDS and stable isotope compositions of McMurray Formation waters, thus providing a three-dimensional approach to water characterization within these oil sands reservoirs. This new methodology provides a tool to understand the origin and movement of reservoir water due to natural groundwater flow, and may be able to detect anthropogenic influence by steam injection. Additionally, novel in-situ extraction technologies that utilize electromagnetic or radio wave heating systems may also benefit from detailed characterization of aqueous reservoir fluids to accurately determine the resistivity and water properties of the reservoir.

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