Aqueous Geochemistry and Stable Isotope Ratios as Predictive Risk Management Tools for Assessing Vertical Hydraulic Connectivity in the Athabasca Oil Sands Region

Benjamin R. Cowie[1], Bruce James[2], 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

Recent unexpected discharges of steam, brine, or bitumen to the surface of oil sands resource developments suggest a gap in understanding of the subsurface fluid flow system in the Athabasca Oil Sands Region (AOSR) and a need to identify where such discharges might occur. These surface discharge events have common spatial and geochemical characteristics that we will attempt to frame in a context of identifying and managing the risks associated with vertical movement of fluids during oil sands resource development by mining or steam-assisted gravity drainage (SAGD). Aqueous geochemistry and stable isotope ratios of McMurray Formation waters and dissolved sulfate can provide a leading indicator of upward groundwater flow from Devonian strata below the sub-Cretaceous unconformity. The highly localized nature of high salinity fluids suggests that upward flow is occurring via karst conduits. Areas of upward groundwater flow across the sub-Cretaceous unconformity are spatially correlated with the partial dissolution edge of the Prairie Evaporite Formation and instances of unanticipated fluid discharge to ground surface. A risk assessment framework that incorporates the aqueous and stable isotope geochemistry of formation waters in the AOSR may help delineate vertical connectivity during the reservoir characterization process and decrease the probability of surface discharge incidents during oil sands development proximal to the Prairie evaporite partial dissolution edge.

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