Investigating biogeochemical alteration of oil sand tailings: Field vs. laboratory studies

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Introduction

The oil sands deposits in Northern Alberta are one of the largest oil reserves in the world, containing an estimated 2.5 trillion barrels of recoverable bitumen held in a mineral matrix consisting of sand, clay and water. The current practice is to store the tailings in large settling basins, to allow the solids to settle out by gravity forming a denser unconsolidated mass termed fluid fine tailings (FFT). FFT is transferred from settling basins into the mined-out pits, being proposed for a series of end pit lakes, a strategy for sustainable environments being evaluated in the Fort McMurray region. As these end pit lakes (EPL) evolve, significant changes in the physicochemical properties, microbiology and geochemistry can occur affecting both the volume and quality of the intended water cap. To date little information exists on the biogeochemical nature (redox mediated reactions) of the FFT product prior to deposition. Our research program is investigating both the chemistry and the microbial community structure within core samples collected from oil sands tailings basins. To compliment and confirm predictive models there is a need for detailed systematic studies bridging the physical (mineralogy) and chemical (redox chemistry abiotic vs. biotic; cycling of Fe and S) gradients observed for samples collected.

Results/Conclusions

Detailed studies in our group have shown that chemical and biological mechanisms play a role in controlling diffusivity, O_2, HS^-, NO_x gradients which may be linked to sulfur and Fe (II/III) cycling during initial settling under aerobic and anaerobic conditions [1, 2]. To validate these assumptions further investigations have assessed the chemical and secondary mineralization mechanisms that occur in REDOX sensitive microaerophilic zones in both laboratory studies and collected field samples from the settling basins. Data will be presented which support these assumptions from the EPL materials by looking at temporal chages of the materials as well as comparing results from bioreactor-studies and field-samples.

[1] Chi Fru (2012) *Bioreactor studies predict whole microbial population dynamics in oil sands tailings ponds, Environmental Science and technology,* in review.
[2] Chen (2012) *Bioreactor assessment of the biogeochemical evolution of sulfur and oxygen in oil sands fluid fine tailings, Science and the total environment*, in review.

Early diagenesis of redox-sensitive elements in the Estuary and Gulf of St. Lawrence

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Redox-sensitive elements (RSEs) are potentially powerful paleo-redox tracers [1]. To realize this potential requires an improved understanding on their geochemical properties and the chemical reactions they participate in during early diagenesis.

We measured the distributions of Fe, Mn, U, Mo, Re, and Cd in solid phase sediment and their porewaters in six cores collected along the Laurentian Trough of the Estuary and Gulf of St. Lawrence and the Eastern Canadian continental shelf. The data were obtained via ICP-MS analysis of porewaters and buffered-ascorbate and 1 N HCl extractible solid phase components. The results are consistent with the conclusions of a previous investigation that the accumulation rates of U, Mo, Re, and Cd are controlled by slow precipitation kinetics [2]. At the most landward station, where the sedimentation rate is highest (~4 mm/yr) and the bottom water dissolved oxygen concentration is lowest (~60 µM), the porewater U, Mo and Re concentrations decrease gradually with depth, supporting diffusion from the bottom water into the sediment. In contrast, porewater U, Mo and Re profiles show little variation with depth in the Gulf and on the continental shelf where the sedimentation rates are lower (0.5-1.5 mm/yr) and the bottom water oxygen concentration is higher (~150 µM). At all stations, the porewater Cd concentration is variable with depth. The extractible solid phase concentrations of Mo, U, Re and Cd increase with depth in all cores. These findings provide a useful test of how RSEs respond to variable overlying water oxygenation and sediment accumulation rates and how their vertical distributions are modified by early diagenetic processes.

[1] Tribovillard *et al*. (2006) *Chem. Geol.* **232**, 12-32.
[2] Sundby *et al.* (2004) *GCA* **68**, 2485-2493.