

Biogeochemical impacts of oil sands process water on aquifer and aquitard materials

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In Northeastern Alberta, Suncor's South Tailings Pond (STP) is one of several oil sands tailings facilities to be sited atop meltwater channel deposits. These sand aquifers are typically separated from the tailings by clay-rich aquitards, but have the capacity to act as potential migration pathways for process-affected (PA) water. The goal of this study is to understand how biogeochemical interactions between PA water and the sediments affect the distribution and mobility of trace elements in the aquitard and aquifer.

Laboratory radial diffusion cell experiments [1] were conducted to examine the long-term effect of geochemical reactions within aquitard sediments in their native redox state, when exposed to diffusion-driven ingress of PA water. To evaluate trace element behaviour in aquifer materials, a series of PA water injection experiments were conducted in a highly permeable Pleistocene glacial outwash channel near the STP. Under natural conditions, these groundwaters are mildly anaerobic and dissolved trace element levels are relatively low. Finally, to assess the initial solid phase distribution of trace elements, sequential extraction techniques [2] were applied to pristine aquitard and aquifer core samples. Preliminary results from the radial diffusion cells suggest that interaction with PA water induced the release of Fe, Sr and Ba, but removal of aqueous B and Mo. Following the introduction of PA water injectate into aquifer sediments, levels of dissolved Fe, Mn, Ba, Co, Sr, and Zn rose above background values [3]. Taken together with extraction results, these observations suggest that PA water may displace a portion of the weakly-sorbed trace elements from both aquifer and aquitard materials. A significant fraction of the observed mobilization is likely due to microbially-mediated reductive dissolution of amorphous and poorly crystalline oxides of Fe and Mn.

[1] van der Kamp *et al.* (1996) *Water Resour. Res.*, **32**, 1815-1822. [2] Herbert Jr (1997) *Water Air Poll* **96**, 39-59. [3] Tompkins (2009) *Masters Thesis*, University of Waterloo.

The role of disturbance in the regulation of carbon exchange by soils

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A small fraction of plant carbon production is stabilized by native soil, yet in the past century disturbance by land-use change resulted in significant destabilization and loss of soil carbon. The forms of soil carbon and the processes by which carbon is stabilized and destabilized vary widely across the globe. Both the forms and processes are key to determining the fate of soil carbon as it is subjected to disturbances such as fire, climate change, tillage, erosion, or urbanization. Here we propose a conceptual framework for evaluating the role of disturbance in soil C stabilization and destabilization.

The input of soil C to mineral soil occurs as a result of autochthonous and/or allochthonous production; isohumification of plant litter before entering soil; and mixing or physical transfer of C via biological or physical processes. The stabilization of C inputs, and therefore the fate of C, is then regulated by physical and biogeochemical processes that interact in context of pedogenesis and disturbance cycles. In early stages of pedogenesis on young landforms, C is being stabilized by the formation of short-order minerals and physical aggregation. In late stages or old landforms, C is destabilizing in response to mineral transformations and reduced plant inputs. As a result, C emission by destabilization of aggregates might be readily regenerated in young soils that naturally sequester C via incipient aggregation. By contrast, C emission by aggregate destabilization might be less resilient in old soils that are losing C as secondary minerals shift to more stable, permanent forms. Therefore such hysteresis effects can exist in soil C exchange, particularly in relation to disturbance regimes in context of landform age.