

EGU2020-1548

<https://doi.org/10.5194/egusphere-egu2020-1548>

EGU General Assembly 2020

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## Effects of snow melt infiltration and geochemical oxidation on the distribution of sulphate in reclaimed oil sands shale overburden

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A key risk to reclamation covers over oil sands shale overburden is salinization of the cover soil due to salt transport from the underlying shale. The objective of this study was to evaluate controls on salt ingress based on observations and modelling of the transport of a conservative chemical species, chloride (Cl<sup>-</sup>), and a produced species, sulphate (SO<sub>4</sub><sup>2-</sup>) within reclamation profiles at the South Bison Hills overburden dump located north of Fort McMurray, Alberta, Canada. The SO<sub>4</sub><sup>2-</sup> is produced as a result of pyrite oxidation. Previously developed water dynamics models, including a fully coupled water and heat transfer model (CM) and a modified CM model (CM-EI) to account for enhanced snow melt infiltration, were coupled with an advective-dispersive transport model to simulate the observed Cl<sup>-</sup> profiles and concomitantly constrain the solute transport parameters. This transport model was then used to simulate SO<sub>4</sub><sup>2-</sup> migration to evaluate the impact of pyrite oxidation (i.e. depth and SO<sub>4</sub><sup>2-</sup> production rate) on the evolving SO<sub>4</sub><sup>2-</sup> profiles. It was found that the observed SO<sub>4</sub><sup>2-</sup> distributions could be simulated using an initially low rate of SO<sub>4</sub><sup>2-</sup> production (0.1 g SO<sub>4</sub><sup>2-</sup> m<sup>-2</sup> d<sup>-1</sup>) in the first 5 years while macropore development as a result of freeze/thaw and wet/dry cycling was occurring, followed by a higher rate (0.62 g SO<sub>4</sub><sup>2-</sup> m<sup>-2</sup> d<sup>-1</sup>) once this soil structure evolution was complete. These average rates were applied over a shale depth of 0.75 m, consistent with field observations of oxygen ingress. Mass balance estimates using measured available pyrite suggest that at these rates oxidation could continue for approximately 93 years. Inclusion of enhanced snow melt (CM-EI model) results in higher rates of both net percolation and evapotranspiration (ET). The increased net percolation enables more rapid flushing of the produced SO<sub>4</sub><sup>2-</sup> deeper into the profile; however, the increased ET also draws produced SO<sub>4</sub><sup>2-</sup> into the cover soils. It is therefore likely that short-term soil salinization of the base of the covers is exacerbated by increased snowmelt infiltration, while in the long run salinity levels will drop due to increased net percolation.