Biogeochemical processes affect tailings' reclamation under end-pit lake scenario

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The current technology of bitumen extraction from surface mined oil sands ore in northern Alberta Canada generate huge volumes of fluid fine tailings (FFT) comprising fine mineral particles, unrecovered bitumen and residual hydrocarbon solvent. Prospective strategy for FFT reclamation is the construction of end-pit lakes (EPL). Currently a full-scale (~8 km^2) demonstration EPL (Base Mine Lake [BML] containing ~186 million m^3 of FFT capped with ~52 million m^3 of fresh water-diluted process water) is monitored for its evolution to a self-sustained ecosystem.

To assess the feasibility of this reclamation approach, twelve anaerobic 140 L acrylic columns (filled with 50 L of FFT capped with 20 L water collected from BML) were incubated at10°C, 20°C and 30°C in dark for 3 years. FFT in half of the columns were amended with hydrocarbons to stimulate methanogenesis to observe how microbial metabolism of entrained hydrocarbons affects the quality of EPL.

Chemical, mineralogical and molecular biological investigations of FFT and cap water revealed that methane ebullition from FFT due to hydrocarbon metabolism brought bitumen to the water surface. Active methanogenesis in FFT created turbidity in overlying cap water and induced chemical flux across FFT-cap water zones. Positive fluxes of naphthenic acids, major cations (Ca^{2+}, Mg^{2+}), anions (HCO_3^-) and some trace metals (primarily Ba and Sr, as well as V, Co, Cr, Ag and Pb) were observed. Positive flux of inorganic constituents was caused mostly by dissolution of carbonate minerals and transformation of Fe^{III} to Fe^{II} minerals. Methanogenesis increased FFT consolidation. Addition of fixed nitrogen increased methanogenesis and chemical flux rates. This study provides valuable insight into the geochemical processes that affect the performance of EPLs as an effective strategy to manage tailings inventory exceeding one billion cubic meter of FFT stored in tailings ponds.