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Environmental and artificial tracers in hydrogeology

title: An investigation of heterogeneous water flow and transport processes in an oxidized glacial till using environmental isotope (δ2H, δ18O) profiles

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The heterogeneity of flow and transport processes in a surficial glacial till was investigated by studying the stable environmental isotopes of water (^{18}O and ^{2}H) in the upper 6 m of the clay rich till at a site in Southern Saskatchewan, Canada. At the site, the transition between oxidized and unoxidized sediments occurred at a depth of 3 and 4.5 m below ground and the water table fluctuated seasonally (1–3 m below ground). Continuous core samples from three vertical sites located over a maximum spatial distance of 65 m were collected three times during 2009. Samples were analyzed for grain size distribution, bulk densities, and water contents. Additionally, transient, high-resolution (0.2 m) profiles of $\delta^{18}O$ and $\delta^{2}H$ in pore waters were measured using a $H_2O_{(liquid)}$-$H_2O_{(vapor)}$ pore water equilibration and laser spectroscopy technique. The depth profiles of the grain size analysis, water contents and bulk densities indicated a highly heterogeneous structure in the upper 6 m. This complex system was supported by the spatial distribution of the water isotopes resulting in distinctly different isotope depth profiles from each site. The temporal distribution of the isotopes in the pore waters indicated variable upward and downward fluxes in the upper two meters. Below this depth, flow appeared stagnant and diffusion was the dominating transport process. The water table fluctuations did not influence the isotope contents. Assuming one-dimensional equilibrium flow and transport processes, the profiles at only one of the sites could be simulated. The isotopic profiles at the other two sites were influenced by either fractured flow or lateral flow at different depths and suggested winter infiltration to greater depth. The combination of water contents, sediment properties, and water isotopes defined the heterogeneous flow and transport processes in this glacial till.

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