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An investigation of heterogeneous water flow and transport processes in an oxidized glacial till using environmental isotope profiles

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The heterogeneity of flow and transport processes of a surficial glacial till in Southern Saskatchewan, Canada, was investigated using environmental isotopes. This study focused on the variable flow conditions of the upper 6m of the clay rich till. This depth covered the transition between oxidized (0-4m) and unoxidized (4-6m) sediments and was subject to seasonal water table fluctuations (1-3m). Continuous core samples of three vertical depth profiles in a distance of maximal 65m were taken three times a year. Grain size distribution, bulk densities, and water contents were analyzed in the drilled cores. Additionally, transient, high-resolution (0.2m) profiles of δ^{18}O and δ^{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 clearly indicated a highly heterogeneous structure in the upper 6m. This complex system was supported by the spatial distribution of the water isotopes resulting in three distinct, different isotope depth profiles. The temporal distribution of the isotopes in the pore waters indicated variable up- and downward fluxes in the upper two meters. Below, the flow was almost stagnant and diffusion was the dominating transport process. The water table fluctuations were not influencing the isotope contents.

Assuming equilibrium flow and transport processes it was possible to describe one of the three profiles. The other two were influenced either by fractured flow or by lateral flow processes in different depths favoring winter infiltration to greater depth.

It was shown that the combination of water contents, sediment properties, and water isotopes were able to identify the significantly heterogeneous flow and transport processes in a glacial till.