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Palaeo-hydrogeology of the Cretaceous Sediments of the Williston Basin using Stable Isotopes of Water

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Hydraulic and isotopic data collected from aquifers are typically used to characterize hydrogeological conditions within sedimentary basins. Similar data from confining units are generally not collected despite their ability to provide insights into important water/solute transport controls. In this study, we characterized palaeo-groundwater flow and solute transport mechanisms across 384 m of a Cretaceous shale aquitard in the Williston Basin, Canada, using high-resolution depth profiles of water isotopes (δ18O and δ2H). Water samples were also collected from wells installed in the underlying regional aquifer (Mannville Fm; 93 m thick) and from seepage inflows into potash mine shafts (to 825 m below ground). 1-D numerical transport modeling of isotopic profiles yielded insight into large-scale/long-term solute transport in both Cretaceous sediments and the Basin. Molecular diffusion was determined to be the dominant solute transport mechanism through the aquitard. Transport model simulations suggest average vertical groundwater velocities of <0.05 m/10 ka and an average excess hydraulic head of <10 m. These values are less than anticipated by successive glaciations. The dominant palaeo-event reflected in present-day profiles is introduction during the Pleistocene of glaciogenic meteoric water to the aquifer underlying the aquitard, likely along an aquifer outcrop area east of the site or through local vertical conduits in the aquitard. Simulations suggest these recharge events occurred during one or more glacial periods. The isotopic profile over the upper 25 m of Pleistocene till and shale is consistent with glacial deposition and transport processes within these units during the Holocene (past 10 ka).