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How useful are isoscapes in fractured rock and what can they tell us about governing hydrogeologic parameters?

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Groundwater isoscapes are increasingly applied to a variety of hydrologic investigations including recharge, paleoclimates and catchment processes. Generating stable water isoscapes from a single sample taken from open-hole wells, as is typically the case, poses issues for fractured rock environments that are not present in porous media. To explore the value of isoscapes produced in fractured rock using open boreholes, a study was undertaken across Central and Eastern Ontario, Canada where both sedimentary and crystalline bedrock are highly prevalent as aquifers. The study also aims to reveal the hydrologic factors dominating the stable isotopic value of shallow groundwater in fractured rock. To explore this, a network of nine multi-level wells (25 intervals total) across three field sites were sampled monthly from February 2017 to November 2018 for δ^2H and δ^{18}O. Two rounds of tritium sampling were also conducted during that time period. Multi-level wells were designed based on the results of 2-m interval constant head tests, which enabled the identification of high transmissivity zones (2–3 per well). To contrast these results, a larger, regional groundwater geochemistry dataset produced by the Ontario Geologic Survey (OGS) was utilized. The OGS dataset, consisting of domestic and monitoring open-hole wells, was filtered to include only drilled bedrock wells in the same geologic formations as the multi-level wells (n=162). Spearman correlations between δ^2H and various hydrologic parameters were analysed for both data sets to identify if stronger correlations existed from multi-level wells than open-hole wells. Parameters included drift thickness, bedrock geology, surficial geology, vadose zone thickness, well depth, well transmissivity, tritium value and average annual precipitation among others. For the temporal multi-level data, δ^2H was averaged seasonally to explore whether a seasonal component of sampling drives the strength of the correlations observed. This could be used to optimize how isoscapes are generated in fractured rock. From the results of the correlation analysis, parameters that highly correlated with δ^2H were used in a multiple regression analysis to identify the dominant parameters governing stable isotopes in shallow fractured rock. Results of these analyses will be presented.