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Constructing speleothem paleoclimate records from caves developed in Quaternary dune limestone (SW Australia): An isotopic and modelling study of flow paths and storage

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We investigated the distinctive shallow sub-surface hydrology of the southwest Western Australia (SWWA) dune calcarenite to assess the suitability of this cave for reconstructing speleothem paleoclimate records. This study presents six years of observed rainfall O isotopes; soil moisture, cave drip rate and dripwater O isotopes (Treble et al., in press). A lumped parameter hydrological model is developed to describe water fluxes and dripwater O isotopic composition. Comparison of observed data and model output allow us to assess the critical non-climatic karst hydrological processes that modify the precipitation isotopic signal and discuss the implications for speleothem paleoclimate records from this cave and those with a similar karst setting. Our findings include evidence of multiple reservoirs, characterised by distinct isotopic values and recharge responses ('low' and 'high' flow sites). Dripwaters exhibit isotopic variations in wet versus dry years at low-flow sites receiving diffuse seepage from the epikarst with an attenuated isotopic composition that approximates mean rainfall. Recharge from high-magnitude rain events is stored in a secondary reservoir which is associated with high-flow dripwater that is 1‰ lower than our monitored low-flow sites. One drip site is characterised by mixed-flow behaviour and exhibits a non-linear threshold response after the cessation of drainage from a secondary reservoir following a record dry year (2006). Additionally, our results yield a better understanding of the vadose zone hydrology and dripwater characteristics in Quaternary age dune limestones. We show that flow to our monitored sites is dominated by diffuse flow with inferred transit times of less than one year. Diffuse flow appears to follow vertical preferential paths through the limestone reflecting differences in permeability and deep recharge into the host rock.

Reference
Treble et al. (in press). An isotopic and modelling study of flow paths and storage in Quaternary calcarenite, SW Australia: implications for speleothem paleoclimate records, Quaternary Science Reviews.