Cave stalagmites as records of past recharge frequency in semi-arid Australia

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Understanding past variability in groundwater recharge over recent time scales (0 – 10 ka) in Australia is essential for future sustainable groundwater management in a changing climate. Currently, there are limited data about past infiltration rates and their relationship to environmental controls that dominate recharge variability. Speleothem (cave precipitates) records may provide a new approach to understanding past infiltration (i.e. recharge rates), in addition to traditional interpretations of connectivity between climate and the hydrological cycle, in drier parts of Australia. In this study we used Cathedral Cave, (SE Australia) located in a temperate semi-arid climate, as a natural laboratory to investigate cave infiltration rates and the climate-karst-cave interactions driving the isotopic (δ18O) and chemical variability in modern drip water. These findings were then used to interpret the δ18O stalagmite record from two modern speleothems growing during the last ~50 years. Modern drip water results showed that the δ18O composition was enriched by up to 2.77 ‰ relative to annually weighted mean rainfall. Isotopically lighter δ18O occurred during infiltration events, followed by subsequent isotopic enrichment as evaporation in the unsaturated zone fractionated δ18O of stored water. Drip rate monitoring revealed that larger events leading to infiltration were infrequent (0 – 3 a-1) and the 'effectiveness' of these infiltration events was controlled by antecedent moisture conditions in the soil zone. In drier climatic zones, evaporation drives the enrichment of δ18O in the unsaturated zone, allowing periods of infiltration to be identified from the stable isotopic composition of drip waters. Our findings are important for interpreting speleothem records from regions with infrequent recharge and high evaporation rates. Such records are likely to contain evidence of past infiltration events moderated by an evaporation signal, allowing records of paleo-recharge to be reconstructed for drier climate regions of Australia.