Geophysical Research Abstracts
Vol. 18, EGU2016-549, 2016
EGU General Assembly 2016

Rainfall Control of Karst Solution and the Inter/Intra Annual Hydrogeochemical Evolution of Cave Dripwater: A Long-term, Site-specific Study, Soreq Cave, Israel

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Speleothem laminae preserve climate information transferred to the cave via dripwater. High spatial resolution methods allow in situ measurement of geochemical and isotopic proxies at seasonal resolution. Existing hydrogeochemical calibration models suggest that high rainfall inhibits karst water chemical evolution, resulting in low δ18O values, and low Mg/Ca and Sr/Ca ratios that are not necessarily correlated. Drought periods display opposite chemical behaviour owing to lower infiltration rates and increased Prior Calcite Precipitation (PCP).

This study aims to provide a site-specific, high-resolution hydrogeochemical calibration for the Soreq Cave. We examine four sites that were continuously sampled since 1990. Four main rainfall conditions are characterized: very wet years, average, drought and very dry years. Two sites are fed by 'fast drips', which only become active after ~250mm rainfall has accumulated since the beginning of the winter season. Two sites, located deeper in the cave, are fed by 'slow drips' that are active all year round. Drip rate measurements identify two main reservoirs – fissure and matrix – that mainly differ in residence time. The δ18O of fissure water is closer to that of mean annual rainfall (~-6 ‰), while matrix values are higher (~-3.5 ‰). Two main Sr and Mg sources are identified – dolomitic bedrock (Mg/Ca ~700 mM/M, Sr/Ca ~0.4 mM/M) and soil leachate (Mg/Ca ~300 mM/M, Sr/Ca ~1.1 mM/M). Most cave dripwater evolves from ~1:1 soil-bedrock solution. PCP effect on dripwater solution at each site is estimated by comparing the ln(Mg/Ca) vs ln(Sr/Ca) linear slope to the PCP slope calculated using cave specific D(Mg) and D(Sr). Soreq Cave PCP slope is similar to the global slope of 0.88±0.13.

The composition and chemical evolution of each reservoir and its contribution to water influx at each site is primarily governed by annual effective infiltration. Higher seasonal amplitude in δ18O, Mg/Ca and Sr/Ca in all sites is positively correlated to increase in rainfall. For the deeper site, with rock cover of >40 m, the 'classic' wet-dry model can be applied - more soil input and less PCP in the wetter years and vice-versa. Conversely, in the shallower sites, high PCP is observed in wetter years.

Results from this study are compared with high-resolution δ18O and trace element records of modern speleothems (age ~20y). The speleothem from the deeper site shows a good match with the hydrogeochemical data, thus supporting the applicability of the model to palaeoclimate studies. However, the speleothem from the shallow site shows a strong winter bias, which may be due to complete secession of summer drip during dry years (micro-hiatuses), or during wetter years, considerable winter calcite precipitation resulting in minimal summer imprint on each seasonal lamina. We plan to analyse a fast growing modern sample from the shallow site to resolve this seasonal bias. Therefore, contemporaneous speleothem records from different sites can be utilized to estimate past changes in annual and decadal effective infiltration, allowing evaluation of water availability in the region during periods of rapid climate change.

[1] Orland, I.J. et al. 2014. Chemical Geology, v. 363, p. 322–333.