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Linking speleothem and soil magnetism

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Speleothem magnetism has experienced a revival in the last decade, mostly due to improvements in dating techniques and in the sensitivity of rock magnetometers. Presently, high-resolution magnetic screening of stalagmites down to decadal timescales is possible. Together with isotopic data, magnetic proxies have the potential to unveil the soil dynamics above the cave, which is intrinsically connected to changes in vegetation cover, precipitation, and soil thickness. But the main processes controlling the fluctuations in magnetic mineral content of stalagmites are still not fully understood. In this respect, we can benefit from systematic cave monitoring programs (monthly to trimester) that constrain geochemical, isotopic and physical parameters, including temperature, humidity, atmospheric CO_2, precipitation, pH, dripwater delta18O and delta13C inside and outside the karst system and combine them with soil profiles above the cave to refine the comprehension of the mechanisms involved in iron oxide formation and evolution at decadal to millennial timescales. We will report a case study in the Pau d'Alho cave stalagmite #6, Midwest Brazil that encompasses the past 1355 years with a mean growth rate of $\sim$168 mm/ka. The main magnetic carriers in the stalagmite are magnetite and goethite with a nearly constant relative proportion. ARM and IRM spectra for samples from the stalagmite and the soil cover are similar to that of pedogenic magnetite. Joint interpretation of delta13C, delta18O data and magnetic data indicate that dry (wet) periods are marked by higher (lower) concentrations of magnetic minerals. Therefore, the concentration of magnetic minerals in the stalagmite is not controlled by precipitation alone. It is instead a result of soil dynamics above the cave. Dry periods are associated with less stable soils and result in higher mineral fluxes carried into karst systems. Conversely, wetter periods are associated with soils topped by denser vegetation that retains micrometer-scale pedogenic minerals and thus reduces detrital fluxes into the cave. This study offers a new perspective for speleothem researchers for how rock magnetic techniques may be combined with isotope methods to arrive at a more nuanced paleoclimate reconstruction accounting for short-term variability in soil dynamics.