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What was the oxygen-isotopic composition of Jurassic precipitation?

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Quantifying past changes in hydrological cycling is a major challenge in pre-Quaternary climatic research. Oxygen-isotopes of precipitation are a powerful tool in studying modern hydrological processes but very few mineral phases are thought to accurately record this in the geological record. Sphaerosiderites are small spheres (diameter of $\sim$0.5 mm) of iron carbonate ($FeCO_3$) that form mainly in wetland soils, leading to the *a priori* expectation that their $\delta^{18}O$ reflects soil temperature and the $\delta^{18}O$ of groundwater, which itself reflects the isotopic composition of precipitation. Thus, it has been argued that well-preserved sphaerosiderite can provide a method of constraining terrestrial palaeohydrology in deep geological time.

We present preliminary petrographic, elemental and stable-isotopic ($\delta^{13}C$, $\delta^{18}O$) data from sphaerosiderites collected from mid-Jurassic non-marine sediments exposed in North Yorkshire (UK). The elemental data suggest very that these siderites are very iron-rich with minor amounts of Ca, Mg and Mn. The average mol% $FeCO_3$ is generally greater than 95%, indicating that the siderites precipitated from predominantly fresh ground waters. The sphaerosiderite stable-isotope data for multiple analyses from each sample show relatively invariant $\delta^{18}O$ values, with typical standard deviations less than 0.25‰. Average $\delta^{18}O$ values for each sample are in the range of $\sim$-2.9 to -0.6‰. Average $\delta^{13}C$ values for each sample have a much larger range than $\delta^{18}O$ values, spanning from $\sim$-7 to -20‰. The wide-range of carbon-isotope values reflects the range of mechanisms occurring within the soil, including evidence for methanogenesis at deeper-levels within the soil profiles. The relatively invariant oxygen-isotope values suggest deposition in an environment that was water logged and was not influenced by major changes in evaporation or mixing with other (e.g. marine) water sources. The relationship between $\delta^{18}O$ and $\delta^{13}C$ suggests that so-called "Meteoric Sphaerosiderite Lines" (MSLs) are preserved allowing us to use the invariant $\delta^{18}O$ to reconstruct the oxygen-isotopic composition of Jurassic groundwater and (by inference) precipitation. Through comparison with sphaerosiderite data from the Cretaceous of southern England and North America we discuss the palaeoclimatic significance of the Jurassic data in the context of understanding the mechanics of greenhouse climates.