

Combined modelling of hydrological and hydrochemical dripwater data to deduce karstic plumbing

IAN J FAIRCHILD¹, GEORGE W TUCKWELL¹, ANDY BAKER² AND ANNA F TOOTH³

¹School of Earth Sciences and Geography, Keele University, Staffs ST5 5BG UK; i.j.fairchild@keele.ac.uk

²Department of Geography, University of Newcastle-on-Tyne, UK

³Department of Geology, University of Innsbruck

Two of the incentives for improving our understanding of the vadose zone of karstic aquifers are the need to model the behaviour of pollutants and the drive to find proxy indicators for palaeoclimate in speleothems formed from dripwaters. Specifically, quantitative knowledge of karstic plumbing could generate a predictive capability. Models of karstic plumbing can be approached by combining hydrological and hydrochemical data.

Here we report on a study on data from the disused limestone mines under Browns Folly, Bathford, near Bath (UK) which contain a number of dripwater sites, associated particularly with major open joint systems. The drip sites offer a range of hydrological behaviours that fall within the seepage flow and seasonal drip categories of previous authors, and there is an overall correlation between variation in drip rate and mean drip rate. A sub-set of sites exhibit hydrological behaviour that is clearly tied to major rainfall input events. Such sites also display distinctive variations in geochemistry with drip rate. At low drip rates there is either an evidence for increased prior calcite precipitation in the aquifer above the drip (decrease in Ca), or an increase in Sr/Ca or Mg/Ca from inferred low discharge sub-sections of the aquifer, or both.

Quantitative modelling of three sites representing the full range of mean drip rates has been approached by a box modelling approach with finite time steps, initially calibrated by hydrological response to rainfall events, but tuned by the geochemical data. The results allow different conceptual models of karstic plumbing to be evaluated. In particular the relative importance of macropore flow routes through soils and fissure flow in relation to seepage flow can be determined and possible geometries of coupling of different flow routes can be assessed.

Significance of oxygen isotopic signature in magnetite [Fe^{III}₂Fe^{II}O₄] under Earth surface conditions: preliminary results

D. FAIVRE¹, P. ZUDDAS¹, P. AGRINIER², F. GUYOT³ AND N. MENGUY³

¹Laboratoire de Géochimie des Eaux, Université Paris 7 & IPGP, 2 place Jussieu, 75251 Paris Cédex 05 France (faivre@ipgp.jussieu.fr and zuddas@ipgp.jussieu.fr)

²Laboratoire de Géochimie des Isotopes Stables, IPGP, 4 place Jussieu, 75251 Paris Cédex 05, France (piag@ccr.jussieu.fr)

³Laboratoire de Minéralogie – Cristallographie, Université Paris 7 & IPGP, 2 place Jussieu, 75252 Paris Cédex 05, France (guyot@lmcp.jussieu.fr and menguy@lmcp.jussieu.fr)

Under present surface Earth conditions, nanoparticles of biotic magnetite are intracellularly formed in the magnetosomes of magnetotactic bacteria. Thus, magnetite nanoparticles found in carbonate globules of Martian meteorites have been related to a possible extraterrestrial life. In order to determine if oxygen isotopes can be used as a proxy of bacterial signature, inorganic magnetite has been synthesized under controlled chemical affinity conditions at temperature of 298 K, oxygen fugacity close to 0, ionic strength of 0.2 M and high solution saturation state (> 100). Total dissolved iron of stoichiometric ratio (i.e. Fe^{II} / Fe^{III} = 0.5) was varied to identify the role of this variable on the kinetic rate and on the oxygen isotope fractionation.

Under our experimental conditions, magnetite particles of an average dimension of 8 nm are formed only when [Fe_{tot}] is higher than 9 mM while in lower dissolved iron concentration, only goethite [Fe^{III}O(OH)] particles are formed. Oxygen isotopes fractionation, 10³ln α_{m-e}, decreases by 6 times when the iron concentration increases more than one order of magnitude.

Since biotic magnetites have similar oxygen isotope signature (Mandernack et al., 1999) to our abiotic magnetite particles, we propose that bacteria may simply produce an increase of solution saturation state in the magnetosomes that, in turn, control the precipitation of magnetite nanoparticles in surface conditions.

Mandernack K. W. *et al.* (1999), *Science* **285**, 1892-1896.