Lecture Abstract:

Tracing carbon isotopes from the atmosphere into the cave

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Stable carbon isotopes measured in speleothem carbonates are difficult to interpret. This is mainly due to the multiplicity of processes, which influence the carbon isotopic composition during its way from the atmosphere and soil air into the cave. Although only two main carbon reservoirs – soil air CO_2 and host rock $CaCO_3$ – are thought to be important in most speleothem environments, fractionation between dissolved and gaseous carbon species in the soil and cave, carbon isotope exchange between the dissolved inorganic carbon and soil air CO_2 or vegetation changes in density and composition (C3 vs. C4 plants) make it difficult to interpret those signals properly. Fortunately, invaluable help is provided by the radiogenic carbon isotopic composition of the carbonate. It behaves in the same way as ^{13}C during fractionation, but the ^{14}C content of the individual reservoirs is completely different due to its radioactive decay. Of special advantage for to interpret the carbon transfer dynamics is that old organic matter is depleted in ^{14}C and that radiocarbon is quasi non-existent in the host rock.

In this lecture, I will provide a short overview of the main processes potentially influencing the carbon isotope composition of speleothem $CaCO_3$. I will mainly focus on those influences, which occur before the drip water enters the cave and show that it is worth to perform multi-proxy studies for a better evaluation of changes in the carbon isotopic composition. This will be shown for interesting datasets already published. Of special attention in my lecture is the disentanglement of the most important carbon isotope influencing processes by the use of the stable and radiogenic isotopic composition of stalagmites plus some support from element measurements.

Some interesting papers:

Fohlmeister J., Schröder-Ritzrau A., Spötl C., Frisia S., Miorandi R., Kromer B. and Mangini A. (2010) The influences of hydrology on the radiogenic and stable carbon isotope composition of cave drip water, Grotta di Ernesto (Italy). Radiocarbon 54, 1529–1544.

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Fohlmeister J., Kromer B. and Mangini A. (2011) The influence of soil organic matter age spectrum on the reconstruction of atmospheric ^{14}C levels via stalagmites. Radiocarbon 53, 99–115.

Genty D. and Massault M. (1999) Carbon transfer dynamics from bomb-14C and d13C time series of a laminated stalagmite from SW France – modeling and comparison with other stalagmite records. Geochim. Cosmochim. Acta 63(10), 1537–1548.

Griffiths M.L., Fohlmeister J., Drysdale R.N., Hua Q., Johnson K.R., Hellstrom, J.C, Gagan M.K., Zhao J.-x. (2012) Hydrological control of the dead carbon fraction in a Holocene tropical speleothem, Quaternary Geochronology 14, 81-93.

Hendy C. H. (1971) The isotopic geochemistry of speleothems – I. the calculation of the effects of different modes of formation on the isotopic composition of speleothems and their applicability as palaeoclimatic indicators. Geochim. Cosmochim. Acta 35, 801–824.

Rudzka D., McDermott F., Baldini L.M., Fleitmann. D., Moreno A. and Stoll H. (2011) The coupled $\delta^{13}C$-radiocarbon systematics of three Late Glacial/early Holocene speleothems; insights into soil and cave processes at climatic transitions. Geochim. Cosmochim. Acta 75, 4321-4339.

Rudzka-Phillips D., McDermott F., Jackson A. and Fleitmann D. (2013) Inverse modelling of the ^{14}C bomb pulse in stalagmites to constrain the dynamics of soil carbon cycling at selected European cave sites. Geochim. Cosmochim. Acta 112, 32-51.