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Microscopical speleothem calcite investigations proofing the existence of two different types of fluid inclusions

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Microscopical fluid inclusions in speleothems represent a valuable archive of paleoenvironmental conditions prevailing during the incorporation of the inclusions into the growing speleothem. In a recent pilot study (Scheidegger, 2005) we analysed dissovled noble gases in speleothem fluid inclusions to determine past climate conditions, e.g. mean annual temperature. Noble-gas results from crushing and a subsequent heating step at 600C indicate that speleothems contain two types of fluid inclusions carrying distinct noble gas components, i.e. air and air-saturated water. Light microscopy of several thin sections of speleothem calcite from various caves in the Middle East confirmed this geochemical based hypothesis. We identified two different types of fluid inclusions, i.e. water filled and air filled inclusions.

In speleothems with high abundance of water inclusions the inclusions are arranged in bands parallel to growth layers and vertical to the main growth axis. The water inclusions always lie within single calcite crystals (intra-granular inclusion). Their shape is elongated and their size varies between 1-20μm. Most of the intra-granular water inclusions contain a single gas bubble, which is expected to contain either CO_2 or air that was entrapped during formation (see companion abstract Badertscher et al. 2007). To determine the salinity that prevailed during the formation of the water inclusions we analysed 8 inclusions from one speleothem specimen under a petrographical freezing stage. The resulting melting temperatures range from -0.8 to -0.4˚C leading to salinities between 0.7% and 1.5%. These results indicate that the "initial" salinity

of the drip water, i.e. just before in corporation into the crystal, can be assumed to be equal to that of freshwater.

The air inclusions are either situated within or between the calcite crystal (intra-granular air inclusions vs. inter-granular air inclusions). The inter-granular air inclusions fill the space between the growing calcite minerals, leading to different shapes and sizes between 20-60μm. The intra-granular air inclusions show similar alignment and size as the intra-granular water inclusions. In our analysis we did not find any indication that the air inclusions are fractures that are connected with the surface of the speleothem.

Our results clearly showed that the characteristic patterns of aligment and the amount of both water and air inclusions strongly differ between individual speleothem samples, leading to different water contents and different abundance of air. Hence a detailed microscopic/optical analysis of speleothem calcite is necessary to find adequate samples for a successful analysis of noble gases from speleothem water inclusions. In addition, optical analysis allows the development of experimental approaches to separate air and water inclusions, which is the key to reconstruct environmental conditions from dissolved noble gases in water inclusions.

Ref.: Badertscher et al. (EGU Vienna 2007) *Trace gas content in air inclusions in speleothems as new paleoclimate archive?*

Scheidegger Y. (2005) *Stalagmiten als mögliche Klimaarchive*, Diploma Thesis, D-UWIS, ETH Zurich