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A step to noble gas temperatures from fluid inclusions in stalagmites

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The concentrations of dissolved noble gases in water inclusions in stalagmites are a record of the temperature at the time of formation of the inclusions, due to the temperature dependence of noble gas solubilities. We analysed noble gases in several recent samples in a stalagmite from Sokotra Island (Yemen) to determine noble gas temperatures (NGTs).

Before noble gas analysis the sample (approx. 2g) is crushed to a grain size of about 300μm. This "offline" crushing step cracks the calcite along grain boundaries and removes mainly air inclusions that are situated between calcite crystals. Noble gases are then extracted in an online heating step. For 4 samples the inversion of noble gas abundance yield temperatures of 26ºC$\pm$15ºC, 25ºC$\pm$32ºC, 26ºC$\pm$14ºC, 32ºC$\pm$16ºC. These NGTs agree with the expected cave temperature of 27ºC. The reason for the large errors of ca. 50% is that NGTs are calculated with noble gas ratios only. To calculate more precise NGTs, noble gas concentrations have to be determined, i.e. the mass of the extracted water must be known.

Therefore we set up a system to manometrically determine the amount of water extracted from stalagmite samples. The pressure of the water vapor is measured in a accurately known volume and at a well defined temperature. The volume of the system guarantees that no condensation of the water vapor occurs. This system allows to determine water amounts in the range of 1mg with a precision of 1%.

First stepwise heating experiments of stalagmite samples indicate that fluid inclusion water is predominantly released at temperatures above 300ºC. At temperatures higher than 400ºC an additional non-condensible gas component is liberated. This component might originate from gas bubbles in water inclusions or from remaining air inlcusions that are not opened in the crushing step.

The calculated noble gas concentrations will be determined with a precision of 2% based on the analysed noble gas abundance and the calculated water mass. Therefore the errors of the calculated NGTs will be significantally reduced and the accurate reconstruction of paleotemperatures from dissolved noble gases in stalagmites seems feasible.