Geophysical Research Abstracts
Vol. 14, EGU2012-10907, 2012
EGU General Assembly 2012

Noble gas paleotemperatures and water contents of stalagmites – a new extraction tool and a new paleoclimate proxy

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Stalagmites represent excellent multi-proxy paleoclimate archives as they cover long timescales and can be dated with high precision [e.g., 1]. The absolute temperature at which a stalagmite grew, can be deduced from the amounts of atmospheric noble gases dissolved in the stalagmite's fluid inclusion water (= noble gas temperature, NGT) [2-4]. We present technical advances towards more robust NGT determinations and also propose a new paleoclimate proxy, namely the stalagmite's water content, which is a "by-product" of NGT determination. Water contents and oxygen isotope records of two Holocene stalagmites from Socotra Island (Yemen) were found to vary systematically: progressively lighter oxygen is accompanied by decreasing water contents and vice versa. Via the oxygen isotope records [5] the stalagmites' water contents are linked to the amounts of precipitation on Socotra Island. High precipitation, i.e. high drip rates lead to homogeneous calcite growth with low porosity and therefore a small number of water-filled inclusions, i.e. low water contents. A reduction of drip water supply fosters irregular crystal growth with higher porosity, leading to higher water contents of the calcite (see also [6]). Therefore the stalagmites' water contents seem to record changes in drip water supply and, under favourable conditions, changes in regional precipitation.

The current method to extract water and noble gases from stalagmite samples is experimentally challenging and subject to certain limitations (e.g., time-consuming sample preparation in a glove box, temperature restrictions for water extraction, and the often inadequate correction for air from residual air-filled inclusions [3, 4]). To overcome these limitations we have developed a new type of crusher directly attached to our noble gas line. It not only allows crushing and separating the samples into different grain size fractions in vacuo, but the separates can be individually heated to significantly higher temperatures than before allowing a more quantitative water extraction. Additionally, air released from air-filled inclusions can be analyzed during the crushing procedure with a new quadrupole mass spectrometer. This additional piece of information will considerably improve the above mentioned corrections resulting in more robust and accurate NGTs.

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