

Noble gas paleotemperature records: Recent developments in dating, archives, and interpretation

WERNER AESCHBACH-HERTIG, MARTIN WIESER AND
THOMAS MARX

Institute of Environmental Physics, University of Heidelberg,
D-69120 Heidelberg, Germany
(*correspondence: aeschbach@iup.uni-heidelberg.de)

Noble gases in combination with ^{14}C dating provide the classical tools to derive paleotemperature records from groundwater. This contribution focuses on recent developments that expand the range of archives and dating methods that can be combined with the noble gas thermometer. It also addresses the interpretation of noble gas data, in particular with regard to the formation of excess air and its significance as a climate proxy.

It has been demonstrated that under certain conditions noble gas temperatures can be derived from fluid inclusions in speleothems [1]. While this method holds great potential, the difficulties imposed by disturbing gas components in stalagmites are still very challenging. On the other hand, the increasing importance of the speleothem climate archive raises the interest for applications of groundwater dating techniques such as ^3H - ^3He to cave drip waters [2].

In the groundwater archive, dating remains problematic. Recent studies have tried to use all available information, including the noble gas temperatures, to constrain recharge conditions and thereby improve the dead-carbon correction in the calculation of ^{14}C ages [3]. Another promising approach to broaden the range of dating tools is the development of atom trap trace analysis for Kr and Ar radioisotopes [4]. Here too, however, big challenges remain to be solved.

It becomes increasingly evident that the excess air component in groundwater is not only a disturbance but holds paleoclimatic information. This is for example demonstrated by a recent study from the Indian monsoon region, where the neon excess correlates with stable isotopes, as both indicate changes in monsoon strength. Nevertheless, the processes of excess air formation and the corresponding models for this component are still under discussion. New field experiments to address these questions are currently conducted.

- [1] Kluge *et al.* (2008) *Earth Planet. Sci. Lett.* **269**, 407-414.
[2] Kluge *et al.* (2010) *Isotopes Environ. Health Studies* **46**, 299-311. [3] Blaser *et al.* (2010) *Appl. Geochem.* **25**, 437-55.
[4] Welte *et al.* (2010) *N. J. Phys.* **12**, doi:10.1088/1367-2630/1012/1086/065031.

Kinetic isotopes effects in speleothems: Insight from clumped isotopes and fluid inclusions

H.P. AFFEK¹, S. ZAARUR¹, T. KLUGE¹, A. MATTHEWS²,
Y. BURSTEIN^{2,3}, A. AYALON³ AND M. BAR-MATTHEWS³

¹Dept. of Geology and Geophysics, Yale University, USA

²Inst. of Earth Sciences, Hebrew University, Jerusalem, Israel

³Geological Survey of Israel, Jerusalem, Israel

Carbonate clumped isotopes (Δ_{47}) is a new paleothermometer, based on ^{13}C - ^{18}O abundance, providing temperature estimates that are independent of $\delta^{18}\text{O}$ of the water in which the carbonate was formed. As such it is most relevant for paleoclimate on land, where the complexity of $\delta^{18}\text{O}$ in the hydrological cycle makes temperature reconstruction difficult. A variety of biogenic carbonates adhere to one Δ_{47} -T calibration, developed by inorganic precipitation, which is assumed to reflect isotope equilibrium. Speleothems are a notable exception, with an offset to lower Δ_{47} values, yielding erroneously high temperatures. This offset, due to kinetic isotope effects in CO_2 degassing, is consistent with the offset from nominal ^{18}O equilibrium typically observed in speleothems. We hypothesize that these kinetic effects are related to speleothems forming from thin films of solution, where fast degassing leads to an isotopic offset in DIC, that is recorded in the CaCO_3 forming soon thereafter, due to the long time required to regain isotopic equilibrium. To gain further insight we synthesized CaCO_3 by surface precipitation, mimicking thin film carbonate formation. The resulting Δ_{47} -T is less steep than in biogenic carbonates, and is consistent with Δ_{47} in modern stalagmites from several caves. Such calibration may enable extraction of drip water $\delta^{18}\text{O}$, while accounting for ^{18}O kinetic offset, using a theory based assumption of a constant $\delta^{18}\text{O}$ - Δ_{47} kinetic trajectory. We will explore this assumption using laboratory experiments of $\delta^{18}\text{O}$ in surface calcite precipitation, and by comparison with fluid inclusions water isotopic composition in Soreq cave.