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Potential and problems of using noble gas temperatures to calibrate the stable isotope thermometer

W. Aeschbach-Hertig

Institute of Environmental Physics, University of Heidelberg, Germany
(aeschbach@iup.uni-heidelberg.de)

The isotopic composition of precipitation reflects temperature as a result of Rayleigh fractionation, but there exists no universal relationship between temperature and stable isotope values. One possibility to address this limitation of the stable isotope paleothermometer is to derive the temperature - δ^{18}O (or δ^{2}H) relationship by correlating stable isotope data and noble gas temperatures (NGTs) obtained from groundwater. Whereas groundwater is not an ideal paleoclimate archive in terms of resolution and age control, it provides the unique opportunity to relate stable isotope values to absolute paleotemperatures derived from dissolved noble gas concentrations. This approach has been used in several studies to derive regional long-term (glacial-interglacial) δ^{18}O - temperature slopes.

Although rather straightforward in principle, this approach also has its difficulties, related to various effects influencing both the stable isotopes and NGTs in groundwater. In semi-arid regions, NGT as a proxy of mean annual air temperature may be affected by changes of the soil temperature - air temperature relationship in response to changing aridity. On long time scales, stable isotopes in groundwaters are affected among other things by changes of the global ice-volume as well as the local continentality and aridity. Strong monsoon-related but apparently temperature independent changes in stable isotope values were observed in a recent groundwater study in China. This and other examples of δ^{18}O - temperature relationships derived from groundwater will be presented and discussed. Apparent δ^{18}O - NGT slopes vary considerably, ranging from slightly negative values up to about 0.5 permil per $^{\circ}$C. In summary, these data sets constitute a warning against direct application of modern δ^{18}O - temperature relationships to paleoclimate records extending back to the last glaciation.