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Paleoclimate reconstruction for the past millennium from groundwater using ^{39}Ar dating and noble gas temperatures

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The combination of age dating tracers with noble gas temperatures (NGTs) has provided much information about past climatic conditions, especially for the time scale accessible by radiocarbon dating, including the transition from the Last Glacial Maximum (LGM) to the Holocene. Now, with the availability of the Atom Trap Trace Analysis method for ^{39}Ar (ArTTA), the corresponding time scale of the past millennium can be examined in more detail in groundwater NGT studies. Combining the centennial-scale age estimates obtained from ^{39}Ar (half-life 269 yr) with established dating tools for younger groundwater, such as anthropogenic transient gas tracers (CFCs, SF_6), as well as ^{14}C for older water componentes can yield much more complete age distributions. This in itself can provide information about environmental changes and processes during the past millennium, which could hardly be identified without ^{39}Ar. Adding temperature and possibly precipitation information gained from noble gas concentrations (NGTs and excess air) opens the door to more detailed climate records involving potential variations such as the Medieval Warm Period (950-1250 BP) and the Little Ice Age (roughly between the 16th and 19th century BP).

Our recent research has included several field campaigns for groundwater sampling in Germany and neighbouring countries, each involving the sampling of ^{14}C, CFCs, SF_6, and ^{39}Ar as well as the measurement of noble gas concentrations. For each of the locations, previous studies indicate groundwater ages on the millennial time scale and, therefore, the applicability of the mentioned tracers. Results involving the age distribution of the groundwater and temperature records will be presented. On this time scale, besides the challenge of obtaining an accurate chronology, the requirements for the precision of NGTs are much higher than for the quantification of the large LGM – Holocene temperature change. Effects such as changes in vegetation or oxygen consumption may alter the conditions in the soil that are recorded by the noble gases. Such potential confounding effects need to be taken into account.