Towards dating ocean water and glacier ice with Atom Trap Trace Analysis of ^{39}Ar

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Atom Trap Trace Analysis (ATTA) is an ultra-sensitive counting method for rare and long-lived isotopes. It is based on the high selectivity of resonant photon scattering during laser cooling and trapping in order to distinguish the rare isotope from the abundant ones. It has been developed during the past two decades for the rare krypton isotopes and is now routinely available for the earth science community [1].

We have focused on the rare argon isotope ^{39}Ar. As an inert noble gas and with a half-life of 269 years it is the perfect tracer to fill the dating gap for ice and water samples between 50 and 1.000 years before present, for which time period no other tracers exist. ^{39}Ar data can therefore strongly improve the information about the age of a sample in groundwater, ice and ocean studies.

The experimental challenge lies in the low atmospheric abundance of ^{39}Ar (^{39}Ar/Ar = $8.23 \cdot 10^{-16}$), which is more than 600 times lower compared to ^{81}Kr, and in the absence of an abundant reference isotope with hyperfine structure. Using atmospheric ^{39}Ar as a reference requires a stable and reproducible performance of the apparatus leading to a robust ^{39}Ar detection efficiency. An atmospheric count rate of 3.6 atoms/h allowed the first demonstration of its applicability for groundwater dating [2]. In order to avoid any cross-sample contamination, several tons of water (corresponding to 500 – 800 ml STP of argon) were sampled and degassed for this first demonstration. Current developments aim at reducing the needed sample size down to 4 - 10 ml STP of argon, which corresponds to 10 - 25 L of water or 4 - 10 kg of ice. Such sample sizes are a prerequisite for a convenient application of ^{39}Ar dating in most environmental systems.

We will report on the status of dating with small samples from studies of ocean water in the oxygen minimum zone of the Eastern Tropical North Atlantic and of ice taken from the tongue of Gorner Glacier in the Swiss Alps.

[1] Jiang et al. (2012) *GCA* **91**, 1–6.
[2] Ritterbusch et al. (2014) *GRL* **41**, 6758–6764