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First Application of ^{39}Ar-ATTA in Lake Water – Highly Enriched ^{39}Ar Concentrations in Lake Kivu

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Understanding the hydrodynamics of meromictic gas-rich lakes is crucial for predicting and preventing hazards posed by limnic eruptions. In this work, the quantum technological argon trap trace analysis (ArTTA) method was applied for the first time in lake water. ArTTA can resolve very low isotopic abundances of about 10^{-16}, requiring only a few liters of lake water. General aspects and physical limitations of the ArTTA method and its application will be explained. Emphasis is placed on experiences and methods for sampling gas-rich lakes.

The depth profile of Lake Kivu, located on the border between the Democratic Republic of the Congo and Rwanda, was sampled in March 2018 and June 2019 down to a depth of 430 m (maximum depth 485 m). Two different sampling methods were used. Water samples were collected above the strong gas pressure gradient at 250 m and gas samples below. Unexpectedly strongly enriched ^{39}Ar isotopic abundances at 280 m and 350 m depths made the use of ^{39}Ar as a dating tracer initially infeasible. Instead, the results were evaluated using the 1D lake model Simstrat adapted to Lake Kivu including its known sublacustrine groundwater intrusions by Bärenbold et al. [1]. New parameters describing the concentrations of the different argon isotopes in the lake and the inflows were added. The application of the extended model to the obtained measurement results allows to draw conclusions about the ^{39}Ar isotope abundances of the groundwater intrusions of Lake Kivu. Two of these intrusions at depths of 310 m and 330 m were identified as having highly enriched ^{39}Ar concentrations. These high ^{39}Ar concentrations provide evidence of volcanic influence on the groundwater system around Lake Kivu, as subsurface ^{39}Ar production is expected in the bedrock of Nyiragongo.

All in all, the ArTTA method was successfully introduced for limnological research. New knowledge was gained about the water column of Lake Kivu and the volcanic groundwater system.

[1] Bärenbold et al. (2022), *Environmental Modelling & Software* 147, 105251.