Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.5856

Upper age limit of cosmogenic ^{39}Ar dating extended to 1,800 years

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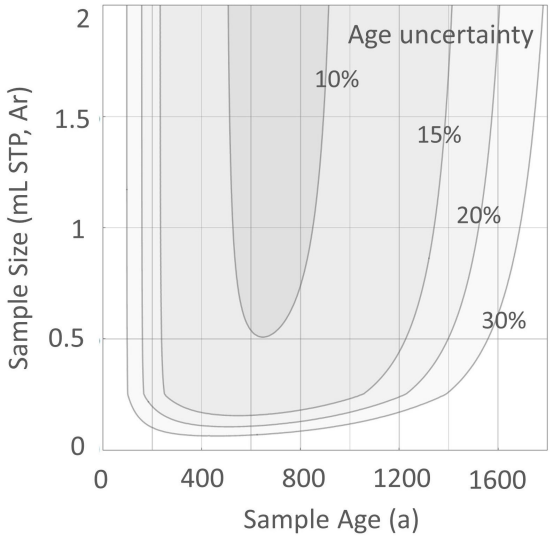

Cosmogenic ^{39}Ar dating is an emerging technique in tracing groundwater flow, dating mountain glacier ice, and mapping ocean circulation. We have realized a system for atom trap trace analysis of the radioactive isotope ^{39}Ar (half-life = 269 years) in environmental samples. The system is capable of analysing small (1 - 5 kg) environmental water or ice samples, and achieves a count rate of 10 atoms/h for ^{39}Ar at the modern isotopic abundance level of 8×10^{-16}. By switching frequently between counting ^{39}Ar atoms and measuring the stable and abundant isotope ^{38}Ar, drift effects in the trapping efficiency are largely suppressed, leading to a more precise measurement of the isotope ratio ^{39}Ar/^{38}Ar. These advances allow us to determine the ^{39}Ar age in the range of 250 – 1,300 years with precisions better than 15%. Moreover, cleaning techniques are developed to alleviate cross-sample contamination. This has made it possible to achieve a detection limit at 1% of the modern ^{39}Ar/Ar level. The upper age reach of ^{39}Ar dating has thus been extended to 1,800 years.

Furthermore, technical developments that may increase the ^{39}Ar count rate by orders of magnitude will also be discussed. This includes a pre-enrichment system that can increase the isotopic abundance of ^{39}Ar in the Ar sample by a factor of 100 before the atom-trap analysis. These developments, if successful, will enable large scale applications of ^{39}Ar dating.

As of 2021, the laboratory for radio-noble gas dating at the University of Science of Technology of China has full capabilities to perform analysis of ^{81}Kr, ^{85}Kr and ^{39}Ar. Together with ^{14}C they can cover a wide age range from a few years to 1.3 million years.

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