^{81}Kr-dating: From dream to practice

Z.-T. LU

Physics Division, Argonne National Laboratory, Dept. of Physics and Enrico Fermi Inst., Univ. of Chicago (lu@anl.gov)

Since radiocarbon dating was first demonstrated in 1949, the field of trace analyses of long-lived cosmogenic isotopes has seen steady growth in both analytical methods and applicable isotopes. The impact of such analyses has reached a wide range of scientific and technological areas. A new method, named *Atom Trap Trace Analysis (ATTA)*, was recently developed and used to analyze ^{81}Kr ($t_{1/2} = 2.3\times10^5$ years, isotopic abundance ~ 1×10^{-12}) and ^{85}Kr ($t_{1/2}$ = 11 years, isotopic abundance ~ 1×10^{-11}) in environmental samples. ^{81}Kr is produced by cosmic rays in the upper atmosphere. It is the ideal tracer for dating ice and groundwater in the age range of 10^4–10^6 years beyond the reach of radiocarbon dating. On the other hand, analyses of ^{85}Kr, a fission product of uranium and plutonium, can serve as a means to help verify compliance with the Nuclear Non-Proliferation Treaty as well as dating young groundwater. In ATTA, individual atoms of the desired isotope are selectively captured into a laser-based atom trap and detected by observing the fluorescence of trapped atoms. As the first real-world application of ATTA, the mean residence time of the old groundwater in the Nubian Aquifer located underneath the Sahara Desert was determined. With this demonstration and further improvements in the ATTA method, wide spread use of ^{81}Kr-dating in Earth sciences seems feasible. This work is supported by the U.S. Department of Energy, Office of Nuclear Physics, under contract W-31-109-ENG-38, and by the U.S. National Science Foundation grant EAR-0126297.

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Project website: http://www-mep.phy.anl.gov/atta/
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News from the oldest ice on Earth buried in Antarctica, and a new cosmogenic tool

J. M. SCHAEFER[1], C. SCHLUECHTER[2], R. WIELER[3], S. IVY-OCHS[3], P. KUBIK[3], D. MARCHANT[4], G. KORSCHINEK[5], K. KNIE[5], G. HERZOG[6] AND F. SEREFIDDIN[6]

[1]Lamont-Doherty Earth Observatory, Palisades (schaefer@ldeo.columbia.edu)
[2]University of Berne, Berne Switzerland
[3]ETH Zuerich, Zuerich, Switzerland
[4]Boston University, Boston, USA
[5]TU Munich, Munich, Germany
[6]Rutgers University, Piscataway/New Brunswick

Methodological progress of Terrestrial Cosmogenic Nuclides (TCN) and their applications to forefront earth scientific problems have been surging over the last 10 years. We present case-studies to illustrate the potential of dating earth surface processes over a time-scale spanning from thousands to millions of years. As an example of the rapid methodological progress, we report very recent measurements of in-situ cosmogenic ^{53}Mn, a new member of the TCN family.

We give an update of our current research regarding the age, formation, and climate significance of the oldest ice on Earth in Beacon Valley, Antarctica, based on new cosmogenic noble gas data. Although there is general agreement that the buried ice bodies in the Dry Valleys represent potentially important climate archives well beyond the ice-core time-range, the formation mechanism and age of these features is still uncertain.

We used the same samples from Antarctica to perform the first successful measurements of terrestrial ^{53}Mn. The consistency between in-situ cosmogenic ^{53}Mn and cosmogenic noble gas data is striking and allows a first quantification of the production rate of terrestrial ^{53}Mn. We give a protocol to apply the new cosmogenic nuclide together with an overview of advantages, current limitations and potential improvements.

Finally, we give a short overview of the existing limitations of the TCN method and strategies to go beyond these limits. Such strategies are the core of the international multi-group CRONUS-Earth initiative, which will be introduced in detail in a companion poster.