



## **$^{81}\text{Kr}$ -dating is now available**

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Due to its simple production and transport processes in the terrestrial environment, the long-lived noble-gas isotope  $^{81}\text{Kr}$  is the ideal tracer for old water and ice in the age range of  $10^5$ - $10^6$  years, a range beyond the reach of  $^{14}\text{C}$ .  $^{81}\text{Kr}$ -dating, a concept pursued over the past four decades by numerous laboratories employing a variety of techniques, is now available for the first time to the earth science community at large. This is made possible by the development of ATTA-3, an efficient and selective atom counter based on the Atom Trap Trace Analysis method and capable of measuring both  $^{81}\text{Kr}/\text{Kr}$  and  $^{85}\text{Kr}/\text{Kr}$  ratios of environmental samples in the range of  $10^{-14}$ - $10^{-10}$ . The instrument was calibrated with 12 samples whose  $^{85}\text{Kr}/\text{Kr}$  ratios were independently measured using Low Level Decay Counting, including six samples that were measured in a blind arrangement. Compared to the previously reported ATTA-2 instrument, the counting rates of ATTA-3 are higher by two orders of magnitude and the required sample size lower by one order of magnitude. For  $^{81}\text{Kr}$ -dating in the age range of 200 – 1,500 kyr, the required sample size is 5 – 10 micro-L STP of krypton gas, which can be extracted from approximately 100 – 200 kg of water or 40 – 80 kg of ice. Moreover, a laser-induced quenching scheme was developed to enable measurements of both the rare  $^{81,85}\text{Kr}$  and the abundant  $^{83}\text{Kr}$ , whose isotopic abundances differ by 11 orders of magnitude. This scheme allows ATTA-3 to directly determine  $^{81}\text{Kr}/\text{Kr}$  and  $^{85}\text{Kr}/\text{Kr}$  ratios without other supplemental measurements. Combining the significant reduction in sample size with numerous advances in the measurement procedure, ATTA-3 represents the state-of-the-art instrument for routine analysis of these rare noble gas tracers in a wide range of earth science applications.

More information regarding ATTA-3 is posted at <http://www.phy.anl.gov/mep/atta/>. This work is supported by the U.S. DOE, Office of Nuclear Physics, under contract DE-AC02-06CH11357; and by NSF, Division of Earth Sciences, under Award No. EAR-0651161.