

⁸¹Kr: a New Tracer of Old Groundwater Flow

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⁸¹Kr-dating is now available to the earth science community at large. Due to its simple production and transport processes in the terrestrial environment, ⁸¹Kr (half-life = 230,000 yr) is the ideal tracer for old water and ice in the age range of 10⁵-10⁶ years, a range beyond the reach of ¹⁴C. An instrument based on the Atom Trap Trace Analysis (ATTA) method is capable of measuring both ⁸¹Kr/Kr and ⁸⁵Kr/Kr ratios of environmental samples in the range of 10⁻¹⁴-10⁻¹⁰. For ⁸¹Kr-dating in the age range of 150 kyr – 1500 kyr, the required sample size is 5 micro-L STP of krypton gas, which can be extracted from approximately 100 kg of water or 40 kg of ice. For ⁸⁵Kr/Kr analysis, the required sample size is 20 kg of water. We are continually developing the ATTA method towards a higher counting efficiency, and therefore expect to require smaller sample sizes in the future.

In the past two years, the Laboratory for Radiokrypton Dating has measured both ⁸¹Kr/Kr and ⁸⁵Kr/Kr ratios in over 80 samples that had been extracted by collaborators from six different continents. The samples were from groundwater wells in the Great Artesian Basin (Australia), Guarani Aquifer (Brazil), and Locust Grove (Maryland); from brine wells of the Waste Isolation Pilot Plant (New Mexico); from geothermal steam vents in Yellowstone National Park; from near-surface ice at Taylor Glacier, Antarctica; and from deep mines in South Africa. Sample purification was performed by collaborators at the University of Illinois at Chicago and University of Bern.

ATTA is a laser-based atom counting method, not a mass spectrometry method. Individual neutral atoms, not ions, of the desired isotope are captured by laser beams, and their fluorescence detected with a CCD camera. ATTA is unique among trace analysis techniques in that it is free of interferences from any other isotopes, isobars, atomic or molecular species.

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Research website: <http://www.phy.anl.gov/mep/atta/>. An article reviewing both the ATTA method and applications: <http://dx.doi.org/10.1016/j.earscirev.2013.09.002>