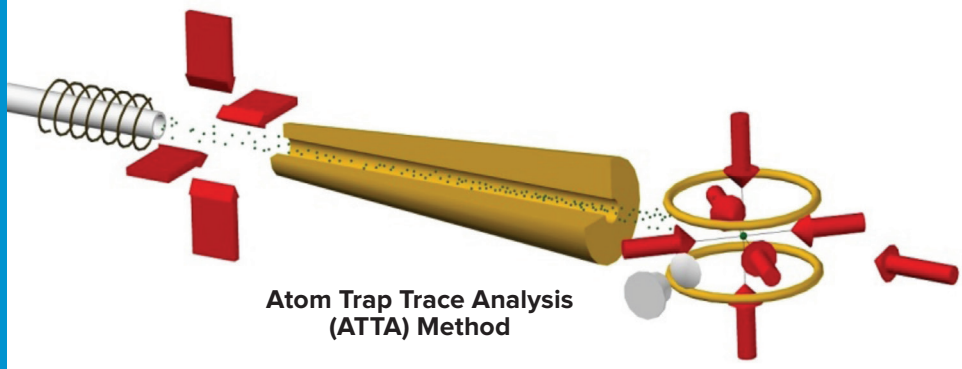
Argonne NATIONAL LABORATORY

ARGONNE TRACER CENTER

Using ATTA technology for your tracer and dating needs



Atom Trap Trace Analysis (ATTA) Method

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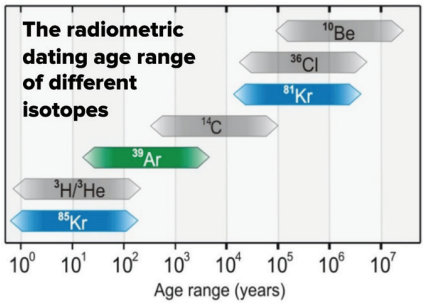
- ☐ Detects ^{81}Kr and ^{85}Kr
- ☐ Single-atom sensitivity at abundances as low as 10^{-16}
- ☐ Enhanced timescales over radiocarbon dating
- ☐ Background and contamination free (unlike LLC and AMS)
- ☐ Rapid dating of small (10µl) krypton gas samples
- ☐ Small sample sizes (less than 100 liters of water)
- ☐ Portable gas extraction systems
- ☐ Dedicated, state-of-the-art, high-throughput measurement system
- ☐ ATTA technique developed at Argonne
- ☐ Samples measured from all seven continents

WHAT IS TRACER?

The TRACER Center uses Atom Trap Trace Analysis (ATTA), a laser-based atom trap, to selectively capture and detect isotopes of interest including ^{81}Kr and ^{85}Kr. The novel and unique technique, developed at Argonne, features unprecedented sensitivity and broad applications in geoscience, geochemistry, and other areas.

WHY ^{81}Kr AND ^{85}Kr?

The different half-lives of ^{81}Kr and ^{85}Kr allow for dating over a wide range of ages. Also, as noble gases, mixing and transport processes for these isotopes are simple and well understood.



The dating range for a particular isotope depends on its decay half-life.

THE ATTA PROCESS

From client-supplied samples, TRACER researchers extract the radioactive noble gas and inject it into the ATTA beamline. Lasers cool and trap atoms of a selected isotope at the end of the beamline, where the trapped atoms scatter laser light into a camera, providing a means by which to count them—down to the single atom. Once the sample measurement is complete, a calibrated reference gas is injected into the system and similarly measured for comparison.

NEW ENHANCEMENTS

Reduced environmental sample sizes: For water and ice dating, TRACER requires a sample of less than 100 liters of water.

Simplified sample collection: TRACER's portable compact gas extraction systems allow clients to collect their own samples.

Two state-of-the-art ATTA instruments: TRACER has a dedicated high-throughput instrument for measurements to broaden the availability of radiokrypton dating, as well an instrument for continued R&D.

U.S. DEPARTMENT OF ENERGY
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RECENT EXAMPLES OF SCIENCE ENABLED BY ATTA DATING

Mapping Groundwater in Arid Regions

One of only a few such facilities in the world, TRACER allows for mapping of groundwater flow, availability, and replenishment rates to inform efforts in water-resource management via radiokrypton dating. Working with Ben-Gurion University of the Negev in Israel, TRACER's high-precision evaluations identified water much older than the expected age of 30,000 – 50,000 years, prompting a reevaluation of the nation's limited water resources and an additional measurement campaign.

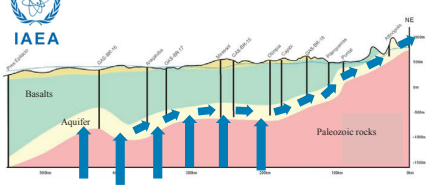
Ben-Gurion University of the Negev

Radiokrypton dating conducted throughout the Negev Desert and Arava Valley in southern Israel.

Continental Degassing of Helium-4

A comparison between the radiokrypton age and a survey of helium isotopes in samples from the Guarani aquifer improved understandings of helium migration pathways into the atmosphere—the results of which imply the need for a reassessment of how the atmospheric helium budget is estimated.

IAEA



Helium rises from the crust and mantle into the aquifer, flows through the aquifer, and is released into the atmosphere at surficial discharge regions.

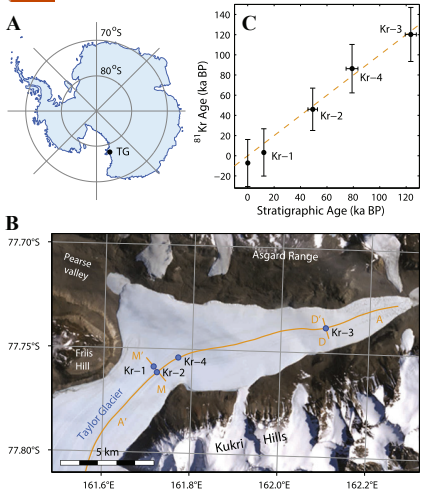
P.K. Aggarwal, et al., *Nature Geoscience*, 8, 35 (2015).

Samples measured from all seven continents in more than 20 collaborative projects

Ancient Ice Dating in Taylor Glacier

Using ice samples from the Taylor Glacier (with a known age obtained through stratigraphic techniques), the TRACER team demonstrated ATTA's ability to reliably date old surface ice. Future sample-size reductions will enable ATTA to date deep ice-core samples where no known stratigraphic age exists, thus extending our knowledge of the earth's atmosphere to several million years ago.

OSU Oregon State

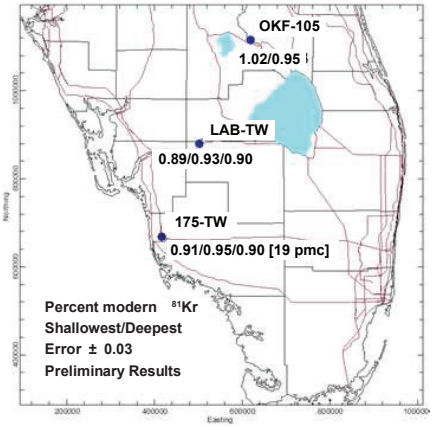


(A) Location of Taylor Glacier
(B) Satellite imagery of Taylor Glacier with sample locations labeled
(C) Comparison of ^{81}Kr radiometric ages to independent stratigraphic ages, in thousands of years before 1950 CE (ka BP)
C. Buizert, et al., 2014 PNAS 111:6877

Floridan Aquifer Investigation

Results of samples taken from the southern end of the Floridan aquifer will allow a better understanding of how these aquifers were recharged after the Last Glacial Maximum and to test for seawater intrusion. TRACER ages will also be used to verify the corrections applied to radiocarbon dating to account for the various sources of radiocarbon within the aquifer.

THE UNIVERSITY OF CHICAGO



Radiokypton dating on wells in Florida with multiple sampling depths for comparison with radiocarbon results.

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