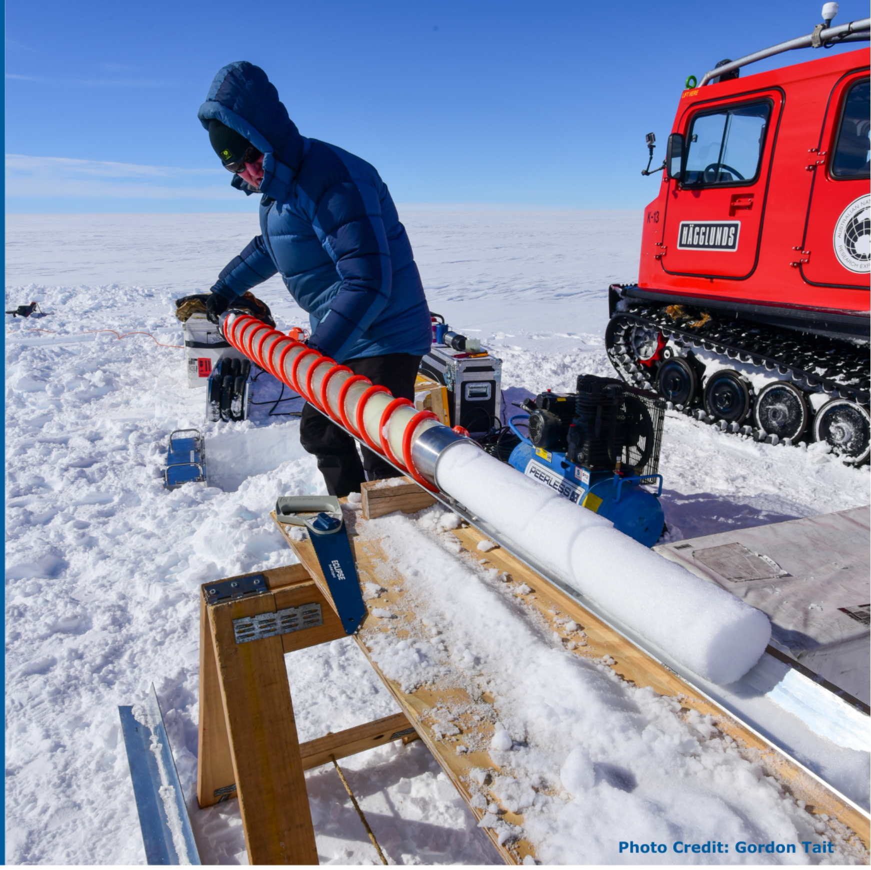
ATOM TRAP TRACE ANALYSIS (ATTA) FACILITIES

"Enabling the measurement of radiokrypton and radioargon at unprecedented levels of detection, requiring comparably small sampling volumes of water or ice."



ABOUT THE FACILITY

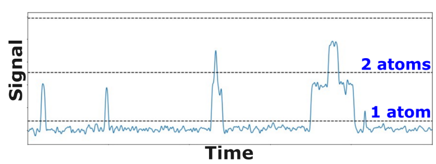
A partnership between the Institute for Photonics and Advanced Sensing at The University of Adelaide and the CSIRO delivering new infrastructure for the detection of naturally occurring radiokrypton and radioargon in groundwater using innovative Atom Trap Trace Analysis (ATTA) laser-based technology.

This new capability will be unique in Australia and will deliver new insights primarily in groundwater hydrology, but equally so in glaciology and ocean circulation. Enabling Australia to position itself to better manage and adapt to our changing climate and respond to future risks and uncertainties.

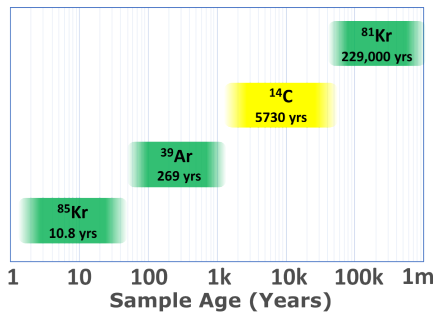
The ATTA facility in combination with CSIRO's stable noble gas facility will provide government, industry, and academia with an unprecedented scientific tool to address Australian challenges: adaptation to climate change via groundwater response to climate variability; improved health outcomes from protection of our finite groundwater resources against contamination from organic and inorganic compounds, and support for the development of a hydrogen roadmap by identifying underground rock conditions suitable for hydrogen storage.

Traditional environmental tracers like CFC's and radiocarbon are an established method for conceptualizing hydrological systems. However, these tracers can often be influenced adversely by chemical reaction rates and environmental unknowns that complicate their use or in cases makes them inapplicable. Noble gas radioisotopes are chemically inert making them ideal environmental tracers, providing a reliable measurement of groundwater residence time. Moreover, they allow dating on important timescales outside the traditional measurement range.

"Noble gas radioisotopes are superior to traditional environmental tracers since they are non-reactive with mineral surfaces and provide dating up to a million years."



Above: The ATTA technique is based on counting single atoms detected via fluorescence from the atom trap and does not suffer from isobars.



Above: The three noble gas isotopes, ^{85}Kr, ^{39}Ar, and ^{81}Kr have half lives that, between them, cover an incredibly broad dating range and are complimentary to traditional tracers like ^{14}C.

These incredible tools come with an immense challenge: they are amongst the most difficult to measure because of their very low concentration, down to parts in 10^{17} and their scientific application has, until recently, been extremely limited.

The advent of the ATTA technique has changed the outlook, it is the only way to do routine analysis on comparably small sample sizes. Our ATTA facility aims to provide a capability to do routine analysis of these isotopes in Australia. Combined with the CSIRO's stable noble gas facility, Australia now has one of the most comprehensive noble gas analysis capabilities in the world.

KEY APPLICATIONS

The ability to deliver insight into the age, origin, and interconnectivity of groundwater systems is crucial for effective management, including for verification of groundwater models, environmental impact assessment and risk management. The half-lives of each isotope make them unique:

From 1 year to several decades: Krypton-85 for migration of contaminants e.g. PFAS, and for environmental nuclear monitoring.

From 50 to 1000's of years: Argon-39 targets anthropogenic impacts, e.g. sustainable mining and agriculture. It is also ideal for mapping processes in physical oceanography, e.g., ocean circulation and ventilation for measuring the global CO_2 uptake.

Up to a million years: Krypton-81 for understanding recharge rates of ancient hydrological systems, and tracing groundwater over geological timescales to inform on the hydraulic connectivity of tight rock formations for safe disposal of nuclear waste, hydrogen, and carbon. Krypton-81 also provides independent age measurements in glaciology, e.g. the age of blue ice outcrops.

OUTLOOK

The radioisotopes of krypton, ^{85}Kr and ^{81}Kr, have been measured at the Adelaide facility since 2022. Individual atoms are imaged and counted using the atom trap designed and developed by our researchers. By comparing the isotope concentration in a sample to measurements from a known reference, the concentration in the unknown sample is determined. Volumes as small as 1 μL of krypton gas, from 20 L of water or 10kg of ice can be measured. These recent advances are enabling us to transition to operation as a semi-commercial facility, servicing government, industry, and academia. The facility is ready to contribute in several key areas:

Water security and **sustainable development**, towards substantially increasing water-use efficiency across all sectors and ensuring sustainable withdrawals and supply of freshwater to address water scarcity.

Climate change and variability and its impact on groundwater systems and groundwater dependent systems.

Supporting **decarbonisation** initiatives such as hydrogen storage where environmental tracers are used to characterise deep rocks for underground storage.

Measurement of **million-year-old ice** and contributing towards understanding of Earth's past climate.

Measurements with Argon-39 and dating with ice cores will be targeted in future work.

Contact to chat about applications!
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