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PORTFOLIO OF RECENT CLIMATE CHANGE STUDIES UTILISING AMS AT ANTARES, ANSTO*

(Abstract)

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The application of Accelerator Mass Spectrometry (AMS) to the measurement of the radionuclides ^{14}C, ^{10}Be, ^{26}Al and ^{36}Cl has dramatically increased our understanding of factors that affect climate and has led to a greater understanding of natural processes. Using the ANTARES AMS facility at ANSTO we are able to analyse samples containing as few as 10^5 atoms of these radionuclides.

Cosmogenic radionuclides produced by the interaction of cosmic rays with the upper atmosphere and exposed surface rocks are stored in natural archives. By measuring small variations in the concentrations of these isotopes over time, information can be inferred about the systems governing these changes.

Over the last four years we have undertaken a broad range of climate change and environmental studies, based on the ultra-sensitive technique of accelerator mass spectrometry (AMS). Some specific examples of projects investigating the ice sheet at Law Dome, Antarctica and minerals extracted from geological surface formations will be given.

To support this research program, ANSTO operates a suite of geochemistry laboratories specifically for the processing of ice, sediment and rock samples into AMS targets, in addition to pre-treatment and preparation laboratories for radiocarbon sample processing.

Cosmogenic Isotopes as Palaeo-archives in Air from Polar Ice: Accumulating ice sheets consist of a porous, compacting layer of snow (the firn) overlying the compacted, impervious ice.

Due to diffusive and gravitational mixing of the air in the firn (age spreading) and the air bubble formation process in the ice which further convolutes the atmospheric signal, there have been difficulties establishing the chronology of palaeo-atmosphere archives within the ice. By measuring the CO_2 ^{14}C bomb pulse it has been possible to improve the numerical modelling of these processes, resulting in direct improvements in the chronology and resolution of important long term Southern Hemisphere atmospheric records.

In addition, CH_4 was extracted from the firn air samples to examine the anthropogenic contribution from fossil fuel use to the global atmospheric methane budget.

Methods of gas extraction, target preparation and AMS measurement were developed to treat samples containing as little as 12μg of carbon. Aspects of these methods and applications will be discussed.

^{10}Be in Antarctic Ice: ^{10}Be concentration in ice is often assumed to be dependent on the snow accumulation rate. We decided to test the validity of this approach in recent times by measuring the ^{10}Be concentration in 3 cores from Law Dome, Antarctica, with known chronology and from sites with widely varying accumulation rates [1]. These sites receive snowfall from the same air mass as it moves from east to west across the dome.

* Only an abstract is given here as the full paper was not available.

The known chronology permitted sampling from mid year to mid year, with an annual sample having an approximate volume of 1L.

Sample handling and preparation techniques were devised to limit contamination of the ice by terrestrial dust and to maximise retention of the ~10^6 ^{10}Be atoms present. A combination of clean room procedures, filter arrays and ion exchange chromatography were used.

This investigation determined that ^{10}Be had been primarily deposited by wet deposition in recent times, and consequently the measured ^{10}Be concentration contained no information about the accumulation rate. Several pilot studies have been conceived by this work, for example examination of the transport processes involved in incorporating ^{10}Be into the ice by utilising the large disparity between half-lives for ^{7}Be and ^{10}Be. Aspects of these studies and the methodology used will be discussed.

In situ cosmogenic radionuclides: By measuring *in situ* produced cosmogenic radionuclides accumulated in minerals, the history or evolution of geomorphic formations, where previously buried mineral material has been exposed to cosmic ray irradiation, can be elucidated [2].

This technique is generally applicable to the time period between 5ka to 5Ma, and where erosion rates are within 0.1 to 10 mm/ka.

Due to the many factors affecting *in situ* accumulation rates (eg altitude, latitude, burial of the surface, shielding from cosmic radiation and carry over of cosmogenic isotopes from previous exposures) an intimate knowledge of the geomorphology and geology of the sampling environment are imperative.

The ANTARES AMS facility, ANSTO, has been used to collaboratively examine a number of geological events. Some examples of such projects are:

- Study of ^{10}Be depth profiles from sand regolith escarpments to determine their formation history.
- To determine the extent and history of Pleistocene glacial advances in key Tasmanian and Antarctic glaciation sites.
- A search for evidence of the Southern Hemisphere younger Dryas in New Zealand and Tasmania.

It has been critical to these projects to provide sample processing abilities of high precision [3]. Young samples (<15ka) such as those required for a younger Dryas search contain less target material (^{10}Be, ^{26}Al and ^{36}Cl) and therefore require more careful handling. Also, to simplify calculation of sample ages from measurement results, a single mineral matrix (generally quartz) is isolated from the sampled rock types and processed. Aspects of these applications for exposure age dating and the sample processing required for these projects will be discussed.

REFERENCES

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