Revealing climate secrets of the past with isotopes.

The study of global climate change recorded and archived in corals, tree-rings, glacial deposits, ocean sediments and ice cores reveals a complex scale of variations ranging from major Glacial Cycles (100,000 years), millennial (1,000 years) timescales and even decadal changes (ie El Nino).

'Global patterns' of climate change are inferred principally from Northern Hemisphere records and modelling approaches. For the major Glaciations this seems to be reliable – however data is now emerging that on shorter timescales, Earth's climate change behaviour, particularly over the transition from the Last Glacial Maximum (about 25,000 years ago) to the beginning of the warmer interglacial period of today, things are not so simple, let alone 'global'. Critical questions are now being asked as to the synchronicity, intensity and mode of abrupt climate transition patterns across Earth's hemispheres. However, with a scarcity of Southern Hemisphere studies, answers are not readily available.

Applications of long-lived cosmogenic radioisotopes, such as ^{10}Be, ^{14}C, ^{26}Al and ^{36}Cl, which are produced by cosmic ray bombardment of Earth's atmosphere and surface, are emerging as key parameters to provide the essential chronological frameworks and rates of climate processes to address these pertinent questions.

The CcASH Project - *C*osmogenic *c*limate *A*rchives of the *S*outhern *H*emisphere

The CcASH project is an ANSTO initiative, establishing a working group of Australasian researchers focussing on select Southern Hemisphere archives to (a) enhance our knowledge of past climate variability in Australasia in order to better predict future change in our region and (b) to study migrations and peopling of the Australian continent and the Pacific which has been directly influenced by climate variability over the past few thousand years. ANSTO has developed strong partnerships with universities, government agencies and international groups to carry out this ambitious project.

The world class ANTARES and STAR Accelerator Mass Spectrometry (AMS) Facility at ANSTO are key to measuring the telltale signals of past climate variability using these cosmogenic isotopic 'clocks'. Understanding paleoclimate change on a global, let alone a regional scale, can only be accomplished by the comparison between different paleo-archives - this project will focus on applications of cosmogenic isotopes and radiocarbon dating in

- glacial deposits from New Guinea, Tasmania and New Zealand
- sediments from the Southern and Pacific Oceans
- exposed rocks from mountain peaks in Antarctica
- tree-rings from Tasmania and South-east Asia
- speleothems from the eastern Australian coastline
- corals from the Indian and Pacific Oceans
- ancient and modern air samples trapped in Antarctic ice cores
- archaeological, heritage artefacts, rock art in Australia
- lake sediments and environmental samples from Pacific islands

Research Objectives:

- Provide new chronological and climate change data pertinent to the Southern Hemisphere to improve our knowledge of regional climate variability
- Provide access to ANSTO's capabilities in application of isotopes related to paleoclimate studies in unique archives and to environmental management and assessment,
- Provide a framework for interaction of researcher scientists and students in this field to exchange their multi-disciplinary expertise.

The four major directives of the project are described below:

Glacial and sedimentary systems

Exposure age dating using in-situ produced ^{10}Be and ^{26}Al in surface rocks is now a powerful tool to determine the chronology of continental glacial cycles. We are using this technique to date the ebb and flow of alpine glacier systems over the past 100,000 years throughout the Southern Hemisphere (Tasmania, New Zealand, Irian Jaya and Antarctica).*These activities are supported by ARC-Discovery Grants (with ANU and Macquarie), a New Zealand Royal Society Marsden Grant (Univ of Canterbury), China-Australia International Science Linkage grant, and AINSE collaborations (Univ of Newcastle, Macquarie and James Cook).*

Atmospheric and ocean systems

Variations in atmospheric transport, ocean water circulation and rainfall histories for the last 15,000 years within the Southern Hemisphere can be studied through measurement of ^{14}C and stable isotopes in tree rings, speleothems and corals. Such information can then be used to better understand the teleconnection of abrupt climate changes, past sea–surface temperatures, and how frequent and intense ENSO was in the past. *These activities are supported by ARC-Discovery Grant (with Univ of Queensland), a Cooperative Research Program coordinated of the IAEA and collaborations with universities of Sydney, Wollongong, and James Cook and from AINSE.*

Radiocarbon signatures of greenhouse gases

Radiocarbon in naturally occurring atmospheric greenhouse gases - such as carbon monoxide (CO), carbon dioxide (CO_2) and in particular methane (CH_4) - can tell us the sources of these gases and their contribution to global warming – both in today's modern world and during periods of past climate change. However, to extract $^{14}CH_4$, requires very large quantities of atmospheric air– a task that is most difficult when the source of ancient air representing past climate change is trapped as bubbles in ice cores. We use the world-class capability at ANTARES to measure extremely small microgram radiocarbon samples to do this. *These activities are supported through collaborations with NIWA (NZ), CSIRO-Atmospheric Research, Australian Antarctic Division and grants from Australian Antarctic Science and National Science Foundation(USA).*

Archaeology & Palaeoclimate of the Pacific and South East Asia during the past 5,000 years

The timing of migrations and changes in cultures across the Pacific islands and the reasons for the demise of thriving population centres over the past few thousand years have intrigued anthropologists and environmentalists as to what are the reasons and causes for such changes in demography. Were they due to climate changes, internal instability or environmental collapse? We focus on two fascinating events in the evolution of cultures in our region over the recent past. The movement and impact of people throughout Far Eastern Pacific islands and the rise and fall of Angkor, Cambodia. *These activities are supported by an ARC-Discovery Grant (with ANU), AINSE collaborations, and the Greater Angkor Project through the Univ of Sydney*

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