IceSked

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Newsletter of the Antarctic Research Centre
Victoria University of Wellington

A Word From the Director

While this IceSked profiles some exciting recent ARC activities, I would also like to bring to your attention the significant contribution made by Peter Barrett over the last 43 years. Peter, who has been a full-time staff member of the University since joining in 1969, will retire from his position as Professor of Geology at the end of 2012. While we are pleased that he will continue to be part of the ARC, keeping a fractional position for the coming years, we will be marking this milestone and celebrating his legacy in early 2013. A future IceSked will feature Peter's many and varied contributions and we encourage alumni, colleagues and friends to contribute any photos or anecdotes.

Tim Naish

Lake Ohau Drilling Project

Much of the year-to-year variability in New Zealand's climate is caused by weather systems originating in the tropics (eg. the El Niño-Southern Oscilation; ENSO) and/or the Antarctic (eg. the Southern Annular Mode; SAM). At this time of year New Zealander's might wish for more climatic influence from the tropics, but the instrumental record of rainfall and temperature change in South Island, New Zealand at least shows that the strongest influence on inter-annual variability at present comes from Antarctica. However, this may not have always been the case. The range of natural variability of these systems over long periods of time is poorly known because instrumental measurements do not extend back beyond the early 20th century.

ARC is part of a collaborative project that has been investigating the climate of past millennia locked away in mm-scale laminated sediments that have accumulated in South Island's, Lake Ohau, since the end of the last ice age, 16,000 years ago. The preservation of these layers permits the team to examine changes that have occurred over very short, perhaps even seasonal, periods of time in our geological past. To date we have examined a number of short cores that cover the past 1000 years of sediment variability.

The initial interpretation of these thin light and dark layers is that they represent seasonal changes in the sediment inflow into Lake Ohau. In periods when there is high rainfall in the lake catchment the inflow of coarser grained sediment-laden water increases along with increased production of diatom algae. In dry winter periods sediment inflow is greatly reduced, very fine-grained and largely free of diatom remains. A simplification, but we hope not an unreasonable one, is that the layering of the lake sediment relates to sediment input to the lake, which in turn relates to rainfall in the catchment enabling us to gain insights into changes in South Island rainfall when past global temperatures were slightly warmer than today.

In March this year new ARC student Heidi Roop was awarded a Sarah Beanland memorial PhD scholarship from GNS Science to work on modern processes and investigate in detail how the sediment layers in Lake Ohau relate to rainfall patterns. Together with Drs Richard Levy and Marcus Vandergoes (GNS Science) we have deployed sensors from the US Geological survey, National Oceanic and Atmospheric Administration and James Cook University into the lake to monitor sediment input. It's always a bit stressful watching expensive equipment disappear over the side of the boat into the murky water below, but the instruments will provide information critical to our understanding of sedimentation patterns within the lake.

Led by GNS Science and VUW and in collaboration with the University of Otago, the long-term goal (and the subject of a Marsden grant application) is to core the entire 16,000 year long sediment record and to be able to interpret this in terms of the rainfall history of South Island. The question is, "Which climate driver, ENSO or SAM, will dominate the mid-southern-latitudes as global climate warms and how will precipitation change? The team anticipate that the Lake Ohau record will deliver an unparalleled history of inter-annual climate variability from a region that is highly sensitive to changes in Antarctic and tropical climate forcing.

Gavin Dunbar

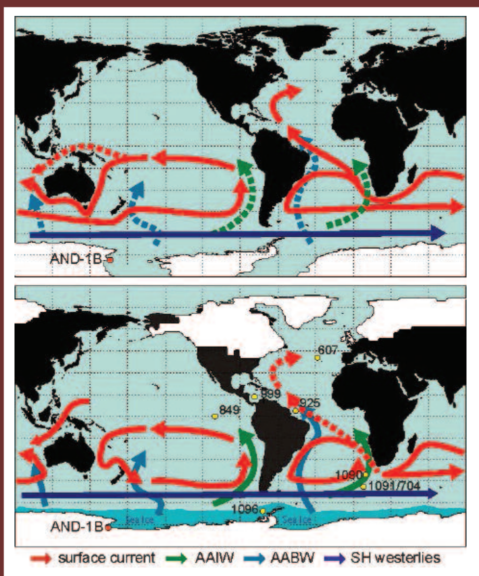
Marcus Vandergoes (GNS Science) and Heidi Roop getting ready to deploy a sediment trap in Lake Ohau

A Science Story - Could Changes in Antarctic Climate have Led to Northern Hemisphere Glaciations?

Rob McKay (left) receiving his award from New Zealand Prime Minister, Rt. Hon. John Key (right)

The time interval from 3.0 to 2.5 million years ago, known as the Late Pliocene, represents one of the most significant climate transitions since the Antarctic ice sheets first developed 34 million years ago. Reconstructions of this time interval based on geological evidence reveal rapid expansion of ice on Northern Hemisphere continents. Since this time Earth's climate and global sea-level changes have been influenced by two polar ice sheets – the more stable Antarctic ice sheet and the highly variable ice sheets on the Northern Hemisphere continents. Today these ice sheets are restricted to Greenland, but in the past they regularly expanded, during "ice ages", to cover North America and Eurasia lowering global sea-level by as much as 120 m. The question of, "what caused the bi-polar glacial world to develop", has remained contentious, although a number of hypotheses have been put forward. These include declining concentrations of atmospheric greenhouse gas - carbon dioxide, as well as changes in atmospheric and oceanic heat transport to the northern high-latitudes as a consequence of tectonic changes or changes in equatorial Pacific sea-surface temperatures.

Up until now the role played by Antarctica and the Southern Ocean on this cooling has remained unclear due to a lack of well-dated geological records near Antarctica. In April 2012, the ARC's Rob McKay led a paper in the prestigious journal *Proceedings of the National Academies of Sciences* (PNAS), that presented ice sheet, sea-surface temperature, and sea ice reconstructions from the ANDRILL AND-1B sediment core recovered from beneath the Ross Ice Shelf. The new data provided evidence for a major expansion of an ice sheet in the Ross Sea that began at ~3.3 million years ago, well before Arctic cooling, which was followed by coastal sea surface temperature cooling and expansion of sea ice in the Ross Sea between 3.3 and 2.5 million years ago. A detailed analysis of fossil marine algae (diatoms) preserved in the ANDRILL core was provided by team members from the University of Nebraska-Lincoln, Florida State University, and Stanford University. Subantarctic diatom species that presently live north of the Polar Front thrived in Ross Sea during the "warm Pliocene" prior to 3.3 million years ago. These were progressively displaced by colder water diatom species and ultimately the occurrence of sea-ice tolerant diatom species in the Ross Sea by 2.6 million years ago. Using a new geochemical technique called TEX_{86}, Rob's co-authors at the University of Utrecht and Yale University showed that mean annual ocean surface temperatures in the Ross Sea cooled through this time period, from an average of +4°C in the "warm" mid-Pliocene to almost +1°C by the Late Pliocene.



Changes in ocean surface circulation and intermediate (AAIW)/deep water masses (AABW) in responses to Late Pliocene Antarctic cooling. Dotted lines represent reduced water mass formation or current strength. Top: The warm Pliocene was characterized by a reduced WAIS volume and sea ice extent and duration during interglacials. Bottom: Antarctic Ice Sheet expansion and sea ice growth in the Late Pliocene, and associated northward migration of the Southern Ocean frontal systems restricted the water exchange between ocean basins, in particular the amount of warm, saline waters entering the Atlantic Ocean from the Indian Ocean.

McKay *et al*. then compared their data with records of wind-blown dust in a Southern Ocean sediment core (ODP 1090) to show that this Antarctic cooling resulted in a strengthening of the westerly winds, and associated northward movement of Southern Ocean frontal systems. They speculate that this restricted the flow of warm surface water between the ocean basins, such as the Aghulus current from the Indian Ocean around South Africa into the Atlantic Ocean (see figure below), and that this was the cause of a previously documented "slow down" in global ocean circulation restricting heat transport via the Atlantic ocean to the northern high latitudes. This same mechanism has been invoked in other studies to explain cooling at the beginning of the last ice age, known as the Last Glacial Maximum. In addition, this Antarctic cooling coincided with a documented reduction in atmospheric carbon dioxide levels that may have been driven by increased sea ice extent and associated changes in the carbon cycle of the Southern Ocean. While Rob's team caution that the new results in their PNAS article do not exclude low-latitude mechanisms as drivers for Late Pliocene cooling, they indicate an additional, and under-appreciated role played by southern high-latitudes on cooling during development of the bipolar world.

ARC researchers Lionel Carter and Tim Naish, together with Dr Richard Levy from GNS Science were also co-authors on this research. In December 2011 Rob received the Prime Minister's MacDiarmid Emerging Scientist Prize for his leadership of this innovative work. The The prize, worth $200,000, includes $50,000 to Rob, and $150,000 for his research. Rob received the award from the Right Honourable John Key at a ceremony in Auckland attended by his parents, wife Jo and ARC colleagues.

Tim Naish

McKay, R., Naish, T., Carter, L., Riesselman, C., Dunbar, R., Sjunneskog, C., Winter, D., Sangiorgi, F., Warren, C., Pagani, M., Schouten, S., Willmott, V., Levy, R., DeConto, R., Powell, R., 2012. Antarctic and Southern Ocean influences on Late Pliocene global cooling. *Proceedings of the National Academies of Sciences* 109(17): 6423-6428, doi:10.1073/pnas.1112248109.

General Staff Award for Excellence

Chancellor, Ian McKinnon (left) presents Darcy Mandeno (right) with his award

Darcy Mandeno, ARC's Field & Operations Engineer received a 2011 General Staff Excellence Award during a ceremony held on 12 March 2012. This award recognises the high level of service, commitment and contribution of individual members of the general staff at Victoria University.

Darcy has made an exceptional contribution in support of our ice core research under the supervision of ARC Projects Manager, Alex Pyne, by designing, constructing, testing and operating a $1M state-of-the-art ice core drill system capable of recovering ice cores up to 1000 m from the Antarctic ice sheet. Darcy has exceptional engineering design skills, and his dedication to testing the drill has so far involved a total of ten months fieldwork in Antarctica and Greenland over the last two years. His ability to work selflessly under considerable time pressure has enabled an international team, led by Nancy Bertler, to successfully begin, in October 2011, a two-year project to recover the highest quality ice core climate record yet from Antarctica for the last 45,000 years.

Phytoplankton Blooms and Ocean Warming

Bella Duncan on board the research vessel Tangaroa

My Master's research addressed a key question facing environmental science: "How will ocean plankton respond to the present phase of changing climate?" Coccolithophores (phytoplankton) play a key role in the ocean carbon cycle, regulating the uptake and release of CO_2. Satellite images show ocean change in a warming world is accompanied by changes in the latitudinal distribution of coccolithophore blooms. My project aimed to establish a longer record of coccolithophore change by using marine sediment cores from subtropical and subantarctic waters, to look at two warm periods 125,000 and 210,000 years ago. I've used a range of techniques including foraminifera geochemistry and grain size analysis to work out when coccolithophore blooms occurred, and what factors were responsible for blooming. Blooms occurred 210,000 years ago at the subtropical core site, due to high light intensity, thermal stratification of the upper ocean, and well mixed source waters from the Tasman Inflow. At the subantarctic site, blooms occurred 125,000 years ago due to decreased windiness, warmer sea surface temperatures and reduced oceanic circulation on the Campbell Plateau. Comparing the conditions that favoured blooms at each core site in the past, with present oceanic trends suggests that blooms are unlikely to increase at the subtropical site, but blooming may increase at the subantarctic core site. While the cores I used were collected a few years ago, I had the opportunity to go on a research cruise to the Southern Ocean. It was great to experience a few weeks at sea, even if a day of 10 metre swells left me feeling a bit worse for wear! *Bella Duncan*

Bella submitted her Master's thesis for examination in May under the supervision of Lionel Carter, Gavin Dunbar and Dr Helen Bostock (NIWA).

Linkages between Antarctica and New Zealand: 3 Million Years Ago

Numerous river crossings, a dead cow, lots of sheep and a blue grey sparsely fossiliferous bioturbated sandy mudstone occupied most of my Wanganui field work experience for 2012. My PhD thesis is focused on the Pliocene Epoch (~5.3 to 2.6 million years ago), the last period in Earth's history with similar boundary conditions (i.e., land sea configuration) to that of today, as well as atmospheric CO_2 concentrations and global mean temperatures matching those predicted for the end of the century. I will be using sedimentological and micropaleontologic approaches, as well as geochemical proxies in order to examine ice dynamic processes and ice volume changes at the East Antarctic Ice Sheet (EAIS) margin, and correlating them with a far field record of global sea-level change preserved in outcrop exposures in Wanganui Basin, New Zealand. These two records, from the Antarctic margin and Wanganui Basin will be complimented by an oceanographic record recovered from the Chatham Rise (east of New Zealand) recording variations in Southern Ocean bottom water circulation as a result of changes in ice volume occurring at the Antarctic margin.

In my first year and a half as a PhD student, supervised by Rob McKay and Tim Naish, I have been fortunate to attend an Integrated Ocean Drilling Program (IODP) post cruise meeting, and the coinciding 11th International Symposium on Antarctic Earth Sciences (ISAES) held in Edinburgh, Scotland, the 8th Urbino Summer School in Paleoclimatology which took place in the medieval city of Urbino, Italy, as well as the field work in Wanganui Basin, New Zealand. *Molly Patterson*

Molly Patterson collecting samples from outcrop exposures along the Turakina River, Wanganui Basin, with Professor Tim Naish

Two New Lecturers Appointed

We welcome on board to the ARC Rob McKay, Lecturer in Sedimentology and Paleoceanography, and Huw Horgan, Lecturer in Geophysical Glaciology. Rob and Huw need no introduction as they have both been long-standing members of the ARC family having just completed Postdoctoral Research Fellowships with us. As you may well have read in previous IceSked issues they are both talented young dynamic researchers, with a well-established network of national and international collaborations. Rob continues to work with the Wilkes Land Margin IODP Expedition team to provide new insights into the behaviour of the East Antarctic Ice Sheet. Huw is currently a principal investigator on a major National Science Foundation (US) proposal looking at the subglacial Whillans Ice Stream lakes and grounding lines in West Antarctica. His skills in glacial active source seismology will be key to our future research plans to better understand the response of the Ross Ice Shelf and West Antarctic Ice Sheet in the Ross Dependency. Both are embracing with great enthusiasm their new teaching duties. These appointments will provide succession for Peter Barrett when he retires at the end of the year and Lionel Carter who will reduce to 0.4 FTE in 2013.

Supporting the Antarctic Research Centre

The Endowed Development Fund Appeal supports emerging Antarctic research and graduate students for field work in Antarctica, conference attendance, travel for collaborative work at other institutions, and preparing manuscripts. You can help contribute by supporting the Fund either through a monthly automatic payment, or through a gift in your will, which is a tremendous way to show support while not impacting on your financial needs during your lifetime.

For support options please refer to: www.victoria.ac.nz/antarctic/about/endowments/endowed-development-fund-donors.aspx All donations are made through the Victoria University Foundation, a registered charity, and are therefore eligible for a charitable gift taxation rebate. For further information on how you can provide philanthropic support to the Antarctic Research Centre, please contact our Director, Professor Tim Naish, Email: timothy.naish@vuw.ac.nz, or Diana Meads, Development Manager - Planned Giving, Ph: 0800 VIC GIFT (0800 842 4438), Email: diana.meads@vuw.ac.nz.

Looking Back: Photos from the Archives

(Photo: Ray Dibble, VUWAE-23, 1978-79)

The late Werner Giggenbach (then DSIR) being lowered into Mount Erebus' Inner Crater, using a Z-pulley system. Ray Dibble (VUW) provided the team with the radios for communication. Werner had just been lowered in and was preparing to climb down a steep slope to the lava lake, when an active vent in the crater wall exploded violently, throwing many bombs in his direction. Fortunately it was seen to bulge first, and Werner was warned via the radio. He swung his two ropes out of the way, brushed out the fire from a small bomb hitting his leg, and was hauled up rapidly by the team above. The NZ Public were delighted, but further descent attempts were cancelled.

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