IceSked

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Newsletter of the Antarctic Research Centre
Victoria University of Wellington

A Word From the Director

As so much has happened since our last newsletter, we decided to double the size of this one. We report on great scientific achievements, some significant events, and a diverse range of research activities being carried out by our staff and students. *Tim Naish*

The Antarctic Research Centre has had a great year with three papers out in *Nature*.

More Snow but Less Ice

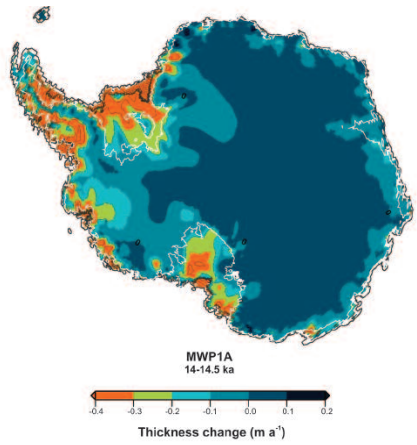
Nick Golledge, is part of an international team of researchers studying a small glacier on James Ross Island, near the northern Antarctic Peninsula. The team, led by Bethan Davies (Royal Holloway, University of London), found that surface melt in this region will increase greatly under even a slight warming, offsetting any gains from increased snowfall.

Published online in the scientific journal *Nature Climate Change* (http://bit.ly/1BE3DNS), Nick developed the glacier model that uses equations to simulate ice flow, and allows changes in climate to be translated into advance or retreat of the glacier depending on the balance between the accumulation of snow in higher areas, and the melting of ice at the glacier front. Using this model, Bethan simulated the present-day extent and flow speed of the glacier, based on climatic conditions interpreted from the nearby Mt. Haddington ice-core record. The research helps reduce some of the uncertainties about how these small glaciers will react to changing temperature and precipitation over the next two centuries.

Warnings from a Warming Ocean

Nick is also working alongside a team of scientists from Victoria University, GNS Science and the University of New South Wales trying to understand the way that the Antarctic ice sheet responds to ocean warming. Together they used sophisticated ice sheet and climate models to recreate the Antarctic ice sheet as it came out of the last ice age, when both the ocean and the atmosphere warmed quickly.

The results, published by the online journal *Nature Communications* (doi: 10.1038/ncomms6107), suggest that oceanic changes might trigger a significant shift in the stability of the Antarctic ice sheet, which could lead to an increase in global sea-level. Using geological data to verify their model results, they found that when the ocean around Antarctica became more stratified (layered), warm water at depth melted the ice sheet faster than when the ocean was less stratified. A dramatic example of this process occurred around 14,000 years ago, and led to an abrupt rise in global sea-level of nearly 3 m over just a few centuries.



Around 14-14.5 thousand years ago the fastest ice loss most likely occurred in the Weddell Sea and around the Antarctic Peninsula, with thinning in the Ross Sea largely restricted to the central embayment

East Antarctic Melting

Research by recently completed PhD student Molly Patterson, under the supervision of Rob McKay and Tim Naish shows that the stability of the world's largest ice sheet is influenced by the presence of a sea ice belt in the Southern Ocean. This sea ice belt, which is frozen ocean water and grows as a protective fringe around Antarctica's ice sheets, is susceptible to ocean warming as greenhouse gases continue to rise.

Published in *Nature Geoscience* (http://bit.ly/1tANqH4), the research shows that prior to 2.5 million years ago, when atmospheric carbon dioxide levels were at the same high level that they are today, the East Antarctic Ice Sheet (EAIS) melt was widespread.

Molly's research contributes to a long-standing ice-age mystery, resolving how exactly the Earth's orbit around the sun contributes to natural ice-age cycles, and how changes in atmospheric carbon dioxide altered the EAIS response to these cycles. It sheds new light on how natural climate processes can dramatically amplify ice sheet responses to relatively small changes in energy provided by changes in the Earth's orbit. This record highlights that the Antarctic ice sheets are highly sensitive to changes in the energy they receive, and are capable of driving global sea-level changes by many tens of metres. Energy changes associated from global warming and any future reduction of the sea ice belt may have profound effects on the stability of the giant EAIS, and if melted would total more than 20 m of increased sea-level.

Double Accolade for Leading Antarctic Researcher

In July, ARC Director Tim Naish, became the first New Zealand recipient of the prestigious Martha T. Muse Prize for Science and Policy in Antarctica for his outstanding research into understanding Antarctica's response to past and present climate change and the role of Antarctica's ice sheets in global sea-level change through time.

This leading international award for Antarctic science is funded by the Tinker Foundation and administered by the Scientific Committee on Antarctic Research (SCAR). The award recognises significant and sustained contribution to Antarctic scientific research and policy. Tim received US$100,000 in prize money with the award which was presented in Auckland during the SCAR Open Science Conference. To find out more about the Martha T. Muse Prize, visit www.museprize.org/index.html

To find out more about the Tinker Foundation visit www.tinker.org

Then in October, Tim was elected as Fellow of the Royal Society of New Zealand, an honour given to top researchers for showing exceptional distinction in research or in the advancement of science, technology or the humanities. Tim was thrilled to receive the award saying,

"I'm very humbled to receive this recognition; it is a huge honour as a scientist in New Zealand.

"It's more than a personal thing—research has and always will be collaborative and this award reflects a whole group both nationally and internationally".

The honours state Tim "has advanced our knowledge of Antarctica's response to past and present climate changes and their effects on the Earth system. He has shown that Antarctica is highly sensitive to small increases in temperatures that can cause marked responses such as rises in global sea level and loss of the vast Ross Ice Shelf. He has been a key contributor to the Intergovernmental Panel on Climate Change".

Tim was honoured along with eleven others at this year's Annual General Meeting of the Academy and joins a prestigious group of 399 Fellows who are involved in promoting best practice and providing expert advice.

Pro Vice-Chancellor Mike Wilson says very many congratulations are due to Professor Naish on receiving this award.

"Tim is an outstanding academic, and a truly worthy recipient of this award, which is a reflection of the hard work and passion he has shown as Director of the Antarctic Research Centre."

S.T. Lee Young Scientist Exchange - Into the Wild: A Journey to the Alaskan Wop-Wops

Hey bear! Go away bear! These are some of the more common calls of the Alaskan tramper, as I quickly found out during my visit to the last frontier from July to August. Facilitated by the S.T. Lee Young Scientist Exchange programme, I was fortunate enough to spend two weeks with the glaciology research group at the University of Alaska Fairbanks. As part of my PhD research, I have been simulating past glacier fluctuations on New Zealand's volcanoes, Tongariro and Ruapehu, during a period known as the Antarctic Cold Reversal (approx. 13,000 years ago). The 'Land of the Midnight Sun' has its fair share of glaciers, volcanoes and glaciers on volcanoes. So this visit gave me an excellent opportunity to interact with senior scientists, postdoctorates and graduate students, all of whom specialise in cryospheric research.

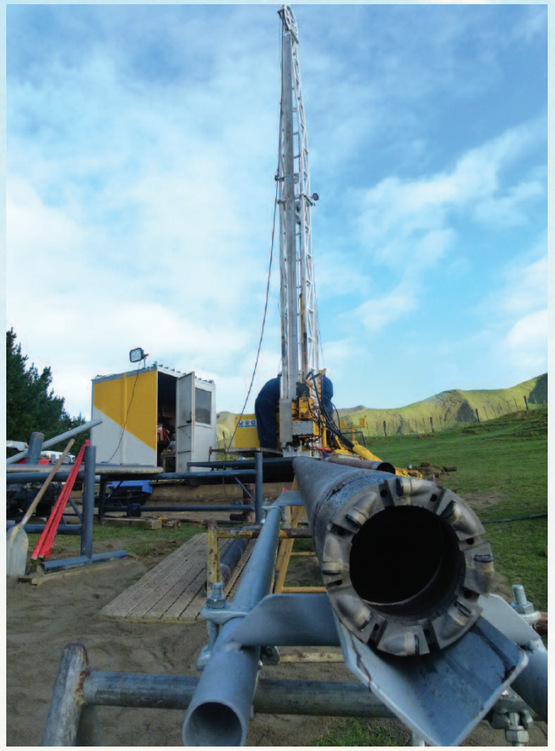
After an extra-curricular jaunt to the stunning Denali National Park, it was into the wild, literally, as I participated in the International Glaciology Summer School. This biennial course for postgraduate glaciologists takes place in the 'town' of McCarthy (population: 28), at the foot of the gigantic Wrangell and St. Elias mountain ranges in south east Alaska. Living out of a tent and bathing amongst the salmon in the glacial river for 10 days, we were schooled in the physics of glaciers by an international cast of glaciologists. This also included excursions onto (and underneath) nearby Kennicott and Root glaciers, where we encountered grizzly bears, black bears and even more oddly, a porcupine. All in all, this was an exhilarating, educational and exhausting trip, to a part of the world that rivals Antarctica and New Zealand for its sheer beauty and isolation.

Shaun Eaves

Shaun Eaves camping at the foot of Denali (Mt. McKinley; 6,168 m), the highest point in North America

Drilling Back to the Past

The ARC's Science Drilling Office together with Porirua-based drilling company, Webster Drilling and Exploration Ltd, co-ordinated the drilling of two, 400 m deep stratigraphic drill holes in the back blocks of Wanganui Basin. The Marsden funded project, led by Tim Naish and involving ARC's Gavin Dunbar and Rob McKay, as well as Brent Alloway (SGEES), Diane Seward (SGEES), Hugh Morgans (GNS Science) and Gillian Turner (SCPS), aims to reconstruct past higher-than-present day sea-levels during the warm climate of the Pliocene around 3 million years ago. Recent results from the ANDRILL and Wilkes Land Antarctic drilling projects suggest that the West Antarctic and marine margins of the East Antarctic ice sheets melted and contributed to global sea-levels 20 m higher than today. Evidence for these past high sea-levels are preserved in the sedimentary rocks under the sheep farms of central North Island east of Taihape. PhD student Georgia Grant, Gavin Dunbar and ARC Engineer Darcy Mandeno collectively spent six weeks at the drill sites recovering and describing the sediment cores.



Looking down the core barrel (Photo: Darcy Mandeno)

The first hole, Siberia Station in the Turakina Valley, was started on 14 July and presented some drilling difficulties in winter weather with snow, rain and mud. The predominate difficulty was in being able to consistently catch the core, with other issues resulting in several drill pipe trips in and out of the hole. Despite this the drillers managed to get the rig dialled in and made good progress during the latter part of the hole.

The second hole at Tiriraukawa on Watershed Road started after a two week hiatus on 18 August, proving to be a more consistent operation and with mostly stunning late winter sun. Lessons from the Siberia operation proved invaluable in achieving good core quality. Drilling was completed on the 10 September and achieved very close to perfect recovery, a credit to the skill of the drillers.

Snow falling at Siberia Station drill site (Photo: Darcy Mandeno)

Deep Fault Drilling

ARC Project Engineer Alex Pyne has been working as a technical advisor for the Deep Fault Drilling Project (DFDP-2) with an international team of scientists from twelve countries co-led by Rupert Sutherland (GNS Science), John Townend (SGEES) and Virginia Toy (University of Otago). The drilling of the 1.3 km-deep bore-hole into the Alpine Fault near Whataroa, north of Franz Josef Glacier, South Island started in late August to find out more about the nature of the fault and the earthquakes it produces. It will enable scientists to install monitoring equipment deep inside the fault to record small earthquakes and measure temperature, pressure and chemical conditions close to where earthquakes are generated. Other major faults around the world have been drilled in this way, but it has always been after a big earthquake. This is the first time a major fault has been drilled before it ruptures.

This highly technical drilling project hasn't been without its challenges, with basement rock being deeper than expected and two major drilling component failures, all requiring a careful planning and processes to resolve, certainly testing every last bit of the skill and expertise of everyone on site. To everyone's credit work continues to progress despite the setbacks with the fault observatory instruments being installed in December.

Antarctic and Arctic Photo Exhibition

The High Commission of Canada approached us with the idea of a photographic exhibition contrasting changes between the Arctic and the Antarctic. This collaboration led to the highly successful and visually stunning *From Pole to Pole* exhibition between the 11 August and 5 September in Victoria University's new Hub space, a main thoroughfare and hang-out space for staff and students. The exhibition contrasted changes particularly in terms of human influence and climate change.

For ARC staff and students it was a great opportunity for friendly competition as photo collections were scoured for images to make the final cut. The exhibition was officially opened by Christian DesRoches, Acting Canadian High Commissioner and Mike Wilson, Victoria University Pro Vice-Chancellor at a function attended by staff, students, friends, colleagues and members of the diplomatic corps, many thanks to Chantal Hickey (Canadian High Commission) and then ARC Administrator Robyn McFarlane for their organization of the event.

The photo exhibition in "The Hub"

Antarctic Time Travel

Victoria University participated as a sponsoring partner in the 2014 NZ IceFest held in Christchurch from 27 September through to 12 October. The festival celebrates New Zealand's activities and interests in Antarctica from science to art to environmental protection, tourism and exploration with a series of public events spread out over the two week period. A major highlight was the Antarctic Time Travel (ATT) exhibition, which was the brainchild of our close colleague Richard Levy (GNS Science), who worked closely with exhibit project manager, Bec McMaster (Christchurch City Council), to create a truly world class science exhibition. The primary sponsors were Victoria University and GNS Science with Tim Naish and PhD student Heidi Roop serving on the Advisory Committee and contributing to content. The ATT comprised nine interconnected shipping containers taking the visitor on a trip through time from the greenhouse world 50 million years ago, when Antarctica had a warm temperate climate with rain forest to the cold glacial environment of today, and then into three possible futures depending on how we choose to deal with climate change. It was a very popular attraction with 10,000 visitors. Victoria is in discussion on how to bring the exhibition to Wellington's waterfront next year.

Kids checking out the Antarctic Time Travel exhibits (Photo: Tim Naish)

ARC PhD student Peter Neff contributed to a public climate change panel discussion and VUW's Rhian Salmon co-ordinated a science meets art symposium with renowned NZ photographer Anne Noble from Massey University. VUW psychologist, Marc Wilson and Tim Naish also did their double act evening talk on, *"Climate science: If it's so obvious why don't we believe that the climate is changing?"*

Rob DeConto presenting his lecture in the Hunter Council Chambers

S.T. Lee Lecture in Antarctic Studies – The Fate of the Antarctic Ice Sheet

The 14th annual S.T. Lee Lecture in Antarctic Studies *"The Fate of the Antarctic Ice Sheet: Lessons from the geological past and how they are informing future predictions"* was presented by Professor Rob DeConto on the 3 September 2014.

Rob is Professor of Geosciences at the University of Massachusetts-Amherst, where he is a senior scientist in the Climate System Research Center. Rob's background spans geophysics, oceanography, and atmospheric science. In the last decade, his focus has been on the polar regions, including fieldwork in Antarctica, the development of numerical climate-ice sheet models, and the application of those models to a wide range of past and future climate scenarios.

With the Antarctic ice sheet containing more than 50 m of equivalent sea-level it poses the single greatest threat to global shorelines and coastal cities. Emerging geological records imply surprising sensitivity of the ice sheet, with serious implications for its future response to climate and ocean warming. Recent observations show accelerating retreat of some major outlet glaciers, especially in West Antarctica where the bed of the ice sheet lies hundreds of metres below sea level-hinting that a massive runaway ice-retreat is already underway. Rob's lecture explored what geological records tell us about the past history of the ice sheet, the attempts to develop numerical models to simulate those past changes, and what the models say about the ice sheet's long-term future over coming decades and centuries.

Antarctic Themed Reading Room Opens

The S.T. Lee Antarctic Reading Room, on level 5 of Victoria's Kelburn Library, was formally opened by Vice-Chancellor Grant Guilford in a ribbon-cutting ceremony on 22 October.

ARC's Director, Tim Naish, says the room was planned and developed as a collaborative effort between the Antarctic Research Centre and the library.

Funded by Singapore philanthropist Dr Lee Seng Tee, the quiet study space features displays, photographs and rock collections highlighting the Antarctic Research Centre's history and research in the Antarctic, as well as a selection of the newly acquired Colin Bull Polar Book Collection, covering both Antarctic and Arctic polar regions.

The Colin Bull Polar Book Collection was donated to the library by his family so that library users could benefit from access to its 1800 titles. Colin Bull was an Emeritus Professor and Physics lecturer at the University from 1956 to 1961, and played a key role in the early development of Victoria's Antarctic research programme, including leading the 1958-59 expedition to the Dry Valleys. A feature of the opening was the address by Colin's wife Gillian, who attended with two of their children. She said that the donation would mean a great deal to the polar scientist who passed away in 2010.

"He would be so pleased to know that his books are available to all people from all walks of life".

For more information on Colin Bull and his collection, visit the Library website: http://library.victoria.ac.nz/library-v2/collections/colin-bull-collection

A two day symposium was also held around the room's opening, featuring talks on past discoveries, including the exploration of Antarctica's Dry Valleys 57 years ago by Barrie McKelvey, one of the first two Victoria students to work on the continent.

Past and present staff and students presented research reports from subsequent expeditions, as well as plans for future research in collaboration with GNS Science and other institutions.

Deep in the Heart of Texas

In September, I was lucky enough to join Rob McKay, Tim Naish and Richard Levy (GNS Science) on a trip to the International Ocean Discovery Program (IODP) facilities at Texas A&M University. We characterised sediment cores in a modern fashion using IODP's state-of-the-art lab equipment. The cores were initially recovered in 1973 by a crew of scientists, which included ARC's Peter Barrett, aboard the ship *Glomar Challenger,* and form the integral part of my Master's research which focuses on the evolution of the early West Antarctic Ice Sheet (WAIS), between 27 and 23 million years ago.

"Lab action": Rob McKay manning the XRF scanner, Richard Levy retrieving more core, Denise Kulhanek (IODP) preparing core for XRF scanning, and Chris Kraus counting iceberg-rafted clasts (Photo: Tim Naish)

The reason for investigating this specific time period is due to recent reconstructions of bedrock topography suggesting that the WAIS first formed as a terrestrial ice sheet. At some point during the Oligocene or Early Miocene glacial erosion or tectonic subsidence caused West Antarctica to become an over-deepened marine-based continental shelf, as is observed today. The evolution of the WAIS through this transition is largely unconstrained; however, determining this history during past greenhouse worlds of ~600 ppm atmospheric CO_2 is critical in the context of understanding past sensitivity of marine-based ice sheet systems to environmental change. The climatic transitions which I will focus on will be the Late Oligocene warming (25-23 million years ago) and the Mi-1 glaciation (~23 million years ago).

The trip was a lot of fun and we collected a great deal of data which will have to be analysed in the months to come.

Christoph Kraus

What is Light and Dark and Forms when it Rains?

My scientific life currently revolves around thousands of little (~0.5 cm) light and dark layers preserved in lake sediments collected from Lake Ohau, South Island. Known as varves, these unique sedimentary layers are deposited over an annual cycle, and are the focus of my PhD research. Using the geochemistry and physical properties of the layers, I am working towards reconstructing the precipitation history of the South Island over the last 1,300 years. This annually resolved record will be one of the first of its kind developed in southern New Zealand. One of the challenges of this research was to determine how varves form in Lake Ohau. Clastic varves typically form in alpine and high-latitude environments and are less common in temperate lakes like Lake Ohau. The morphometry of Lake Ohau, paired with a pronounced seasonal change in the lake's temperature structure allow for the deposition of coarse (summer) and fine (winter) particles. My research shows that the stratigraphic pattern of each varve is a direct indicator of the shape of the annual hydrograph. This relationship will allow me to determine when in the past the South Island was dominated by spring, summer or autumn precipitation. The next step in my research is linking these annual changes in hydrology to larger climate features such as the Southern Annular Mode and El Niño Southern Oscillation. Once completed, this research will serve as the foundation for interpreting longer cores (70 m) that will be collected in early 2015 as part of a Marsden-funded research project being led by researchers at GNS Science and the ARC.

Heidi Roop

Heidi Roop and Marcus Vandergoes (GNS Science) admiring a sediment core collected from Lake Ohau (Photo: David Barrell, GNS Science)

From Ice to Water

I'm doing a PhD working with the water stable isotopes record from the Roosevelt Island Climate Evolution (RICE) ice core drilled at Roosevelt Island, Antarctica. My PhD is a split position between Victoria University and GNS science.

I have had the opportunity to go down to Antarctica and work with the ice core drilling at Roosevelt Island for two field seasons 2011-12 and 2012-13. During the 2012-13 season I was responsible for the ice core processing during the night shift. Most of the 763 m core was drilled during this season in just over a month, so we had a pretty slick operation going.

During the first part of my PhD I also developed a continuous flow water stable isotope system that was used at the RICE 2013 melt campaign. Under supervision from Troy Baisden (GNS Science) I built a setup that continuously evaporates a water sample stream from the ice core melter and introduces the sample to an analyser. I use an absorption spectroscopy analyser from Los Gatos Research (LGR) to get the real time measurements of water stable isotopes from the core. One of the advantages with this system is that it has an unprecedented short response time, which allow us to resolve the isotope signature that is preserved in ice with high temporal resolution. You can read more about the system and its performance during the 2013 melt campaign in a paper that has been accepted in *Atmospheric Measurement Techniques Discussions* (Emanuelsson *et al.* 2014).

Daniel Emanuelsson at Roosevelt Island camp

Currently I'm working with the upper part of the RICE core where there is an overlap with observational data (satellite data and data from automatic weather stations), to investigate which climate drivers influence the water isotopic signal at RICE. This is a crucial step for the interpretation of the deeper part of the core.

Daniel Emanuelsson

The Wanganui Basin – World Famous in New Zealand Since Ages Ago

Juliet Sefton aligning a hack into a carefully-cut mudstone block

One of New Zealand's most valuable geological archives, the Wanganui Basin, is beckoning scientists once again – this time, from an Antarctic perspective. Although far from the vast white of Antarctica, my Masters research involves investigating how Earth's ice sheets have varied on longer timescales, using a local record of sea-level change.

The Wanganui Basin contains a high resolution sedimentary succession, capturing relative sea-level changes from around 1 million to more than 3 million years ago. These sea-level changes reflect the waxing and waning of ice sheets, which are thought to be driven by Milankovitch cycles; the wavering of the Earth's orbit. These cycles occur on timescales of tens of thousands of years, and we are searching for their geological representation in the Wanganui Basin.

While this quest has meant examining largely homogenous, unchanging mud, I've gained a huge appreciation for the depths of sheep-farming country in the Rangitikei – a rather spectacular and under-rated slice of New Zealand. Alas, the field work is complete and so continues the process of data analysis, lab-work, and bringing together a 3-million-year-old story of sea-level change.

Juliet Sefton

Ariadna Salabarnada Roset in front of Mt Ngauruhoe, North Island

Visiting PhD Student

I am a PhD student from the Instituto Andaluz de Ciencias de la Tierra, Granada, Spain working under the direction of ARC collaborator Carlota Escutia. A Spanish Government grant enabled me to spend four months in Wellington working with Rob McKay and Tim Naish. Because of my fascination with Antarctic exploration and science, working in the world-leading ARC has been amazing. The objective of my PhD research project is to carry out a detailed analysis of sediments collected by the Integrated Ocean Drilling Program Expedition (318) in the Wilkes Land Margin, East Antarctica. The research aims to reconstruct paleoenvironmental, paleoceanographic and global sea-level changes during glacial events and warm transitional periods, to refine our understanding of the rate, magnitude, and frequency of glacial and interglacial changes in the East Antarctic region. I am focussing on three different major climatic events during the geological past, including the Oligocene-Miocene cooling transition, the Early Pliocene warm period, and the last deglaciation leading into the Holocene.

All three events are characterised by high temperature and atmospheric CO_2 concentrations. To achieve this, I am using sedimentary, physical properties and geochemical techniques. During my visit to the ARC, we were making circum-Antarctic correlations during the warm Pliocene between the continental margin of Wilkes Land, Pryzd Bay and ANDRILL records, to identify the continental scale significance of these regional drill core records, increasing our knowledge of how Antarctica's ice sheet may respond during future warm climate scenarios.

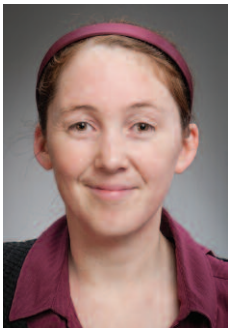
It has not only been a major learning experience but also a delightful living experience. As a geologist and an outdoor lover, New Zealand has offered me great landscapes and experiences difficult to forget.

Ariadna Salabarnada Roset

OTHER ACTIVITIES

SCAR Open Science Conference Comes to New Zealand

From the 23 August to 3 September, about 1,000 scientists from around the world converged on Auckland for the 2014 SCAR Open Science Conference. ARC staff and students were there enforce and delivered a range of excellent talks and posters, networked with new and old collaborators and friends, and enjoyed the associated public and outreach events. Highlights included an ANTCLIM21 Project session convened by Nancy Bertler and the presentation of new results from the RICE Project, the PAIS project session where both Nick Golledge and Molly Patterson presented summaries of their newly published *Nature* papers, Heidi Roop receiving a best poster award for the presentation of her Lake Ohau PhD research, and Tim Naish receiving the Martha T. Muse Prize for Antarctic Science and Policy at the conference dinner. This highly successful conference was well-organized by Convener Bryan Storey, Director of Gateway Antarctica.



Introducing a New Member to Our Team

The ARC welcomes our new Administrator, Shannon Digby, who joined the team in September. Shannon worked in the SGEES Administration Office from 2004-2006 before travelling through Europe and teaching English in Germany and South Korea. Shannon returned to New Zealand in 2010 working at the Te Kōkī New Zealand School of Music. Shannon is enjoying catching up with former colleagues, and learning about everyone's fascinating research projects. In her spare time she plays bassoon in orchestras and other ensembles.

Graduate Completions

The ARC congratulates the following students on completing their degrees:

Molly Patterson (PhD) *"The response of Antarctic ice volume, global sea-level and southwest Pacific Ocean circulation to orbital variations during the Pliocene to Early Pleistocene"*

Katrin Sattler (PhD) *"Periglacial preconditioning of debris flows in the Southern Alps, New Zealand"*

Rory Hart (MSc) *"The ice thickness distribution of a debris-covered glacier: Tasman Glacier, New Zealand"*

That Was Then - This is Now

The people have changed but the sled looks the same…..

VUWAE13 1968-69 (Photo: Barry Kohn)

VUWAE56 2011-12 (Photo: Cliff Atkins)

Antarctic Research Centre, Victoria University of Wellington, PO Box 600, Wellington 6140, New Zealand
Ph +64-4-463 6587 • Fax +64-4-463 5186 • Antarctic-Research@vuw.ac.nz • www.victoria.ac.nz/antarctic

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
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