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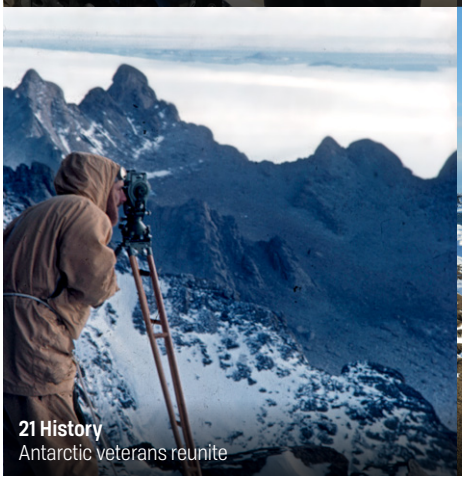

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ABOUT THE COVER

Davis station plumber Neil Brown took this photo of snow groomers constructing a sea ice runway just north of the station. The runway is needed to bring in expeditioners heading to Mawson or arriving from Casey, and allows the movement of people before resupply and the opening of the Davis Plateau ski landing area.

The Australian Antarctic Division, a Division of the Department of the Environment and Energy, leads Australia's Antarctic program and seeks to advance Australia's Antarctic interests in pursuit of its vision of having 'Antarctica valued, protected and understood'. It does this by managing Australian government activity in Antarctica, providing transport and logistic support to Australia's Antarctic research program, maintaining four permanent Australian research stations, and conducting scientific research programs both on land and in the Southern Ocean.

Australia's Antarctic national interests are to:

- Preserve our sovereignty over the Australian Antarctic Territory, including our sovereign rights over the adjacent offshore areas.
- Take advantage of the special opportunities Antarctica offers for scientific research.
- Protect the Antarctic environment, having regard to its special qualities and effects on our region.
- Maintain Antarctica's freedom from strategic and/or political confrontation.
- Be informed about and able to influence developments in a region geographically proximate to Australia.
- Derive any reasonable economic benefits from living and non-living resources of the Antarctic (excluding deriving such benefits from mining and oil drilling).
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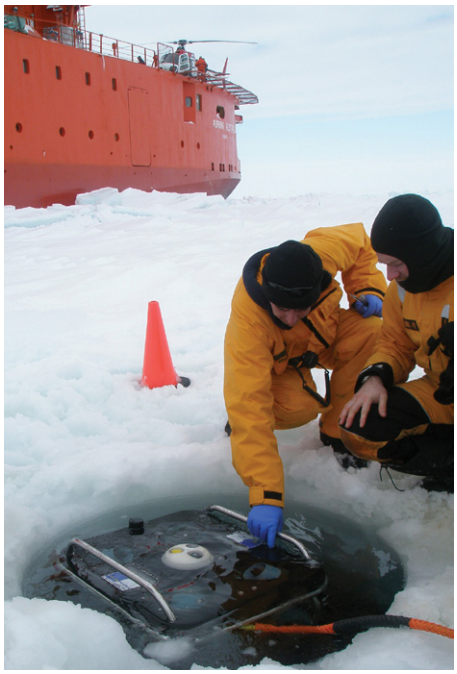


From the Director

Technology has been critical to solving individual and societal problems around the world, from reducing our footprint on the planet, to improving health and safety, and providing opportunities to do things in ways never previously conceived.

So it makes sense that technology is a key enabler of the Australian Antarctic Program. Everywhere I look I see the opportunities it offers and the solutions it provides, including by supporting scientific research that improves our understanding of Antarctica and its global connections, and helping us to protect and conserve the Antarctic environment.

Our new icebreaker, RSV *Nuyina*, is a perfect example. The technology packed into its 160.3 metre length is astounding. With its huge range of deployment and data acquisition systems it can sample, measure, monitor and visualise the ocean, sea ice and atmosphere in ways limited only by scientists' imaginations.

The research we will be able to do on this ship will enhance our ability to support and improve scientific management and conservation outcomes through such bodies as the Commission for the Conservation of Antarctic Marine Living Resources and the Intergovernmental Panel on Climate Change, and further our understanding of the influence of Antarctica and the Southern Ocean on global weather and climate.

To cope with this new capability the Australian Antarctic Division is augmenting our Technology and Innovation team to help scientists make the most of what the ship offers and the data they collect (page 10).

This team will also contribute to the running of containerised laboratories that are integral to the ship's design. These 'science modules' have been designed by Antarctic Division staff to have a standard service interface that plugs directly into the ship's power and alarm systems, improving the safety and efficiency of installation or removal during port calls, and enhancing safety and research flexibility while at sea (page 8).

Technology is also critical to our Million Year Ice Core Project, to drill 3000 metres into the Antarctic ice sheet and extract a core containing climate information from a critical period in Earth's climate history. Our scientists and the technology team are adding Australian innovation and technology development to American and European ice drill designs, and building the drill right here (page 30).

Technology is not confined to our science. As part of our Australian Antarctic Arts Fellowship program this season, two digital artists will capture a virtual representation of the *Aurora Australis* and its complement as they sail south, providing a life beyond the ship's last Antarctic voyage. The pair's tool kit includes drones, a portable motion capture system, LiDAR scanning, and cameras, to map the physical aspects of the voyage. Their recordings will be joined together into playable artworks for immersive experiences at galleries and festivals, and via mobile, gaming and virtual reality technology (page 31).

Last but not least, technology is teaching us more about the world in which we live, and our research environment. Acoustic moorings developed at the Australian Antarctic Division have captured a year of sound in the Southern Ocean, providing valuable insights into the movement and presence of marine mammal species, including whale species recovering from human exploitation (page 12).

As the Australian Antarctic Program seeks to modernise and reach towards its future, I'm excited about how the technology and innovation we apply to managing our own workloads and achieving our research objectives can be applied to broader Australian and international issues.

In the next issue of the magazine we'll look at the application of our work to some of these issues, including understanding and adapting to climate change and contributing to space exploration, and the role of technology in facilitating this.

Kim Ellis
Australian Antarctic Division

CLOCKWISE FROM LEFT Senior Technical Officer Chris Richards with the Computer Numerical Control (CNC) machining centre, used to manufacture ice core drill components. (Photo: Jessica Fitzpatrick) **Story page 31**

Newly recruited design engineers will help maximise use of the RSV *Nuyina's* scientific capabilities, by developing and running specialised scientific equipment, such as remotely operated vehicles (pictured). (Photo: Klaus Meiners) **Story page 11**

Australian Antarctic Division Director, Kim Ellis, beside a solar panel installation at Casey research station. (Photo: Nisha Harris)

Biodiversity surveys inform Davis Aerodrome Project

Ecological and geotechnical surveys are in full swing this season around the site of Australia's proposed new year-round runway near Davis research station, as the project team develop a detailed environmental assessment.

In 2018, after three field seasons of geotechnical and environmental investigations, a suitable site was identified for the 2700 metre-long paved runway, about six kilometres from Davis, in the Vestfold Hills (*Australian Antarctic Magazine* 34: 32, 2018).

Since then, the team has continued their geotechnical investigations at and around the 'Ridge Site', an elevated and undulating rocky plateau, to better inform construction requirements.

"The Ridge Site consists mostly of a very hard granitic bedrock, but the proposed runway alignment does run across two narrow sediment-filled valleys," said the project's Field Coordinator, Aron Gavin.

"So we're trying to understand the ground and sub-surface conditions around these areas to work out how best to stabilise them, and the effect of that on the project."

To understand the impacts that construction and use of the runway may have on the environment, a team of scientists has been assembled to survey the animals, plants and microbes in the operational area of interest.

"We need to get baseline data about the ecology in the area to inform the extensive environmental assessment process," Mr Gavin said.

"This will feed into our environmental impact assessments addressing the requirements of the Antarctic Treaty (Environment Protection) Act (1980) and the Environment Protection and Biodiversity Conservation Act (1999)."

Spatial ecologist Dr Aleks Terauds is overseeing the ecological surveys being undertaken by Australian Antarctic Division scientists.

"We're aiming to get baseline information in the operational area of interest on seals, seabirds, vegetation, seabed communities, soil and lake communities, noise levels, and air and water quality," Dr Terauds said.

"But we also want to get contextual information; so whether species are unique to the operational area, or if they occur in the wider Vestfold Hills area or throughout Antarctica."

Wilson's storm petrels nest in rock cavities in the Vestfold Hills. Seabird ecologists will use endoscopes to monitor the duration of their breeding season. (Photo: Peter Layt)

To understand the impacts that construction and use of the runway may have on the environment, a team of scientists has been assembled to survey the animals, plants and microbes in the operational area of interest.

Seabird ecologists Dr Louise Emmerson and Dr Colin Southwell have spent years at sites around Davis, and Australia's other Antarctic stations, studying the distribution, abundance, foraging behaviour and breeding success of Adélie penguins and flying seabirds, to inform long-term conservation and fisheries management practices.

More recently, they've been conducting population and migration surveys of flying seabirds, including cape petrels on the islands around the Vestfold Hills, and skuas at Rookery Lake near Davis. But it's the Wilson's storm petrels and snow petrels that are proving difficult to study.

"We want to understand where the birds' breeding sites are distributed in relation to the proposed runway and aircraft flight paths so that we can assess how they might be impacted during construction and operation," Dr Emmerson said.

"Cavity nesters like Wilson's storm petrels and snow petrels are difficult to study because you have to crawl around on hands and knees looking into the tiniest cracks. The snow petrels also nest in cliff areas, so we can't send teams there for safety reasons."

This season the seabird team will put small endoscope cameras into Wilson's storm petrel nest cavities, to see how long the breeding season lasts and when chicks hatch and leave their nests. They'll also look for places to deploy remotely operating cameras to monitor Adélie penguin colonies near the proposed aerodrome, and they'll attach satellite trackers to penguins to track their migratory routes across the sea ice, close to possible aircraft flight paths.

"Large numbers of Adélie penguins breed on ice-free land near Davis station between October and late February," Dr Southwell said.

"In spring they travel across the fast-ice to reach their breeding sites and back again to their foraging grounds, and at the end of summer they have to stay out of the water for about three weeks to moult.

"At both these times it's important that they conserve energy, for feeding their chicks or self-maintenance.

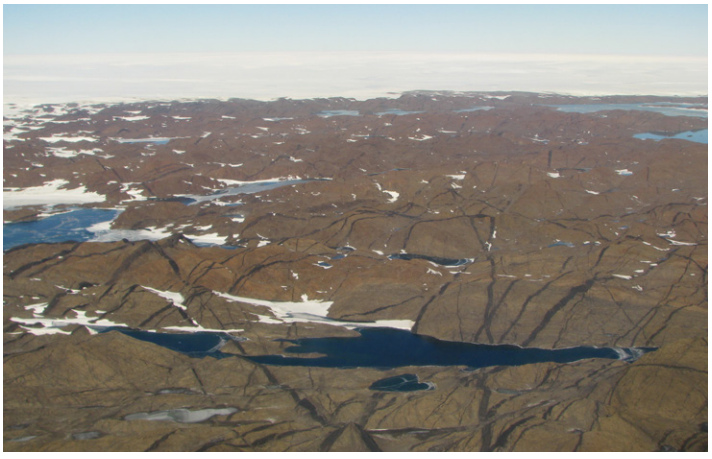
"The satellite trackers and remote cameras will help determine the energetic costs that any disturbance from the aerodrome may have."

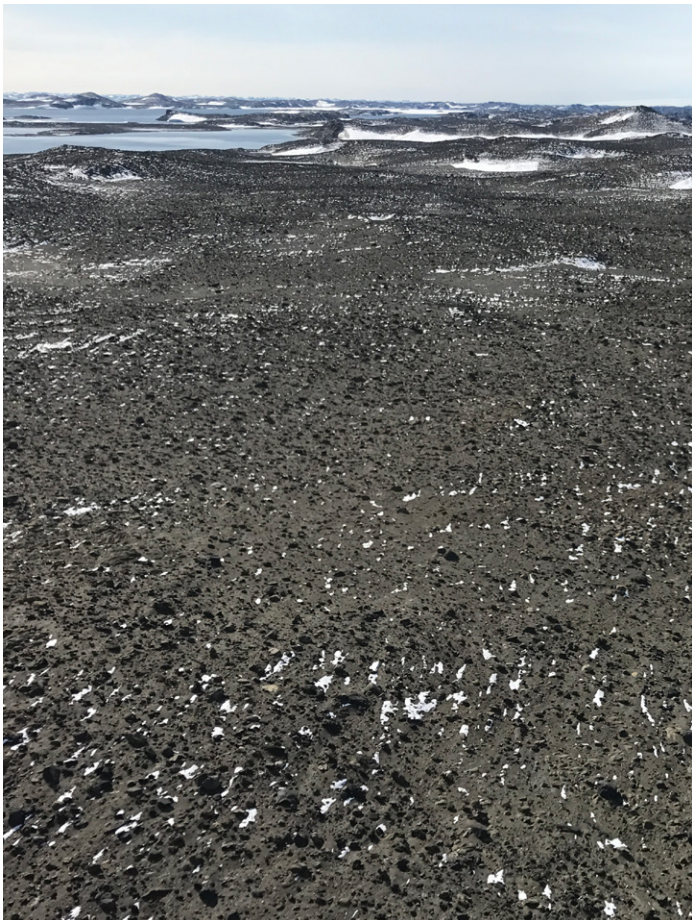
Also scrambling around and overturning rocks, conducting terrestrial surveys within and outside the operational area, will be Dr Dana Bergstrom and

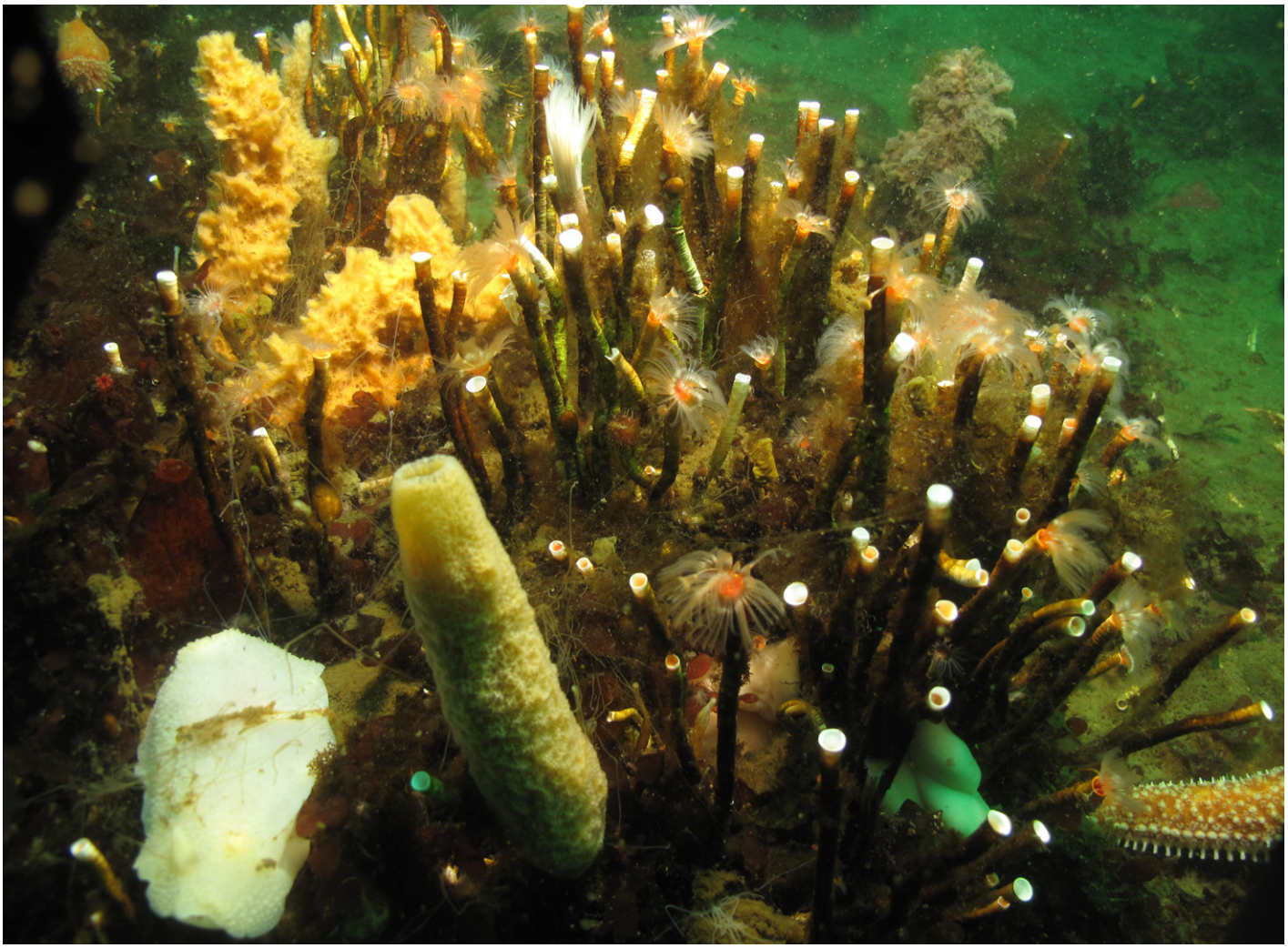
CLOCKWISE FROM LEFT
The Vestfold Hills contains many ponds and lakes which are being studied for their biodiversity. (Photo: Nisha Harris)

Geotechnical studies of the 'Ridge Site' near Davis are underway to refine the requirements for the proposed aerodrome. The Vestfold Hills encompasses over 410 square kilometres of ice free area, with the Davis Aerodrome footprint taking up one square kilometre. (Photo: Andrew Garner)

Terrestrial biologists will look at communities of mosses, lichens, algae and cyanobacteria in the Vestfold Hills. This image shows moss-covered lichen. (Photo: Kris Carlyon)







Dr Patti Virtue. They will focus on areas identified by habitat modelling as likely to contain vegetation, based on a vegetation survey at Davis station last year, and environmental characteristics such as wind, water availability and sunlight.

"The Vestfold Hills is a rare Antarctic oasis with a diverse range of plants including mosses, about 20 species of lichen, and a lot of algae and cyanobacteria," Dr Bergstrom said.

"It might look like a desert, but if you get down on your hands and knees you'll find plants growing under and within rocks, especially quartz, which acts like a mini greenhouse.

"The yellow and orange lichens are easier to see on the surface of rocks, and the cyanobacteria often form large black mats in moist areas below snow banks.

"We'll broadly describe the presence or absence of vegetation, and its abundance, at each of our modelled locations, and any life we see as we move between these locations. We'll also take samples for species identification."

One of the key questions the pair will be asking is whether the vegetation-friendly habitats within the operational area of interest, also occur outside it.

The work will enable identification of useful sites for future vegetation monitoring, to tease out the impacts of climate change from that of infrastructure construction and operation.

The terrestrial surveys will overlap with lake surveys being undertaken by Dr Catherine King and Dr Kathryn Brown. The Vestfold Hills contains thousands of water bodies of varying sizes and salinities, from small ponds to lakes stretching more than four kilometres. Many of the lakes were once inundated by seawater, about 6000 years ago, and have unique properties, including hypersalinity, or discrete layers of fresh and salty water.

"Each water body is likely to not only have different physico-chemical properties, but may also be home to very distinct biological communities," Dr King said.

"Our primary aim is to understand the uniqueness of these communities both within and outside the proposed operational area."

The lakes team will do vertical tows for phytoplankton and zooplankton and measure water chemistry, using an inflatable rubber boat to access the larger lakes. They will also collect sediment and soil samples from the base of each lake or pond, the water's edge, and at varying distances from each site.

"We'll be collecting representative samples from the wet and dry zones of each lake so that we can get an overall picture of what lives within the lakes and in the transition zone between the lakes and terrestrial communities," Dr Brown said.

Most of the samples will be analysed by microscopy back in Australia, to identify

"Ninety-nine percent of biodiversity lives in ice free areas and there are elements of the Vestfold Hills that are unique, such as the number and diversity of lakes. So that's the context of our surveys – looking at it with regard to its special values and ensuring we present the best information available upon which to base a decision."

Benthic (sea floor) communities at sites around the Vestfold Hills, including these polychaetes (tube worms) at Long Fjord, will be studied using a remotely operated vehicle deployed beneath the sea ice. (Photo: Chris Gillies)

The fjords are also home to populations of Weddell seals, which tend to haul out on the fast ice during the day, beside their specially maintained access holes.

microalgae and micro-invertebrates such as ciliates, rotifers, nematodes and tardigrades, but broader community composition will also be assessed by DNA sequencing of water, benthic mat and soil samples.

Moving to the coastal zone, sea floor communities will be the focus of benthic ecologists Dr Jonny Stark and Dr Glenn Johnstone. The pair will trial a bespoke remotely operated vehicle (ROV) beneath the sea ice in fjords and other coastal locations between Davis and the proposed aerodrome area.

Among its many high-tech features (see page 6), the ROV has two GoPros and a forward looking camera, to take video and stills of the sea floor, allowing operators to identify species, such as sponges, sea cucumbers, sea urchins and polychaetes (tube worms), and measure their abundance.

"Our plan is to trial some video transect and photo-quadrat methods with the ROV, so that we can come up with a methodology for a long-term monitoring program," Dr Stark said.

"We also want to investigate suitable sites that we could survey routinely if the runway goes ahead."

The pair will visit up to 30 sites, drilling through about 1.7 metres of sea ice to deploy the ROV.

"We'll try and capture the diversity of habitats and we know from previous work near Davis that this could range from rocky habitats to sediment-filled basins," Dr Johnstone said.

Seal biologists will count Weddell seals in Long Fjord and elsewhere in the Vestfold Hills and compare them to population surveys between the 1970s and 1990s.
(Photo: John van den Hoff)

"The fjords will be really interesting. Work at Ellis Fjord in the 1980s found an extensive polychaete reef, stretching up to eight kilometres."

The fjords are also home to populations of Weddell seals, which tend to haul out on the fast ice during the day, beside their specially maintained access holes.

A long-term monitoring program from the 1970s to 1990s conducted population counts on the animals, which raise pups in the area close to the proposed airstrip from October to November, returning to moult in January and February.

For the past two seasons and again this year, seal biologist Mr John van den Hoff has been coordinating the reinvigoration of population surveys of Weddell seals in Long Fjord, near the proposed runway site.

"We need to compare the locations and numbers of seals in the area and across the Vestfold Hills now, to the surveys of the past, to see if anything has changed in 25 years," Mr van den Hoff said.

"If there's no change, then we will have a good baseline to compare things to if construction of the runway goes ahead.

"If there are changes, then we'd need to think how to understand what's causing the changes, and how to separate them from potential future operational disturbance effects."

Field teams led by marine biologist Mr Andrew Irvine, will travel on foot, or by over-ice vehicle or helicopter, and count the animals from the ground or the air. They will also count them using aerial photographs and satellite images.

As well as Weddell seals, the team will count the (usually male) elephant seals that haul out at Davis research station each summer to moult, and any leopard and crabeater seals in the survey area.

Dr Terauds said that while the project will have unavoidable environmental impacts, Australia is committed to understanding and addressing the impacts to the highest standard.

"The Vestfold Hills might only represent a small part of Antarctica but it doesn't make it any less important," he said.

"Ninety-nine percent of biodiversity lives in ice free areas and there are elements of the Vestfold Hills that are unique, such as the number and diversity of lakes. So that's the context of our surveys – looking at it with regard to its special values and ensuring we present the best information available upon which to base a decision."

Wendy Pyper
Australian Antarctic Division

Mini-submersible to study coastal communities beneath the ice

A sophisticated underwater mini-submersible, designed and built in Tasmania, will spend the summer in Antarctica exploring under the sea ice at Australia's Davis research station. The Remotely Operated Vehicle (ROV) has been purpose built for Antarctica and is packed with hi-tech features including lasers that can measure the size of objects on the sea floor.

Australian Antarctic Division scientists and ROV pilots, Dr Glenn Johnstone and Dr Jonny Stark, said the $60,000 machine was designed to fit down a 40 centimetre hole in the sea-ice.

"One or two scientists can take this small ROV out onto the sea ice, drill a hole and lower it in to do the same work we would have previously used a team of divers to do, which required significant logistics and equipment," Dr Johnstone said.

The ROV measures 35 centimetres in diameter and will carry three cameras as it explores up to 30 different sites around the station. It can dive down to 100 metres below the sea ice and spend 3-4 hours exploring.

"This season, we're focused on learning the capabilities of the ROV and testing a range of methods and techniques to develop a long-term monitoring program," Dr Stark said.

"We have a reasonable understanding of the habitats in the coastal areas around Davis research station, but we know very little about the surrounding fjords and a ROV is the most efficient way of exploring these areas."

The ROV was built by Southern Ocean Subsea (SOSub) located in Kingston, south of Hobart.

SOSub Director Peter Colman, said designing and building the Antarctic-bound ROV was an interesting challenge.

"The ROV was designed to be as agile as a modern aerial drone, with technology that's known in the ROV industry as 'six degrees of freedom', which means it can move in any direction whilst holding any altitude, much like a spacecraft," Mr Colman said.

"Our use of 3D computer aided design and manufacturing were essential to the project, particularly given the very small size of the ROV and the timeframe we had to design and build it."

Dr Johnstone said the ROV can also be modified to dive deeper and collect samples.

"It's like a meccano set in that we can change the capabilities as we need.

"We can use 3D printing to produce customised brackets to mount different types of scientific instruments to meet future research needs.

"By changing the electronic housings, the ROV could also dive down to depths of 300 metres."

This research is part of the baseline data gathering and long-term environmental monitoring for Australia's proposal to build a paved runway near Davis research station, subject to environmental approvals (see previous story).

The data collected by the ROV will be included in the impact statements and extensive environmental assessment processes.

Eliza Grey
Australian Antarctic Division

Dr Jonny Stark (left), SOSub Director Kelsey Treloar, and Dr Glenn Johnstone, with the ROV, specially designed to fit through a 40 cm hole in the Antarctic sea ice to study sea floor communities. (Photo: Eliza Grey)

Benthic ecologist Dr Glenn Johnstone takes the ROV through its paces in Hobart. (Photo: Eliza Grey)

Captains of *Nuyina*

Captain Scott Laughlin and Captain Paul Clarke will soon share a rare privilege – leading alternating crews operating Australia's new Antarctic icebreaker, RSV *Nuyina*. It is a privilege hard earned, having both spent more than a decade each at the helm of other icebreakers, operating out of the Antarctic gateways of Hobart (Tasmania), and Stanley (Falkland Islands).

For Hobart-based Captain Laughlin, the Southern Ocean is a captivating place to work. With more than 50 voyages to Antarctica under his belt, as Captain of Australia's current icebreaker, *Aurora Australis*, he is familiar with its cold and challenging conditions.

"I began my career in the ice on the *Aurora Australis* in 1994, starting at a junior rank and working my way up to Master," he said.

"There is nothing more satisfying than successfully transiting through the roaring 40s, howling 50s and screaming 60s, sighting the sea ice edge, and crossing hundreds of miles through the ice to conduct science operations, or to resupply one of the Australian Antarctic stations."

Captain Laughlin spent more than 10 years as Master, before a brief stint in the offshore industry. He recently joined Serco to assist with the design and build of the new icebreaker.

His Antarctic service has not been without challenges, including two ship fires in 1998, besetments in the ice, and assisting other vessels in trouble. In 2013, in recognition of his outstanding service to the Australian Antarctic Program and his "immense resilience in dealing with often dangerous sea conditions to ensure the safety of the ship, its crew and expeditioners", he received the Australian Antarctic Medal.

Captain Laughlin has also been awarded the Peter Morris Medal by the Australian Maritime College, for improving international maritime safety and personnel standards (2014), and is the recipient of a Seacare Award for Best Individual Contribution to Safety (2006).

On the other side of the world, Captain Clarke has spent 11 years working for the British Antarctic Survey, and undertaking more than 20 voyages to Antarctica.

Born and raised in the Falkland Islands, in a family of seafarers, Captain Clarke began working for the British Antarctic Survey (BAS) as a deck hand in the 1994–95 season. He worked his way up the ranks, sailing on the ice strengthened cargo vessel RRS *Bransfield*, and later the RRS *James Clark Ross* and the RRS *Ernest Shackleton*. During that time he witnessed the breakup of the Larsen B ice shelf in 2002.

"When the ice shelf collapsed, we were working nearby and were asked to collect some photographs and samples," he said.

"It was exciting and sobering being the first people to see this ice shelf, floating as a huge mass of debris; to see on the ground what had only been observed from satellites, and to be able to collect real time images and samples."

Captain Clarke left BAS in 2006 to broaden his experiences, mostly working in South East Asia and Australia's northwest shelf. He has spent the last decade sailing as a Master for shipping company Solstad/Farstad in the oil and gas industry, but he has been keen to return to the Antarctic fold.

"My ambition was always to become the Master on one of the polar research vessels, as I very much enjoyed the ice navigation challenges, research and survey work and resupply of the stations that we carried out with BAS," he said

"This is an amazing opportunity with Serco and the Australian Antarctic Program to deliver world class support for their polar and science operations.

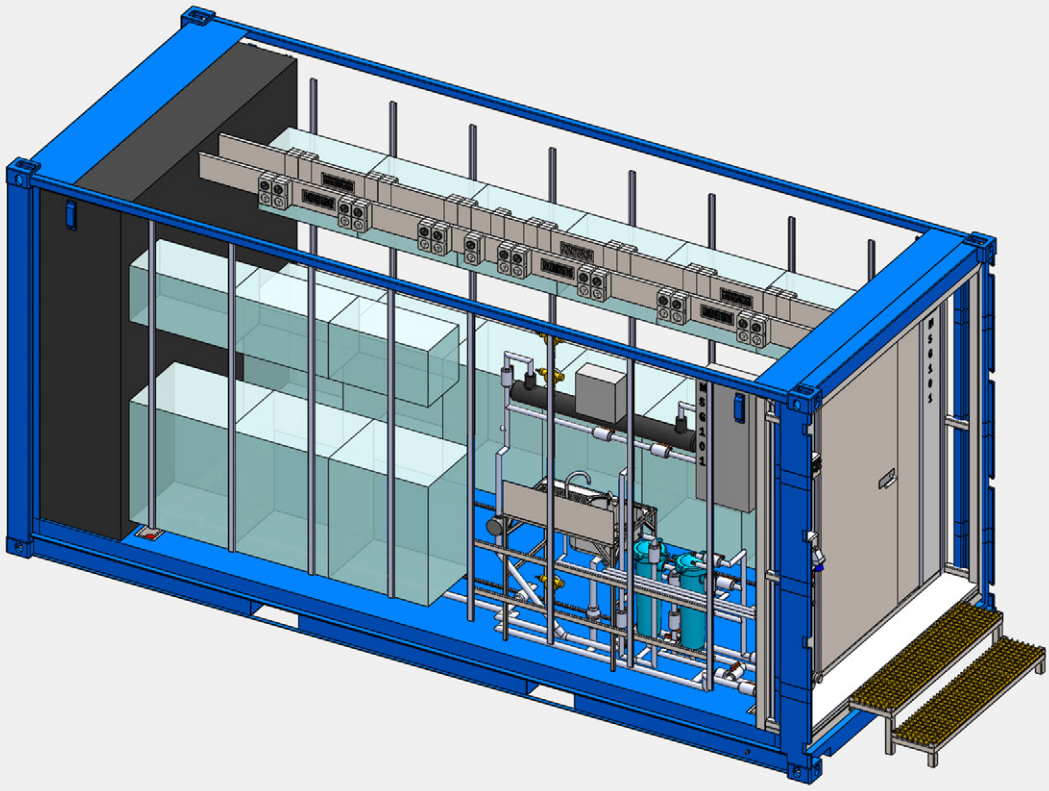
"This is going to be one of the best polar research and resupply vessels in the world when it's completed next year. Who wouldn't want to be the Captain on that?"

Follow the captains as they prepare for the arrival of the ship in Hobart in 2020, and share their experiences in Romania and Antarctica in their 'Captains' Log'. http://www.antarctica.gov.au/icebreaker/captains-log.

Australian Antarctic Division and Serco

Captain Scott Laughlin at the helm of the *Aurora Australis* in 2013. (Photo: Scott Laughlin)

Captain Paul Clarke has worked with the British Antarctic Survey and on offshore supply rigs in south-east Asia and Australia. He recently travelled to Davis on the *Aurora Australis* to familiarise himself with Australia's Antarctic operations and sea routes. (Photo: Mark Horstman)



Modular science

Six bespoke 20-foot shipping containers, designed to house scientific laboratories and aquaria, are being built by Tasmanian company Taylor Bros. Marine, to bring a safe and flexible research capability to Australia's new icebreaker, RSV *Nuyina*.

A model of an aquarium container showing the zones designated for a variety of specialised aquaria, with electrical power and data mounted on the overhead duct (which also supplies chilled air), and a wall-mounted sink and water filtration devices. (Image: Steve Whiteside)

The new 'science modules' are an integral part of the ship's design, with pipes and cables already installed on the ship to provide power, water, vacuum and air directly to the modules' standardised 'service interfaces'.

Australian Antarctic Division Instrument Workshop Manager, Steve Whiteside, said the science modules form part of a larger containerised capability on the ship, which has space for up to 13 laboratories and 11 science support facilities (for storage and mechanical equipment).

The six modules include a general laboratory, a temperature controlled laboratory for temperature-sensitive experiments, an explosive gas laboratory for the use of hydrogen, two aquaria for krill and fragile marine organisms, and a container for the aquaria mechanical equipment.

"The *Nuyina* is a big step forward in scientific capability because half the space is fixed laboratories and the other half is flexible space in the form of science modules and other 20- and 10-foot containers," Mr Whiteside said.

"The modules have been designed so that they can be pre-configured for different science projects before they're loaded on to the ship, and they can be plugged directly into the ship's power and alarm systems via their standard service interface. This will save time and improve safety during the busy turnaround time between voyages."

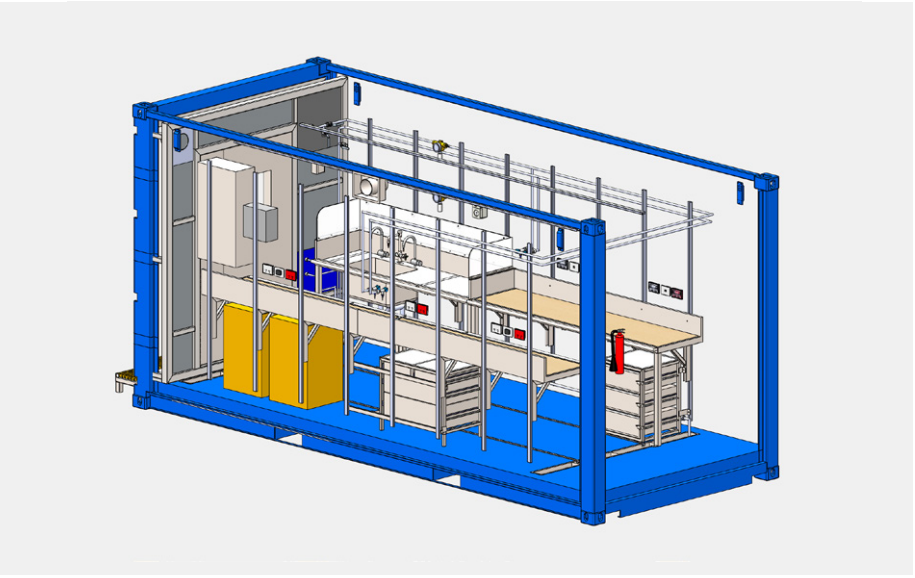
The modules will be built to a safety standard used for laboratories and special facilities in the offshore drilling industry. Safety features include a fully sealed steel shell and other non-combustible materials, such as rock wool insulation, designed to resist fire from inside and out. Their gas and fire detection systems will also shut down power automatically and alarm the ship.

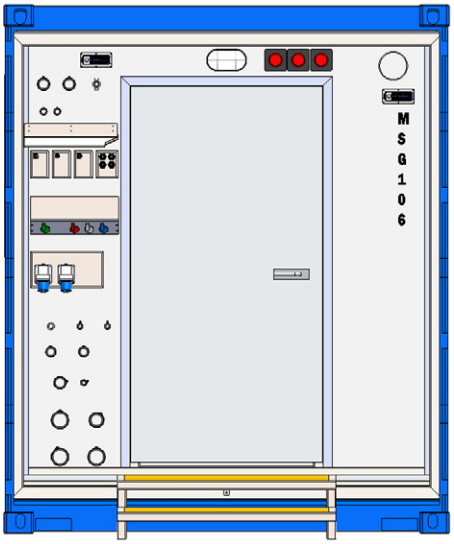
The modules will be built and certified to the required safety standard (DNV-GL 2.7.2) based on detailed design drawings and material specifications provided by the Antarctic Division. However Mr Whiteside's team and the Antarctic Division's krill aquarium scientist, Rob King, will fit-out the aquaria and aquaria mechanical containers, due to the complexity and specialist nature of the job.

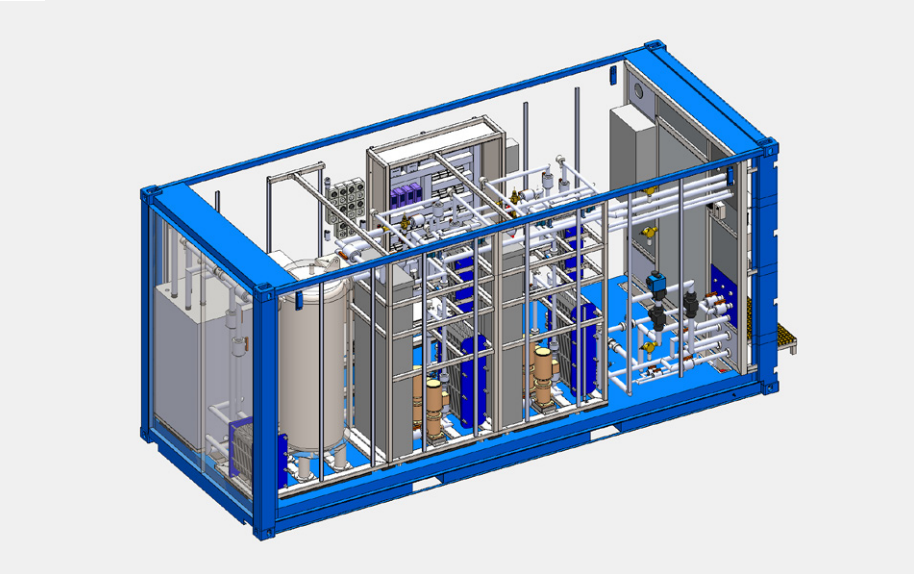
"Contamination is a big issue for the aquaria, and everything that has contact with sea water has to be built from inert materials, such as titanium and silicone, so that poisonous metals or chemicals don't leach into the water and kill our organisms," Mr King said.

To design the aquaria Mr King drew on his 25 years of knowledge working in the *Aurora Australis*' krill aquarium and the Antarctic Division's unique land-based facility at Kingston, to present Mr Whiteside with his ideal containerised version.

"The main constraint for us is space and Rob had an infinite requirement for a finite space," Mr Whiteside said.







CLOCKWISE FROM TOP LEFT A model of the general purpose laboratory showing overhead gas lines, wet area with sink, laboratory benches with associated electrical power and data, and below-bench storage for equipment and chemicals. (Image: Steve Whiteside)

The science modules' standard service interface links directly to the ship's power, water, vacuum, air and alarm systems. Gases such as oxygen and carbon dioxide can also be piped from the ship's gas storage areas into the science containers, through flexible transit points in the container interfaces. (Image: Steve Whiteside)

The aquarium mechanical module includes a chiller and associated coolant reservoir, water pumps, heat exchangers for manipulating water temperatures, and an automated control system. (Image: Steve Whiteside)

On our way south we might catch some organisms in temperate or sub-Antarctic waters, and we'll be able to maintain them at that water temperature for the whole voyage. We can also hold animals collected in colder Antarctic waters in separate tanks, for the voyage home.

"Our job was to bring an engineering reality to the design and work with Rob to model and tweak it until we came up with something that worked for both of us."

The end result is an aquarium system that can accurately control the temperature of seawater no matter the location of the vessel, and maintain two aquaria containers at different temperatures, anywhere from -1.5°C to 15°C.

"We will have gigalitres of clean seawater available to us to keep our animals healthy, but it won't always be at the right temperature, so we've had to design an efficient temperature exchange system," Mr King said.

"On our way south we might catch some organisms in temperate or sub-Antarctic waters, and we'll be able to maintain them at that water temperature for the whole voyage. We can also hold animals collected in colder Antarctic waters in separate tanks, for the voyage home.

The containerised aquaria will improve the survival rate of krill during their transfer from ship to shore. Previously, krill were hand-netted from tanks in the *Aurora Australis*' cold room and transferred in 10 litre buckets, packed in ice, to the Antarctic Division's Kingston aquarium; a slow, labour-intensive process that reduced the number and quality of precious live specimens.

"Now we'll be able to take the whole container off the ship, plug it in to our land-based aquarium facilities and then remove the specimens over a few days. This will keep the animals in good condition and reduce the rush for our staff and students," Mr King said.

While the idea is to move towards standardised containers for the Antarctic Division's fleet, Mr Whiteside's team is developing a package that can be installed inside containers supplied by other national and international scientists, to hook up to the ship's fire and gas detection systems.

With so much experience working at sea in both fixed and containerised laboratories, Mr King is excited by the safety and flexibility the new system will offer, and how much easier it will be to find his designated workspace – on and off the ship.

"Over the years we've evolved a Frankenstein fleet with so many different sized, shaped and coloured containers. Now our marine science containers will be easy to spot because they'll all have a standard size, shape, and ship interface, and they'll all be 'periwinkle blue'."

Wendy Pyper
Australian Antarctic Division

Assembling an 'A-team' for science support

A team of technology and innovation recruits will provide 24 hour support to scientists during marine science voyages and station resupply trips on the new icebreaker RSV *Nuyina*. (Photo: Damen)

Are you keen to work on Australia's new icebreaker, RSV *Nuyina*, and play your part in Australian Antarctic shipping history? The Australian Antarctic Division will soon offer opportunities to join a crack team of electronic, mechanical, technical and data specialists, to support the scientific capabilities offered by the new icebreaker.

New members will join the Antarctic Division's Technology and Innovation team, to provide 24 hour support to scientists during marine science voyages and station resupply trips.

They will be part of a technical team also supporting deep-field Antarctic research projects, including the search for an ice core dating back more than a million years, and projects at Australia's Antarctic and Macquarie Island research stations.

Technical Services Manager, Lloyd Symons, said the new ship will be the most capable scientific research vessel plying the Southern Ocean, with a "dazzling array" of instruments to sample, measure, monitor and visualise the ocean, sea ice and atmosphere.

"The *Nuyina* offers a step-change in what we can do compared to the *Aurora Australis*," Mr Symons said.

To begin with, the *Nuyina* has 14 acoustic instruments in its hull and drop keels, to map and visualise the ocean, sea floor and sub-floor environments, and it can collect data from many other atmospheric and seawater instruments and sensors.

It also has a range of unique deployment systems, including the moon pool, a 'forward outboard deployment system' (FODS), fibre optic winches, and eight-metre high A frame on the aft deck.

"The moon pool is a 13 metre vertical shaft in the centre of the vessel that will allow instruments to be deployed safely into the water even when the ship is surrounded by ice," Mr Symons said.

The new ship will be the most capable scientific research vessel plying the Southern Ocean, with a "dazzling array" of instruments to sample, measure, monitor and visualise the ocean, sea ice and atmosphere

"The ship also has an extendable boom that protrudes 10 metres over the bow, to place instruments in clean air forward of the vessel, or down near the ice surface.

"Fibre optic winches will allow instrument packages to be deployed to the deep ocean, while maintaining a high speed communication link between the ship and the package for transmission of high definition video or other data streams.

"And the A frame will allow us to deploy and recover heavy science equipment over the stern, including large scientific trawl systems."

National and international investigators will also bring their own instruments and equipment to add to or integrate into the ship's capability, and there are 24 dedicated spaces for containerised laboratories and science support facilities (see page 8).

To cope with this exciting opportunity and help turn ambitious, never-before-done research into reality, the Technology and Innovation team will welcome new acousticians, electronics and mechatronics design engineers, science systems engineers, mechanical engineers, laboratory technical officers, gear officers, aquarium staff and data officers.

"We will have a lot of machines collecting data, so someone will need to make sure it makes sense, maintain the systems and trouble shoot," Mr Symons said.

While the new recruits will have many different and specialised skills, they will have one thing in common.

"Their most important qualification is that they can adapt and fit in. We prize the qualities of a team player in this very demanding environment," Mr Symons said.

Wendy Pyper
Australian Antarctic Division

Supporting roles

Acousticians

Among the instruments the new acousticians will maintain and run are the ship's multibeam echo sounders, which can map swathes of the sea floor up to 25 kilometres wide in one pass and work at depths of 11,000 metres. They will also be responsible for the sub-bottom profiler, which images layers of sediment and rock below the sea floor, and bubble monitoring cameras and noise monitoring hydrophones – both for silent scientific operations.

Science system engineers

The science systems engineers will run the complex systems and instruments on the ship and the science tender, such as the meteorological systems, ice and weather radars and oceanographic equipment. They will also run the ship's data collection systems and 'Data in Real Time' (DIRT) – a web-based service that allows ship personnel to receive data from scientific instruments via their mobile phones and laptops (see *Australian Antarctic Magazine* 35: 4, 2018)

Design engineers

Design engineers will develop, run and troubleshoot specialised scientific equipment for deployment on the icebreaker and science tender, including underwater camera systems and instruments for remotely operated and autonomous underwater vehicles.

Mechanical engineers

Mechanical engineers will design, build and maintain the specialised mechanical equipment required to support diverse science operations, both on board the ship and for continental science programs, including the ice core drill for the Million Year Ice Core Project.

Aquarists

Aquarists will care for krill and fragile marine organisms collected in the ship's unique 'wet well' (*Australian Antarctic Magazine* 31: 7-8, 2016). This watertight space will process up to 5000 litres of seawater per minute, piped from large inlets below the ocean surface into viewing tanks and collection tables.

Marine specimens will be transferred to one of two containerised aquaria (see page 8). These will help keep the organisms in perfect condition until they reach the Antarctic Division's land-based aquarium at its Tasmanian headquarters.

Gear officers

Gear officers work with the ship's crew to help scientists to collect marine specimens, water and other samples, particularly via nets over the trawl deck and deployments from the moon pool, forward deployment boom, and CTD (conductivity, temperature and depth) instrument room.

Laboratory technical officers

New laboratory officers will oversee the safe and responsible use of the ship's two wet and two dry laboratories, meteorological laboratory, air chemistry sampling space, wet well, containerised laboratories, hazardous material store, gas lockers and lines, and refrigerated/frozen sample storage areas.

Data officers

Data officers on board the ship and back at the Australian Antarctic Division will ensure that data are being collected and stored appropriately.

Wendy Pyper

CLOCKWISE FROM TOP Gear officers help deploy equipment, such as this beam trawl. This trawl includes a camera system developed by design engineers. (Photo: AAD)

Laboratory technical officers will oversee the safe and responsible use of wet and dry laboratories on the *Nuyina*. (Photo: Brett Free)

New Technology and Innovation recruits will support deep field projects including the search for the million year ice core, by designing and manufacturing componentry for the ice core drill. Here, Senior Technical Officer Chris Richards (left) and Million Year Ice Core Project Lead, Tim Lyons, work on the drill head in the Antarctic Division's instrument workshop. (Photo: Simon Payne)

Sound science enhances whale conservation

French oceanographer Jacques Cousteau famously described the ocean as 'the silent world', but according to Australian Antarctic Division underwater acoustician, Dr Brian Miller, he couldn't have been more wrong.

To demonstrate, Dr Miller has captured the enormous spectrum of sounds in the Southern Ocean to produce a range of visual soundscapes.

"There are so many sounds in the Southern Ocean, including the physical sounds of wind, rain and icebergs, occasional man-made sounds from ships and construction, and copious biological sounds, especially those made by whales, dolphins and seals," Dr Miller said.

The sounds were recorded over several years using specially designed acoustic instruments*, moored to the sea floor at different sites off East Antarctica, for up to one year at a time.

The acoustic moorings assist research into the recovery from whaling of endangered Antarctic blue whales and fin whales. They are also part of the Southern Ocean Hydrophone Network, a network of about 20 listening stations deployed around Antarctica by international collaborators, to passively monitor blue and fin whales.

"Blue and fin whales are rarely seen, but they are very vocal and we can hear them over very large distances. So listening for them is an efficient way to study them and to monitor whether their populations are recovering," Dr Miller said.

The Australian Antarctic Division has up to three moorings deployed on the shipping routes between Hobart and Australia's Antarctic stations

Blue and fin whales are rarely seen, but they are very vocal and we can hear them over very large distances. So listening for them is an efficient way to study them.

After a year moored to the sea floor this acoustic mooring, being retrieved from the Southern Ocean, will contain more than 8000 hours of sound recordings. (Photo: Gerard O'Doherty)

It's so exciting, it's like Christmas. The first thing I do is generate a graphic to visualise the year of sound. Each coloured vertical slice is the average of about four hours of sound.

Dr Brian Miller listens for whales during a voyage. (Photo: Elanor Miller)

at any one time, as well as opportunistic locations, including in the Ross Sea and off Heard Island and McDonald Islands.

The instruments, developed by the Australian Antarctic Division's Science Technical Support group (see Australian Antarctic Magazine 34: 22-23, 2018), continuously record sound in the 1 to 6000 Hz bandwidth, enabling them to capture the very low frequency calls of blue whales, as well as fin, minke, humpback and sperm whales, and most seal species.

After a year of recording, each instrument contains some 8760 hours of stored audio.

"After the moorings are recovered, our electronics engineer downloads the data from the 32 SD cards and converts them to audio files," Dr Miller said.

"It's so exciting, it's like Christmas. The first thing I do is generate a graphic to visualise the year of sound. Each coloured vertical slice is the average of about four hours of sound.

"I can see how well the instrument has recorded, if there were any big icebergs or storms, and if we've recorded any sounds we've never heard before. I can also get an indication of what species were and weren't present."

As the years of data accrue, Dr Miller hopes to make comparisons to identify trends in the presence and number of whales, and the sounds they make, within and between sites.

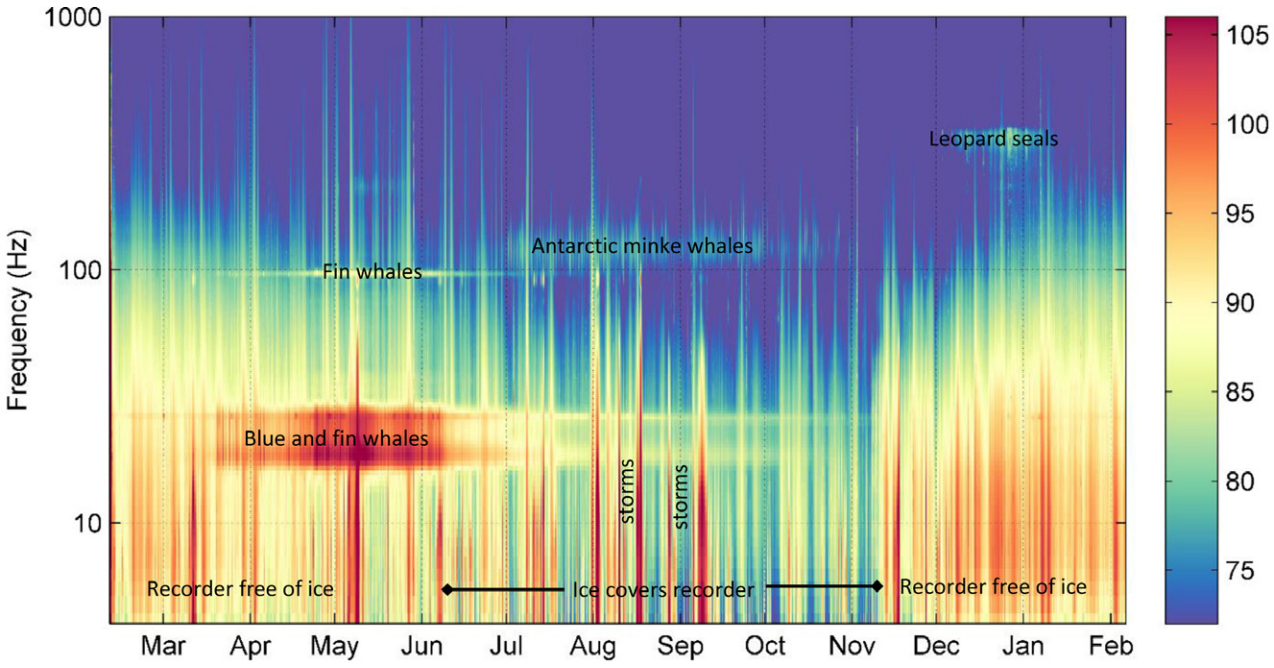
He is currently working on ways to standardise data collected by different acoustic recorders in the hydrophone network, so that circumpolar recordings can be meaningfully compared.

"We hope to be able to count the number of calls and measure the amount of sound energy so we can make robust statistical comparisons between sites or within a site over time," he said.

"A lot of the questions that we're trying to answer seem simple, for example: how many whales are there, where are they, when do we see them? These are fundamental questions that you need to be able to answer if you want to have any chance of conserving and managing populations of whales effectively.

"For some species, particularly Antarctic blue whales, fin whales, and sperm whales, these questions would be prohibitively expensive to answer without acoustic monitoring."

Wendy Pyper
Australian Antarctic Division
**Australian Antarctic Science Project 2683*



This summary of noise over a year shows the dominant sounds recorded by an acoustic mooring at the southern end of the Kerguelen Plateau (on the shipping route between Hobart and Mawson station). Each vertical line represents the average of four hours of sound. The moored recorder also captures many other sounds not pictured here, such as the songs of humpback whales in late autumn, echolocation clicks of sperm whales in summer, and the trills of crabeater seals in late spring. At the year-long time-scale of this graph only the loudest and most prevalent sound sources are visible. (Image: Brian Miller)

Antarctic lead records chapters in human history

The amount of snowfall a site gets, and whether that snow is wet or dry, affects lead deposition. As a result, scientists need to collect an array of ice cores from across Antarctica to understand and account for regional differences when analysing cores for different chemical properties. This Australian ice core drill camp is at Aurora Basin north, deep inland in East Antarctica. (Photo: Tas van Ommen)

Atmospheric lead pollution from Australia reached Antarctica two decades before Douglas Mawson's Australasian Antarctic Expedition set foot on the icy continent, according to ice core records. Australian Antarctic Division ice core scientist, Dr Mark Curran, said the evidence of industrial activity since the late 1880s, in Australia and globally, was laid down in annual layers of ice, much like tree rings.

As a result, changes in atmospheric lead pollution from world events and government policies are clearly visible (see Figure 1).

"We've found that pollution characteristics of lead mined at Broken Hill and smelted at Port Pirie reached Antarctica by 1889," Dr Curran said.

"This ore was exported around the world and concentrations of lead pollution in Antarctica remained high until a temporary low during the Great Depression in about 1932 and again at the end of World War II."

"The concentrations then increased rapidly until lead was eliminated from petrol in many southern hemisphere countries in the late 1990s and through the Clean Air Act in the United States."

The discovery was made after the analysis of 16 ice cores from around Antarctica, including cores collected by Australian scientists at Law Dome.

A team at the Desert Research Institute in the United States, led by Dr Joe McConnell, used a unique 'continuous flow analysis system', which involved connecting an ice core melter to an instrument (a mass spectrometer) that measures lead and other chemicals continuously along the length of each core.

Precise dating of the deposition of lead pollution in the ice cores was made possible by using annual markers in the ice to count each year, and chemical signatures from volcanic events to confirm exact dates.

Dr McConnell said the research showed that some 660 tonnes of industrial lead had been deposited over Antarctica during the past 130 years, and while pollution has declined considerably, a smaller amount persists.

It is a similar story in the northern hemisphere, with newly published research, led by Dr McConnell, showing the correlation of lead in Arctic ice cores with the rise and fall of the Roman empire, plagues, pandemics, wars, climate disruptions and government policy (Figure 2).

"Lead pollution increased by 250 to 300 fold from the Early Middle Ages to the 1970s industrial peak, reflecting large-scale emissions changes from ancient European silver production, recent fossil fuel burning and other industrial activities," Dr McConnell said.

"North American and European pollution abatement policies have reduced Arctic lead

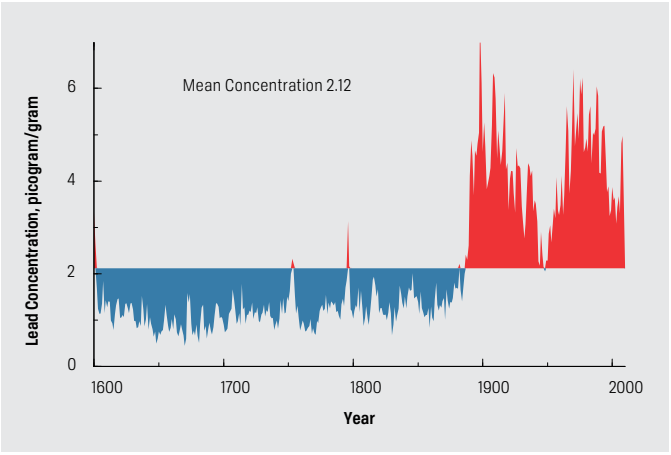


FIGURE 1 The concentration of lead in a composite of 16 Antarctic ice cores, each year since the 1600s, showing the rapid increase in lead pollution from the late 1880s, and changes corresponding to historical events in human history. (Scientific Reports 4: 5848; DOI: 10.1038/srep05848 www.nature.com/articles/srep05848)

pollution by more than 80 per cent since the 1970s but recent levels remain about 60 fold higher than at the start of the Middle Ages."

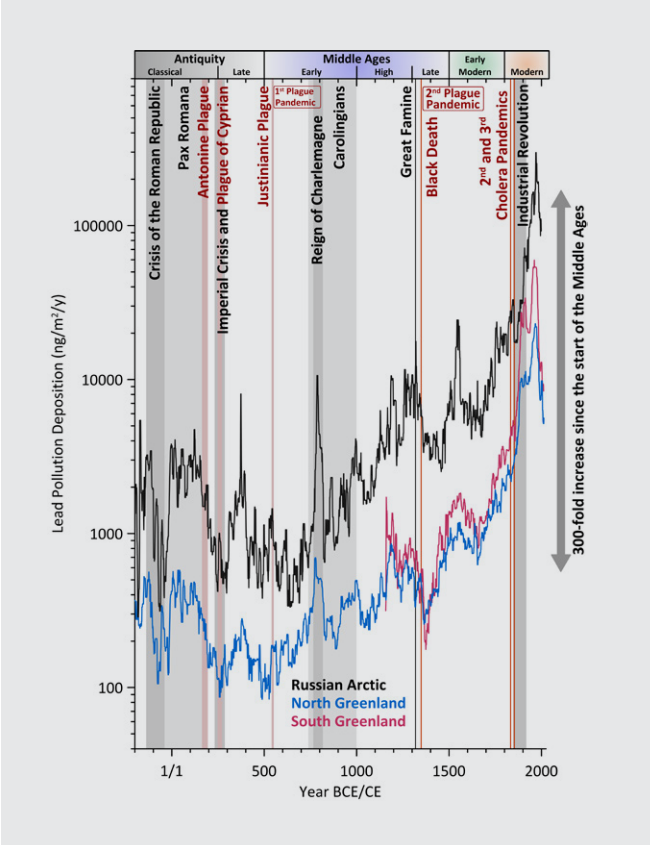
The rise and fall of lead observed in the Antarctic cores since the 1880s is also reflected in the Arctic results.

Despite the continued presence of lead pollution in the Arctic and Antarctic, Dr Curran said the ability to track the impacts of humans through pollution was a good news story.

"If we make science-based decisions to change our practices, and we see a positive effect, then we've demonstrated that it was worthwhile," he said.

Wendy Pyper
Australian Antarctic Division

FIGURE 2 This graphic shows lead pollution deposited in Arctic ice cores over the past 2200 years, aligned with historical events. A long period of high lead levels occurred during Pax Romana (height of the Roman Empire), when the Romans minted coins made of silver from lead ore. New lead-silver deposits were discovered in Germany in about 1000 CE, resulting in a further increase. Subsequent outbreaks of famine and disease saw lead pollution decline, but deposits surged again during the Industrial Revolution from the late 1700s. Lead deposits in the Arctic have been declining since European and American clean air initiatives were implemented in the 1970s. (www.pnas.org/cgi/doi/10.1073/pnas.1904515116)



Teasing out lead pollution from climate variables

Antarctic ice cores collected by Australian scientists, including Dr Mark Curran (pictured), have contributed to an understanding of lead pollution history on the continent. (Photo: Tony Fleming)

Identifying changes in lead pollution in Antarctic ice cores is complicated by changes in regional and global atmospheric circulation that direct air masses from other parts of the world over Antarctica.

Other climate variables, such as the El Niño-Southern Oscillation and the Southern Annular Mode, also alter the ease with which aerosols can be transported from populated areas to Antarctica.

"These climate variables can superimpose a signal on top of the lead pollution signal," Australian Antarctic Division ice core scientist Dr Mark Curran said.

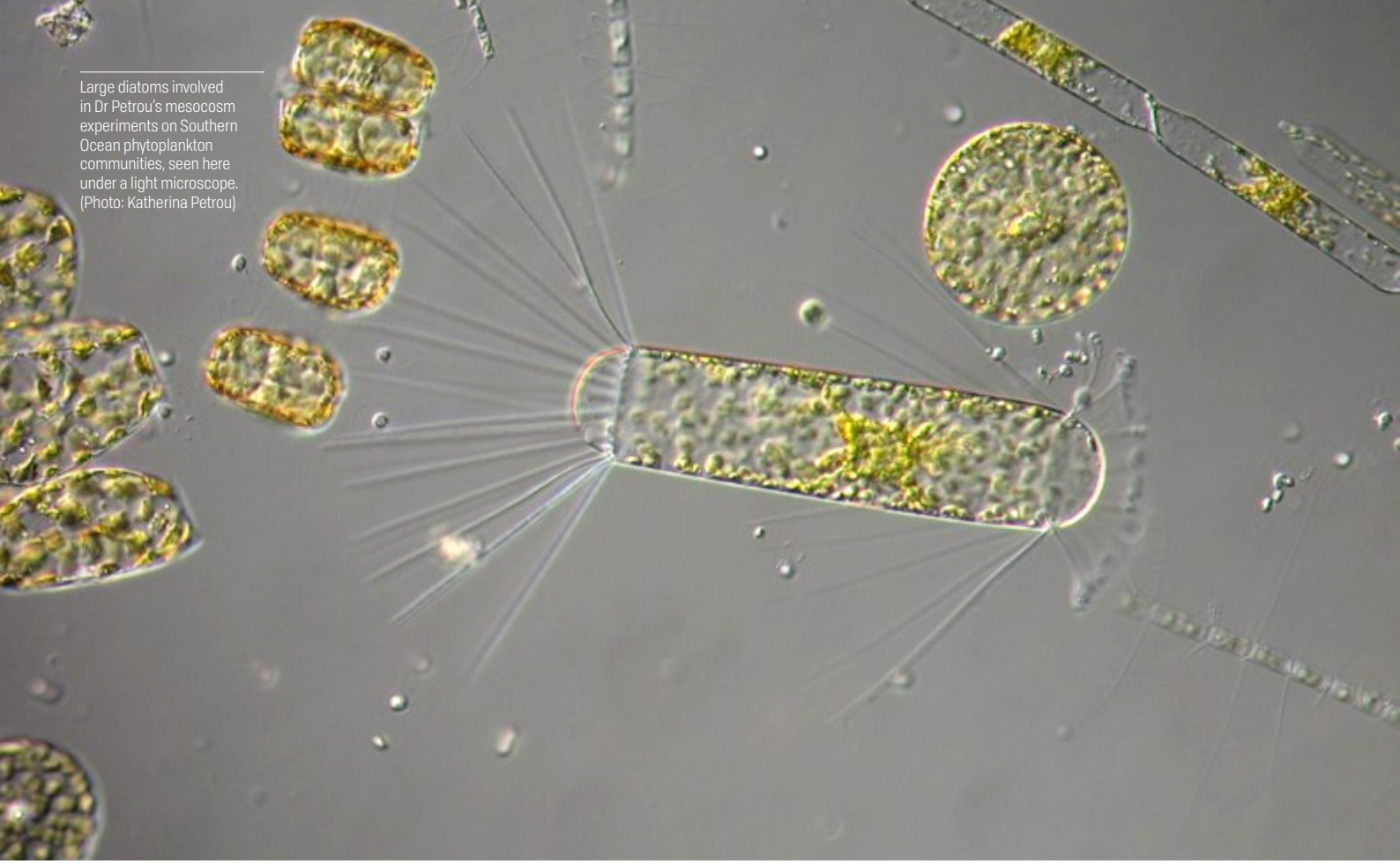
To tease out changes in lead from these climate influences, scientists look at three measurements - concentration, flux, and enrichment. Concentration is the peak detected by the mass spectrometer (see main story and figures), flux accounts for differences in the amount of snowfall at different ice core sites, and enrichment accounts for background levels of lead from dust, volcanos and other sources.

"We found changes in lead deposition in Antarctica since the 1600s was surprisingly similar across the continent, indicating that anthropogenic lead is well mixed in the Antarctic atmosphere and its deposition is ubiquitous across the continent," Desert Research Institute hydrologist Dr Joe McConnell said.

The factors that complicate measuring lead pollution also make lead a useful way of studying atmospheric circulation and aerosol transport.

"If we can remove the pollution signal, we can see the natural climate signal behind it. That can help us better understand air mass transport, atmospheric circulation and the Antarctic influence on the global climate system," Dr Curran said.

Wendy Pyper



Large diatoms involved in Dr Petrou's mesocosm experiments on Southern Ocean phytoplankton communities, seen here under a light microscope. (Photo: Katherina Petrou)

Glass-like diatoms at risk in acid ocean

Microscopic marine algae encased in glass-like 'armour' could struggle to build their protective cell walls as ocean acidification increases.

The Australian Antarctic Program research*, led by Dr Katherina Petrou of the University of Technology Sydney, found that ocean acidification, caused by carbon dioxide dissolving in seawater, produces changes in Southern Ocean diatom communities that could adversely affect the ocean's food web and carbon cycle.

Diatoms, like other phytoplankton, are an important food source for krill, fish and whales, and are responsible for more than 40% of ocean productivity.

"Diatoms build cell walls or 'frustules' out of silicic acid, producing a dense, glass-like armour that's thought to protect against grazers, and helps them to sink," Dr Petrou said

"This provides an important method for exporting carbon to ocean depths where it may be locked in ocean sediments.

"However, our research shows that ocean acidification leads to changes in the ability of different diatoms to incorporate silica into their cells, which may alter the effectiveness of silicon and carbon cycling, as well as food web dynamics."

The research, which also involved scientists from the Australian Antarctic Division, Southern Cross University and the University of Tasmania, was conducted at Davis research station in six 650 litre 'mesocosms' (incubation tanks) containing natural Antarctic microbial communities.

The communities were exposed to different concentrations of carbon dioxide over 18 days to cover a range of current and future carbon dioxide scenarios.

On day 12, diatoms were removed from each mesocosm to look at their ability to incorporate silica into their cell walls.

"Silicification strongly and significantly diminished with increased acidity, with newly deposited silica declining more than 60% between the lowest and highest carbon dioxide treatments," Dr Petrou said.

"Thinner frustules have less ballast, which is likely to reduce sinking rates. This means fewer diatoms may end up on the ocean floor, resulting in less carbon dioxide being removed from our atmosphere and transported to the deep ocean."

Regular sampling to look at community structure and abundance also showed a shift towards small diatoms in response to high carbon dioxide.

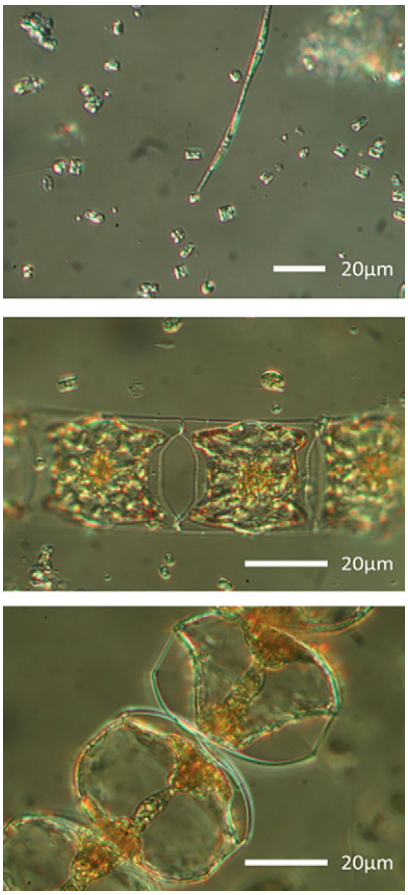
"We found that the number of large diatoms decreased from about 40% of the diatom community under current carbon dioxide levels, to just three per cent at the highest levels, Dr Petrou said.

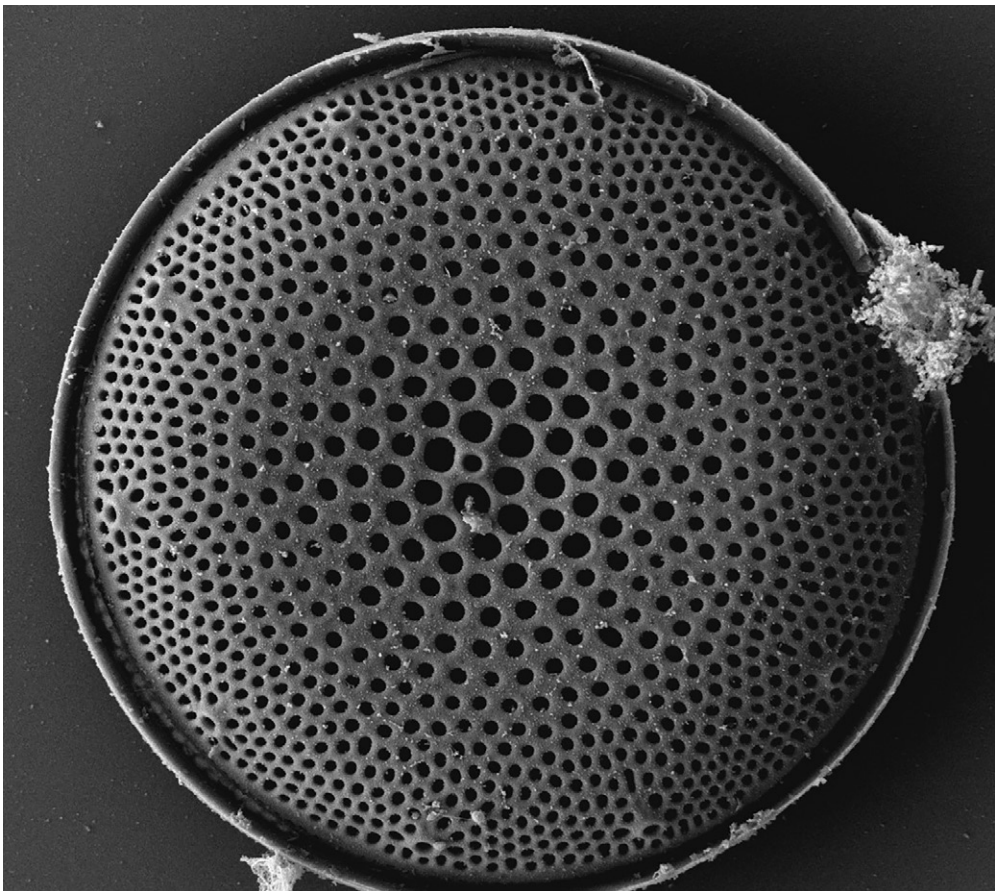
"The diatoms most affected were heavy silicifiers and bloom formers that underpin phytoplankton productivity in the Southern Ocean."

As the Southern Ocean links the rest of the world's oceans, the research team said the observed changes in diatoms could affect surface nutrients, primary productivity and the cycling of carbon, globally.

The research was published in Nature Climate Change in August https://www.nature.com/articles/s41558-019-0557-y.

Wendy Pyper
Australian Antarctic Division
**Australian Antarctic Science Project 4026*





Diatoms, like other phytoplankton, are an important food source for krill, fish and whales, and are responsible for more than 40% of ocean productivity.

CLOCLWISE FROM TOP Smaller diatoms such as *Fragilariopsis cylindrus* (top image) increased in abundance as carbon dioxide levels increased in Dr Petrou's mesocosm experiments. However concentrations of larger diatoms, including *Eucampia antarctica* (middle image) and *Stellarima microtrias* (bottom image) declined as the carbon dioxide concentrations increased. Silicification in all species declined as carbon dioxide levels increased. (Photo: Andrew Davidson)

Scanning electron microscopy image of a 'centric' (circular) diatom, *Thalassiosira gracilis*. The cell walls of diatoms fit together in two halves like a box, with the lid and base of the box known as 'valves', connected by a 'girdle'. The whole structure is known as a 'frustule'. Frustules are generally centric or pennate (boat-shaped), although there are many variations on these themes. (Photo: Alyce Hancock)

Dr Petrou filtering phytoplankton samples in a 0°C containerised laboratory at Davis research station. (Photo: Daniel Aagren Nielsen)

Macquarie Island diatom named after Antarctic ecologist

A tiny freshwater alga with glass-like cell walls has been named after Australian Antarctic Division ecologist Dr Dana Bergstrom. The single-celled diatom, called *Navicula bergstromiana*, is only 39-50 microns (0.039-0.05 millimetres) in size.

It was found in 2013 in a small lake on Macquarie Island, where Dr Bergstrom has spent a large part of her 36-year career.

Like all freshwater and marine diatom species, it has a tough silica-based cell wall, similar to glass, which remains in sediments long after the plant cell itself has died.

"I'm either as fragile as glass or I stay around forever," Dr Bergstrom quipped, while also expressing how deeply honoured she is to be recognised for her work in protecting and conserving Antarctic and sub-Antarctic ecosystems.

"Because diatoms basically last forever, they are useful indicator species of change," she said.

"For example, you can reconstruct the climate of a region from hundreds to many thousands of years ago, based on what types of diatoms appear in different layers of sediment cores."

Diatoms are responsible for almost half the primary production in the world's oceans, contributing significantly to the oxygenation of the atmosphere and the removal of carbon dioxide. They are also a key food source for krill, fish and whales.

Large deposits of fossilised diatoms (diatomaceous earth) are used in a range of abrasive and absorbent products (such as toothpaste and kitty litter), in water filtration, and as a stabilising component of dynamite.

Dr Bergstrom's canoe-shaped diatom is present in low numbers in many of the lakes on Macquarie Island. Coincidently, Dr Bergstrom said her Scandinavian surname means 'cold stream'.

The diatom was identified by Dr Bart Van de Vijver (Botanic Garden Meise, Belgium), Dr Koen Sabbe (Ghent University, Belgium), and a small international team, in a paper in *Plant Ecology and Evolution*.

"We named *N. bergstromiana* in honour of Dr Bergstrom for her outstanding work on the botany and ecology of Antarctic and subantarctic ecosystems, and more specifically for her work in identifying and managing the impacts of humans and invasive species on Macquarie island," the team said in their paper.

"She has also played a leading role in initiating and coordinating several international Scientific Committee on Antarctic Research science programs."

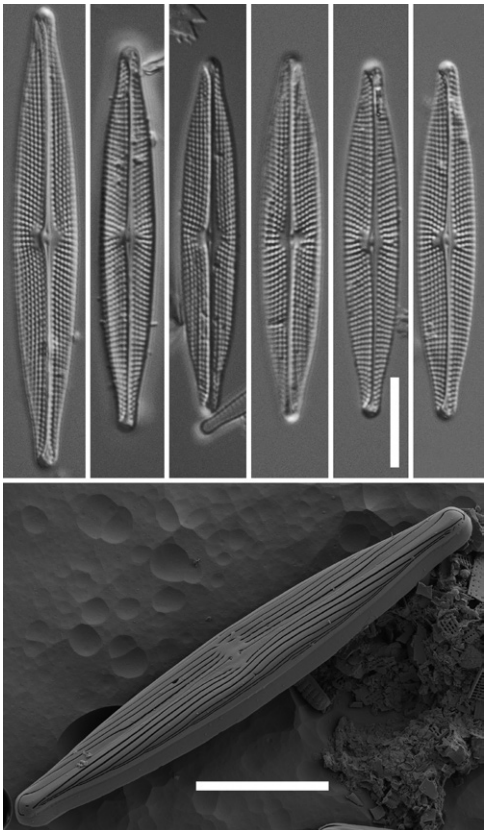
Read more about Dr Bergstrom's work at http://www.antarctica.gov.au/science/meet-our-scientists/dr-dana-bergstrom

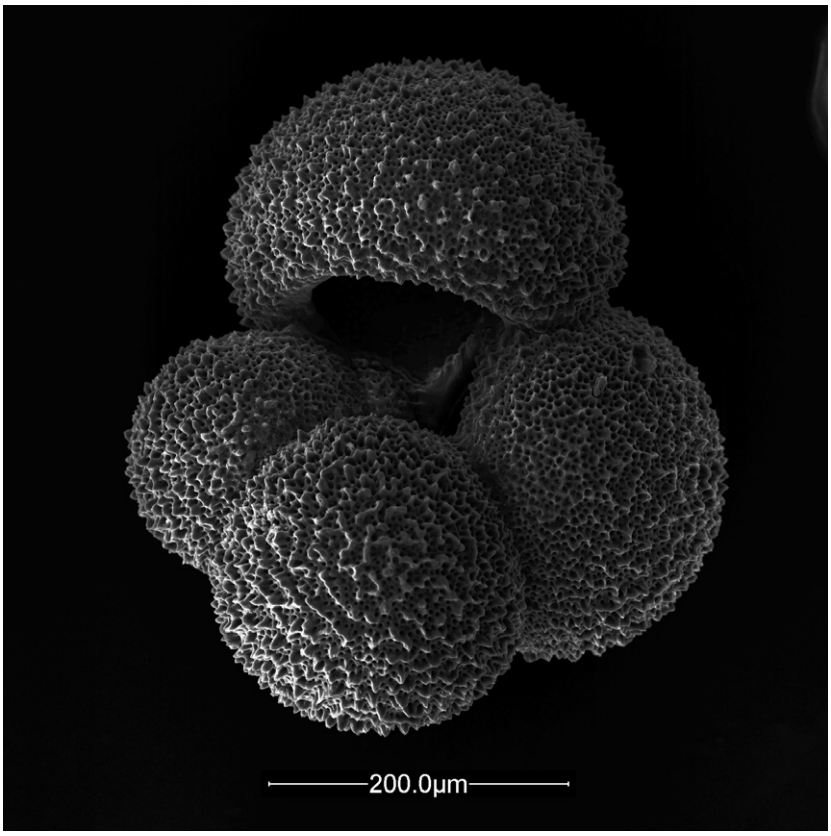
Wendy Pyper
Australian Antarctic Division

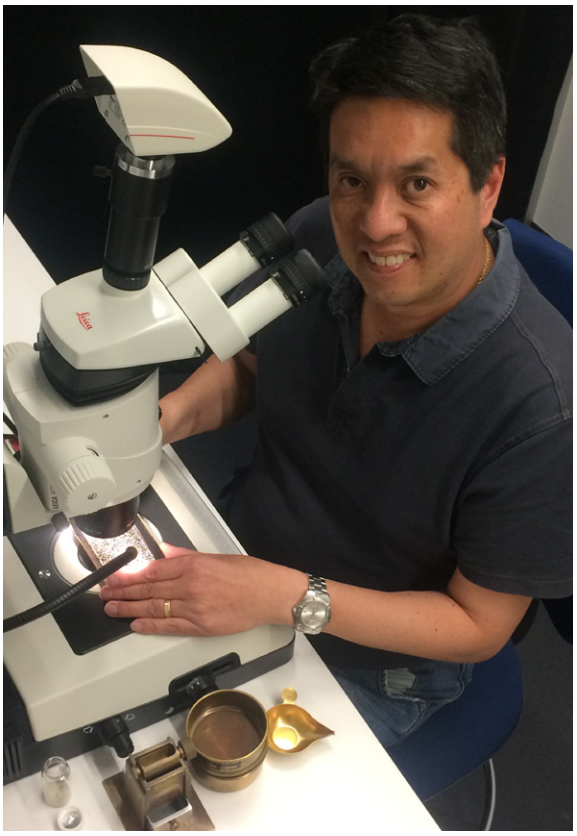
More information: DOI 10.5091/plecevo.2019.1607. www.plecevo.eu/index.php/plecevo/article/view/1607

LEFT Dana Bergstrom during her first visit to Macquarie Island as a Masters student in 1983. (Photo: Dana Bergstrom)

RIGHT Light microscopy shows the silica cell wall or 'frustule' of different *Navicula bergstromiana* diatoms in the top panel. A scanning electron micrograph in the lower panel shows the external appearance of the canoe-shaped diatom. The scale bar represents 10 µm (0.01 mm). (Image: Sabbe K et al., 2019. *Plant Ecology and Evolution*, 152(2), pp. 313-326. doi: 10.5091/plecevo.2019.1607)







Tiny fossils reveal 25,000 years of Southern Ocean carbon history

A reconstruction of 25,000 years of South Ocean carbon chemistry, using micro-fossils buried in sediments, shows sub-Antarctic waters have played a key role in regulating atmospheric carbon dioxide since the Last Glacial Maximum (LGM).

Chemical changes measured in micro-fossil shells, as well as sediments, showed that different regions of the Southern Ocean varied in their circulation, chemistry and biological productivity, during the last glacial-interglacial cycle.

This resulted in regional variations in the exchange of carbon dioxide (CO_2) between the atmosphere and the ocean, with some parts of the Southern Ocean becoming a net 'sink' of atmospheric CO_2 and others a source of the gas.

The research*, published in *Nature Geoscience* in October, was undertaken by Australian Antarctic Division palaeoclimate scientist, Dr Andrew Moy, and an international team from Australia, United Kingdom, Germany and Spain.

"The Southern Ocean currently takes up more atmospheric CO_2 than any other ocean, and it has played a crucial role in regulating past atmospheric CO_2," Dr Moy said.

"However, the physical, biological and chemical variables that control this ocean-atmosphere CO_2 exchange during glacial-interglacial cycles are not fully understood."

To help fill this knowledge gap, the research team measured the chemical composition of microscopic 'foraminifera' shells in sediment samples collected from 3,000 metres below the ocean's surface, in the 'Indo-Pacific' sector of the Southern Ocean, south of Tasmania.

From this they were able to reconstruct dissolved CO_2 levels in surface waters and compare them to CO_2 levels measured in Antarctic ice cores.

They found that Southern Ocean surface waters in the Indo-Pacific region were a net 'sink' for atmospheric CO_2 during the LGM and up until about 12,000 years ago, when they became a net source of CO_2.

"There was increased biological productivity in this part of the Southern Ocean during the LGM, resulting in the draw-down of atmospheric CO_2," Dr Moy said.

"At the same time there was reduced upwelling and exchange of CO_2-rich deep-waters with the surface ocean.

"As the Earth moved from the LGM to a warmer interglacial period, changes in the strength of the biological pump in these waters, and increased upwelling and subsequent release of stored CO_2 from the deep-ocean, contributed to a rise in atmospheric CO_2."

A similar study in the 'Atlantic sector' of the sub-Antarctic Southern Ocean showed that region was a strong net source of CO_2 during the deglaciation, before declining intermittently to be in equilibrium with the atmosphere (neither a source nor a sink), about 4000 years ago.

Dr Moy said the research will help improve geochemical models that explain glacial-interglacial variations in atmospheric CO_2 change, and improve modelling of future change.

"Current models tend to assume the physical, biological and chemical variables that control the CO_2 exchange process between the ocean and the atmosphere are uniform across the Southern Ocean. But this and other new research shows that these processes are variable," he said.

Wendy Pyper
Australian Antarctic Division

**Australian Antarctic Science Project 4061*

More information: DOI 10.1038/s41561-019-0473-9; www.nature.com/articles/s41561-019-0473-9

One of the foraminifera used in the study – *Globigerina bulloides*. (Andrew Moy)

Australian Antarctic Division palaeoclimate scientist Dr Andrew Moy examines planktonic and benthic foraminifera shells extracted from ocean sediments. (Photo: Conor Moy).

Antarctic maps go digital

More than 1500 Antarctic and sub-Antarctic maps, from Douglas Mawson's expeditions to today, are now accessible from a digital database hosted by the Australian Antarctic Division's Australian Antarctic Data Centre.

The SCAR (Scientific Committee on Antarctic Research) Map Catalogue provides scientists, researchers, operations personnel, historians and the public with access to the Australian Government maps, from the comfort of their desks.

Amongst the treasures are the first map of the Australian Antarctic Territory, published in 1939, based on Douglas Mawson's expeditions, and sketch maps by George Dovers, a cartographer for Mawson's Australasian Antarctic Expedition (1911–14).

There is also a large selection of maps produced during the Australian National Antarctic Research Expedition (ANARE) years, from the 1950s to 1990s, and a range of modern operational maps for aviation, traverse, station and field needs.

Mapping and Spatial Data Manager, Ursula Harris, said that before the maps were digitised, clients would require a mapping officer to retrieve a hard copy from the physical map store. Now, they can simply preview a thumbnail and downloaded the required map as a pdf or archival quality tiff file.

"Our biggest clients are operations staff looking for the latest station maps, which they can print out and provide to expeditioners," Ms Harris said.

"Our scientists might access mid-20th century maps that show bird colonies or biological census information, which they can compare with current information.

"And we often get requests from families for maps showing features named after a loved one."

The maps can be found using a search function, or through a list of popular maps, at https://data.aad.gov.au/aadc/mapcat/.

Wendy Pyper
Australian Antarctic Division

Celebrating a century of mapping

Mapping technologies have changed considerably in the more than 100 years since Australia has been mapping the Antarctic continent.

To celebrate, Australia Post recently released a four stamp issue illustrating three distinct eras of mapping in the Australian Antarctic Territory.

The first two stamps show maps of Antarctica published in 1911 and 1939, based on Douglas Mawson's and other expeditions, charting the Antarctic coast by ship and dog sledges.

The third map, published in 1973, illustrates the type of map produced during ANARE days, using aerial photography and manual ground calculations.

The final map, published in 1993, illustrates how the use of satellite imagery and computer technology (through Geographical Information Systems) today, produces more accurate maps.

LEFT Part of a map featuring the Australian Antarctic Territory, printed in 1939, and including information from Douglas Mawson's expeditions. (Bayliss and Cumpston, Map 1059)

Above Australia Post's stamp issue shows examples of maps produced using different technologies. (Image: Australia Post)

Antarctic veterans reunite to celebrate Mawson station's 65th birthday

Antarctic veterans celebrated 65 years since the opening of Mawson research station in September.

Mawson is one of Australia's three permanent research stations in Antarctica, and is the longest continuously operating station south of the Antarctic Circle.

Some 36 veterans from the 1954 to 1965 era, and other Australian National Antarctic Research Expeditions (ANARE) members who once called Mawson home, gathered at the Australian Antarctic Division to reminisce and learn more about life on the continent today.

Acting Director, Mr Rob Bryson, reflected on the changes since the early years of Australian Antarctic exploration, when much of the Antarctic continent had never been seen or mapped, when huskies were a vital mode of transport, and when having a shower meant heating snow on a coal briquette stove.

But while much has changed, some things remain the same, including the spirit of adventure, comradery and awe that Antarctica inspires amongst those privileged to visit.

For legendary ANARE surveyor, Syd Kirkby, the place and the people saw him return six times after his first winter in 1956-57.

"Even until the last day I stood in Antarctica, it could still stop me in my tracks," he said.

"To climb a mountain and look out across the Amery Ice Shelf, the Lambert Glacier, the extent of the Prince Charles Mountains and the Mawson escarpment disappearing 200 miles into the distance; it hit me that in all time no eyes had ever seen this. It was an astoundingly humble realisation."

Syd was only 22 when he joined ANARE in 1956, after impressing the Antarctic Division Director Phil Law with his "cheekiness", a shared interest in boxing, and his previous credentials working on the Great Sandy Desert expedition as a surveyor.

MAIN The Dakota aircraft being unloaded from the *Thala Dan* at Mawson in 1960. George Cresswell and the rest of the team had to help put the wings back on once it was ashore. The aircraft, which had been supporting a traverse George was involved in, was later wrecked in a blizzard.
(Photo: John Bechervaise)

INSET Syd Kirkby, at the Mawson celebrations at the Australian Antarctic Division this year, surveyed vast areas of East Antarctica during six expeditions from 1956 to 1980. (Photo: Wendy Pyper)

RIGHT Syd Kirkby taking a sighting with a theodolite from Rumdoodle Peak. (Photo: Syd Kirkby)

LEFT George Cresswell was 22 when he wintered at Mawson in 1960 as an auroral physicist. He later became an oceanographer and participated in a marine science voyage to the Mertz Glacier in 2001. (Photo: Wendy Pyper)

"Even until the last day I stood in Antarctica, it could still stop me in my tracks... To climb a mountain and look out across the Amery Ice Shelf, the Lambert Glacier, the extent of the Prince Charles Mountains and the Mawson escarpment disappearing 200 miles into the distance; it hit me that in all time no eyes had ever seen this."

After a two hour interview with Dr Law, where they spoke "only about fighting" Syd began a career that saw him personally survey more Antarctic territory than any other explorer – including Scott, Shackleton and Mawson.

As the youngest member of the wintering team in 1956 Syd remembers being impressed by the men, many ex-servicemen, who knew about fear and weren't afraid to give things a go.

He was nicknamed the 'Boy Bastard' by two ex-servicemen who took him under their wing.

"Later that year they held a ceremony and graduated me from being the Boy Bastard to being the 'Uncouth Youth'," he said happily.

"The next year I was nick-named 'Jungle' after the surveyor in the book *The Ascent of Rumdoodle*, who was always lost."

Just as Syd's older colleagues left a lasting and positive impression on him, former auroral physicist George Cresswell remembers the colleagues who made his 1960 winter at Mawson so memorable.

"Seeing blokes like Syd Kirkby and Ian Bird [electronics engineer] work so hard; I had great respect for them and I developed a good work ethic as a result," George said.

George joined ANARE for the adventure, after watching the movie *South with Scott* as a young boy. His adventure started immediately with the unloading of the Dakota aircraft from the *Thala Dan.*

"We dragged the plane up the hill with the D4 tractors and then we all had to help put the wings on. There were 350 nuts and bolts for each wing and it was cold," he said.

George was also part of a four-person team trying to bring two tractor trains about 600 kilometres from Binders Base to Mawson station. They had flown in to Binders Base in the Dakota and were relying on it for fuel drops. But the Dakota and a Beaver were destroyed in a blizzard.

"We told the station leader we didn't have enough fuel to get back and he said he'd sort something out and come to our rescue; but that didn't happen," George said.

Two of the party navigated by sextant to an old fuel dump 160 kilometres from Mawson, allowing the return of one tractor train, while the other had to be left behind.

Sometimes though, it's the little things that stick in your mind – like going to the toilet in a blizzard during a field trip.

"You get into the lee of a tractor and the wind and snow is swirling around and you want to hurry up. When you pull up your underdacks they're full of snow. I tell you, you don't forget that!" George said.

Wendy Pyper
Australian Antarctic Division

Founding Mawson

Dr Phil Law raised the flag and commissioned Mawson, Australia's first continental station in Antarctica, on 13 February 1954. (Photo: Richard Thompson)

Huskies were the 'workhorses' of Antarctic expeditions until the early 1990s, including this team at Mawson in 1975. (Photo: Russell Marnock)

George Cresswell (left) on a Velocette motorcycle, with Doug Machin and Viv Hill on the sea ice near Mawson, 1960. (Photo: Jim Kitchenside)

After the British, Australian and New Zealand Antarctic Research Expedition (BANZARE) voyages led by Douglas Mawson, between 1929 and 1931, a vast area of Antarctica between the Ross Sea and Enderby Land (45°E to 160°E) had been mapped and claimed for the British crown. Sir Douglas began lobbying the Australian Government to cement its territorial claim to 42 per cent of the continent, but by the mid-1940s little had been achieved.

In 1946-47, a large military exercise by the US Navy, called Operation Highjump, spurred the Australian Government to act. A meeting of interested government departments was convened and, with Mawson as an adviser, they recommended establishing a base in Antarctica, and the formation of the Australian National Antarctic Research Expeditions (ANARE).

Dr Phil Law (ANARE's new Chief Scientific Officer) and Mawson set the scientific agenda for ANARE, with the priority areas being meteorology, geology, mapping, geophysics, biology, upper atmospheric physics and cosmic ray physics. But it wasn't until the suitably ice-strengthened ship, *Kista Dan*, was found in 1953 that plans to establish a station could really get underway.

Law and Mawson used aerial photographs from Operation Highjump to locate an exposed area of rock with what appeared to be a natural harbour in Mac.Robertson Land – an area near the Amery Ice Shelf that Mawson had explored during BANZARE.

On 4 January 1954 the *Kista Dan* set sail for Mac. Robertson land, with materials to set up buildings, two Auster aircraft, Weasel oversnow vehicles, 27 huskies and food for two years. It was a voyage of adventure and near disaster, with the ship having to be freed from pack ice with crowbars, shovels and dynamite at one point.

On 11 February the *Kista Dan* reached what was later named Horseshoe Harbour. Unloading began the next day, after a blizzard that saw the two Auster aircraft wrecked. Fortunately, the airforce fitters were able to patch together a flyable Auster out of the remains of the two aircraft (but it was wrecked in a storm and washed overboard a few weeks later).

On the evening of 13 February 1954, Law raised the Australian flag and officially named ANARE's first continental station Mawson. The pre-fab buildings were erected and, on 23 February, the ship departed, leaving 10 pioneering expeditioners to overwinter.

During the year the wintering team made a number of trips inland to the Framnes Mountains and Stinear Nunataks. From here they were the first to see the northernmost extremity of the Prince Charles Mountains. Parties also travelled east along the coast to Scullin Monolith and west to Edward VIII Gulf, mapping, collecting rock samples, taking astro-fixes, and discovering the Taylor Glacier emperor penguin colony.

Read more about the founding of Mawson station in *Australian Antarctic Magazine* 22: 16-19, 2012.

See historic footage of the establishment of the station at http://www.antarctica.gov.au/news/2019/65-years-of-mawson-research-station

Wendy Pyper
Australian Antarctic Division

Rumdoodle Hut a 'must visit' destination

The 2019 remodelled Rumdoodle Hut secured in position in the North Masson Range. Mawson station's meteorology technician displayed his artistic flair by preserving and reviving the art work on the exterior of the hut with the Australian flag and the huskies. (Photo: G. Blackwell & C. George)

Living and working in the field has always been a feature of life for Australian National Antarctic Research Expeditions (ANARE). The chance to break up routine station life and visit one of the many iconic ANARE field huts is a treasured experience. With well over a dozen field huts spread across the four research stations, debating the 'best' field hut is always a lively topic of conversation amongst expeditioners.

For those that have experienced the wonders of Mawson research station though, there is little to debate – visits to Rumdoodle Hut are consistently cited as season highlights.

Nestled on the leeward side of the North Masson massif in the Framnes Mountains (about 20 kilometres south of Mawson station), Rumdoodle Hut sits in one of the most spectacular locations in Antarctica. Fronted by the blue-ice beauty of nearby frozen Rumdoodle Lake and coupled with breathtaking views of the epic Masson Range to the rear, the chance to enjoy the view from the Rumdoodle deck is a true bucket list moment.

Yet its iconic location has also proved its Achilles heel, with the North Masson massif transforming the frequent blizzards into extremely strong downslope winds that funnel directly into Rumdoodle. Suffice to say, the hut has certainly had a weathered history!

Between its first iteration in 1960 as a depot for Royal Australian Air Force DC-3 flights, and 2017, the hut has been totally obliterated by blizzard (1972), so badly damaged it was swapped out for a new hut (1986), and twice condemned as unsafe following blizzard damage (2001 and 2017), which required use of a van for alternate accommodation.

Thus, for this season's Mawson winter team (72nd ANARE), the recovery and restoration of Rumdoodle Hut has been a priority project. Leading the charge has been returning Mawson carpenter Chris 'Scottish' George. In the past 10 years Scottish has wintered at Davis (twice), Casey, and Mawson in 2011-12.

"Rumdoodle is my favourite hut... Prior to coming south this time, I read the previous end of season report and it basically said that Rumdoodle was closed for business."

In conjunction with Building Services Supervisor, Glenn Blackwell, a recovery plan was developed and a core team of six expeditioners assembled.

The first step of the plan involved the recovery of the hut in a two-day operation in May. The team spent a full day of back-breaking work extracting the badly damaged hut from its last remaining moorings, before carefully winching it onto a K1 Foremost Pioneer for towing back to station.

The second stage of the plan saw an intense two-week block of rebuilding and refurbishment during August 2019. Led by the core team, the Rumdoodle makeover works included fitting a new door and window, rebuilding the deck, installing new carpet, commissioning a new heater, adding new cushions, refitting electrical switches, and upgrading communications equipment. Rumdoodle Hut quickly gained a station-wide focus, with many others undertaking external and internal repainting to assist the core team.

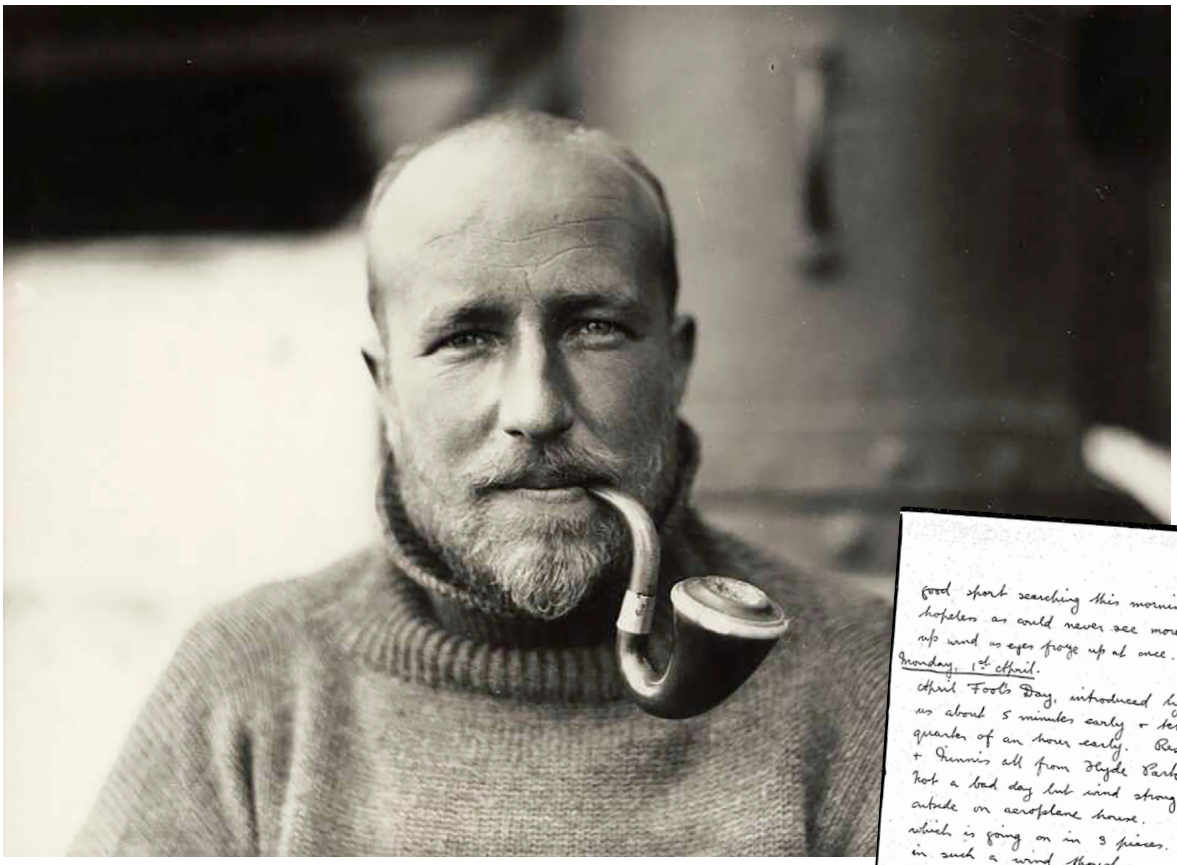
Once the last lick of new paint had dried, Rumdoodle Hut was returned to the field by the recovery team in early October. Its return was back-dropped by two rare, near-windless sunny days, allowing the recovery team to enjoy a star-gazing night on the deck once work was completed. As best put by Scottish: "Rumdoodle is now back open for business!"

Read more about Rumdoodle Hut's renovation and history at www.antarctica.gov.au/living-and-working/stations/mawson/this-week-at-mawson/2019/this-week-at-mawson-18-october-2019

Kyle Williams
Station Leader, Mawson

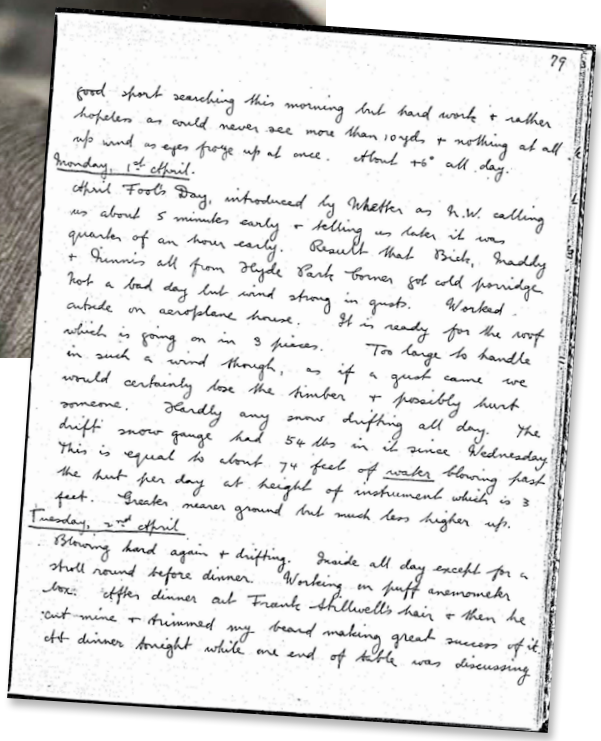
LEFT The 2019 Rumdoodle Recovery Team (L-R): Dave Davies, Tom Dacy, Glenn Blackwell, Warren Arnold, Chris George and James Terrett. (Photo: C. George)

RIGHT Rumdoodle Hut in a sad state after a blizzard blew out the windows and filled the living area with shattered glass and snow. (Photo: G. Blackwell & C. George)



MAIN Bob Bage was the Astronomer, Assistant Magnetician and Recorder of Tides during the Australasian Antarctic Expedition (1911-1914). He also led the Southern Sledging Party in search of the South Magnetic Pole. (Photo: Frank Hurley/ held by NLA)

INSET A page from Bob Bage's diary written during the Australasian Antarctic Expedition on April Fool's Day in 1912. MS 14209 is held at State Library of Victoria.



79

good start searching this morning but hard work + rather hopeless as could never see more than 10yds + nothing at all up wind as eyes freeze up at once. about +6° all day.

Monday, 1st April.

April Fools Day, introduced by Wheller as N.W. calling us about 5 minutes early + telling us later it was quarter of an hour early. Result that Bick, Maddy + Dennis all from Hyde Park Corner got cold porridge. Not a bad day but wind strong in gusts. Worked outside on aeroplane house. It is ready for the roof which is going on in 3 pieces. Too large to handle in such a wind though, as if a gust came we would certainly lose the timber + possibly hurt someone. Hardly any snow drifting all day. The drift snow gauge had 54 lbs in it since Wednesday. This is equal to about 74 feet of water blowing past the hut per day at height of instrument which is 3 feet. Greater nearer ground but much less higher up.

Tuesday, 2nd April

Blowing hard again + drifting. Inside all day except for a stroll round before dinner. Working on puff anemometer box. After dinner at Frank Wellwells hair + then he cut mine + trimmed my beard making great success of it. At dinner tonight while one end of table was discussing

Heroic Era of Antarctic exploration enters digital age

A century-old Antarctic diary is being brought to life for a new generation of Antarctic enthusiasts, thanks to a volunteer army of DigiVol transcribers.

"If we do nothing else we will at least go back with the world's record for heavy winds," observed Edward Frederick Robert 'Bob' Bage in his diary entry of Sunday 17th March 1912. History has shown that the Australasian Antarctic Expedition (AAE) of 1911–14, to which Bage was referring, achieved much more than wind world records, but at the time of writing, Bage would have had no inkling as to how the rest of his adventure in Antarctica would transpire.

It is that raw, in-the-moment, lived experience of the expedition, as it unfolded, that makes Bage's neatly handwritten diary, held by the State Library of Victoria, such a fascinating insight into the day-to-day life of what would arguably become Australia's most famous Antarctic expedition.

Taking leave from the Royal Australian Engineers, 23 year old Bage joined the AAE, led by Douglas Mawson, as Astronomer, Assistant Magnetician and Recorder of Tides. A man of steady character and a natural leader, Bage was popular with his fellow expeditioners. His optimistic outlook and good humour are clearly apparent in his diary entries and letters home to his mother and sisters in Melbourne, in which he describes the work and recreation activities of the expedition.

Of particular amusement are the diary entries that capture the camaraderie amongst the group, as grand occasions such as birthdays, the King's Day and Midwinter are celebrated with gusto. As are the smaller moments, such as the ever present threat of being officially recognised for a badly cooked meal, "great amusement at dinner when Dr Mac was nominated by Hurley for Honorary membership of the Crook Cook's Association".

Tasked with leading the Southern Sledging Party in search of the South Magnetic Pole, the diary entries end as Bage, accompanied by Eric Webb and Frank Hurley, embark on their journey. Bage's final diary entry encapsulates his feelings about Antarctica: "There is only one thing I can add now & that is that a trip like this is a great thing & an experience that I wouldn't have missed for anything, even if we were to get no sledging at all. It is quite worth the isolation & "hardships??"

However, Bage's hardships did not end in the harsh conditions of the Antarctic. After returning to Australia, at the conclusion of the AAE, Bage was further tested in the fiery crucible of Gallipoli.

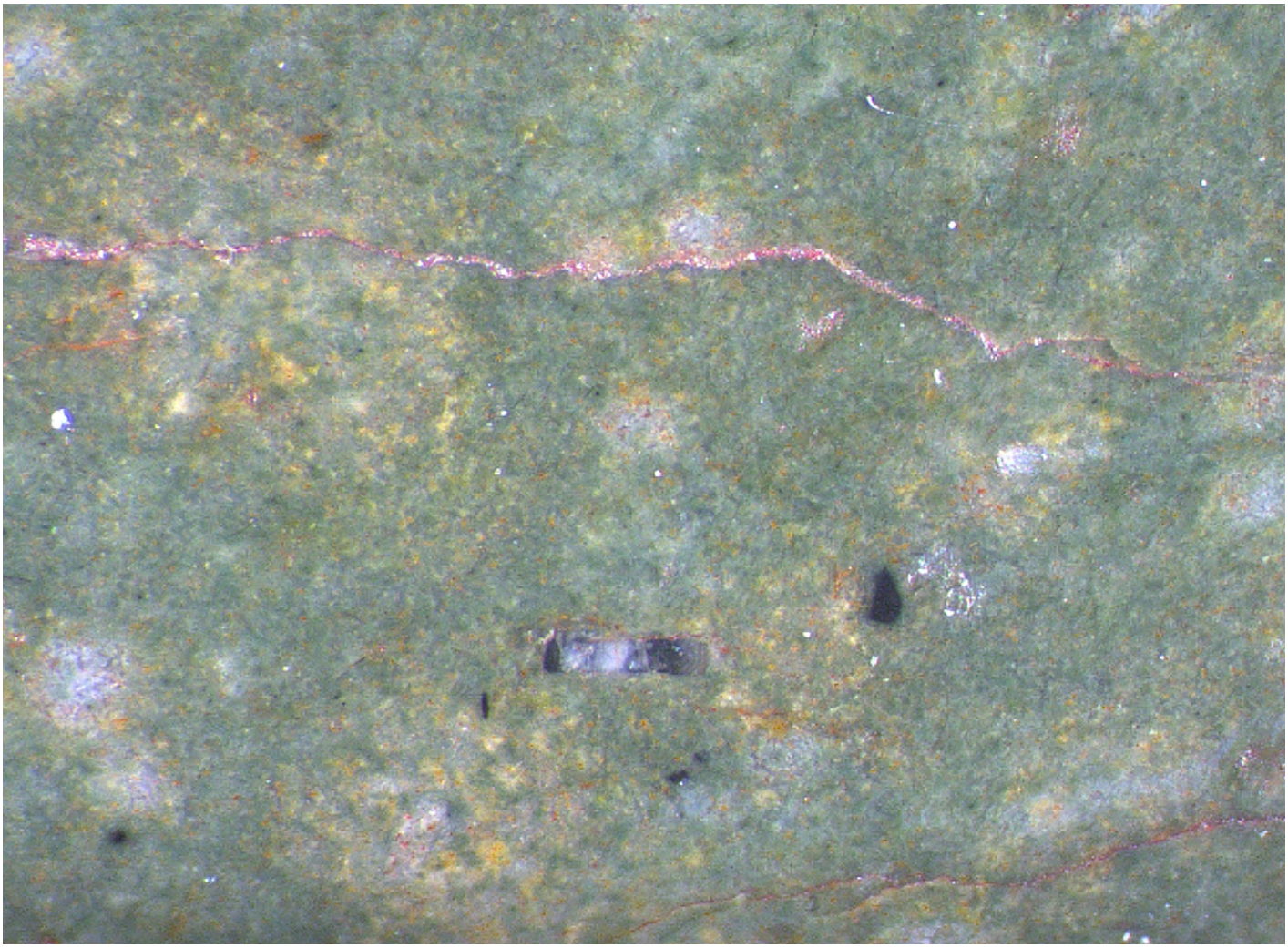
Bage joined the Australian Imperial Force (AIF) and landed at Gallipoli on 25th April 1915, as a Captain and second in command of the 3rd Field Company of Engineers. Little more than two weeks later he was, incredulously, ordered to mark out a forward trench, in broad daylight, in front of the Turkish trenches near Lone Pine. Under a withering hail of Turkish machine gun and rifle fire, Bage was hit three times and killed.

Antarctic diaries such as Bage's are found throughout Australia's national, state, university and government libraries. Increasingly they are being digitised and transcribed by volunteers on platforms such as DigiVol (https://volunteer.ala.org.au/), making the information discoverable and accessible to a new generation of Antarctic enthusiasts.

Find Bob Bage's diary (MS 14209) at the State Library of Victoria http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER2285098

Jane Black and Chris Carson

Cape Adare pendant mystery



Mystery surrounds a green stone pendant that was recently donated by Janet Sykes of Melbourne to the Australian Antarctic Division. Handwriting on a torn piece of card attached to the pendant claims it is "A polished stone pendant from a stone obtained from Cape Adare, Antarctica, by a member of expedition, 1900".

The pendant was found in a charity shop in Kew in the 1980s by Marie Eberbach, who liked the look of it. Twenty years later it was identified by her co-worker at another charity shop as an object of possible historical interest, and donated to the Australian Antarctic Division.

To clarify whether the artefact is genuinely from Cape Adare, Dr Barbara Frankel, a Senior Environmental Officer at the Division with a geological background, was asked to examine the stone and provide an opinion on its authenticity.

The stone is mostly an amorphous dull green colour, with a few flecks of grey or black prisms that can readily be identified as an igneous volcanic texture. To see the stone fabric more clearly, micrographs were taken to magnify it and X-ray fluorimetry undertaken to check its mineralogy.

With the help of an expert alumni network the stone was identified as phonolite or trachyte, which is an intermediate volcanic rock with a high feldspar and low quartz content. So are there phonolites and trachytes at Cape Adare?

There are a few publications on the geology of Cape Adare from the numerous expeditions that have now visited the area, which confirm that these sorts of rock are present. The authenticity of the stone being from Cape Adare looks promising, but what about the connection with an expedition in 1900?

It quickly became evident that this stone had to be from the first ever British wintering Antarctic 'Southern Cross Expedition' of 1899, led by Norwegian, Carsten Borchgrevink. This expedition returned in 1900, two years before Robert Falcon Scott's first attempt at the South Pole in 1902.

Borchgrevink had seized an opportunity to be the first to winter in Antarctica, thanks to Sir George Newnes, a wealthy London publisher, who funded the expedition. By all accounts the expedition and its subsequent publications were shunned by the Royal Geographical Society and other distinguished scientific bodies because of its lack of scientific method. Borchgrevink was not a scientist, a naval officer, nor an aristocrat. He may have fared better in reputation had he been a good leader, but sadly the accounts are scathing. None more so than by his meteorological and magnetic observer, the Belgian-born Tasmanian, Louis Bernacchi.

In fact, it took 30 years for Borchgrevink to be acknowledged as a pioneer in Antarctic exploration, proving the effective use of dogs and equipment, and discovering access to the Ross Ice

Micrographs to magnify the stone's crystal fabric, and X-ray fluorimetry to check its mineralogy (courtesy of Dr Alistair Reed), showed it is a phonolite or trachyte – an intermediate volcanic rock with a high feldspar and low quartz content. (Photo: Ashley Cooper)

One possible link is with Louis' brother Roderick, who had moved to Melbourne from Tasmania, while the rest of the family, including Louis, had moved back to the UK. Is it possible that Roderick was given a trinket by his brother on the return of the Southern Cross Expedition?

Shelf that Scott and others would later use in their fight to be first at the South Pole.

The success of the expedition is likely due to the presence of the other Norwegians in the group. There were only two Brits and one Australian (Bernacchi), out of 10 men. None of these men were geologists, and no field descriptions of the collections seem to exist. In fact the biological notes made by the ill-fated zoologist, Nicolai Hanson, were inexplicably lost after his death in October 1899. All geological and biological specimens were thus returned to London without notes, and donated by Sir George Newnes to the British Museum; now the Natural History Museum.

The geological specimens were described by the museum's resident mineralogist, George Prior, and published in Borchgrevink's book *First on the Antarctic Continent* (1901), and in a later publication on the discoveries of the Southern Cross Expedition in 1904. This collection still resides at the Natural History Museum and I was surprised to find I could search the names of the hand-collected specimens within the museum website. To my delight, phonolites and trachytes are listed.

While I have contacted the museum to try and match the pendant with other specimens from the same expedition, it is difficult to tell from photographs if the rock types match; a closer personal inspection is needed to confirm their identity. My next visit to the United Kingdom (UK) will no doubt include a trip to this and other museums!

Apart from Louis Bernacchi, there is no obvious link between the Southern Cross Expedition and Australia, apart from Hobart being the last port of call on departure, and one of the ports visited on return (after stopping in New Zealand). One possible link is with Louis' brother Roderick, who had moved to Melbourne from Tasmania, while the rest of the family, including Louis, had moved back to the UK. Is it possible that Roderick was given a trinket by his brother on the return of the Southern Cross Expedition?

The print on the reverse of the card holding the pendant alludes to a wild flower exhibition by a Victorian club, opened by the Governor General in October 1917. This was a large exhibition by the Field Naturalists Club of Victoria that opened on 2 October 1917. When I contacted the club to seek any Antarctic connection I discovered that the club has records of Borchgrevink's visit to them in 1895, in the days he was seeking funding for his expedition (unsuccessfully). The club also has a record of sending congratulations to Borchgrevink on his return. However, they confirmed that no Bernacchis were members, placing doubt on Roderick as a link to the piece of card.

In October this year I travelled to the Canterbury Museum in Christchurch to see a New Zealand Natural Heritage Trust exhibition of artefacts from the Southern Cross Expedition, retrieved from Cape Adare for conservation, before their return this summer. The Heritage Trust has no record of any instruments used to polish a stone pendant during the Southern Cross Expedition, so the question of whether the pendant was crafted on site remains unanswered. However Artefacts Conservation Manager, Lizzie Meek, suggests it could have been crafted by the young dog handlers from Lapland who may have had the traditional skills.

So my search for clues continue, including a search for Bernacchi's grand-daughter, Janet Crawford, who studied the diaries of Louis and other expedition members and published them in *That First Antarctic Winter* (1998).

For now though we can only speculate. Perhaps Borchgrevink requested that the pendant and others like it were made so that he had souvenirs to hand out on return, including to those clubs and societies that had wished him well.

Roderick Bernacchi died in 1962, a widower. His only son perished in World War II, leaving no members of the Bernacchi family left in Australia. Perhaps the pendant was given to Roderick by his brother Louis, and his deceased estate was disseminated to the charity shops where Marie was to stumble on it decades later.

I can only thank Marie for keeping such an interesting artefact that has provided so much intrigue, and the Tasmanian Museum and Art Gallery for taking custody of it.

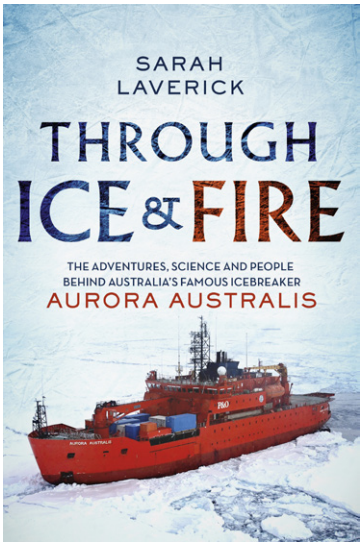
Barbara Frankel
Australian Antarctic Division

CLOCKWISE FROM TOP The only clue to the origin of the polished stone pendant is written on a torn card from a 1917 exhibition by the Field Naturalists Club of Victoria. (Photos: Tasmanian Museum and Art Gallery)

One theory is that the pendant was crafted by the young dog handlers from Lapland on the Southern Cross Expedition. (Photo: Ashley Cooper)

A phonolitic trachyte from Cape Adare – a similar rock to the pendant. (Photo: Natural History Museum)

New book brings icebreaker legacy to life



Main Sarah during her trip to Davis research station in 2017. (Photo: Sarah Laverick/Doug Thost)

Inset (Image: Wendy Pyper/Pan Macmillan)

A tale of ice, fire, heaving seas and human endeavour, will help mark 30 years of Antarctic service for Australia's icebreaking ship *Aurora Australis*.

Through Ice & Fire, published by Pan Macmillan in August, was written by former Deputy Voyage Leader and scientist, Sarah Laverick. Sarah is also a member of the family who built the icebreaker in their Newcastle shipyard.

"My husband's family regaled me with astounding stories of the problems they faced during the icebreaker's construction," Sarah said.

"This inspirational seed eventually grew into an overwhelming urge to tell the *Aurora's* story."

To help with her research for the book, Sarah visited the Australian Antarctic Division several times and travelled to Davis research station on the *Aurora Australis* in late 2017.

She interviewed dozens of voyage leaders, scientists, captains, crew, engineers and many others involved in the ship's history. Sarah also pored through family scrapbooks, voyage reports, library and image archives and much more.

"I struggled under the weight of this mixed blessing," she said.

"The hardest part was deciding what not to include in a single readable book about the ship."

While the book is structured around the dramatic voyages in the ship's 30 year history, Sarah said these events were the exception rather than the rule, with much of the *Aurora's* life an "exercise in quiet, routine accomplishment".

Sarah's efforts are rewarded with the publication of what is, essentially, an inspirational human story in the face of besetments, rescues, strandings, earthquakes, fires and explosions.

Read an excerpt from the book on the following page.

Through Ice & Fire is available in book stores and from Pan Macmillan.

Wendy Pyper
Australian Antarctic Division

Aurora on the rocks

Following is an edited extract from *Through Ice & Fire* by Sarah Laverick, published by Pan Macmillan Australia.

The *Aurora Australis* and her crew had just begun a busy day delivering cargo at Mawson station. The bright orange ship nestled comfortably within the arms of Horseshoe Harbour, and the inhabitants of the colourful buildings dotting the rocky Antarctic hillside supervised the resupply operations with interest. The *Aurora's* cranes danced over the ship, brightly punctuating the overcast sky as they feverishly lifted heavy pallets onto barges waiting patiently beside the icebreaker. The squat craft motored back and forth across the steel water to the snow-speckled granite shores of the station, where a shore crane eagerly took possession of the valuable bounty.

But a slight breeze that had begun to ripple the water at lunchtime soon intensified to a gale that sent wavelets and spray whipping across the harbour, bringing the hectic operations to a halt late in the afternoon. A blizzard was coming: the crew and expeditioners packed up their equipment and the cranes and barges were stowed for the day. Their efforts had already paid off: the ship and shore teams had managed to unload a large portion of the precious stores that would see Mawson station through the harsh, dark months of the approaching Antarctic winter of 2016. It had been a good day.

That evening, the *Aurora's* complement lined up for their well-earned dinner in the ship's mess. The room slowly filled with buzzing chatter and the chink of cutlery on plates, and someone pointed out that snow was now swirling against the portholes.

Main The *Aurora Australis* grounded on West Arm after the blizzard. (Photo: Brett Free)

Inset The *Aurora Australis* begins to limp home after surviving her grounding at Mawson. (Photo: Brett Free)

Unperturbed, the 68 people on board continued their evening's business; they'd already withstood a blizzard two days earlier and they all knew it was just a matter of time until it would ease off. They would simply get comfortable and wait it out.

But this was no ordinary blizzard.

By the next morning, the *Aurora* was mercilessly buffeted by vicious winds and driving snow, and the screaming gales showed no sign of moderating. The ship's massive mooring lines strained against the load, then stretched taut as the winds gusted at over 176 kilometres an hour. Then, incapable of taking any more, the hefty ropes and cables snapped; the resounding cracks and booms of the parting lines stifled by the immense white noise of the blizzard. The blizzard, now unimpeded, ruthlessly drove the *Aurora* toward the shore. Minutes later, the icebreaker shrieked and juddered in protest as her sturdy metal hull ground roughly against the uneven, dark rock of West Arm.

On station, the Mawson search-and-rescue alarm wailed throughout the corridors. The station's expeditioners gathered in the mess, then squinted anxiously against the whiteout while they were briefed on the unfolding crisis. For a fleeting moment the blizzard eased, revealing Australia's Antarctic flagship lying helplessly on the rocks at West Arm. A hazy photograph of the forlorn, snow-crusted ship was hastily taken and emailed to headquarters in Hobart.

The image went global. As news of the *Aurora's* grounding spread, the world's media and the international Antarctic community held their collective breath while the ferocious storm continued to lash at the stricken ship. Was history repeating itself? Had the *Aurora*, just like her predecessor the *Nella Dan* 29 years earlier, met an untimely end on a desolate rocky shore at the far reaches of the Southern Ocean? All over the world, they waited.

New Antarctic Arts Fellows, Dr Adam Nash and Dr John McCormick.will use technology to capture a virtual representation of the Aurora Australis and its complement. (Photo: Wild System)

Artists to create virtual Antarctic voyage

Two digital artists will capture a virtual representation of the *Aurora Australis* and its complement as they sail south this season, providing a life beyond the ship's last Antarctic voyage.

Dr Adam Nash and Dr John McCormick have been awarded the 2019–20 Australian Antarctic Arts Fellowship. Together they are known as Wild System, and develop mixed reality art works and installation.

"We hope to capture the experience of being on the *Aurora Australis* and create an immersive, affecting work," Dr Nash said.

"We want to create a work that honours the spirit of those who have explored the world's last great wilderness area," Dr McCormick said.

The pair will travel to Antarctica on the *Aurora Australis* in January 2020 to re-create a virtual representation of the ship and those who sail on it.

They will use cutting-edge technologies, such as drones, a portable motion capture system, ambisonic recordings (full-sphere surround sound), LiDAR scanning, and still, 360 and video cameras, to map the physical aspects of the voyage.

These recordings will be joined together into playable artworks for immersive experiences at galleries and festivals, and via mobile, gaming and virtual reality technology.

The project is supported by RMIT University School of Design and Swinburne University Centre for Transformative Media Technologies.

Learn more about Wild System at https://www.wildsystem.net/about.html

Eliza Grey

Drilling deep for climate puzzle

Australian Antarctic Division instrument technicians are putting the finishing touches on an ice core drill 'head' – a key component in the future success of Australia's Million Year Ice Core Project.

The cutting head will be critical to the ice drill's successful operation when it descends up to 3000 metres, to extract cores from the bottom of the Antarctic ice sheet.

Chemical information in the ice, and trapped in air bubbles in the ice, will provide a window into a period in history when the Earth's climate shifted from a 40,000 year cycle of recurring ice ages to one every 100,000 years (*Australian Antarctic Magazine* 33: 6, 2017).

While scientists don't know what caused this shift, an ice core spanning this period will allow them to extract a direct record of carbon dioxide to see what role, if any, it may have played.

Construction of the cutting head began in March. The full nine-metre drill is being developed using European and US designs, together with Australian innovation and technology development.

The drill is machined from specialised stainless steel, aluminium, bronze and titanium. It will be able to extract cores up to three metres at a time.

Scientists will use the drill at a remote field camp, about 1200 kilometres inland from Casey research station, over a four year period from 2021.

Corporate Communications

Senior Technical Officer Chris Richards (left) and Instrument Workshop Manager Steven Whiteside with the drill head and drill head components. (Photo: Jessica Fitzpatrick)

Antarctic barges baptised

The two Antarctic landing barges undergoing open water trials in the River Derwent. (Photo: Nisha Harris)

Antarctic landing barges destined to work alongside Australia's new icebreaker RSV *Nuyina* undertook sea-trials on Hobart's River Derwent in October.

The two aluminium landing barges will carry up to 45 tonnes of cargo from ship to shore at Australia's Antarctic and sub-Antarctic stations.

The testing involved open water trials to demonstrate a range of requirements relating to speed, propulsion and manoeuvring capability. They were also tested for their ability to carry large trucks ashore as part of a 'roll-on roll-off' capability, where vehicles can drive on or off the barge over a ramp.

The barges were built by historic Hobart marine engineering company Taylor Bros (*Australian Antarctic Magazine* 36: 6-7, 2019).

Nisha Harris

Treasure trove of Antarctic Division history now online

The *Australian Antarctic Magazine*'s predecessor, *ANARE News* has now been digitised. *ANARE News*, the Australian Antarctic Division's official publication from 1981 to 1996, covered seasonal activities, major science projects, events and international Antarctic news. The magazine is a rich resource for researchers of Australia's modern Antarctic history.

Digital copies of the magazine are available via the National Library of Australia's Trove database and the National e-Deposit scheme: https://trove.nla.gov.au/version/264093343

Tess Egan
Librarian

Doctors without appendixes

It has to be one of the most unusual job requirements – Antarctic doctors must have their appendix removed before heading south.

"It's a unique request and it's always a discussion point at the interview and the medical screening," Chief Medical Officer Dr Jeff Ayton said.

The appendix removal policy came into force after a doctor on Heard Island fell ill, requiring a complex emergency evacuation. Later, in 1961, Russian Antarctic doctor, Dr Rogozov, conducted his own appendectomy under local anaesthetic, with assistance from a lay surgical team.

"It was a remarkable feat and one that no doubt saved his life, but it's something we want to avoid at our stations," Dr Ayton said.

Despite the unusual job requirement, doctors are still lining up to go south. Learn more at http://www.antarctica.gov.au/news/2019/operation-appendix-antarctica-calls

Nisha Harris

Tradeswoman of the year

Davis station diesel fitter and mechanic, Amy Chetcuti, won 'Tradeswoman of the Year' at the Empowering Women in Industry gala awards night, held in Chicago in September (https://www.empoweringwomeninindustry.com/award-nominees). Amy has been working in the trade since 2010 and in Antarctica since October 2018.

Amy completed an apprenticeship in her early 20s and built up her experience working with vehicles and equipment in the fields of logistics, earthmoving, construction, mining and snow sport. Her career has taken her around Australia, and to New Zealand, Hong Kong and now Antarctica.

"I enjoy the variety the trade brings. There's different machinery, locations, people, and different problems to solve. I get great satisfaction from troubleshooting faults and seeing a non-functional machine returned to action," she said.

At Davis, Amy is responsible for operating and maintaining the station's power generation facilities, and maintaining and repairing mechanical plant and equipment, including portable generators, pumps, 4x4s, over-snow vehicles, earth-movers, trailers and cranes.

Accepting her award via a video link from Antarctica, Amy encouraged other women to continue to unite and empower each other, and break down stereotypes. Her advice: "let your work do the talking".

"Don't be afraid to back yourself and your abilities. The moment that I stopped doubting and second guessing myself, was when I really started to succeed," she said.

Wendy Pyper

Tradeswoman of the Year – Davis mechanic Amy Chetcuti. (Photo: Meg McKeown)

Norwegian-Australian luncheon celebrates the *Wyatt Earp*

A luncheon held at Hadleys Hotel in Hobart on 27 September 2019, commemorated the maritime history of the Norwegian fishing vessel *Fanefjord* and her later Antarctic voyages as the *Wyatt Earp*.

Organised by the Australian National Antarctic Research Expeditions (ANARE) Club and the Royal Norwegian Embassy in Canberra, the luncheon celebrated the 100th anniversary of the launch of the ship in Molde, Norway (27 September 1919), the 80th anniversary of the ship's purchase by the Australian Government for the American adventurer Lincoln Ellsworth, and the 60th anniversary of the ship's loss off the Queensland coast in a storm (see *Australian Antarctic Magazine* 36: 28-29, 2019).

Special guest, 96 year old Mr Norman Tame, attended the luncheon as the only surviving crewman from the HMAS *Wyatt Earp*'s 1947–48 Antarctic voyage. Mr Tame rang the ship's bell, in the strict Navy tradition, at the opening and closing of the event.

The Norwegian Ambassador to Australia and the ANARE Club Past President unveiled a commemorative brass plaque recording the ship's maritime history, which was presented to the Maritime Museum of Tasmania for permanent display.

David Dodd
ANARE Club

Former *Wyatt Earp* crew member, 96 year old Norman Tame, rang the ship's bell at the celebratory luncheon. (Photo: Tess Egan)

Chill out to our new podcast. (Photo: Frank Hurley)

Chill out with our new podcast

The Australian Antarctic Division is developing a new podcast series called 'Chill'. In our first one, go behind-the-scenes for this year's Macquarie Island resupply, and hear the stories of those who travel there, those who stay, and why they keep coming back.

Find it on Sound Cloud https://soundcloud.com/user-59436224/resupply-2019-macquarie-island

Antarctica in virtual reality

A 360 degree virtual reality film about life and work at Davis research station, filmed in early 2018 (*Australian Antarctic Magazine* 24: 6-7, 2018), is receiving rave reviews by viewers. *The Antarctica Experience* is now the 12th most viewed documentary in Australian Box Office history, with more than 65 000 people having seen it.

The National Museum in Canberra is extending its showing of the 20 minute documentary for another six months, and the film is also running at the National Maritime Museum in Sydney. The film featured at the World Science Congress in Tokyo in December, and as part of Antarctic Treaty 60th anniversary events in Argentina, Chile and Brazil. The Christchurch International Antarctic Centre will show the film for the next two years and there is interest in hosting it at museums in London and Adelaide. Learn more at https://www.facebook.com/pg/theantarcticaexperience/posts/?ref=page_internal

Correction

In Issue 35 (2018) of this magazine we ran a story about the history of powered flight over Antarctica (Opening up Antarctic skies pp 22-23). In the article we said that from 1929–1930 Douglas Mawson and expedition pilot Stuart Campbell mapped a large stretch of coastline from the Ross Sea to beyond Enderby Land. In fact it was Stuart Campbell and fellow RAAF pilot Eric Douglas. Thanks to Eric's daughter Sally Douglas for correcting the record. Read more about Eric Douglas's and Stuart Campbell's Antarctic flights in Trove https://trove.nla.gov.au/list?id=17913.

PHOTO: RYAN KUNST

Freeze Frame Neil Brown

Neil Brown currently works as the Davis station plumber, where he installs and operates the building services equipment and systems. He previously wintered at Casey in 2015 and spent 18 months at the British Antarctic Survey's (BAS) Rothera station in 2017-18. During his time with BAS he saw large parts of England and visited Ascension Island, the Falkland Islands and Signy station on the Antarctic Peninsula. He lives in Derrinallum, Western Victoria.

I took this photo just after I had finished a time lapse of the aurora australis from a different location and saw that the lights were getting stronger. There were many different colours and they were all visible to the eye. It was 2 am and I had just enough battery left to take a few pictures on my way back to my donga. It took about five attempts to get an image I was happy with, using my Canon EOS 80D with an 11-20mm lens, at f/2.8, 8s.

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