GEOQ EXTERNAL NEWS

Engineering team completes ambitious Antarctic expedition in the 'deep-field'

A team of four British Antarctic Survey (BAS) engineers has returned to the UK after completing a gruelling journey to one of the most remote and hostile locations on the planet to put in place equipment and supplies for an ambitious project later this year. Enduring temperatures of minus 35°C the Subglacial Lake Ellsworth 'Advance Party' has successfully paved the way to explore an ancient lake buried beneath 3km of Antarctic ice. A powerful 'tractor-train' towed nearly 70 tonnes of equipment across Antarctica's ice over deep snow and steep mountain passes. This December a science and engineering team will make the 16,000km journey from the UK to collect water and sediments from the buried lake.

Lake Ellsworth will be the first Antarctic subglacial lake to be measured and sampled directly through the design and manufacture of space-industry standard 'clean technology'. Scientists have been planning for more than 15 years to access the lake, which is one of more than 400 known subglacial lakes in Antarctica, in the quest to yield new knowledge about the evolution of life on Earth and other planets. Lake-bed sediments could also provide vital clues about the Earth's past climate. Through a bore hole, drilled using high-pressure hot water, the team will lower a titanium probe to measure and sample the water, followed by a corer to extract sediment from the lake.

The Advance Party team paved the way for this mission by transporting the drilling equipment more than 250km through the Ellsworth Mountain range, over deep-snow terrain and crevasses to the Lake Ellsworth drilling site. The final leg of this journey was the most challenging and required powerful tractors to tow heavy containers of equipment on sledges and skis, forming a 'tractor-train'. The soft, deep snow and concrete-hard 'sastrugi' snow forms caused the Advance Party's progress to slow, but after three days they safely reached the Lake Ellsworth drilling site.

The Ellsworth Mountains. (Credit: British Antarctic Survey)

The tractor train passing through the Ellsworth Mountains. (Credit: British Antarctic Survey)

Andy Tait, Advance Party Member and Hot Water Drill Designer / Engineer from BAS says,

"Lake Ellsworth is extremely remote, cold and hostile – ambient temperatures dropped to -35°C and with wind chill they dropped further still making living and working on site a physical challenge. We deliberately located the equipment over a kilometre (1.7km) from the drill site to protect it during the harsh Antarctic winter. We will move it to its final position and set up the rig ready for drilling in December.

"Severe winds and the extreme environmental conditions of the area made it vital that we spent a number of days winterising the equipment. Windblown snow will partially bury the equipment and this area of Antarctica is so vast that it would be difficult to find it again without the GPS locators we fitted at the corners of the site. Going back to live there for three months in November will certainly be an experience!"

Chris Hill, Advance Party Member and Lake Ellsworth Programme Manager from BAS says,

"This is a major milestone for the programme and we are delighted that our complex logistical operations were a success this season. Working within the short Antarctic summer season adds pressure to our time on the continent, which is why we had to plan two stages of the programme. The drilling season is nearly upon us, and we still have a long way to go before we can access Lake Ellsworth, but the success of the Advance Party this season certainly puts us in a good position for November."

The Lake Ellsworth Programme Principal Investigator, Professor Martin Siegert from the University of Edinburgh says,

"The completion of this stage of the mission is a welcome one – we are now one step closer to finding out if new and unique forms of microbial life could have evolved in this environment. The samples we hope to capture from Lake Ellsworth will be hugely valuable to the scientific community. This year we will complete and test both the water sampling probe and the sediment corer. Extracted sediment samples could give us an important insight in to the ancient history of the West Antarctic Ice Sheet, including past collapse, which would have implications for future sea level rise."

Reference

The Lake Ellsworth consortium has published a paper describing how the sampling of Lake Ellsworth can be undertaken with minimal environmental impact – Reviews of Geophysics: Clean access, measurement, and sampling of Ellsworth Subglacial Lake: A method for exploring deep Antarctic subglacial lake environments.

Release issued by British Antarctic Survey Press Office on behalf of the Subglacial Lake Ellsworth consortium

Warmer climate, warmer European mountains

The decade from 2000 to 2009 was the warmest since the initiation of worldwide climate measurements, and while localised studies have shown evidence of changes in mountain plant communities that reflect this warming trend, no study has yet taken a continental-scale view of the situation – until now.

With the publication of "Continent-wide response of mountain vegetation to climate change," as an Advance Online Publication (AOP) in *Nature Climate Change* on 8 January 2012, researchers from 13 countries report clear and statistically significant evidence of a continent-wide warming effect on mountain plant communities.

These results are "clearly significant," says Ottar Michelsen, a researcher at the Norwegian University of Science and Technology (NTNU) and one of the article's co-authors. "You can find studies that have shown an effect locally, and where researchers try to say something more globally, but in this case, when you have so many mountains in so many regions and can show an effect, that's a big thing."

60 sites, 17 mountain areas

The article describes the results of a comprehensive effort to measure plant community changes in the mountains over the whole of Europe, with nearly a decade of time between the sampling efforts.

Researchers looked at 60 summit sites and 867 vegetation samples from 17 mountain areas across Europe in 2001 and then revisited the mountain sample sites in 2008. In Norway, a team of researchers including Michelsen and former NTNU researcher Bård Pedersen, now at the Norwegian Institute for Nature Research, studied mountain plots in the Dovre region in central Norway.

By comparing the vegetation found in the sample plots in 2001 and 2008, the researchers were able to see a clear shift in the species in the plots towards species that preferred warmer temperatures.

More specifically, the researchers assigned what they called an altitudinal rank to all 764 plant species included in the study. The rank reflects the temperature at which each species has its optimum performance. And because altitude and temperature are directly correlated in each mountain area (the higher your altitude in the mountains, in general, the colder it will be) the location on the mountain where a plant is found reflects its response to the actual temperature at that location.

Ranking the plant mix?

By summing the altitudinal ranks for the species in the plots, the researchers then used a mathematical formula to give each plot a "thermic vegetation indicator". The indicator was calculated for each plot for 2001 and 2008, and the change in the indicator over the seven years between sample periods showed researchers whether the mix of plants in each plot had stayed the same or shifted on average to plant types that preferred either colder or warmer temperatures.

They then combined the data for the 17 mountain areas for the two time periods to get a continental-scale view of what kind of larger changes, if any, might be underway.

"The transformation of plant communities on a continental scale within less than a decade can be considered a rapid ecosystem response to ongoing climate warming," the researchers wrote. "Although the signal is not statistically significant for single mountain regions, it is clearly significant when data throughout Europe are pooled."

The finding is significant both because the shift in plant communities could be clearly detected over time, but also because it suggests that plants adapted to colder temperatures that are now found in alpine plant communities will be subject to more competition, which "may lead to declines or even local disappearance of alpine plant species," the researchers note. "In fact, declines of extreme high-altitude species at their lower range margins have recently been observed in the Alps."

While the *Nature Climate Change* paper reports on European results, the overall effort is a part of a worldwide monitoring programme being coordinated out of the University of Vienna, Austria that extends over more than 90 mountain sites on five continents. The monitoring programme is called GLORIA, or the Global

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Observation Research Initiative in Alpine Environments. University of Vienna researchers and GLORIA coordinators Michael Gottfried and Harald Pauli are the paper's lead authors.

Release published by the Norwegian University of Science and Technology

Unprecedented, man-made trends in ocean's acidity

Nearly one-third of CO_2 emissions due to human activities enters the world's oceans. By reacting with seawater, CO_2 increases the water's acidity, which may significantly reduce the calcification rate of such marine organisms as corals and molluscs. The extent to which human activities have raised the surface level of acidity, however, has been difficult to detect on regional scales because it varies naturally from one season and one year to the next, and between regions, and direct observations go back only 30 years.

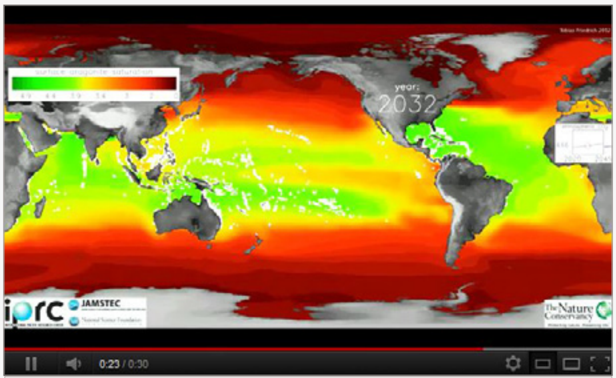
Combining computer modelling with observations, an international team of scientists concluded that anthropogenic CO_2 emissions over the last 100 to 200 years have already raised ocean acidity far beyond the range of natural variations. The study is published in the January 22 online issue of *Nature Climate Change.*

The team of climate modellers, marine conservationists, ocean chemists, biologists and ecologists, led by Tobias Friedrich and Axel Timmermann at the International Pacific Research Center, University of Hawaii at Manoa, came to their conclusions by using Earth system models that simulate climate and ocean conditions 21,000 years back in time, to the Last Glacial Maximum, and forward in time to the end of the 21st century. They studied in their models changes in the saturation level of aragonite (a form of calcium carbonate) typically used to measure of ocean acidification. As acidity of seawater rises, the saturation level of aragonite drops. Their models captured well the current observed seasonal and annual variations in this quantity in several key coral reef regions.

Today's levels of aragonite saturation in these locations have already dropped five times below the preindustrial range of natural variability. For example, if the yearly cycle in aragonite saturation varied between 4.7 and 4.8, it varies now between 4.2 and 4.3, which – based on another recent study – may translate into a decrease in overall calcification rates of corals and other aragonite shell-forming organisms by 15%. Given the continued human use of fossil fuels, the saturation levels will drop further, potentially reducing calcification rates of some marine organisms by more than 40% of their preindustrial values within the next 90 years.

"Any significant drop below the minimum level of aragonite to which the organisms have been exposed to for thousands of years and have successfully adapted will very likely stress them and their associated ecosystems," says lead author Postdoctoral Fellow Tobias Friedrich.

"In some regions, the man-made rate of change in ocean acidity since the Industrial Revolution is hundred times greater than the natural rate of change between the Last Glacial Maximum and preindustrial times," emphasises Friedrich. "When Earth started to warm 17,000 years ago, terminating the last glacial period, atmospheric CO_2 levels rose from 190 parts per million (ppm) to 280ppm over 6,000 years. Marine ecosystems had ample time to adjust. Now, for a similar rise in CO2 concentration to the present level of 392ppm, the adjustment time is reduced to only 100–200 years."



The animation shows how aragonite saturation at the ocean's surface is projected to decrease towards the end of the 21st century as man-made carbon dioxide accumulation in the atmosphere continues to rise.

On a global scale, coral reefs are currently found in places where open-ocean aragonite saturation reaches levels of 3.5 or higher. Such conditions exist today in about 50% of the ocean – mostly in the tropics. By end of the 21st century this fraction is projected to be less than 5%. The Hawaiian Islands, which sit just on the northern edge of the tropics, will be one of the first to feel the impact.

The study suggests that some regions, such as the eastern tropical Pacific, will be less stressed than others because greater underlying natural variability of seawater acidity helps to buffer anthropogenic changes. The aragonite saturation in the Caribbean and the western Equatorial Pacific, both biodiversity hotspots, shows very little natural variability, making these regions particularly vulnerable to human-induced ocean acidification.

"Our results suggest that severe reductions are likely to occur in coral reef diversity, structural complexity and resilience by the middle of this century," says co-author Professor Axel Timmermann."

Release published by the University of Hawaii

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Researchers discover particle which could ‘cool the planet’

Scientists have shown that a new molecule in the Earth’s atmosphere has the potential to play a significant role in off-setting global warming by cooling the planet

In a breakthrough paper published in *Science*, researchers from the University of Manchester, the University of Bristol and Sandia National Laboratories report the potentially revolutionary effects of Criegee biradicals.

These invisible chemical intermediates are powerful oxidisers of pollutants such as nitrogen dioxide and sulphur dioxide, produced by combustion, and can naturally clean up the atmosphere.

Although these chemical intermediates were hypothesised in the 1950s, it is only now that they have been detected. Scientists now believe that, with further research, these species could play a major role in off-setting climate change.

The detection of the Criegee biradical and measurement of how fast it reacts was made possible by a unique apparatus, designed by Sandia researchers, that uses light from a third-generation synchrotron facility, at the Lawrence Berkeley National Laboratory’s Advanced Light Source.

The intense, tunable light from the synchrotron allowed researchers to discern the formation and removal of different isomeric species – molecules that contain the same atoms but arranged in different combinations.

The researchers found that the Criegee biradicals react more rapidly than first thought and will accelerate the formation of sulphate and nitrate in the atmosphere. These compounds will lead to aerosol formation and ultimately to cloud formation with the potential to cool the planet.

The formation of Criegee biradicals was first postulated by Rudolf Criegee in the 1950s. However, despite their importance, it has not been possible to directly study these important species in the laboratory.

In the last 100 years, Earth’s average surface temperature increased by about 0.8°C with about two thirds of the increase occurring over just the last three decades.

Most countries have agreed that drastic cuts in greenhouse gas emissions are required, and that future global warming should be limited to below 2.0°C (3.6°F).

Dr. Carl Percival, Reader in Atmospheric Chemistry at the University of Manchester and one of the authors of the paper, believes there could be significant research possibilities arising from the discovery of the Criegee biradicals.

He said: “Criegee radicals have been impossible to measure until this work carried out at the Advanced Light Source. We have been able to quantify how fast Criegee radicals react for the first time.

“Our results will have a significant impact on our understanding of the oxidising capacity of the atmosphere and have wide ranging implications for pollution and climate change.

“The main source of these Criegee biradicals does not depend on sunlight and so these processes take place throughout the day and night.”

Professor Dudley Shallcross, Professor in Atmospheric Chemistry at the University of Bristol, added: “A significant ingredient required for the production of these Criegee biradicals comes from chemicals released quite naturally by plants, so natural ecosystems could be playing a significant role in off-setting warming.”

Release published by the University of Manchester

Acidification provides the thrust

How diamond-bearing kimberlites reach the surface

Kimberlites are magmatic rocks that form deep in the Earth’s interior and are brought to the surface by volcanic eruptions. On their turbulent journey upwards magmas assimilate other types of minerals, collectively referred to as xenoliths (Greek for “foreign rocks”). The xenoliths found in kimberlite include diamonds, and the vast majority of the diamonds mined in the world today is found in kimberlite ores. Exactly how kimberlites acquire the necessary buoyancy for their long ascent through the Earth’s crust has, however, been something of a mystery. An international research team led by Professor Donald Dingwell, Director of the Department of Geo- and Environmental Sciences at LMU, has now demonstrated that assimilated rocks picked up along the way are responsible for the providing the required impetus. The primordial magma is basic, but the incorporation of silicate minerals encountered during its ascent makes the melt more acidic. This leads to the release of carbon dioxide in the form of bubbles, which reduce the density of the melt, essentially causing it to foam. The net result is an increase in the buoyancy of the magma, which facilitates its continued ascent. “Because our results enhance our understanding of the genesis of kimberlite, they will be useful in the search for new diamond-bearing ores and will facilitate the evaluation of existing sources,” says Dingwell. (*Nature* 18 January 2012)

Most known kimberlites formed in the period between 70 and 150 million years ago, but some are over 1200 million years old. Generally speaking, kimberlites are found only in cratons, the oldest surviving areas of continental crust, which form the nuclei of continental landmasses and have remained virtually unchanged since their formation eons ago.

Kimberlitic magmas form about 150km below the Earth’s surface, i.e. at much greater depths than any other volcanic rocks. The temperatures and pressures at such depths are so high that carbon can crystallise in the form of diamonds. When kimberlitic magmas are forced through long chimneys of volcanic origin called pipes, like the water in a hose when the nozzle is narrowed, their velocity markedly increases and the emplaced diamonds are transported upwards as if they were in an elevator. This is why kimberlite pipes are the sites of most of the world’s diamond mines. But diamonds are not the only passengers. Kimberlites also carry many other types of rock with them on their long journey into the light.

In spite of this “extra load”, kimberlite magmas travel fast, and emerge onto the Earth’s surface in explosive eruptions. “It is generally assumed that volatile gases such as carbon dioxide and water vapour play an essential role in providing the necessary buoyancy to power the rapid rise of kimberlite magmas,” says Dingwell, “but it was not clear how these gases form in the magma.” With the help of laboratory experiments carried out at appropriately high temperatures, Dingwell’s team was able to show that the assimilated xenoliths play an important role in the process. The primordial magma deep in the Earth’s interior is referred to as basic because it mainly consists of carbonate-bearing components, which may also contain a high proportion of water. When the rising magma comes into contact with silicate-rich rocks, they are effectively dissolved in the molten phase, which acidifies the melt. As more silicates are incorporated, the saturation level of carbon dioxide dissolved in the melt progressively increases as carbon dioxide solubility decreases. When the melt becomes saturated, the excess carbon dioxide forms bubbles. “The result is a continuous foaming of the magma, which may reduce its viscosity and certainly imparts the buoyancy necessary to power its very vehement eruption onto the Earth’s surface,” as Dingwell explains. The faster the magma rises, the more silicates are entrained in the flow, and the greater the concentration of dissolved silicates – until finally the amounts of carbon dioxide and water vapour released thrust the hot melt upward with great force, like a rocket. The new findings also explain why kimberlites are found only in ancient continental nuclei. Only here is the crust sufficiently rich in silica-rich minerals to drive their ascent and, moreover, cratonic crust is exceptionally thick. This means that the journey to the surface is correspondingly longer, and the rising magma has plenty of opportunity to come into contact with silicate-rich minerals.

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Release published by LMU, the University of Munich