

Report for SCAR GSSG 2014 from the UK

Geological highlights 2012-4

Ice sheets since the Last Glacial Maximum

An important focus of geoscience research at BAS in recent years has been on constraining the changes in the Antarctic ice sheets since the Last Glacial Maximum. Synthesis papers that collate results to date from different sectors are about to be published in a Special Issue of Quaternary Science Research [September publication]. BAS geoscientists led work on three of the six synthesis papers.

Over recent field seasons BAS marine geologists have collected a unique set of sediment cores from beneath the Larsen C, George VI Sound and Pine Island Glacier ice shelves. The cores were collected in collaboration with BAS and US oceanographers who were using hot-water drills to access the cavities beneath the ice shelves. These cores have the potential to provide valuable new information about processes in the sub-ice-shelf environment and about changes that have taken place in the past few decades or centuries.

In collaboration with the Alfred Wegener Institute, MARUM (University of Bremen) and the NERC UK-IODP Programme, BAS geoscientists will carry out the first investigations in Antarctica using the MeBo sea-floor drilling system in February-March 2015. The MeBo system will be deployed at sites in the Amundsen Sea Embayment during RV Polarstern Expedition ANT/3. The objectives of the project are to improve knowledge of West Antarctic Ice Sheet history from its inception in the Tertiary through to late Quaternary fluctuations, and to improve understanding of the factors that have influenced its dynamic behaviour.

Palaeoclimate and the evolution of life

A four-year NERC-funded Life and the Planet project entitled "Impact of global disturbances on the evolution of life in the polar regions during the Early Cenozoic (PALEOPOLAR)" is near completion. Much of this work has centred on the Late Mesozoic-Early Cenozoic sedimentary succession of Seymour Island, Antarctic Peninsula, where key sections across the K/Pg boundary have been studied, and a new Maastrichtian - Paleocene palynostratigraphy established. Exciting new discoveries include the possibility that there was sea ice in the region during the latest Cretaceous, and the use of new geochemical proxies to establish cool palaeotemperatures through the first 10 m.y. of the Cenozoic era. We have found evidence that the K/Pg boundary re-set the macro-evolutionary stage in the polar region and was the precursor to a pronounced mid-Paleocene - mid-Eocene evolutionary radiation event. The origins of many modern polar marine faunas lie within the Early Cenozoic greenhouse world rather than the later Cenozoic icehouse.

Long-term geological mapping

Over the last three years, the geological mapping group have produced six new geological maps across key areas of the Antarctic Peninsula and sub Antarctic islands. The mapping is a collection of archive field data, combined with new geological mapping, geochemistry and geochronology. The mapping has helped refine geological correlations into West Antarctica and South America. A significant new area of research is the development of satellite and airborne spectral remote sensing to aid lithological mapping and understanding patterns of hydrothermal alteration.

Aerogeophysics

The aerogeophysics group at BAS has been at the forefront in international studies of sub-ice geology, crustal architecture and ice sheet dynamics in several previously unexplored Antarctic frontiers. Recent exciting discoveries include the identification of the East Antarctic Rift System that provided a tectonic trigger for the uplift of the Gamburtsev Mountains and evidence for widespread accretion beneath the East Antarctic Ice Sheet, with significant implications for the search of the oldest ice. Fundamental knowledge of bedrock topography and sub-ice geology of the Wilkes and Aurora basins, which underlie a potentially more unstable sector of the East Antarctic Ice Sheet, has also emerged. Our current research focuses on understanding the structure and evolution of the Recovery Frontier in East Antarctica, the Weddell Sea region and the West Antarctic Rift System. A new European-led international initiative is being launched to explore the region between South Pole and the Weddell Sea, the so-called Polar Gap, where global satellite missions currently lack key potential field and radar data coverage. A next-generation international digital-magnetic-anomaly mapping project has also been launched and a preliminary new map is planned by the end of 2015.

Future work from 2014 onwards:

Impact of surface melt and ponding on ice shelf dynamics and stability

Principal Investigator: Prof. Adrian Luckman (Swansea University), Co-Investigators: Dr Bernd Kulessa, Dr Ian Rutt (Swansea University); Prof. Bryn Hubbard (Aberystwyth University).

The investigation includes two successive field seasons, commencing during 2014/15. A central objective is to understand the impact of melt and ponding on firn compaction and ice dynamics, and, by numerical modelling, to assess the overall impact of surface processes on stress, fracture and ultimately stability. Fieldwork will be on the Larsen C ice shelf.

Antarctic Peninsula (UKANET): better constraints on Earth structure and uplift.

Principal Investigator: Prof. Graham Stuart (University of Leeds), Co-Investigators: Prof. Andrew Hooper (University of Leeds), Dr Pippa Whitehouse (University of Durham), Dr Alex Brisbane (BAS).

Fieldwork will commence during the 2014/15 season. Analysis of recordings from a deployment of broadband seismometers, installed at various locations in the southern part of the Antarctica Peninsula, will be used to estimate three-dimensional variations in the rheology of the underlying rocks, by developing shear-wave velocity-depth models from inter-station surface waves. The objective is to provide better understanding of the tectonic evolution of the region.

Ice shelves in a warming world: Filchner Ice Shelf system, Antarctica.

The Principal Investigator (Hugh Corr) and five of the Co-Investigators (Dr Hilmar Gudmundsson, Dr Adrian Jenkins, Dr Gareth Marshall, Dr Scott Hosking and Dr Keith Nicholls) are at BAS. Other Co-Investigators are based at: University College London (Prof. Paul Brennan), University of Exeter (Prof. Matthew Collins), and the National Oceanographic Centre, Southampton (Stephen McPhail).

The primary aim of the project is to determine how a large sector of the Antarctic Ice Sheet will evolve in a warming world. A carefully targeted observational programme, in support of a comprehensive modelling activity, will be conducted of the Filchner Ice Shelf and its five tributary ice streams, which spans sections of both the East and West Antarctica Ice Sheet. Specifically, projections will be made, to the end of this century, of the contribution to global sea-level rise from this sector. The project will commence in 2015.

A research cruise on RRS James Clark Ross in January-February 2015

Led by R.Larter (BAS)

This will collect site survey data for an International Ocean Discovery Program expedition (IODP proposal 732-Full2). The aim of the drilling expedition will be to recover continuous, high-resolution records of Tertiary and Quaternary ice sheet fluctuations from sediment drifts on the continental rise west of the Antarctic Peninsula and in the southern Bellingshausen Sea. The objectives of the site survey cruise, which will include participants from the USA, Spain and Germany are to collect 2,500 line-km of new multichannel seismic data that will reveal the detailed pattern of development of the drifts, and piston cores that will be used to test the feasibility of using relative palaeomagnetic intensity records to provide high-resolution chronology for the drill sites.

Transport and mixing of Circumpolar Deep Waters on the West Antarctic Peninsula shelf.

A NERC Independent Research Fellowship Grant was awarded to Dr Alex Brearley, BAS.

The research project aims to identify the mechanisms by which warm deep waters intrude onto the West Antarctic Peninsula shelf; also, to quantify and understand the mixing processes that affect these waters as they are advected across the shelf towards the continent. A number of hypotheses relating both to heat delivery onto the shelf and to the on-shelf mixing will be tested. Specifically, the relative importance of widespread flooding of CDW onto the shelf (particularly within deep troughs) versus eddies or intrusions fluxing in warm water across the shelf break. Fieldwork for the project

(commencing during the 2014/15 season) centres principally on water sampling in two regions: one close to the shelf break and another in Ryder Bay, near Rothera research station. The initial stage involves the testing, deployment and recovery of a number of Webb Research 'Slocum' Seagliders. These are equipped with conductivity-temperature-depth (CTD) recorders, and one is also instrumented with a Rockland MicroRider package measuring centimetre-scale velocity shear in the water column, from which quantities such as the turbulent diffusivity can be estimated.

Reducing the uncertainty in estimates of the sea level contribution from the westernmost sector of the East Antarctic Ice Sheet since the Last Glacial Maximum.

Principal Investigator: Prof. Mike Bentley (University of Durham), Co-Investigators: Prof. Peter Clarke, Dr Rory Bingham and Dr Matt King (Newcastle University); Prof. Dominic Hodgson and Dr Rob Mulvaney (BAS).

The project is intended to reduce the level of uncertainty in Global Isostatic Adjustment predictions, by examining ice-loading history. It will provide this improvement by extracting a ~150m ice core in a low accumulation zone, to obtain annual accumulation patterns for the period 2000-4000 years before present. This will be supplemented by cosmogenic isotope dating of former ice thickness changes on nunataks in three key areas, in order to further constrain ice sheet extent. The results will be used to force a new ice model which, together with an Earth model, can be validated by existing and newly-collected GPS-derived uplifts (also obtained by this project). The geographical focus for the fieldwork is Coats Land.

Dating and modelling fast ice-sheet grounding-line retreat over the last 4000 years in the SW Weddell Sea, Antarctica.

Principal Investigator: Dr Richard Hindmarsh (BAS), Co-Investigators: Hugh Corr, Dr Ed King, Dr Rob Mulvaney (BAS); Prof. Mike Bentley (University of Durham)

The SW Weddell Sea region drains ~22% of the Antarctic ice-sheet and shows some of the most recent sustained change in Antarctica. Understanding of how this region has changed over the last few thousand years is important for predicting the trajectory of future Antarctic ice-sheet change, by helping to constrain ice-sheet models and explore mechanisms for grounding-line change. This project uses an innovative approach to provide new constraints on grounding-line retreat through the SW Weddell sea during the last 4000 years, by measuring the time of the last flow-disturbance of ice-rises as the grounding-line retreated past them. The BAS PRes radar system will be used to measure strain-rates at ice divides and combine those data with radar observations of englacial layer architecture, using the BAS DELORES radar system to date flow-change. The resulting data will be integrated with recently obtained geological and glaciological information, to constrain new models that will explore the mechanisms, style and timing of grounding-line retreat in the SW Ronne ice-shelf area, where long-term average retreat rates are amongst the fastest in Antarctica. The project will provide critical quantifications of, and novel mechanistic insights into,

grounding line retreat in a region that is inaccessible to conventional geological approaches.

Outreach programmes:

- Antarctic geoscientists in the UK undertake many outreach activities, especially many through BAS.
- The UK Polar Network (UK branch of APECS) is also very active with schools in particular.

Reported by Jane Francis