

Antarctic Funding Initiative [AFI]

Fifth Workshop

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ABSTRACTS OF ORAL PRESENTATIONS

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Abstracts are listed in order of the respective AFI round and project reference number.

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AFI5/03	Glacial history of the Ellsworth Mountains, Weddell Sea embayment, west Antarctica	Dr Mike Bentley ¹ Dr Chris Fogwill ² Professor David Sugden ²	¹ University of Durham ² University of Edinburgh
AFI5/32	Dissolved organic nitrogen cycling in Antarctic soils	Dr Paula Roberts ¹ Professor Davey Jones ¹ Dr Kevin Newsham ² Dr John Farrar ¹ Dr Peter Darrah ³	¹ University of Wales, Bangor ² British Antarctic Survey ³ University of Oxford
AFI5/39	The physiological and ecological correlates of successful reproduction in the black-browed albatross	Dr Alexander Kabat ¹ Professor Pat Butler ¹ Dr Anthony Woakes ¹ Professor John Croxall ² Dr Richard Phillips ²	¹ University of Birmingham ² British Antarctic Survey
AFI6/16	Gene flow in Antarctic fishes: The role of oceanography and life history	Dr Jenny Rock ¹ Dr Emma Young ² Professor Gary Carvalho ¹ Dr Bill Hutchinson ³ Professor Paul Rodhouse ² Dr Eugene Murphy ² Dr Mike Meredith ² Dr Sally Thorpe ² Dr Tony North ¹	¹ University of Wales, Bangor ² British Antarctic Survey ³ University of Hull
AFI6/28	Terminal Cretaceous climate change and biotic response in Antarctica	Professor Jane Francis ¹ Dr Vanessa Thorn ¹ Dr Duncan Pirrie ² Dr Alan Haywood ³ Dr Jim Riding ⁴ Professor Rob Raiswell ¹ Stephen Hunter ³	¹ University of Leeds ² University of Exeter ³ British Antarctic Survey ⁴ British Geological Survey

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AFI6/33	Did Antarctic octopuses colonise the deep sea?	Dr Jan Strugnell ^{1,2} Dr Louise Allcock ¹	¹ Queen's University Belfast ² British Antarctic Survey
AFI2/34	Temperature sensitivity of capacities: a latitudinal comparison of temperature adaptation in Antarctic ectotherms	Professor Lloyd Peck Dr Simon Morley	British Antarctic Survey
AFI4/02	Behaviour of stable isotopes and trace elements: Reconstructing the Antarctic sea-ice environment	Kate Hendry ¹ Damien Carson ² Dr Ros Rickaby ¹ Dr Raja Ganeshram ² Professor Harry Elderfield ³	¹ Department of Earth Sciences, University of Oxford ² School of Geosciences, University of Edinburgh ³ Department of Earth Sciences, University of Cambridge
AFI4/13	Biogeochemical particle flux study in Marguerite Bay – season 2004-05	Dr Mark Brandon ¹ Professor Tim Jickells ² Professor Andy Clarke ³ Paul Dennis ² Dr Mike Meredith ³ Dr Keith Weston ² Mags Wallace ^{3,1}	¹ Open University ² University of East Anglia ³ British Antarctic Survey
AFI4/09	Improving ice core interpretation: The role of storm track changes on the sub-annual peninsula precipitation variability.	Dr Georgina Miles Dr Gareth Marshall John Turner Dr Robert Mulvaney Dr Tom Lachlan-Cope	British Antarctic Survey
AFI5/01	A seasonal cycle of alkyl nitrates and organohalogen trace gas concentrations in Marguerite Bay on the Antarctic peninsula.	Dr Claire Hughes ¹ Dr Adele Chuck ¹ Dr Sue Turner ¹ Professor Peter Liss ¹ Professor Andy Clarke ²	¹ University of East Anglia ² British Antarctic Survey
AFI3/03	The Chemistry of the Antarctic Boundary Layer and Interface with Snow – <i>CHABLIS</i>	Dr Anna Jones ¹ Dr Stephane Bauguitte ¹ Dr Rhian Salmon ¹ Dr Eric Wolff ¹ Dr David Ames ² Dr William Bloss ³ Dr Kevin Clemmishaw ²	¹ British Antarctic Survey ² Department of Environmental Science and Technology, Imperial College of Science ³ Department of Chemistry, University of Leeds

Project	Title	Authors	Affiliations
		Dr Zoe Fleming ² Dr Paul Hamer ⁷ Dr Dwayne Heard ³ Dr Andrea Jackson ⁴ Dr James Lee ⁵ Dr Ally Lewis ⁵ Dr Graham Mills ⁶ Professor John Plane ⁶ Dr Katie Read ³ Dr Alfonso Saiz-Lopez ⁶ Dr Dudley Shallcross ⁷ Dr Bill Sturges ⁶ Sarah Walker ⁴ Dave Worton ⁶	University of Leeds ⁵ Department of Chemistry, University of York ⁶ School of Environmental Sciences, University of East Anglia ⁷ School of Chemistry, University of Bristol
AFI5/38	A meteor radar at Rothera for studies of the mesosphere and lower thermosphere	Dr Patrick Espy ¹ Dr Peter Younger ² Professor Nick Mitchell ²	¹ British Antarctic Survey ² Centre for Space, Atmospheric and Oceanic Science, University of Bath
AFI4/05	Testing Gondwana plume and break-up models: Constraints from magma flow directions	Professor Donny Hutton ¹ Professor Peter Turner ¹ Dr Bill Owens ¹ Dr Phil Leat ² Dr Mike Curtis ² Dr Ken Thomson	¹ School of Geography, Earth and Environmental Sciences, University of Birmingham ² British Antarctic Survey
CGS7/20	Late Cenozoic glacier-volcano interaction on James Ross Island and in adjacent areas, Antarctic Peninsula region	Professor Mike Hambrey ¹ Dr John Smellie ² Dr Anna Nelson ² Dr Jo Johnson ²	¹ University of Wales at Aberystwyth ² British Antarctic Survey
CGS7/21	Extending the Americas palaeoclimate transect through the Antarctic Peninsula to the pole	Anna Hey ¹ Dr Dominic Hodgson ² Dr Claire Allen ² Dr Jennifer Pike ¹	¹ University of Cardiff ² British Antarctic Survey
CGS7/22	Southern Ocean predator-prey interactions: the importance of krill in the surface zone	Martin Cox ¹ Dr Andy Brierley ¹ Dr Keith Reid ² Dr Jon Watkins ²	¹ University of St Andrews ² British Antarctic Survey
CGS7/23	Microbial biodiversity in Antarctic marine ecosystems	Rachel Malinowska ¹ Dr David Pearce ¹ Dr David Billett ²	¹ British Antarctic Survey ² National Oceanography Centre

**GLACIAL HISTORY OF THE ELLSWORTH MOUNTAINS, WEDDELL SEA
EMBAYMENT, WEST ANTARCTICA [AFI5/03]**

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We report here the initial results from a programme of geomorphological mapping and sampling for cosmogenic isotope analysis in the Ellsworth Mountains. The overall aim of the project is to establish the timing and rate of thinning of the West Antarctic Ice Sheet from its maximum extent in an area inland of the Weddell Sea embayment. In season 05/06 we worked along a c. 350 km transect, stretching from Pirrit Hills (81°06'S, 85°31'W) in the south to the ridge between Mt. Bentley and Mt. Hubley in the north (78°09'S, 86°41'W). Most sites were on the western (West Antarctic Ice Sheet) side of the range but we also worked in the Flowers Hills (78°24'S, 84°31'W) on the east side of the range, adjacent to the Rutford Ice Stream. We studied the geomorphology of 11 field locations in detail, including studies of drift sheets, and weathering of sediments and bedrock plus closely-spaced sampling of erratics and bedrock along altitudinal transects at each site. Our geomorphological mapping has allowed us to determine a series of ice sheet advances and we discuss a preliminary landscape and glacial history of the Ellsworth Mountains extending from the pre-Quaternary to the present-day. The first exposure dates will also be presented.

DISSOLVED ORGANIC NITROGEN CYCLING IN ANTARCTIC SOILS [AFI 5/32]

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Nitrogen is believed to be a primary nutrient regulator of plant productivity in many polar regions. It may therefore prevent higher plants and soil organisms from responding to drivers of environmental change, which would otherwise increase productivity and growth rates, and force altered competitive relations. This is particularly so if the formation of NH_4^+ and NO_3^- is much slower at low temperatures. However, the supposition that plants acquire N mainly in inorganic form has recently been questioned, exposing our very poor understanding of N cycling in polar environments. Some Antarctic ecosystems are believed to be undergoing rapid climate change and this can be expected to have profound effects on plant and soil community structure and function. We expect that elevated temperatures will significantly alter the patterns of N cycling in Antarctic soils, leading to enhanced NO_3^- production and potentially to selection against species that preferentially use DON or those that rely on rain-fed N.

The main aims of this project were to:

- 1). Determine whether DON constitutes the dominant soluble N pool in continental and maritime Antarctic soils and to develop an understanding of factors that may influence and exploit this nutrient source.
- 2). Study the effects of increased temperature on the transformation of DON to NH_4^+ and NO_3^- .
- 3). Confirm that flux of N in Antarctic soils is regulated by the conversion of high molecular weight to low molecular weight DON.

Field locations were chosen that have contrasting N inputs and ecosystem complexity. We established a soil sampling regime, taking small quantities of soil and extracting soil pore water throughout the growing season. We are quantifying the soil N pool sizes and determining turnover times for four key soil N pools. Amino acid turnover times have been determined using ^{14}C labelled amino acids. The final stage of the project will be to construct and validate a mathematical model to describe plant-soil-microbial N fluxes in Antarctic soils.

THE PHYSIOLOGICAL AND ECOLOGICAL CORRELATES OF SUCCESSFUL REPRODUCTION IN THE BLACK-BROWED ALBATROSS. [AFI 5-39]

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Rates of successful fledging vary enormously within a species despite individuals experiencing similar environmental constraints. Some long-lived seabirds improve breeding ability with increasing age and effort, or with differences in body size, fat or protein reserves. Nevertheless, some breeding pairs continuously fledge chicks more successfully than others. The underlying reasons for this disparity and the extent to which phenotype or genotype influence fledging success remains unclear. Much of this variation may well be determined by the parents' capacity to provide adequate resources for maximal growth. This adequate resources availability may reflect foraging proficiency, as only females of a minimum body condition can attempt to breed, and both sexes are not likely to risk their own life over a single rearing attempt. Following the study by Bevan *et al.* (1995) of free-ranging black-browed albatross (*Thalassarche melanophrys*), the present investigation uses heart rate loggers to estimate field metabolic rate to determine why some breeding pairs are more successful than others. By careful selection of 16 breeding pairs and with known reproductive histories (8 successful and 8 unsuccessful) and of similar age, this study examines how energetic constraints and parental investment affects the fledging success of *T. melanophrys*. Metabolic rates and foraging effort data are used to calculate indices of foraging proficiency in order to understand the variation in parental resource provisioning to the chicks, as well as the partitioning of paternal and maternal investment. This is contrasted with growth and overall condition at fledging, as presumably those chicks in better condition will have greater survival prospects.

This season on Bird Island went extremely well considering the large number of animals, remote field location and lack of technical support. Fifty-two heart rate loggers were successfully implanted into the black browed albatross. Twenty validations and calibrations of heart rates against metabolic rates on land and water were conducted and sixteen 36-48 hour continuous respirometry studies examining metabolic rate and heart rates in black browed albatrosses were performed. Fifty-two sets of weight, morphometric and fat score measurements were collected. At the end of the season, 20 removal surgeries of heart-rate loggers were completed. This season I was also fortunate in the successful recovery of all but one of the loggers that were scheduled to be retrieved before the end of the breeding season.

Morphometric and body condition analysis has already demonstrated a strong relationship between adult levels of subcutaneous and peri-renal fat deposits and variation in historic survivorship of chicks. This emphasises the importance of determining which aspects of a particular foraging strategy provide increased foraging efficiency or economy. The data has also shown a difference in egg lay date, brood guard duration, and rate of feeding. This season alone has already amassed a large energetics data set that will allow for extensive analysis and interpretation, and in the following season we should retrieve twice as much again. This may provide us with greater understanding of what allows some albatrosses to breed successfully while others fail.

GENE FLOW IN ANTARCTIC FISHES: THE ROLE OF OCEANOGRAPHY AND LIFE HISTORY [AFI6/16]

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A low level of genetic population differentiation is generally assumed for marine organisms, particularly those with pelagic larvae, due to an apparent lack of barriers to gene flow. However, variability in a variety of life history and environmental characteristics can have marked effects on the dispersal of all life stages, and the mechanisms and effects of these relationships are only beginning to be investigated.

Our research examines the influence of oceanographic processes and life history variation on dispersal and gene flow in two Antarctic fishes, *Champsocephalus gunnari* and *Notothenia rossii*. These species differ in several aspects of life history that are expected to strongly affect their dispersal capabilities, including variation in spawning sites, and the pelagic or demersal nature of their eggs. They are sympatrically occurring across the Scotia Sea, and both species appear to exhibit inter-population variation in certain biological features (e.g. morphology). We are using the Ocean Circulation and Climate Advanced Model (OCCAM) to predict the large scale transport of planktonic eggs and larvae spawned at various locations around Antarctica. A high resolution model, using the Proudman Oceanographic Laboratory Coastal Ocean Modelling System (POLCOMS), is being developed for the South Georgia region to enable us to look at the finer scale processes of cross-shelf transport and retention. Using these different scales of resolution allows us to examine the drift and retention of early life history stages in more detail, such that behaviour and life history can be more fully incorporated into the larger scale transport patterns.

To analyse population structure at both circumpolar and regional geographic scales we are using genetic markers to examine historic and contemporary gene flow (mtDNA and microsatellites, respectively). Patterns of population differentiation will then be compared with predictions from the oceanographic models, allowing us to assess the impact of oceanographic regime on dispersive larval phases and adult migration. Such an analysis provides novel insight into the nature of biological and environmental constraints on dispersal and gene flow. Understanding the transport of organisms by passive and active processes is fundamental to an understanding of colonization, evolution and biodiversity, subjects of theoretical importance as well as of utmost practical merit for assessing the recovery of exploited fish stocks.

Four months ago we completed our first field season, having successfully sampled both species in different regions of the Scotia Sea (South Shetlands, South Orkneys and South Georgia). Additional samples in the Scotia Sea, unfortunately limited to one species, were collected from further S along the peninsula (King George Island, Deception Island, Bellingshausen Sea) as well as from Shag Rocks and, for circumpolar comparisons, from the Indian Ocean sector (Kerguelan and Heard Islands). In October we will conduct sampling on the Discovery 2010 cruise to collect larvae of both species from South Georgia, Shag Rocks and the South Orkneys. Here we present preliminary molecular results for 1) strong circumpolar differentiation of populations, 2) relatively weak differentiation within the Scotia Sea but with some evidence for population genetic structuring. We also present preliminary results from a high resolution hydrodynamic model of the South Georgia shelf and surrounding Scotia Sea, and a large scale (circumpolar) particle tracking scheme.

TERMINAL CRETACEOUS CLIMATE CHANGE AND BIOTIC RESPONSE IN ANTARCTICA [AFI6/28]

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This project investigates latest Cretaceous to early Palaeogene (Maastrichtian to earliest Danian, ~71-65Ma) climates in Antarctica to determine the nature of end Cretaceous climate change. Geological evidence suggests that after the peak mid-Cretaceous greenhouse warmth climates cooled considerably during the Maastrichtian. Some scientists now argue that cooling was at times so severe that polar regions suffered short term glaciations, causing sea level changes worldwide. This challenges the current view that the Cretaceous greenhouse world was ice-free, implying instead that short term glacial climates may have punctuated supposedly stable high-CO₂ climates.

During the field season in January-February 2006 the latest Cretaceous and earliest Palaeogene (Maastrichtian-Danian) sedimentary sequence on Seymour Island was measured, logged and sampled (over 1200 metres of the López de Bertodano Formation). The sediments consist mainly of a superficially monotonous sequence of bioturbated muddy siltstones, originally eroded from the volcanic arc to the west (now the Trinity Peninsula region) and deposited in a subsiding but rapidly filling marine basin (the James Ross basin). Exceptionally rich fossil beds are common in the upper parts of the sequence. The fossil remains of a diverse fauna of ammonites, bivalves, gastropods, echinoids, marine reptiles, corals, fish and sharks were discovered.

Within this sequence, however, there are intervals of glauconite-rich beds. Glauconite is a green iron-rich silicate mineral that requires very quiet conditions to form within the seafloor sediment. The presence of glauconite in this sequence thus indicates that at times sedimentation on the sea floor stopped for some time. Why did sedimentation cease – was it due to higher sea levels and deeper water conditions in this area or a change in sediment supply from the Peninsula region? Was this related to phases of glaciation?

Future work using isotope analysis, and palynological and macrofossil analysis should provide information about changing climates and ecology over the last few million years of the Cretaceous, before the catastrophic end-Cretaceous extinction event. Our detailed sampling will allow us to construct a high-resolution record of climate change. Drastic change would have stressed terrestrial and marine biotas and made them particularly susceptible to early extinction related to the global environmental catastrophe. In addition, evidence for ice sheets before the currently accepted onset of Cenozoic glaciation (Oligocene, ~38Ma) would indicate that environmental conditions on Antarctica were predisposed for glaciation, therefore ice sheet growth during the Neogene represents the return of icehouse conditions, not the initiation.

DID ANTARCTIC OCTOPUSES COLONISE THE DEEP SEA? [AFI6/33]

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This study uses octopuses as model organisms to test the hypothesis that the Antarctic has acted as a centre for evolutionary innovation and radiation and as a source of taxa that have invaded the deep sea. It is likely that the deep-sea fauna was depauperate following extinction events associated with past global climate change causing, for example, deep-ocean oxygen minima. Such events have been recorded from the Late Cretaceous and Palaeocene / early Eocene, prior to the opening of the Drake Passage. The subsequent development of deep-water connections between the Southern Ocean and the major oceans which surround it would have facilitated the expansion of biogeographic boundaries. The present study characterises macro-evolutionary processes of endemic Antarctic octopod fauna and deep-sea octopod fauna using molecular methodologies. Bayesian analytical procedures incorporating fossil constraints will then be used to estimate the divergence times of these taxa thereby providing a means of testing the hypothesis that, in evolutionary history, Antarctic taxa invaded the deep sea.

A LATITUDINAL COMPARISON OF TEMPERATURE ADAPTATION IN ANTARCTIC ECTOTHERMS [AFI2/34]

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Antarctic marine animals live in a cold environment that has experienced stable temperatures over evolutionary time scales. The physiology of Antarctic ectotherms is constrained by low temperatures, which slow down the rate of biochemical reactions and limit aerobic capabilities. Investigations of the physiological capabilities and temperature tolerances of animals that live at different latitudes and therefore experience different annual temperature ranges can provide insights into the mechanisms of temperature adaptation especially when these comparisons are controlled for phylogenetic differences. This study combined latitudinal comparisons of animals from both within and outside the Southern Ocean to investigate the correlation between short term and medium term environmental temperature fluctuations and corresponding physiological flexibility. Knowledge of these flexibilities will help us to predict the impacts of climate change on Antarctic benthic communities and further test the developing theory of oxygen limitation of thermal tolerance.

Study animals, the limpet *Nacella concinna*, the clam *Laternula elliptica* and the spiny plunderfish *Harpagifer spp.* were collected by SCUBA diving at Signy (60°S), South Georgia (54°S), Rothera research station (67°S) and Jubany (62°S). Invertebrate species with contrasting ecology were chosen for comparisons; *L. elliptica* are known to have a limited temperature tolerance (stenothermal) and *N. concinna* were expected to have a wider temperature tolerance (eurythermal).

The responses of muscle morphology, metabolic rate, circulation, and muscle biochemistry were examined in response to short and medium term elevated temperature. Ecological differences between populations may have a greater influence on physiological flexibility than latitudinal temperature differences within the Southern Ocean. On a global scale, exercise capacity was correlated with annual temperature range. Burrowing was stenothermal in stable temperature environments, both Antarctic *L. elliptica* (67°S) and tropical *L. truncata* (Singapore - 1°N) lost burrowing capacity at +2°C above mean maximum summer temperature. However the temperate *L. gracilis*, which experiences an annual seawater temperature range of 12°C was much more eurythermal and was able to maintain burrowing until +10°C above mean summer maximum temperature. Mitochondrial density measures are still being processed but there was no elevation of mitochondrial densities in *L. elliptica* compared to tropical *Laternula*, contrary to the currently held paradigm of mitochondrial compensation of exercise capacity in Antarctic animals. Further experiments have shown that the upper temperature limit for exercise capacity in *L. elliptica* can be increased by increasing the oxygen concentration, providing further evidence that thermal tolerance is set through oxygen limitation.

**BEHAVIOUR OF STABLE ISOTOPES AND TRACE ELEMENTS:
RECONSTRUCTING THE ANTARCTIC SEA-ICE ENVIRONMENT [AFI4/02]**

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Central to the global impact of the Southern Ocean and Antarctica on both past and future climate change is the sea-ice surrounding the continent. Sea-ice plays a significant role in atmospheric gas exchange, regional weather patterns and biological productivity. Variations in biological productivity may be an important factor modifying atmospheric carbon dioxide levels, for example, over glacial-interglacial timescales. However, we do not yet fully understand how biological productivity has varied in the past, how past and future changes in sea-ice extent may influence this productivity and how these changes may impact carbon dioxide levels. In addition, we do not understand how biogeochemical cycling in a sea-ice environment may impact geochemical proxies such as the stable isotopic and trace element composition of organic matter and diatom opal.

The purpose of this project is to understand how primary productivity in the surface oceans varies in a nearshore, seasonal sea-ice environment off the Western Antarctic Peninsula. Field expeditions and cruises to Ryder Bay, Adelaide Island, have been undertaken to collect sea-ice, water column, phytoplankton, sinking particulates and surface sediment samples in combination with nutrient assays and physical oceanographic measurements. A final sampling trip is to be carried out in the austral spring, 2006. Time series sediment traps were deployed in January 2005, recovered and redeployed in February 2006 and will be finally recovered during the 2006-2007 field season. Samples are being analysed in Edinburgh, Oxford and Cambridge for stable isotope (carbon, oxygen, nitrogen and silicon) and trace elements (barium, uranium, germanium, silver, aluminium, cadmium and zinc). The aims of this talk are to explain our methods and present preliminary results. This unprecedented time series of geochemical and physical data is coming to a close, and will illuminate biogeochemical processes in a sea-ice environment which will have important implications for high latitude palaeoproductivity proxies.

BIOGEOCHEMICAL PARTICLE FLUX STUDY IN MARGUERITE BAY [AFI4/13]

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AFI4/13 is an interdisciplinary project that is investigating physical and biogeochemical processes and variability at the Western Antarctic Peninsula (WAP), the region of most rapid climate change in the Southern Hemisphere. Physical moorings data and sediment trap sampling is combined with quasi-weekly sampling from the Rothera Oceanographic and Biological Time Series (RaTS) to understand the forcings and responses on seasonal and interannual timescales.

Physically, we are addressing the temporal dependence of freshwater inputs to the ocean using oxygen isotope data. This has revealed glacial ice melt to be the most prevalent freshwater input, and to be equally important as sea ice melt in determining the seasonality of the upper-ocean freshwater content. The extended RaTS time series has provided insight into large-scale climatic forcing of the WAP, with the El Nino phenomenon appearing to dominate via an atmospheric teleconnection. The moorings data reveal the presence of internal tides and potentially coastally-trapped internal waves, the latter of which have a putative atmospheric forcing.

Primary, new and regenerated production measurements were made in the upper water column from late December-late February at the RaTS site. Primary production remained high during the whole sampling period (maximum of $8.1 \text{ gC m}^{-2} \text{ d}^{-1}$), and was dominated by new production (as measured by nitrate uptake) also throughout the whole sampling period. This new production represents the portion of primary production that can be exported from the upper water column as flux. This flux is being directly measured using samples from the sediment traps moored during this period at the RaTS site and also at a deeper site in Marguerite Bay. Samples are currently being processed although inspection of bottles shows an intense period of flux in the upper trap at the RaTS site in comparison to a longer period of flux at the deep site. At both moorings there is a limited proportion of flux to the bottom mooring.

Ongoing work is being conducted to further elucidate the key processes in this climatically-sensitive region, with a particular emphasis on understanding the impacts that the evolving physical environment might have on variability and change in the biogeochemical system.

**IMPROVING ICE CORE INTERPRETATION: THE ROLE OF STORM-TRACK
CHANGES ON SUB-ANNUAL PENINSULA PRECIPITATION VARIABILITY
[AFI4/09]**

**Georgina Miles, Gareth Marshall, John Turner, Robert Mulvaney and
Tom Lachlan-Cope**

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This project uses concurrent in-situ accumulation data and highly sampled ice core records from the same site, together with data derived from atmospheric models, in order to better understand how regional meteorological processes are manifested and preserved in ice cores.

In the 2005/2006 field season six shallow ice cores were retrieved from three islands along the southwest coast of the Antarctic Peninsula, at sites where automatic weather stations (AWS) were deployed the previous year. 2005 saw much higher than expected accumulation in the south-west Peninsula, and two of the three AWS were buried and lost. Only the station at Latady Island (71.0°S, 75.0°W) could be retrieved. Initial analysis of the temporal variability of the Latady Island ice core chemistry shows over 8m of accumulation in the last two years, far in excess of that suggested by operational forecast models and a previous ice core obtained there.

At each site the two cores were drilled a few metres apart so that variability over short distances could be investigated. Analysis of surface elevation and ice-core chemistry revealed large disparities between the two cores over depths of the order of 20cm. These are thought to arise from the spatial and temporal variability of snow-surface features or sastrugi. The AWS data indicate that the majority of precipitation fell in a few large events. Such events will form the basis of case studies in which the history of the precipitating air masses will be examined and compared to their chemical signature in the ice cores. These case studies will employ back trajectory analysis, satellite imagery and operational forecast data: preliminary analysis of some of these large precipitation events will be presented in the talk.

**A SEASONAL CYCLE OF ALKYL NITRATE AND ORGANOHALOGEN TRACE
GAS CONCENTRATIONS IN MARGUERITE BAY, ANTARCTIC PENINSULA
[AFI5/01]**

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It is known that a whole suite of volatile compounds such as the alkyl nitrates and the organohalogens are produced naturally in seawater. By transferring across the sea surface these compounds play important roles in the biogeochemical cycles of important elements, and atmospheric processes related to regional and global climate. The alkyl nitrates have been proposed to be a significant proportion of the reactive oxidized nitrogen reservoir in the atmosphere and therefore could be involved in ozone formation in the troposphere. Additionally, the organohalogens mediate the sea-air flux of chlorine, bromine and iodine which are known to be involved in both ozone depletion and new particle formation in the atmosphere. Here we report alkyl nitrate and organohalogen concentrations measured during a seasonal cycle at the Rothera Time Series (RaTS) in Marguerite Bay on the Antarctic Peninsula. Temporal variations in seawater trace gas concentrations are compared to biological, chemical and physical parameters also measured at the site to assess the likely causes of the observed seasonal cycles. The period of study encompasses sea ice-free and ice-covered conditions, and a major diatom bloom that occurs in the bay during the summer months. Depth profiles measured through the summer and the results of incubation studies, designed to identify the factors controlling alkyl nitrate and organohalogens concentrations at the RaTS site, are also reported.

A METEOR RADAR AT ROTHERA FOR STUDIES OF THE MESOSPHERE AND LOWER THERMOSPHERE [AFI5-38]

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The mesosphere and lower thermosphere (MLT) region at heights of ~ 50 - 100 km is the least explored part of the Earth's atmosphere and is notoriously difficult to observe. In February 2005, a meteor radar was deployed at Rothera Point to study the Antarctic MLT. The radar routinely makes three types of measurement:

- 1. horizontal winds at heights of ~ 75 – 105 km from the drifting of meteors as they are carried by the winds of the MLT*
- 2. atmospheric temperature from the decay rate of meteor echoes*
- 3. meteor fluxes, derived from several thousand meteors per day*

The radar is being used with an identical system in Northern Sweden to investigate Antarctic/Arctic asymmetries, free from instrument biases and so investigate inter-hemispheric differences in wind and temperature. The radar has operated faultlessly from first operation on February 14th, 2005. Data are being recorded continuously and more than 4,000 individual meteors are detected per day. In this presentation, the meteor radar and its installation will be described. Also meteor flux, wind and temperature measurements from the first year of operation will be presented.

**TESTING PLUME MODELS: DOLERITE SILL FLOW DIRECTIONS AND
EMPLACEMENT MECHANISMS IN THE THERON MOUNTAINS,
NORTHERN TRANSANTARCTIC RANGE [AFI4/05]**

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The Theron Mountains contain nearly 100Km of spectacularly exposed horizontal Jurassic (~173Ma) dolerite sills with individual bodies reaching up to 200m, but averaging 30-40m, in thickness. The sills have been attributed to two possible plume locations associated with Gondwana break up: one at the Limpopo triple junction which lies to the northeast; the other in the Weddell Sea to the north. Geochemical work has distinguished four types: Series 1 and Series C (correlated with the Antarctic Ferrar province); Series B, correlated with the African Lembombo area; and Series A also seen in the Karoo of South Africa and in West Dronning-Maud Land in Antarctica.

Field-based flow data (flow axes) come from bridge and step axes and a large data set show a northerly alignment with an increased range of orientations as one moves along the escarpment from north to south. This is consistent with a flow-dispersal pattern towards the south. Imbricated and shear-aligned phenocrysts at the base of the extensive Series B sill and more rarely at the base of the major Series C record flow towards the south. This is also recorded, although the directions are more variable, in shear structures in partially melted sediments below a Series 1 sill.

AMS work on orientated samples collected during fieldwork shows that the dolerites in general are very weakly anisotropic (on average < 2%) with low susceptibilities. Nevertheless there is some consistency in the directional data and general northerly/northeasterly aligned flow axes are indicated. Although anisotropies are low, some are statistically well defined and much of these data show oblique fabrics near sill tops and bases which are consistent with overall southerly directed flow. As with the field data there appears to be no systematic differences between the four geochemically-defined provenanced types.

Sill emplacement appears to be by simple wedging apart of strata, often exploiting weak coal seams. Spectacularly exposed bridge structures, from meters to tens of meters in length, are preserved in many states of development. These show evidence of brittle and ductile deformation associated with sill emplacement and also partial melting. Based on these data a new model for sill emplacement will be presented which sees thick sills developing as a merging of thinner sills propagating ahead of the main body. These precursor sills then propagate to overlap and form bridges. It appears that further tip propagation is then prevented, thus triggering vertical inflation and bridge breaking. This inflation, often in excess of 500%, then takes over as the main body moves forward through the locations of the precursor, thin sills.

THE CHEMISTRY OF THE ANTARCTIC BOUNDARY LAYER AND THE INTERFACE WITH SNOW – *CHABLIS* [AFI3/03]

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CHABLIS is a major initiative to explore the atmospheric chemistry of the Antarctic boundary layer in far greater detail and for a longer period of time than has been achieved hitherto. It combines the skills and expertise of research groups from 5 U.K. universities plus the British Antarctic Survey (BAS). From the small amount of work that had previously been done, it was already clear that the Antarctic boundary layer behaves in very unexpected ways, driven by the extreme cold, long periods of darkness alternating with continuous sunlight, and a strong chemical coupling between the snowpack and the overlying atmosphere.

CHABLIS activities are framed within 3 specific research foci, each with a number of underlying questions:

1) Seasonal studies of oxidant chemistry in coastal Antarctica:

- *What is the annual climatology of radical precursors in the Antarctic troposphere?*
- *Is there evidence for radical chemistry during the Antarctic winter period?*
- *Can we balance the budget of tropospheric O₃ in Antarctica during spring/summer?*

2) Year-round studies of the NO_y budget in coastal Antarctica:

- *What controls the NO_y budget throughout the year?*
- *How does this affect tropospheric NO_x and ice core nitrate ?*

3) Air/snow transfer studies:

- *What is the connection between snow and the boundary layer concentrations of key species?*

To address these foci, field measurements for *CHABLIS* commenced during the summer season 2004, and ran throughout the Antarctic winter. During the summer season 2005, additional instruments were deployed to allow intensive study of Antarctic oxidants.

Early results have revealed a number of surprises. Halogen species appear to be absolutely key in determining the boundary layer chemistry, rather than the expected HO_x-O_x-NO_x system. Springtime mixing ratios of IO were the highest recorded anywhere in the atmosphere, and furthermore show a surprising coincidence with the seasonal BrO peak. A 5-week record of OH and HO₂ was retrieved – the longest ever in coastal Antarctica. The magnitudes measured reveal that snowpack chemistry is important for HO_x also in this part of Antarctica. The NO_y budget is almost completely dominated by organic species during the winter, and by inorganic compounds during the summer. A strong association exists between surface snow nitrate and inorganic NO_y, but at the moment the driver is not clear.

In this talk, we present an overview of the project, including the challenge of conducting such an extensive campaign in Antarctica, and early results.

**LATE CENOZOIC GLACIER-VOLCANO INTERACTION ON JAMES ROSS
ISLAND AND IN ADJACENT AREAS, ANTARCTIC PENINSULA REGION
[CGS7/20]**

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The northern Antarctic Peninsula region has experienced approximately 10 Ma of eruptive activity by basaltic volcanoes, mainly in subglacial settings. Spectacular exposures of lava-fed deltas, capped by basalt flows and commonly underlain by glacial sediments on top of a Cretaceous sedimentary 'basement' characterize James Ross, Vega, and other islands and promontories in the region. Collectively known as the James Ross Island Volcanic Group, the strata record a cryptic history of glaciation, with the timing of events determinable by argon-isotope dating. Focusing especially on the glacial sediments themselves, and their relationships with overlying or bounding volcanic rocks, we define sedimentary characteristics related to eruption beneath both thick and thin ice. A combination of provenance studies on clasts in the glacial sediments, some of which are derived from the Antarctic Peninsula, and geochronology, leads to the conclusion that an Antarctic Peninsula Ice Sheet extended over James Ross and Vega islands at around the time that the main volcanic edifices began to grow, c. 4 to 2.5 Ma. All subsequent development of the succession is attributed to the interaction between the growing volcanoes and the local polythermal ice-caps. Full resolution of glacial/interglacial events in this region promises to inform the debate about the stability of the Antarctic Ice Sheet during the Pliocene Epoch, since these outer fringes of the continent are the most susceptible to climatic change.

**EXTENDING THE AMERICAS PALAEOCLIMATE TRANSECT THROUGH
THE ANTARCTIC PENINSULA TO THE POLE
(CACHE-PEP) [CGS7/21]**

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Cruise (JR149) participants: Claire Allen; Elizabeth Petrie (BAS); Anna Hey (Cardiff University and BAS)

CACHE-PEP is a component project of the BAS core science Programme ‘Climate and Chemistry (CACHE): Forcings, Feedbacks and Phasings in the Earth System’ led by Dr Eric Wolff, running from 2005-2010. The project will determine how the climate of the Antarctic Peninsula (AP) has varied in comparison to that of the rest of the world; and especially where, in the latitudinal transect from the AP through the Americas, the climate influence gives way to a climate pattern following Greenland. This will be achieved through integration of a number of palaeoclimate proxies observed in ice core records, lake and marine sediments from the AP and Scotia Sea.

During the 2005-06 Antarctic field season, the Collaborative Gearing Scheme project (CGS7/21) supported the Cardiff / BAS CASE funded PhD student (Anna Hey) to participate in a marine geology cruise (JR149). During the cruise, several marine sediment cores were collected from the Northern Peninsula/South Orkney region and the Georgia Basin. The principal aim was to collect cores made up of sediments from the last 10,000 years (the Holocene), which contain a fossil diatom record of oceanographic and hence climate changes over this period. Preliminary results will be presented from ship-based analyses and subsequent laboratory work. In addition, Geophysical survey and water sampling was also carried out during the cruise on an opportunistic basis. Swath data was recorded along the cruise track and TOPAS sub-bottom profiles were logged specifically at core sites. Bottled and filtered seawater samples were collected for isotope analysis and assessment of the autumn diatom community in the Scotia Sea respectively. The modern diatom data has augmented previous work undertaken during spring and summer (under CGS grants) to determine seasonal variability and distribution of diatom assemblages and to assess taphonomic processes in the water column.

The student’s work at Cardiff University and BAS forms part of the CACHE-PEP project, studying marine sediment cores collected on previous cruises to the Antarctic Peninsula. Participation in cruise JR149 has formed an essential component of the student’s training, in research methods and transferable skills. The support given by the CGS has been invaluable, providing the student with a fantastic and highly rewarding opportunity to experience marine science and the Antarctic environment first hand.

SOUTHERN OCEAN PREDATOR-PREY INTERACTIONS: THE IMPORTANCE OF KRILL IN THE SURFACE ZONE? [CGS7/22]

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The food web of the open ocean around Antarctica is centred on Antarctic krill *Euphausia superba*. Krill form the vital link in the classic short phytoplankton-krill-whale food chain and are also an essential prey for numerous other predators such as fur seals, penguins and fish. Krill undertake diel vertical migrations, often frequenting the near surface zone at night while spending the daylight hours in swarms deeper in the water column. Such changes of vertical distribution have important implications for air breathing predators searching for krill as well as for scientists using acoustic surveys to estimate krill biomass. Commonly used acoustic systems do not detect near-surface krill swarms that predators may be exploiting and so, to reduce bias, surveys are often confined to daylight hours when krill are assumed to occur deeper in the water column. However visual observations and knowledge of predator feeding and diving behaviour indicate that surface swarming is unlikely to be a purely nighttime phenomenon. On a recent cruise around South Georgia we have used a towed acoustic system to detect krill swarms in the surface zone as well as deeper in the water column. Here we assess the degree of daytime surface swarming and consider whether significant krill biomass is systematically excluded in traditional surveys. In conjunction with contemporaneous predator observations we also consider the implications of the observed level of surface swarming on the diving behaviour of air breathing predators.

MICROBIAL BIODIVERSITY IN ANTARCTIC MARINE ECOSYSTEMS [CGS7/23]

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The bacterioplankton in the surface waters of the Scotia Arc, in the Southern Ocean, was examined to determine the diversity and variability of predominant groups present. Surface sea-water samples were collected from CTD deployments at sites around the Scotia Arc during the JR144 Antarctic cruise between February and April 2006. For microbial analysis, the techniques in use are; total counts of DAPI stained cells, in-situ hybridization with group specific, fluorescently- labelled oligonucleotide probes, PCR amplification of 16S rRNA gene fragments and sequencing of clones constructed from denaturing gradient gel electrophoresis bands. Overlap found between results from different areas would enable identification of potentially significant trends and the differences in results from each method will be discussed. This work illustrates the importance of a comprehensive polyphasic approach in the analysis of marine bacterioplankton samples and allows a preliminary assessment of the bacterioplankton ecology in the surface waters of this unique region.