



Report of Canadian Geoscience Activities
Presented to the Geoscience Working Group
XXVII SCAR Meeting
Shanghai, PRC
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Canadian Antarctic Geoscience Activities 2000-2002

Introduction

The main foci of Canadian Earth Science research in Antarctica are periglacial and permafrost studies, marine geology, glacial geology and paleoenvironmental reconstruction. Canadians are working with (United States, Great Britain, New Zealand and Italy). In the past 3 years 13 Canadians have been involved in earth science research concerned with Antarctica.

International Collaborations

Great Britain (BAS): Dr. Kevin Hall, University of Northern British Columbia worked with the British Antarctic Survey

Italy: Programme Nazionale de Ricerche in Antartide (PNRA). Drs. Hugh French and Anthoni Lewkowicz of the University of Ottawa in association with Drs. F. Dramis and M. Guglielmin

USA: (United States Antarctic Program, JPL & NSF) Dr. Thomas James, Natural Resources Canada, Dr. Robert Gilbert, Queens University, Dr. Marianne Douglas, University of Toronto and Dr. Wayne Pollard, McGill University.

New Zealand, Dr. Stephen Hicock, University of Western Ontario and Dr. Wayne Pollard, McGill University. Dr. Peter Barret and Dr. Warren Dickinson (University

of Victoria Antarctic Research Centre) in the analysis of Sirius Group deposits Alan Hills, Table Mountain and Mount Feather.

International: 1998 Dr. Nick Eyles (University of Toronto) participated in ODP leg 178 and in 2000 N. Januszczak participated in ODP Leg 188

Recent Activities

Dr. Nick Eyles and Nicole Januszczak (graduate student)

Department of Geology
University of Toronto at Scarborough
Toronto, Ontario

The primary objective of Dr. Eyles research is to integrate sedimentological, biofacies and geophysical databases from three Ocean Drilling Program (ODP) cruises - Leg 178, Antarctic Peninsula; Legs 119 and 188, Prydz Bay - in an attempt to constrain the history of the Antarctic Ice Sheet and develop a model for glaciated continental margin growth. Data from the Antarctic continental margin suggests that the shelf aggrades ("upbuilds") during periods of ice front retreat, whereas the slope progrades ("outbuilds") during episodes of ice advance to the shelf break. Other glaciated continental margins have similar glacial marine successions suggesting that a common or "unified" model of glaciated margin deposition exists, regardless of latitude and geological age.

Ongoing research includes a detailed integration of sedimentological and geophysical data from the Prydz Bay continental shelf in an effort to constrain the onset of continental-scale glaciation in Antarctica and the pre-glacial environment of Prydz Bay. This is a collaboration between Nicole Januszczak and Dr. Samantha Barr at the Lamont Doherty Earth Observatory (LDEO) Borehole Research Lab at the University of Leicester. Quentin Stossel received an Undergraduate Scholarship from Canada ODP to assist Nicole Januszczak in this study. In April 2002, a significant application of the ODP work will be put into practice when the model that was constructed for the Antarctic continental margin will be used as an analogue for understanding very ancient "Snowball Earth" deposits in Namibia. These sediments were deposited in a marine environment very similar to those drilled along the Antarctic continental margin, however they supposedly show evidence of global glaciation in the Neoproterozoic. Our understanding of processes along glaciated continental margins should shed new light on this controversial and currently "hot" topic. Nick and Nicole's participation in the Ocean Drilling Program was supported by the Natural Sciences and Engineering Research Council of Canada (NSERC). Januszczak acknowledges support from an NSERC Postgraduate Scholarship.

Dr. Nick Eyles was a Shipboard Sedimentologist on ODP Leg 178, Antarctic Peninsula (Feb-Apr 1998) and Nicole Januszczak (PhD candidate) was a

Shipboard Sedimentologist on ODP Leg 188, Prydz Bay (Jan-Mar, 2000).

Eyles, N., Daniels, J., Osterman, L.E., and Januszczak, N., 2001. Ocean Drilling Program Leg 178 (Antarctic Peninsula): sedimentology of glacially influenced continental margin topsets and foresets. Marine Geology, 178: 135-156.

Januszczak, N., and Eyles, N., 2001. ODP drilling leads to a new model of shelf and slope sedimentation along the Antarctic continental margin. Geoscience Canada, 28(4): 203-210.

Drs. H.M. French and A.G. Lewkowicz,

Department of Geography,
University of Ottawa.
Ottawa, Ontario

Personnel from the University of Ottawa, Department of Geography, continue their collaborative research with Francesco Dramis (Third University of Rome) and Mauro Guglielmin (PNRA and ARPA Lombardia) in the permafrost conditions and periglacial geomorphology of the Terra Nova Bay region, Northern Victoria Land. Hugh French conducted fieldwork in the 1998-99 summer field season and Toni Lewkowicz conducted fieldwork in the 1999-2000 summer field season. Research to date has concentrated upon permafrost-related phenomena (e.g. frost mounds, thermal-contraction cracking; ground ice characteristics), borehole ground thermal monitoring at two sites (Boulder Clay Glacier; Mt Keinath)), cryogenic weathering of granite, and the measurement of surface and near-surface temperature regimes. Logistical support was provided by PNRA. In July 2000, Mauro Guglielmin and Nicoletta Cannone visited Fosheim Peninsula, Ellesmere Island, Canada, to undertake comparative studies. Logistical support was provided by PCSP under the PCSP-Antarctic collaborative agreement. Hugh French plans further fieldwork with Mauro Guglielmin in Northern Victoria Land during 2002-2003, again with PNRA logistical support. Future fieldwork will concentrate upon (i) the cryogenic weathering experienced on high-elevation nunataks in the Deep Freeze Range, (ii) the Quaternary history and permafrost conditions of the Tarn Flats lowlands, (iii) the coastal (beach) characteristics of Inexpressible Island (the over wintering site of Scott's Northern Party in 1911-1912), and (iv) Richter slope development in the vicinity of the PNRA station.

Publications

H. M. French and M. Guglielmin, 1999. Observations on the ice-marginal periglacial geomorphology of Terra Nova Bay, Northern Victoria Land, Antarctica. Permafrost and Periglacial Processes, 10, 331-347.

H. M. French and M. Guglielmin, 2000a. Frozen ground phenomena in the vicinity of Terra Nova Bay, Northern Victoria Land, Antarctica: A preliminary report. Geografiska Annaler 82A, 513-526.

H. M. French and M. Guglielmin, 2000b. Cryogenic weathering of granite, Northern Victoria Land, Antarctica. Permafrost and Periglacial Processes, 11, 305-314.

H. M. French and M. Guglielmin, 2002a. Cryogenic grooves on a granite nunatak, Northern Victoria Land, Antarctica. Norsk Geografisk Tidsskrift, 56, in press.

H. M. French and M. Guglielmin, 2002b. Pseudo-rinnenkarren and other granite weathering phenomena, Mount Keinath, Northern Victoria Land, Antarctica. Permafrost and Periglacial Processes, submitted, 15 ms pages + 5 figures.

Dr. Robert Gilbert and **Asa Chong** (grad student),
Department of Geography, Queens University.
Kingston, Ontario

In May 2000 Dr. Gilbert took part in a U.S. Antarctic Program cruise on the N.B. Palmer under the leadership of Dr. E. Domack, Hamilton College, to study the paleohistory of the Larsen Ice Shelf on the east side of the Antarctic Peninsula. This project detailed studies of the area under the former Larsen A Ice Shelf north of the Seal Nunataks and in Prince Gustov Channel, as well as of the Vega Drift north of James Ross Island (Harris et al. 1999; Gilbert, 2000). In May 2000 Gilbert and Chong returned to conduct a study of the sea in an area formerly under the Larsen A Ice Shelf which has broken up in a very brief period. Cores, acoustics, and oceanographic observations address the question of the history of the shelf (Domack et al. 2001; Camerlenghi et al. in press). Between December 5 and January 18 2002 Gilbert returned to the Peninsula to map the seafloor beneath the now disintegrating Larsen B Ice Shelf. Randy Dirszowski is completing neutron activation analysis of the mineralogy of a core from the Larsen A area (KC23) to understand the provenance of the sediments.

Gilbert, R. and Domack E.W. Glacimarine record of the disintegration of the Larsen A Ice Shelf, Antarctica. International Workshop Antarctic Peninsula Climate Variability. An Historical and Paleoenvironmental Perspective.

Gilbert, R., Domack, E., Leventer, A., Camerlenghi, A., Brachfeld, S., Ishman, S. 2001. Glacimarine sedimentary environment at the former Larsen A Ice Shelf, Eastern Antarctic Peninsula. Glacier-Influenced Sedimentation on High-latitude Continental Margins. University of Bristol. Programme with Abstracts. p. 30.

Gilbert, R. Chong, A., Dunbar, R., and Domack, E. 2001. Glacimarine sedimentary environment at Muller Ice Shelf, Lallemand Fjord, Western Antarctic Peninsula. Glacier-Influence Sedimentation on High Latitude Continental Margins. University of Bristol. Programme with Abstracts, p. 31.

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Camberlenghi, A., Domack, E., Rebesco, M, Gilbert, R., Ishman, S., Leventer, A., Brachfeld, S., and Drake, A. in press. Glacial morphology and post-glacial contourites in northern Prince Gustav Channel (NW Weddell Sea, Antarctica). Marine Geophysical Research.

Chong, A. and Gilbert, R. 2000. Sediment trap records of deposition in Lallemand Fjord adjacent to Muller Ice Shelf, Antarctic Peninsula. 30th Arctic Workshop, Boulder Colorado, March 2000, Program with Abstracts, p. 39-40.

Dr. Kevin Hall,
Department of Geography,
University of Northern British Columbia.
Prince George, British Columbia

Dr. Hall has been active in Antarctica for many years and is currently involved in research concerned with cryogenic weathering and periglacial processes at a number of field sites in Antarctica. Drs. K. Hall and J. Arocena (also from UNBC) are involved in the analysis of Cape Roberts drill core. This work involves analysis of the weathering rinds chemistry to reconstruct terrestrial conditions at the time of entrainment in the depositing glacier. In 2001-02 Dr. Hall was in Antarctica from late October to mid-December with the British Antarctic Survey. Working in the field at the southern end of Alexander Island in the "Mars Oasis" and on the Syrtis Hill area on rock weathering processes, development of taffoni, and the origin of 'cryoplanation' terraces. This work was undertaken in conjunction with the BAS Life Sciences and with French colleague : Prof Marie-Francoise Andre.

Dr. Hall is also Co-chair of the International Permafrost Association Working Group on Southern Hemisphere Permafrost and Periglacial Phenomena.

Thorn, C. and Hall, K. In Press. Nivation and cryoplanation: The case for scrutiny and integration. Progress in Physical Geography.

Hall, K., Thorn, C., Matsuoka, N. and Prick, A. In Press. Weathering in cold regions: Some thoughts and perspectives. Progress in Physical Geography.

Hall, K. In Press. The sub-Antarctic, In J. Ehlers and P.C. Gibbard (eds.): Asia, Africa, Latin America, Australia and Antarctica. INQUA Commission on Glaciation, Work Group: Extent and Chronology of Glaciations, Volume 3.

Hall, K. In Press. Glaciation in southern Africa, In J. Ehlers and P.C. Gibbard

(eds.): *Asia, Africa, Latin America, Australia and Antarctica. INQUA Commission on Glaciation, Work Group: Extent and Chronology of Glaciations, Volume 3.*

Hall, K., Boelhouwers, J. and Lamont, N. In Press. *Bibliography on Southern hemisphere permafrost and periglacial landforms and processes. International Permafrost Association, Southern hemisphere Working Group, 86pp.*

Bockheim, J. and Hall, K. 2002. *Periglacial processes and landforms of the Antarctic continent: A review. South African Journal of Science. 98,82- 101 .*

Boelhouwers, J. and Hall, K. 2002 *Introduction: Southern Hemisphere Working Group. South African Journal of Science. 98, 46-47*

Hall, K. 2002. *Present and Quaternary periglacial processes and landforms of the Maritime and sub-Antarctic: A Review. South African Journal of Science, 98, 71-81.*

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Hall, K. and André, M-F. 2001. *New insights into rock weathering as deduced from high-frequency rock temperature data: An Antarctic study. Geomorphology, 41, 23-35.*

Hall, K. 2001. *The necessity for high-frequency rock temperature data for rock weathering studies: Antarctic and northern examples. Proceedings of the 1st European Permafrost Conference.*

Hall, K., Arocena, J. and Smellie, 2001. *Weathering rinds as palaeoenvironmental indicators: Evidence from the Cape Roberts drill core (CRP-3). Terra Antarctica, 8, 275-280.*

Hall, K.2000. *The role of thermal stress fatigue in the breakdown of rock in cold regions, In R. Giardino and R Marston (eds): Changing the Face of the Earth: Engineering Geomorphology. Elsevier, Amsterdam, 47-63.*

Hall, K. 2000. *New insights into rock weathering as deduced from high-frequency rock temperature data: An Antarctic study. Weathering 2000, Program and Abstracts (Queen's University, Belfast), 24-25.*

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Siegmund, M. and Hall, K. 2000. A study of valley-side slope asymmetry based on the application of GIS analysis: Alexander island, Antarctica. Antarctic Science, 12, 471- 476.

Dr. Steven Hicock and Phil Holmes (grad student)
Department of Earth Sciences,
University of Western Ontario
London, Ontario

The main objectives of Dr. Hicock's Antarctic research over the past two years are: a) to examine the glacial character of the Tertiary Sirius Group in the Dry Valleys area and its implications for East Antarctic Ice Sheet (EAIS) drainage and stability. b) to reconstruct the nature of glaciation of the Allan Hills during the last glacial maximum (LGM). In December, 2000, Dr. Hicock studied Sirius outcrops in the Allan Hills, at Mt. Feather, and at Table Mountain. Drill core was collected from Allan Hills and Table Mountain by the team from Victoria University of Wellington. Dr. Hicock plans to conduct mesoscopic analysis on the core from Allan Hills and Table Mountain and relate it to outcrop studies. Dr. Hicock found two boulder pavements in Sirius tillite at Mt. Feather that were formed by a Tertiary outlet glacier that flowed perpendicular to modern outlet glaciers. This occurred prior to the development of the modern drainage when the Transantarctic Mountains were lower and tectonic uplift was less advanced. In the Allan Hills at LGM, dry-based glaciers eroded substrate and deposited deformation till and glacitectorite as the glaciers slid over their beds. Dr. Hicock's research involves Canadian Ph.D. candidate Philip Holme (from North Vancouver, B.C.) who is completing his thesis on the glacial character, extent, and inferred dynamics associated with the Sirius Group in the Allan Hills. Steve co-supervises Phil at Victoria University of Wellington with Prof. Peter Barrett, as well as Ph.D. candidate Clifford Atkins (from New Zealand) who is comparing subglacial erosional characteristics of selected substrates in Antarctica and New Zealand. Dr. Hicock is an Honorary Research Associate with the Antarctic Research Centre, Victoria University of Wellington, and am sponsored by Antarctica New Zealand (logistical field support), as well as NSERC and the University of Western Ontario (financial support). Principal investigators are Prof. Peter Barrett and Dr. Warren Dickinson, both of the Antarctic Research Centre at Victoria University.

Dr. Marianne Douglas,
Department of Geology,
University of Toronto.
Toronto, Ontario

Dr. Douglas' research is involved in the paleolimnological investigation of ice covered lakes in the McMurdo Dry Valleys. This project took place in 1999 and

was associated with the McMudro Dry Valleys LTER and is supported by PCSPs Canadian Arctic-Antarctic Exchange Program. (no new information)

Dr. Tom James

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Dr. James is a member of the SCAR GOS ANTEC, he has recently been working on a collaboration with Terry Wilson at Ohio State to continue GPS observations in Victoria Land. Dr. James publications and presentations, which are based on computer modelling, are with Erik Ivins of Jet Propulsion Laboratory, California Institute of Technology. Total support for Dr. James Antarctic research activities (including salary and overhead) are estimated to \$30-40k/yr. Ivins support is from NASA (\$100-150k per year) from internal proposals on which James is a collaborator. The research objective of this work is to determine, from computer modelling of the Earth's response to ice mass change, the geodetic and seismological observations and measurements that would best put constraints on the past and present ice mass balance of Antarctica. James and Ivins research activities in 2000 and 2001 focussed on predicting the pattern of crustal rebound that could be observed with space-based geodetic observations (especially GPS) and the long-wavelength gravitational signatures that could be observed by analysis of satellite orbits.

Activities:

My Antarctic-related activities are generally connected to my membership in the SCAR Antarctic Neotectonics (ANTEC) Group of Specialists. Solicited contributions for Antarctic Neotectonics session at the European Geophysical Society meeting, April, 2000. Session was sponsored by ANTEC.

Participated in the Antarctic Neotectonics workshop convened in Siena, Italy, in July, 2001. At this workshop goals and priorities for future neotectonics research in Antarctica were discussed. I led discussion of priorities for the ANTEC "Plate-scale Kinematics" science program and drafted a report. This report, together with the results from the other 4 ANTEC science programs, will be published, hopefully in time for the SCAR meeting in July.

Talks and Posters:

James, T.S., Waddington, E.D., and H. Conway, Late Holocene ice thinning in the eastern Ross Shelf and predicted crustal uplift in western Marie Byrd Land, European Geophysical Society Meeting, Nice, France, April, 2000.

Ivins, E.R., T.S. James, and C.A. Raymond, Present constraints and future

observations of postglacial rebound in Antarctica, European Geophysical Society Meeting, Nice, France, April, 2000.

Ivins, E. R., X. Wu, C.A. Raymond, C.F. Yoder, and T.S. James, Temporal geoid of a rebounding Antarctica and potential measurement by the GRACE and GOCE satellites, Geodesy, Gravity and Geodynamics 2000 conference, Banff, July 31- Aug. 4, 2000.

James, T.S., E.R. Ivins, E.D. Waddington, H. Conway, J.O. Stone, A. Donnellan, and C.A. Raymond, Predicted crustal uplift in Marie Byrd Land from Late Holocene ice thinning, Antarctic Neotectonics Workshop, Siena, Italy, July 11-15, 2001.

Ivins, E.R., and T.S. James, Rebound driven time-dependent geoid, crustal motions, and issues related to seismicity patterns in Antarctica, Antarctic Neotectonics Workshop, Siena, Italy, July 11-15, 2001.

Ivins, E. R., and T. S. James, Antarctic ice mass change and predictions of crustal seismicity and lithospheric stress, EOS Trans. AGU, 82, F1196, 2001.

Publications:

Ivins, E. R., C. A. Raymond, and T. S. James, The Influence of 5000 year-old and younger glacial mass variability on present- day crustal rebound in the Antarctic Peninsula, Earth, Planets, and Space, 52, 1023-1029, 2000.

Ivins, E. R., X. Wu, C.A. Raymond, C.F. Yoder, and T.S. James, Temporal geoid of a rebounding Antarctica and potential measurement by the GRACE and GOCE satellites, in Gravity, Geoid, and Geodynamics, ed. M. G. Sideris, Int. Assoc. of Geodesy Symposia, v. 123, pp. 361-366, 2001.

Dr. Wayne Pollard and Derek Mueller (grad student)

Department of Geography,
McGill University.
Montreal, Quebec

The aim of Dr. Pollard's research is to assess the nature and significance of ground ice in Antarctica with a focus on the McMurdo Dry Valleys. Initially (1998) Pollard undertook field research supported by the USAP that looked at the permafrost stratigraphy and ice properties of buried ice deposits in the Ross Sea drift. This research was also concerned with assessing the importance of ground ice processes on landscape development. The area around Garwood Valley was found to contain extensive massive ice in excess of 20m thick. Degradation of this ice has produced numerous closed depressions 4-7 m deep. In 2001 Pollard

joined a drilling project lead by Dr. Warren Dickenson from Victoria University, Antarctic New Zealand. Pollard's role in this project was to evaluate the nature of ground ice in the stratigraphy of the Sirius Formation in the Allan Hills. As part of the Students on Ice expedition Dr. Pollard examined ash covered glacier ice on Deception Island in the South Falkland Islands. A secondary focus of this research is the use of polar landscapes as analogues for geomorphic systems on other planets.

Derek Mueller's research involves a bi-polar examination of cryoconite hole ecology. This work is conducted with the support of Dr. Peter Doran, University of Illinois and is part of the McMudro Dry Valleys LTER.

Pollard, W., Doran, P. and Wharton, R. (in press accepted Nov 2000). Massive ground ice in the Ross Sea Drift, Garwood Valley, McMurdo Sound. In Gamble, J. (ed.) Proceedings of the Eighth International Symposium on Antarctic Earth Science, Wellington New Zealand, July 1999.

Soare, R., Pollard, W.H., Green, D., (2001) Deductive model proposed for evaluating terrestrial analogues. EOS, Transactions, American Geophysical Union, 83, 42, 501.

Mueller, D.R., Vincent, W.F., Pollard, W.H. and Fritsen, C.H. (2001) Glacial cryoconite ecosystems: A bipolar comparison of algal communities and habitats. Nova Hedwigia Beihefte, 123, 173-197