Programma Nazionale di Ricerche in Antartide (PNRA)

Final project report

Project ID:	2002/4.10
Title:	Response of the northern Victoria Land glacial system to Late Cenozoic climatic variations
Principal investigator:	Carlo Baroni
Institution:	Dipartimento di Scienze della Terra, Università di Pisa
Email:	baroni@dst.unipi.it
Duration:	2 years
Assigned funding:	€ 77.468,53 + 10.329,14 inv.

Activities and results

The primary research goal of this project was to characterize the responses of the northern Victoria Land glacial system to main Cenozoic climatic and environmental changes. Recognizing, characterizing, and dating the forcing mechanisms that have driven Antarctic glacial variations are highly relevant in understanding current global changes, and studying changes and responses in the past may help us project future changes and responses to possible climate scenarios (IPCC, 2007).
A wide portion of northern Victoria Land (East Antarctica) has been investigated, extending from the David Glacier basin in the south to Cape Adare in the north, through detailed geomorphological and glacial geological surveys. Quantitative geomorphic analysis has been performed for determining morphometric parameters of drainage basins and for defining the processes responsible of the formation of the northern Victoria Land valleys system.
For dating relict landforms and glacial deposits, and for reconstructing erosion rates, we utilized the method of surface exposure dating (SED) using in situ cosmogenic isotopes. To maximize the information gained from this analysis, we combined the use of both radioactive and stable components (3He, 10Be, 21Ne, 26Al, and 36Cl).
Through stratigraphic investigation of marine and ornithogenic sequences, a great amount of datable fossiliferous materials are available, including marine shells, seaweed, sealskin, penguin guano and bones. Radiocarbon dating of these remains provided novel information regarding the post-LGM deglaciation phases and the subsequent isostatic rebound with the definition of a new relative sea-level curve.
Main results can be sintetized as follows.

a) ***Old glacial history – Origin and evolution of the drainage system***
The northern Victoria Land (NVL) was shaped by a complex glacial system that has responded to environmental and climatic variations throughout the Cenozoic, independently of the EAIS. On the basis of morphometric analysis and quantitative geomorphic parameters, we conclude that the hierarchy of flow paths of the NVL valley networks reflect the distinctive features of the natural fluvial basin, and are fluvial in origin. Consequently, the valley network was carved in a morphoclimatic system completely different from the present. Since at least 55 Ma and before the Eocene-Oligocene boundary (34 Ma), following the most vigorous uplift phase of the Transantarctic Mts, fluvial erosion has enhanced the denudation of NVL (Baroni et al., 2005).

b) ***Pliocene and Pleistocene glacial phases***
Surface exposure dating confirms that the mountain ridges of the Deep Freeze Range (Mt. Keinath) have been ice-free since 5.3 Ma. Since that time period, neither the EAIS nor the valley glaciers were able to cover the rounded summit of Mt. Keinath (1090 m a.s.l.). Furthermore, the erosion rate has been particularly slow since that period, and has progressed at less than 20 cm/Ma (Oberholzer et al., 2003). This reduced erosion rate is further testament to the slowness of weathering processes acting during the hyperarid polar environment since the Pliocene.
In the Deep Freeze Range and along the Priestley Glacier basin, the Terra Nova drift showed surface exposure ages ranging from 11 Ka to 34 Ka. The age of the Older Drift is more complex, and it is likely

composed of at least two pleistocene glacial phases. Indeed, surface exposure dates at Black Ridge (mid Priestley Glacier) and on the Deep Freeze Range range from 147 Ka to 309 Ka (Oberholzer et al., 2003).

c) ***The Last Glacial Maximum and the Holocene glacial retreat***
During the Last Glacial Maximum (ca 20 Ka BP), the Antarctic ice sheets and their shelves expanded onto the continental shelf. At Terra Nova Bay, marine based ice inundated coastal areas up to 400 m above present sea level in the Northern Foothills, and possibly to over 500 m above sea level at Inexpressible Island. After the last glacial maximum, recession of the Ross Sea ice-sheet grounding line from Terra Nova Bay occurred no earlier than 7200 14 C yr (8000 cal. yr) BP, while the final unloading of grounded ice from the southern Scott Coast took place 6600 yr BP, as suggested by the new relative sea-level curves defined for Victoria Land coast (Terra Nova Bay and Scott Coast, Baroni and Hall. 2004; Hall et al., 2004). The new relative sea level curves are based on radiocarbon dates of organic remains collected in marine sediments, as well as marine shells (*Adamussium colbecki* and *Laternula elliptica*), elephant seals (*Mirounga leonina*) and Adélie penguin remains. During the last 8000 years, Victoria Land coast has experienced 32 m of relative sea-level fall, with rates ranging from 2 to 15 mm/yr.

d) ***Adélie Penguin and Holocene climatic and environmental changes***
After the deglaciation, the ice-free coastal terrain allowed Adélie Penguin (*Pygoscelis adeliae*) to recolonize their ancestral nesting sites. In areas no longer occupied by Adélie penguin, the presence of abandoned penguin colonies is documented in the ornithogenic soils. These locations still contain the signature of organic material formed by the accumulation of penguin guano as well as remains such as bone, skin, feathers and eggshells. Datable penguin organic remains recovered from ornithogenic soils through stratigraphic excavation were used to reconstruct a chronology of penguin occupation during the Holocene. For their excellent preservation, penguin remains collected from ornithogenic soils have proven a powerful tool in multiple areas of research, particularly in the field of evolutionary molecular biology. Ancient DNA sequences of Adélie penguin's bones have been used to estimate phylogenetic trends of this species in conjunction with Antarctic environmental changes during the past 10,000 yrs. These genetic approaches have allowed us to better define not only the evolutionary trends of Adélie penguin but also the climatic and environmental background during the Holocene (Lambert et al, 2002; Ritchie et al, 2004; Shepherd et al., 2005).

Products

A – papers in scientific magazines

1. LAMBERT D.M., RITCHIE P.A., MILLAR C.D., HOLLAND B., DRUMMOND A.J. and BARONI C. (2002) - *Rates of evolution in Ancient DNA from Adélie Penguins*. Science, 295, 2270-2273. DOI: 10.1126/science.1068105
2. OBERHOLZER P., BARONI C., SCHAEFER J.M., OROMBELLI G., IVY OCHS S., KUBIK P.V., BAUR H. and WIELER R. (2003) – *Limited Pliocene/Pleistocene glaciation in Deep Freeze Range, northern Victoria Land, Antarctica, derived from in situ cosmogenic nuclides*. Antarctic Science 15(4), 493-502. DOI: 10.1017/S0954102003001603
3. BARONI C., HALL B.L. (2004) - *A new relative sea-level curve for Terra Nova Bay, Antarctica*. Journal of Quaternary Science, 19(4), 377-396. DOI: 10.1002/jqs.825
4. HALL B.L., BARONI C. and DENTON G.H. (2004) - *Holocene relative sea-level history of the Southern Victoria Land coast, Antarctica*. Global and Planetary Change, 42, 241-263. DOI: 10.1016/j.gloplacha.2003.09.004
5. RITCHIE P.A., MILLAR C.D., GIBB G.C., BARONI C. and LAMBERT D.M. (2004) – *Ancient DNA Enables Timing of the Pleistocene Origin and Holocene Expansion of Two Adélie Penguin Lineages in Antarctica.* Molecular Biology and Evolution, 21 (2), 240-248. DOI: 10.1093/molbev/msh012
6. BARONI C., FREZZOTTI M., SALVATORE M.C., MENEGHEL M., TABACCO I.E., VITTUARI L., BONDESAN A., BIASINI A., CIMBELLI A., and OROMBELLI G. (2005) - *Antarctic Geomorphological and Glaciological 1:250,000 map series. Mt. Murchison Quadrangle (northern Victoria Land). Explanatory notes*. 7th International Symposium on Antarctic Glaciology, Milano 25-29 Aug. 2003. Annals of Glaciology, v. 39, 256-264.
7. BARONI C., NOTI V., CICCACCI S., RIGHINI G. and SALVATORE M.C. (2005) – *Fluvial Origin of the Valley System in northern Victoria Land (Antarctica) from Quantitative Geomorphic Analysis*. Geological Society of America Bulletin, 117 (1-2), 212-228. DOI: 10.1130/B25529.1
8. SHEPHERD L.D., MILLAR C.D., BALLARD G., AINLEY D.G., WILSON P.R., HAYNES G.D., BARONI C. and LAMBERT D.M. (2005) – *Microevolution and mega-icebergs in Antarctica*. Proceedings of the National Academy of Sciences of the United States of America, 102 (46), 16717-16722. DOI:10.1073/pnas.0502281102

B – book chapters

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C - proceedings of international conferences

1. HALL B. and BARONI C., (2002) – *Relative Sea-level changes along the Victoria Land Coast, Antarctica*. EOS, Trans. AGU, 83(19), Spring Meeting suppl., Abstract.
2. OBERHOLZER P., SCHAEFER J.M., BARONI C., IVY-OCHS S., OROMBELLI G., BAUR H. and WIELER R. (2002) - *Limited Pleistocene glaciation in Deep Freeze Range, Northern Victoria Land, Antarctica, derived from in-situ cosmogenic nuclides*. Goldsmidt 2002, Davos (CH). Abstract, oral comunication.
3. BARONI C. (2003) – *Archaeology of relict penguin rookeries as an aid in reconstructing Holocene deglaciation of Antarctic coasts*. XVI INQUA Congress, "Shaping the Earth, A Quaternary Perspective", Reno, Nevada, July 2003, Abstract (invited oral comunication), p. 227.
4. BARONI C., BIASINI A., BONDESAN A., CIMBELLI A., FREZZOTTI M., MENEGHEL M., OROMBELLI G., SALVATORE M.C., TABACCO I.E. and VITTUARI L. (2003) – *Antarctic Geomorphological and Glaciological 1:250,000 map series. Mt. Murchison Quadrangle (northern Victoria Land)*. 7th International Symposium on Antarctic Glaciation, Milano, agosto 2003. Abstract (oral presentation), Università di Milano Bicocca, p. 37.
5. BARONI C., BIASINI A., BONDESAN A., MENEGHEL M., OROMBELLI G. and SALVATORE M.C. (2002) - *Geomorphological Map of the Northern Foothills and Inexpressible Island, Victoria Land (1:50,000).* 7th International Symposium on Antarctic Glaciation, Milano, agosto 2003. Abstract (poster), p. 39.
6. BARONI C., FASANO F., GIORGETTI G. and SALVATORE M.C., (2003) - *Warm-based ice advance and continental chemical weathering documented by the "Ricker Hills Tillite" (Victoria Land, Antarctica)*. International Symposium on Antarctic Earth Science, IX, Potsdam, Sept. 2003. Abstract (oral comunication), Terra Nostra, Fütterer D.K. ed., Alfred Wegener Inst., p. 16.
7. BARONI C. and GIORGETTI G. (2003) - *Electron microscopic characterization of "rock varnishes" from Northern Victoria Land*. International Symposium on Antarctic Earth Science, IX, Potsdam, Sept. 2003. Abstract (poster), Terra Nostra, Fütterer D.K. ed., Alfred Wegener Inst., p.15.
8. OBERHOLZER P., BARONI C., SALVATORE M.C., BAUR H. and WIELER R. (2003) – *Constraints to the amplitude of Pleistocene ice level variations in the Transantarctic Mountains from glacial geomorphological mapping and surface exposure dating*. XVI INQUA Congress, "Shaping the Earth, A Quaternary Perspective", Reno, Nevada, July 2003, Abstract (Poster), p. 237.
9. BARONI C., BASTONCELLI D., SALVATORE M.C., CICCACCI S., NOTI V., and RIGHINI. (2004) - *Fluvial origin of valley network and Cenozoic glacial-dynamic variations in northern Victoria Land (Antarctica) documented by landscape and quantitative geomorphic analyses.* 32nd International Congress, Firenze, August 2004. Abstract.
10. BARONI C., FASANO F., GIORGETTI G. and SALVATORE M.C., (2004) - *The "Ricker Hills Tillite" (Victoria Land, Antarctica): New contribution for reconstructing the Cenozoic history of the East Antarctic Ice Sheet.* 32nd International Congress, Firenze, August 2004. Abstract.
11. BARONI C. (2005) - *Fluvial origin of valley network and Cenozoic glacial dynamic variations in northern Victoria Land (Antarctica) documented by landscape and quantitative geomorphic analyses*. Workshop on "Cenozoic onshore and offshore stratigraphic record from the East Antarctic margin: recent results and future directions" Spoleto (Italy) 18-20 September 2005. Abstract.

D – proceedings of national meetings and conferences

1. BARONI C. and BASTONCELLI D. (2002) - *Cartografia geomorfologia in Antartide: confronto tra diverse scuole di pensiero ed applicazione nelle Northern Foothills (Terra Vittoria settentrionale)*. 4° Convegno Nazionale di glaciologia Antartica (CONGA), Milano 25-26 giugno 2002. Abstract Poster.
2. BARONI C., BIASINI A., BONDESAN A., FREZZOTTI M., MENEGHEL M., OROMBELLI G., SALVATORE M.C., TABACCO I.E. and VITTUARI L. (2002) - *Carta Geomorfologica e del foglio Mount Murchison, in scala 1:250,000* (Terra Vittoria, Antartide). 4° Convegno Nazionale di glaciologia Antartica (CONGA), Milano 25-26 giugno 2002. Abstract Poster.
3. BARONI C., BIASINI A., BONDESAN A., MENEGHEL M., OROMBELLI G., SALVATORE M.C. (2002) - *Carta geomorfologica delle Northern Foothills e di Inexpressible Island (Terra Vittoria Antartide) in scala 1:50,000.* 4° Convegno Nazionale di glaciologia Antartica (CONGA), Milano 25-26 giugno 2002. Abstract Poster.
4. FASANO F. and BARONI C. *Micromorphological analysis of glacial sediments in Antarctica: an example from the Ricker Hills tillite*. 4° Convegno Nazionale di glaciologia Antartica (CONGA), Milano 25-26 giugno 2002. Abstract.
5. BARONI C. and SALVATORE M.C. (2002) - *Carta geomorfologica del settore meridionale delle Ricker Hills (Terra Vittoria, Antartide)*. 4° Convegno Nazionale di glaciologia Antartica (CONGA), Milano 25-26 giugno 2002. Abstract.
6. BARONI C. (2005) - *Deglaciazione e modificazioni ambientali oloceniche nella Terra Vittoria settentrionale.* V° Convegno Nazionale di Glaciologia Antartica (CONGA), "Venti anni di glaciologia italiana in Antartide, 19-21 Ottobre 2005, Milano. Abstract.
7. BASTONCELLI D., BARONI C. and SALVATORE M.C. (2005) - *Morphometric and statistic analysis of Antarctic "cirque like forms".* Quinto Forum Italiano di Scienze della Terra, Spoleto, 20-22 Settembre 2005. Abstract.

E – thematic maps

1. BARONI C. (2002) in: CAPPONI G., CRISPINI L., MECCHERI M., MUSUMECI G. and PERTUSATI P.C., (2002) - *Antarctic Geological 1: 250,000 map series - Mount Joyce Quadrangle (Victoria Land)*. Museo Nazionale dell'Antartide, Dipart. Scienze della Terra, Univ. Siena.
2. BARONI C. (ED.), BIASINI A., BONDESAN A., DENTON G.H., FREZZOTTI M., GRIGIONI P., MENEGHEL, M., OROMBELLI G., SALVATORE M.C., DELLA VEDOVA A.M. and VITTUARI L. (2005) - *Mount Melbourne Quadrangle, Victoria Land, Antarctica 1:250,000 (Antarctic Geomorphological and Glaciological Map Series)*. In: Haeberli W., Zemp M., Hoelzle M. and Frauenfelder R. (eds.), 2005, *Fluctuations of Glaciers*. A contribution to the Global Environment Monitoring Service (GEMS) and the International Hydrological Programme, Vol VIII (1995-2000), pp. 38-40. World Glacier Monitoring Service, International Association of Hydrological Sciences (International Commission on Snow and Ice), United Nations Environment Programme, and United Nations Educational, Scientific and Cultural Organization, Zuerich.
3. BARONI C. (ED.), BIASINI A., CIMBELLI A., FREZZOTTI M., OROMBELLI G., SALVATORE M.C., TABACCO I. and VITTUARI L. (2005) - *Relief Inlet Quadrangle, Victoria Land, Antarctica 1:250,000 (Antarctic Geomorphological and Glaciological Map Series)*. In: Haeberli W., Zemp M., Hoelzle M. and Frauenfelder R. (eds.), 2005, *Fluctuations of Glaciers*. A contribution to the Global Environment Monitoring Service (GEMS) and the International Hydrological Programme, Vol VIII (1995-2000), pp. 43-44. World Glacier Monitoring Service, International Association of Hydrological Sciences (International Commission on Snow and Ice), United Nations Environment Programme, and United Nations Educational, Scientific and Cultural Organization, Zuerich.
4. BARONI C., FREZZOTTI M., SALVATORE M.C., MENEGHEL M., TABACCO I.E., VITTUARI L., BONDESAN A., BIASINI A., CIMBELLI A., and OROMBELLI G. (2005) - *Antarctic Geomorphological and Glaciological 1:250,000 map series. Mt. Murchison Quadrangle (northern Victoria Land). Explanatory notes* in: Annals of Glaciology, v. 39, 256-264.

NB: maps 2 and 3 were printed before 2002 but in 2005 have been published in the volume of "World Glacier Monitoring Service"

F – patents, prototypes and data bases

1. Data base on radiocarbon dates from Terra Nova Bay and Scott Coast.

G – exhibits, organization of conferences, editing and similar

Introducing seminars for the PNRA training courses at the Brasimone center, on Antarctic physical geography and exploration history and on northern Victoria Land geomorphologic evolution and Antarctic glacial history.

H - formation (PhD thesis, research fellowships, etc.)

DEGREE THESIS

Gianni Evangelista, 2002 - *Analisi geomorfica quantitativa dei bacini dei Ghiacciai Campbell, Tinker e Aviator (Terra Vittoria settentrionale, Antartide).* Università di Pisa, Corso di Laurea in Scienze Geologiche (quinquennale). Rel. Carlo Baroni

PhD (THESIS) DISSERTATIONS

Francesco Fasano
XVI ciclo del Dottorato in Scienze Polari, Università di Siena (2000-03)
ANALISI MICROMORFOLOGICHE, SEDIMENTOLOGICHE E MINERALOGICHE DI SEDIMENTI GLACIALI ANTARTICI PER LA RICOSTRUZIONE DELLA DINAMICA GLACIALE.
Tutors: Carlo Baroni and Franco Talarico

Dimitri Bastoncelli
XVII ciclo del Dottorato in Scienze Polari, Università di Siena (2001-04)
ANALISI GEOMORFICA QUANTITATIVA DI FORME DEL RILIEVO RELITTE E SEPOLTE PER LA RICOSTRUZIONE DELLA STORIA GLACIALE CENOZOICA DELLA TERRA VITTORIA SETTENTRIONALE (ANTARTIDE).
Tutor: Carlo Baroni

Peter Oberholzer (2001-04)
PhD thesis No. 15472, ETH Zurich
RECONSTRUCTING PALEOCLIMATE AND LANDSCAPE HISTORY IN ANTARCTICA AND TIBET WITH COSMOGENIC NUCLIDES.
Tutors: Rainer Wieler, Christian Schlüchter, Carlo Baroni, Joerg Shaefer

Research units

Research unit 1 (GHE-BAR)
PI: Carlo Baroni
Relevant istitute: Diparimento di Scienze della Terra, Università di Pisa
Research task: geomorphological, sedimentological, petrographical studies on glacial environment and materials; quantitative geomorhic analysis

Dimitri Bastoncelli
Alberto Carton
Mauro Cremaschi
Francesco Fasano
Giovanna Giorgetti
Valerio Noti
Adriano Ribolini
Luca Trombino

Research unit 2 (GHE-BIAS)
PI:Alessandro Biasini
Relevant institute: Dipartimento di Scienze della Terra Università di Roma "La Sapienza"
Research task: remote sensing, aerial photograph interpretation, quantitative geomorphic analysis

Sirio Ciccaci
Maria Cristina Salvatore
Michele Saroli

Research unit 3 (GHE-MEN)
PI: Mirco Meneghel
Relevant institute: (Dipartimento di Geografia, Università di Padova)
Research task: aerial photograph interpretation, geomorphologic mapping

Aldino Bondesan
Giovanni Badino
Jean Louis Tison

Date:

Notes

Antarctic Expeditions
2002/03:
C. Baroni, D. Bastoncelli (Italian National Antarctic Expedition, PNRA)
In collaboration with D. Lambert and J. McDonald, event NZ-K030, research program "*Measuring Evolution Directly: Ancient DNA from Adélie in Antartica*", resp. David Lambert, Molecular Ecology, Institute of Molecular Biosciences, Massey University, NZ;
collaboration with Brenda Hall, NSF; NSF support in the Scott Coast.

2003/04:
M.C. Salvatore, D. Bastoncelli (Italian National Antarctic Expedition, PNRA)

International collaborations
1) Brenda Hall, George Denton, Dept. Geological Sciences, Climate Change Inst., University of Maine, U.S.A. (landscape analysis, geomorphology and glacial geology, paleoenvironmental research)
2) Christian Schluecter, Institute of Geological Sciences, University of Bern, Switzerland (surface exposure dating)
3) Rainer Wieler, Susan Ivy-Ochs, Isotopengeochemie und mineralische Rohstoffe, ETH Zurigo

(surface exposure dating).
4) Joerg Schaefer, Lamont-Doherty Earth Observatory Columbia University. USA (surface exposure dating),
5) David Lambert, Allan Wilson Centre for Molecular Ecology and Evolution, Institute of Molecular BioSciences, Massey University, Auckland, NZ (DNA and genetic research on penguin remains)

Abstracts of the published papers

LAMBERT D.M., RITCHIE P.A., MILLAR C.D., HOLLAND B., DRUMMOND A.J. and BARONI C. (2002) - *Rates of evolution in Ancient DNA from Adélie Penguins*. Science, 295, 2270-2273. DOI: 10.1126/science.1068105
Well-preserved subfossil bones of Adélie penguins, *Pygoscelis adeliae*, underlie existing and abandoned nesting colonies in Antarctica. These bones, dating back to more than 7000 years before the present, harbor some of the best-preserved ancient DNA yet discovered. From 96 radiocarbon-aged bones, we report large numbers of mitochondrial haplotypes, some of which appear to be extinct, given the 380 living birds sampled. We demonstrate DNA sequence evolution through time and estimate the rate of evolution of the hypervariable region I using a Markov chain Monte Carlo integration and a least-squares regression analysis. Our calculated rates of evolution are approximately two to seven times higher than previous indirect phylogenetic estimates.

OBERHOLZER P., BARONI C., SCHAEFER J.M., OROMBELLI G., IVY OCHS S., KUBIK P.V., BAUR H. and WIELER R. (2003) – *Limited Pliocene/Pleistocene glaciation in Deep Freeze Range, northern Victoria Land, Antarctica, derived from in situ cosmogenic nuclides*. Antarctic Science 15(4), 493-502. DOI: 10.1017/S0954102003001603
The question of how stable the climate in Antarctica has been during the last few million years compared to the rest of the planet is still controversial. This study attempts to add new information to the discussion by reconstructing the timing and spatial extent of glacial advances in northern Victoria Land over tens of thousands to millions of years. In Terra Nova Bay region, surface exposure ages and erosion rates of glacially rounded bedrock and glacial erratics have been determined using the cosmogenic nuclides 3He, 10Be and 21Ne. Three morphological units have been analysed. They yield minimum ages of 11 to 34 ka, 309 ka, and 2.6 Ma, respectively. Erosion rates were as low as 20 cm Ma-1 since middle Pliocene time. Taking erosion into account, the oldest surface is 5.3 Ma old. Pleistocene glacier advances had considerable extent, reaching up to 780 m above modern ice levels, but have been restricted to the valleys since at least mid-Pliocene. The existence of landscapes of mid-Pliocene age in northern Victoria Land implies that the climatic stability of the McMurdo Dry Valleys is not unique within the Transantarctic Mountains, but rather the expression of a constantly cold and hyperarid climate regime in entire Victoria Land.

BARONI C., HALL B.L. (2004) - *A new relative sea-level curve for Terra Nova Bay, Antarctica*. Journal of Quaternary Science, 19(4), 377-396. DOI: 10.1002/jqs.825
More than 100 radiocarbon dates of penguin guano and remains, shells and seal skin afford ages for raised beaches adjacent to Terra Nova Bay, Antarctica. These dates permit construction of a new relative sea-level curve that bears on the timing of deglaciation. Recession of the Ross Sea ice-sheet grounding line from Terra Nova Bay occurred no earlier than 7200 14C yr (8000 cal. yr) BP. Retreat along the Victoria Land coast may have been rapid, possibly contributing to eustatic sealevel rise centred at ca. 7600 cal. yr BP. The presence of a significant amount of ice remaining in the Ross Sea Embayment in Holocene time lessens the chance that Antarctica contributed significantly to meltwater pulse 1A several thousand years earlier.

HALL B.L., BARONI C. and DENTON G.H. (2004) - *Holocene relative sea-level history of the Southern Victoria Land coast, Antarctica*. Global and Planetary Change, 42, 241-263. DOI: 10.1016/j.gloplacha.2003.09.004
More than 130 radiocarbon dates of penguin remains and guano, sealskin, shells, and seaweed from raised beach ridges afford relative sea-level information for southern Victoria Land. A new relative sea-level curve suggests that the final unloading of grounded ice from the coast took place about 6600 14C years BP, inkeeping with previous estimates of the timing of deglaciation. Since this time, the coast has experienced 32 m of relative sea-level fall at rates ranging from 2 to 15 mm/year, consistent with glacioisostatic rebound.

RITCHIE P.A., MILLAR C.D., GIBB G.C., BARONI C., and LAMBERT D.M. (2004) - *Ancient DNA Enables Timing of the Pleistocene Origin and Holocene Expansion of Two Adélie Penguin Lineages in Antarctica.* Molecular Biology and Evolution, 21 (2), 240-248.
DOI: 10.1093/molbev/msh012
The timing of divergent events in history is one of the central goals of contemporary evolutionary biology. Such studiesare however dependent on accurate evolutionary rates. Recent developments in ancient DNA analysis enable

the estimation of more accurate evolutionary rates and therefore more accurate timing of divergence events. Consequently, this leads to a better understanding of changes in populations through time. We use an evolutionary rate calculated from ancient DNA of Adélie penguins (*Pygoscelis adeliae*) to time divergent events in their history. We report the presence of two distinct and highly variable mitochondrial DNA lineages and track changes in these lineages through space and time. When the ancient DNA and the phylogenetic rates are used to estimate the time of origin of the lineages, two very different estimates resulted. In addition, these same rates provide very different estimates of the time of expansion of these lineages. We suggest that the rate calculated from ancient DNA is more consistent with the glacial history of Antarctica and requires fewer assumptions than does a narrative based on the phylogenetic rate. Finally, we suggest that our study indicates an important new role for ancient DNA studies in the timing of divergent events in history.

BARONI C., FREZZOTTI M., SALVATORE M.C., MENEGHEL M., TABACCO I.E., VITTUARI L., BONDESAN A., BIASINI A., CIMBELLI A., and OROMBELLI G. (2005) - *Antarctic Geomorphological and Glaciological 1:250,000 map series. Mt. Murchison Quadrangle (northern Victoria Land). Explanatory notes*. 7th International Symposium on Antarctic Glaciology, Milano 25-29 Aug. 2003. Annals of Glaciology, v. 39, 256-264.
Geomorphological and glaciological features are represented on a georeferenced satellite image mosaic of the Mount Murchison quadrangle, northern Victoria Land, Antarctica (73–74° S, 162– 166°30° E), at a scale of 1 : 250 000. Landforms and deposits of glacial and periglacial environments, forms related to mass wasting, wind action, weathering and geological structures are identified and mapped. The chronological sequence of landforms and deposits, morphography and lithology is also indicated. Glacier velocities (up to 180ma–1) and ice-front fluctuations (1964–99) were determined by analysis of aerial photography and satellite imagery. Airborne radar surveys reveal that the greatest ice thickness (about 1500 m) is located in the grounding zone of Aviator Glacier. Up to 1000m of ice bury the subglacial relief of Deception Plateau, Hercules NeÅLveÅL and the Deep Freeze Range. Snow accumulation rates (average = 170 kgm–2 a–1) exhibit an overall negative correlation with altitude and distance from the coast. The relationships among relict erosional landforms and volcanic activity provide chronological constraints for the palaeogeographic evolution of this sector of the Transantarctic Mountains.

BARONI C., NOTI V., CICCACCI S., RIGHINI G. and SALVATORE M.C. (2005) - *Fluvial Origin of the Valley System in northern Victoria Land (Antarctica) from Quantitative Geomorphic Analysis*. Geological Society of America Bulletin, 117 (1-2), 212-228. DOI: 10.1130/B25529.1
A network of sinuous valleys with typical dendritic pattern characterizes northern Victoria Land (NVL) in Antarctica. Subparallel to parallel and angular to rectangular patterns are also present. Quantitative geomorphic analysis of the valley network has been carried out utilizing GIS spatial analysis. While drainage densities and drainage frequencies show low values, segments of the NVL valley network are substantially well organized, as indicated by bifurcation ratio (Rb) and direct bifurcation ratio (Rbd) parameters. All basins faithfully adhere to Horton's laws of drainage network composition. Quantitative geomorphic analysis suggests that the valley system can be ascribed to fluvial origin and that consequently, a morphoclimatic system completely different from that of present day must have driven its carving. The resulting data provide indications about the origin of the valley network and this invaluable information can be used for the reconstruction of earlier phases of glacial history and climatic and tectonic evolution of this signifi cant Antarctic region. Fluvial erosion enhanced the denudation of the Transantarctic Mountains from at least 55 Ma to at least the Eocene-Oligocene boundary (ca 34 Ma). Fluvial basins adapted to the tectonic structure, following the main regional fault systems. A well-developed alpine topography postdates the fl uvial morphology. Temperate glaciers were responsible for denudation until the Late Miocene. Parasitic glaciers presently mantle the previously sculpted topography. Present-day glacial erosion is negligible and denudation has been exceedingly slow since 7.5 Ma.

SHEPHERD L.D., MILLAR C.D., BALLARD G., AINLEY D.G., WILSON P.R., HAYNES G.D., BARONI C. and LAMBERT D.M. (2005) – *Microevolution and mega-icebergs in Antarctica*. Proceedings of the National Academy of Sciences of the United States of America, 102 (46), 16717-16722. DOI:10.1073/pnas.0502281102
Microevolution is regarded as changes in the frequencies of genes in populations over time. Ancient DNA technology now provides an opportunity to demonstrate evolution over a geological time frame and to possibly identify the causal factors in any such evolutionary event. Using nine nuclear microsatellite DNA loci, we genotyped an ancient population of Ade´ lie penguins (*Pygoscelis adeliae*) aged 6,000 years B.P. Subfossil bones from this population were excavated by using an accurate stratigraphic method that allowed the identification of individuals even within the same layer. We compared the allele frequencies in the ancient population with those recorded from the modern population at the same site in Antarctica. We report significant changes in the frequencies of alleles between these two time points, hence demonstrating microevolutionary change. This study demonstrates a nuclear gene-frequency change over such a geological time frame. We discuss the possible causes of such a change, including the role of mutation, genetic drift, and the effects of gene mixing among different penguin populations. The latter is likely to be precipitated by mega-icebergs that act to promote migration among penguin colonies that typically show strong natal return.