

Final project report

Project ID: 2004/4.02
Title: Origin and behaviour of the northern Victoria Land glacial system

Principal investigator: Carlo Baroni
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Duration: 3 years
Assigned funding: € 190.000,00

Activities and results

Trough the combined application of multidisciplinary methodologies (geomorphological and glacial geological surveys, quantitative geomorphic analysis, surface exposure age dating -SED-, sedimentological, petrographical, micromorphological studies of glacial sediments, and rock varnish analysis), we investigated a wide portion of Victoria Land, extending from the David Glacier basin in the south to the upper Rennick Glacier (Mesa Range) in the north. Radiocarbon dates and exposure age analysis supplied reliable absolute dating of relict landforms and glacial deposits. Geomorphological and glacial geological researches concur in defining the landscape analysis of Victoria Land that, in turn, provides a powerful tool for investigating Cenozoic paleoenvironmental evolution. Results obtained emphasize the identification of different behaviour of the complex Antarctic system, with clearly evident regional differentiations (i.e. NVL).

Relict landscape features

SED of glacially scoured bedrock demonstrates that coastal rounded summits and relict surfaces in the interior have been free of ice for at least 6 Ma. This implies that this sector of the TMA has not been overridden by erosive ice (EAIS, outlet glaciers, local valley glaciers) since at least the Pliocene. Our results extend the concept of long-term landscape stability beyond SVL.

The Ricker Hills Tillite, the oldest glacial deposit in Victoria Land

RHT is a new discovered continental glacial drift that was deposited in wet conditions, under an Oligocene warm-based ice sheet. Denudation on the Ricker Hills has been extremely low and only minimal modification of the landscape has occurred in the Ricker Hills since that time.

Multiple low-amplitude Pliocene and Pleistocene glacial variations

Consistent neon and beryllium exposure ages indicate three main glacial advances in the Ricker Hills, (1.4, 1.0, 0.67 Ma). The Northern Foothills have been repeatedly exposed and buried by Pleistocene expanding ice bodies, as complex exposure history documents. All these glacial fluctuations were of limited amplitudes of less than ~500 m.

Response of Adélie Penguins and Elephant Seals to Climate and Habitat Change in VL

The multi-millenary record of Adélie penguin community preserved in ornithogenic soils has answered so far a wide range of multidisciplinary questions and it has to be considered as a unique natural fossil heritage, especially useful in the context of paleoenvironmental and paleoecological researches.

Ancient DNA sequences extracted from penguin bones have defined paleo-evolutionary trends and genetic variations of Adélie penguins occurred in the last 37,000 years, as a result of paleoenvironmental changes affecting their natural habitat such as the Pleistocene cooling and later Holocene warming of Antarctica.

Elephant seals (*Mirounga leonina*) once occupied large areas of the Victoria Land coast at times between about 500 and 7000 years ago. Through the discovery of elephant seal remains over a widespread area where they do not exist today, we show evidence not only that a warming occurred, but that the Ross Ice Shelf survived that event. This is particularly important because it speaks to the staying capacity of the ice shelf in the face of global warming (G. Denton, The Antarctic Sun, Feb. 4, 2007).

Products

A – papers in scientific magazines

1. Baroni C., Fasano F. (2006) - *Micromorphological evidence of warm-based glacier deposition from the Ricker Hills Tillite (Victoria Land, Antarctica)*. Quaternary Science Reviews, 25, 976-992. doi:10.1016/j.quascirev.2004.11.011
2. Hall B.L., Hoelzel A.R., Baroni C., Denton G.H., Le Boeuf B.J., Overturf B. & Töpf A.L. (2006) - *Holocene elephant seal distribution implies Sub-Antarctic climate in the Ross Sea*. Proceedings of the National Academy of Sciences of the United States of America, 103 (27), 10213-10217. doi:10.1073/pnas.0604002103
3. Fasano F., Baroni C., Talarico F.M., Bettuzzi M. e Pasini A. (2007) - *Glacial Stress Field Orientation Reconstructed through Micromorphology and X-Ray Computed Tomography of Till*. In: Hambrey M., Christoffersen P., Glasser N. and Hubbard B. (eds.), *Glacial Sedimentary Processes and Products*. Special Publ. N. 39 of the Intern. Association of Sedimentologists Series, Blackwell, p. 289-294.
4. Finocchiaro F., Baroni C., Colizza E., Ivaldi R. (2007) - *Pre-LGM open-water conditions south of the Drygalski Ice Tongue (Ross Sea, Antarctica)*. Antarctic Science, 19 (3), 373-377. doi: 10.1017/S0954102007000430
5. Giorgetti G., Baroni C. (2007). *High-resolution analysis of silica and sulphate-rich rock varnishes from Victoria Land (Antarctica)*. European Journal of Mineralogy, 19 (3), 381-389. doi: 10.1127/0935-1221/2007/0019-1725
6. Baroni, C., Fasano F., Giorgetti G., Salvatore M.C., Ribecai C. (2008) - *The Ricker Hills Tillite provides evidence of Oligocene warm-based glaciation in Victoria Land, Antarctica*. Global and Planetary Change, 60 (3-4), 457-470. doi: 10.1016/j.gloplacha.2007.05.004
7. Millar C.D., Dodd A., Anderson J., Gibb G.C., Ritchie P.A., Baroni C., Woodhams M.D., Hendy M.D., Lambert D.M. (2008) - *Mutation and Evolutionary Rates in Adélie Penguins from the Antarctic*. PLoS Genetics 4(10): e1000209. doi: 10.1371/journal.pgen.1000209
8. Oberholzer P., Baroni C., Salvatore M.C., Baur H., Wieler R. (2008) - *Dating Late-Cenozoic erosional surfaces in Victoria Land, Antarctica, with cosmogenic Neon in Pyroxenes*. Antarctic Science, 20 (1), 89-98. doi: 10.1017/S095410200700079X
9. Di Nicola L., Strasky S., Schlüchter C., Salvatore M. C., Kubik P. W., Ivy-Ochs S., Wieler R., Akçar N. & Baroni C. (2009) - *Complex exposure history of pre-LGM glacial drifts in Terra Nova Bay using multiple cosmogenic nuclide concentrations (10Be and 21Ne)*. Quaternary Research, 71 (1), 83-92. doi: 10.1016/j.yqres.2008.07.004
10. Strasky S., Di Nicola L., Baroni C., Salvatore M. C., Baur H., Kubik P. W., Schlüchter C., Wieler R. (2009) - *Surface exposure ages imply multiple low-amplitude Pleistocene variations in East Antarctic Ice Sheet, Ricker Hills, Victoria Land*. Antarctic Science, 21 (1), 59-69. Published online by Cambridge University Press 09 Jul 2008. doi: 10.1017/S0954102008001478
11. Lorenzini S., Olmastroni S., Pezzo F., Salvatore M.C. & Baroni C. (2009) - *Holocene Adélie Penguin diet in Victoria Land, Antarctica*. Polar Biology, 32 (7), 1077-1086. Published online March 2009. doi:10.1007/s00300-009-0607-4
12. De Bruyn M., Hall B.L., Chauke L.F., Baroni C., Koch P.L. & Hoelzel A.R. (2009) - *Rapid Response of a Marine Mammal Species to Holocene Climate and Habitat Change*. PLoS Genetics, 5(7): e1000554. doi:10.1371/journal.pgen.1000554

B – book chapters

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C - proceedings of international conferences

1. Baroni, C., S. Lorenzini, Salvatore M. C., & Olmastroni S. (2007) - *Adélie Penguins colonization history and paleodiet trends document Holocene environmental changes in Victoria Land (Antarctica)*. In Antarctica: A Keystone in a Changing World – Online Proceedings of the 10th ISAES X, edited by A. K. Cooper and C. R. Raymond et al., USGS Open-File Report 2007-1047, 108, 4 p.
2. Di Nicola L., Strasky S., Schlüchter C., Salvatore M. C., Kubik P. W., Ivy-Ochs S., Wieler R., N. Akçar & Baroni C. (2007) - *Complex exposure history of pre-LGM glacial drifts in Terra Nova Bay using multiple cosmogenic nuclide concentrations (10Be and 21Ne)*. In Antarctica: A Keystone in a Changing World – Online Proceedings of the 10th ISAES X, edited by A. K. Cooper and C. R. Raymond et al., USGS Open-File Report 2007-1047, 120, 4 p.
3. Strasky S., Di Nicola L., Baroni C., Salvatore M. C., Baur H., Kubik P. W., Schluechter C., & Wieler R. (2007) - *Multiple Early to Mid-Pleistocene East Antarctic Ice Sheet variations in the Ricker Hills (Victoria Land, Antarctica)*. In Antarctica: A Keystone in a Changing World – Online Proceedings of the 10th ISAES X, edited by A. K. Cooper and C. R. Raymond et al., USGS Open-File Report 2007-1047, 138, 5 p.

Extended abstracts and abstracts (reviewed)

1. Baroni C., Bastoncelli D., Righini G. & Salvatore M.C. (2005) - *Glacial landscape and morphometric analyses for the reconstruction of Cenozoic glacial history in northern Victoria Land*. Sixth International Conference on

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- Geomorphology, Saragoza, 7-11 Settembre 2005.
2. Fasano F., Baroni C., Talarico F.M., Bettuzzi M. & Pasini A. (2005) - *Glacial stress field orientation reconstructed through micromorphology and μ X Ray Computed Tomography on sediments*. International Conference on "Glacial Sedimentary Processes and Products, University of Wales, 22-27 August 2005, Aberystwyth.
 3. Hall B.L., Henderson G.M., Baroni C. & Kellogg T. (2005) - *The Holocene Radiocarbon Reservoir Effect in the Western Ross Sea*. Twelfth Annual West Antarctic Ice Sheet Workshop, Sept.28 – Oct. 1, 2005, Sterling, VA, USA.
 4. Giorgetti G. & Baroni C. (2006) - *High-resolution analysis of silica and sulphate-rich rock varnishes from northern Victoria Land (Antarctica)*. European Geosciences Union, General assembly, Vienna, 2-7 Apr. 2006. Geophysical Research Abstracts, Vol. 8, 03006. (eISSN: 1607-7962)
 5. Di Nicola L., Strasky S., Baroni C., Salvatore M. C., Kubik P. W., Ivy-Ochs S., Wieler R., Akcar N. & Schlüchter C. (2007) - *Exposure history of pre-LGM glacial drifts in Terra Nova Bay: field work and first results from the XX and XXI Italian Antarctic expeditions*. Geophysical Research Abstracts, Vol. 9, 04097, 2007. European Geosciences Union, General ass., Vienna, 15-20 Aprile 2007. SRef-ID: 1607-7962/gra/EGU2007-A-04097.
 6. Koch P., Hall B., Baroni C., Newsome S., Salvatore M.C. (2007) - *The distribution and ecology of Southern Elephant Seals and Adélie Penguins on the Holocene Ross Sea coast*. Journal of Vertebrate Paleontology, Vol 27, supplement to number 3, p. 101A.
 7. Lorenzini S., Olmastroni S., Salvatore M.C. & Baroni C. (2007) - *Fish otoliths from ornithogenic soils for investigating Holocene Adélie Penguin diet variation in Victoria Land, Antarctica*. 6th International Penguin Conference, 3-7 September 2007. Hobart, Tasmania AUSTRALIA.
 8. Strasky S., Di Nicola L., Oberholzer P., Baroni C., Salvatore M. C., Baur H., Kubik P. W., Wieler R. & Schlüchter C. (2007) - *Pleistocene East Antarctic Ice Sheet variations in the Ricker Hills*. Geophysical Research Abstracts, Vol. 9, 02911, 2007. European Geosciences Union, General assembly, Vienna, 15-20 Apr. 2007. SRef-ID: 1607-7962/gra/EGU2007-A-02911.
 9. Strasky S., Di Nicola L., Baroni C., Salvatore M. C., Baur H., Kubik P.W. Wieler W. and Schlüchter C. (2007) - *Cold-based ice limits the potential of cosmogenic nuclide dating in Antarctica*. XXVII INQUA Congress, Cairns, Australia, 28th July - 3rd August, 2007.
 10. Baroni C., Fasano F., Giorgetti G. & Salvatore M.C., (2008) - *Continental tillites document Late Oligocene change from chemical to physical weathering under a wet-based east Antarctic ice sheet*. 33rd International Geological Congress, Oslo, August 6-14 2008.
 11. Baroni C., Fasano F., Finocchiaro F. (2008) - *Ice sheet conditions in western Ross Sea (Antarctica) during LGM from micromorphological marine core observations*. Geophysical Research Abstracts, Vol. 10, 09152, 2008. Eur. Geosciences Union, General assembly, Vienna, 13-18 Apr. 2008. SRef-ID: 1607-7962/gra/EGU2008-A-09152.
 12. Koch P.L., Hall B., Baroni C., Newsome S., Salvatore M.C. (2008) - *The distribution and ecology of southern elephant seals and Adélie penguins on the Holocene Ross Sea coast*. The 6th International Conference on Applications of Stable Isotope Techniques to Ecological Studies, Honolulu, 25-29 August 2008.
 13. Di Nicola L., Baroni C., Strasky S., Salvatore M. C., Schlüchter C., Akcar N., Kubik P. W. & Wieler R. (2009) - *Cenozoic landscape evolution in Terra Nova Bay region: new evidence from multiple cosmogenic nuclides*. Geophysical Research Abstracts, Vol. 11, 13130, 2009. European Geosciences Union, General assembly, Vienna, 15-20 Aprile 2009. SRef-ID: 1607-7962/gra/EGU2009-A-04097
 14. Baroni C., Di Nicola L., Strasky S., Salvatore M.C., Schlüchter C., Akçar N. Kubik P.W. & Wieler R. (2009) - *Cenozoic glacial history of northern Victoria Land (Antarctica): geomorphologic evidences and surface exposure ages*. 7th International Conference on Geomorphology, Melbourne, Australia 6-11 July 2009. (<http://www.geomorph.org/main.html>).
 15. Baroni C., Salvatore M.C., Lorenzini S. & Lambert D. (2009) - *Adélie Penguins Relict Colonies Provide Evidence of Environmental and Ecological Changes in Victoria Land (Antarctica)*. 7th International Conference on Geomorphology, Melbourne, Australia 6-11 July 2009. (<http://www.geomorph.org/main.html>).

D – proceedings of national meetings and conferences

1. Baroni C. (2005) - *Fluvial origin of valley network and Cenozoic glacial dynamic variations in northern Victoria Land (Antarctica)*. Workshop on "Cenozoic onshore and offshore stratigraphic record from the East Antarctic margin: recent results and future directions" Spoleto (Italy) 18-20 September 2005.
2. 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.
3. Finocchiaro F., Baroni C., Colizza E. & Corradi N. (2005) - *Pre-LGM open water conditions along the Scott Coast (Ross Sea, Antarctica)*. Quinto Forum Italiano di Scienze della Terra, Spoleto, 20-22 Settembre 2005.
4. Bastoncelli D., Baroni C. & 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.
5. Fasano F., Baroni C. & Talarico F.M. (2005) - *From micromorphology to μ X Ray Computed Tomography: characterization and interpretation of glacial sediments*. Quinto Forum Italiano di Scienze della Terra, Spoleto, 20-

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22 Settembre 2005.

6. Lorenzini S., Zanchetta G., Fallick A.E., Salvatore M.C. & Baroni C. (2009) - *Analisi isotopiche dell'ossigeno delle uova di pinguino di Adelia (Pygoscelis adeliae) indicano variazioni ambientali oloceniche nella Terra Vittoria (Mare di Ross, Antartide)*. AIQUA - La variabilità del clima nel Quaternario: La Ricerca Italiana, Roma 18 - 20 Feb. 2009

E – thematic maps

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F – patents, prototypes and data bases

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G – exhibits, organization of conferences, editing and similar

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

1. **Valerio Noti**, XIX ciclo Dottorato in Scienze Polari, Università di Siena (2003-06), *ANALISI GEOMORFOLOGICA QUANTITATIVA DEL RETICOLATO DI DRENAGGIO E DEI PARAMETRI MORFOMETRICI DI ALCUNI BACINI GLACIALI DELLA TERRA VITTORIA SETTENTRIONALE (ANTARTIDE) CON L'UTILIZZO DI TECNOLOGIE GIS*. Tutor: Carlo Baroni
2. **Luigia di Nicola**, XX ciclo Dottorato in Scienze Polari, Università di Siena (2004-07), *MULTIPLE COSMOGENIC NUCLIDE DATING OF LATE CENOZOIC ROCK SURFACES AND GLACIAL DRIFTS IN THE TERRA NOVA BAY REGION (ANTARCTICA)*. Tutor: Carlo Baroni. Co-tutors: Prof. Christian Schlüchter e Dr. Naki Akçar, University of Bern (CH)
3. **Stefan Strasky**, PhD thesis No. 17569, ETH Zurich (2007), *GLACIAL RESPONSE TO GLOBAL CLIMATE CHANGES: COSMOGENIC NUCLIDE CHRONOLOGIES FROM HIGH AND LOW LATITUDES*. Tutors: Rainer Wieler, Christian Schlüchter, Carlo Baroni.
4. **Sandra Lorenzini**, XXI Ciclo, Scuola di dottorato in Scienze della Terra, Università di Pisa (2006-2008), *COLONIE RELITTE DI PINGUINI E SUOLI ORNITOGENICI PER LA RICOSTRUZIONE DELLA STORIA GLACIALE RECENTE E DELL'EVOLUZIONE CLIMATICO-AMBIENTALE OLOCENICA DELLA TERRA VITTORIA (ANTARTIDE)*. Tutor: Carlo Baroni

Research units

Research unit 1. PI: Carlo Baroni; Dipartimento di Scienze della Terra, Università di Pisa

Research task: glacial geomorphology and geology; geomorphological mapping; micromorphology of glacial deposits; SEM, rock varnish.

Carlo Baroni
Alberto Carton
Mauro Cremaschi
Adriano Ribolini
Giovanna Giorgetti
Luca Trombino
Dimitri Bastoncelli
Francesco Fasano
Roberto Seppi
Valerio Noti
Luigia di Nicola,
Sandra Lorenzini

Research unit 2. PI: Maria Cristina Salvatore; Dipartimento di Scienze della Terra, Università di Roma "Sapienza"

Research task: photogeological analysis; geomorphological survey; thematic maps; quantitative geomorphic analysis;

Maria Cristina Salvatore
Alessandro Biasini
Sirio Ciccacci
Michele Saroli

Research unit 3. PI: Mirco Meneghel; Dipartimento di Geografia "G. Morandini", Università di Padova

Research task: geomorphological survey and mapping

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Mirco Meneghel
Aldino Bondesan
Nicola Surian
Alberto Carton (at Padova since 2007)

Date: 25 Sept. 2009
