

Final project report

<i>Project ID</i>	2006/4.01
<i>Title</i>	Climatic changes, paleoceanography of the Southern Ocean (Indian Ocean sector) and fluctuations of the EAIS in the middle Miocene, inferred from the analysis of the calcareous sediments of the Kerguelen Plateau, Antarctica
<i>Principal investigator</i>	Luca Maria Foresi
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<i>Duration</i>	2 years
<i>Assigned funding</i>	70.000,00 Euro

Activities and results

During this research project, we carried out micropaleontological analysis on planktonic foraminiferal assemblages and biogeochemical analysis ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ analysis and Mg/Ca ratio measurements). Statistical analysis on foraminiferal assemblages, spectral analysis on stable isotope data, clay mineral and tephra analysis complemented the acquired dataset.

Washed residues of 205 samples from the middle Miocene (14.8 -11.9 Ma) of ODP Site 747 were prepared according to standard methodologies. For micropaleontological study, about 300 planktonic foraminifers were determined and counted in the fraction $>125\ \mu\text{m}$. Principal component analysis and the R-mode cluster analysis were performed on the foraminiferal dataset to better understand the assemblage structure. For stable isotope analyses, between 3 and 10 *Globigerina praebulloides* specimens from the $>125\ \mu\text{m}$ size fraction were analysed at the isotope geochemistry laboratory of *Istituto per l'Ambiente Marino Costiero - Consiglio Nazionale delle Ricerche* (CNR) at Naples, Italy. Furthermore, selected specimens of *G. praebulloides* were analysed through Laser Ablation-Inductively Coupled Plasma Mass Spectrometry (LA-ICP MS) at *Istituto di Geoscienze e Georisorse – CNR, Pavia* (Italy) in order to determine the Mg/Ca ratio. Mg/Ca analysis were also performed on the same set of samples through Inductively Coupled Plasma – Optical Emission Spectrophotometry at GEOMAR Kiel (Germany). The results obtained at Pavia and Kiel highlighted the presence of contaminants. Field-Emission SEM images were acquired at the University of Granada (Spain) on fragments corresponding to the inner and outer part of the foraminiferal tests wall in order to study the ultramicroscopic texture. Subsequently, we performed Mg/Ca analysis through a third method (isotope dilution by ICP MS) on a suite of 13 samples at the *Universitat Autònoma de Barcelona* (Spain). These samples were split into four aliquots. One of them underwent the standard cleaning procedure (the same applied at Kiel), in order to test the interlaboratory reproducibility, while the other three underwent three different cleaning tests in the attempt to eliminate contamination.

At 13.8 Ma, a prominent faunal change, a positive 2.0‰ shift in $\delta^{18}\text{O}$ (Mi3 event) and a related positive 1.0‰ shift in $\delta^{13}\text{C}$ (CM6 event) witnessed a substantial reorganization of Southern Ocean waters, the northward migration of the Polar Front and a strong increase in primary productivity. Another change occurred at 12.9 Ma (gradual decrease in the abundance of polar fauna, positive 1.5‰ shift in $\delta^{18}\text{O}$ (Mi4 event) and a concurrent gradual negative shift in $\delta^{13}\text{C}$). Variations in sea surface temperature, considered as the main factor causing changes of surface hydrography at the Kerguelen Plateau, seem to have been driven by obliquity and long-term eccentricity, thus suggesting a key role played by the astronomical forcing on the evolution of Southern Ocean dynamics during the Middle Miocene.

Programma Nazionale di Ricerche in Antartide (PNRA)

Products

A – papers in scientific magazines

1. Verducci M. (2006): Middle Miocene planktonic foraminifera from the Kerguelen Plateau: biostratigraphic and biogeochemical study of the Middle Miocene Climatic Transition. Ph.D. in Polar Sciences – Cycle XIX.
2. Iaccarino S.M., Premoli Silva I., Biolzi M., Foresi L.M., Lirer F., Turco E. & Petrizzo M.R. (2007). Practical manual of Neogene Planktonic Foraminifera. International School on Planktonic Foraminifera (6th course). 141 pp. Biolzi M. et al. (eds.), Perugia.
3. Riforgiato F., Verducci M. and Foresi L.M. (2007): I Foraminiferi: incredibile fonte di informazioni sul passato e sul presente del nostro pianeta. *Etruria Natura*, 4: 132-137.
4. Verducci M., Foresi L.M., Scott G.H., Tiepolo M., Sprovieri M. and Lirer F. (2007): East Antarctic Ice Sheet fluctuations during the Middle Miocene Climatic Transition inferred from faunal and biogeochemical data on planktonic foraminifera (ODP Hole 747A, Kerguelen Plateau). In *Antarctica: A Keystone in a Changing World – Online Proceedings of the 10th ISAES*, edited by A. K. Cooper and C. R. Raymond et al., USGS Open-File Report 2007-1047, Short Research Paper 037, 5 p.; doi:10.3133/of2007-1047.srp037.
5. Verducci M., Foresi L.M., Scott G.H., Sprovieri M., Lirer F. and Pelosi N. (2009): The Middle Miocene climatic transition in the Southern Ocean: Evidence of paleoclimatic and hydrographic changes at Kerguelen Plateau from planktonic foraminifers and stable isotopes. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 280 (2009): 371-386, doi:10.1016/j.palaeo.2009.06.024.
6. Verducci et al. (in progress) - Effects of diagenesis on fossil planktonic foraminifers and its detection through laser ablation and solution analysis: implication for Mg/Ca-based temperature reconstructions.

B – book chapters

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C - proceedings of international conferences

1. Sprovieri M., Verducci M. and Lirer F. (2008): Planktonic/benthonic foraminifer stable isotope/trace element characterization: preliminary results. ANDRILL Southern McMurdo Sound Project Core Sampling Workshop, Florida State University, Tallahassee, Florida, USA.

D – proceedings of national meetings and conferences

1. Verducci M., Foresi L.M. and Tiepolo M. (2005): Climatic changes and East Antarctic Ice Sheet fluctuations during the Middle Miocene (15-13 Ma), inferred from the analysis of the planktonic foraminiferal faunas of the Kerguelen Plateau, Southern Ocean (southern sector of the Indian Ocean). *Geoitalia 2005* (Spoleto, 21-23 settembre 2005). *Epitome*: 18.
2. Verducci M. (2007): Micropaleontological and biogeochemical proxies for paleoclimatic and paleoceanographic reconstructions: the Middle Miocene Climatic Transition in the Southern Ocean (ODP Hole 747A – Kerguelen Plateau). *Geosed 2007* (Siena, 24-28 settembre 2007). *Atti del Convegno Geosed 2007*: 82-85.
3. Museo Nazionale dell'Antartide – sezioni di Genova, Siena e Trieste (2008): Paleontologia ed il Museo Nazionale dell'Antartide: vita ed ambienti estremi in un percorso ipertestuale. *Giornate di Paleontologia, VIII Edizione* (Siena, 9-13 settembre 2008), 110.
4. Verducci M., Scott G.H. and Foresi L.M. (2008): *Neogloboquadrina nympha* (Jenkins): preliminary results of a morphometric study. *Giornate di Paleontologia, VIII Edizione* (Siena, 9-13 settembre 2008): 43-44.

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

1. 2010 - The climate history and ice caps: an archive in a shell. In "icebreaker ship on the horizon. Europe and the scientific and technical challenge of the future. Aurora Borealis a new and modern oceanographic ship to discover the secrets of polar oceans and to understand the effects of climate change on our planet - "Galata Museo del Mare - Genoa, Friday 5 November 2010
2. 2008 - National Antarctic Museum - sections of Siena and Genoa and Trieste (2008): Paleontology and the National Museum of Antarctica: extreme life and environments in an hypertextual path. *Giornate di Paleontologia, VIII Edizione* (Siena, 9-13 settembre 2008), 110.
3. 2007 - Participating in the 10th International Symposium on Antarctic Earth Sciences – X ISAES", Santa Barbara, California, USA, 26-31 August 2007
4. 2007 - Inauguration of the Siena Section of the National Antarctic Museum - May 11, 2007. It has been prepared a temporary educational laboratory with 1) the possibility of observing Antarctic samples under the

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- stereomicroscope 2) an outline of the geochemical research in paleoclimatic reconstructions
- 2005 – Participating in the International Workshop on “Cenozoic onshore and offshore stratigraphic record from the East Antarctic margin: recent results and future directions”, Geoitalia 2005- Spoleto, 18-20 September 2005

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

- Fellowship, National Museum of Antarctica (Siena, Italy). Research project on “Bottom water formation during the Miocene in relation to the evolution of the Antarctic cryosphere, and implications on the paleoceanography of the Southern Ocean”. Supervisor: Prof. Carlo Alberto Ricci (Department of Earth Sciences, University of Siena). 2011
- Post-Doctoral Research (University Grant), Department of Earth Sciences, University of Siena, Italy. Research project on “Expansion and growth phases of the East Antarctic Ice Sheet during the Middle Miocene Climatic Transition and related paleoclimatic and paleoceanographic changes in the Southern Ocean”. Supervisor: Prof. Carlo Alberto Ricci (Department of Earth Sciences, University of Siena). 2009-2010
- Post-Doctoral Fellow, Department of Earth Sciences, University of Siena, Italy. Research project on “Development and use of micropaleontological and biogeochemical methods based on planktonic foraminifera for the analysis of the paleoceanographic and paleoclimatic changes that occurred in the Southern Ocean during the Middle Miocene, with estimates on the Antarctic cryosphere evolution”. Supervisor: Dr. Luca M. Foresi (Department of Earth Sciences, University of Siena). 2007-2008
- Ph.D. in Polar Sciences (Department of Earth Sciences and National Museum of Antarctica, University of Siena, Italy). Thesis title: “Middle Miocene planktonic foraminifera from the Kerguelen Plateau: biostratigraphic and biogeochemical study of the Middle Miocene Climatic Transition”. Advisors: Dr. Luca M. Foresi (Department of Earth Sciences, University of Siena), Dr. George H. Scott (GNS Science, Lower Hutt, New Zealand). 2003-2006.

Research units

Dipartimento di Scienze della Terra – Università di Siena

Luca Maria Foresi	Ricercatore	Dip. Sc. Terra - Univ. Siena
Marina Verducci	Dottoranda di Ricerca	M. N. Antartide - Univ. Siena
Francesca Donia	Dottoranda di Ricerca	Dip. Sc. Terra - Univ. Siena
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Damiano Damiani	Borsista	M. N. Antartide - Univ. Siena

Istituto per l’Ambiente Marino Costiero - CNR Napoli

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Mario Sprovieri	Ricercatore	IAMC - CNR Napoli
Nicola Pelosi	Ricercatore	IAMC - CNR Napoli
Michele Iavarone	Tecnico di laboratorio	IAMC - CNR Napoli

Istituto di Geoscienze e Georisorse CNR Pavia

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Nicola Raffone	Borsista post-dottorato	Dip. Sc. Terra-Univ. Pavia
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Date:

3/02/2012

Notes