

## **Final Project Report**

*Project ID:* 2004/4.08  
*Title:* Bottom water production in the Ross Sea during the Late Quaternary: a geochemical and micropaleontological study

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*Duration:* 3 years  
*Assigned funding:* Euro 30,000

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### **Activities and results**

#### *Project goals*

1. to recover a biological proxy for Antarctic bottom water formation (relationship between modern foraminifera assemblages and bottom water properties);
2. to obtain information on the variability of bottom water production during the last interglacial cycle (MIS1-5), on the ventilation of bottom water and, indirectly, on sea ice cover variability by integrating data on modern assemblages with sediment geochemistry (bulk mineralogy, TOC, biogenic silica, C stable isotopes).

#### *Materials*

The material necessary for the project (box-cores and cores) was collected during the XX Antarctic Italian Cruise (01/15/2005-02/27/2005). To satisfy the first goal of the project, 10 box-cores were collected from surface sediment in the Drygalski Basin, in correspondence of the Terra Nova Polynya (site of High Salinity Shelf Water formation), and on the western continental shelf and the adjacent slope, along the pathway of bottom water spreading. Each box core was sub-sampled just after the collection to get four short cores for micropaleontological, geochemical and X-ray investigations. CTD profiles were obtained in six sites. For the second goal of the project, four gravity cores were collected on the slope off Cape Adare. The sampling sites were selected on the basis of high resolution seismic profiles produced by a 3.5 kHz Sub-Bottom Profiler. The cores were frozen at -20°C to ensure the preservation of sediments for micropaleontological investigation.

#### *Methods*

Magnetic susceptibility: each core and selected box-cores were scanned by means of a Bartington ring sensor for whole-core magnetic susceptibility.

Dry density: it has been calculated on the basis of the water content for 209 samples

Micropaleontology: To distinguish living and dead foraminifera, the sediment was treated with CellTracker<sup>®</sup> Green CMFDA just after collection following the method suggested by Bernhard et al. (2006), instead of using only Rose Bengal treatment as formerly planned in the project. Quantitative vertical distribution of CTG reactive foraminifera within the sediment has been investigated. Also quantitative analysis of RB biocenosis along with thanatocenosis has been also performed. Samples were never dried and split into aliquots with a wet-splitter for the counting of all the samples (box-cores, short cores and long cores): 179 samples (63 from box cores, 19 from short cores, 97 from long core) were analyzed.

IRD content: it has been determined counting at light microscope all the grains excluding the ones of biologic origin. The counting has been performed on three fractions of 107 samples: >2mm, between 1 and 2mm, and between 0.5 and 1mm.

TOC,  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ : TOC and Nitrogen contents were obtained for 188 samples using a FISONs NA2000 Element Analyzer after removal of the carbonate fraction. Stable isotope analyses were carried out on the same samples using a FINNIGAN Delta Plus mass spectrometer directly coupled to the Elemental Analyzer by means of a CONFLO interface for continuous flow measurements.

$^{210}\text{Pb}$  analysis: performed using alpha-spectrometry for chronology purposes

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<sup>14</sup>C AMS analysis: 24 samples were sent to National Ocean Sciences AMS Facility (Woods Hole Oceanographic Institution, USA) for analysis on bulk organic fraction

Biogenic silica: it was determined following the progressive dissolution method of DeMaster (1979, 1981) and the colorimetric analysis of Strickland and Parsons (1972) on 41 samples.

Total rock analysis: the semi-quantitative estimation of crystalline phases in the bulk rock was performed on 229 samples using an X-ray Philips diffractometer, based on the area measurements (Barahona, 1974); the bulk rock was grounded by hand in agate mortar and pressed with a frozen glass into an aluminium holder.

Grain size: the analysis was carried out on 60 samples using a Malvern MasterSizerE laser particle sizer, which identifies grain-size intervals from 0.1 to 1000 µm. Results are presented in fraction percentage of few granulometrical classes in accordance to Udden-Wentworth granulometrical scale.

### Results

#### Surface samples

CTD parameters indicate that during the sampling High Salinity Shelf Water was present on the shelf and modified Circumpolar Deep Water on the slope, along which no energetic gravity currents were observed.

The surface CTG benthic foraminifera assemblage is generally poor and shows strong dominance of calcareous taxa, such as *Nonionella* spp, in the Terra Nova Bay area probably in response to the high productivity of the polynya area, accompanied by agglutinated taxa such as *Reophax* spp, *Recurvoides contortus*, and *Trochammina* spp. On the slope, the living assemblage, always poor, is dominated by agglutinated taxa. In general, but not always, RB counting confirms the qualitative, but not the quantitative, composition of the assemblage, confirming the overestimation of living specimens treated with RB. The thanatocenosis assemblage revealed the presence of *Trochammina multiloculata* in all the stations, in particular in the slope sites. As this species is not present in the living assemblage, it is interpreted as a species proliferating during a season different from the one of the sampling time. Moreover, considering the strong dominance of this species in the record of the studied long core, it is to be hoped a deeper investigation of this intriguing problem in the future. At last, the vertical distribution into the sediment of CTG reactive foraminifers suggested a shallow infaunal microhabitat for *Nonionella* spp, an intermediate (shelf sites) to shallow (slope sites) infaunal position for *Reophax* spp, probably in response to lower oxygen content in the slope bottom water.

#### Core

Although the second goal of the project was to obtain information on the variability of bottom water production during the last interglacial cycle, it has been decided to shorten the time interval to be investigated to MIS2 and 1, because of the relatively high expansion of the Holocene in core AS05-10 selected for the paleoceanographic reconstruction. Therefore, it has been considered worthy to focus the study on this time interval, but with the highest resolution achievable, that is analyzing each centimetre of the uppermost 200 cm of the core by integrating data on foraminifera assemblages with sediment geochemistry (bulk mineralogy, Total Organic Carbon, biogenic silica, C and N stable isotopes) and IRD. This choice has been also suggested by the possibility to get results comparable with the very high resolution studies recently published in literature for the area (see for instance Crosta et al., 2007, Denis et al., 2008).

The chronology is based on the best fitting of twelve control points selected among twenty-two <sup>14</sup>C AMS datings performed on the bulk organic carbon and <sup>210</sup>Pb excess data. The trend of the parameters allows the following observations:

- 1) two main intervals (15-10 and 7.5-6 cal kyr BP) mark a subsequent enhanced nutrient supply, interpreted as a higher efficiency in the Upper CDW upwelling;
- 2) within this general context, an oscillatory trend is present from 15 kyr BP to present time. The interpretation is still under debate and two hypotheses are proposed: a) minima in foraminifers concentrations reflect relatively stronger dissolution, weaker bottom currents (minima in dry density) and lower nutrient supply, b) alternatively, minima in foraminifers, corresponding to minima in %OC and to reversal of <sup>14</sup>C (relative increase of older carbon), reflect dilution in the sediment because of rapid accumulation of fine sediment re-suspended at the shelf edge by the cascading currents.

The comparison of the D/H ratio in ice-cores from the Ross Sea sector with the core AS05-10 record indicates that the foraminifers minima always correspond to colder condition. This scenario also correlates to the record reported in literature on the slope off Wilkes-Adelie Land.

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## Products

### A - papers in scientific magazines

1. Piva A., A. Asioli, L. Langone, D. Ridente, F. Tateo, F. Trincardi 2008. Cruise results and preliminary study of living benthic foraminifera assemblages in the western Ross Sea (XX Antarctic Expedition, 2004-2005). *Terra Antartica Reports*, 14, pp. 247-254.

### B - book chapters

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### C - proceedings of international conferences

*Extended abstracts and abstracts (reviewed)*

1. Asioli A., Langone L., Giannossi M.L., Summa V., Tateo F., Piva A., Ridente D. and Trincardi F. 2008. Bottom water production variability in the Ross Sea slope during the Late-Pleistocene-Holocene as revealed by benthic foraminifera and sediment geochemistry. Riassunto accettato per presentazione poster in: "Quaternary Climate: from Pole to Pole: EPICA Open Science Conference", Venezia, 10-13 November 2008.
2. Asioli, A., L. Langone, F. Tateo, M.L. Giannossi, F. Giglio, V. Summa, A. Piva, D. Ridente and F. Trincardi. 2009. Bottom water production variability in the Ross Sea slope during the Late-Pleistocene-Holocene as revealed by benthic foraminifera and sediment geochemistry. EGU General Assembly (Vienna, April 19-24, 2009) *Geophysical Research Abstracts*, Vol. 11, EGU2009-4017, 2009
3. Asioli A., Langone L., Tateo F., Giglio F., Ridente D., Summa V., Carraro A., Giannossi M. L., Piva A., Trincardi F. 2009. Bottom water production variability in the Ross Sea slope during the Late Pleistocene-Holocene as revealed by benthic foraminifera and sediment geochemistry. Abstract accettato per Geoitalia 2009, VII Forum Italiano di Scienze della terra, Rimini, 9-11 settembre 2009
4. Langone, L., A. Asioli, F. Tateo, F. Giglio, D. Ridente, V. Summa, A. Carraro, M.L. Giannossi, A. Piva, F. Trincardi 2010. Bottom water production variability in the Ross Sea slope during the Late Pleistocene-Holocene as revealed by benthic foraminifera and sediment Geochemistry. *Geophysical Research Abstracts*, Vol. 12, EGU2010-7848, EGU General Assembly 2010 (Vienna, 2-7 May 2010).

### D - proceedings of national meetings and conferences

1. Piva A., A. Asioli, L. Langone, D. Ridente, F. Tateo, F. Trincardi 2005. Cruise results and preliminary foraminifera results and cruise report of the PNRA project 4.8 "Bottom water production in the Ross Sea during the Late Quaternary: a geochemical and micropaleontological study". V Convegno Nazionale di Glaciologia Antartica, Milano, 19-21 October 2005.

### 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.)

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## Research Units

**Research Unit 1.** PI: Alessandra Asioli, Istituto Geoscienze e Georisorse, C.N.R.- Sede di Padova, Italy  
Research task: micropaleontology (foraminifers), IRD counting, total rock mineralogy, magnetic susceptibility, grain size

Alessandra Asioli  
Fabio Tateo  
Andrea Piva

## Programma Nazionale di Ricerche in Antartide (PNRA)

Lorenzo Franceschin  
Anna Carraro  
Vito Summa  
Maria Luigia Giannossi  
F. Tellini

**Research Unit 2.** PI: Leonardo Langone, Istituto di Scienze Marine del C.N.R. – Sede di Bologna, Italy  
Research task: CHN,  $^{13}\text{C}$ , and  $^{15}\text{N}$  analyses, sedimentology, seismic stratigraphy, magnetic susceptibility, biogenic silica

Leonardo Langone  
Domenico Ridente  
Fabio Trincardi  
Gabriella Rovatti  
Federico Giglio

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