Late Quaternary sediment record of six glacial/interglacial cycles off the Wilkes Land - Adelie Land Coast (East Antarctica): Preliminary geochemical results

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Summary The IMAGES-CADO (Coring Adélie Diatom Oozes) research cruise targeted in 2003 the Adelie Land Coast, which lays seaward of one of the largest, marine-based sectors of the East Antarctic Ice Sheet (Wilkes Basin). It is also a site of production of the Adelie Land Bottom Water, which ventilates the deep ocean and contributes to the global thermohaline circulation. MD03-2603, a ~32 m long piston core, was collected on a sediment mound on the continental rise, with the aim of investigating the late-Quaternary depositional environment in relation to the past ice-sheet and oceanographic conditions. Geochemical/compositional information has been compared to isotopic, biostratigraphic and paleomagnetic data, leading to the identification of six glacial/interglacial climatic cycles in the sediment. Preliminary data suggest that interglacial cycles are characterised by hemipelagic biogenic muds, deposited in sub-oxic environment. Glacial periods display instead a sequence of turbiditic and contouritic deposits, in which lateral focussing is predominant and the detrital fraction more abundant.

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Introduction

The Adèlie Land margin of East Antarctica (136°-140° E) is characterised by a series of canyons on the slope and rise, some of which appear to be connected directly to the shelf (Fig. 1). Geophysical and geological surveys of the slope and rise of the area to the west of the Adelie Land margin (the George Vth Land margin, 140°-146° E), have revealed that canyons were formed down the slope during the initial stages of glaciation, and develop as channel and levee systems further down on the rise. These systems have been related to the past action of gravity and contour currents during the ice sheet growth and expansion over the shelf (Escutia et al., 2000; De Santis et al., 2003, Donda et al., 2007). In more recent times (probably since the late Miocene, De Santis et al., 2003) the previous rugged morphology has been filled and partially buried by a shelf margin prograding wedge marking a reduction in erosive turbiditic events. A further decrease of turbiditic events has been locally recorded on the continental rise since MIS 10, whilst weaker down-slope and contour bottom current action continued (Caburlotto et al., 2006).

Some of the canyons connected to shelf edge sills of the George Vth Land margin (Fig. 1) are inferred to be swept by Adelie Land Bottom Water (ALBW) that is formed today on the shelf at about 140°-146° E (Gordon and Tchernia, 1972), spills out and flows downslope, until it joins the Antarctic Bottom Water that flows towards the west deeper than 3000 m (Rintoul, 1998; Bindoff et al., 2000). The dynamics of this water mass is one of the factors influencing global thermohaline circulation (Broeker, 1991).

On the basis of chemical composition and physical character of water masses measured along two north-south transects across the Wilkes Land margin, the "young" ALBW masses can be clearly distinguished from "older" Antarctic Bottom Water masses flowing along the isobaths, originated further to the east (Bindoff et al., 2000). Nevertheless, it is not known at present how much ALBW is produced from the Adelie Land coast and from the George Vth Land coast and what are the mechanisms of its mixing with the Ross Sea Bottom Water and the Antarctic Circumpolar Current.

Detailed geological and geophysical studies in the George Vth Land margin (Fig. 1) have discovered a current-related sediment drift in the deepest sector of the Mertz-Ninnis trough (The Metz Drift, Brancolini and Harris, 2000; Harris, 2001) that recorded a significant decrease in the ALBW erosion and deposition throughout the Holocene warmest time interval (3000-5000 years, Harris and Beaman, 2003, Presti et al., 2003). Preliminary studies on sediment cores and swath bathymetry in the George Vth Land rise have detected signs of bottom currents having flowed down slope and of their variations during Quaternary glacial and interglacial cycles (Busetti et al., 2003, Macrì et al., 2005, Caburlotto et al., 2006, see also De Santis et al., this volume). The discovery on the shelf of a laminated diatomaceous ooze deposit, in the Dumont D'Urville Basin on the shelf (Leventer et al., 2001; Michel, Crosta et al., 2003, Crosta et al., 2005), would suggest a generally low-energy environment in this sector of the shelf during the Holocene.

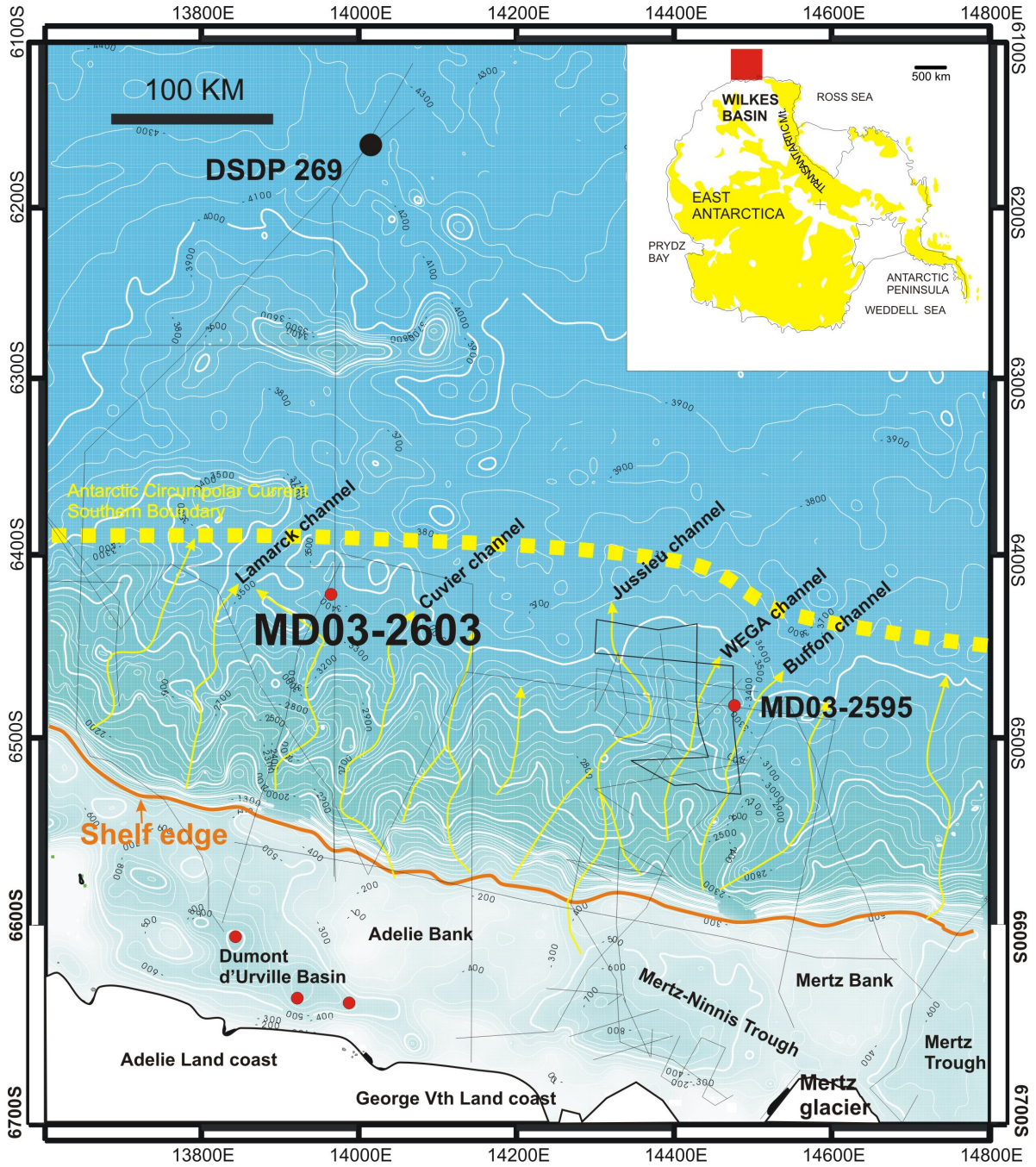

Figure 1. Bathymetry map (Mercator projection) of the Adelie and George Vth Land margins (From De Santis et al., 2003, modified). Red dots: location of MD03-2603 and of the other IMAGES-CADO 2003 cores. Thin black lines: location of some existing reflection seismic data. The Southern Boundary of the eastward flowing Antarctic Circumpolar Current (ACC) is also shown (from Bindoff et al., 2000). South of this boundary the current is westward flowing (Polar Current). The present Antarctic subglacial topography corrected for isostatic uplift is shown in the small insert on the upper right (from Denton et al., 1991), in which areas presently above sea level are shaded.

As for the adjacent George Vth Land sector, the slope and rise sediments may have recorded the flow of saline and dense waters that were produced in the deep inner shelf basins (Adelie Deep), spilled out over the shelf edge and flowed down slope before flowing westward (Bindoff et al., 2000). The study of the sediment record of the Adelie Land and George Vth Land margins is therefore crucial in understanding the contribution of Antarctic waters to the Southern Ocean circulation during past glacial and during interglacial periods warmer than present.

This work presents preliminary geochemical and diatom analyses of core MD03-2603, collected during the

IMAGES-CADO (Coring Adélie Diatom Oozes) research cruise on the continental rise of the Adelie Land margin (Michel, Crosta et al., 2003). These results are compared and integrated with those of other stratigraphic records from the area in order to provide new understanding about Quaternary environmental conditions.

Further coordinated multidisciplinary investigations of this margin are planned in the frame of the International Polar Year, and include multiannual oceanographic measurements of bottom currents and sedimentological and biological sampling to define the present and recent past environmental conditions and ecosystems.

Materials and methods

Core MD03-2603 is ~32 m long and was recovered in about 3200 m water depth on the continental margin off the Adelie Land during the MD130 Images-CADO cruise in 2003. Magnetic susceptibility and reflectance were measured on board immediately after core recovery, splitting and description. $\delta^{15}N$ and N_{org} content have been determined on 380 samples, 20 samples have been analysed for their ^{232}Th and ^{238}U contents, and 40 samples have been analysed for diatom biostratigraphy control at EPOC- University of Bordeaux I. Paleomagnetic data have been collected at the LSCE in Gif sur Yvette. Geochemical analyses (major and minor elements) have been performed on ~400 samples at the OGS in Trieste analysing the digested samples by ICP-AES at Chelab (chemical labs, Treviso).

Results

From visual description the core appears homogeneous in the upper 9 m, with sparse pebbles and traces of bioturbation. From ~9 to ~19 m depth there are sparse *laminae* and few erosive surfaces, whereas at depths from 19 m to the bottom of the core laminations and beddings are more common. The reflectance shows higher values in the top ~9 meters than in the section below (Fig. 2). High magnetic susceptibility values are often considered to represent abundant detrital fraction and an IRD (Ice-Rafted Debris) component. Higher magnetic susceptibility peaks occur deeper than 15 m down-core.

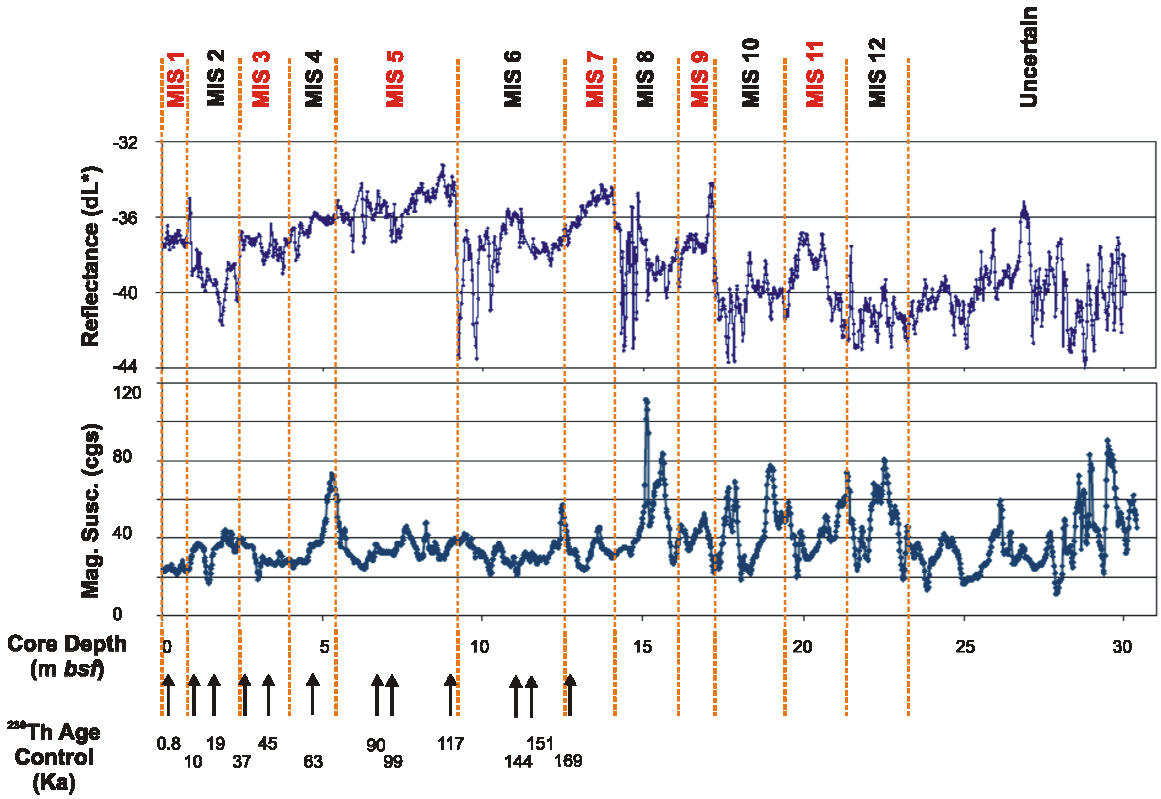

Figure 2. Down-core profile of Reflectance and Magnetic Susceptibility in core MD03-2603 in relation to ^{230}Th-excess age control (diatom biostratigraphy control not shown here). The core appears to record at least 6 glacial/interglacial cycles.

The average sedimentation rate based on ^{230}Th excess has been estimated as ~7.7 cm/kyr and is considered reliable up to MIS 6, that is down to 13 m depth (Fig. 2). The $\delta^{15}N$ content varies between 2.9‰ and ~6‰ down-core, with

higher average values in the upper 5 m (*data not reported here*). The N_{org} content varies between 0.05% at the core top to 0.02% at about 19 m (*data not shown*). The content and ratios of major and minor elements are very variable, with higher abundances of Al, Fe and Ti associated with laminated intervals and higher ratios of Mn and Cu, Ni, Zn (towards Al or Ti) towards the core top (*data not shown*).

A preliminary stratigraphy has been defined by using the ^{230}Th-excess, diatom biomarkers and the reflectance variations (Fig. 2). Identified diatoms (*data not shown here*) include specific biomarkers such as *Rouxia leventerae*, *Rouxia constricta* and *Hemidiscus karstenii* and support the Thorium stratigraphy. The reflectivity variation itself appears to match glacial and interglacial stages, together with the magnetic susceptibility. Several subunits in each glacial stages (younger than MIS 6) have been identified: dark, coarse-grained, detrital-rich sub-units lay above erosional surfaces and are followed by finer-grained, laminated sub-units, grading upward into less dark, biogenic-rich sub-units.

A characteristic of this margin is the continuous sediment supply during both glacial and interglacial periods. The magnetic susceptibility data show that glacial intervals are characterised by peaks in susceptibility which in some cases correspond to turbidites (e.g. in MIS 8, 10 and 12 intervals, Fig. 2). These are consistent with the beginning of a glacial stage, when the ice-sheet advance toward the shelf edge, and was likely accompanied by frequent episodes of slope instability and turbidity currents. Present day interglacial bottom turbidity is demonstrated by nepheloid layers (Eittreim et al., 1971).

In distal sites like the one of core MD03-2603 turbidites, probably interbedded with entrained hemipelagic biogenic material, were redeposited as sediment drift by contour currents, during the glacial and interglacial times. The MD03-2603 record represents therefore a good archive for investigating the dynamics of depositional processes related to both downslope and alongslope bottom currents. These contour currents are linked in this sector of the Antarctic margin to the flow and strength of the Antarctic Bottom Water mass and therefore their deposits are potentially a long-term record of AABW variations.

Since the role of lateral sediment focussing has to be clearly evaluated in order to better characterise the "primary productivity" information provided by $\delta^{15}N$ and N_{org}, a comparison with compositional elemental data (major and minor elements and their ratio to Al or Ti – linked to the detrital component) has proved to be very useful.

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