

# SCAR Prince of Asturias Fellow Barbara Delmonte - Final Report

## Final report on the activity developed by Barbara Delmonte in the framework of the Prince of Asturias Fellowship awarded from SCAR

Delmonte Barbara

University Milano-Bicocca, Piazza della Scienza, 1, 20126 Milano (Italy)

LGGE-CNRS, 54, Rue Moliere BP 96, 38402 St. Martin D'Hères Cedex (France)

barbara.delmonte@unimib.it

bdelmonte@nest.it

Nationality: Italian

Academic Degrees:

- Bachelor of Environmental Science - University of Milano - Date: 09-11-1998
- PhD in Polar Science- University of Siena (Italy), in co-agreement with University Joseph Fourier, Grenoble (France) 16-12-2003

### Institution where activities have been developed:

LGGE-CNRS - Laboratory of Glaciology and Geophysics of the Environment -National Scientific Research Center - 54, Rue Moliere BP 96, 38402 St. Martin D'Hères Cedex (France)

University Milano-Bicocca, DISAT - Dept. Environmental Sciences - Piazza della Scienza, 1, 20126 Milano (Italy)

**Supervisor:** Dr. Jean Robert Petit, Research Director at CNRS

Period at host institute: October 2004 to June 2004 (6 months)

### Description of the project

Under the Prince of Asturias Fellowship awarded by SCAR, Dr. Barbara Delmonte developed some innovative research aimed at understanding the atmospheric circulation changes occurred during the Late Quaternary in East Antarctica. In particular, she used the mineral dust windblown long-range from the Southern Hemisphere continental regions to East Antarctica as indicator for atmospheric circulation changes and also as indicator for hydrological conditions at the sources (arid or wet periods).

The paleo-dust cycle from analysis of 4 deep East Antarctic ice cores drilled on the high Plateau in the following locations:

EPICA (European Project for Ice Coring in Antarctica)-Dome C site [75° 06' S, 123° 24' E]

Vostok station [78° S, 106° E]

Dome B [77° 05' S, 94° 55' E]

Komsomolskaya [74° 05' S, 97° 29' E]

The research was articulated along two principal branches. The first [A] is the characterization of the geographic provenance for mineral dust during the late Quaternary at all sites. The second [B] is the investigation of the timing and pattern of mineral dust variability, from which information on (1) continental aridity and (2) atmospheric circulation patterns were inferred. A third minor study developed under the fellowship [C] was the mineralogical characterization and geochemical dating of a bedrock inclusion from Lake Vostok accreted ice.

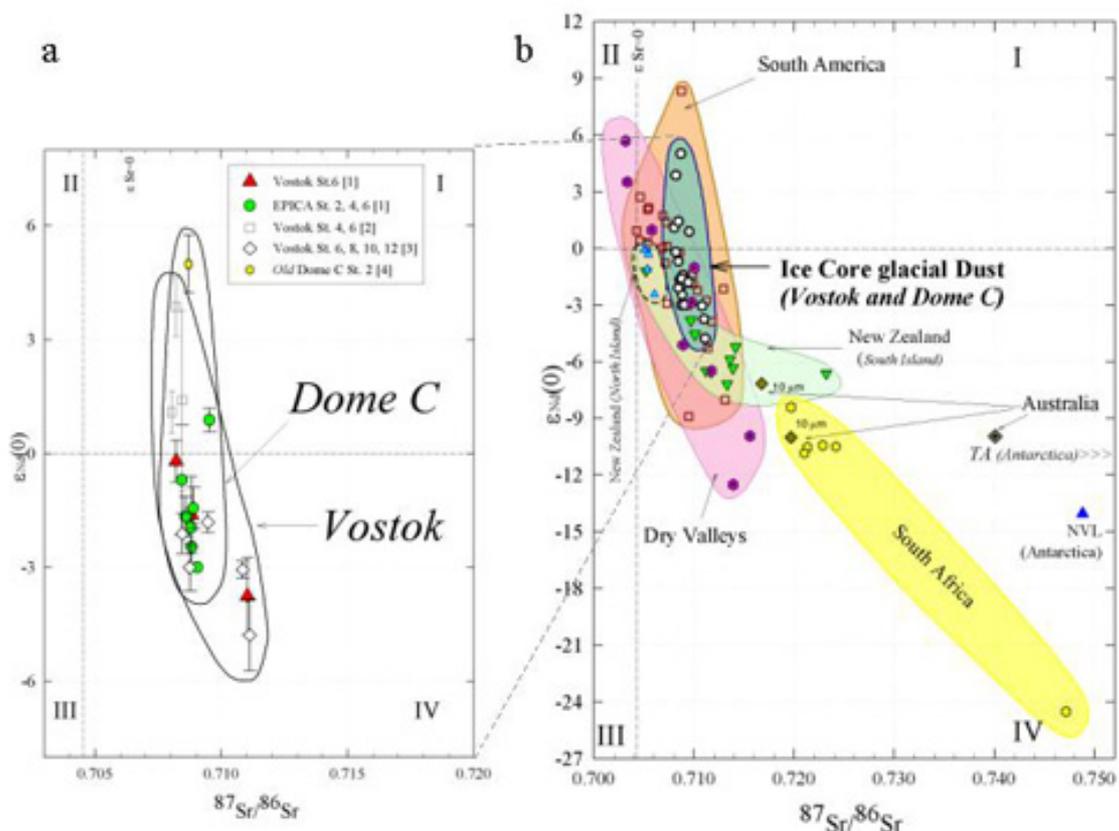
## A. Depicting the geographic provenance for Aeolian dust in Antarctica

### The work

B. Delmonte depicted the geographical origin of continental dust archived in the ice cores by analyzing the geochemical ( $^{87}\text{Sr}/^{86}\text{Sr}$  versus  $^{143}\text{Nd}/^{144}\text{Nd}$ ) fingerprint the small (less than  $5\mu\text{m}$  diameter) mineral grains transported long-distance by winds up to the high east Antarctic Plateau. She also measured the signature of mixed samples (loess, Aeolian deposits, ...) collected from the potential source areas (PSA) of the Southern Hemisphere, and selected within the equivalent size fraction ( $<5\mu\text{m}$ ), in order to compare them with ice core dust. The equipments used were two different Thermo-Ionization Mass Spectrometers having different sensitivity. This is particularly important because of the very low amount of sample available, which makes Nd isotopic measurements particularly difficult.

This part of the work was carried out in collaboration with Dr. I. Basile (CEREGE laboratory, Aix en Provence, France) and Dr. E. Jagoutz (Max-Planck-Institut, Mainz, Germany).

### The results



Results (reported in Delmonte *et al.*, 2004a) show an almost identical 'source fingerprint' for the 4 different ice cores analysed, suggesting a common provenance for dust to the East Antarctic sites investigated during Late Quaternary times. Southern South America was identified as the dominant dust source during cold glacial stages. On the other hand, the isotopic signature of warm interglacials points to a different source mixture, and an additional Australian contribution cannot be excluded. At this step, however, no definite conclusions on interglacials were drawn.

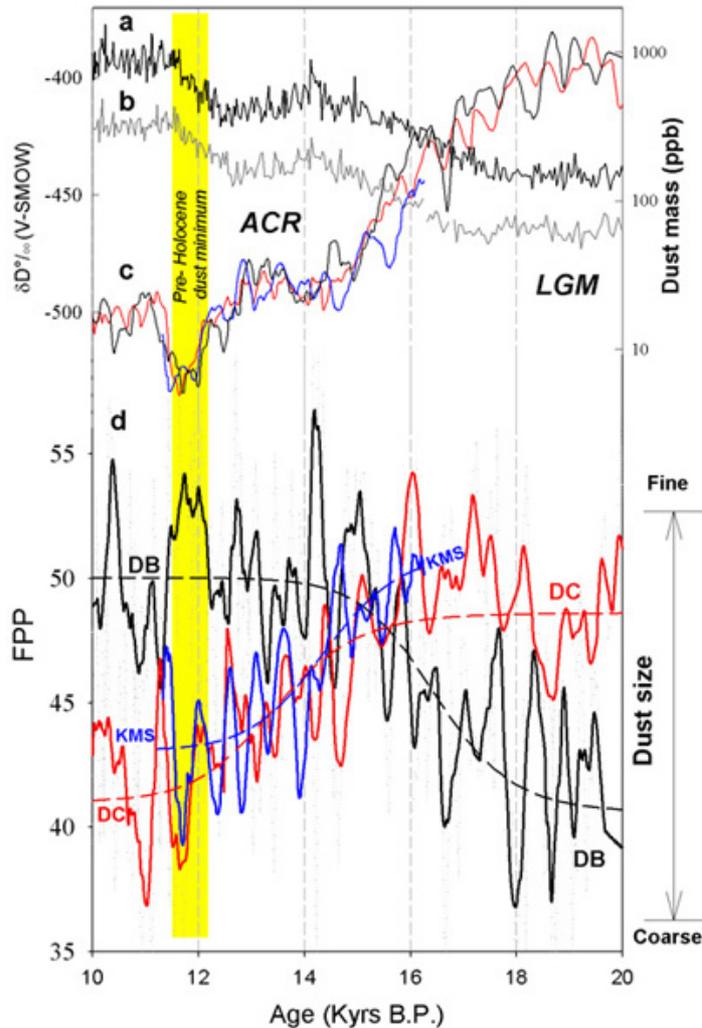
## B. Late Quaternary dust flux and transport variability in East Antarctica

The EPICA-Dome C ice core dust flux (concentration) and size records allowed Delmonte *et al.* (2002) to point out the different significance of these two paleoclimate indicators. While dust flux depends mostly on source conditions (mainly linked to the hydrological cycle), the dust size has proven to be dependent on atmospheric transport path. Interestingly, millennial and secular scale periodicities of atmospheric circulation around Antarctica were pointed out for the Holocene from EDC ice core (Delmonte *et al.*, 2002-a)

### The work

In the framework of the Fellowship, B. Delmonte investigated the timing of dust concentration and size variability at the 4 sites cited above (EPICA-Dome C, Vostok, Dome B and Komsomolskaia) at high temporal resolution by using Coulter Counter Multisizer II apparatus. This part of the work has been carried out at LGGE-CNRS (Grenoble, France).

### The results



The last glacial/interglacial transition highlighted an overall uniformity of pattern and timing of dust flux (and concentration) changes over the Plateau. Conversely, the dust size records unequivocally showed opposite regional changes of dust transport paths, and also a different timing of changes. During the Last Glacial Maximum, the dust transport time was longer to Dome C than to Dome B. As the geographic dust origin was the same, this suggested different dust trajectories and possibly a different altitude of transport. During the climatic transition (Termination I) a clear seesaw pattern was observed between the two sites and for the whole Holocene an opposite situation prevailed (longer dust transport time to Dome B with respect to Dome C). The authors suggested subsidence phenomena played an important role, and they interpreted the records as a progressive southward displacement of the Polar Vortex during glacial/interglacial transitions. This study (Delmonte *et al.*, 2004b) provide the first unequivocal evidence for a regional variability of dust transport patterns to the East Antarctic Plateau.

Finally, another study (Delmonte *et al.*, 2005), focused on the Holocene, allowed depicting a high-frequency (200-years) mode of climate and atmospheric variability in East Antarctica, and again an out-of-phase behaviour between Vostok and EPICA-Dome C ice core sites. In the line of Delmonte *et al.* (2004b) a possible high frequency mode of variability of the polar vortex was suggested for interpreting these regional dipolar mode of variability, which could be ultimately related to the behaviour of the Southern Ocean.

### C. First characterization and dating of a bedrock inclusion from subglacial Lake Vostok accreted ice.

Basement rock fragments from freezing of subglacial Lake Vostok water represent unique samples for the geological investigation of the East Antarctic continent, which is covered by 2-4 km of ice. The geochemical ( $^{87}\text{Sr}/^{86}\text{Sr}$  versus  $^{143}\text{Nd}/^{144}\text{Nd}$ ) and mineralogical characterization as well as dating (Nd model age) of a mm-size bedrock inclusion from Lake Vostok accreted ice has given evidence for a Mid-Proterozoic age of the basement lying below the ice sheet. The geochemical characteristics of the Antarctic basement also proved to be markedly different from Aeolian dust, thus allowing easy discrimination between the two contributions (Delmonte *et al.*, 2004c).

**Publications outcoming from the works developed under the fellowship:**

**Delmonte B.**, Basile-Doelsch I., Petit J.R., Maggi V., Revel M., Michard A., Jagoutz E., Grousset F. Comparing the Epica and Vostok dust records during the last 220,000 years: stratigraphical correlation and provenance in glacial periods, *Earth Science Reviews*, 66, 63-87, 2004a.

**Delmonte B.**, Petit J.R., Andersen K.K., Basile-Doelsch I., Maggi V. Lipenkov, V. Dust size evidence for opposite regional atmospheric circulation changes over East Antarctica during the last climatic transition, *Climate Dynamics*, 23: 427-438, 2004b. DOI: 10.1007/s00382-004-0450-9.

**Delmonte B.**, Petit J.R., Basile-Doelsch I., Lipenkov V., Maggi V. First characterization and dating of East Antarctic bedrock inclusions from subglacial Lake Vostok accreted ice, *Environmental Chemistry*, 1, 90-94, 2004c. DOI:10.1071/EN04029.

**Delmonte B.**, Petit J.R., Krinner G., Maggi V., Jouzel J. and Udisti R. Ice core evidence for secular variability and 200-year dipolar oscillations in atmospheric circulation over East Antarctica during the Holocene. *Climate Dynamics*, 2005, DOI 10.1007/s00382-005-0012-9.