

Final project report

<i>Project ID</i>	2004/6.09
<i>Title</i>	Marine and continental aerosol at Baia Terra Nova: chemical interactions, mixing and transport processes
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<i>Institution</i>	Dipartimento di Fisica "G. Galilei"; Università di Padova
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<i>Duration</i>	Two years (2004/2005)
<i>Assigned funding</i>	35.000,00 Euro

Activities and results

Premise: the results should be considered in the framework of a multiannual programme, in continuous development. They therefore include the analysis of samples collected in 2002/2003 campaign, as well as work performed until now (2009). Further work is needed and a distinct project was correspondingly proposed in year 2006.

(A) Activity in Antarctica.

Two aerosol sampling campaigns were performed during the Antarctic summer 2003/2004 and 2004/2005. Samplings were continuous, each one with 48h duration. One SDI 12 stage impactor modulus was used during the initial part of the first campaign whereas two twin modules were used in the remaining part of the campaigns. 49 samples and, respectively 32 samples were collected on nuclepore backings during the two campaigns; further 9 and respectively, 30 samples on Al backing. A large number of blanks (two per each sample in the last campaign) was used.

(B) Experimental activity in Italy.

The full set of 2002/2003, 2003/2004 and 2004/2005 was submitted to absolute PIXE multielemental analysis with our set-up at LNL during years 2006 to 2009. 1757 subsamples and blanks were measured and the corresponding areal densities (ng cm^{-2}) of 8-9 elements were obtained. Large delays in the measurements were determined by two X-ray detector break-downs.

Three 2002/2003 samples were also submitted to microPIXE analysis. The first four SDI stages were used, thus covering the 12. μm to 1.6 μm size region. Three Al samples were successfully analysed with LDI TOF MS mass spectrometry at University of California (Davis)

(C) Results.

C.1) Results of a "bulk" PIXE analysis of the size-segregated aerosol samples collected at Baia Terra Nova during the three Antarctic summer campaigns 2002/2003, 2003/2004, 2004/2005.

Several stages can be distinguished:

C.1.1) The areal densities (ng cm^{-2}) of 8-9 elements (including Na and Fe) in a total of 81 samples, and the corresponding blanks are now available.

C.1.2) The size distributions of the mass concentrations (ng m^{-3}) of the elements in the above samples are now available. This is a unique set of data on Antarctic coastal aerosol, and, to some extent, its interest is, in itself, independent of the subsequent analyses mentioned below.

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- C.1.3) A successful fit of the large majority of the above size distributions with lognormal functions was performed. One to three size modes are determined in each case.
- C.1.4) The following further manipulations of the data are now being performed: bidimensional plots displaying (for each sample) the interelemental correlations (e.g.: Si, Fe); subtraction of certain distributions (e.g.: ssS (sea-salt-Sulphur) from total S, to get the nssS (non-sea-salt_Sulphur), size distribution; manipulations on Cl distributions, etc.
- C.1.5) The overall results of the last two stages (C1, C2), allow the geochemical identification, in each sample, of three major aerosol components: "sea-salt", "crustal", and submicrometric "accumulation mode" of Sulphur, and the determination of their respective size modes. These results are relevant for the study of sea-air aerosol production processes; for the study of the internal mixing of sea-salt and crustal materials, and of the formation of S-containing particles.
- C.1.6) The previously mentioned nssS is determined, in the supermicrometric size range, by the interaction of gaseous S compounds with the sea-salt particles. The shape and intensity of its size distribution do appear strongly variable among the various samples, with respect to the much more stable behaviour of the S submicrometric mode. The comparison of these two modes allows to determine their relative importance in determining the fluxes of S-gaseous compounds out of the atmosphere. nssS size distribution also allows to determine, in principle, the localization (on particle surface or volume) of the above mentioned interactions. In an analogous way, the distribution of the quantity $\Delta Cl = Cl(Na) - Cl$ ("Chlorine Depletion", with $Cl(Na)$ being the undepleted Cl amount (as computed by Na and by the sea-salt Cl/Na ratio) allows a determination of the Cl flux towards the atmosphere and a knowledge of some properties of the relevant gas-particles interactions.

Conclusions.

The above described procedures (C.1.4 to C.1.6) were already applied to a majority of samples. They widely exceed the programme foreseen in the 2004/2005 research project and, due to the substantial success in both sampling campaigns and PIXE analysis, concern an impressive amount of data. For these reasons, we proposed to CSNA – in year 2006 – a distinct research project, aimed to cover, among other aspects these and other developments, being described below.

Prospects.

The above described data and results will allow (if conveniently supported):

- a study of the intra- and inter-seasonal time distributions of the main parameters characterizing, on one side, the dimensional modes of the various aerosol component; on the other, the parameters describing the chemical interactions involving S and Cl.
- an investigation of the possible relationship among the properties of the above data and the major environmental parameters (wind intensity and direction, temperature, ice sea coverage, etc.)

Furthermore:

- the present success of the PIXE analyses now allows to conveniently face other types of analyses for which a convenient number of samples is available and which should adequately integrate the PIXE data with further, partially complementary, data.

- C.2) Results concerning single aerosol particle, "SAP", analysis of size-segregated samples, in the supermicrometric range (12. μm to 1.6 μm).

Three, well representative, samples of the 2002/2003 campaign were microPIXE measured. 2800 particles, belonging to the first four stages (12 to 9) of the SDI impactor, were analysed and the absolute masses (fg) of up to 8 elements were determined. All particles containing crustal materials (~60% of the total) were found to contain also sea-salt materials.

An extensive use of Principal Component Analysis, PCA, allowed a satisfactory description of each particle's content by means of two components, both corresponding to an internal mixing of sea-salt and crustal materials.

A recent study aims at the enrichments in S of the individual particles, i.e. at their nssS content. Preliminary results display an increased presence of n.s.s.S in those particles containing not only sea-salt but also crustal materials. Further measurements are being carried out on other samples.

Products

A – papers in scientific magazines

1. F. Chiminello, P. Mittner, A. Trevisiol and D. Ceccato. **Three Major Components of Natural Aerosol and Their Interactions at an Antarctic Coastal Site.** *Proceedings of 16th ICNAA (International Conference on Nucleation and Atmospheric Aerosols), Kyoto, Kyoto University press, editors: Mikio Kashara, Markku Kulmala ISBN 4-87698-635-5, (2004) pp. 649-652*
2. D. Biancato, D. Ceccato, F. Chiminello, P. Mittner. **Micro-PIXE and Principal Component Analysis in a Study of Internal Mixing Phenomena in Antarctic Coastal Aerosol.** *Nucl. Instr. and Meth. in Physics Research Section B, Volume 249, Issue 1-2 SPEC. ISS., (2006) pp. 561-565*
3. P. Mittner, D. Biancato, D. Ceccato, F. Chiminello. Single particle study of Sulphur enrichment of Antarctic coastal supermicrometric aerosol. *Proceedings of 18th ICNAA. (International Conf. on Nucleation & Atmospheric Aerosol) Prague Czech Republic, August 10-14. (2009). To be published.*

B – book chapters

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C - proceedings of international conferences

1. F. Chiminello, P. Mittner, A. Trevisiol, D. Ceccato, **Size Distribution, Geochemical Components and Interactions of Aerosol in an Antarctic Coastal Site.** *Proceedings of EAC 2004 Conference (European Aerosol Conference 2004), September 6-10, Budapest Hungary, Journal of Aerosol Science. p. s589-s590*
2. P. Mittner, F. Chiminello, D. Ceccato, A. Trevisiol, **Use of elemental mass size distributions and of principal component analysis in the study of Antarctic aerosol.** *PIXE 2004 Conference (10th International Conference on Particle-induced X-ray Emission and its Analytical Applications), Portorose, Slovenia.*
3. D. Ceccato, F. Chiminello, P. Mittner, D. Biancato, **Single Particle Elemental Analysis of Aerosol Collected in an Antarctic Coastal Site** *ECAART-8 (8th European Conference on Accelerators in Applied Research and Technology), September 20-24, 2004, Paris, France. p. 102*
4. D. Biancato, D. Ceccato, F. Chiminello, P. Mittner, **Aerosol Internal Mixing Phenomena At An Antarctic Coastal Site.** *Proceedings of IAMAS 2005 Conference, (International Association of Meteorology and Atmospheric Sciences), August 2-11, 2005, Beijing, China, p. F-3*
5. P. Mittner, D. Ceccato, F. Chiminello, V. Trovo, **Size Distributions Of The Elemental Volume Concentration Of Some Major Coastal Antarctic Aerosol Components: Preliminary Results.** *Proceedings of IAMAS 2005 Conference, (International Association of Meteorology and Atmospheric Sciences), August 2-11, 2005, Beijing, China, p. F-4*
6. P. Mittner, D. Ceccato, F. Chiminello, A. Trevisiol, **Three Major Components of Natural Aerosol and their Interaction at Baia Terra Nova (Antarctica): (I) Time-Averaged Properties in the 1999/2000 Austral Summer, Preliminary Results.** *IBA 2005 (Ion Beam Analysis Conference), June 26- July 1, 2005, Seville, Spain. P-Thu-053*
7. P. Mittner, D. Ceccato, F. Chiminello, V. Trovo, **Three Major Components of Natural Aerosol and their Interaction at Baia Terra Nova (Antarctica): (II) Time Variability in the 2002/2003 Austral Summer, Preliminary Results.** *IBA 2005 (Ion Beam Analysis Conference), June 26- July 1, 2005, Seville, Spain. P-Thu-051*
8. D. Biancato, D. Ceccato, F. Chiminello, P. Mittner, **Internal Mixing of Crustal and Sea-Salt Aerosol Components in an Antarctic Coastal Site: a Micro-PIXE Analysis of Size Segregated Aerosol Samples.** *Proceedings of EAC 2005. (European Aerosol Conference) August 28 – 2 September 2005, Ghent Belgium, Editor: Willy Maenhaut, ISBN 9080915939, p. 646*
9. P. Mittner, D. Ceccato, F. Chiminello, V. Trovo, **Aerosol Elemental Mass Size Distributions at Baia Terra Nova (Antarctica): Individual Representations and their Variability.** *Proceedings of EAC 2007. (European Aerosol Conference), 9-14 Settembre 2007, Salzburg, Austria*
10. P. Mittner, D. Ceccato, V. Trovo, F. Chiminello, **Aerosol Elemental Mass Size Distributions at Baia Terra Nova (Antarctica): Properties and Interactions of Three Major Components of Natural Aerosol.** *Proceedings of IAMAS Conference (International Association of Meteorology and Atmospheric Sciences). Perugia, 2-13 luglio 2007*
11. P. Mittner, D. Biancato, D. Ceccato, F. Chiminello. **Possible role of internally mixed crustal materials in the enrichments in sulphur of supermicrometric Antarctic coastal aerosol particles.** *Proceedings of EAC 2009. (European Aerosol Conference) Karlsruhe, Germany. September 6-11*

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. Assegno di ricerca dott. Francesco Chiminello
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Research units

Unità operativa di Padova

Paolo Mittner, prof. Ordinario f.r. (2004-2006)

Daniele Ceccato, Tecnico Univ. Cat. D (ex. Funzionario Tecnico) (2004-2005)

Francesco Chiminello dr. ricerca. Assegno di Ricerca (2004)

Stefania Gilardoni. Dottoranda. Università di California Davis (2004-2005)

Arianna Trevisiol. Laureanda corso di laurea in Fisica. (2004)

Daniele Biancato. Laureando corso di laurea in Fisica. (2004-2007)

Vito Trovò. Laureando corso di laurea in Fisica (2005-2007)

Date: 25/06/2009

Notes