



Trace element analysis of size classified aerosol particles

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Introduction

Sampling with the cascade impactor

Measurements by SEM – EDXA

Measurements by ETV-ICP-MS

Catalyst borne elements in Berlin air

Air borne elements over the Atlantic Ocean

Conclusion



Atmospheric particles

Natural sources:

volcanism

mineral dust

biomass burning

sea spray

Composition: Na, Mg, K, Sr, Si, Al, Ca, Fe, Ti, S, Mn, Ba...

Anthropogenic sources:

power plant

waste incineration

industrial processes

transportation

Composition: Be, Cd, Hg, Mo, Ni, Sb, Se, As, Sn, V, Cr, Cu, C, Pb, Pt...



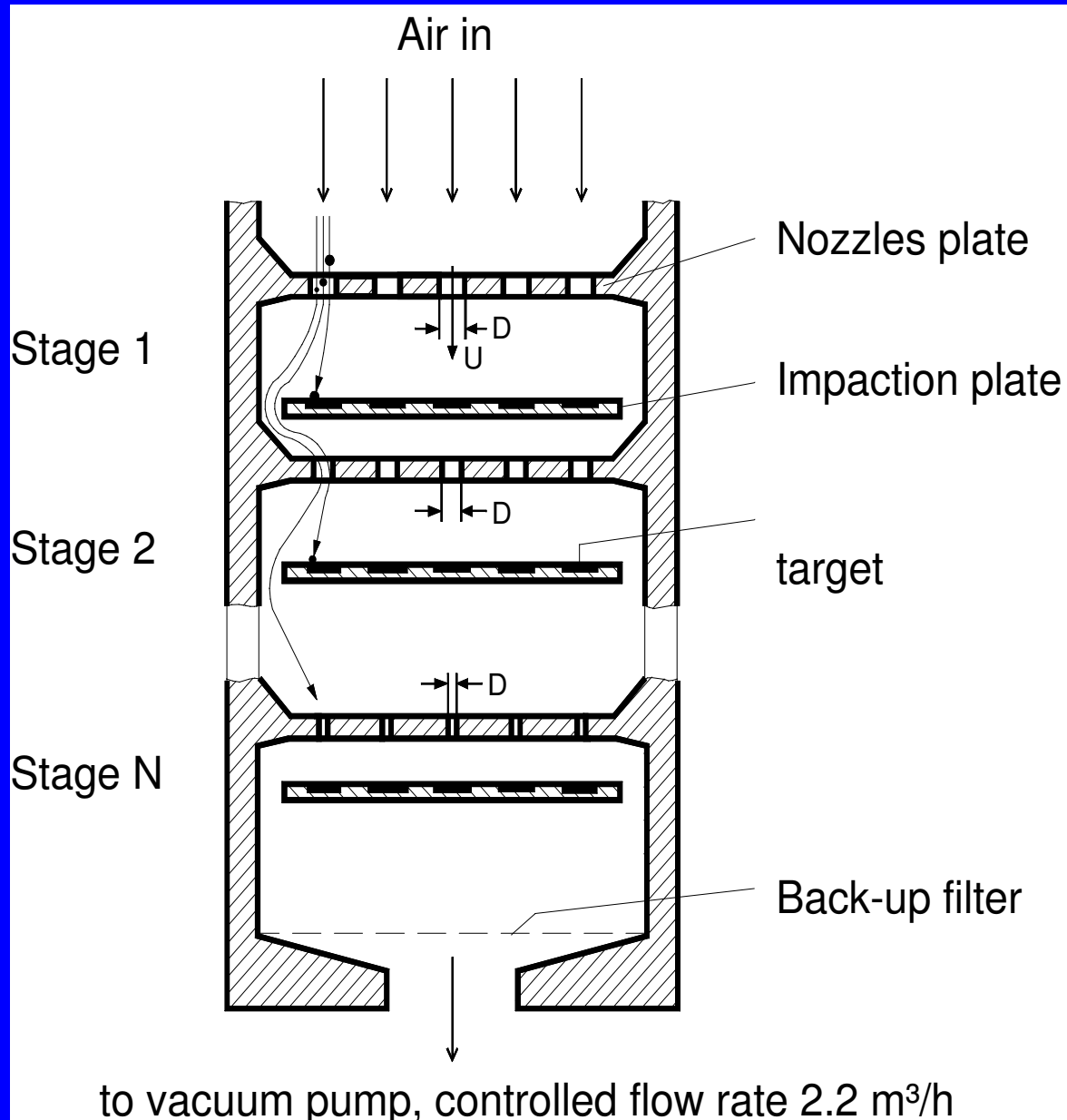
Atmospheric particles

The composition of aerosol particles is determined by the course of chemical and physical reactions occurring in particle generation and transportation.

Required monitoring: Relevant sources, Deposition,
Atmospheric monitoring
Effect on man and environment,

Measurable property: Chemical composition, Shape
Number of particles,
Size distribution

Cascade Impactor



$$d_{ae} = \sqrt{\frac{D}{U}} \times \sqrt{\frac{9 \eta St}{C \rho}}$$

d_{ae} : $16.5 \mu\text{m} \dots 0.35 \mu\text{m}$

aerodynamic diameter

D : $2.7 \text{ mm} \dots 0.35 \text{ mm}$

diameter of the orifice

U : $48.0 \text{ cm/s} \dots 7057 \text{ cm/s}$

lineare gas velocity

η : gas viscosity

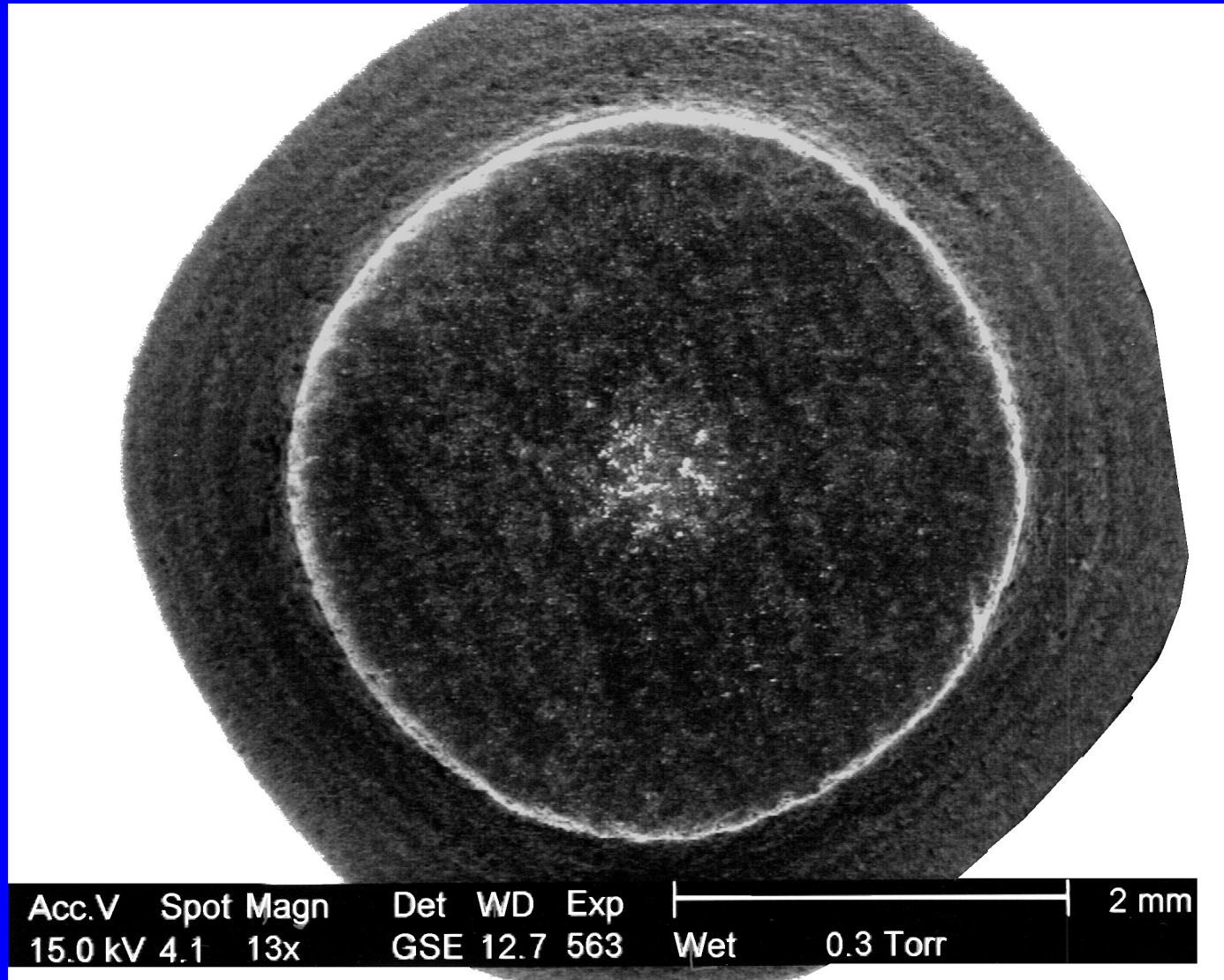
St : Stokes number

C : Cunningham factor

ρ : particle density

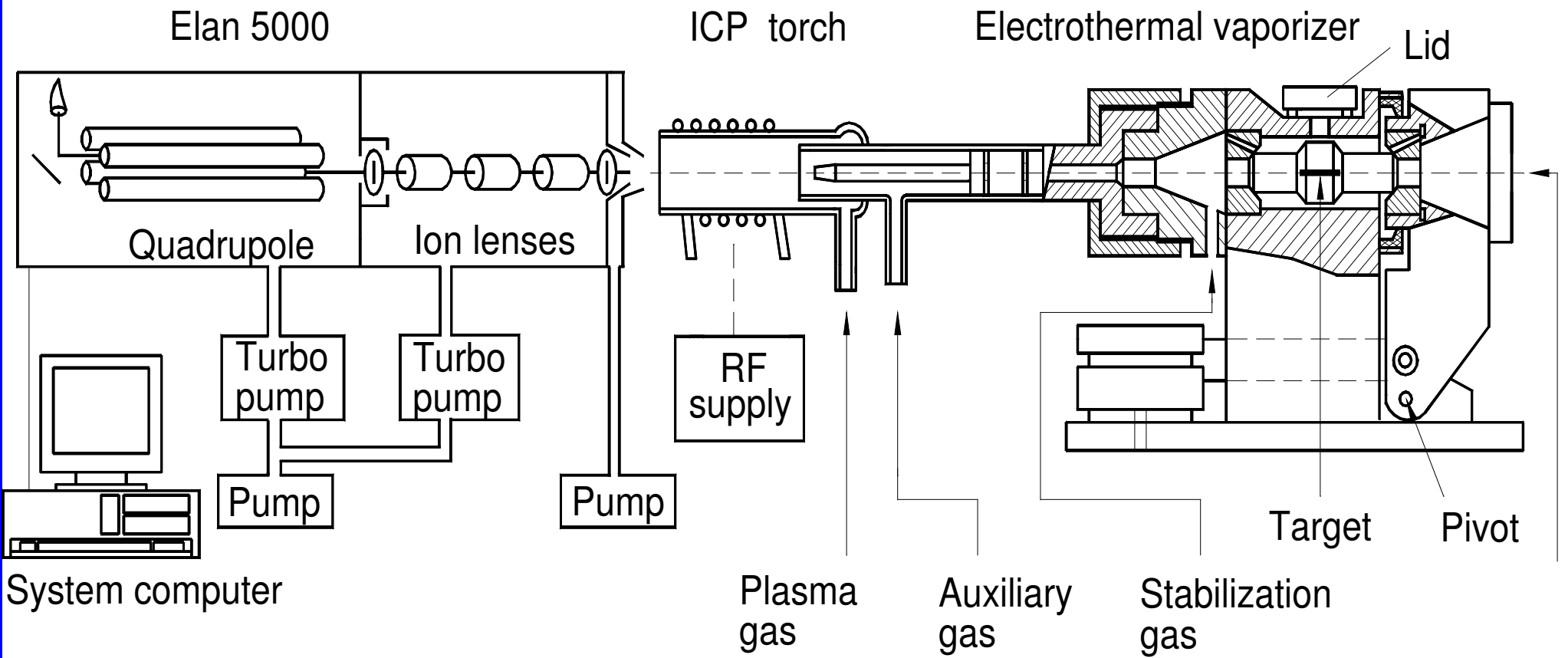
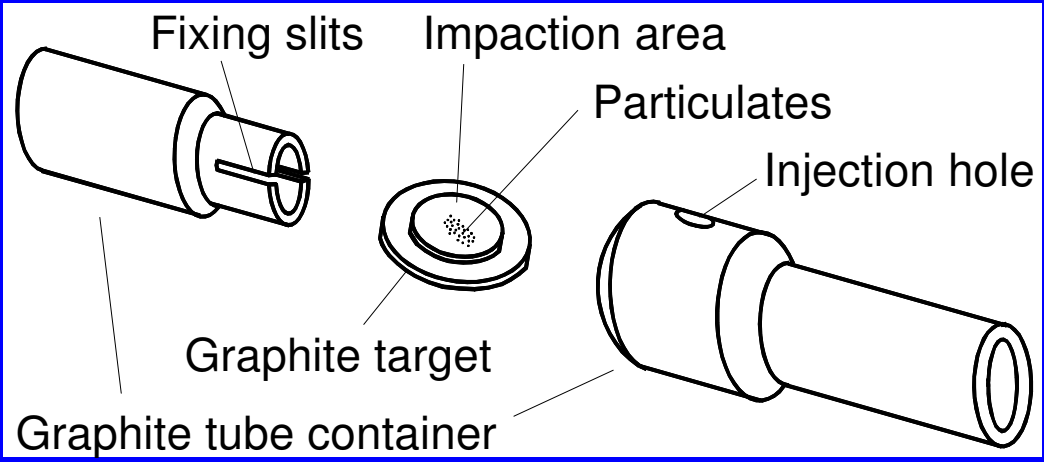


SEM picture of a graphite target with impacted particulates





Experimental set-up for ETV-ICP-MS





Limits of detection, based on the 3σ criteria

Measured isotope	^{55}Mn	^{59}Co	^{105}Pd	^{107}Ag	^{111}Cd	^{118}Sn
LOD pg/m^3	1	0.8	0.2	0.03	0.2	0.5
Measured isotope	^{121}Sb	^{130}Rh	^{140}Ce	^{195}Pt	^{205}Tl	^{208}Pb
LOD pg/m^3	1	0.1	3	0.6	0.05	0.2



Sampling conditions:

Location:

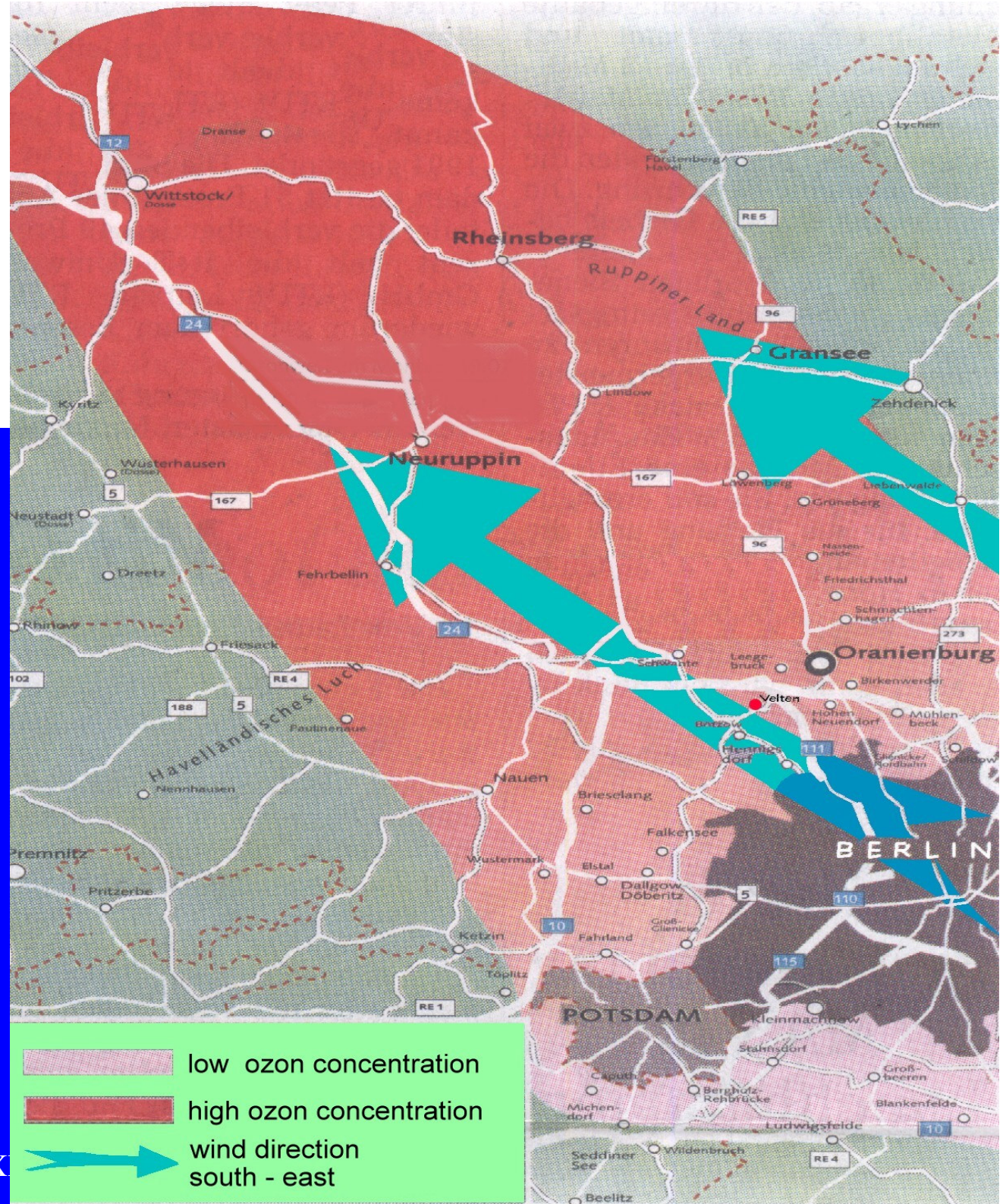
40 km north-west of
town centre,

4 m above ground;

Time: 76 h;

Volume:

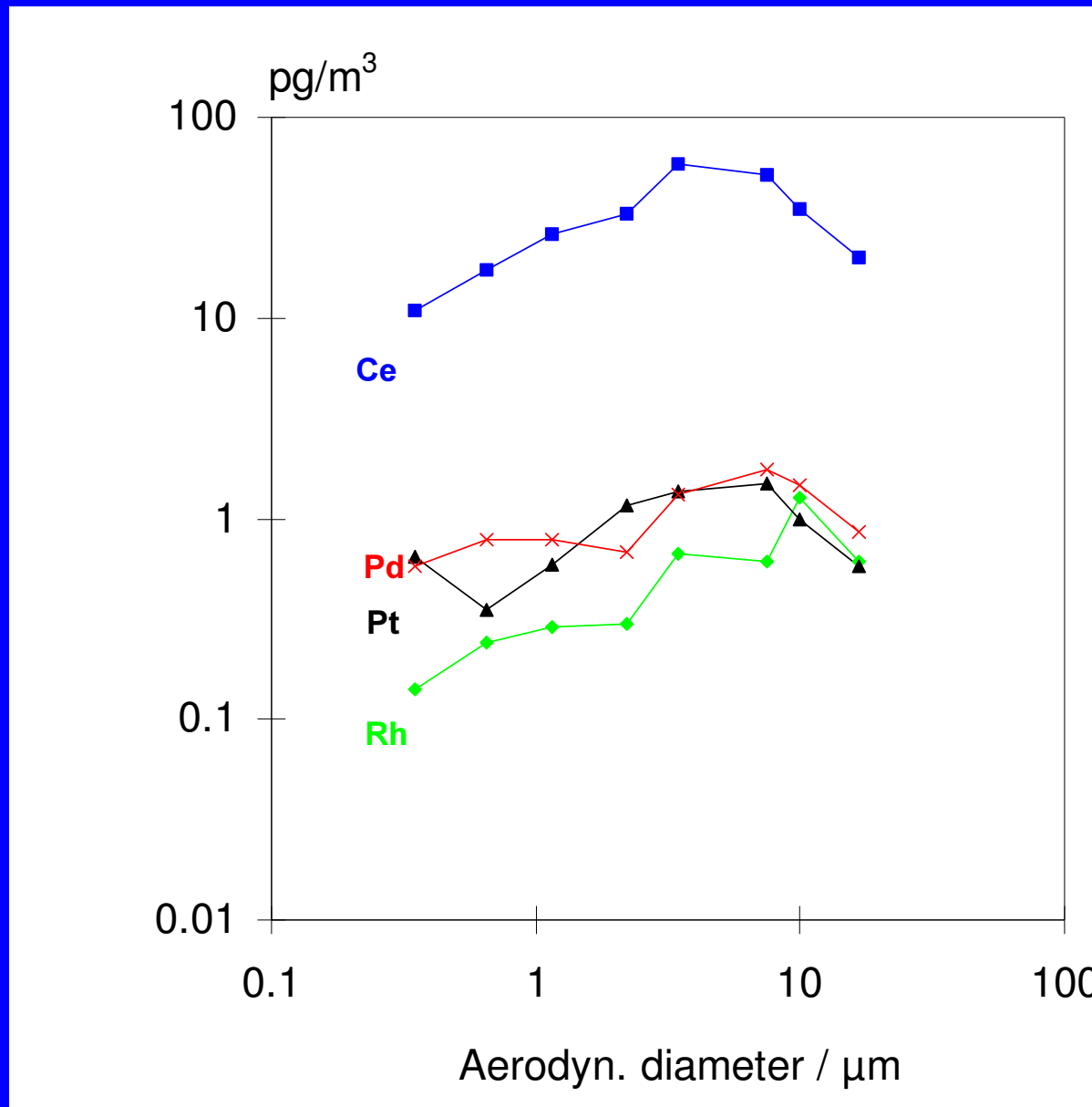
0.93 m³ per target



XXX



Platinum group elements in Berlin air correlated to Ce



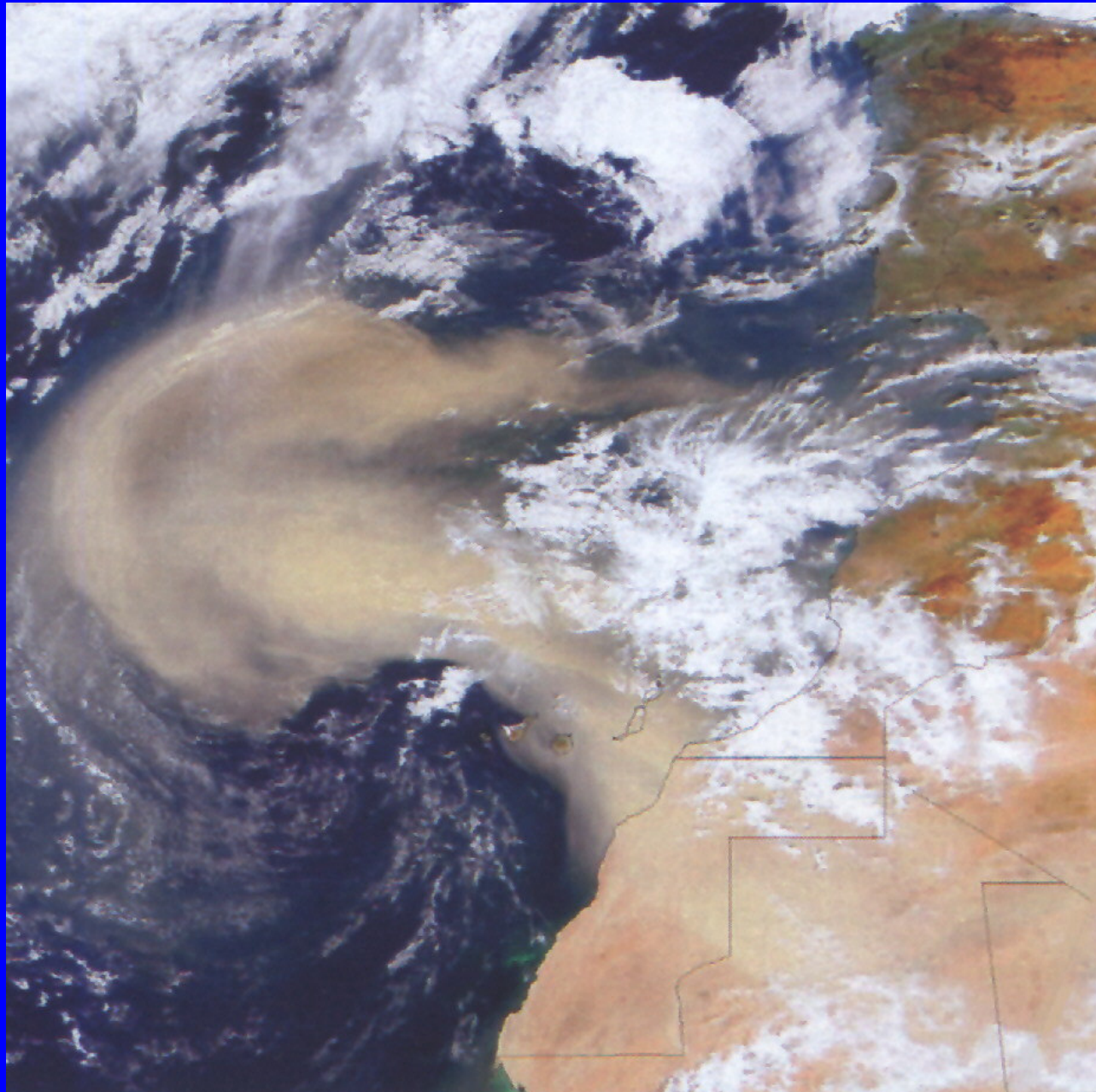


Mean concentration of platin group elements in Berlin air

	Element content (sum over all diameters) pg/m ³				Correlation coefficient	Maximum in particle distribution
	¹⁴⁰ Ce	¹⁰³ Rh	¹⁰⁵ Pd	¹⁹⁵ Pt		
Isotope	¹⁴⁰ Ce	¹⁰³ Rh	¹⁰⁵ Pd	¹⁹⁵ Pt	¹⁴⁰ Ce : ¹⁹⁵ Pt	all
Plume of Berlin	250 ± 25	4 ± 1	8 ± 1	7 ± 1	0.903	3 - 5µm
Motorway tunnel	1140 ± 100	28 ± 5	16 ± 2	35 ± 6	0.899	7 µm



Satellite picture of Sahara dust



Ref.:
Der Spiegel
Nr. 50
Dec. 11, 2000



Research vessel „Polarstern“

© U. Bathmann, AWI - Bremerhaven



XXXII CSI, Pretoria, South Africa



On board sampling station



Sampling conditions:

Daily aerosol sampling,

22 m above sea level

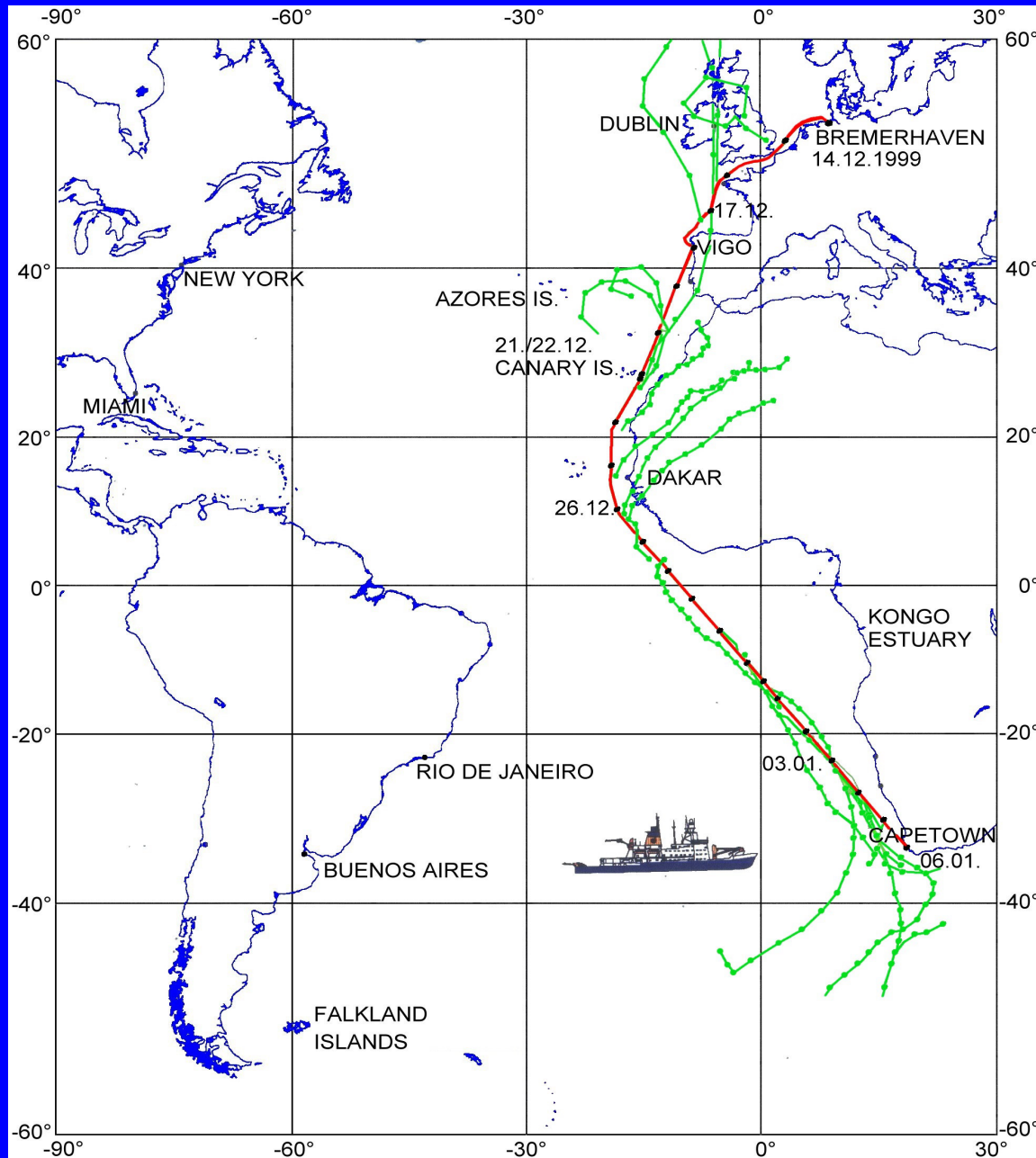
Time: 23 h

Air volume: 0.3 m³ per target



Polarstern Cruise ANT XVII/1

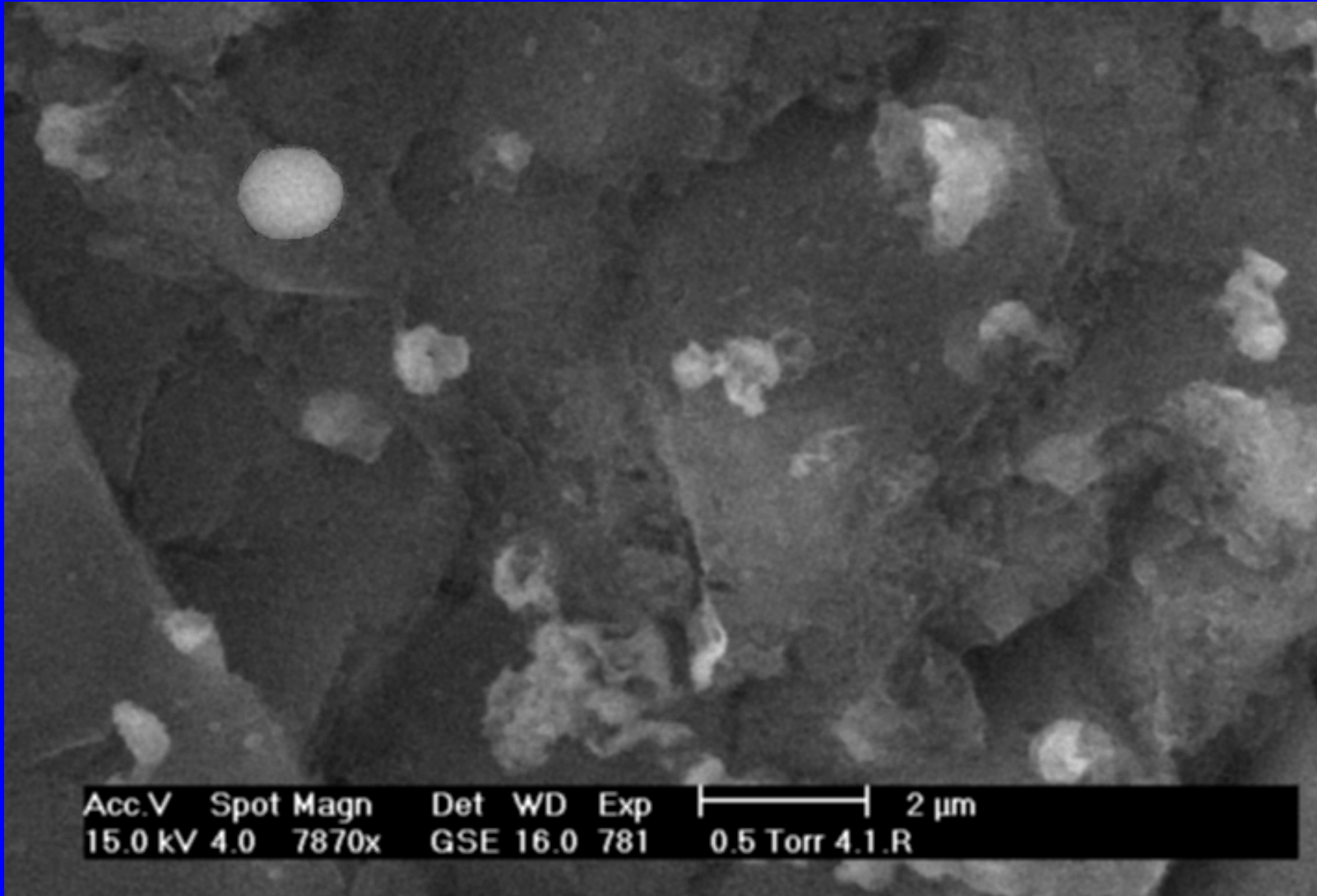
(Bremerhaven-Las Palmas-Cape Town, Dec. 14, 1999 till Jan. 06, 2000)



XXXII CSI, Pretoria, South Africa



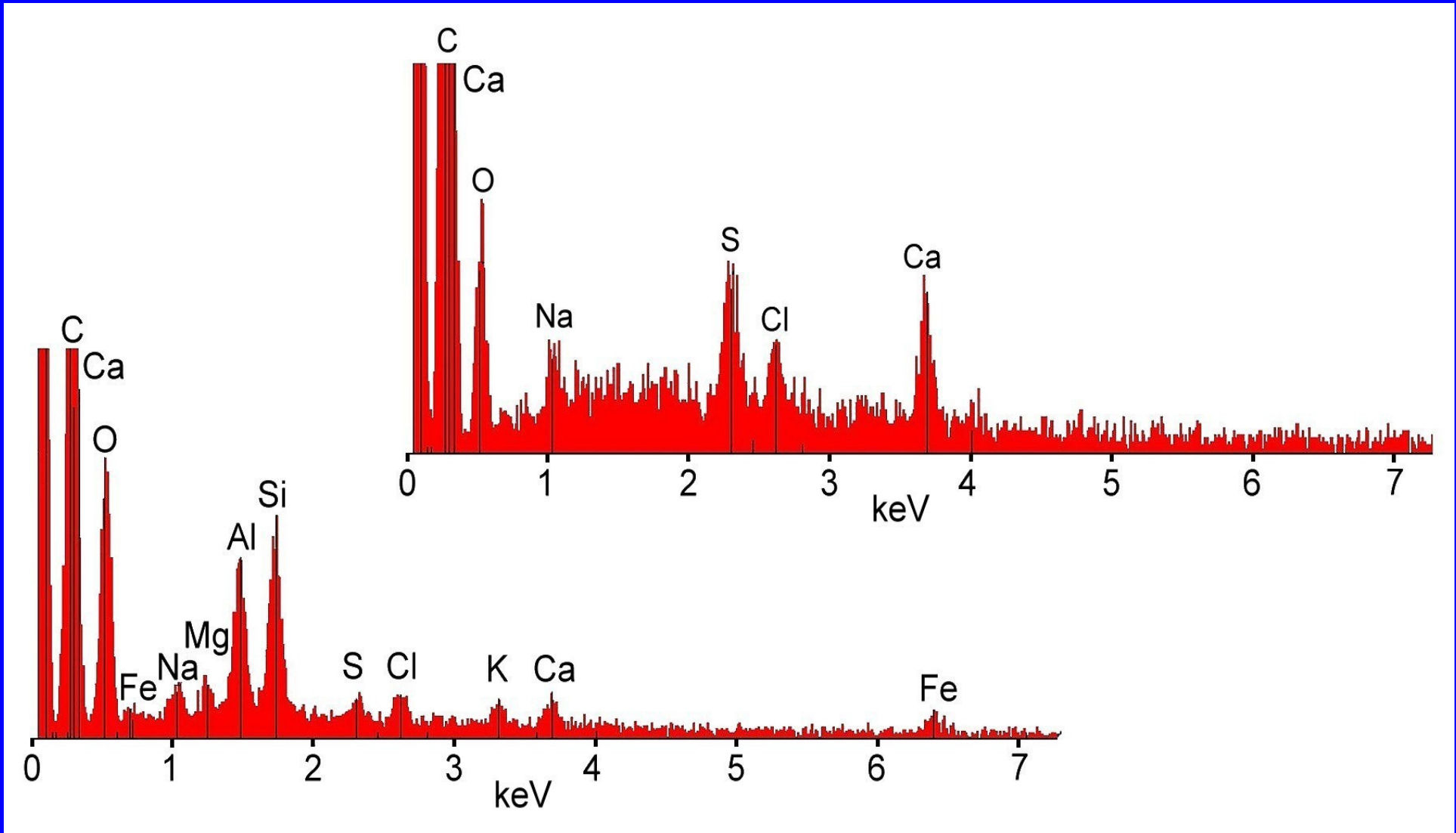
Particles of the 1.1 μm stage (site of sampling: the British Channel)



Philips XL 30 ESEM

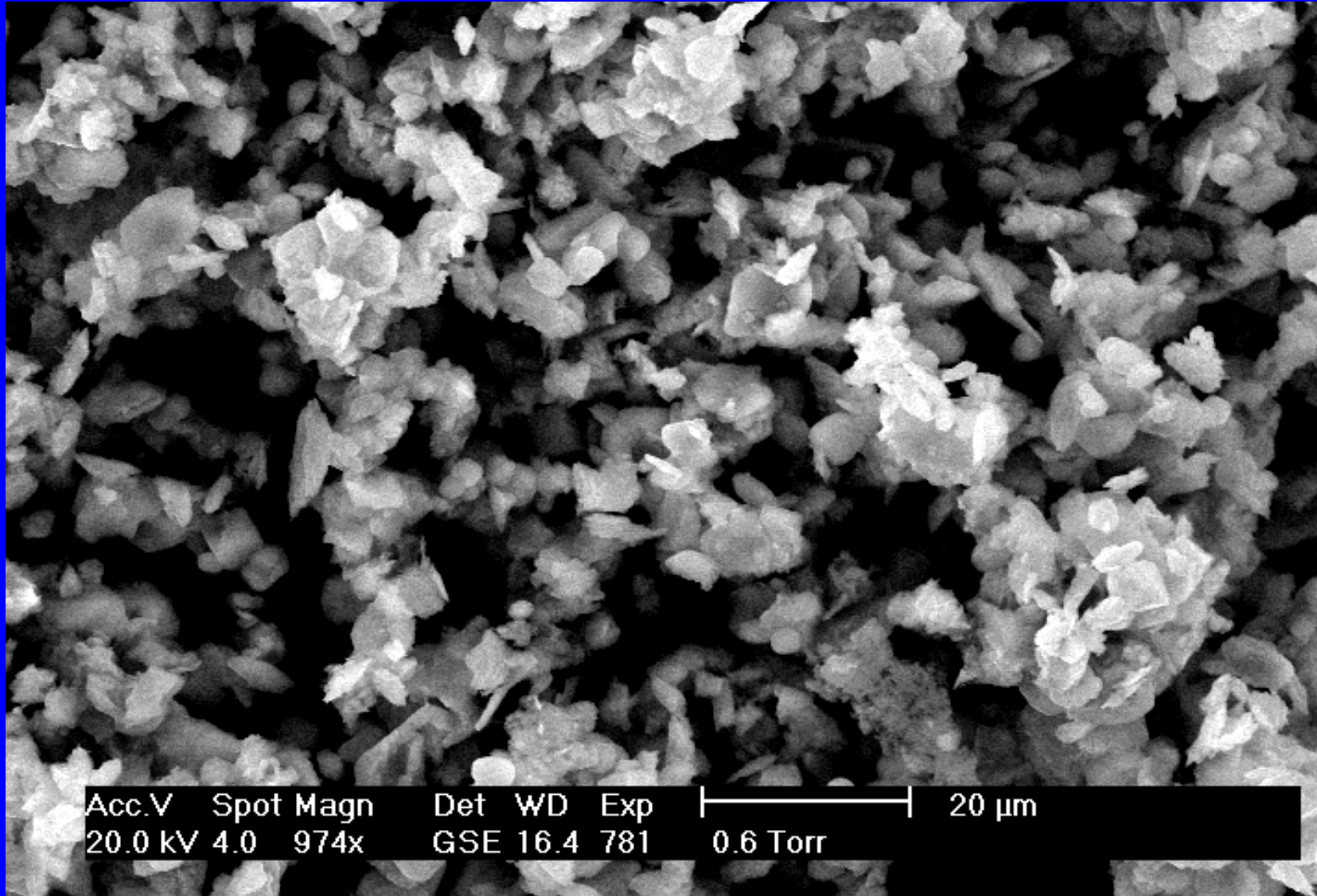


SEM-EDX analysis



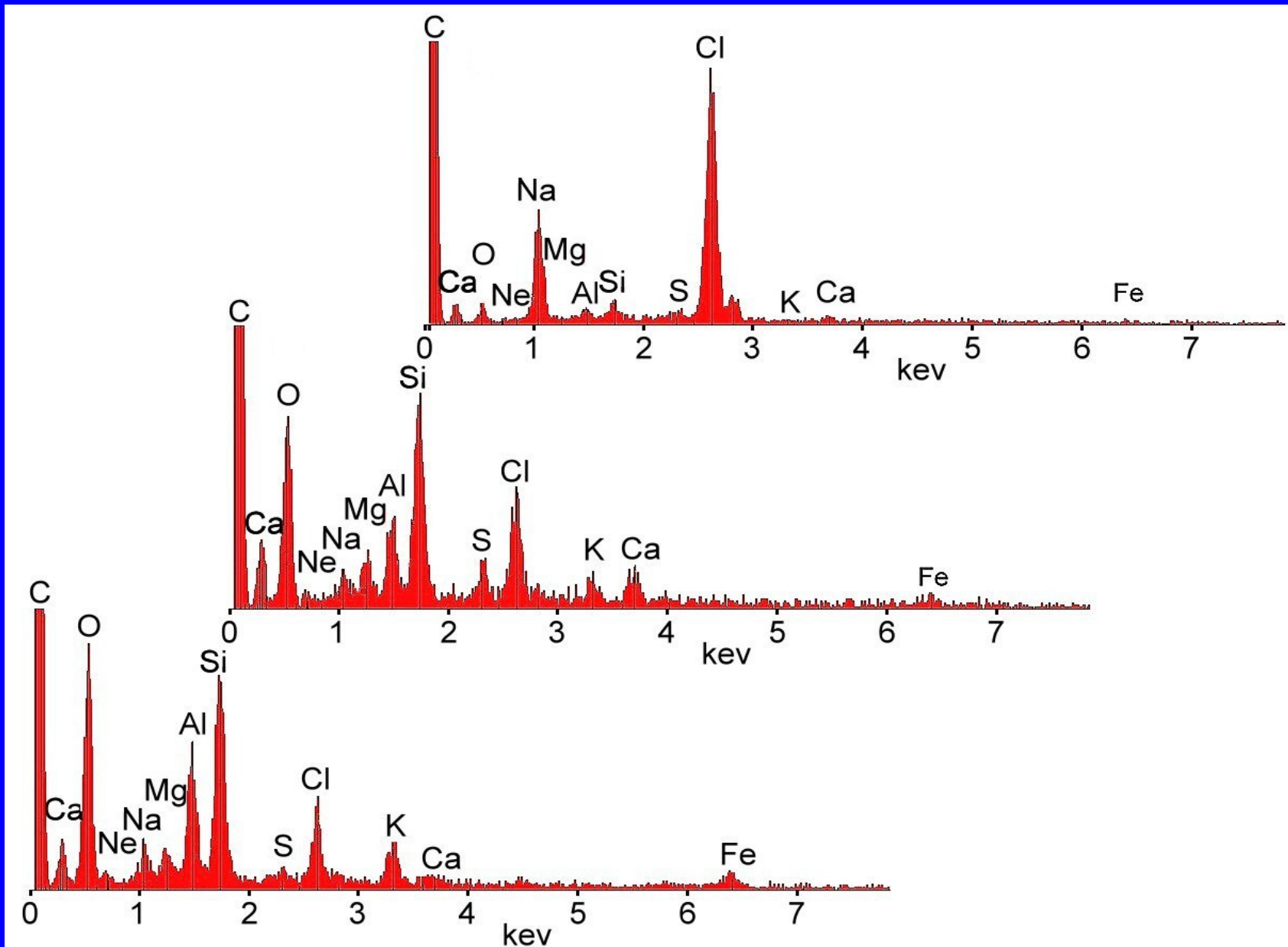


Particles of the 3.5 μm stage site of sampling 14°N (Sahara dust)



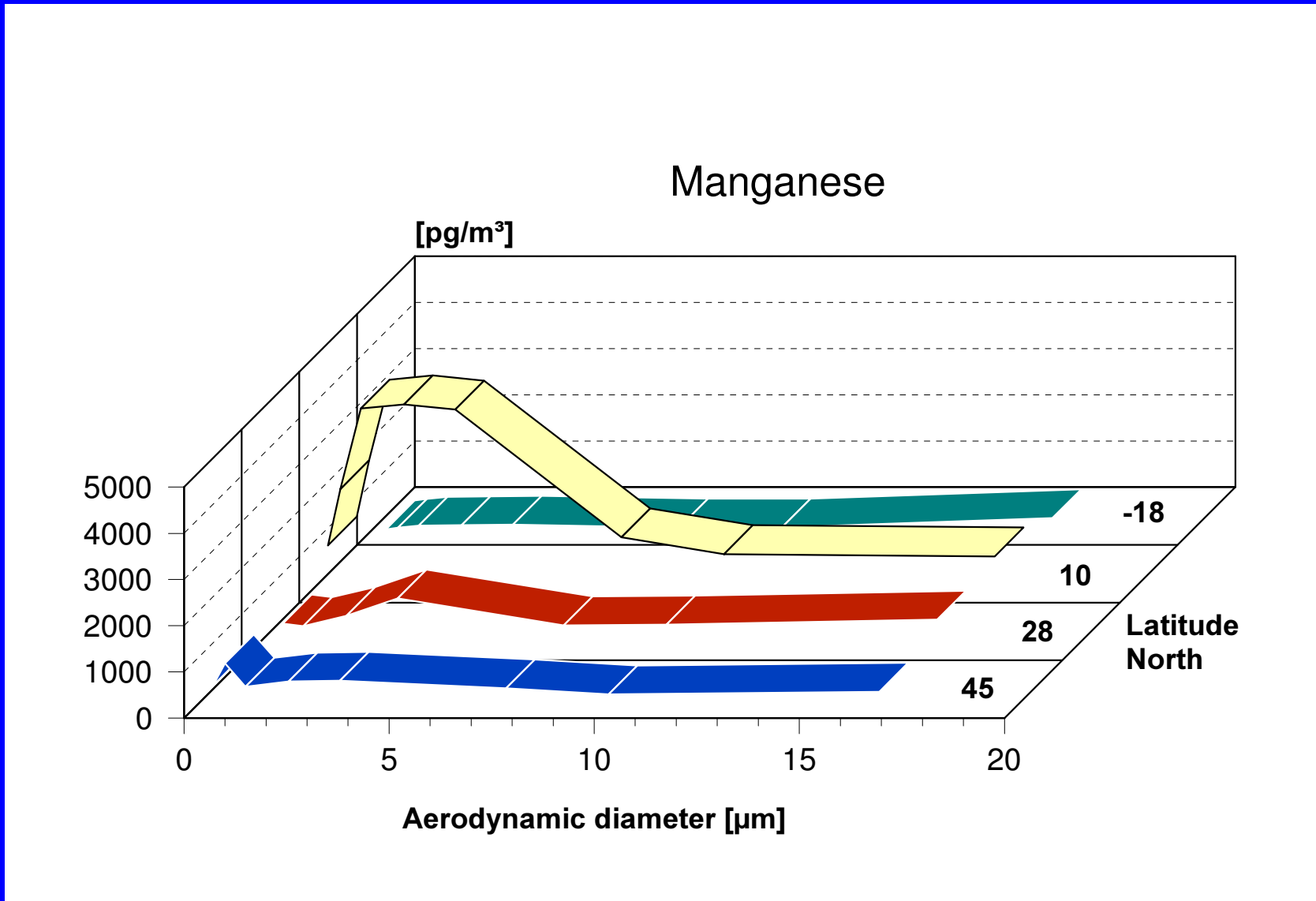


SEM-EDX analysis



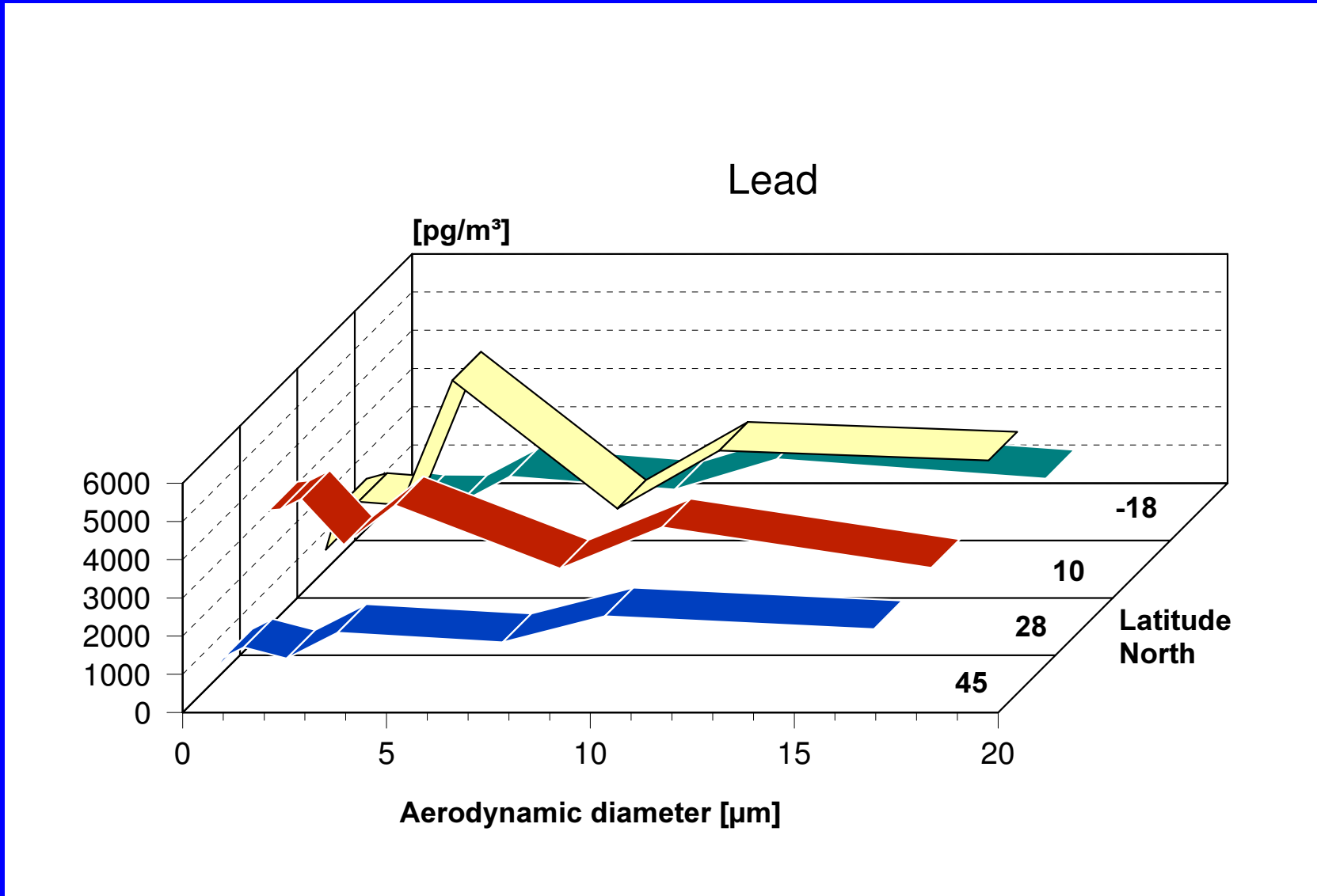


Mn



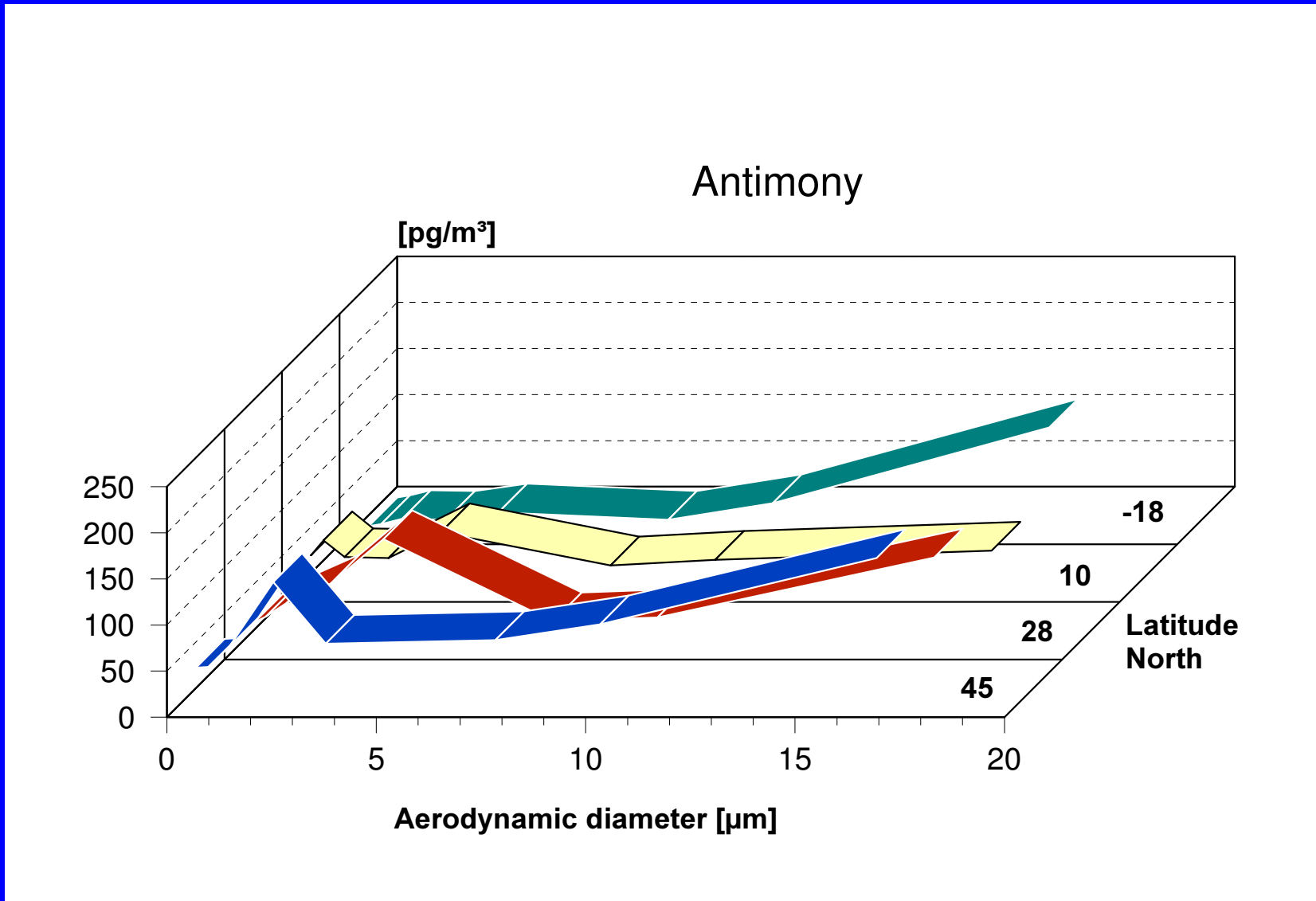


Pb



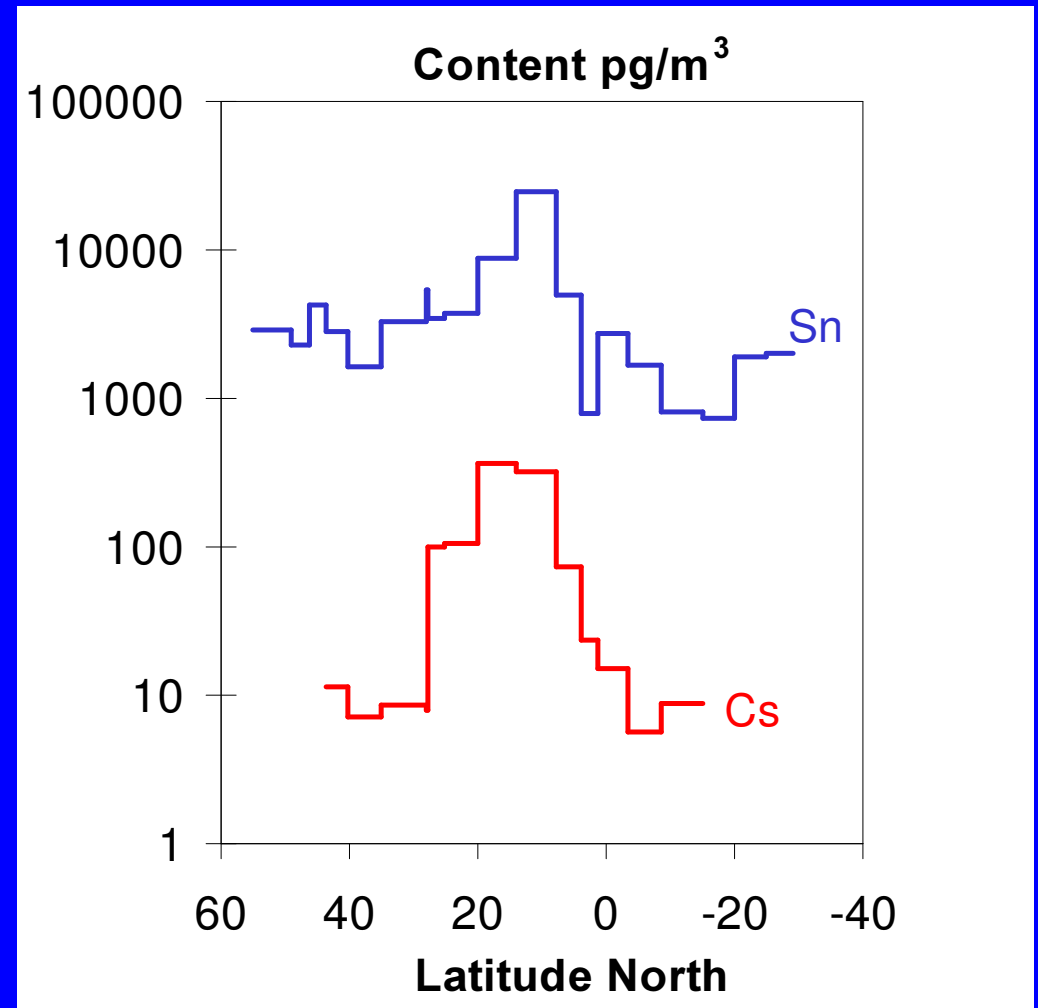
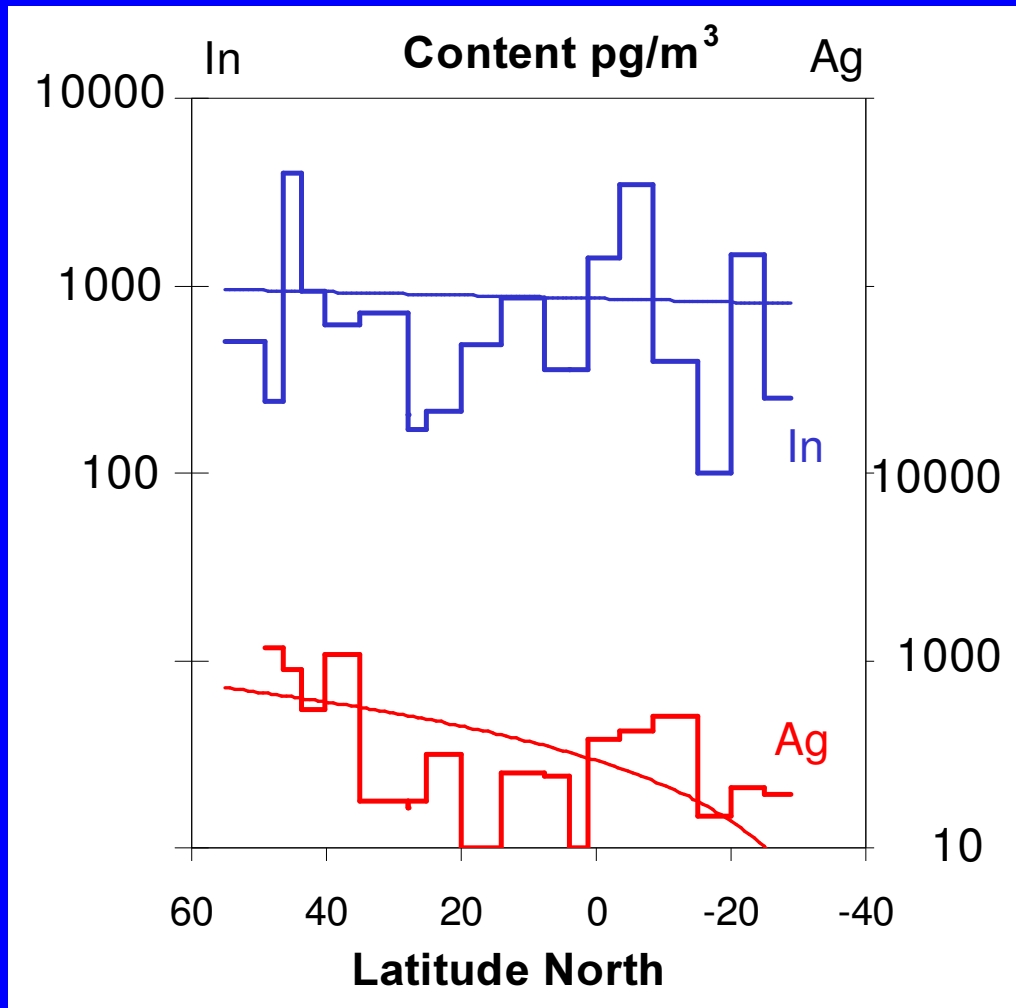


Sb





Spatial distribution of element concentrations in aerosol over the Atlantic Ocean





Mean element concentration in aerosol (pg / m³)

Element	North Atlantic 52°N - 22°N	Region of Sahara dust 22°N – 6°N	South Atlantic 6°N – 31°S
Ag	580 ± 130	220 ± 50	270 ± 50
Sb	1100 ± 290	300 ± 25	260 ± 60
Tl	28 ± 4	78 ± 20	16 ± 3
Sn	3950 ± 860	20800 ± 5100	1970 ± 470
Mn	3600 ± 870	15000 ± 2000	2480 ± 550
Pb	18200 ± 2800	18900 ± 1800	13600 ± 2600
Cs	21 ± 9	215 ± 65	21 ± 7
In	920 ± 300	520 ± 150	940 ± 300
Bi	250 ± 40	450 ± 50	200 ± 30



Conclusion

- Size classified sampling of aerosol particles on separate graphite targets and subsequent multielement analysis is a useful tool for the characterization of aerosol particles.
- The high efficiency of the sampling system combined with the powerful analytical technique permits the study of isotope correlations allowing the identification of particle sources as well as transport and deposition processes.



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