# Analysis of size classified aerosol particles from an urban site in Berlin and a remote area in the high Arctic


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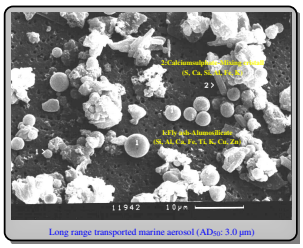
## INTRODUCTION

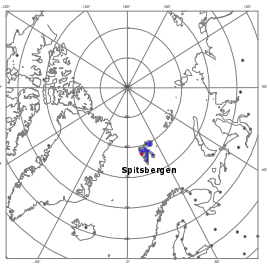


Long range transported marine aerosol ($AD_{50}$: 3.0 µm)

Studies of element composition in small atmospheric particles serve to the clarification of processes such as long-range transport, deposition and transformation of particles, or quantification of emission from natural and anthropogenic sources. Varying sampling conditions caused by changing meteorological conditions or sampling locations causes a need for short sampling times.

Therefore powerful analytical techniques are imperative for time-resolved measurements.

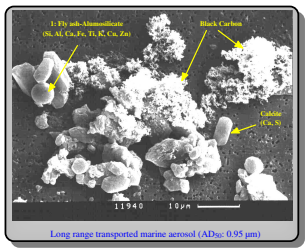
For this purpose a highly sensitive method was developed for the trace analysis of atmospheric particles[1].



Geographical position for aerosol sampling in the high Arctic

The particles were sampled, separated according to size, directly on separate small graphite discs arranged behind the jet-nozzles of an eight-stage cascade impactor.

We will present results fror trace element analyses carried out by ETV-ICP-MS and ETV-TOF-ICP-MS in aerosol particles from Berlin and Ny Alesund at Spitsbergen (79°N, 12°E). In addition data from electron microscopy measurements will be presented to have information about morphology and composition of main constituents.



Long range transported marine aerosol ($AD_{50}$: 0.95 µm)

## EXPERIMENTAL

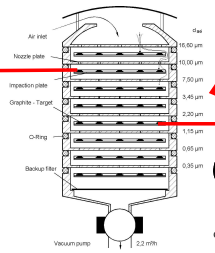
### Aerosol sampling with an eight stage cascade impactor

During the ASTAR campaign (Arctic Study of Trpospheric Aerosols and Radation) in March/April 2000 size classified aerosol sampling at Spitsbergen was carried out during special events 24 hourly with an eight stage impactor (0.35-16.5 µm) on grapite targets for subsequent multielement analysis by ETV-ICP-MS. Separate graphite discs (6 mm diam.) first act as an impaction target serve in a second step as an platform in the ETV and permit the particle analysis without any sample preparation.

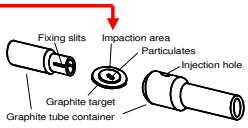
The impactor was installed on top of the roof of the Japanese Station (8 m above ground) located 4 km northwest of the settlement to avoid contamination. In addition SEM/EDXA studies were carried out to characterize the morphology of the aerosol particles and to get informations about the major components.
The pump rate for the eight stage impactor was 2.2 $m^3$/h.

At the urban site of Berlin sampling was performed in Berlin-Adlershof. The equipment was installed in 1 m height above ground. Sampling time was 4 hours.

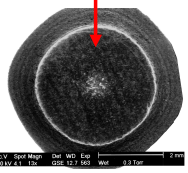

Eight stage cascade impactor



Schematic diagram of the cascade impactor



Graphite tube for ETV-ICP-MS


SEM picture of a graphite target with impacted particles

### Aerosol characterisation by ETV-ICP-MS

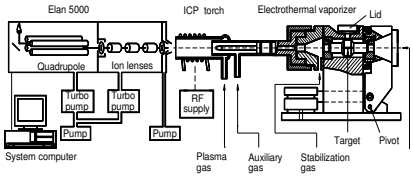
For the samples from Spitsbergen aerosol characterisation was carried out for typical tracer elements by ETV-ICP-MS (Quadrupole based ELAN 5000): As tracer elements for mineral dust Mn, Fe, Co were measured and for anthropogenic sources Pb, Ni, Sb, Pt, Cd, Ag and Tl were analysed.

The aerosol particles from Berlin were analysed with an ETV-ICP-TOF-MS device, developed at the Institute for Spectrochemistry and applied Spectroscopy in Berlin –Adlershof.

### Aerosol characterisation by SEM/EDXA

Morphological characterisation of aerosol samples as well as determination of main components were performed by SEM/EDXA.

The measuremnts were performed by the usage of a Phillips XL30 ESEM.This instrumnt is a further development of conventional SEM. Imaging of natural state, damp and insulating materials is possible without any coating. The instrument is also equipped with Secondary Electron and Back Scattered Electron detectors



Experimental setup for ETV-ICP-MS

## RESULTS

### Morphological and main component determination by SEM/EDXA

Typical aerosol particles from anthropogenic sources, sea salt as well as from mineral dust and ammonium sulphate are exemplarily shown together EDXA spectra in the following section.

### ETV-ICP-MS results for the remote sampling site in the high Arctic

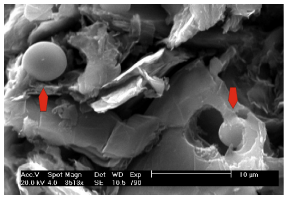
For the aerosols sampled at Spitsbergen in March/April 2000 selected trace element concentrations measured by ETV-ICP-MS (quadrupole ELAN 5000) are shown in the following section.

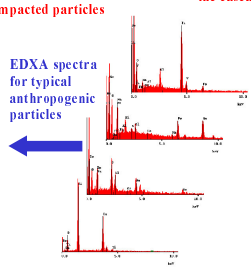
Fe size distributions (tracer for mineral dust) and Pb size distributions (tracer for anthropogenic sources) are exemplarily shown for two different atmospheric situations. Impactor 4 represents an enriched aerosol, while impactor 10 shows the distribution for a background aerosol.

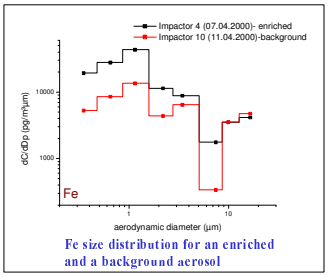
| Measured isotope | $^{55}$Mn | $^{59}$Co | $^{105}$Pd | $^{107}$Ag | $^{111}$Cd | $^{118}$Sn |
|---|---|---|---|---|---|---|
| LOD pg/m³ | 1 | 0.8 | 0.2 | 0.03 | 0.2 | 0.5 |

| Measured isotope | $^{121}$Sb | $^{130}$Rh | $^{140}$Ce | $^{195}$Pt | $^{205}$Tl | $^{208}$Pb |
|---|---|---|---|---|---|---|
| LOD pg/m³ | 1 | 0.1 | 3 | 0.6 | 0.05 | 0.2 |

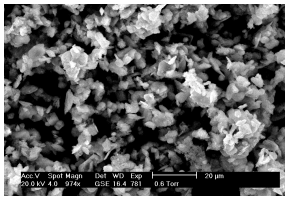
Limits of detection, based on the 3σ criteria

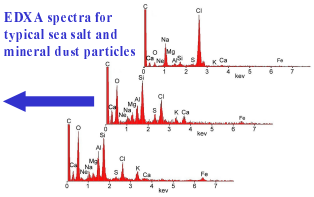

SEM picture for typical anthropogenic particles from high temperature combustion processes stage 3.45 µm for Impactor 4.


EDXA spectra for typical anthropogenic particles



Fe size distribution for an enriched and a background aerosol

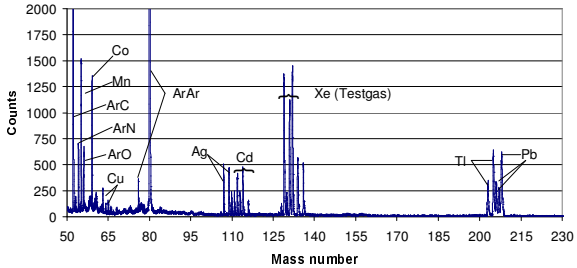

SEM picture for typical sea salt and mineral dust particles for impactor 10, stage 3.45 µm.


EDXA spectra for typical sea salt and mineral dust particles

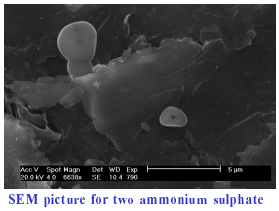
### ETV-ICP-TOF-MS results for the urban sampling site Berlin

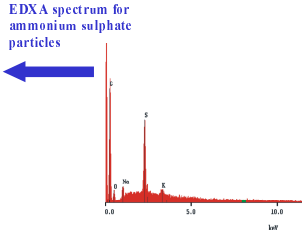
As first results for element analysis performed with the graphite target equipped eight stage impactor and coupling the ETV-system to a ICP-TOF--MS a typical spectrum for a standard and for sampled particles (3.5 µm) from Berlin air are shown.

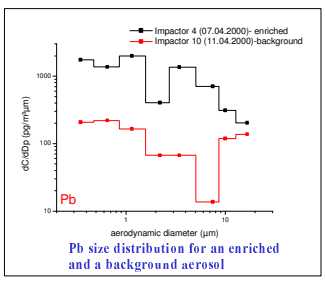
Technical details about the ICP-TOF-MS ca be find on poster board no. P-IN-082.



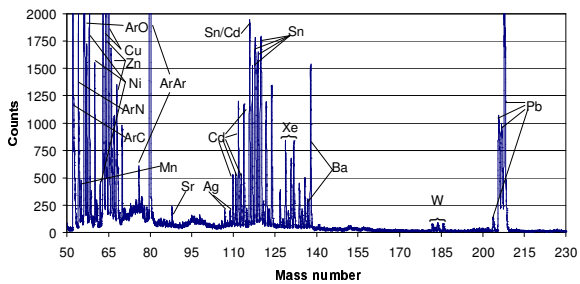
TOF spectrum of Mn, Co, Ag, Cd, Tl, Pb; 500 pg each element


SEM picture for two ammonium sulphate particles for impactor 4, stage 0.35 µm.


EDXA spectrum for ammonium sulphate particles



Pb size distribution for an enriched and a background aerosol



TOF spectrum of sampled particles from the 3.5 µm stage

## SUMMARY AND OUTLOOK

* It has been demonstrated that trace element analysis in size classified atmospheric particles can be determined succesfully by ETV-ICP-MS.
* The impaction of particles on graphite targets permits their direct analysis without any sample preparation and very good contamination control.
* The detection power is high enough to allow sampling of only about 2 h in urban areas and 12-24 h in remote areas like the high Arctic.
* This leads to a much better time resolution for studying short time atmospheric processes.
* For a better understanding of atmospheric chemistry processes and the optical properties of aerosols morphological studies were carried out by SEM in combination with EDXA measurements to determine major components.
* The first measurements of ETV-ICP-TOF-MS using the in-house developed TOF in combination with an ICP and electrothermal vaporizer presented here illustrate the excellent performance of our TOF for the analysis of transient signals. Further improvements are necessary to handle the huge flood of data (4MB / s).
* In collaboration with the AWI, Bremerhaven studies of size classified atmospheric particles in the clean air region of Antarctica are in progress. Future campaigns (spring 2004) will be used also for measurements of aerosol concentration with improved systems in the high Arctic in combination with airborne measurements.


## ACKNOWLEDGMENT

We would like to thank T. Adam and U. Bock (AWI-Bremerhaven) assistance in SEM operation and EDX analysis.


## REFERENCES


[1] C. Lüdke, E. Hoffmann, J. Skole, M. Kriews. J. Anal. At. Spectrom.,1999,**14**, 1685-1690;