IN SITU DUST ANALYSIS WITH ROSETTA AT COMET CHURYUMOV-GERASIMENKO

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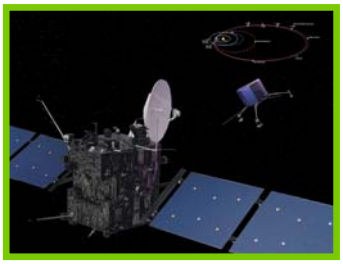
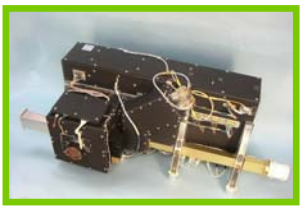
ABSTRACT

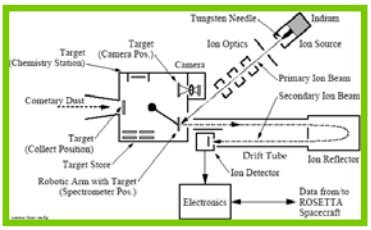


The COSIMA instrument on board the Rosetta spacecraft uses time-of-flight secondary ion mass spectrometry (TOF-SIMS) to analyze dust particles in the coma of comet Churyumov-Gerasimenko. Rosetta will reach the comet in 2014.
Comets are remainders from the formation of the solar system and, therefore, analysis of cometary material can give insights into solar system formation.
The aim of the work is to calibrate COSIMA. In order to do it, the first step was to prepare samples of different minerals with known composition and which are believed to exist in comets.
Reference spectra were obtained using high resolution TOF-SIMS mass spectrometers located at University of Münster and University of Orléans.
Each mineral sample has its well determined composition; using the spectra measured in Münster we found a good agreement between the expected and the measured element abundances.
The next step will be to perform the same type of measurements with the COSIMA flight-spare model located in our laboratory and with more realistic cometary dust analogues in order to show that Cosima can accurately measure the mineral and isotopic composition of cometary dust.

FUNCTIONAL PRINCIPLE

1. Dust is collected on metal black targets which are stored in Target Manipulator Unit
2. Dust grains are located by microscopic camera COSISCOPE
3. A pulse Indium ion beam partially ionizes the dust grains
4. Secondary ions are accelerated by an electric field and travel through a drift tube with ion reflector
5. Ions are detected by ion detector, flight times are recorded by T/D converter
6. Mass spectra are calculated from the time-of-flight spectra





The measurements presented here have been performed with a high resolution TOF-SIMS located at University of Münster.

ELEMENT ABUNDANCES

- mineral: clinopyroxene
- chemical composition: (Mg, Fe, Ca) Si O_3

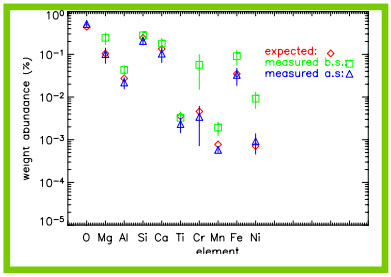
$$\frac{Mg}{Si}+\frac{Fe}{Si}+\frac{Ca}{Si}=1 \longrightarrow$$

r = (1.004 ± 0.256)

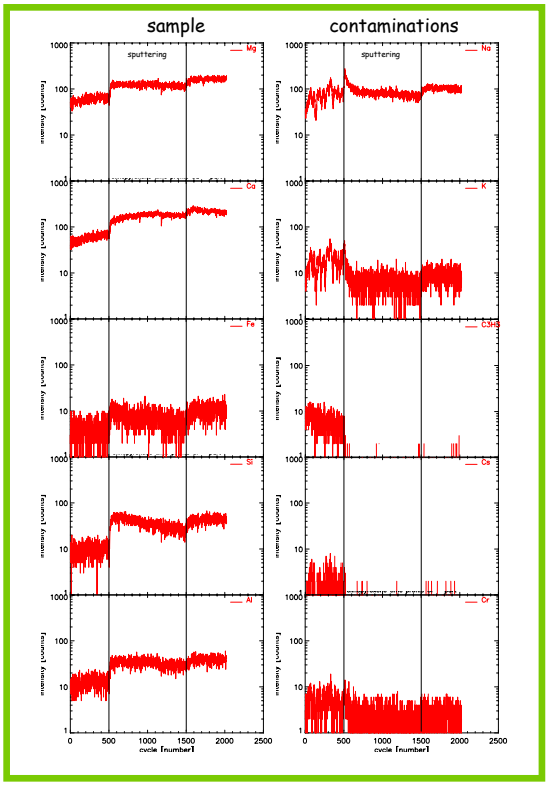
calculated ratio

Since TOF-SIMS analyzes the uppermost layer of the sample, surface contaminations have to be reduced as much as possible. It can be done by *sputtering* the sample with a primary ion beam.

Thanks to a chemical analysis of the mineral, the element abundances in the sample are well known. Knowing reliable sensitivity factors, we determined from the mass spectra the element abundances before and after sputtering for some elements. The error bars vary within ± σ.



For the majority of the considered elements a good agreement exists between the 'expected' (◇) and the 'measured' (△) abundances after sputtering.



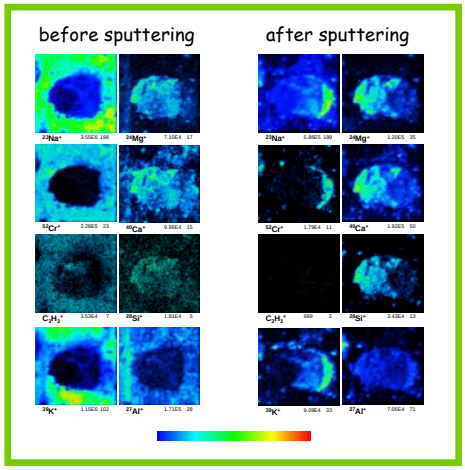
TIME PROFILES

We measured time profiles of different elements and compounds before, during and after sputtering. At cycle = 500 the sputtering starts and at cycle = 1500 it stops.

The ion beam used for sputtering is Ar-beam with a voltage V = 3 kV.

The profiles show two behaviors:

- an increasing of the line intensity when the considered element or compound comes from the sample (left column)
- a depletion of the intensity when the considered element or compound is a contamination (right column). In some cases after the end of the sputtering the intensity increases again due to re-absorption.



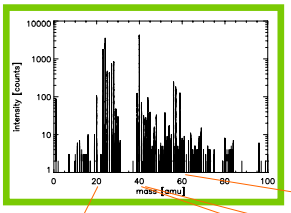
Secondary ion images show the intensities of element lines before and after sputtering. They confirm the results previously obtained with the time profiles.

After sputtering the line intensities are:

- strongly reduced in contaminations
- increased for the sample

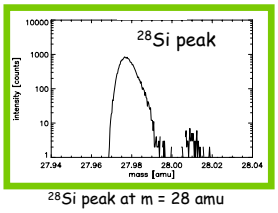
The sputtering works well to reduce the surface contamination (as shown in the time profiles and in the secondary ion images) and to allow a more realistic determination of element abundances in the mineral.

MASS SPECTRA

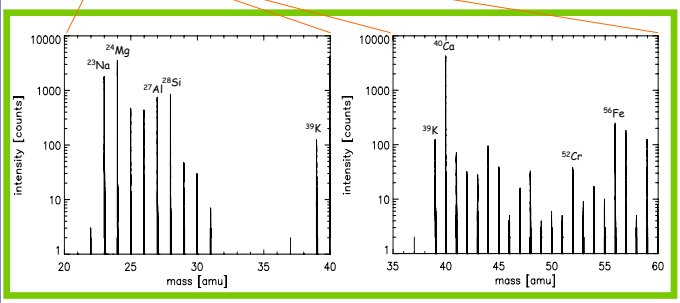


Mass spectrum of the sample (intensity vs mass).

Thanks to the high mass resolution, many peaks are well defined.



^{28}Si peak at m = 28 amu



CONCLUSIONS

1. The sputtering with Ar primary ions works well to reduce sample contaminations.
2. Element abundances after sputtering are in good agreement with the values expected from the chemical analysis of the sample.
3. The analysis of the uncertainties on the weight abundances and the analysis of other minerals is 'work in progress'.

OUTLOOK

1. Measure the same minerals with COSIMA, to check if the sputtering works (sputtering ion beam: ^{115}In).
2. Get a total calibration of COSIMA, to be able to determine element abundances.
3. Measure more realistic cometary dust analogues in order to show that Cosima can measure accurately the mineral and isotopic composition of cometary dust.

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