ALKALI METALS AND OTHER ELEMENTS IN 67P/CHURYUMOV-GERASIMENKO DUST PARTI-CLES.

O. J. Stenzel[1], M. Hilchenbach[1], J. A. Paquette[1], J. Rynö[2], [1]Max-Planck-Institut für Sonnensystemforschung, Justus-von-Liebig-Weg 3, D-37077 Göttingen, Germany (stenzel@mps.mpg.de), [2]Finnish Meteorological Institute, Erik Palménin aukio 1, 00560 Helsinki, Finland.

Introduction: The COSIMA experiment onboard the ESA Rosetta mission to the comet 67P/Churyumov-Gerasimenko collected about 35,000 particles in the inner cometary coma [1,2]. Many of the particles were subjected to time-of-flight secondary ion mass spectrometry (ToF-SIMS), yielding a picture of matter rich in macromolecular carbonaceous material [3], in terms of elementary abundances similar to 1P/Halley [4] and more primitive than some carbonaceous chondrites [5].

While Mg and Ca are less abundant in the analyzed particles than in CI and CR chondrites, the alkali metals sodium and potassium are enriched. Lithium can also be seen in the cometary grains but its abundance is harder to quantify because it is much less abundant than Na and K. High abundances (up to ten times the CI values) were also found in 81P/Wild 2 grains (see e.g., Fig. 4 of [6]).

In this work we are looking for clues in which chemical context the alkali metals appear and whether Na and K share the same sources.

Methods: COSIMA is a time-of-flight secondary ion mass spectrometer The positive indium ions of its pulsed primary ion beam have an energy of 8 keV [7]. The SIMS can be operated in either positive or negative secondary ion mode. The footprint of the primary ion beam on the particles and target is an ellipse of about 35 μm x 50 μm full width at half maximum.

We are analyzing the SIMS data from the particle Fred Kolima.3 on target plate 2CF. Spectra for both negative and positive ion mode were acquired in an array covering a large part of the ~ 62,000μm^2 particle. The secondary ion counts from the center of the particle were quite low; therefore, we excluded those spectra from our analysis.

We are presenting two steps of our analysis: In the first step we are looking at positive spectra, only. The positive spectra contain information from the rock forming elements like Mg, Fe, and the alkali metals in positive ion form. The second step is to link positive and negative spectra. Oxide and halogen ions are mainly found in the negative mode of the instrument. Matching positive ions of the elements with these species is useful to obtain a better picture of the actual chemical compounds present in the particle. This second step has not been done before on the COSIMA data and is work in progress, therefore the results are preliminary.

Positive spectra only: The counts at each element peak of the spectra are fitted with Gaussian functions. The integrals of these fitted Gaussians are analyzed in terms of ion images and in terms of correlations across different masses. This type of correlation analysis has been done before on SIMS data [8], but here we correlate the integrated peaks instead of the counts at single time of flight channels.

Correlating positive and negative spectra: Positive and negative spectra are merged, i.e. the spectrum is doubled in size, and the correlation is calculated in the same manner again as in [8].

Results and Discussion: This is ongoing work but so far we can show that for a particular particle (Fred Kolima.3 on target plate 2CF) Na and K show different distributions with maxima at different places, as can be seen from Fig. 1 and 2. For comparison the distributions for Fe and Al are shown in Fig. 3 and 4, respectively. Na and K both have a local maximum close to the top left corner of the particle which is also shared with local maxima of aluminum and iron. In the lower left part, a maximum of both K and Al can be seen, a possible hint at an isolated K-feldspar rich sub-unit of the particle.

Correlation functions for Na and K with other elements look quite different. Na is more strongly correlated with C and Fe than K. Both are correlated with Al (see Fig. 5).
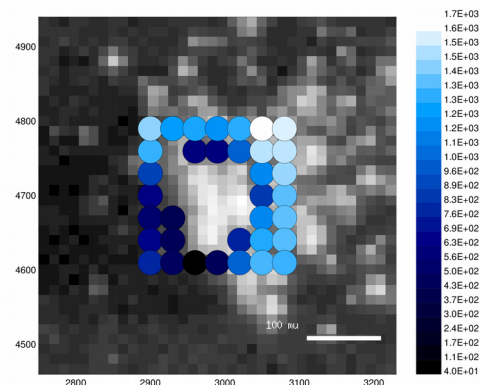

Figure 1: Normalized logarithms of the integrated ion counts of Na at different positions on the grain, low count spectra in the center of the grain have been omitted.
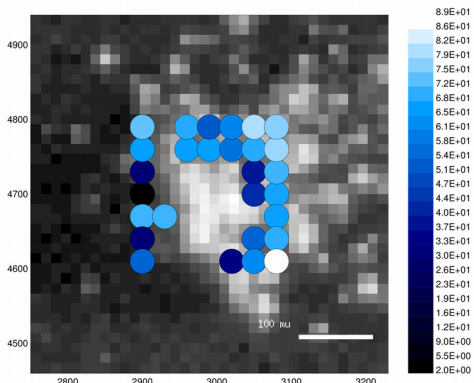
Figure 2: Normalized logarithms of the integrated ion counts of K at different positions on the grain, low count spectra in the center of the grain have been omitted.
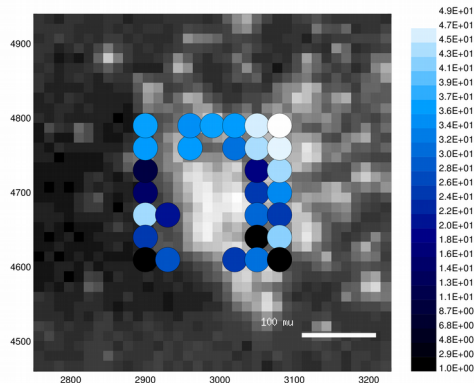

Figure 3: Normalized logarithms of the integrated ion counts of Al at different positions on the grain, low count spectra in the center of the grain have been omitted.
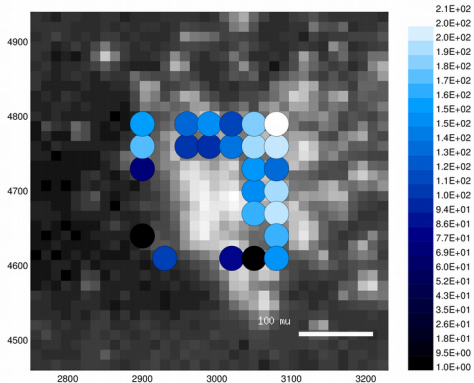

Figure 4: Normalized logarithms of the integrated ion counts of Fe at different positions on the grain, low count spectra in the center of the grain have been omitted.

The positive Na ions are related to the negative C, O and F ions as show in Fig. 6. There is no correlation for Na^+ with Cl^- on the particle but on the target. The relation shows as a pattern of anti-correlation on the left shoulder and a correlation at the main mass. This is due two effects. Charging of the particle by the positive primary ion beam results in strong left shoulders of peaks in the negative spectra [4]. The further towards the center of the particle the measurement is done, the stronger are the shoulders. In the positive spectra no left shoulders are seen from charging. Instead the ion count drops to very low values. In both positive and negative spectra the secondary ion count increases towards the rim of a particle.
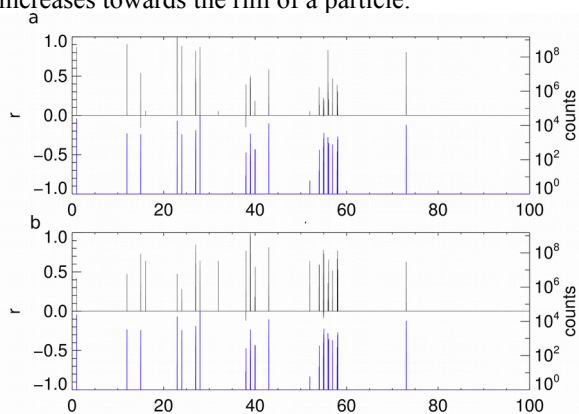

Figure 5: Correlations of a) Na and b) K with different masses in the range of 0 to 100 u (top) and sum of fitted peaks (bottom).
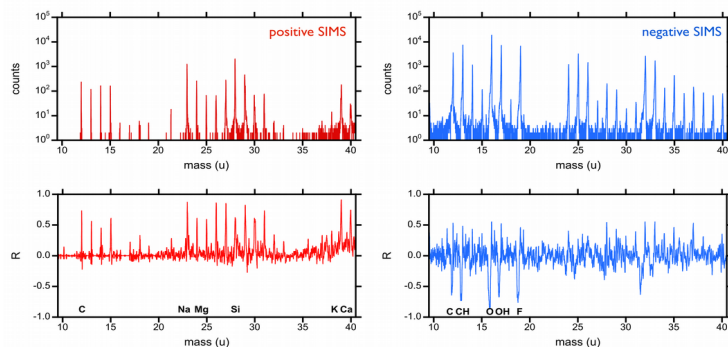

Figure 6: Correlation of Na^+ with positive and negative mode spectra. The top row shows the summed ion counts in the mass range of ~ 10-40 u. The bottom row shows the filtered correlation coefficient. The left and right columns present the positive and negative modes, respectively.

References: [1] S. Merouane, et al., Astron. Astrophys. (2016). [2] S. Merouane, et al., Mon. Not. R. Astron. Soc. **469**, S459 (2017). [3] N. Fray, et al., Nature **53**8, 72 (2016). [4] A. Bardyn, et al., Mon. Not. R. Astron. Soc. **469**, S712 (2017). [5] O. J. Stenzel, et al., Mon. Not. R. Astron. Soc. **469**, S492 (2017). [6] G. J. Flynn, et al., Science **31**4, 1731 (2006). [7] J. Kissel, et al., Space Sci. Rev. **12**8, 823 (2007). [8] O. J. Stenzel, et al., in *LPI Contrib.* (2015), p. 2200.