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Elemental Composition of Cometary Dust Particles in the Coma of Comet 67P

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Abstract

The COSIMA instrument (COmetary Secondary Ion Mass Analyser) on board ESA's Rosetta mission to comet 67P/Churyumov–Gerasimenko has collected and analysed dust particles in the inner coma from August 2014 to September 2016. The instrument has applied optical microscopy and secondary ion mass spectrometry (SIMS) to in-situ analysis of cometary particles collected between 1.25 and 3.8 AU solar distance and 4 to 1000 km off the comet nucleus. The dust particles impacted at low speeds on metal targets, are collected and constitute a sample of the dust particles in the inner coma of the comet. After impact, the larger particles tend to stick together, spread out or consist of single or a group of clumps, and the flocculent morphology of the fragmented particles has been revealed. The elemental composition is heterogeneous on small and more homogenous on a larger scale[1-9]

1.Methods

Dust particles were identified with an optical microscope with 14 um resolution. The footprint of the primary ion beam of the SIMS mass spectrometer was 35x50 μm^2 FWHM, thus much larger than in laboratory SIMS instruments. The instrument temperature is about 10°C, therefore dust particles are analysed without any ices [10]. The advantage is a large integration area and therefore achieving reasonable averaging for the elemental composition analysis. The spectra of the time-of-flight reflectron mass spectrometer were calibrated, summed up for elemental ratios and analysed by statistical methods [11]. The fragmentation of the particles on impact as well as break-up due to charging by the primary ion beam was quantified by modeling as well as laboratory experiments with terrestrial analog material [12-14]. Fragments of different meteorites have been analysed with the COSIMA laboratory reference model [15].

2. Summary

The elemental composition of the dust particles collected and analysed with SIMS is heterogeneous. for the mineral forming elements Mg, Si, Ca and Fe within a factor of 2. The composition might be comparable to unequilibrated meteorites such as Tieschitz except for the high carbon content of up to 45% by weight. The fragmentation, either by low speed impact or by the Lorentz forces due to charging shows clumps or elements in the 10 to 40 µm size range which do not seem to break further up unlike laboratory analog material such as SiO_2 beads. Meteorite fragments from Renazzo, Murchison, Allende, Tieschitz, Ochansk do not break up on charging in the COSIMA reference instrument. The potential relation between reflectance and dust particle composition has been studied.

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