Heterogeneity of Cometary Dust Particles in the Coma of Comet 67P.

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Introduction: The COmetary Secondary Ion Mass Analyser (COSIMA) instrument 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 the laboratory techniques of optical microscopy and secondary ion mass spectrometry (SIMS) to in-situ measurements 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 have been collected at low impact speeds on metal targets and constitute a sample of the dust particles in the inner coma collected during the whole mission. 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 have been revealed. The elemental composition and the optical reflectance of the dust particles is heterogeneous [1-9]

Methods: Captured 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 composition measurements. The mass spectra of the time-of-flight reflectron mass spectrometer were calibrated and either summed up for elemental ratios or analysed by statistical methods [11]. The optical images were re-calibrated and the reflectance of the collected dust particles analysed for the illumination by red LED diodes at 645 nm. The fragmentation of the particles on impact as well as 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].

Discussion: The elemental composition of the dust particles collected and analysed with SIMS is heterogeneous. and no statistical significant differences beyond the one sigma confidence limit have been identified for the mineral forming elements Mg, Si, Ca and Fe. The composition is close 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 reflectance of the dust particles at 645 nm covers a wide range from 3 to 23%. No relation between reflectance and dust particle composition has been identified yet.

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