PHYSICAL PROPERTIES OF DUST PARTICLES COLLECTED BY THE COSIMA INSTRUMENT ON BOARD ROSETTA. N. Ligier[1,2], Y. Langevin[2], M. Hilchenbach[3], S. Merouane[3] and the COSIMA Team[3]. [1]School of Physical Sciences, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK. [2]Institut d'Astrophysique Spatiale, Univ. Paris-Saclay, 91405 Orsay Cedex, France. [3]Max-Planck Institute for Solar System Research, Göttingen, Germany. Contact: nicolas.ligier@ias.u-psud.fr

Introduction: The Rosetta spacecraft and its comprehensive payload reached comet 67P/Churyumov-Gerasimenko (67P hereafter) in August 2014 and, until September 2016, orbited around its nucleus. One of the prime objectives of the Rosetta mission was to better constrain the nature and the origin of cometary material. COSIMA (COmetary Secondary Ion Mass Analyzer), one of the instruments on-board the orbiter, is a Time of Flight Secondary Ion Mass Spectrometer (ToF-SIMS) dedicated to the chemical analysis of cometary particles, which are collected on nano-porous targets [**1**]. We present results concerning the physical properties of these particles based on imaging data from the microscope of COSIMA, COSISCOPE, which imaged the target with a resolution of 13.7 µm/pixel. This resolution allows to optically characterize the particles which fill up a significant fraction of the chemically analyzed spot (~100 µm FWHM).

Methodology: ~35.000 particles with an area larger than 100 µm² have been collected between August 2014 and April 2016. ~2.500 particles were collected on three targets exposed simultaneously during the first 4 months of the mission. The unexpected number of relatively large collected particles has made necessary the implementation of an automated method to detect and to characterize the outline of the collected particles. This method is based on a ratio of images taken after exposition to the cometary environment divided by reference images acquired before exposition. Each target is illuminated at high incidences (70° to 85° from the near to the far edge of the target) first from a LED at the right of the target, then from another LED at the left of the target. A study on the detection threshold has been carried out: if a pixel exhibits an increase of +100% of the signal after exposition, it is considered as an element of one of the collected grains (**figure 1**), that are sorted out by a connexity alogrithm. The position and area of each identified particle is then stored in a database for statistical analysis purposes.

Particles size distribution: The very high number of detection permits to get statistically significant results on the size distribution and its evolution over time: on average it follows a cumulative power law in $r^{-2.66}$ (excluding the mono-pixel grains that are the most difficult to detect, therefore very likely underestimated)

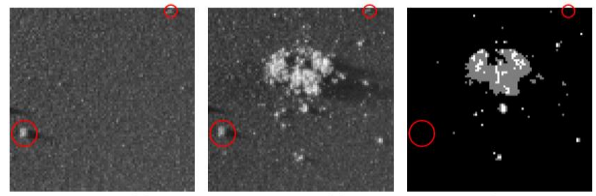

Figure 1. Result of the detection method. Artifacts (red circles) are not detected, thus showing the reliability of it. White pixels in the detection map correspond to the summit of the particles as they exhibits an increase of +100% of the signal for both LEDs illumination.

with a coefficient of determination (R^2) very close to 1 (**figure 2**). This result is slightly different of the cumulative power law of 30–150 µm particles ($r^{-1.9\pm0.3}$) obtained through a non-automated approach to analyze similar COSIMA data [**2**]. Further investigations on this subject will be carried out by the time of the meeting. Otherwise, the evolution of the power index does not change markedly over time, expect possibly during the frist few months with a slightly steeper slope ($r^{-2.35}$). Comparison with other laws obtained at different scales by other instruments highlights differences [**3, 4**] that can be interpreted by ejection mechanisms depending on the size associated with a bias caused by fragmentation of the grains during collection by COSIMA. This database will be complemented up to the end of the mission (September 2016) before LPSC.

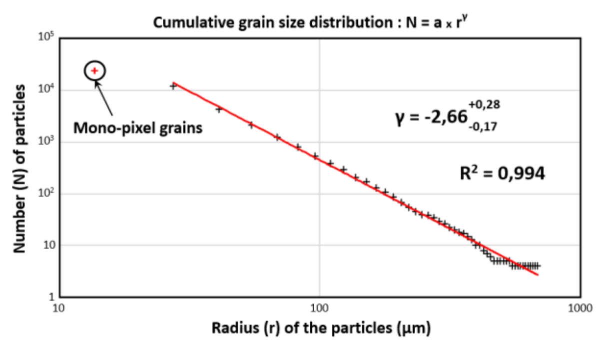

Figure 2. Cumulative grain size distribution of all the grains collected between August 2014 and May 2016.

Particles typology: ~500 large particles (surface ≥ 50 pixels) have been identified among collected particles. They have been categorized into two different families: (i) compact particles, which represent a small minority of grains (~10%), and (ii) aggregates which have a porous structure similar to that of micrometeorites collected in Antarctica and IDPs [**5**]. This supports a large contribution from complex organic material, a conclusion that is in agreement COSIMA ToF-SIMS analysis that confirmed the presence of high-molecular-weight organic matter in the particles of comet 67P [**6**]. The proportion of large particles with lower porosity ("compact particles" in the typology of [5] is > 20% during the first four months, then becomes very small (< 5%) close to perihelion (**figure 3**).

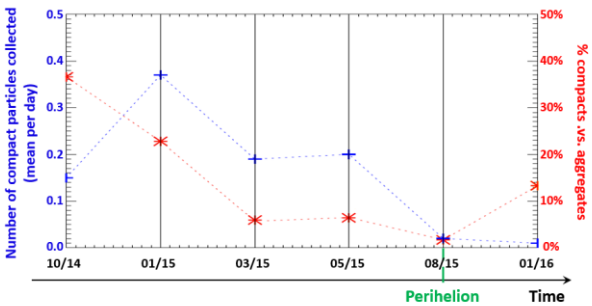

Figure 3. Evolution of the typology of the collected particles along the orbit. It clearly appears that the contribution of the compact particles decreases with the distance to the Sun.

Identifying compact particles becomes increasingly difficult for particles smaller than 100 µm, which are only imaged with a few pixels. However, the proportion of particles with lower porosity seems to remain high (> 20%) throughout the mission for particles in the 50 - 100 µm size range. The increasingly dominant contribution of aggregates in larger size ranges as the nucleus approach the perihelion could support the hypothesis of a "dust coat" covering a more pristine surface [**7**]. Finally, the electrostatic forces created by the primary ion source of COSIMA are able to modify the morphology of aggregates particles, including compact particles (**figure 4**). It suggests that even particles with low porosity have a low cohesive strength, as observed for cometary material at macroscopic scales [**8**] which support the view that 67P nucleus results from a non-collisional process in the proto-solar nebula [**9**].

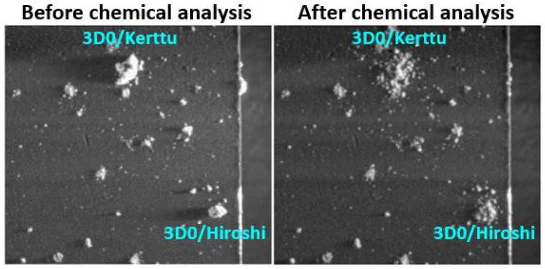

Figure 4. Morphological evolution of two compact particles (3D0/Kerttu and 3D0/Hiroshi).

References: [**1**] Kissel et al., (2007), SSRv, 128, 823–867. [**2**] Merouane et al., (2016), A&A, 596, A87. [**3**] Rotundi et al., (2015), Science, 347, aaa3905. [**4**] Poulet et al., (2016), MNRAS, 462, S23–S32. [**5**] Langevin et al., (2016), Icarus, 271, 76–97. [**6**] Fray et al., (2016), Nature, 538, 7623, 72–74. [**7**] Schulz et al., (2015), Nature, 518, 7538, 216–218. [**8**] Groussin et al., (2015), A&A, 583, A32 [**9**] Davidsson et al., (2016), A&A, 592, A63.