Microstructure of 67P dust: Insight into dust agglomeration and comet formation

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The MIDAS (Micro-Imaging Dust Analysis System) atomic force microscope on board the Rosetta orbiter acquired high-resolution 3D images of relatively unaltered, micrometre-sized dust particles of comet 67P/Churyumov-Gerasimenko. This unique dataset allows the morphological investigation of cometary dust on the micro- to nanometre scale, in particular the identification of its subunits and a structural analysis. As subunit size and arrangement are key parameters determining where, when and how dust agglomerated in the presolar disk, MIDAS results are an important input for the post-Rosetta understanding of the evolution of our early Solar System. This talk gives an overview and a first interpretation of the morphologic features of the dust particles collected by MIDAS. Among hundreds of dust units all show an agglomerate character (1) where the subunit size distributions of over 20 investigated particles seem independent of particle morphology or collection time. The smallest detected subunits measure less than 100 nanometres (2), a size in agreement with measurements for the smallest units at comet Halley and Wild 2; however, it cannot be concluded if they are the fundamental building blocks or again agglomerates. The general structure of the dust is suggested to be that of hierarchical agglomerates, as all dust units investigated with sufficient resolution are found to be built of smaller subunits where the subunits show rather narrow size distributions. A more detailed structural analysis was conducted on the tens of micrometre sized dust particles. Most show a packing far from maximally compact, but also less porous than the structure of one outstanding particle revealing a fractal structure with a dimension as low as 1.7 ± 0.1 (3). The latter structure matches the predictions for particles created in the early Solar System by subsequent agglomeration of aggregates (Cluster-Cluster Agglomeration) rather than the steady accretion of smallest monomers to a larger agglomerate (Particle-Cluster Agglomeration)(4,5). As dust growth is predicted to transition into a compaction phase (6), the more compact particles could be representative of the dust after compaction and integration into the comet, whilst the fractal dust would be a well-preserved remnant of an early growth phase. This interpretation is further strengthened by the surprisingly similar subunit size distributions of the fractal and the compact particles, suggesting a similar origin for all the dust particles.