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# Single minerals, carbon-and ice-coated single minerals for calibration of GIADA onboard ROSETTA to comet 67P/Churyumov-Gerasimenko

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## Abstract

In preparation of the rendezvous of the ESA Rosetta spacecraft with comet 67P/Churyumov-Gerasimenko we undertook the selection and characterization of mineral grains to serve as cometary dust analogs for payload calibration activity. In particular we used them to check the performances of the Grain Impact Analyser and Dust Accumulator (GIADA) mounted on-board Rosetta.

## 1. Introduction

The ESA Rosetta spacecraft will rendezvous during July 2014 with short period J-F comet 67P/CG. It will follow the active comet along its orbit from ~4 A.U. to perihelion, and possibly beyond. The Rosetta orbiter includes GIADA [1, 2], which will analyze the dust environment of 67P/CG as a function of decreasing heliocentric distance. GIADA consists of three subsystems: the Grain Detection System (GDS), which will detect the transit of each grain entering inside GIADA and will measure its optical cross section; the Impact Sensor (IS) that will measure the momentum released by the same grain passed through GDS and the Micro Balance System (MBS) that will measure the cumulative dust deposition rate. The coupled detection GDS + IS will determine the speed and mass of individual dust particles. Our selection of suitable natural analog minerals was guided by the asteroid-like mineralogy detected in the Jupiter Family comet Wild 2 grains. Using the GIADA Proto Flight Model (PFM) a wide selection of well-characterized comet dust grain analogs is used to calibrate the GIADA responses.

## 2. Experimental Procedures

We produced three types of analogs: monomineralic grains, monomineralic grains + C coating and monomineralic grains + $Na_2SiF_6$ coating. The analog grains morphology, size and composition were characterized using a ZEISS Supra25 FE-SEM/EDS.

### 2.1 Monomineralic grains

The monomineralic analogs are all natural materials from well-documented geological locations. The selected minerals with the relative average chemical (EDS) composition are shown in Table 1. The size fractions for each analog mineral, except corundum, were obtained by milling 15 g of material inside a centrifugal ball mill. Corundum grains were milled with a 20-ton press. Afterwards, all milled materials were sieved using a vibratory sieve shaker. Four size fractions, viz. 500-250 µm, 250-100 µm, 100-50 µm and 50-20 µm, were obtained for each mineral.

Table 1: FE-SEM/EDS analyses of the selected cometary dust analog.

| Minerals | Average composition |
|---|---|
| Forsterite | $Mg_{1.90}Fe_{0.10}Si_{1.00}O_4$ |
| Fayalite | $Fe_{1.75}Mg_{0.13}Mn_{0.02}Si_{1.00}O_4$ |
| Melilite | $Ca_{1.61}Na_{1.40}Al_{0.41}Mg_{0.51}Fe_{0.08}Si_{1.99}O_7$ |
| Enstatite | $Mg_{1.80}Fe_{0.20}Si_{2.00}O_6$ |
| Alkali-feldspar | $Na_{0.05}K_{1.04}Al_{10.5}Si_{2.95}O_8$ |
| Anorthite | $Ca_{0.97}Na_{0.08}Al_{1.88}Si_{2.10}O_8$ |
| Serpentine | $Mg_{2.75}Fe_{0.15}Cr_{0.02}Al_{0.20}Si_{1.89}O_7$ |
| Talc | $Mg_{3.06}Si_{3.97}O_{11}$ |
| Kaolinite | $Al_{2.01}Si_{2.00}O_7$ |
| Pyrrhotite | $Fe_{0.98}S$ |
| Corundum | $Al_{2.00}O_3$ |

### 2.2 **Monomineralic grains + C**

To cover the monomineralic grains with C, a Nd-YAG solid state pulsed laser is used to hit a carbon target inside a condensation chamber in which the grains are positioned, using the same experimental conditions previously used by [3]. Operating under different experimental conditions it is possible to have two different structures of the carbon coating. The carbon deposition process at low pressure (8 x $10^{-3}$ mbar) produces a compact and continuous layer of globular aggregates of carbon nanograins that are ~20 nm in diameter. When produced at higher pressure (10 mbar, Ar) the coating is a highly porous (low-density), fluffy aggregate material. While the globular carbon layer is typically well adhered to the mineral surface, the fluffy carbon aggregates are more loosely attached. During the coating process the grains were manipulated to ensure that the entire grain surface was coated.

### 2.3 **Monomineralic grains + $Na_2SiF_6$**

To simulate comet particles with a water-ice surface layer we used sodium hexafluorosilicate ($Na_2SiF_6$) crystals. They are stable at room temperature, and their refractive index is close to that of water-ice [4] at the GDS laser source wavelength (915 nm). We prepared a solution of deionized water and $Na_2SiF_6$ to cover individual mineral grains of each material and in each selected size range. This solution was then dropped onto single grains. Depending on the crystal growth rate it is possible to obtain two different types of surface covering: columnar hexagonal crystals (size range 100-200 µm) and stellar dendrites or radiating dendrites (~5 µm wide branches) (Fig. 1). The mineral grains were then turned upside down and the crystallization process was repeated to cover also their underside.

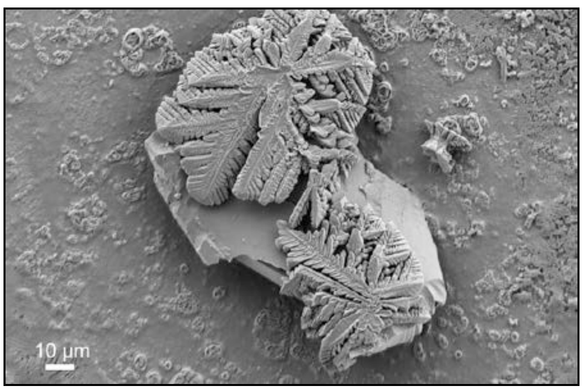


Figure 1: forsterite grain (100-50 µm size bin) partially covered by stellar $Na_2SiF_6$ dendrites.

## 5. Discussion and Conclusions

The comet dust analogs are used to calibrate GIADA performances and support data reduction once at the comet. The calibration activities are conducted inside a class-100 clean room using GIADA PFM. A stereo-microscope, connected to a PC equipped with an images acquisition and processing software is installed next to GIADA PFM. It is used to select and image each individual comet dust analog grain to be measured by the GDS and the IS sub-systems. Single analog grains of a specific mineral and specific size bin are placed under the stereo-microscope for preliminary inspection and imaging; the specific size of each grain is measured and the shape is recorded. A grain that is judged suitable to be measured is then launched into GIADA PFM. The capture of the grain can be done in two different ways depending on the method used to shoot the grain: (a) catch and shoot with an electrostatic micromanipulator [5]; (b) catch and shoot with an air gun. The response of the GDS, IS and combined GDS + IS sub-systems to the different comet analog grain types and different sizes will generate the calibration curves that constitute the database.
We present our rationale for selecting comet dust analog minerals, and minerals coated with a carbon or water-ice analog layer, and the characterization of their chemical compositions, size, shape and morphology.

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## References

[1] Colangeli, L., et al., 2007. Space Sci. Rev. 128, 803-821.

[2] Della Corte, V. et al., 2014. J. Astronom. Instrum. 1350011, 1-11.

[3] Rotundi, et al., A. 2002. Meteorit. Planet. Sci. 37, 1623-1635.

[4] Ulanowski, Z. et al., 2003. J. Quantit. Spectr. Rad. Transf. 79–80C, 1091-1102.

[5] Sordini, R. et al., 2013. MemSAit. In press.