Mineralogy, defect microstructure and shock metamorphism of Hayabusa particle RB-QD04-0042

F. Langenhorst[1], D. Harries[1], K. Pollok[1] and P.A. van Aken[2]. [1]Institute of Geoscience, Friedrich Schiller University Jena, Carl-Zeiss-Promenade 10, D-07745 Jena, Germany. E-mail: Falko.Langenhorst@uni-jena.de. [2]Max Planck Institute for Intelligent Systems, Heisenbergstr. 3, D-70569 Stuttgart, Germany.

Introduction: In the first international announcement of opportunity for Hayabusa sample investigation we have received two precious samples [1]: RA-QD02-0115 and RB-QD04-0042. Here we report detailed scanning (SEM) and transmission electron microscopic (TEM) investigations of Hayabusa sample RB-QD04-0042, which was originally described to be mainly composed of olivine. Our study aimed at characterizing the mineral´s defect microstructures as clues to the origin of asteroidal regolith.

Methods: Mineral grains and morphology of RB-QD04-0042 were at first studied by scanning electron microscopy and energy dispersive X-ray microanalysis (EDX) using a FEI Quanta3D cross beam workstation. Furthermore, this workstation was used for precise focused ion beam (FIB) preparation of TEM foils. Defects and mineral structures were subsequently studied by means of a Philips CM200 transmission electron microscope equipped with an EDX microanalysis system.

Mineralogy: The olivine grain RB-QD04-0042 being 40 x 50 µm in size turned out to carry an intimate 10 µm wide intergrowth of FeNi alloy and iron sulfide on its surface. Furthermore a 6 µm diameter diopside inclusion emerged in the course of FIB cutting of the olivine.

TEM analyses of the FeNi alloy show a high Ni content of about 50 atom% and electron diffraction patterns reveal a face-centered cubic (fcc) structure, both being compatible with tetrataenite [2]. Electron diffraction patterns of the iron sulfide were in agreement with the stoichiometric iron sulfide troilite.

Defect microstructures: All phases discovered in the SEM were then studied by TEM in terms of their defect microstructures. Olivine contains locally a high density of [001] dislocations, while in other regions olivine is devoid of defects. Tetrataenite exhibits a large number of mechanical microtwins and dislocations. Troilite contains some stacking faults with partial dislocations but is mainly characterized by a recrystallization texture with numerous subgrains composing the entire grain. Diopside is basically defect-free.

Discussion: In agreement with previous studies [2] the compositions of silicates and FeNi alloy point to an ordinary chondrite signature of Hayabusa dust. The majority of defects found in RB-QD04-0042 minerals are known to form by shock metamorphism, in particular the [001] dislocations in olivine and the microtwins in tetrataenite. The heterogeneous distribution of defects may indicate micro-impacts as possible cause.

Acknowledgments: Financial support was provided by the Deutsche Forschungsgemeinschaft (LA 830/14-1). We are very grateful to JAXA for providing access to Hayabusa samples.

References:

[1] Abe M. et al. 2012. *Meteoritics & Planetary Science* 47:A35. [2] Uehara et al. 2011. *EPSL* 306: 241-252. [3] Nakamura T. et al. 2011. *Science* 333: 1113-1116.