RAMAN MICROSCOPY OF HAYABUSA PARTICLE RA-QD02-0051.

U. Böttger[1], C. Alwmark[2], S. Bajt[3], H. Busemann[4], J.D. Gilmour[4], U. Heitmann[5], H.-W. Hübers[1,6], M.M.M. Meier[2], S.G. Pavlov[1], U. Schade[7], N.H. Spring[4], I. Weber[5]. [1]Inst. of Planet. Res., DLR Berlin, Germany (ute.boettger@dlr.de), [2]Dept. of Geol., Univ. of Lund, Sweden, [3]Photon Sciences, DESY, Hamburg, Germany, [4] SEAES, Univ. of Manchester, UK, [5]Inst.f. Planet., WWU Münster, Germany, [6]Techn. Univ. Berlin, Germany, [7]Helmholtz-Zentrum Berlin (HZB), Germany.

Introduction: Raman microscopy measurements are performed on Hayabusa sample RA-QD02-0051, provided by JAXA to our consortium in the scope of the 1st International Announcement of Opportunity[1]. Raman microscopy is applied to identify the mineral phases of the particle. The interpretation of the spectra shows that the sample consists of olivine, pyroxene and feldspar.

Sample: The Hayabusa sample RA-QD02-0051 (size 50µm) is one of seven samples provided by JAXA to our consortium [2]. The particle was already investigated with SEM and SIMS by Yurimoto [3]. For this the particle was embedded in epoxy, and cut with an ultramicrotome. The remaining "potted butt" was scanned by SEM and mass spectroscopy. Thus, the surface of the particle and the epoxy were coated with Au as well as with C. This has to be considered for the interpretation of the Raman spectra. In addition, it led to high fluorescence in the spectra.

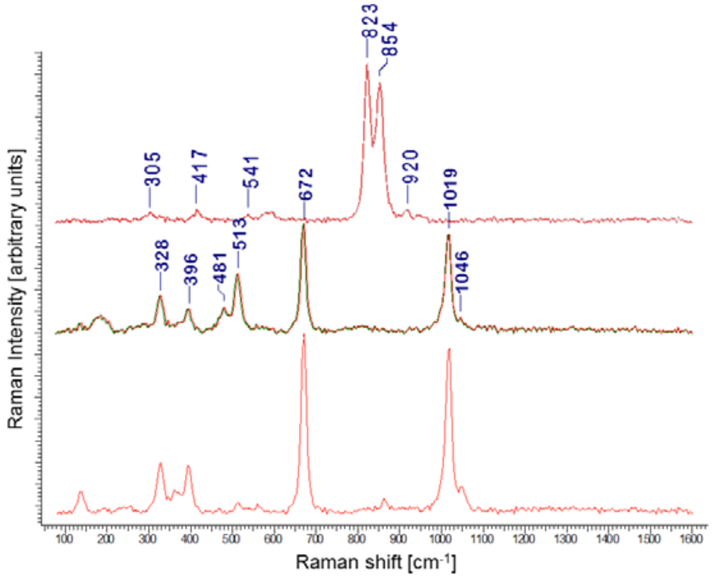

Fig. 1: Background-corrected Raman spectra from single points of the sample. The top spectrum represents olivine. The Raman spectrum in the middle represents pyroxene and feldspar. The bottom spectrum represents pyroxene.

Measurements: Single spectra were measured on different parts of the sample to identify the minerals. Additionally, a scan was performed to demonstrate the distribution of these phases. The Raman measurements were performed with a Witec Alpha 300 Raman microscope. The laser wavelength is 532 nm. The spectral resolution is about 4 cm^{-1}. With the 100x objective the spot size on the sample is less than 1 µm. The polarization effects of the sample were taken into account by including at each point measurements at different positions of the polarizer. For the single measurements the measurement time is 120s and the power on the sample is 200 µW. For the scan the measurement time is 10s per spectrum and the power on the sample is 4 mW. Tests and calculations according to Dubessy [4] indicate that this laser power should not heat a particle of a size of ~50 µm consisting of the aforementioned minerals more than 22 K. However, since the sample resin remained covered with some C and Au coating even after cleaning, the resin was heated and a ductile mass was produced by the laser. Nevertheless, the sample appears not to be influenced by this heating.

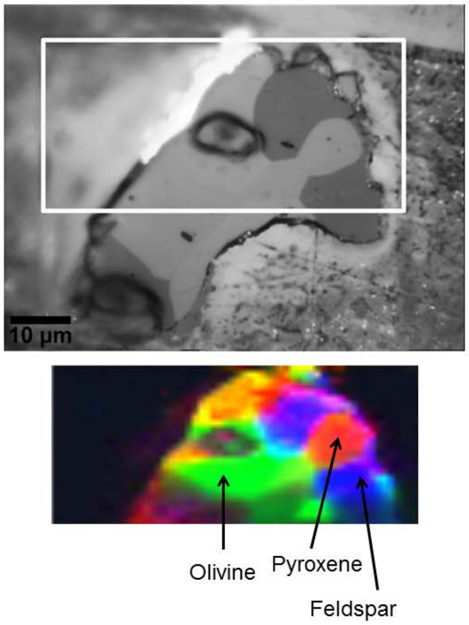

Fig. 2: Upper part - microscopic image of the Hayabusa sample RA-QD02-0051. Lower part – Raman scan of the sample (white square in upper image); the colors represent the mineral phases derived from the Raman spectra: red - pyroxene, green – olivine, blue – feldspar. The mixed colors contain more than one mineral phase.

Results and discussion: The Raman spectra measured on single points of the sample are shown in Figure 1. The upper Raman spectrum represents olivine. The Raman shifts of the main spectral lines are at around 823cm^{-1} and 854 cm^{-1}. Hence, the olivine consists mainly of forsterite. According to [5] and [6] it ranges between Fo$_{80}$ – Fo$_{90}$. The bottom spectrum represents pyroxene. The characteristic Raman shifts are at 672 cm^{-1}, 1019 cm^{-1}, 328 cm^{-1} and 395 cm^{-1}. Further investigation is necessary to determine the specific composition and crystalline symmetry. The Raman spectrum in the middle is a mixture of pyroxene and feldspar. The Raman shifts of the symmetric T-O stretching and the O-T-O deformation modes in the TO groups (T can be K, Ca, Na) characterizing the feldspar are around 481 cm^{-1} and 513 cm^{-1}. According to Freeman et al. [7,8] the mineral phase is probably K- feldspar. A more detailed investigation is necessary to find out weather it is an orthoclase or a plagioclase and will be presented at the meeting. Figure 2 shows the scan of one area. Mineral phases and mixtures of phases up to dimensions of 20 µm can be distinguished. The mineral phases derived from the Raman spectra are pyroxene, olivine, and feldspar. These phases correspond to the minerals reported by Noguchi et al. [9] determined by SEM measurements on the sample. The areas with mixed colors contain more than one mineral. These areas will be compared with SRXTM measurements to separate the phases in 3D [10].

Conclusions: Raman microscopy on Hayabusa particle #51 was applied for initial nondestructive mineralogical analysis and showed a heterogeneous distribution of pyroxene, feldspar and olivine. The specific position of the Raman lines allows the more precise classification e.g. of olivine as Mg-rich Fo$_{80\text{-}90}$ and feldspar as a K-feldspar. For a more precise characterization of the pyroxene and feldspar a more detailed analyses of the spectra is planned. The annealed appearance of the mineral structures may suggest that this particle might be a part of an LL6 area [8].

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References: [1] http://adsabs.harvard.edu/abs/2012M%26PSA..75.5251A. [2] Busemann H. (2013) *LPSC* (this meeting). [3] Yurimoto H. (2012) Curational Data. [4] Dubessy J. et al. (2012) *EMU Notes in Mineralogy*, *Vol. 12*, Chapter 3, 83–172. [5] Kuebler, B. L. et al. (2006) *Geochimica et Cosmochimica Acta 70*, 6201–6222. [6] Gaisler S.V. et al. (2007) *J. Struct. Chem. Vol. 48*, No. 1, pp. 61-65. [7] Freeman J. et al. (2003) *LPSC XXXIV*, Abstract #1676. [8] Nakamura T. et al. (2011) *Science 26*, *Vol. 333*, 1113 – 1116. [9] Noguchi T. (2012) Curational Data. [10] Meier M.M.M. et al. (2013) *LPSC* (this meeting).