LUMINESCENCE SPECTROSCOPICAL PROPERTIES OF PLAGIOCLASE PARTICLES FROM HAYABUSA SAMPLE RETURN MISSION. A. Gucsik[1,2], H. Nishido[3], K. Ninagawa[4], A. Kereszturi[1], T. Nakamura[5], A. Tsuchiyama[6], C. Jäger[7], U. Ott[8] and M. Kayama[9] [1]Konkoly Thege Miklós Astronomical Institute, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences; [2]Department of Geology, University of Johannesburg, Johannesburg, 2600 Auckland Park, South Africa, (E-mail: argu1986@hotmail.com). [3]Department of Biosphere-Geosphere System Science, Okayama University of Science, 1-1 Ridai-cho, Okayama, 700-0005, Japan; [4]Department of Applied Physics, Okayama University of Science, 1-1 Ridai-cho, Okayama, 700-0005, Japan; [5]Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, Sendai 980-8578, Japan; [6]Kyoto University, Faculty of Science, Graduate School of Science, Division of Earth and Planetary Sciences, Kitashirakawaoiwake-cho, Sakyu-ku, Kyoto-shi, 606-8502, Japan; [7]Max Planck Institute for Astronomy, Helmholtzweg 3, Jena, D-07745, Germany; [8]Savaria University Center, University of West Hungary, Karolyi Gaspar ter 4., Szombathely, H-9700, Hungary; [9]Department of Earth and Planetary Sciences, Faculty of Science, Kobe University, 1-1 Rokkodai-cho, Nada-ku, Kobe 657-8501, Japan

Introduction: We report a systematic spectroscopical investigation of plagioclase particles (RA-QD02-0025-01 and RA-QD02-0025-02) returned by the Hayabusa spacecraft from asteroid Itokawa, by means of scanning electron microscopy, cathodoluminescence microscopy/spectroscopy as well as Micro-Raman Spectroscopy. The cathodoluminescence properties are used to evaluate the crystallization effects and shock wave history as well as the degree of space weathering processes of asteroid Itokawa. This can aid in understanding more about the formation mechanism of the LL chondrites. Furthermore, they provide new insights regarding spectral changes of asteroidal bodies due space weathering processes.

Samples and Experimental Procedure: A systematic cathodoluminescence investigation was done at Okayama University of Science (Okayama, Japan), as follows. A SEM-CL system containing a SEM (JEOL: JSM-5410LV) combined with a grating monochromator (OXFORD: Mono CL2), having a retractable parabolic mirror coated with aluminium (collecting efficiency of 75 %), provided the CL spectral measurements for this study.

Raman spectral measurements were carried out using a LabRam Confocal Spectrometer (632 nm excitation) for the single spectrum at Max Planck Institute for Astronomy (Jena, Germany) and for the Raman mapping by a WITec Alpha 300 spectrometer (532 nm) at Department of Geology, University of Johannesburg (South Africa).

Results: Two plagioclase samples (RA-QD02-0025-01 and RA-QD02-0025-02) were selected for the systematic Scanning Electron Microscope-Cathodoluminescence (SEM) imaging including Backscattered Electron (BSE), Secondary Electron Images (SE) and Cathodoluminescence (CL) (Fig. 1a-e). In general, there is a homogeneous distribution of the CL patterns. Only the RA-QD02-0025-01 sample shows some CL-zoning, which may be due to the thermal effect of the irradiation delivered from the synchrotron-XRD investigation [1,2]. Otherwise, neither shock metamorphism including high-pressure polymorphs (i.e, maskelynite) nor shock-induced microdeformations such as Planar Deformation Features (PDFs) can be discernible in the selected samples and imaging properties.

Cathodoluminescence spectral features of two Hayabusa plagioclase samples exhibit two emission centers: a broad band at around 450 (2.82 eV) and a shoulder peak at around 420 (3.04 eV) nm (Figs. 1a and 1b; 2a,b,d,e). Spectral composition after deconvolution shows two components at around 2.8 (defect center) and 3.0 eV (Ti-activator) (Figs. 2c and f). Raman spectral features have peak positions at 485, 500 and 514 cm^{-1} (bending modes) [3], which are superimposed on relatively high background fluorescence. These observations indicate that both particles have a highly disordered crystalline structure, which would be occurred by a shock event or radiation effect. However, further investigation must be done to classify these processes.

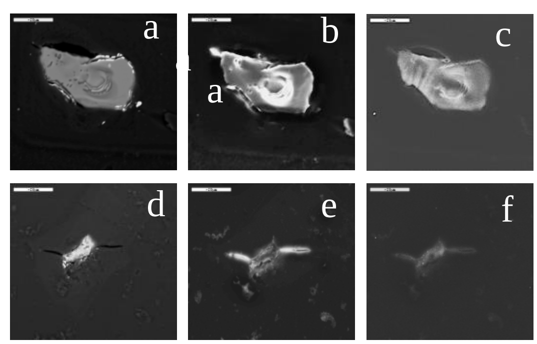

Figure 1. *Scanning Electron Microscope-Cathodoluminescence (SEM-CL) imaging of the selected grains (upper row:RA-QD02-0025-01, lower row: RA-QD02-0025-02) showing backscattered electron (BSE-a and d), secondary electron (SE-b and e) as well as cathodoluminescence (c and f) images.*

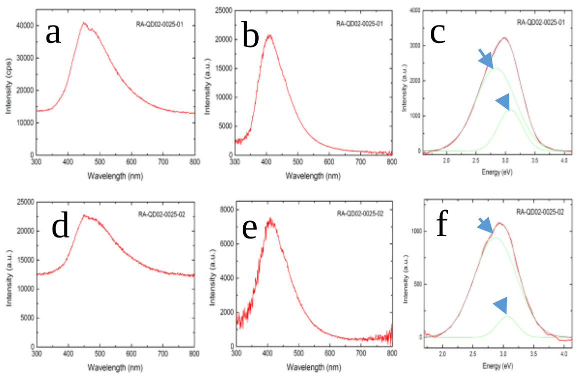

Figure 2. *Cathodoluminescence (SEM-CL) spectral features of the selected grains (upper row:RA-QD02-0025-01, lower row: RA-QD02-0025-02) showing measured (a and d), corrected (b and e) as well as deconvoluted (c and f) spectra.*

Discussion: The activator-related emission centers in feldspars can be summarized as follows. In general, the luminescence emission band centered at around 570 nm is due to Mn^{2+} in M sites (most probably Ca^{2+} sites) and is most clearly detected in plagioclases [4,5]. It is less common in K-feldspars because of the difficulty of the Mn^{2+}-K^{+} substitution (Mn concentrations in terrestrial alkali feldspars are mostly< 10 ppm). Measurements on synthetic [5] and natural plagioclases [6] have shown a clear correlation between the intensity of the green emission band and the manganese content from <10 ppm up to a critical self-quenching value of about 1 mole percent Mn^{2+}. Furthermore, Mn^{2+} activation is common in extraterrestrial plagioclases. For example, in the studied lunar and meteoritic plagioclases the emission due to Mn^{2+} plays a key role as one of the most intense emission centers [7,8]

Because of the sensitivity of the Mn^{2+} emission to the local crystal field, a shift of the emission band to longer wavelength due to the shock metamorphism can be detected. Reddish-orange emission in feldspars due to vitrification of plagioclase by shock waves was reported by Sippel and Spencer [9] or due to lattice damage caused by impact events by Ramseyer et al. [10].

Geake et al. [7] and Telfer and Walker [5] showed that the red emission band around 700 nm is due to the $^4T_1$ 6 $^6A_1$ emission of Fe^{3+}, which occupies Al^{3+} tetrahedral sites in the feldspar. Generally, the Fe^{3+} emission is very common in many terrestrial feldspar types, but it is weak or absent in lunar plagioclases, which has been ascribed to low f_{O2} during plagioclase crystallization [4]. Nevertheless, the occurrence of the CL emission band at ~700 nm indicates that at least some of the iron in lunar plagioclases is ferric iron [8].

Conclusions: It was observed that the CL image as well as spectral properties of plagioclase samples exhibit bright emissions in blue region with relatively homogeneous intensity. This implies that the plagioclase formed by thermal metarmorphism at subsolidus temperature at an extreme low oxygen fugacity. In this case, plagioclase has often little or no Mn^{2+}, because Mn^{2+} does not fit well in the Na^{+} position. However, further analyses on these particles must be done in the future work.

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