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X-ray diffraction analysis of Itokawa regolith particles returned by Hayabusa space mission

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Introduction

The spacecraft Hayabusa has succeeded to collect dust particles from MUSES-C Regio of the asteroid Itokawa (Nakamura et al., 2011). The dust particles are very small, ranging in size typically from several to one hundred microns. High-quality, multidiscipline analyses are required to draw maximum information from such tiny particles. We performed, as a part of the initial analysis of Itokawa particles, synchrotron X-ray diffraction analysis of individual dust particles at beamline 3A to identify mineral species and to determine relative mineral abundances.

Experimental procedures

Samples are 40 Itokawa particles that were recovered from Room A in the sample catcher device of Hayabusa sample capsule (Nakamura et al. 2011). The 40 particles were individually attached to the tops of carbon fibers 5 μm in diameter (Fig. S5) in the atmosphere in the class 1000 clean room, using a small amount of epoxy resin EMbed 812 that was preheated for 5 minutes at 90°C to increase the viscosity. After attachment to the carbon fiber, each sample particle was immersed into epoxy resin again that was preheated for 1 minute at 90°C to reduce the viscosity, so that the entire surface of the particle become covered with thin layers of epoxy, to prevent further atmospheric weathering. CT analysis confirmed such a thin (~ several μm thick) coverage of epoxy around the particles. Each sample particle with an epoxy surface was then heated in a constant-temperature bath for 20 minutes at 90°C to consolidate the epoxy completely. The duration of time for the sample particle exposed to atmosphere in the clean room, i.e., time interval between removal from the nitrogen atmosphere of room 2 and being covered by epoxy resin was 6 hours or shorter, which minimized alteration of Itokawa particles by terrestrial air.

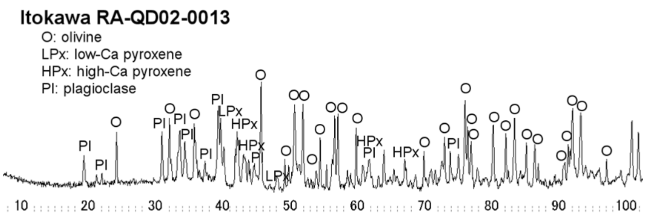
Synchrotron-radiation X-ray diffraction analysis was performed using an undulator beam of 2,16Å at beamline 3A. The sample particle was set in a Gandolfi camera equipped with an X-ray fluorescence detector. The average exposure time was 30 minutes and the diffraction pattern was recorded in an imaging plate. The data was read by BAS 2500 imaging plate reading system and transferred to PC in order to analyze the diffraction pattern using a GANCON software developed by us.

Results and discussion

The results show that almost all Itokawa particles gave very sharp diffraction maxima, suggesting that constituent minerals are well crystalline (Fig. 1). However, plagioclase crystals exhibited a wide range of crystallinity probably due to shock-induced deformation. Major constituent minerals are olivine, low- and high-Ca pyroxene, plagioclase, and troilite and minor phases include chromite, Ca-phosphates, and NiFe metal. The high crystallinity indicates that the minerals underwent thermal annealing in the interior of the parent body that had broken up into pieces from which asteroid Itokawa formed.

References

[1] T. Nakamura et al., *Science* **321**, 1664-1667 (2008). [2] T. Nakamura et al. Abstract #1776. 42nd Lunar Planet. Sci. Conf. (2011). [3] Tsuchiyama A. et al. Abstract #1777. 42nd Lunar Planet. Sci. Conf. (2011).



(Fig. 1) X-ray diffraction pattern of a Itokawa regolith particle with size of 100 micron.