MS095.O02

Mineralogy and crystallography of return samples from primitive asteroids

Tomoki Nakamura[1], Takaaki Noguchi[2], Masahiko Tanaka[3]
[1]*Tohoku University, Sendai, Japan,* [2]*Kyushu University, Fukuoka, Japan,* [3]*National Institute for Materials Science, Sayo, Japan*
E-mail: tomoki@m.tohoku.ac.jp

Mineralogy and crystallography of dust particles returned from primitive asteroid Itokawa are summarized. Itokawa is a small rubble-pile S-type asteroid with a dimension of 0.5 x 0.3 x 0.2km. Spacecraft Hayabusa returned small amounts of dust particles from the surface of Itokawa in June 2010, with the ultimate objective to answer to the question "Are S-type asteroids really parent objects of ordinary chondrites that are the most common meteorites falling to the Earth?". In spite of small particle size, formation and evolution process of the asteroid was elucidated based on mineralogical and crystallographic evidence. Synchrotron X-ray diffraction analysis was applied to many Itokawa dust particles and the results indicate that they are mainly composed of well-crystalline olivine, low- and high-Ca pyroxene, plagioclase, Fe-sulfides and FeNi metal. Chemical compositions of the silicates are highly equilibrated within the compositional range of ordinary chondrites. This clearly indicates that ordinary chondrites came from S-type asteroids. The homogeneous silicate compositions suggest the particles experienced long-term thermal metamorphism at subsolidus temperature of silicates [1]. The crystallization temperature of Itokawa plagioclase was estimated based on a plagioclase geo-thermometer using sodic plagioclase triclinisity and the observed plagioclase crystallization temperatures were in a range from 655 to 660 °C [2]. Pyroxene thermometry was applied to Itokawa pyroxene and the results indicate that the peak metamorphic temperature is approximately 800°C [1]. The observation suggests that Itokawa was originally formed as a S-type asteroid with a radius of 20km or larger, most likely 2.2Myr after CAIs, the oldest solar system material [e. g., 1]. The asteroid was likely an onion shell asteroid, but later a catastrophic impact has broken the asteroid into smaller fragments and re-accumulation of fragments lead to the formation of a smaller rubble-pile asteroid [1]. Therefore, impacts played an important role for formation and evolution of asteroid Itokawa. A variety of impact effects are identified in Itokawa dust particles. Short cosmic exposure age suggests that Itokawa surface is not matured. Itokawa surface experienced space weathering and the weathered particles have surface covered with FeS-rich sputtered deposition, and subsurface consists of thin layers of amorphous silicates with many Fe-rich nanoparticles [3]. This suggests that solar-wind irradiation has induced sputtering and reduction of surface layers of regolith particles, which is responsible for incipient space weathering effects.

[1] Nakamura T. et al. (2011) Science 333, 1113.
[2] Tanaka M. et al. (2014) Meteor. & Planet. Sci. 49, 237.
[3] Noguchi T. et al. (2011) Science 333, 1221.

Keywords: Itokawa, Return sample analysis, Hayabusa mission