SUBARU Spectroscopy of Asteroid (832)Karin; Determining Time Scale of Space Weathering. T. Sasaki[1], S. Sasaki[1], J. Watanabe[2], H. Kawakita[3], T. Fuse[4], N. Takato[4], and T. Sekiguchi[2], [1]Department of Earth & Planetary Science, Graduate School of Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan, takanori@eps.s.u-tokyo.ac.jp, [2]National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan, [3]Gunma Astronomical Observatory, 6860-86 Nakayama, Takayama, Gunma 377-0702, Japan, [4]Subaru Telescope, National Astronomical Observatory of Japan, 650 North Aohoku Place, Hilo, HI96720, USA.

1. Introduction: Space weathering is the term applied to the darkening and reddening of the surface in the planetary materials with time. The reflection spectra of asteroids show unknown mismatches to those of meteorites due to the weathering, though asteroids are believed to be parents of meteorites. The detailed mechanism of this space weathering has been remained to be unsolved until 2001, when Sasaki et al. [1] confirmed Hapke's old hypothesis that the spectral darkening and reddening are caused by formation of nano iron particles on the basis of pulse-laser irradiation experiments simulating micrometeorite impacts [2, 3]. As shown in Fig.1, the reflection spectra of the altered olivine in which high-energy laser experiments match with typical spectra of two S-type asteroids produced the iron nano-particles.

The next step to be done is to estimate the time scale of the space weathering by seeing the spectra of new-born asteroids. The time-scale for weathering at 30-100 mJ levels for reproducing the observed spectra of asteroids are generally thought to be an order of 10^8 years [1]. If there is a new-born asteroids which the age is well known, we may be able to see the relatively un-weathered surface, and to know the time-scale of the weathering by comparing the their spectra with those of olivine and pyroxene in laser experiments.

2. New-born asteroid (832)Karin: Surprisingly, recent researches in the celestial mechanics shows an existence of such a new-born group of asteroids, which is (832)Karin cluster group thought to be remnants of a recent breakup of only 5.8 million years ago [4]. We contacted to people in the celestial mechanics about this findings, especially to Dr. Yuasa who insisted in the existence of new-born asteroid families about 20 years ago. They do not have any doubt on the procedure of deriving the age of (832)Karin group. Therefore, we decided to propose this trial by seeing the brightest asteroids (832)Karin for the above purpose.

3. Observation and data analysis: A near-infrared spectroscopic observation of Karin was performed by the 8-m Subaru telescope with Cooled Infrared Spectrograph and Camera for OHS (CISCO) [5] on 2002 September 14.6 (UT). In order to obtain wide range spectrum in the near-infrared region, the grisms named "zJ", "JH", and "wK" were used. The slit size was 108 arcsec x 0.5 arcsec in our observation, and the typical seeing size at the observation was about 0.3 arcsec in K band.

The total integration time for Karin was 2400 s for each setting. We put the asteroid on the slit at two different positions (A and B) to subtract sky background emissions by the (A-B) operation. Nodding angle was 20 arcsec for the observations. For the cancel of telluric absorption features, a reference star (HIP3990) was observed just after Karin observation. The difference in the airmass at the observations of the asteroid and the reference star was smaller than 0.1 for each grism setting. The reference star was also observed at the A and B positions.

We used NOAO IRAF astronomical software package to reduce the near-infrared spectra obtained by CISCO. First of all, dark-subtraction and flat-fielding were applied for all frames. The OH sky emission lines were used for the wavelength calibration. The Karin spectra were divided by spectra of the reference star to cancel the telluric absorption features. Thus we can get the near-infrared spectrum of the reflectance in asteroid (832)Karin. Then we also carried out photometry of Karin to scale our spectra.

4. Result and discussion: Fig.1 shows the relative reflectance spectrum of Karin on 2003 September 14.6 (UT) smoothed by running average of 5 pixels along with the previous observations of S(IV)-type asteroid (11)Parthenope and L5 meteorite Tsarev. The spectrum is normalized to the unity at 1.0 μm.

The first analysis of the spectrum allows us to determine that Karin is an S-type asteroid. The shape of 0.8-2.5 μm is consistent with an S-type object. We tried to better analyze the data in order to identify which S subclass of the Gaffey et al. [6] classification scheme best describes the Karin spectrum. In this classification, the S class is divided into 7 subclasses on the basis of the area ratio between the 2 μm/1 μm band, the center position of these two bands, the depth and slope of the 1 μm absorption, as these parameters are intrinsically related to the mineralogy of the asteroid surface. On the basis of this analysis, (832)Karin is well placed in the space of S(IV) class. In contrast, we could not find any spectra of ordinary chondrites to match our observational result.

Compared with the spectrum of meteorite, Karin's spectrum seems to be reddened by space weathering. This result suggests that Karin has experienced space weathering enough to be darkened and reddened at the same level as typical S(IV)-type asteroids.

In conclusion, our result indicates two possibilities as follows; (1) time scale of the space weathering to darken and redden adequately is shorter than the age of Karin group, 5.8 million years, or (2) the surface of Karin at our observational rotational phase is not a fresh surface in contrast to other rotational phase observation. Because Karin is the largest asteroid in Karin family, there is a possibility of remaining old surfaces.

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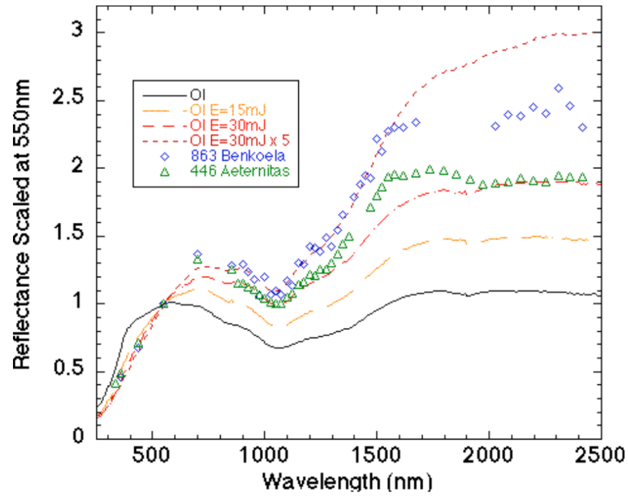

Fig.1: Reflectance spectra of olivine pellet samples before and after pulse laser irradiation. The spectra scaled at 550 nm, and compared with the observed spectra of two asteroids (446)Aeternitas and (863)Benkoela, which are considered to belong to an olivine-rich clan of S-type asteroid [1].

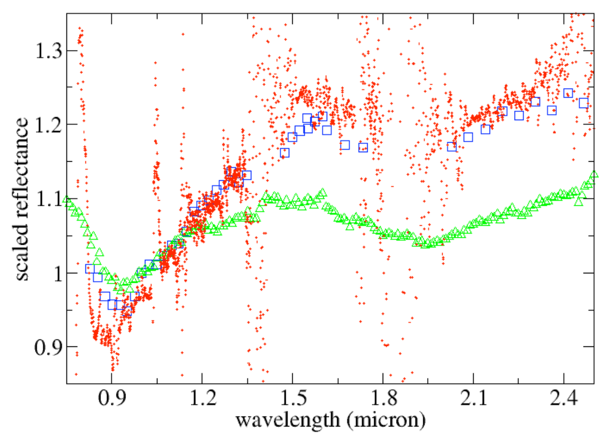

Fig.2: Reflectance spectrum of Karin (red dots) smoothed by running average of 5 pixels compared with S(IV)-type asteroid (11)Parthenope (blue squares) and L5 meteorite Tsarev (green triangles). All spectra are normalized to unity at 1.0 μm. Karin's spectral slope and shape is obviously consistent with not so much meteorite as an S-type asteroid. Meteorite spectrum is from Dan Britt.