

SUBARU Spectroscopy of new-born Asteroid 832 Karin; Determining Time Scale of Space Weathering

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The term space weathering is applied to the darkening and reddening of the surface in the planetary materials with time, along with the changes to the depths of absorption bands in their optical spectra. 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 (Chapman & Salisbury, 1973; Gaffey & McCord, 1978; Wetherill & Chapman, 1988; Chapman, 1996; Pieters et al., 2000). The detailed mechanism of this space weathering has been remained to be unsolved until recently, when Sasaki et al. (2001) confirmed Hapke's old hypothesis that the spectral darkening and reddening are caused by formation of nano iron particles (Hapke et al., 1975; Hapke 2001; Pieters et al., 2000) on the basis of pulse-laser irradiation experiments simulating micrometeorite impacts. They showed that the reflection spectra of the altered olivine in which high-energy laser experiments match with typical spectra of S-type asteroids produced the iron nano-particles.

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 108 years (Sasaki et al., 2001). 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.

Surprisingly, recent researches in the celestial mechanics shows an existence of such a new-born group of asteroids, which is Karin cluster group thought to be remnants of a recent breakup of only 5.8 million years ago (Nesvorný et al., 2002). Therefore, we decided to propose this trial by seeing the brightest asteroids 832 Karin for the above purpose.

A near-infrared spectroscopic observation of Karin was performed by the 8-m Subaru telescope with Cooled Infrared Spectrograph and Camera for OHS (CISCO) (Motohara et al., 2002) on 2003 September 14 (UT). In order to obtain wide range spectrum in the near-infrared region, the grisms named zJ, JH, and wK were used. The integration time for Karin was 2400 s for each setting. We obtained 3 sets of spectra, so total integration time was 7200 s.

Our observational data show that there is an obvious difference among observational set of Karin meaning that Karin's surface composition is inhomogeneous in each rotational phase. Three sets are observed at 7:57-8:40 (UT), 8:46-9:29 (UT), and 10:45-11:50 (UT); rotational phases are 0.30-0.34 (first set), 0.35-0.38 (second set), and 0.45-0.50 (last set). This result indicates that Karin has two different surfaces, reddened and un-reddened surfaces, and the difference among spectra reflects the degree of space weathering. Because Karin is the largest asteroid in Karin family, there is a possibility of remaining parts of not only fresh surfaces but also mature surfaces.

The first analysis of the spectrum allows us to determine that Karin is an S-type asteroid. And on the basis of Gaffey's analysis (Gaffey et al., 1993), the spectrum of Karin is well placed in the space of S(IV) class. We compared the reflectance spectra of Karin (first set and last set) along with the previous observations of S(IV)-type asteroid 584 Semiramis and L6 ordinary chondrite meteorite Paranaíba. The first set's spectrum of Karin matches to the spectrum of S(IV) class asteroid. In contrast, the last set's spectrum of Karin excellent matches to the typical slopes for L6 ordinary chondrite meteorite, and seems to be de-reddened spectrum of first one, which has been reddened by space weathering.

Our mature and fresh surfaces' spectra strongly stand up for the idea that space weathering is responsible for the mismatches between asteroid types and meteorite classes. Our result is priceless in that we observed two different surfaces (mature and fresh) on a single asteroid.