Presence of mature and fresh surfaces on new-born asteroid Karin.

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Spectral mismatch between asteroids and meteorites:

There is a long-standing spectral mismatch between asteroids and meteorites. Although S-type asteroids are the most common among the inner-part main belt asteroids as well as near-Earth asteroids, reddened reflectance spectra and derived mineralogy of S-type asteroids are different from those of ordinary chondrites, the most common meteorites. Space weathering is thought to be able to explain the spectral mismatch [1,2]. Recent asteroid surveys have discovered a strong link between S-type asteroids and ordinary chondrites [3,4]. Multispectral observation of Ida by Galileo spacecraft showed that relatively fresh surface such as crater interiors and ejecta have reflectance like ordinary chondrites [1]. Futhermore, NEAR-Shoemaker spacecraft revealed an ordinary chondrite composition of S-type asteroid 433 Eros [5,6]. The laboratory experiments using high-energy pulse laser irradiation showed that the reflectance change forming S-type spectra is caused by formation of nanophase iron particles within vapour-deposited rim around regolith particles [7]. The degree of space weathering can be used to discuss the age of asteroids [7].

Recently, using numerical integration of asteroid orbits, Nesvorny *et al.* found a new-born group of asteroids named Karin cluster group, which is thought to be remnants of a recent breakup of only 5.8 million years ago [8]. Here, we observed the brightest asteroids 832 Karin in this group to consider the relation between the asteroid age and the effect of space weathering.

Observation of new-born asteroid Karin:

A near-infrared spectroscopic observation of Karin was performed by the 8-m Subaru telescope with Cooled Infrared Spectrograph and Camera for OHS (CISCO) on September 14 (UT) 2003. In order to obtain wide range spectrum in the near-infrared region, we used grisms named zJ (0.88-1.40 μm), JH (1.06-1.82 μm), and wK (1.85-2.51 μm). The integration time for Karin was 800 s for each grism i.e. 2400 s for each setting (zJ + JH + wK). In order to cancel telluric absorption features, a reference star (G2V star HIP3990) was observed just after Karin observation. And for the wavelength identification, another reference star (A0 star SAO165395) was observed during Karin observation.

We observed Karin at 7:57-8:40 (UT), 8:46-9:29 (UT), and 10:45-11:50 (UT). The synodic rotational period of Karin is 18.348 hours, which was derived from the light-curve obtained by supporting observations (Fig.1). In comparison with the light curve, rotational phases of Karin in our observation are 0.30-0.34 (the first set), 0.35-0.38 (the second set), and 0.45-0.50 (the last set).

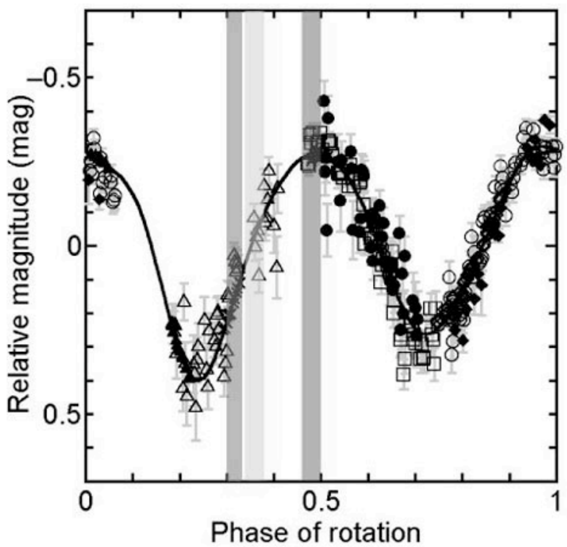

Figure 1 Light-curve of 832 Karin [9]. Based on data obtained by the 1.8-m VATT at the Vatican observatory at Mt. Graham, Arizona, by the 1-m Schmidt telescope at the Kiso observatory, Japan, and by the 40-cm telescope in Fukuoka University of Education, Japan. Total observing duration is nine nights from August to September 2003. The rotational period of this asteroid is 18.348 hours. The amplitude of the light-curve is 0.7 mag at the zero Solar-phase-angle. The zero phase of rotation is at 2004 July 31 0:00 UT. Our observation corresponds to the phase of rotations of three vertical lines.

Karin has heterogeneous surface:

Fig.2 shows the relative reflectance spectra of Karin for these three observation sets. Bottom, middle, and top spectra in Fig.2 are those of the first, the second, and the last observational sets, respectively. The difference in the airmass at the observations of the asteroid and the reference star was smaller than 0.1 for first set and second set. There is obvious difference between the top two and bottom spectra at wavelength between 0.9 and 1.4µm. Spectra of reference star SAO165395 were unchanged before the first set and after the second set of Karin observation: the difference of zJ band spectra in Fig.2 is not artifact. Large color changes with rotation have been hardly observed on asteroids, and this would be the biggest color change with rotational phase ever observed. This result suggests that Karin's surface is inhomogeneous for each rotational phase.

Mature and fresh surfaces on Karin, Discussion:

The shape of 0.8-2.5 µm in the first set's spectrum is consistent with an S-type object. The latter two spectra can match typical spectrum of L6 ordinary chondrite. And the first set should be the redden spectrum of the last set by space weathering. Our result indicates that Karin has two different surfaces, reddened and un-reddened surfaces, and the difference among spectra would reflect the degree of space weathering. These color changes were also derived by supporting observations, which observed Karin at B(0.44µm), V(0.54µm), R(0.63µm), and I(0.81µm), bands in visible wavelength [9]. Their result suggests that reflectance at phase 0.3 is more weathered than that at phase 0.5 and less weathered than that at phase 0.2.

The mature and fresh surfaces' spectra strongly stand up for the idea that space weathering is responsible for the mismatch between asteroid types and meteorite classes. The change of space weathering degree on Karin's surface can be explained if Karin is one of cone-shaped fragment at low-velocity impact forming the Karin family. Impact disruption experiments suggest that in the low-velocity impact regime (v < 1 km/s) the target is shattered into cone-shaped fragments, pointing towards the impact point [10]. In this case, only the base of this cone is mature surface darkened by space weathering, which is consistent with a feature of the light-curve of Karin described above. Probable sharp edged boundary between the cone base and cone side of the fragment could explain the observed change of the space weathering degree around phase 0.2-0.5. Around the phase 0.3-0.4, both matured and fresh surfaces would have been observed.

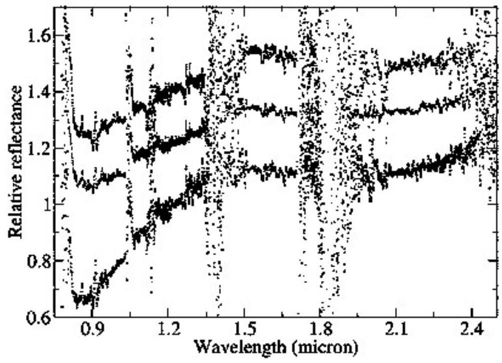

Figure 2 Relative reflectance spectra of 832 Karin: Bottom one is the spectrum of the first set of the night, middle one is that of the second set, and top one is that of the last set. Spectral data are smoothed by running average of 5 pixels, and top and bottom spectra are vertically shifted by 0.2 for clarity. Reflectance spectra of reference star SAO165395 were unchanged before the first set and after the second set of Karin observation.

References:

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