1. INTRODUCTION

A parent body of an ordinary chondrite, one of the most common stony meteorites, is believed to be an S-type asteroid that is commonly distributed in the inner-main-belt region and is thought to consist of silicate rocks covered with regolith. However, there are discrepancies between the reflectance spectra of ordinary chondrites and S-type asteroids: S-type asteroids show redder spectral slope in the visible wavelength and the depth of the absorption band at ~0.95 μm is shallower than that of ordinary chondrites (Chapman & Salisbury 1973).

These spectral discrepancies are attributed to “space weathering,” which alter fresh, chondritic spectra to S-type asteroid spectra (e.g., Clark et al. 2002). Although the details of the physical process of space weathering have not been fully understood, it is thought that irradiation of high-energy particles (solar wind or cosmic rays) and/or bombardment of meteorites produces nanophase iron in the surface of regolith that changes the reflectance spectrum (Adams & McCord 1971; Hopke 2000; Pieters et al. 2000; Sasaki et al. 2001).

One of the unsolved issues in space weathering is the determination of the timescale of the weathering process. Dynamical investigations of asteroid families are enabling us to create a timescale of the history of asteroid evolution (e.g., Nesvorny et al. 2005). Nesvorny et al. (2005) related the family age and the spectral slope, and Willman et al. (2008) revised their results and found that the timescale of the change in spectral slope by space weathering was 570 ± 220 Myr. However, Chapman et al. (2007) and Vernazza et al. (2007) observed (832) Karin, whose age was estimated to be 5.8 Myr, and found that the depth of the 0.95 μm absorption band was as shallow as a typical S-type asteroid. These observations suggest that the depth of the 0.95 μm absorption band changes faster than the reddening of the spectral slope.

Recently Nesvorny et al. (2006b) found a very young asteroid cluster, the Datura cluster, whose age was estimated to be 0.45 ± 0.05 Myr. The Datura cluster has been exposed for only 1/10 of the age of the Karin cluster. Thus this cluster is a good target to examine the alteration speed by space weathering at the 0.95 μm absorption band.

(1270) Datura has a diameter of about 11 km and is orbiting in the inner-main-belt region (\(a = 2.2\) AU). I have observed (1270) Datura, which is the largest member of the Datura cluster, expecting to find a “fresh” region on its surface because the space-weathered old surface was removed by the cluster-forming breakup, and a fragment might expose a fresh, interior surface on the whole area or at least in some area. In this Letter I report the rotation-resolved reflectance spectra of (1270) Datura and its implication for space weathering.

2. OBSERVATIONS AND RESULTS

Light curve observations were made on 2008 February 16 and 20 (UT) by using \(J\)-band imaging of MOIRCS (Ichikawa et al. 2006) on the Subaru Telescope in order to determine the rotational phases at our spectral observations. Most of the exposure times were set to 30 s. A photometric standard star, FS132, was also observed. The nights were photometric. Figure 1 shows the obtained \(J\)-band light curve of (1270) Datura. The sidereal rotation period was derived to be 3.359 hr and the amplitude was about 0.4 mag, which are consistent with previous results (Szekely et al. 2005).

Spectroscopic observations were made on 2008 February 26 (UT) using the grism mode of FOCAS (Kashikawa et al. 2002) on the Subaru Telescope. The wavelength range was \(\lambda = 0.6–1.0\) μm and the slit width was set to 1.0″, which resulted in a spectral resolution of \(R = 400\). The position angle of the slit was set to the direction of the asteroid motion. The sky was clear and the spectra of (1270) Datura were taken continuously and covered about \(\frac{1}{2}\) of a full rotational phase with 26 spectra. The exposure time of each spectrum was 180 s. Spectra of a solar analog star HD 60298 (G2 V) were taken during the observation to compensate for atmospheric absorption features and to derive the reflectance spectra of (1270) Datura.

The spectra were traced and extracted using the IRAF package and then were divided by the spectra of the solar analog star observed at an air mass similar to that of (1270) Datura. Figure 2 shows the obtained reflectance spectra of (1270) Datura averaged at several rotational phases. No significant spectral variations were detected along the rotational phases.

3. DISCUSSION

The rotation curve shows a fairly large amplitude, which means that we are not seeing (1270) Datura from above its pole; thus we see most of its surface when observing nearly a full rotational period. The fact that there is no significant dif-
ference among the spectra obtained at different rotation phases indicates that the surface of (1270) Datura has no significant large-scale spatial variation in composition and in the degree of space weathering. The rotation speed of (1270) Datura is slow enough and the size is large enough for it to be covered with regolith that must have been newly created at the cluster-forming collision 0.45 Myr ago and then deposited onto the surface. Since the deposition timescale might be longer compared to the rotation period of (1270) Datura, the dust/gravel evenly covered the surface. Thus it is natural that the surface of (1270) Datura is almost homogeneous when observed on a large spatial scale as discussed by Nesvorný et al. (2006a) and Vernazza et al. (2007) for (832) Karin.

To see the degree of space weathering of the surface of (1270) Datura, the phase-averaged spectrum is compared with that of an old S-type asteroid (15) Eunomia (estimated age is 2.5 Gyr; Nesvorný et al. 2005) and some of the ordinary chondrites as shown in Figure 3. Contrary to our expectation, the spectrum of (1270) Datura does not resemble that of ordinary chondrites, but is close to that of an old S-type asteroid (15) Eunomia. This means that the surface of (1270) Datura was already altered to the same degree as an old S-type asteroid with respect to the depth of the $0.95 \mu m$ absorption band.

Because the surface was renewed 0.45 Myr ago by a cluster-forming collision, the change of the reflectance spectrum (from ordinary-chondrite-like one to that of S-type asteroids) must have been completed in less than 0.45 Myr, if the age estimate by Nesvorný et al. (2006b) and the concept of space weathering are correct.

Binzel et al. (1996, 2001) found that many of the near-Earth objects (NEOs) are Sq- or Q-type, which connects S-type spectra to ordinary chondrite spectra. If NEOs have been space weathered in the same manner as (1270) Datura, the surface of these objects have been exposed much less than 0.45 Myr. If the surface was exposed by a recent collision in the main
belt, we can estimate the current collision rate in the main belt. However, we must be careful that the environment of space weathering in the NEO region differs from the inner main belt. Also, the establishment and stability of regolith might be different since the size of the objects of Binzel et al. (1996, 2001) are 1 order of magnitude smaller than (1270) Datura.

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Facilities: Subaru(FOCAS, MOIRCS)

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