Lithification process of the HED parent body: Estimation from mineralogy of carbonaceous chondrite clasts

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1. Introduction The asteroid Vesta found in 1907 is the most probable candidates of the parent body of the HED meteorites. Airless celestial bodies have been exposed to solar wind and bombardment of interplanetary dust whose intensities vary with time. This is also true for the case of Vesta. An infrared spectral study of Vesta by Hasegawa et al. (2003) showed that the surface layer of Vesta contains a few % of water that probably exists as interlayer molecules of hydrated silicates. Regolith breccias of howardites that were made near the surface of the parent body often contain carbonaceous chondrite clasts (e. g. Gounelle et al., 2003). In this study, we would like to show the detailed mineralogy of carbonaceous chondrite clasts in EET87513, Bholghati, and Kapoeta and discuss the lithification process of unconsolidated regolith on asteroids.

2. Methods We found carbonaceous chondrite clasts form the above three meteorites by SEM and the clasts were analyzed by EPMA. Some of the clasts were extracted by a sharp tungsten needle. In the case of Kapoeta, we also used dark clasts from a chip under a stereomicroscope. Bulk mineralogy of the individual extracted clasts were investigated by synchrotron radiation X-ray diffraction at KEK-PF. We identified major minerals in each clast and their relative abundances.

3. Results and discussion We found 103 carbonaceous chondrite clasts from the three meteorites. EET87513 contains 26 clasts. Their sizes range from 18 x 22 to 500 x 700 m (average: 90 x 132 m). Bholghati contains 14 clasts. Their sizes range from 26 x 35 to 200 x 230 m (average: 102 x 117 m). Kapoeta contains 63 clasts. Their sizes range from 12 x 17 to 200 x 450 m (average: 72 x 105 m).

SEM observation and EPMA analysis revealed that all the clasts in the three meteorites can be divided into two types. One type is composed of fine-grained matrix containing PCP-like objects that embedding partially altered chondrules (CM-like clasts). Anther is composed of fine-grained matrix often containing framboidal aggregates of magnetite (CI-like clasts). EPMA data suggest that the major silicate mineral in the matrix is serpentine and the latter are saponite and serpentine. The relative abundances in EET87513, Bholghati, and Kapoeta are 25:1 , 13:1, and 46:16, respectively.

Based on the synchrotron radiation X-ray diffraction analysis, CM-like clasts in EET87513 are composed of serpentine, olivine, low-Ca pyroxene, calcite, and kamacite. CM-like clasts in Bholghati are composed of olivine, low-Ca pyroxene, magnetite, and troilite. CI-like clasts in Bholghati are of magnetite and low-Ca pyroxene. CM-like clasts in Kapoeta are composed of serpentine, olivine, low-Ca pyroxene, tochilinite, kamacite, and magnetite. CI-like clasts are composed of saponite, serpentine, olivine, low-Ca pyroxene, pyrrhotite, and siderite.

SR-XRD data clearly display that the degree of heating experienced by the three meteorites are different. Clasts in Bholghati contain secondary olivine and low-Ca pyroxene that were formed by decomposition of serpentine and saponite around 700 oC. Clasts in EET87513 contain serpentine. It means that the clasts did not experience 600 oC for a long duration. CM-like clasts in Kapoeta contain tochilinite definitely. Because tochilinite decomposes around 300 oC, it is suggested that unconsolidated regolith can solidify under 300 oC.