Shock degrees of eucrites from petrographic and XRD analyses

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Shock metamorphism is one of the most important geologic processes on the surface crust of asteroids. The evaluation of shock metamorphism is indispensable for better understanding of the material evolution at the early solar system. Eucrites are believed to have derived from the outer crust of the asteroid 4 Vesta. Eucrites experienced a complex shock history [e.g., 1]. Therefore, we propose the shock degrees of eucrites combing XRD analysis with petrographic observations. We have three specific purposes in this study, 1) the determination of the shock degrees of eucrites on the basis of textures, 2) the semi-quantitative measurement of shock degrees from XRD data, and 3) the better understanding of impact history on the eucrite parent body.

We performed petrological and mineralogical studies using an optical microscope, an FE-SEM, an EPMA, a micro-Raman spectroscopy at NIPR, and a luminoscope at the Okayama University of Science. We performed XRD analyses by the in-plane rotation method of polished sections [2], using an X-ray diffractometer (SmartLab), on the conditions of Cu Kα1 (wavelength = 0.15406 nm) with 40 kV and 40 mA through the slit of 10 mm in height and 5 mm in width with the divergence angle of (1/6) °. The measured range of the twofold Bragg angle is 8 to 75°. The rotation speed of the polished sections was 100 rpm. We measured 12 basaltic eucrites and 4 cumulate eucrites.

We proposed the shock degrees of eucrites from A to E, based on the petrographic textures. The textural criteria include the angles of undulatory extinction, and the relative abundance of maskelynite to plagioclase. Shock degree A represents unshocked eucrites, characterized by a sharp (< ~2º) optical extinction of plagioclase and pyroxene (e.g., Agoult and EET 90020). Shock degree B represents weakly shocked eucrites, characterized by an weak undulatory extinction (< 15º) (e.g., NWA 5356 and Y 983366). Shock degrees C, D, and E show strong undulatory extinction (>15º) and are divided by the relative abundance of maskelynite to plagioclase. Shock degree C represents the moderately shocked eucrites, characterized by the absence of maskelynite (e.g., Stannern and Y-792510). Shock degree D represents the moderately to highly shocked eucrites, characterized by small abundances of maskelynite (Msk/Msk+Pl = < 0.1) (e.g., Y-790266 and Y 980433). The maskelynite in the eucrites with the degree C located only near the shock vein. The occurrence of maskelynite may be explained by at high-temperature conditions along shock veins [3]. Shock degree E eucrites are characterized by abundant maskelynite (Msk/Msk+Pl = >> 0.5) (e.g., A-87272). The occurrence of maskelynite suggests that the A-87272 experienced near the equilibrium shock pressure of maskleynization.

The macroscopic XRD data such as averaged FWHM (full width at half maximum) values, shows the correlation for the shock degrees estimated from textures. The averaged FWHM values increase as shock degrees increases. Since the FWHM values reflect the lattice spacing, the increasing of the averaged FWHM values indicates the disturbance of the crystal lattice. Therefore, the peak broadening of the shocked eucrites is closely related to the degree of shock metamorphism.

In summary, the results of petrographic observations and XRD analyses are consistent and are a useful indicator for evaluating shock degrees of eucrites to infer the impact history on the Vestan crust.

References
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