The consideration regarding formation environment of the nakhlite meteorites inferred from deformation microstructures

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The nakhlite is classified as one of the Martian meteorites, and are interpreted to have originated from the Tharsis region (Treiman et al., 1987). In contrast to the Earth’ s rock, the nakhlite meteorites crystallized in thick lava flows (>125m) or in shallow intrusion (probably less than a kilometer depth), however, the details of the formation environment is still unknown (Treiman et al., 1987). Therefore, it is important to investigate the formation process and environment of the nakhlite based on comprehensive observations of crystallographic orientations in constituting minerals.
In this study, we examined a polished thin section of the Yamato 000593 nakhlite (Y000593) by mineralogical, textural and crystallographic observations using an optical microscope and electron probe micro analyzer (EPMA) at Hiroshima University and scanning microscope combined electron backscatter diffraction (SEM-EBSD) at Shizuoka University.
The Y000593 mainly composed of augite, olivine and mesostasis that is consistent with previous reports for nakhlites (e.g., Mikouchi et al., 2003). The lattice-preferred orientations for minerals in whole rock of the meteorite were determined from EBSD patterns for understanding of deformation under metamorphic conditions. We found that Y000593 has crystal preferred orientation patterns in clinopyroxenes. It is suggested that the shear stress had acted on to augites when they crystallized. Thus, we inferred the nakhlites deposited in some kind of flows such as a stream of lava that flows out of a volcano.
On the other hand, we considered the impact effect when Y000593 was ejected from Mars. In general, pyroxenes are good indicator of shock deformation, which induces mechanical twins as one of the examples of crystal defects (e.g., Mori and Takeda 1983). To estimate the effect of impact process, we measured the mechanical twin planes, which were observed in many augites in Y000593. Consequently, most of augites with mechanical twin have been formed on (100) planes. This mechanical twin is known to induce deformation in clinopyroxenes at high strain rates and moderate temperatures (Leroux et al., 2004). In comparison with the microstructural observations in experimentally shocked clinopyroxene to the results of Y000593, it is suggested that the Y000593 pyroxenes are not strongly shocked and affected by impact event. This result is consistent with a previous study that has demonstrated impact effect using degree of extinction in olivine and pyroxene in Martian meteorites (Fritz et al., 2005).

Keywords: nakhlite, crystal preferred orientation, formation environment, impact effect

