PRELIMINARY STUDY OF WATER CONTENT IN THE MARS INFERRED FROM DEFORMATION MICROSTRUCTURES IN MARTIAN METEORITES.

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Introduction:

Mars might be hot and wet planet in the Hesperian period, since many hydrous minerals in the terranes older than three billion years have been recently recognized [1]. However, the source of this water is poorly understood. Current estimates for the water content of the martian mantle range from about 1 to 36 ppm H_2O [2]. Such low values are incompatible with magmatic degassing as a primary source for this water. On the other hand, there is another estimate range from 140 to 250 ppm, in which water contents were estimated using hydrous minerals and melt inclusions in the SNC meteorites by SIMS analysis [3]. As hydrogen is a mobile element, it can be influenced by later stage events such as alteration at the Earth's surface. The SNC meteorite has been experienced complex history since it was originated from the Mars, including impact-induced shock effect and terrestrial contamination. In this study, we try to infer original water content in the martian meteorite (Yamato 000593) based on the analysis of deformation microstructures using EBSD analysis. Advantage of this method is free from the contamination of terrestrial water, and thus martian water content can be estimated from the fluid-sensitive deformation textures. While this method has been frequently applied to terrestrial materials [e.g., 4,5], application to meteorite has not been reported.

Meteorite sample, Yamato 000593:

The sample used in this study is Yamato 000593 Nakhlite, in which subgrain boundaries are frequently developed in pyroxene [6]. In general, subgrain boundaries are introduced by a deformation related to the impact events, but it can be disappeared by a high impact pressure [4]. The Y000593, however, is experienced by relatively low impact pressure of less than 7 GPa [7]. Thus, Yamato 000593 is one of a plausible sample to analyze deformation microstructure to infer water content on Mars.

Experiment and Method:

Since the laboratory experiments have shown that the deformation microstructures such as active slip system in olivine is influenced by water content [5], determination of slip system can be used to trace water content in meteorite samples. In this study, we first conducted optical observation to detect subgrain boundary in the samples using optical microscope. The observed subgrain boundaries are then analyzed by EBSD at Shizuoka University. In the EBSD analysis, we measure crystal orientations across low-angle subgrain boundaries or tiltwalls. Because tiltwalls are formed of edge dislocations, the orientation of the tiltwall and the lattice rotation across the tiltwall can be used to evaluate the active slip system [8]. The differential stress can be estimated from the subgrain-size piezometer, in which a spacing of subgrain boudanry is propotional to differential stress [9].

Results and Discussion:

Although we haven't analyzed the subgrain boundary in the meteorite samples using EBSD, we observed development of subgrain boundary in pyroxene which is not crystallized under optical microscope. The spacing of these boundaries is larger than 610 μm, which indicates the differential stress less than 2.8 MPa based on the piezometer. Although this piezometer is used for olivine, the application to pyroxene is possible because of similar shear modulus and lattice length between olivine and pyroxene (in the order estimate). In this stress range, active slip system should be A-type (010)[100] for water content less than ~14 ppm. If water content is higher than this value, either E-type (001)[100] or C-type (100)[001] should appear.

References:

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