HETEROGENEOUS DISTRIBUTIONS OF SHOCK METAMORPHIC FEATURES IN EQUILIBRATED ORDINARY CHONDRITES

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Introduction: Chonrites experienced two different types of metamorphism since their formation into parent bodies; temperature-dominant thermal metamorphism [1] and pressure-dominant shock metamorphism [2, 3]. While thermal metamorphic features are more or less homogeneous (i.e., equilibrated) within a single chondrite, especially at that of high degree thermal metamorphism, shock features seem not. We have examined the distributions of shock features in (thermally) equilibrated ordinary chondrites.

Samples and Methods: We chose four H6 chondrites which experienced different degrees of shock metamorphism; Thiel Mountains 07004 (TIL 07004; H6, S2), Thiel Mountains 08008 (TIL 08008; H6, S3), Frontier Mountain 10018 (FRO 10018; H6, S4), Frontier Mountain 10035 (FRO 10035; H6, S5) (TIL 07004 and TIL 08008 are from SNU; FRO 10018 and FRO 10035 are from KOPRI). Shock effects in olivine, plagioclase and orthopyroxene were examined with polarizing microscopes. Scanning electron microscope equipped with energy dispersive X-ray spectroscopy was used for mineral identification, if necessary.

Results and Discussion: Since Stöffler et al. [2] and follow-up studies [3-7], degrees of shock metamorphism are divided into six shock stages, S1 (unshocked) to S6 (very strongly shocked) based on observations of shock effects in olivine, plagioclase and orthopyroxene produced by shock recovery experiments and also of those in natural meteoritic minerals. However, some of these schemes contain ambiguous expressions. For example, 'weak' and 'strong' mosaicism are used to distinguish S4 and S5 olivine grains [2] and 'occasionally', 'commonly' and 'typically' observed planar deformation features (PDFs) to distinguish S3, S4 and S5 olivine grains [4]. Thus, Schmitt & Stöffler [5] and Schmitt [6] suggest to use domain size to define weak mosaicism (~20μm) and strong mosaicism (~5μm). We suggest that degree of undulatory extinction can be used to distinguish olivine grains of S2 and S3 by measuring the range of extinction angle as method suggested by [8]. We found that the ranges of extinction angles are 2-30˚ at S2 and > 30˚ at S3. In previous studies, S2 and S3 of plagioclase and S3 and S4 of orthopyroxene were distinguished mostly using the presence or absence of irregular fractures [2, 3, 6]. However, since irregular fractures are found even plagioclase of S4 and orthopyroxene of S5, we do not recommend to use plagioclase to distinquish S2 and S3, similar pyroxene for S3 and S4.

Since shock features are heterogenous within chondrites, it was recommended to choose the highest shock stage shown by any significant fraction of grains (at least 25%) for shock level of a chondrite [2]. Using these slightly modified shock classification scheme, we examined 150-870 olivine grains, 50-90 plagioclase grains and 100-165 orthopyroxene grains from each thin section.

Our results of olivine agree with previous values in Meteoritcal Bulletin Database. All three minerals of TIL 07004 (S2) and FRO 10035 (S5) show the same results. However, minerals in FRO 1008 (S4) and TIL 08008 (S3) do not agree to each other in shock degree. For example, 55% of plagioclase in FRO 10018 indicate S5 (i.e., maskelynite). Orthopyroxene grains in TIL 08008 are mostly (82%) S2, and only 13% are S3 or higher. Our results quantitatively confirm the heterogenous distributions of shock features. We thus suggest that at least two minerals should be used for shock classification. In order to future examine the heterogeneous distribution of shock features, shock stages of adjacent mineral pair were compared. No obvious correlation was found indicating that even nearby minerals record different shock degree.

Conclusion: We reexamined shock criteria of olivine, plagioclase and orthopyroxene in four H6 chondrites. We found that the range of extinction angle can be used to distinguish olivine of S2 and S3. We suggest that irregular fracture can not be use to distinguish S2 and S3 of plagioclase and S3 and S4 of pyroxene. All four H6 chondrites we studied show highly heterogenous distributions of shock stages recorded in minerals. Shock metamorphic level need to be assigned by studying at least two kinds of minerals. The heterogeneity found even in nearby minerals.

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