Bulk X-ray random diffraction patterns using polished thin sections of ordinary chondrites: primordial, thermal, and shock features

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Introduction: Ordinary chondrites, consisting of three different chemical group of H, L, and LL, are major meteorite species occupying more than 80% of the meteorite falls, and have experienced various degrees of thermal metamorphism (types 3 to 6) and shock metamorphism (stages 1 to 6 and melted). In the present study, X-ray random diffraction patterns were obtained from the in-plane rotation of polished thin sections of ordinary chondrites.

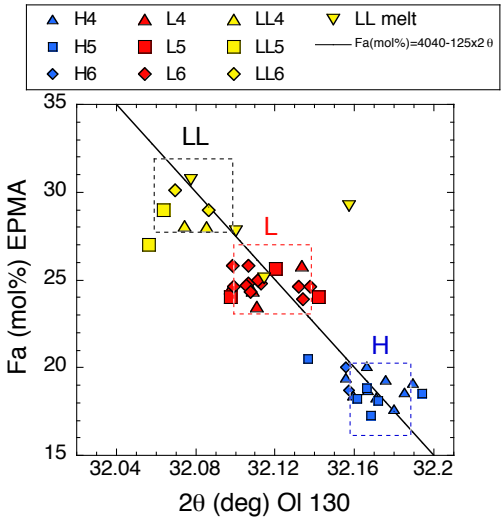
Experiments: Sixty polished thin sections of ordinary chondrites (H 23, L 21, LL 16) were used. The measurement conditions using Cu Kα were the same as Imae and Nakamuta (2018). The focused indices were olivine (Ol) 130, low-Ca clinopyroxene (Cpx) $22\bar{1}$ and $\bar{3}11$, low-Ca orthopyroxene (Opx) 321 and 511, Ca-pyroxene (Ca-px) $\bar{2}21$, $\bar{3}10$, and $\bar{3}11$.

Results: Obtained X-ray diffraction patterns were divided into four types, (1) weakly-shocked and unequilibrated, (2) weakly-shocked and equilibrated, (3) intensely-shocked and equilibrated, and (4) shock-melted. The follwings show typical features. (1) Y-790448, LL3.2, S1. The peak of Ol 130 is duplex. The peak of 2θ = 30.3º corresponding to Opx 321 and Ca-px $\bar{3}10$ is weak. Opx 511 is absent. (2) Y-7301, H5, S1. The peak of Ol 130 is sharp and intense. The 2 θ value of the peak is consistent with the chemical group of H. The peak of 2 θ = 30.3º is intense, and the peak of Opx 511 appears at 2 θ = 31.5º. (3) Tenham, L6, S6. The FWHM of Ol 130 is larger than the (2). The intensity of Opx 511 is significantly smaller than the (2). (4) Y-790522, LL-melt. The peak of Ol 130 is intense and sharp. The intensity of pyroxenes is low, Opx 321, Ca-px $\bar{3}10$, Opx 511 are subtle.

Discussion: 2θ values of Ol 130 for equilibrated chondrites are consistent with the correlations obtained by electron probe micro analyzer (EPMA) (Fig. 1). Among studied sample, FWHM of Ol 130 for L6 (11 samples) is positively correlated with shock stage independently determined from optical microscope (Fig. 2). When the integrated intensity of Opx 511 increases for type 4 of H chondrites (14 samples), FWHM of Opx 511 once increases, then change decreases, suggesting the process from unequilibrium to equilibrium. The intensity of Cpx decreases from type 3 to more than type 4. However, those of Tenham and NWA 4719 with the shock stage of S6 detect the increase, being deviated from the trend. This strongly suggests that some part od Opx transformed to Cpx during the shock metamorphism. Polysynthetic twinnings of Cpx are observed from Tenham and NWA 4719 under an optical microscope, supporting the interpretation.

Reference:

Imae, N. and Y. Nakamuta, A new mineralogical approach for CO3 chondrite characterization by X-ray diffraction: Identification of primordial phases and thermal history, Meteoritics & Planetary Science 53, 232-248, 2018.



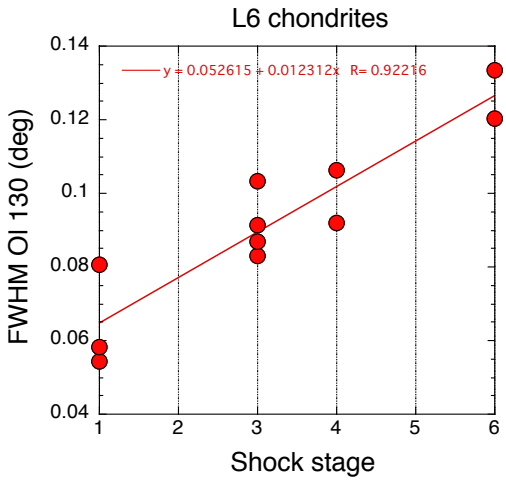


Fig. 1 (Left). Variation of 2θ values for Ol 130 of equilibrated ordinary chondrites in comparison with mean Fa (mol%) from EPMA.
Fig. 2 (Right). The positive relationship between FWHM of Ol 130 and shock stages for 11 L6 chondrites.