Primordial, thermal and shock features of ordinary chondrites: Bulk X-ray diffraction study using in-plane rotation of polished thin section

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Introduction

The X-ray diffraction data of stony meteorites includes information on the thermal and shock metamorphism modified from primordial features as well as the chemical group. The X-ray diffraction method is convenient, and rapidly clarifies bulk features of stony meteorites. In the present study, mainly Antarctic ordinary chondrites were examined using in-plane rotation method of polished thin section, and we established the criteria for the characterization.

Experiments

Sixty ordinary chondrites (23 H, 21 L, and 16 LL) were used for X-ray measurements (RIGAKU, SmartLab) on the condition of Cu Kα with 40kV and 30mA through the slit of 10x10 mm in size. Peaks were mainly focused on olivine 130, clinopyroxene (Cpx) 22-1, orthopyroxene (Opx) 511 and kamacite 110.

Results and Discussion

Olivine 130 position is clearly correlated with the chemical group for equilibrated ordinary chondrites (EOCs), while the peak was splitted or broad for unequilibrated ordinary chondrites (UOCs) corresponding to olivines with different compositions in chondrules and matrices. The intensity ratios of kamacite was useful for distinguishing the chemical group between H and L-LL, but not definite, mainly due to terrestrial weathering of kamacite in H chondrites. The intensity of orthopyroxene (Opx) 511 is positively correlated with the metamorphic sequence from 3 to 6, and that of clinopyroxene (Cpx) 22-1 is inversely correlated. Shock stage is positively correlated with the full width of half maximum (FWHM) of Opx 511 and olivine 130 for each class. Part of Opx (Pbca) transformed finally to Cpx ($P2_1/c$) through Cpx (C2/c), where Cpx (C2/c) is stable under high pressure condition for shock stage S6 (Tenham and NWA 4719). The shock melted LL chondrite is characterized by deficiency in Cpx but instead abundant homogeneous olivine. Both effects of thermal and shock metamorphism are thus included in the bulk X-ray diffractions.

Implications

The present method can apply for initial analyses of various extraterrestrial samples. We emphasize that it is newly developed approach for characterizing extraterrestrial materials without any significant damage during the measurements.

キーワード：X線回折、普通コンドライト、かんらん石、輝石
Keywords: X-ray diffraction, ordinary chondrites, olivine , pyroxene

