ガンドルフィ・アタッチメントを用いたX線回折実験：微小地球外物質への適用

X-ray diffraction study using Gandolfi attachment: Implications for small extraterrestrial materials

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Introduction

Recent studies have established the bulk features of various chondrite species based on the X-ray diffraction patterns (Howard et al. 2009; Imae and Nakamuta 2018; Imae et al. 2019). In the present study, X-ray diffraction experiments were carried out using Gandolfi attachment in order to apply for small extraterrestrial materials of various kinds of stony meteorites. The present technique is convenient in the laboratory and also useful for rapidly identifying the mineral species without any significant sample loss.

Experiments

We used the X-ray diffractometer in air with the goniometer radius of 30 cm (RIGAKU, SmartLab) at NIPR on the following conditions: (1) CuKa1 with 40 kV, and 30 mA for glass X-ray tube and 40 mA for ceramic X-ray tube, (2) the X-ray beam of 0.4 mm in diameter obtained from the polycapillary focusing optics (CBO-f unit), (3) the strip detector (D/teX Ultra 250) for counting diffracted X-rays, (4) the revolution rate of the goniometer head on the Gandolfi attachment at 30 rpm, and (5) the scan speed of normally 0.2 º/min or 0.5 º/min with the step of 0.01º and the average of the repeated analyses.

Glass fiber (13 μm in diameter) attached with glass rod (1 mm in diameter) was mainly used for holding samples. Both powder and grain samples with the diameter of ~0.2-0.8 mm were used for the measurements.

Powders and single grains for San Carlos olivine and NWA 4719 L6 chondrite were used for the calibration focused on olivine 130 index. So far, 36 stony meteorites have been measured and they are 27 ordinary chondrites (mostly Antarctic meteorites), 5 carbonaceous chondrites, an E chondrite (NWA 7401), a eucrite (Cachari), a diogenite (Bilanga), and an aubrite (Pena Blanca Spring).

Results and discussion

Calibration: The two-theta position of the olivine 130 peak for the powder samples of San Carlos olivine shows nearly consistent value by Yoder and Sahama (1957), on the contrary, the intensity of the San Carlos olivine grains is lower than that of powder on the similar measurement condition, and in addition

the position of the two-theta is slightly higher than that of powder. In case of chondrite (NWA 4719 L6), the intensity is significantly lower than San Carlos olivine. Although the two-theta values for powder samples and grain samples are within the mean Fa# range of L group, the intensity of grain is significantly lower than that of powder.

Samples: The systematic differences of olivine 130 two-theta values were observed among ordinary chondrites: 32.18º-32.29º for H, 32.15º-32.21º for L, and 32.13º-32.16º for LL. These ranges include that the two-theta values are obviously higher than the ranges expected from the mean Fa# for three chemical groups (32.18º-32.21º for H, 32.12º-32.16º for L, and 32.08-32.12 for LL, Yoder and Sahama 1957). The existence of orthoenstatite 511 peak is an indicator for equilibrated ordinary chondrites but not definite, since the peak intensity is normally low. More ferroan olivine peak than ordinary chondrites appears from carbonaceous chondrites. EL6 consists of orthoenstatite. Diffraction patterns of achondrites are different from those of chondrites: pigeonite and anorthite peaks for eucrite and dominant orthopyroxene for diogenite, and dominant clinoenstatite for an aubrite. Fine-grained powder samples may represent the bulk chondrite compositions, but not for grains. This may lead to the different diffraction pattern.

Summary

The present technique is useful conveniently for examining limited or small extraterrestrial materials, when we take into consideration the variations for chondrite species depending on the different sample conditions of powder or grain and the relative modal abundance of olivines and pyroxenes for grains with the limited range of variation of the chemical groups.

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