A NEW MINERALOGICAL APPROACH OF THE CO3 CHONDRITES FOR THE IDENTIFICATION OF PRIMORDIAL PHASES AND THE THERMAL HISTORY.

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Introduction: The CO3 chondrites have been subdivided by various methods [e.g., 1-3], and this would reflect the thermal history on the parent body. Primordial phases have been also identified from the least metamorphosed type [e.g., 4]. In the present study, we newly developed the revealing methods mainly using the X-ray diffraction combining with FE-SEM and EPMA, and obtained new understanding.

Experiments: The X-ray diffractometer (RIGAKU, SmartLab) installed at NIPR in 2014 was used using the X-ray of Cu $K\alpha_1$ (λ=0.15406 nm) on the conditions of X-ray tube voltage 40 kV and tube current 30 mA. The focusing method obtained the X-ray beam with ~1 cm width. One-dimensional solid-state detector (D/teX Ultra 250) was used for the X-ray counting. The scan speed of the goniometer was normally 0.2 °/min. The height of the sample was adjusted using the attached CCD camera. The in-plane rotation at 100 rpm polished thin section (PTS) obtained the powder diffraction pattern. The incident beam position and the diffracted beam was synchronously scanned in the range of 2θ = 28-50º. Compositions of metals were measured using EPMA (JXA-8200). The plessite texture was observed using FE-SEM (JSM-7100F). The studied PTSs were ALH 77307 3.03, Y-81020 3.05, Colony 3.0, A-881632 3.1, Y-983589 3.4, Lancé 3.5, A-882094 3.5, Y-791717 3.6, ALH 77003 3.6, and Isna 3.8.

Results: We mainly focused on the X-ray diffractions of olivine 130, clino low-Ca pyroxene 22-1, ortho low-Ca pyroxene 511, kamacite 110, taenite 111, and tetrataenite -111, since the peaks are not significantly overlapped with peaks of other major phases. The lower subtypes show the double peaks (or triple in ALH 77307) for olivine 130, corresponding to the ferroan olivines in matrices and magnesian olivines in chondrules. The 2θ converted into Fa# using the empirical equation developed by [5] and slightly corrected using the measured position of synthetic forsterite [6]. Then 2θ clearly correlates with the full width of half maximum (FWHM) of olivine 130 for each subtype, especially for higher 2θ corresponding to the chondrule magnesian olivines, although it is not so clear for lower 2θ corresponding to the matrix ferroan olivines. The slight peak observed several samples of ortho low-Ca proxene 511 would suggest the high temperature type directly crystallized from chondrule melt during the chondrule formation [e.g., 7] since there is no correlation among subtypes. The tetrataenite -111 grows rapidly more than subtype 3.5.

Discussion: The relative integrated intensity ratios ($I_{\text{Mg-rich olivine}}/I_{\text{Fe-rich olivine}}$) of splitted peaks for olivine 130 were linked with subtype, and showed clearly the higher values for ALH 77307 3.03 and Y-81020 3.05 deviated from the correlation. They are commonly the subtypes of 3.0 although ferroan olivine of Colony has been disappeared due to the terrestrial weathering. The deviated two meteorites (ALH 77307 3.03 and Y-81020 3.05) would suggest that the matrices include significant amount of amorphous silicates instead of ferroan olivines. We estimated the mode of amorphous silicates to be ~20% for ALH 77307 and ~10% for Y-81020. On the other hand, the correlation more than subtype 3.1 is linked with the Mg-Fe volume diffusion of olivine grains (typically 50 μm in diameter) in chondrules that forsteritic olivine changes to ferroan from the rim with the thickness increasing. The modeled numerical analyses gave the peak temperature on the parent body 580-880 K at the cooling time scale of 10^6-10^8 y, and this range is nearly consistent with the recent estimation (660-850 K) [8]. Kamacite and taenite commonly coexist for studied samples, however, the high Ni content (~7-10 wt%) in some FeNi grains which do not show decomposed texture would imply martensite. Thus it is suggested that the martensite is primordial phase crystallized in the solar nebula. Plessite grains observed only in ALH 77307 would transform from martensite during the weak metamorphism on the parent body. Therefore the martensite is more sensitive than amorphous silicate during the thermal metamorphism.

Summary: We obtained new understanding on the primordial phases and the thermal history for the CO3 chondrites using the unique analytical methods.

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