

MINERALOGY OF MAC88177 AND COMPARISON WITH AUGITE-BEARING LODRANITE, YAMATO 74357; Hiroshi Takeda, Jun Saito, Mineralogical Inst., Faculty of Science, Univ. of Tokyo, Hongo, Tokyo 113, Masamichi Miyamoto, College of Arts and Sci., Univ. of Tokyo, Komaba, Meguro-ku, Tokyo 153, Japan, and Takahiro Hiroi, Dept. of Geol. Sci., Brown Univ., Providence, RI02912

MAC88177 has been described as a carbon-free ureilite (1). Because this meteorite has texture and mineralogy similar to an augite-bearing lodranite, Yamato 74357 (2,3), we studied MAC88177 by electron probe microanalysis (EPMA) and scanning electron microscope (JEOL 840A SEM) with chemical mapping analysis (CMA) utilities, and discuss relationship between ureilites and primitive achondrites (including lodranites). There are reported evidences of remnants of primitive materials in these meteorites, which preserve high abundances of the planetary-type noble gases (4,5). An oxygen isotope anomaly similar to that found in the carbonaceous chondrites has also been detected in ureilites (6). Bild and Wasson (7) pointed out a relationship of the Lodran meteorite with the ureilites. Reflectance spectra of modified lodranites have been related to those of S-asteroids common to the main belt asteroids (2).

MAC88177 is a coarse-grained ultramafic rock with rounded olivine and orthopyroxene (opx) crystals up to 2 mm in diameter and minor augite (aug), FeNi metal and troilite. Grain boundaries are not filled with carbon veins, and at some boundaries thick metal-troilite veins appear to fill the interstices of mafic silicate crystals, and interstices of a few boundaries are left vacant. The chemical compositions of minerals in the polished thin sections (PTS) of MAC88177, 55 were measured by EPMA, and color processed back-scattered electron images (BEI) and CMA were employed to obtain mineral distribution map. Modal abundances of minerals obtained from these maps are: olivine 39 vol. %, opx 44, aug 6, FeNi metal and troilite 5. The chemical compositions of these minerals are uniform within and between the crystals (Fig. 1). Olivine $\text{Fe}_{13.3}\text{Mg}_{86.7}$ and opx $\text{Ca}_{3.4}\text{Mg}_{84.6}\text{Fe}_{12}$ and aug (bulk) $\text{Ca}_{42}\text{Mg}_{52}\text{Fe}_6$ are in equilibrium and the opx-aug pair gives equilibrium temperature of 1100 to 900°C. An aug crystal up to 1.5 mm along the c axis shows exsolution of low-Ca pyroxene of 0.6 μm wide with 4 μm intervals.

The Y74357, 62-1 PTS (3) was examined as a part of the NIPR consortium study. An apparent overall texture of Y74357 is more similar to that of ureilites than MAC88177 (8), except for that troilite veins and oxydized iron minerals are abundant in Y74357 in stead of carbon in ureilites. The PTS shows a coarse-grained granular aggregate of mafic silicates up to 1.5 mm across and consists mainly of the same minerals as MAC88177. One prominent difference is fine fractures in euhedral olivine crystals decorated by mainly troilites. Modal abundances of minerals are: olivine 83 %, opx 6, aug 3, metal and traces of chromite and troilite 8. The chemical compositions of olivine and opx in Y74357 are not an equilibrated pair. Olivine $\text{Fe}_{7.9}\text{Mg}_{92.1}$ is more Mg-rich than opx $\text{Fe}_{13.8}\text{Mg}_{86.2}$. The chemical zonings of Mg/Fe, CaO and MnO detected at 20 μm from the rims of the Y74357 opx suggest that the olivine was completely reduced during a subsolidus annealing episode, because of higher diffusion rate of Fe in olivine than in opx.

The olivine and pyroxene compositions of MAC88177 are close to those of Y74357 before reduction. The MAC88177 pyroxene composition is outside the compositional ranges known for the ureilitic pigeonites and is at the Fe-rich end of the ureilite opx trend (Fig. 1). The opx-aug-bearing ureilites Y74130 and MET78008 have their pyroxene compositions and textures

different from MAC88177. The CaO contents in the Y74357 olivine decrease towards the edges. By applying the method of Miyamoto et al. (9), we obtain cooling rate $0.3^{\circ}\text{C}/\text{year}$ from 1000 to 500°C . The Mg/Fe zoning profile due to reduction of outer 20 μm of the Y74357 opx also gives cooling rate of $0.1^{\circ}\text{C}/\text{year}$ (9). By the same cooling rate, an olivine crystal 2 mm in diameter will be homogenized by the Mg/Fe interdiffusion. MAC88177 does not show zoning by reduction, but the presence of exsolution in augite supports the slow cooling, which is different from those experienced by ureilites.

Because Lodran has been proposed to be related to the ureilites (7), it is natural to propose a similar origin related to the planetesimal-scale collision (PSC) model proposed for ureilites (8). Takeda and Hiroi (10) suggested that the presence of volatiles in the source carbonaceous materials of ureilites will make large difference in removing Ca-Al partial melts and residuals of crystal growth and Fe-Ni-S eutectic melts in the case of ureilites during the PSC. The PSC model for the primitive achondrite formation does not encounter as many difficulties as in the ureilite formation, because their chondritic chemistries are more or less preserved.

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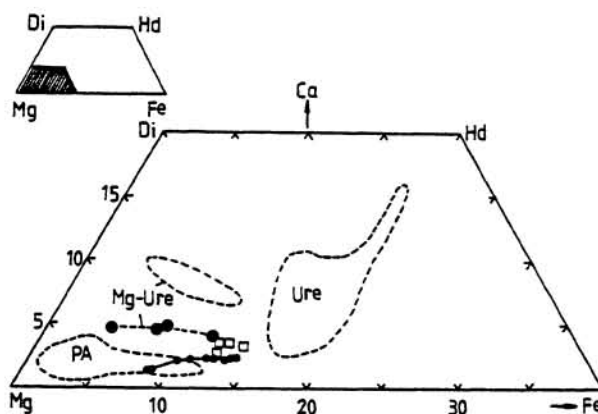


Fig. 1. Chemical compositions of pyroxenes in primitive achondrites (PA) (11) and ureilites (Ure) plotted in an enlarged pyroxene quadrilateral. Dotted area are for Ure and PA. Large solid circles: opx in Mg-ureilites, small circles: Y74357, squares: MAC88177