

MINERALOGY OF APOLLO 12 LOW-Ti BASALTS IN RELATION TO LUNAR METEORITES FROM MARE REGION; Hiroshi Takeda, Tomoko Arai and K. Saiki, Mineralogical Inst., Faculty of Science, Univ. of Tokyo, Hongo, Tokyo 113, Japan.

In order to characterize mineralogically a possible new type of low-Ti mare basalts in the Antarctic lunar meteorites, which were formerly classified as VLT basalts, we investigated two low-Ti basalts in the Apollo samples, 12064 and 12031 by mineralogical techniques including chemical mapping analysis utilities (CMA) of SEM and EPMA. The pyroxene chemical zoning trends of an oriented pyroxene crystal along nearly the c-axis of 12064 showed a trend intermediate between the Apollo 12 pigeonite basalts and low-Ti lunar meteorite, Y793169. The spinel chemical variations of chromite-ulvöspinel in 12064 are within one spinel crystal produced during the crystal growth, whereas those of Y793169 and A881757 (YA meteorites) are from grain to grain variations. The $Ti/(Ti+Cr)$ versus $Fe/(Mg+Fe)$ Mol ratios for the 12064 pyroxenes are distinct from the YA meteorites and support the proposal that they represent a new low-Ti type.

Consortium studies of the YA meteorites have indicated that they are intermediate between VLT and low-Ti mare basalts [1,2]. They appear to represent a new type of low-Ti mare basalt that crystallized at about 3.9 Ga [3]. Y793169 contains considerable amounts of Ti-bearing oxides in the mesostasis area. The chemical variations of these phases are not in the same trends as in the low-Ti pigeonite basalts of Apollo 12 and 15 in spite of its higher TiO_2 contents [4]. Rock 12064 has been found to be closest to this basalt in the grain size and mineral assemblages [4,5].

We investigated polished thin sections (PTS) 12031,21 and 12064,9 to compare them with Y793169,51-3 and A881757,51-4 supplied by the National Inst. of Polar Res. (NIPR) for the consortium studies. 12031 is a pigeonite basalt but has not been studied, because it was kept for future studies during the Apollo mission [6]. Mineral chemistries and textures were examined by an electron probe microanalyzer (EPMA) and scanning electron microscope (SEM), JEOL 840A with X-ray CMA utilities. We measured zoning profiles selected on color maps produced by the PXQUD system of Saiki [7].

The 12031,21 PTS consists of one large single crystal 5.2X1.8 mm in size and small aggregates of plagioclase, ilmenite, troilite, a silica mineral are attached. The pyroxene crystal includes small grains of chromite and Fe metal. The CMA data showed that 12031 is a pigeonite basalt intermediate between 12021 and 12037 [4]. Rock 12064 is a ilmenite basalt with a microgabbro texture. Mineralogy and petrography have been reported by Klein et al. [5]. Modal abundances of minerals of 12064 is pyroxene 57 %, plagioclase 33 %, opaques 7 % [4], which are nearly equal to Y793169 with pyx. 56 vol. %, plag. 42 %, ilmenite 1 %, ulvöspinel 1 % etc.

Rock 12064 shows texture and pyroxene chemical zoning trends comparable to those of Y793169. The zoning trend of 12064 was examined on a partly oriented crystal which has an hour glass texture. The trend along the c-axis (Fig. 1, left) is one found in Y793169 [2], and the trend perpendicular to c is similar to those of the pigeonite basalts such as 12031. The $Ti/(Ti+Cr)$ versus $Fe/(Fe+Mg)$ trend of the 12064 pyroxene is distinct from those of the YA meteorite pyroxenes (Fig. 2). Chemical variations of ulvöspinel and chromite in 12064 are compared with the YA meteorite spinels in Fig. 3. The $Ti/(Ti+Cr+Al)$ versus $Fe/(Fe+Mg)$ variation (Fig. 3) of 12064 represents the core to rim variation but is similar to

LOW-Ti BASALTS IN RELATION TO LUNAR MARE METEORITES: Takeda H. et al.

Y793169. The trend of Y793169 is grain-to-grain variation representing only very last stage of the local differentiation of the mare basalt.

It is to be noted that the YA meteorites show resemblance to 12064, but others are distinct. The variation may represent difference in the condition during crystal growth process and their bulk chemistries. The precipitation of Ti-bearing phases in Y793169 took place at the last stage of the small-scale differentiation. Comparisons of 12064 and 12031 with those of the YA meteorites support the previous conclusions [1] that the YA meteorites represent a new type of low-Ti basalts not known in the Apollo samples.

We thank NASA and NIPR for the samples, and to Drs. M. Lindsrom, P. H. Warren, and K. Yanai for discussion, and T. Ishii, E. Yoshida, O. Tachikawa, K. Hashimoto, M. Ohtsuki and M. Hatano for their technical assistances.

REFERENCES: [1] Yanai K. et al. (1993) LPSC XXIV 1555-1556. [2] Takeda H. et al. (1991) Proc. NIPR Symp. Antarct. Meteorites 6, 3-11. [3] Misawa K. et al. (1992) *ibid*, 5, 3-22. [4] Pipike J. et al. (1976) *Rev. Geophys. Space Phys.* 14, 475-540. [5] Klein C. Jr (1971) *Proc. Lunar Planet. Sci.* 2nd, 265-284. [6] Takeda et al. (1975) *Proc. Lunar Sci. Conf.* 6th, 987-996. [7] Saiki K. et al. (1992) *Lunar Planet. Sci.* XXIII 1201-1202.

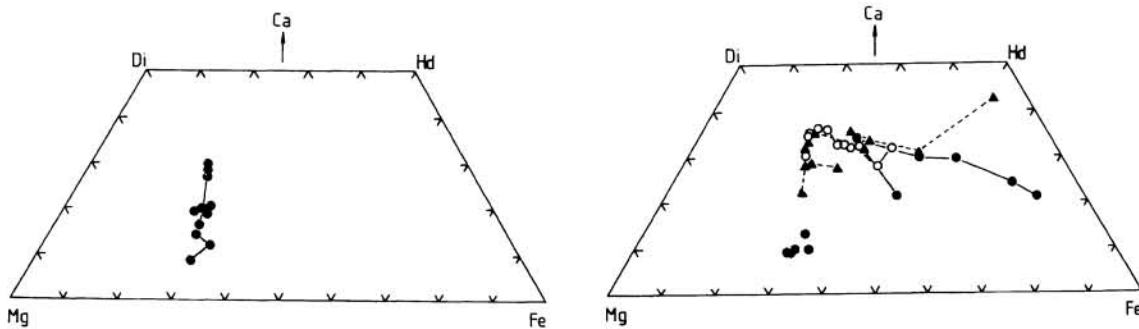


Fig. 1. Pyroxene quadrilaterals of 12064. Left: traverse parallel to the c-axis. Right: perpendicular to c; open circles: trends at the center of the hour glass texture; solid circles: open ends; and triangles: middle.

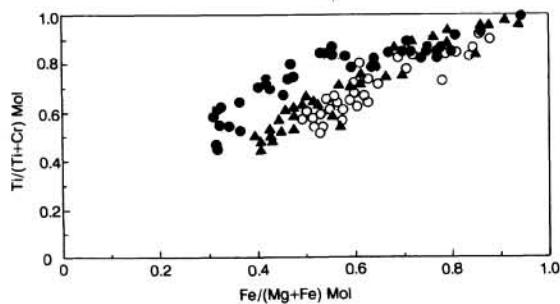


Fig. 2. $Ti/(Ti+Cr)$ vs. $Fe/(Fe+Mg)$ Mol. ratios for pyroxenes in 12064,9 (solid circles), Y793169 (solid triangles), and A881757 (open circles).

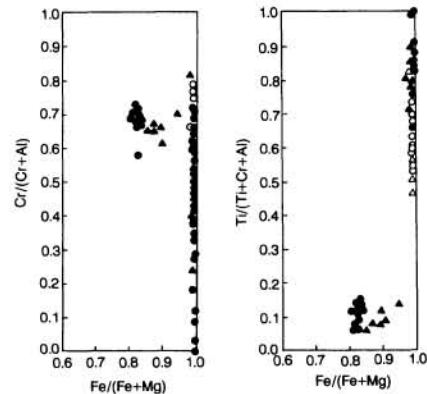


Fig. 3. $Ti/(Ti+Al+Cr)$ and $Cr/(Cr+Al)$ vs. $Fe/(Fe+Mg)$ diagrams for ulvöspinel-chromite from mare basalt, 12064,9 (solid circles), Y793169 (solid triangles) A881757 (open circles)