MINERALOGY OF THE DHOFAR 489 LUNAR METEORITE, CRYSTALLINE MATRIX BRECCIA WITH MAGNESIAN ANORTHOSITIC CLASTS. Hiroshi Takeda[1], Kazuto Saiki[2], Teruaki Ishii[3], and Mayumi Otsuki[3], [1]Research Inst., Chiba Inst. of Technology, 2-17-1 Tsudanuma, Narashino City, Chiba 275-0016 Japan, e-mail: takeda@pf.it-Chiba.ac.jp, [2]Research Inst. of Materials and Resources, Faculty of Eng. and Resource Sci. , Akita Univ., 1-1 Tegatagakuen-machi, Akita, 010-8502, Japan, e-mail: ksaiki@rimr.akita-u.ac.jp, [3]Ocean Research Institute, Univ. of Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo 164-0014, Japan.

Introduction: Lunar meteorites from Antarctica and hot deserts provide us with information not known in the Apollo and Luna samples. For example, Yamato (Y) 86032 [1] possibly derived from the lunar far-side crust contained a "gray anorthositic clast", and especially important is that bulk Sm-Nd data give a slightly negative value of ε_{Nd} at 4.4 Ga ago [2]. Nazarov *et al*. [3] reported 5 non-paired lunar meteorites from the Dhofar region of Oman. Dhofar(D) 489 weighing 34.4 g was recovered from Oman and described by us as a crystalline matrix feldspathic breccia [4]. The mg numbers of mafic silicates in this meteorite are higher than those of ferroan anorthosites (FAN) trend in the An *vs.* mg number diagram and extend into the top of the Mg-suite (MgS) rocks. This trend has been reported for the lunar granulitic rocks [5, 1], but D489 does not show such granulitic texture. We report the mineralogy of D489 and discuss the origin of this possible magnesian anorthosite.

Samples and experimental methods: A polished thin section (PTS) of D489 was made from a 0.42 g chip at CIT. Two aliquots of samples were extracted from 6 g block kept at National Sci. Museum in Tokyo (NSMT) for Ar-Ar dating (D. Bogard) and cosmogenic nuclide studies (K. Nishizumi). The elemental distribution maps of Mg, Al, Ca, Fe, Si, Cr, Ti, S, P, Na, K have been obtained by JEOL 8900 EPMA equipment at the Ocean Res. Inst. of Univ. of Tokyo. Chemical compositions of minerals and bulk chemical compositions of the crystalline matrices were analyzed by JEOL 733 EPMA.

Results: On the cut surface of the 6 g block, we can observe snow white feldspathic clasts and light brownish gray matrices. The sample is weathered, but is very hard. In the PTS, fine Ca carbonate veins penetrate into the specimen. A feldspathic fragmental breccia consisting of clasts of various feldspathic lithologies are embedded into a fine-grained crystalline matrix. Fig. 1 shows ophitic textures with acicular plagioclase crystals (crystals up to 0.04 mm in length) with minor olivine and pyroxene. The fragmental breccia matrices rich in angular fragments of mafic minerals, common in lunar meteorites were not observed in the PTS. Clasts include cataclastic feldspar fragments up to 1.4×1.0 mm and fragment-laden devitrified dark glassy impact melt breccia clast 3.2 × 2.2 mm in size (Fig. 1) with feldspar fragments. Unlike known lunar meteorites, this lunar rock is a feldspathic crystalline matrix breccia.

The largest feldspar grain is up to 1.8 × 0.6 mm in size, and shows twin lamellae. Many parts of the feldspathic clasts are converted to dark colored, fine-crystalline materials with small amounts of FeO and MgO. The An values of plagioclase in the PTS (An95~98) distribute in a much smaller range than those in common lunar feldspathic meteorites (An89~99). Plagioclase compositions in D301 distribute from An 90 to 99 and D303 from 94 to 99 [3]. However, their highest frequency compositions distribute within the same range, *i.e*. An95~97. The An contents of the acicular plagioclase in the crystalline matrix (An95.5~96.5) also distribute in the same range as large fragments.

Pyroxene crystals in plagioclase and crystalline matrix range from $Ca_{4.6}Mg_{85.1}Fe_{10.3}$ (mg# 89.2) to $Ca_2Mg_{74}Fe_{24}$ (mg# 75.5) (Fig. 2). The most Mg-rich pyroxene is more Mg-rich than those of common lunar feldsparthic regolith breccias and similar to those of the 60019 poikilitic clasts. Lunar highland breccias such as 67016 and other lunar highland meteorites [1, 6] have pyroxene compositions with mg# a little over 80 to around 60. Some pyroxenes in D301, 302 and 303 [3] distribute more Mg-rich side. The D489 pyroxenes distribute within a smaller range than those of other Dhofar meteorites, and lack some iron-rich members (Fig. 2). Inverted pigeonite with exsolved high-Ca pyroxene has not been found in D489.

Olivine grains (up to 0.21×0.15 mm) in the anorthositic matrices often show subrounded shapes. The Fo contents of olivine (Fo74 to Fo86) show bimodal distribution with their higher frequency compositions at Fo75~77 and Fo84~85. These trends define two lithologies in the An *vs.* mg# diagram. The fine-grained olivines in the crystalline matrices give Fo74~76 and pyroxenes in them $Ca_{11}Mg_{69}Fe_{20}$.

The bulk compositions of the crystalline matrices contain lower FeO and MgO concentrations (FeO 1.5~2.8 wt%, MgO 2.6~5.2) than those of other lunar anorthositic meteorites, Apollo anorthositic breccias and granulites (FeO 4~7.0 wt %, MgO 5.6~11). Suevite-like impact melt veins (FeO 2.5 wt%, MgO

4.2) penetrate into an impact melt clast and the anorthositic clast and matrices.

Discussion: D489 differs from other known lunar meteorites from the Dhofar region, which are either feldspathic regolith breccias, fragmental breccias or impact melt breccias [3]. The small ranges in their compositions suggest that the plagioclase fragments in the PTS came from a region with small numbers of lithology.

Compositions of coexisting plagioclase, olivine, and low-Ca pyroxene in D489 bridge the "gap" between FAN and MgS rocks in the An *vs*. mg number diagram. This trend has been proposed for the Apollo granulitic rocks [5] and granulitic clasts in lunar meteorites [1]. Some investigators have attributed this trend to a mixed lithology containing contributions from MgS rocks. However, D489 does not show such granulitic texture, but exhibits a crystalline matrix texture. One group (An 95.3, mg# 75.3) distributes just in the middle of the "gap" and the Mg-rich trend (An 95.7, mg# 88.2) is located near the top of the Mg-S trend. There is no indication in mineralogical data that this meteorite contains FAN lithologies. All pyroxenes and olivines found in D489 have mg number higher than the FAN trend. However, it is too soon to believe that this possible magnesian anorthosite lithology represents one of the early crystallized lunar crustal material.

One reason why this pair plots in the granulitic trend is because all mafic silicates are too Mg-rich and the An values distribute within the small range. Mg-rich compositions can be attributed to reduction processes during thermal metamorphism. Homogenization of pyroxenes during metamorphism has been proposed for the Apollo poikilitic rocks [7]. The pyroxene compositions of D489 resemble those of the Apollo 16 poikilitic rocks. Pyroxenes in D302 and D303 also extend towads mg number=90, and pyroxenes in D301 to enstatite [3]. Nazarov *et al.* [3], who studied these samples also proposed reduction processes. Homogenization in pyroxene is a common phenomena in metamorphosed eucrites. Two distinct Fo values of olivine are not in favor of homogenization and reduction. Absence of Fe-rich mafic silicates may be explained by melting to produce crystalline matrices. If we do not accept the reduction hypothesis, we may have to assume more Al_2O_3-CaO-rich magma ocean than presently believed to make a gap between the MgS and FAN. Comparing the mineralogical data and reflectance spectra of this meteorite, we propose that we will look for such lithology in lunar highland for our future SELENE mission.

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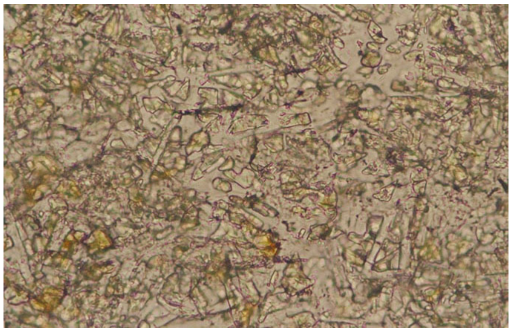

Figure 1. Photomicrograph of PTS of D489 (top, width 6 mm) and a close up view of the crystalline matrix (bottom, width is 0.6 mm).

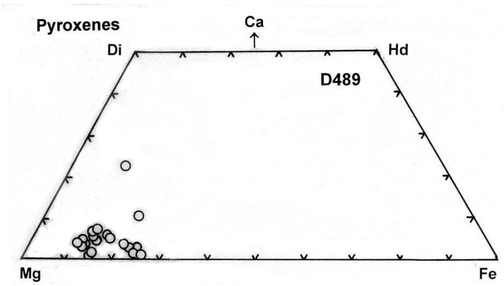

Figure 2. Pyroxene quadrilateral of D489.