IRON CONTENTS OF PLAGIOCLASES IN DHOFAR 307 LUNAR METEORITE AND SURFACE MATERIALS OF THE FARSIDE LARGE BASINS.

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Introduction: We reported mineralogy of magnesian olivine-rich clast-types in Dhofar 489 [1], 309, [2] and 307 [3] and discussed varieties of magnesian lithologies of the farside crust of the Moon. Korotev et al. [4,5] reported likely 15 stones from Dhofar with unique chemical compositions in the pair group, consistent with the estimated low concentrations of Th and FeO by the remote sensing data on the farside of the Moon [6]. Dhofar 309 [2], 908 [6] and 307[3], are paired samples of the Dhofar 489 group, and include clasts of the magnesian anorthosites (MAN) and mafic rich clasts. Now we compare all the clasts found in the above samples and propose a model of formation of such breccia in a large basin of the farside to explain the common origin of the magnesian lithologies with olivine.

Ohtake et al. [7], Matsunaga et al. [8] found nearly pure anorthosites at near and far side highlands based on the 1.25 μm absorption of plagioclase observed by MI (multiband imager) and SP (spectroprophiler). and Ogawa et al. [9] observed fresh small craters with bright rays. In order to clarify the relashinship between FeO content of plagioclase and 1.25 μm absorption , we searche for clear plagioclase crystals in Dhofar 307 and measured their FeO contents. The data were used to interprete 1.25 μm absorption by SP and MI.

Samples and Methods: One polished thin section of Dhofar 307,t6 prepared at National Inst. of Polar Res. (NIPR) was employed for mineralogical and petrographic studies. FeO contents and chemical compositions of plagioclases were obtained by electron probe microanalysis (EPMA) at the Ocean Res. Inst. (ORI) of Univ. of Toyo and NIPR. Line analyses with 5 μm intervals were emplyed to detect local variations of FeO in plagioclase.

Results: The An contents of Dhofar 307, 309 and 908 distribute around the same range (An96). Angular and subround clasts of troctolitic anorthosites and magnesian anorthosites are embedded in fine grained recrystallized or devitrified impact melt glassy matrices. The clast types are different from one sample to others. The clast population in Dhofar 307 is dominated by granulitic clasts of mainly anorthositic and troctolitic compositions, and fragments of large olivine fragments are common in dark matrices.

Mineralogy of plagioclase in Dhofar 307. We searched for fragments of clear crystals in Dhofar 307. FeO contents of such crystals were compared with those of large fragments of plagioclase with some dusy cores (Table 1). The FeO contents of the clear crystals are close to those (FeO 0.06 wt. %) of crystalline cumulate eucrites, Y980433. The paired sample, Y980318 has crystallization age of 4.56 Ma [10].

The FeO contents of plagioclase with dusty cores are as high as those of FAN and MAN (Table 1). Fine acicular crystals grown in devitrified impact glassy matrices have the highest FeO concentrations.

Clasts with affinity to Spinel Troctolites. We recognized two major clasts, embedded in a matrix of devitrified glass and fragments of shocked plagioclase. One prominent clast is granulitic rock with a reddish orange colored olivine with subrounded shapes in granoblastic plagioclase, but the granoblastic texture is obliterated by shock effect. Another large clast is coarse-grained troctorite similar to the spinel troctolite in Dhofar 489.

Crystalline rock clasts with rapid growth features grown from an impact melt pool, as were observed in Dhofar 309 clast, such as elongated lath-shaped plagioclase crystals with minor zonings (An 95.0-96.6) and fragments of twinned plagioclase of 1.1 × 0.8 mm in size with uniform composition, were not found in other samples. The mineral assemblage of this clast is similar to that of spinel troctolite clast in Dhofar 489 [1]. The modal abundances in volume % of the minerals of all three types clast are practically the same.

Discussion: A question we have is how the prominent 1.25 μm absorption of plagioclase observed by MI and SP is related to the original anorthositic crust. The plagioclase with FeO contents (FeO 0.06 wt. %) of crystalline cumulate eucrites, Y980433 does not show 1.25 μm absorption [11]. The eucrite represnts a pristine product of the thin magma ocean of Vesta. Since the clear plagioclase in Dhofar 307 has the same FeO content as that of Y980433, such plagioclase can be a candidate of the original lunar crust, but such plagioclase may not show 1.25 μm absorption. Plagioclase grains of the magnesian anorthosites and Y980433 we studied have polysynthetic twin textures, which is used to eliminate granulitic plagioclase. If we assume bulk composition of a MAN when it was formed with trapped liquids, is the same as the bulk composition of d-1 anorthosite clast (Table 1) [1], we can calculate the FeO content of plagioclase formed from such materials. By employing partition coefficient of 0.05 [12] , we obtain FeO of 0.14 wt %. This value is comparable to those of dusty plagioclases in MAN and is higher than those of the claear plagioclase in Dhofar 307. Original pure plagioclase formed in the magma ocean may have FeO 0.05 wt % with no 1.25 μm absorption, but shock heating and metamorphic events will increase the FeO contents large enough to be detected by the MI and SP based on 1.25 μm absorption.

Formation model of the Dhofar 489 breccias. It was argured that the feldspathic composition coupled with low Th concentration is not in itself good evidence of farside origin [3]. The Dhofar 489 contain more magnesian olivine than those of the FAN of the Apollo samples. In addition, Dhofar 489 contains some deep seated rocks such as a spinel troctolite and their granulitic varieties. The impact which excavated and mixed the breccia components would have mixed the FAN lithologies of the near side with the magnesian anorthosites, because much of the surface of the nearside feldspathic highlands contains ferroan mafic silicate. The absence or very low abundance of FAN in the Dhofar 489-type feldspathic lunar meteorites is in favor of the farside origin.

We suggest the following formation model of the Dhofar 489 group breccias. Based on the remote sensing data of Th and FeO distribution, we assume magnesian anorthosites (MAN) constitute major parts of the northern farside highland. Spinel troctorites are present ca. 15 km beneath the MAN crust. A large impact, which excavated a basin more than 80 km in diameter, produced impact melts at the basin flower and crystallized IM-like clast by rapid cooling. Granulites were produced by thermal metamorphism at the flower of a large basin. Smaller impacts within the basin produced breccias of these materials. A small fresh crater within such basin may excavate lunar meteorites to Earch. However, Ogawa et al. detected pyroxene absortion in and around such craters [9]. Impact produced SiO_2-rich liquid coating plagioclase may devitrify to produce fine pyroxene.

The magma ocean (LMO) model initially proposed by Warren and Wasson [13] emphasize that FANs have very little trapped liquid. This model was proposed, because the FANs have uniformly low incompatible elements (IE) concentrations that show no relationship with their low to extremely low mafic contents. They also advocated that FANs, are direct plagioclase-flotation products of the LMO. Since the amounts of trapped liquid is small, such anorthosites are practically similar to "pure anorthosite". Both 60025 FAN and magnesian anorthosite Dhofar 489 have low IE concentration [10]. If such pure anorthosites exist, we cannot say whether they are FAN or MAN, because of the low concentration of the trapped liquids. Amounts of trapped liquids and their Mg numbers might characterize MAN and FAN.

Table 1. Plagioclase compositions (wt%) of Dhofar 307 and 489.

	307 Plag [b]		489 Plag		489 d-1	489 Matrix	
	Clear	Dusty	L Frag [c]	Mg An [d]	Bulk	Acic. [e]	Bulk [f]
No. [a]	17	19	10	16		10	21
SiO_2	44.58	44.73	44.01	44.28	43.92	44.55	44.89
TiO_2	0.01	0.08	0.02	0.03	0.12	0.08	0.12
Al_2O_3	35.87	35.25	35.46	35.43	29.84	35.27	31.47
FeO	0.06	0.15	0.10	0.16	2.83	0.20	1.46
MnO	0.01	0.02	0.00	0.02	0.04	0.01	0.06
MgO	0.07	0.24	0.16	0.16	5.58	0.18	2.70
CaO	19.67	19.14	19.46	19.55	17.17	19.50	17.97
Na_2O	0.37	0.46	0.39	0.39	0.36	0.43	0.36
K_2O	0.02	0.02	0.01	0.01	0.07	0.01	0.01
Cr_2O_3	0.01	0.01	0.01	0.01	0.06	0.01	0.04
V_2O_3	0.01	0.00	0.00	0.01		0.00	0.00
NiO	0.02	0.04	0.03	0.02		0.00	0.00
P_2O_5	0.02	0.03	0.00	0.00		0.00	0.00
Total	100.72	100.16	99.65	100.06	100.00	100.25	99.14

[a] numbers of measurements; [b] clear crystal and one with dusty core; [c] large fragment; [d] magnesian anorthosite with twinned plagioclase & olivines; [e] acicular plagiocalse in crystalline matrix; [f] bulk matrix composition.

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