P144-012 **Room: 304** **Time: May 16 15:00-15:15**

Orthopyroxenes in lunar highland breccias with reference to remote sensing spectroscopy

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Remote sensing data indicate that the nearside and the farside of the Moon are substantially different in terms of inferred chemical compositions and rock lithologies The estimated low concentrations of Th and FeO by the remote sensing data are consistent with the presence of the Dhofar-489-type lunar rocks on the farside of the Moon. Dhofar 307, 309, 908, are paired samples of the Dhofar 489 group, and include clasts of the magnesian anorthosites (MAN) and mafic rich clasts. Nyquist et al. reported isotopic studies of another lunar meteorite, Yamato 86032 from the farside and proposed a magma sea model of the FAN anorthosites.

Ogawa et al. observed fresh small craters with bright rays of the farside of the Moon by the spectroprophiler (SP) on boad Kaguya (LISM/PI, SP: T. Matsunaga, MI:M. Ohtake, TC:J. Haruyama). In order to clarify the common presence of pyroxene observed by SP of these craters, we reexamined matrices of the Dhofar 489 group and reflectance spectra of recrystallized matrices of Apollo 16 feldspathic breccias, 60019 and 67016 samples.

We recognized three major clasts, embedded in matrices of devitrified glass and fragments of shocked plagioclase. One prominent clast is granulitic rock in Dhofar 307 with olivine with subrounded shapes in granoblastic plagioclase, Another type clast is coarse-grained troctorite similar to the spinel troctolite (ST) in Dhofar 489. Dhofar 309 contains impact melt crystalline clasts of such ST. Our observation of more olivine fragments in Dhofar 489, 309 and 307 from the lunar farside, produces some problems to support an idea that the more pyroxene are expected to be present by the SP data. Orthopyroxene fragments were not so dominant in these lunar meteorites from highlands, especially from the far side highland (FHT) as in Dhofar 489 and the paired group.

The observation of the fresh small craters, also may not be in line with mineralogical information obtained by lunar meteorites from the farside, in which olivines are dominant minerals present. We have to find reasons of this discrepancy of mineralogical data. Impact produced SiO2-rich liquid coating plagioclase may devitrify to produce fine pyroxene. Projection of low pressure pseudoternary liqudus diagram for Fe/(Fe+Mg)=ca.0.3 given by Walker et al. is useful in discussion on the formation of pyroxene-rich melt. Partial melting of an olivine, low Ca pyroxene-plagioclase assemblage seems the most reasonable mechanism for producing the pyroxene-rich material of the Apollo 14 landing site, such as rock 14310. Compositions of the impact melts are generally intermediate between total melting and equilibrium partial melting as was proposed for the origin of rock 14310. If such melts were produced by the impact of the small crater, devitrified glasses or recrystallized glasses may contain fine pyroxene crystallets as was observed in the matrices of Dhofar 489.

Mineralogical studies of minerals in the matrices of lunar highland regolith breccias, 60019 and 67016 showed that all kinds of pyroxene fragments from the Mg-suite type rocks of the PKT are present. However, dark glassy matrices of the impact melt breccias of 67016 and 60019 are similar to those of the Dhofar 489 type meteorites. Poikilitic clasts in 60019, for exmple, sample WF-4 (60019,190) is one of the large clasts in this rock. The texture of PTS 60019,208 of WF-4 resembles that of typical low-K Fra Mauro poikilitic breccia 65015. The matrix consists of very fine-grained aggregates of pyroxene, plagioclase, and olivine. The resmblance of their reflectance spectra of these samples measured by Yamamoto et al. to those of the fresh-rayed small crater support the origin of pyroxene proposed above.