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Mineralogy and Petrology of A New Lunar Meteorite M16005

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1 Introduction

M16005 is a lunar meteorite found recently. Optical and microprobe examinations reveal that it is a well consolidated, polymict regolith breccia. M16005 is composed of abundant mineral fragments and a few lithic clasts, glasses, agglutinates that set in fine-grained matrix. The lithic clasts, glasses, and mineral fragments show irregular shapes and variable sizes (from ~10 μm to ~4.1 mm across) and textures. The matrix is made up of fine-grained minerals bound by glassy cement. Some glassy spheres were observed in the thin section. The Fe/Mn ratios of pyroxene and olivine in M16005 lie approximately along the lunar line (Fig. 1), although the range of values is very large (44-79 for pyroxene and 72-127 for olivine). However, this spread is typical for lunar pyroxenes and olivines, and ratios for M16005 are bracketed by the range of values seen in other lunar rocks (32-84 for pyroxene and 65-160 for olivine) (Papike et al., 1998).

2 Petrography and Mineral Chemistry

Angular to sub-angular mineral fragments (4.1mm to 10 μm) were identified using SEM. These include plagioclase, pyroxene, olivine, and minor ilmenite, chromite, silica, Ni-Fe metal, troilite. Plagioclase compositions vary in the range of $An_{91-96}Or_{<0.4}$. Pyroxene mineral fragments show a wide range of compositions $Wo_{4-36}En_{7-69}$. Several pyroxene fragments possess exsolution lamellae up to 8 μm wide. Some grains exhibit compositional zoning from $Wo_{11}En_{64}$ (core) to $Wo_{25}En_{30}$ (rim). The composition of olivine fragments vary from Fo_{56} to Fo_{64}. We also found some symplectitic intergrowths of fayalite (Fo_{10-13}) + hedenbergite ($Wo_{37-42}En_{12-17}$) + silica after former pyroxferroite.

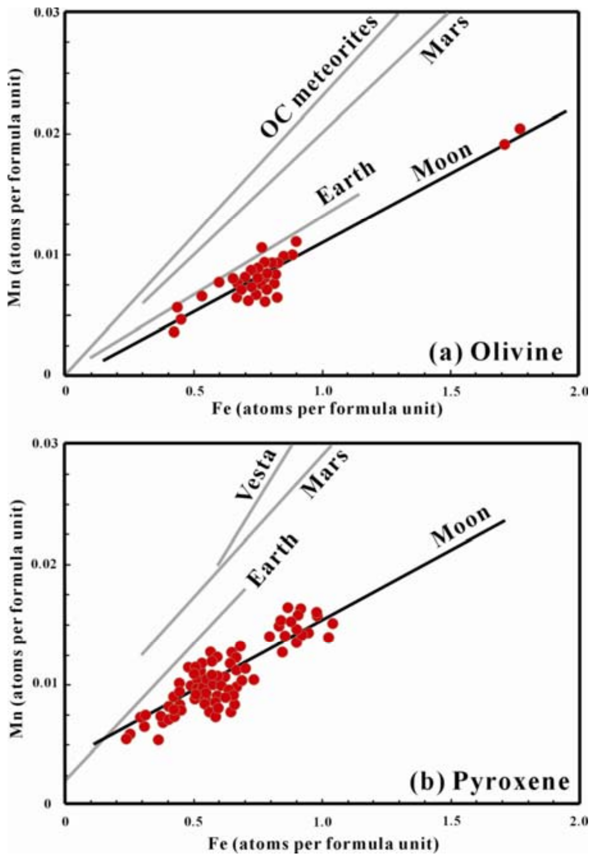

Fig. 1. Mn vs. Fe atoms per formula unit in (a) olivine, and (b) pyroxene (modified after Papike et al. (2009), Berlin et al. (2011) and Joy et al. (2014)).

M16005 contains various types of lithic clasts (anorthosite, anorthositic gabbro, anorthositic troctolite, olivine gabbro, gabbro, and crystalline impact melt breccia). All clasts are sub-angular, feldspathic, and the majority have an ophitic-subophitic texture, whereas others are granular. The detailed textural and WDS

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examination of 4 representative lithic clasts in one thin section are depicted as follows:

Clast 1. A 1.4mm × 1.1mm anorthosite clast with subophitic texture. Plagioclase has a narrow compositional range ($An_{95.6-97.4}$) and olivine is free. Xenomorphic clinopyroxene is $Wo_{39}En_{48}$. Accessories are ilmenite, ferro-pseudobrookite, brookite, and chromite.

Clast 2. A 2.8mm × 1.1mm granular olivine gabbro with accessory chromite, ilmenite, and troilite. Clinopyroxene shows a wide range of compositions: $mg^{\#}$=59.5-71.3; olivine is Fo_{65}. The plagioclase is relatively sodic and homogeneous, $An_{90.5-94.1}$, $Or_{0.3-0.4}$.

Clast 3. A 0.82mm × 0.73mm subophitic gabbro clast with accessory Fe-Ni metal and ilmenite enclosed within a sub-angular fragment. Clinopyroxene ($mg^{\#}$=60-68, $Wo_{13.9-29.9}$), and plagioclase ($An_{93.3-95.3}$, $Or_{0.1-0.2}$) have little compositional variation.

Clast 4. A 0.69mm × 0.58mm crystalline impact melted breccia. Most of this clast consists of a fine, quench-textured intergrowth of olivine, plagioclase, clinopyroxene, and ilmenite grains with larger relict plagioclase fragments. Late-stage assemblages have crystallized in the interstices with the fragements of apatite, k-feldspar, and silica.

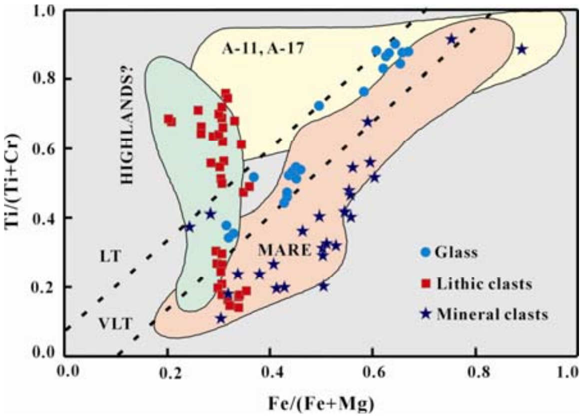

Fig. 2. Ti/(Ti+Cr) vs. Fe/(Fe+Mg) in pyroxene and glass (modified after Tomoko et al. (1996) and Heiken et al. (1991)).

3 Glass Spheres

Several 40-500μm spheroidal to ellipsoidal or fragmentary glass particles with variable composition are scattered throughout the meteorite matrix. Several spheres are texturally homogeneous, and others contain relict phases and/or quench crystallites. Most of the glasses analyzed have Mg/Al > 1, and are likely of volcanic origin (Delano, 1986). The compositions of all glasses are mafic and closed to the mare volcanic glasses(Shearer et al., 2006), and fall along a mixing line of very low Ti (VLT) and/or low Ti (LT) mare basalts components.

4 Discussion

Zoning patterns (Fig. 2) in glasses , pyroxenes from mineral fragements follow the correlated Ti and Fe enrichment trend characteristic of very low Ti (VLT), and/or low Ti (LT) mare basalts (Tomoko et al., 1996). Pyroxene compositions from lithic clasts (Fig 2) fall within a field of possible highlands lithologies (Tomoko et al., 1996). These petrographic and mineral chemical characteristics, showing multiple sources for the M16005 clasts, suggest that M16005 is a mixed mare and highland regolith breccia, the location of which possible near the the Procellarum KREEP Terrane.

Acknowledgements

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