LAP02205 LUNAR METEORITE: LUNAR MARE BASALT WITH SIMILARITIES TO THE APOLLO 12 ILMENITE BASALT. T. Mikouchi[1], J. Chokai[1], T. Arai[2], E. Koizumi[1], A. Monkawa[1], M. Miyamoto[1], [1]Dept. of Earth and Planetary Science, University of Tokyo, Hongo, Tokyo 113-0033, Japan (mikouchi@eps.s.u-tokyo.ac.jp), [2]Lunar Exploration Tech. Office, Japan Aerospace Exploration Agency (JAXA), Tsukuba, Ibaraki, 305-8505, Japan.

Introduction: LAP02205 is a new lunar meteorite recovered from the Antarctica. Although most lunar meteorites are brecciated, LAP02205 is a crystalline rock showing a basaltic texture, thus offering useful information to understand crystallization of lunar mare basalt. In this abstract, we present initial results of our ongoing petrological and mineralogical study of this meteorite and discuss its relationship to other lunar meteorites and Apollo samples.

Petrography: The thin section (LAP02205,34) shows a medium-grained subophitic texture (Fig. 1a) with evidence for moderate shock metamorphism (e.g., rare shock melt pocket and maskelynitization of plagioclase, undulatory extinction of pyroxene and olivine). The modal abundances of minerals are 53.1% pyroxene, 30.4% plagioclase, 6.9% olivine, 4.4% ilmenite, 2.2% silica, 1.3% Si-, K-rich glass, 1.2% fayalite, 0.2% spinel, 0.2% Fe sulfide, and 0.1% others.

Most pyroxenes are subhedral and somewhat elongated grains (~0.5 mm) although some large grains reach up to 1 mm. Plagioclase grains are equant to lath-shaped (~1 mm long). Most plagioclase grains show clear birefringence, but there are small areas where plagioclase has been partly or completely maskelynitized. Olivine grains are rounded and up to 1 mm in size. They usually present as clusters of a few grains. Ilmenite grains are generally elongated and reach up to 1 mm long (Fig. 1b). Silica grains (a few hundreds µm) are anhedral and scattered throughout the section. Their birefringence is very weak. Spinel is chromite-ulvöspinel and ~100 µm in size. There are abundant areas (~a few %) of mesostasis mainly composed of fayalite with Si-, K-rich glass, ilmenite, silica, Fe sulfide and apatite (Fig. 1b). Fayalte is irregularly shaped and often contains small spherical blebs (~20 µm) of Si-, K-rich glass (Fig. 1c). Rare accessory phases are baddeleyite, zirkelite(?), and Fe metal.

Mineral Chemistry: Pyroxenes are extensively zoned and their compositions widely range in the Fe-rich region of the pyroxene quadrilateral (Fig. 2a). The zoning pattern in a single grain is irregular, but the most inner core is usually pigeonite ($En_{55}Fs_{30}Wo_{15}$) and partly mantled by augite ($En_{40}Fs_{25}Wo_{35}$). Then, outer parts are zoned to nearly Mg-free compositions (some are probably pyroxferroite). The Al_2O_3, TiO_2 and Cr_2O_3 contents range 0.5-4.0 wt%, 0.4-1.8 wt%, and 1.0-0 wt%, respectively. Both Al and Cr show monotonous decrease as *fe#* (atomic Fe/(Fe+Mg)) increases, while Ti shows increase at first (*fe#*=0.35-0.6) and then decreases. The plagioclase composition ranges from $An_{91}Or_0$ to $An_{80}Or_7$ (Fig. 2b). Plagioclase contains 0.5-2.5 wt% FeO and 0-0.5 wt% MgO. Olivine is remarkably zoned (Fo_{67-48}) as pyroxenes (Fig. 2c). Minor elements in olivines are 0.3-0.4 wt% CaO and 0.1-0.4 wt% Cr_2O_3. Most ilmenite grains contain very small amounts (~0.1 wt%) of MgO and Cr_2O_3. Silica contains ~1 wt% Al_2O_3 and ~0.3 wt% TiO_2. Spinels in LAP02205 are chemically zoned from the chromite core (6 wt% TiO_2, 44 wt% Cr_2O_3, and 12 wt% Al_2O_3) to thin ulvöspinel rim (32-25 wt% TiO_2, 3-14 wt% Cr_2O_3, and 2-4 wt% Al_2O_3). Fayalite in the mesostasis is Fo_3 with ~1 wt% CaO. Si-, K-rich glass is ~80 wt% SiO_2, ~10 wt% Al_2O_3, ~1 wt% CaO and ~7 wt% K_2O.

Crystallization of LAP02205: The texture and mineral chemistry of LAP02205 suggest fairly fast cooling history typical for mare basalts. Probably, olivine was the first phase to crystallize. The most magnesian pigeonite is in equilibrium with olivine of Fo_{60}. Therefore, after the crystallization of olivine of Fo_{67-60}, pigeonite started crystallizing. The crystallizing pyroxene immediately changed to augite as suggested by small areas of magnesian pigeonite cores. After the onset of plagioclase crystallization, augite crystallization was replaced by Fe-rich pigeonite and grew into very Fe-rich pyroxenes. The ilmenite texture suggests that ilmenite would crystallize prior to Fe-rich pyroxenes. The compositional kink of Ti in pyroxene at *fe#*=0.6 may suggest the onset of ilmenite crystallization. More detailed analysis is necessary to conclude this. Finally, the mesostasis formed to crystallize various late-stage phases. High degree of fractionation of magma apparently produced silicate liquid immiscibility, forming fayalite and Si-, K-rich glass.

Comparison with other lunar meteorites and Apollo lunar rocks: When we compare LAP02205 with other crystalline lunar mare meteorites (only four samples known: Yamato 793169, Asuka 881757, NWA032/479, Dhofar 287A), LAP02205 shows some affinities to them. When we consider that LAP02205 contains olivine, Yamato and Asuka meteorites are different [e.g., 1]. NWA032/479 shows a very fine-grained groundmass texture, which is also clearly different from LAP02205 [2]. Texturally, LAP02205 is most similar to Dhofar 287A [3]. The abundance of olivine in Dhofar 287A is ~20%, which is clearly higher than that in LAP02025 (~7%), but the presence of abundant mesostasis of fayalite with Si-, K-rich glass is remarkably similar [3]. Also, olivine compositions of these two meteorites nearly overlap (Fo_{70-40}) (Fig. 2c). Pyroxene compositions are also similar between them, but Dhofar 287A lacks magnesian pigeonite unlike LAP02205 (Fig. 2a). Although LAP02205 contains ~2% silica, it is rare in Dhofar 287A. Thus, LAP02205 is different from any other lunar meteorites found so far.

When we compare LAP02205 with Apollo rocks, we have better matching samples. The Apollo12 ilmenite basalt suite shows a wide compositional variation from olivine-rich partial cumulates to highly evolved samples [e.g., 4,5]. Among them, 12056 is a subophitic basalt showing many similar features to LAP02205 [5]. Pyroxene, plagioclase, olivine and spinel compositions are nearly identical between 12056 and LAP02205 (Fig. 2). The presence of the mesostasis and its unique texture is also identical. The abundances of olivine (10.8%) and silica (0.8%) in 12056 are slightly higher and lower than those in LAP02205, respectively [5]. However, the Apollo 12 ilmenite basalt shows a modal variation from quartz-normative to olivine-normative depended upon olivine control [4,5]. Probably, LAP02205 became slightly more silica-rich because it contains less olivine phenocryst than 12056. In this respect, Dhofar 287A is also similar to an olivine-normative member of this basalt series. The Fe/Mg ratio and K abundance in plagioclase are function of olivine abundance and cooling rate [5], and LAP02205 plagioclase is identical to 12056 in these abundances (Fig. 2d). Among olivine-normative Apollo 12 ilmenite basalt, 12005 has the highest Mg/Fe ratio and K abundance of plagioclase, suggesting slowest cooling. In contrast, 12016 and especially, 12056 have low K abundance at low Fe/Mg ratio, which would be responsible for the abundant presence of mesostasis due to faster cooling. Nevertheless, apparent differences are present between LAP02205 and 12056, suggesting slightly different histories. Fe-Ni metal is rare to absent in LAP02205 and rather present as Fe sulfide. Very low Mg and Cr abundances of the LAP020025 ilmenite are also different from 12056. However, their similarities are striking in many respects and there will be a possibility that LAP02205 originated from the Oceanus Procellarum region. In order to further explore similarities and differences between LAP02205 and 12056 (or similar types of Apollo 12 ilmenite basalt), trace element analysis and isotopic studies will be required.

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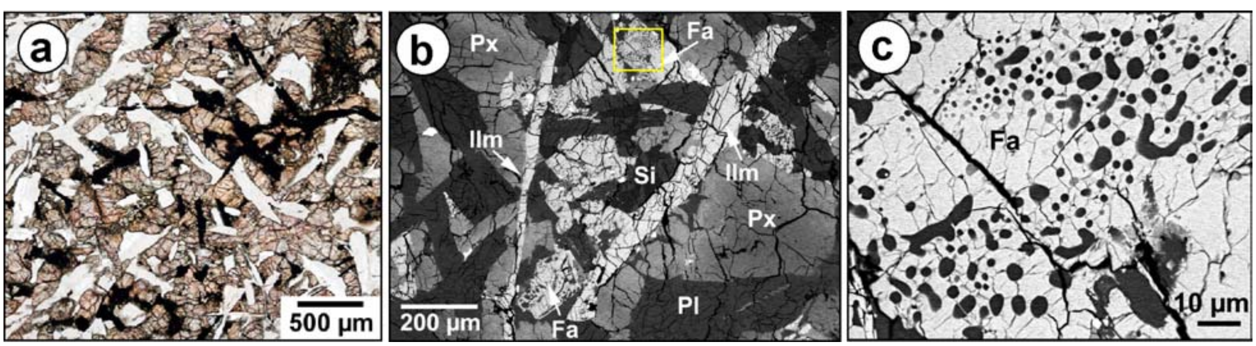

Fig. 1. (a) Photomicrograph of LAP02205, showing a subophitic texture composed of pyroxene, elongated plagioclase and ilmenite with minor olivine. The mesostasis area is seen at the upper corner of the image. Plane-polarized light. (b) Back-scattered electron image (BEI) of the mesostasis area of LAP02205. Px: Fe-rich pyroxene. Fa: fayalite. Ilm: ilmenite. Pl: plagioclase. Si: silica. (c) BEI of an enlarged area shown as a yellow square in (b). Note the presence of tiny blebs of Si-, K-rich glass in fayalite.

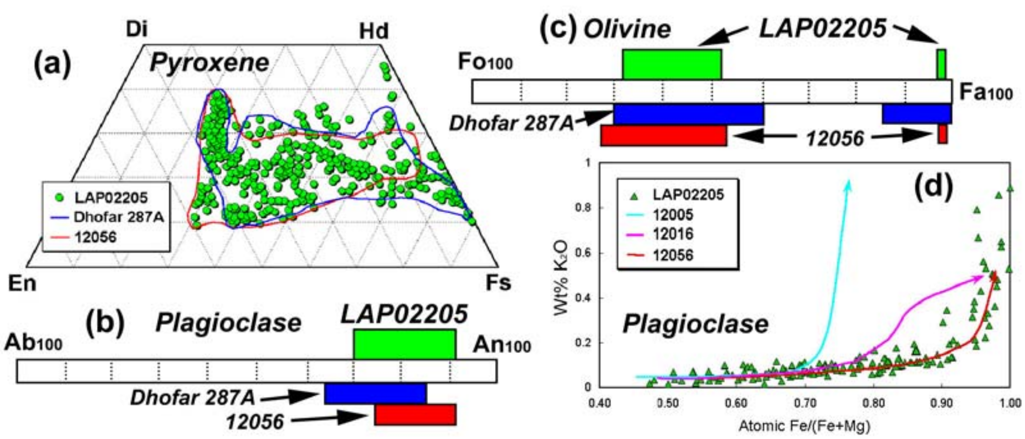

Fig. 2. (a) Pyroxene major elements, (b) plagioclase major elements, (c) olivine major elements, and (d) plagioclase minor elements compositions of LAP02205 along with those of Dhofar 287A lunar meteorite and Apollo 12 ilmenite basalts (12056, 12005, and 12016) [3-5].