Mineralogy and petrology of unbrecciated lunar basaltic meteorite LAP 02205. K. Righter[1], A.D. Brandon[2], and M.D.Norman[3] [1] Mail Code ST, NASA Johnson Space Center, Houston, TX 77058, kevin.righter-1@nasa.gov; [2]Mail Code SR, NASA Johnson Space Center, Houston, TX 77058; [3] Research School of Earth Sciences, Australian National University, Canberra ACT 0200, Australia.

Introduction

LAP 02205 is a 1.2 kg unbrecciated basalt found in the LaPaz icefield of Antarctica during the 2002-2003 ANSMET season [1]. It has been classified as a lunar basalt on the basis of pyroxene Fe/Mn ratios (~60) and oxygen isotopes [1]; both are within previously defined compositional ranges for the Moon [2].

We have initiated a comprehensive study of the mineralogy, petrology and geochemistry of this new and unique meteorite. The results reported here will allow the comparison of this sample both to the other lunar basaltic meteorites (NWA 032, A881757, Y793169, Dho287A), as well as to lunar basalts in the Apollo and Luna collections.

Petrography

LAP 02205 is a coarse grained basalt with a subophitic to intergranular texture. Olivine phenocrysts are very sparse and make up 0.2 % of section ,30. Plagioclase (40.0 %) and ilmenite (8.0 %) laths and granular pyroxene (52.1 %), and chromian ülvospinel (0.2 %) define the subophitic to intergranular texture. Throughout the section are small and finer-grained clusters of fayalite, silica, plagioclase and troilite. The entire section is cut by numerous veins of glass. Although usually linear, some of the glass is found in pockets. The glass is variable in color from orange to dark brown, suggesting a heterogeneous composition.

Analytical

X-ray maps of nearly the entire section were constructed (Fig. 1), and individual mineral grains and glasses were analyzed with the CAMECA SX100 electron microprobe at NASA-JSC. Operating conditions were 15 kV, 20 nA and standards utilized include apatite, $CaSiO_3$, tephroite, TiO_2, Al_2O_3, kaersutite, hematite, chromite, NiO, and periclase.

Results

Analysis of a single olivine phenocryst yielded Fo_{65} core and Fo_{59} rim. The olivine contains Ca, Cr, and Mn contents typical of other lunar mare basalt olivines (e.g., [3]). The olivine phenocrysts overlap in composition with olivines from many Apollo samples (Fig. 2). In addition, fayalite-rich olivine is abundant in the groundmass, again, as is common in Apollo mare basalts and lunar basaltic meteorites [3]. Pyroxene compositions are variable from augite/sub-calcic augite to ferroaugite/sub-calcic ferroaugite to ferrohedenbergite (Fig. 3). These are similar in composition to calcic pyroxenes in other lunar mare basalts; however, we found no pigeonite as is found in several Apollo suites (Fig. 3). Plagioclase laths are weakly zoned from An_{95} cores to An_{93} rims. These compositions are similar to plagioclase feldspar in many Apollo 12 and 15 mare basalts, but more calcic than plagioclase in Dho287A [4].

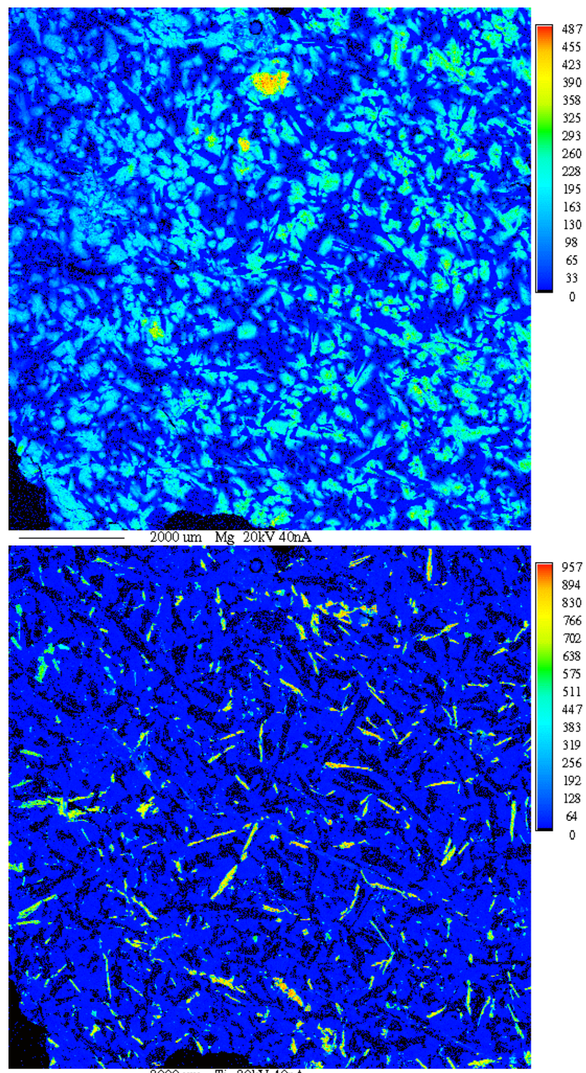

Figure 1. Mg and Ti Ka x-ray maps of LAP 02205,30, illustrating the sparse olivine phenocrysts (yellow in top figure) and numerous ilmenite (yellow/orange in bottom figure) and plagioclase (black) laths. Note the 2 mm scale bar at lower left of each figure.

There are several different oxides present in LAP 02205, including chromite, Cr-ülvospinel, Ti-ülvospinel, and ilmenite. The chromite occurs as small (50-75 μm) inclusions in olivine phenocrysts. They are the most chromian rich of all the spinels, and presumably were included in the olivine during the

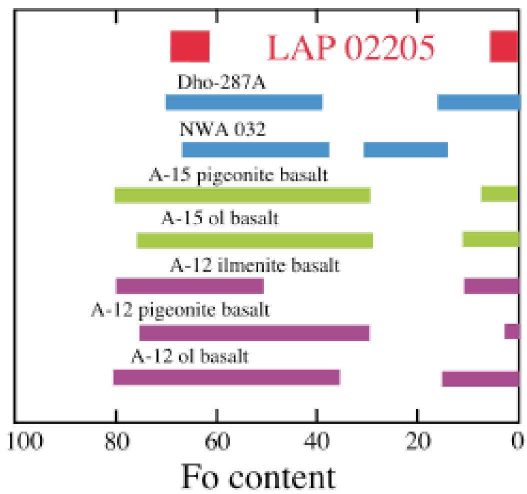

Figure 2: Composition of olivine phenocrysts and groundmass in LAP 02205, compared to two lunar basaltic meteorites, Dho-287A [4] and NWA032 [5], as well as Apollo 12 and 15 mare basalt olivines (figure after [4]).

very earliest crystallization of the basalt (Fig. 4). The ilmenite laths and Cr-ülvospinel granules make up part of the intergranular texture of the rock. The ilmenites are similar to other ilmenites in mare basalts [3], and the ülvospinel have a large compositional range from Cr-bearing to Cr-poor (Fig. 4).

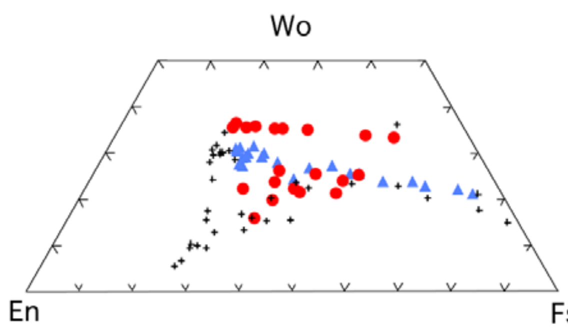

Figure 3. Pyroxene compositions for two different pyroxene grains in LAP 02205 (red and blue symbols). Also shown are representative pyroxene analyses [3] from Apollo 12 mare basalts (crosses). The LAP 02205 pyroxenes show a range of compositions starting from cores similar in composition to Apollo 12 pyroxenes, and becoming much more FeO-rich at rims.

Finally, an average of 15 analyses of the heterogeneous melt veins yield a composition that is basaltic with 44.1(1.0)% SiO_2, 14.5(1.9)% Al_2O_3, 12.1(0.3)% CaO, 4.0(1.0)% MgO, 4.2(0.8)% TiO_2, and 18.0(1.3)% FeO (standard deviation from the mean is given in parentheses). Further analysis of the melt veins should reveal the extent of heterogeneity.

Discussion and Conclusions

The presence of chromite inclusions with olivine phenocrysts allows calculation of a magmatic temperature of 1170 ˚C using the olivine-spinel geothermometer [6]. This temperature implies an MgO content of 6 to 7 wt. % considering the MgO whole rock thermometer [7]. Both the temperature and MgO content indicate a somewhat evolved basalt, compared to some of the other Apollo mare basalts with > 7 wt. % MgO. LAP 02205 has some mineralogic similarities to the Apollo 12 ilmenite basalts, including a texture somewhat similar to 12051 [3]. However, detailed study of the whole rock composition awaits future analysis.

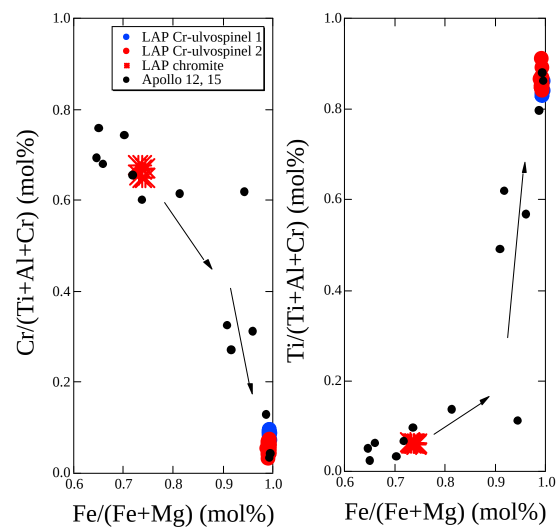

Figure 4. Spinel compositions determined for LAP 02205, showing early Chromian spinel inclusions in the olivine phenocrysts, followed by more Cr-poor and Ti-bearing ülvospinel found as equant grains in the matrix. Apollo 12 and 15 spinel data are from [3].

References: [1] Antarctic Meteorite Newsletter 26 (2003), p. 17; [2] Shearer et al. (1998) Rev. Mineral. 36, Planetary Materials (ed. J. Papike), 28-94; [3] Papike, J.J. et al. (1976) Rev. Geophys. Space Physics 14, 475-540; [4] Anand, M. et al. (2003) Met. Planet. Sci. 38, 485-500; [5] Fagan, T.J. et al. (2002) Met. Planet. Sci. 37, 371-394; [6] Sack, R.O. and Ghiorso, M.S. (1991) Amer. Mineral. 76, 827-847; [7] Jones, J.H. (2003) *Lunar Planet. Sci. XXXIV,* 1130.