PETROGENESIS OF APOLLO 17 MARE BASALTS - REVISITED. E. Hill[1], J. M. D. Day[1], J. Davidson[2] and L. A. Taylor[1] [1]Planetary Geosciences Institute, University of Tennessee, Knoxville, TN 37996, USA (ehill10@utk.edu), [2]Department of Earth Sciences, University of Durham, DH1 3LE, UK.

Introduction: We present new mineralogical analyses of six Apollo 17 Mare basalts, 70017; 70035; 70135; 70215; 74255; and 75075. This work is part of an ongoing study to understand the petrogenetic histories of these basalts (e.g., [1]). The broad range of ages, and similar incompatible-element compositions of these rocks, may be representative of a long-lived magmatic system. In addition, the variety of textures and degree of crystal disequilibria encountered, may offer insight into shallow-level magmatic processes on the Moon.

Methods: Major-element analyses of mineral phases, metals, and glass were performed using a Cameca SX-50 EMP.

Results: *70017,115.* Medium grained, ophitic rock, suggesting relatively slow cooling. Subhedral pyroxenes contain embayed ilmenite, armalcolite, and olivine. Plagioclases enclose pyroxenes, olivines and ilmenites. Ilmenites show exsolution lamellae of rutile and Cr-spinel. Pyroxenes in this section contain up to 3.3 wt.% TiO_2 and up to 4.2 wt.% Al_2O_3. Olivines are Fo_{57-75}, a larger range than previously reported for this rock [2]. Plagioclases range from An_{76-89}. Also present are Fe grains (containing 0.6 to 0.9 wt.% Co; Ni 0.05 to 0.1 wt.%), K-rich glass (5 to 7 wt.% K_2O), troilite, and silica.

70035,13. Interstitial plagioclase encloses pyroxene, olivine, and ilmenite. Large pyroxenes enclose ilmenites and armalcolites. Ilmenites show exsolution lamellae of rutile and Cr-spinel. Pyroxenes contain up to 3.3 wt.% TiO_2 and up to 4.3 wt.% Al_2O_3. Olivines are Fo_{52-71}. Plagioclase covers the range An_{78-89}. High-K and low-K glasses occur in the section. The high-K glass contains up to 5.7 wt.% K_2O. Fe-metal contain up to 0.5 wt.% Co and 0.1wt.% Ni. Also present is silica.

70135,65. Sub-ophitic rock composed mainly of plagioclase, pyroxene, and ilmenite. Plagioclase encloses pyroxenes and olivines. Pyroxenes enclose olivines, ilmenites, and armalcolites. Pyroxene compositions contain up to 3.8 wt.% TiO_2 and 4.6 wt.% Al_2O_3. Plagioclase ranges from An_{84} to An_{88}. Olivine is Fo_{35-70}. The lower Fo contents belong to olivines held within inclusions in embayed ilmenites, where olivine appears within pyroxene. Also in these inclusions are silica, a K-rich glass (6.1 wt.% K_2O), and Fe-metal containing up to 1 wt.% Co and 0.08 wt.% Ni. As is the case with the other rocks described here, ilmenites show exsolution lamellae of rutile and Cr-spinel.

70215,156. Fine-grained, spherulitic rock, containing micro-phenocrysts of pyroxene, olivine, and ilmenite. Olivines are anhedral and skeletal in habit, characteristic of fast cooling. They commonly have overgrowths of pyroxene. Ilmenites appear as laths and contain exsolved rutile. Pyroxenes contain up to 3.9 wt.% TiO_2 and up to 4.5 wt.% Al_2O_3. Pyroxene overgrowths on olivine are higher in CaO than those encountered in the finer material of this rock. The latter being richer in Fe. Olivines are Fo_{54-71} and plagioclases ranges from An_{81-87}.

74255,59. Coarse-grained rock, containing crystals of olivine, plagioclase, pyroxene, and ilmenite. Interstitial Fe-metal with up to 0.7 wt.% Co and 0.8 wt% Ni, and glass with up to 5.6 wt.% K_2O are also present. A single grain of FeNi (4.0 wt.% Co and 3.9 wt.% Ni) was found in a large olivine. Pyroxenes contain up to 4.8 wt.% TiO_2 and up to 6.3 wt.% Al_2O_3. Olivines are Fo_{59-80}. Plagioclase is An_{87}.

75075,90. Medium-grained, sub-ophitic rock composed of plagioclase, embayed ilmenite, and pyroxene containing olivine. Armalcolite, troilite, silica, glass with up to 8 wt.% K_2O, a CaP phase (merrillite?), and Fe-metal with up to 0.53 wt.% Co and 0.1 wt.% Ni, are minor constituents. Cr-spinel and rutile are present as exsolution in ilmenites. Pyroxene contains up to 3.6 wt.% TiO_2 and 4.5 wt.% Al_2O_3. Olivines are Fo_{52-70}. Plagioclases are An_{84-92}.

Discussion: Pyroxene Ti : ^{vi}Al ratios are generally used to distinguish between Apollo 12, 15, and Apollo 17 rocks, with the ratio for the latter always reported as 1:2. In our analysis, we have determined pyroxenes to be silica deficient to the point that most of the Al in the crystal is assigned to the tetrahedral site. Assum-

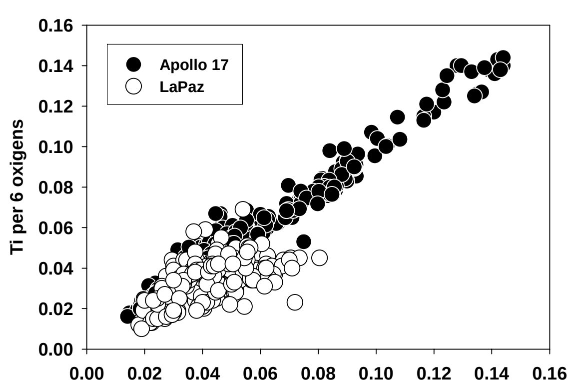

Figure 1

ing the simple stoichiometric arrangement of (Ca, Mg)$TiAl_2O_6$, ^{iv}Al is sufficient to charge-balance Ti in the pyroxene; thus, when we plot Ti against $^{iv}Al/2$, we obtain a ratio of 1:1 (Fig. 1). The relationship for LaPaz and other low-Ti mare basalts is not so simple [3].

Apollo 17 rocks have a range of ages [4]. For example, 70017 has an age of 3.6 Ga, whereas 70215 has an age of 3.8 Ga. Despite their different ages, all but the fastest cooled sample (70215), have consistent incompatible-trace-element patterns (Fig 2), implying a common mantle source.

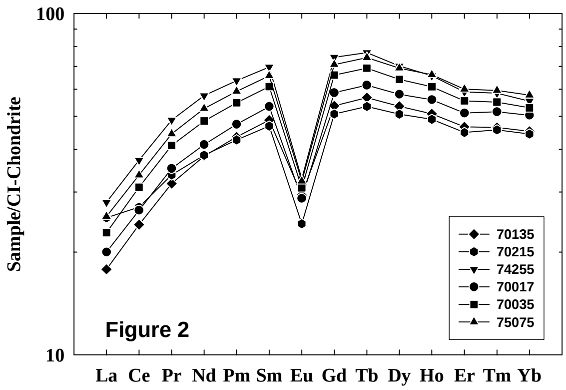

Figure 2

Slightly different cooling rates are likely to have generated the varied textures encountered for these rocks, and are indicative of extrusive events at different stages of melt evolution, possibly in a shallow magma chamber. Furthermore, embayed ilmenites reveal disequilibrium during crystallization. Experimental studies show the stability of armalcolite at crustal depths but instability on the lunar surface [2]. Further evidence for crystal-melt disequilibria processes is provided by the relatively high-Mg content of pyroxene cores. These are attributed to olivine resorption early in their crystallization [5], with later progression towards more Fe–rich rims (Fig 3). With the exception of 70215,156, early-pyroxene-Mg contents are similar in all rocks studied. The presence of large olivines in 70215,156, held in a spherulitic matrix, is indicative of a melt extruded and cooled before resorption of the olivine could occur. The most magnesian olivines, however, correspond to 74255,59. Pyroxene compositions vary from Mg- to Fe-rich from core to rim in all cases except 75075,90. Textural evidence indicates this rock to be the slowest cooled of our samples. 75075,90 has equant crystals and no interstitial glass. It is possible that this is the result of accumulation processes.

Our studies reveal complex, shallow-level processes, superimposed on long-lived, relatively homogenous mantle-derived magmatism at the Apollo 17 site.

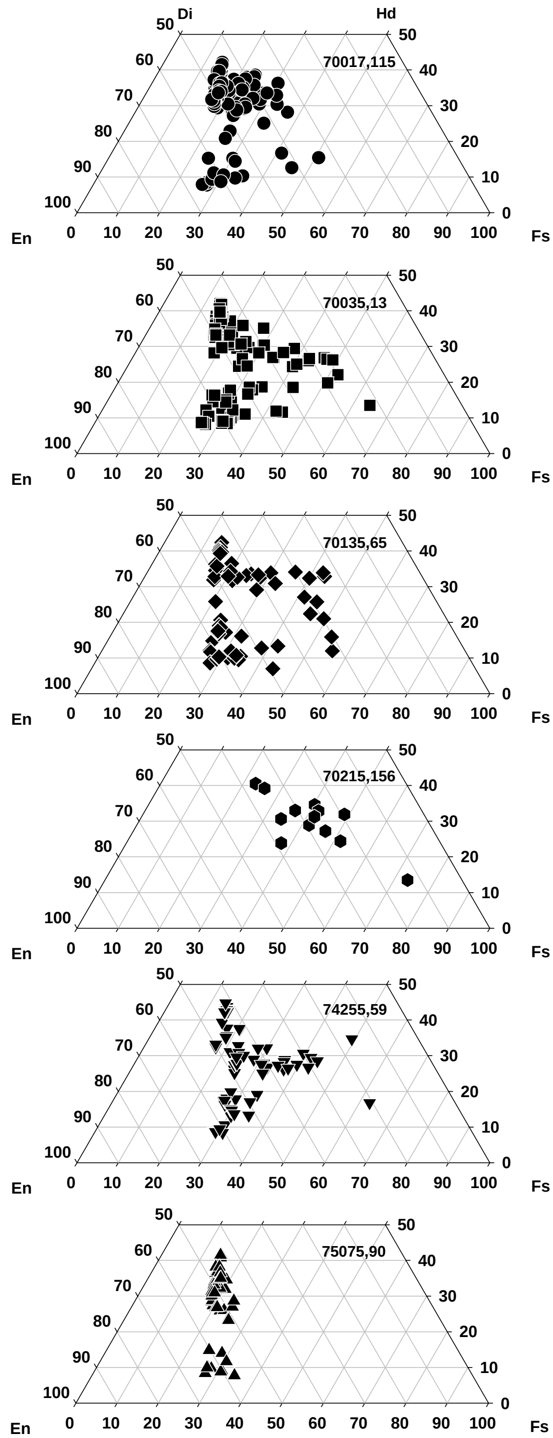

Figure 3

[1] Day J. M. D. et al. (2006) LPSC XXXVII This volume. [2] Longhi J. et al. (1974) *Proc. Lunar Sci. Conf.* 5th, 447-469. [3] Day J.M.D. et al. (2006) *Geochim. Cosmochim. Acta* [4] Snyder G. A. et al. (2000) Canup R.M. & righter K. (eds) Origin of Earth and Moon. 361-395 [5] Brown G. M. et al. (1975) *Proc. Lunar Sci. Conf.* 6th, 1-13.