Investigation into the petrogenesis of Apollo 14 high-alumina basaltic melts through crystal stratigraphy of plagioclase

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Abstract. The Apollo 14 high-alumina basaltic samples were collected from the Moon's Fra Mauro region, which is composed mostly of impact ejecta from the Imbrium basin and some pristine basalts (and pristine basalt clasts in some breccias). We investigated the petrogenesis of Apollo 14 high-alumina basaltic melts using compositions of plagioclase crystals. Melt evolution of the individual basaltic melt was investigated by comparing the equilibrium-melt compositions (calculated from plagioclase compositions using relevant partition coefficients) to the fractional crystallization (FC) and assimilation and fractional crystallization (AFC) models. Petrogenetic modeling of trace elements in Group A basalts revealed that petrogenesis continued beyond 40% total crystallization required to model whole-rock compositions[1], and that there were open-system processes that affected the magma during plagioclase crystallization. Trace-element petrogenetic modeling of pristine high-alumina basalts (14072 and Group A, B and C) shows that the equilibrium-melt compositions do not fall on a single AFC or FC trajectory. This could be indicative of fluctuating degrees of assimilation (i.e., variable *r*-values) and/or variable assimilant compositions during petrogenesis. Petrogenetic modeling reveals that the impact melts experienced only closed-system fractional crystallization. The compositional micro-heterogeneity in pristine basalts observed in this study may partially result from the following volcanic scenario. The basaltic melts crystallized in fast moving lava flows that had open channels connecting the vents to the flow fronts after their rapid emplacement on the lunar surface. During lava flowing, the lava crust that was assimilated with KREEP/granite-rich loose regolith continually created and destroyed by entrainment into the lava core. Thus, the assimilant changed in terms of both composition (KREEP and/or granite) and mass (*r*-value) throughout magma crystallization. In contrast, the petrogenesis of impact melts can be explained by fractional crystallization with little assimilation. Hence, the impact melts may be solidified in a more static environment, such as the impact-generated melt lake. This scenario indicates a slower cooling rate comparing to the basaltic lava flow. The cooling rates of pristine basalts and impact melts are consistent with the slopes of their crystal size distribution curves from the textural analysis[2].

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[1] C.R. Neal, G.Y. Kramer, *Am. Mineral.* 91, 1521-1535 (2006).
[2] J.G. Oshrin, C.R. Neal, *LPS XXXX.* Abstract # 1706 (2009).