

APOLLO 14 GREEN VOLCANIC GLASSES WITH A COMPOSITIONAL MEMORY OF MELTING PROCESSES IN THE LUNAR MANTLE. J. W. Delano; Department of Geological Sciences; State University of New York; Albany, NY 12222

Introduction: The picritic volcanic glasses are generally believed to be samples of primary magmas from the lunar mantle [1-4]. Although the twenty-four groups [4] define a wide compositional range (e.g., factor of 70 in Ti), these magmas have experimentally determined, multiple-saturation points within the limited pressure-range of 15-25 kilobars [5-7]. Assuming that these picritic magmas were generated by an isobaric, batch melting process, the source regions of these primary magmas were located at depths of 300-500 km [5-7]. Although the isobaric, batch melting process was a popular concept in terrestrial MORB petrology until the mid-1980s, dynamic melting processes are now considered to be more realistic for MORB petrogenesis [e.g., 8-14]. These concepts have recently been applied to the lunar picritic compositions [e.g., 15,16]. Since the mineralogy, phase relations, and bulk composition are known with much less certainty for the lunar mantle than for the terrestrial upper mantle, dynamic melting models for the primary lunar magmas are comparatively underconstrained and non-unique. The challenge becomes even greater if these superheated picritic magmas also assimilated complex, late-stage cumulates during their ascent through the uppermost mantle and lower crust [e.g., 5,17-19]. The fact that the highest-Ti picritic melts become negatively buoyant at >15-20 kilobars [20,21] provides new constraints on the depths and melt-extraction processes [22].

When an isobaric, batch melting process was considered appropriate to these picritic melts, the *intra-group* compositional variations were considered to be the result of low-pressure processes [4]. Since olivine is the liquidus phase on the low-pressure liquidus of these picritic melts, all of the observed trends *should* be explicable by olivine fractionation. While that was thought to be true for some picritic glasses, it was not true for others [4]. The latter cases were interpreted as being due to fractionation caused by non-equilibrium crystal growth in individual melt droplets during rapid cooling in the fire-fountain [4]. However, with the realization that dynamic melting processes ± assimilation processes were probably involved in the petrogenesis of these magmas, the intra-group compositional trends take on new significance, especially those that are not explicable by any known low-pressure process. High-precision, electron microprobe analyses of lunar picritic glasses (see also accompanying abstract on Apollo 17 orange glasses) indicate that the magmas were *not* compositionally uniform within the conduits leading to the lunar surface.

Observations: The Apollo 14 green 'A' volcanic glasses [4,23] exhibit a strong fractionation trend that is distinct from an olivine fractionation vector (Figures 1,2). High-precision, electron microprobe analyses of these glasses using newly developed procedures [24] have been performed to define these trends with unprecedented detail. The 17% decrease in MgO abundance from 16.6 wt% to 13.8 wt% is associated with the following correlated changes: 145% increase in TiO₂; 15% increase in Al₂O₃; 6% increase in CaO; and 150% increase in Na₂O+K₂O. Analogous to the view that 'enriched'- and 'depleted'-MORBs provide important constraints on melting processes in the terrestrial mantle [e.g., 8-10,13,14], this compositional trend among the Apollo 14 green 'A' volcanic glasses may be a memory of deep-seated processes in the Moon. If correct, this indicates that the picritic volcanic glasses are not only aggregate melts, in the context of dynamic melting models [e.g., 9], but preserve a *range* of melt compositions that existed within the plumbing system of an ascending diapir of lunar mantle that was undergoing dynamic melting. Therefore, instead of treating *each* of the 24 primary melt compositions among the picritic glasses as a single, homogeneous, primary magma [4], *all glasses* along an intra-group, compositional trend are aggregate primary magmas that are products of dynamic melting processes. For example, the Apollo 14 green 'A' glasses (Figures 1,2) display mixing trends between 'enriched' and 'depleted' melts that are broadly analogous to the compositional variations observed among MORB suites [e.g., 14]. Specifically, the lower-MgO, high-Na,K,Ti melts (Figures 1,2) contain a higher proportion of accumulated melts from *enriched* source-regions than the higher-MgO, low-Na,K,Ti melts that contain a higher proportion of accumulated melts from *depleted* source-regions.

Conclusions: (a) Picritic magmas associated with fire-fountain events on the Moon were compositionally heterogeneous. This fact is indicated not only by the presence of cogenetic glass spherules having chemical trends *unrelated* to low-pressure fractionation of liquidus phases (Figures 1,2), but also by compositional heterogeneity within composite melt droplets [25]. (b) The compositional heterogeneity within a picritic lunar magma reflects incomplete mixing of aggregate melts from different regions of an ascending mantle diapir. (c) Detailed information about this heterogeneity can provide additional constraints on melt-production and melt-extraction processes in the lunar mantle. (d) Intra-group fractionation trends among other varieties of lunar picritic glass

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need to be investigated using high-precision analytical methods (see accompanying abstract on Apollo 17 orange glasses).

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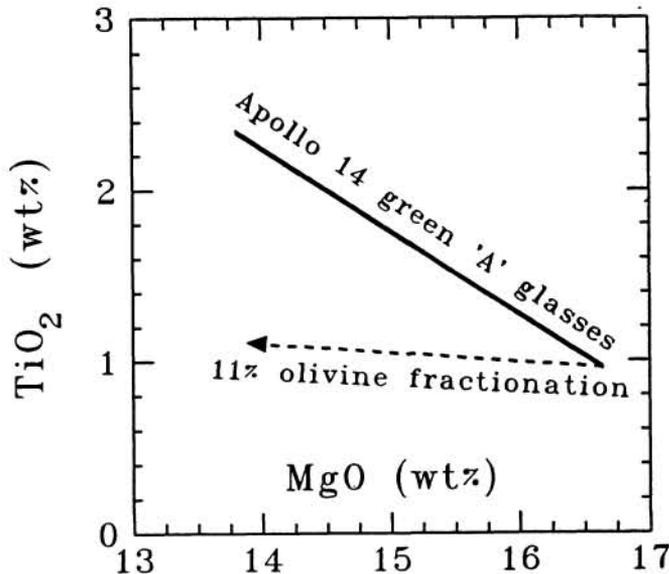


Figure 1. The 145% increase in TiO_2 along the length of the compositional trend within the Apollo 14 green 'A' volcanic glasses was not caused by olivine fractionation. Olivine is the liquidus phase of this melt composition up to pressures of about 20 kilobars.

Figure 2. Although olivine is the liquidus phase in this magmatic composition, olivine fractionation was not the cause of the compositional trend observed among the Apollo 14 green 'A' glasses.

