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THE SECOND CONFERENCE ON THE LUNAR HIGHLANDS CRUST AND NEW DIRECTIONS

Low-pressure crystallization of a volatile-rich lunar basalt: A means for producing local anorthosites?†

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Abstract

The presence of anorthosite in the lunar highlands containing plagioclase that is compositionally less calcic than plagioclase in the ferroan anorthosites cannot be readily explained by the current lunar paradigm in which lunar anorthosite was produced as a floatation cumulate in the lunar magma ocean. Phase-equilibrium experiments were conducted to investigate whether such anorthosite could arise locally from crystallization of aluminous magma at shallow levels within the lunar crust. The experiments were conducted on a synthetic analog of Cl-, F-, and S-bearing aluminous highland basalt 14053 at pressures of approximately 1 bar and f_{O_2} at ~QIF. Pyroxene and plagioclase (An_{93-89}) saturation occurs early, and with continued crystallization, the residual liquid evolves to a silica-poor, halogen-, Fe-, and Ti-rich melt with a computed density of >3.1 g/mL. This liquid remains higher in density than the plagioclase over the crystallization interval, providing the possibility of plagioclase/melt separation by liquid draining.

A model is proposed in which “alkali” anorthosite, consisting of sodic anorthite or bytownite, coupled with underlying pyroxenite (or harzburgite) is produced locally during crystallization of plagioclase from “Al-rich” magmas at or within roughly a kilometer of the lunar surface. In this model, segregation of plagioclase would be attained by settling of ferromagnesian minerals to the bottom of a shallow magma chamber, and draining of low-viscosity, low-silica, Fe-Ti-K-REE-P-enriched residual basaltic melt to deeper regions of the crust, or into topographic lows. Such residual melt may be represented by magma compositions similar to some of the intermediate- to high-Ti mare basalts. This model would provide a mechanism that can account for the more “alkali” anorthosite identified in widespread isolated locales on the Moon and allow for variable ages for such anorthosite that may extend to ages of the mare basalts.

Keywords: Lunar Highlands, anorthosite, experimental petrology, fractional crystallization