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THE SECOND CONFERENCE ON THE LUNAR HIGHLANDS CRUST AND NEW DIRECTIONS

The mafic component of the lunar crust: Constraints on the crustal abundance of mantle and intrusive rock, and the mineralogy of lunar anorthosites†

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Abstract

Most models of early lunar evolution predict that the anorthositic highlands crust is the result of plagioclase flotation on a magma ocean. However, the lunar highlands crust typically contains 4 wt% FeO and so is more mafic than the strict definition of the anorthosites thought to comprise it. We used new Clementine-based mineral maps of the Moon as inputs to a series of mixing models that calculate the abundance and distribution of major highland rock types and shed light on three possible sources of excess mafic material in the lunar highlands: mafic (15 vol% mafic minerals) anorthosites, post-magma ocean igneous activity, and mafic basin ejecta. Mixing models that feature pure anorthosites like the purest anorthosite (PAN) described by Ohtake et al. (2009) and Pieters et al. (2009) are most compatible with the data. They allow us to place an upper limit of 10–20 vol% mantle material that could be mixed with the primary highlands crust. The upper limit on mantle material indicated by the mixing models is significantly lower than the 30–40 vol% mantle material expected from simple geometric calculations of the major lunar basins' excavation cavities based on an excavation cavity depth/diameter ratio of 1/10; this discrepancy allows us to conclude that the excavation cavities of the three largest lunar basins may have been significantly shallower than those of the smaller basins. Our results are consistent with excavation cavity depth/diameter ratios for these largest basins in the range of 0.035 to 0.06, which agrees with previous gravity measurements by Wieczorek and Phillips (1999).

Keywords: Lunar highlands, anorthosite, magma ocean, spectroscopy