Constraints on the origin and eruption of Lunar Silicic "Red Spot " Magmas

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Introduction. Evidence of silicic lunar magmas, comes from small (< 2 cm) samples of granites, felsites, and quartz monzodiorites (QMD) in Apollo collections and lunar meteorites, and from remote sensing studies of the lunar surface (1,2,3). Remotely identified "Red Spots" are sites (< 35 km across) of viscous magma eruptions mostly within the PKT terrain on the lunar near side, some of which have the spectral characteristics of silica-rich magmas, including high Th (10-20 ppm) and relatively low FeO (5-10 wt%). Red Spot eruption ages generally overlap with those of nearby mare volcanism (~3.3-3.8 by). These constraints are most consistent with a QMD magma composition. Models for the origin of the Red Spot" magmas generally involve a Kreep basalt and either fractionation of this material and/or partial melting of the Kreep-contaminated lower crust (1,2,3,4), possibly with late stage immiscibility (SLI).

Results. The phase equilibria of A15 Kreep basalt and a range of QMD's have been determined (50-200 MPa, fO_2=IW, and 0-2 wt% dissolved H_2O) to help constrain conditions where these source materials would yield an eruptable magma (< 40 % xals; > 1 wt% H_2O) without encountering SLI, a constraint required by the high Th abundance in many red spots. A QMD derived from A15 Kreep magma meets these criteria with 1-2 wt% H_2O, but SLI still does occasionally occur. The SLI field lies very close to the Opx-Cpx-Plag-Ilm cotectic melt trend, particularly where the melt FeO reaches the 8-6 wt% range, i.e., at ~1040 C. The presence of up to 2 wt % water does slightly affect the position of the SLI field, moving it so that evolved melts can reach the 6-10 wt% range without encountering SLI. This is critical because without ~1-2 wt% dissolved water, the silica-rich magma is likely uneruptable from within the lunar crust given its relatively high viscoisty and the low density compared to the crust. The low lunar gravity compared to earth is an added problem.

Refs. [1] Glotch et al., 2010 *Science* 310, 1510. [2] Hagerty et al., 2006, *JGR 111,EO6002*. [3] Jolliff et al. 2011 *NGEO* 4, 566. ; (4) Boyce et al., 2018, *PPS* 162 62.