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Experimental constraints on the igneous differentiation and stratigraphy of lunar impact melt seas.

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On the Moon, impact craters over 300 km in diameter can generate "seas" of impact melt ~3 orders of magnitude more voluminous than the largest measured terrestrial impact melt sheets [1,2]. Lunar impact melt seas are projected to cover ~5% of the Moon's surface [1], but their composition and capacity for igneous differentiation, as observed in terrestrial impact melt sheets [2], is unknown. Petrological and geophysical models offer competing hypotheses on whether lunar impact melt seas cooled too rapidly to differentiate, producing a homogenous composition [3], or stratified by crystal settling or flotation during differentiation [1,4]. Many models are limited by the simplified CMAS system (CaO-MgO-Al_2O_3-SiO_2) with lithologies and vertical density profiles considering pure mineral endmembers only. In addition, the kinetic effects on impact melt crystallization remain essentially unconstrained [5].

This study presents results from high temperature, 1 atm gas-mixing experiments designed to broaden the impact melt compositional space from CMAS to 10 components, test a range of impact excavation depths, evaluate kinetic effects through both isothermal and dynamic crystallization runs, and produce a more unified, comprehensive model of how impact melt composition and cooling rate influence impact melt sea stratigraphy.

Preliminary EPMA analyses of experimental runs have produced updated partition coefficients and identified spinel and high-Ca pyroxene, the latter of which preferentially crystallizes with rapid cooling rates [5]. Geochemical data will be used to calculate feasible stratigraphic sequences formed by crystal flotation or settling as well as compositionally realistic density profiles. We anticipate that this updated experimental framework will improve our ability to identify diagnostic petrologic and geophysical signatures of impact melts and will recontextualize our understanding of surface lithologies in impact basins.

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