Overturn of the mantle and its consequence on evolution of the lunar interior: Insights from experiments

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Lunar mantle overturn caused by gravitational instability of the Fe-Ti rich KREEP layer may introduce Fe-Ti enriched heterogeneities deep inside the lunar interior. Here, we experimentally investigate the phase equilibria of the overturned Fe-Ti rich layer mixed with the mantle, at *P*-*T* conditions deep inside the lunar interior (2 – 4 GPa, 1230 – 1700 °C). Our aim is to estimate the buoyancy of the Fe-Ti-rich partial melts w.r.t the surrounding mantle to test whether they would be stable at the core-mantle boundary (CMB, explaining seismic attentuation) [1], or reactively ascend through the overlying mantle and contrbute to basalt formation.

The densities calculated for the Fe-Ti rich partial melts from this study [2] yield inconclusive results about buoyancy. However, we discuss the possible two scenarios: (A) if the partial melts are neutrally buoyant at the CMB, 5–30% partial melt (from seismic analysis, [1]) would constrain the CMB temperatures between 1330(±1) and 1470(±19) °C, which can be used by future studies to derive the selenotherm better; (B) if the partial melts are positively buoyant, they should ascend and react with the mantle along their path. Upon reaching shallow depths below the crust, they may likely assimilate any Fe-Ti rich layer that was left over from the gravitational overturn, as well as undergo olivine fractionation upon pooling in a shallow magma chamber. We modeled AFC of the Fe-Ti rich partial melts and our results show that their reactive ascent through the lunar mantle and subsequent olivine fractionation in a shallow magma chamber is a promising way to evolve the melt compositions to converge with the lunar basalts better. Shallow level assimilation of Fe-Ti rich lithology post reactive-ascent through the mantle is also feasible, but only for low degrees of assimilation.

[1] Weber *et al.* (2011) *Science* **331**, 309–312. [2] Mallik *et al.* (2019) *GCA* **250**, 238–250.