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The Duration and Extent of Lunar Volcanism

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It is widely accepted that lunar volcanism started before the emplacement of the mare fill (3.1 – 3.9 Ga b.p.) and lasted for probably more than 3 Ga. While the early volcanic activity is relatively easy to understand from a thermal point of view, the late stages of volcanism are harder to explain, because a relatively small body like the Earth's Moon is expected to cool rapidly and any molten layer in the interior should solidify rather quickly. We present thermal evolution models, where we varied the boundary condition at the surface to evaluate its influence on the extent and lifetime of a molten layer in the lunar interior. For our modeling of the lunar thermal history we use a fully three-dimensional spherical shell convection code, where the viscosity depends on the azimuthally averaged temperature. In all models a partial melt zone forms nearly immediately after the simulation starts, consistent with the identification of lunar cryptomare and early mare basalt volcanism. The initially global melt layer becomes disrupted by cold downwellings from the growing lithosphere. Due to the characteristic thickening of the Moon's lithosphere the melt zone solidifies from above. This suggests that the source region of volcanic rock material proceeds to increasing depth with time and is consistent with the variation of titanium content with depth evaluated by measurements. The duration of the melt zone also corresponds with basalt ages obtained by crater chronology, but suggests the existence of a insolating layer (regolith), which prevents the interior from cooling due to its low capability to transport heat.