Spatial correlation of deep moonquakes and mare basalts and implications for lunar present-day mantle structure, magmatism and thermal evolution

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Abstract. The genesis of mare basalts and deep moonquakes are important events that have major implications for understanding the thermal evolution and interior dynamics of the Moon. The eruption of mare basalts from 3.9 Ga to 3 Ga ago represents one of the most important events in lunar geological history[1-4]. Deep moonquakes recorded by the Apollo Seismic Network show the dynamic nature of the present-day lunar mantle[5-7]. In this study, we have correlated the presence of mare basalts, using FeO concentration as a proxy, with the epicenters of 52 deep moonquake clusters (DMQ). We determine FeO concentrations of 13wt% or higher to be representative of the mare basalt deposits. Our analysis shows that over 55% of the DMQ occur within mare basalt deposits. Our analysis also rejects a random distribution of DMQ with regard to mare basalts. The correlation between mare basalts and DMQ from our analysis suggests that the mare basalts may be derived from melting processes at relatively large depths, consistent with previous petrology and geodynamic studies[8-9]. We propose that the water and volatiles in the mare basalt source material (i.e., a mixture of ilmenite cumulates and olivine-orthopyroxene, together called MIC)[10] plays an important role in causing DMQ[11] and that DMQ delineate the present-day locations of MIC in the deep mantle. Since mare basalts are predominately distributed on the nearside, our results further suggest that DMQ may indeed be largely nearside features, which is a prediction that can be tested in future lunar seismic exploration.

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