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The Moon's Compton-Belkovich Volcanic Complex revealed through geothermal heat flux

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Using microwave-wavelength measurements, we have mapped a subsurface, granitic body on the Moon. We present evidence of highly-evolved volcanism associated with the farside thorium-rich feature known as Compton-Belkovich. This result represents the first discovery of a volcanic pluton on the Moon and the first measurement of geothermal heat from an orbital platform. Here we combine data from multiple orbital missions and lunar samples to comprehensively characterize the system feeding this dormant lunar volcano.

Passive microwave radiometry is sensitive to the integrated thermal radiation from several wavelengths depth due to the low dielectric loss of the lunar surface. From Chang'E 1 and 2 mission data, we have detected an extremely enhanced geothermal gradient that implies the presence of a subsurface body with high concentrations of heat-producing radiogenic elements. From the enhanced brightness temperature at frequencies from 3-37 GHz taken from 100-200 km altitude, we constrain a peak heat source of ~180 mWm^{-2}, surrounded by a halo of moderately enhanced heat flux above the expected 5-10 mWm^{-2} background. This result is best explained by two >10 km diameter plutons below the surface. The heat flux signature is consistent with a shallow pluton (~1km deep) with ~130 ppm Th and a larger, deeper pluton (~8km deep) with ~70 ppm Th. The only lunar samples with this high of Th, U, and K concentrations are the lunar granite and 'felsite' clasts from Apollo 12 and 14, suggesting that these plutons are granitic.

Our study pioneers a method for constraining radiogenic heat production without the need to drill into a surface. This advancement effectively images subsurface volcanic plumbing systems making it a milestone in lunar volcanology. We anticipate this methodology will be used to map similar high heat flux features on the Moon and other planetary bodies while providing a novel method for exploring planetary interiors.