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Strong tidal heating inside an ultralow-viscosity zone over the lunar core-mantle boundary

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Tidal heating due to viscous dissipation in a planetary body is an important energy conversion process, depending on its internal structure, and connected to its thermal and orbital states. Our moon is not an exception. Previous studies have calculated the tidal response including dependence of the dissipation on the lunar interior structure, but these studies did not completely explain the geodetically-observed dependence of the dissipation on the lunar tidal period. One possibility to interpret this frequency-dependence is a low-viscosity layer inside the mantle as a natural consequence of the strong seismic attenuation zone, because such a viscosity contrast affects this dependence. However, previous studies have not considered its potential impact. Here we show that the explicit influence of the low-viscosity zone successfully provides the frequency-dependent dissipation on the Moon consistent with the geodetic observables. We found that the above-mentioned high attenuation zone is equivalent to the low-viscosity layer. Furthermore, we also found that the resultant viscosity value is remarkably low, signifying a relaxation time close to the tidal period. This ultralow viscosity implies partial melting as formerly suggested. Our result demonstrates that the most effective dissipation is localised to this layer, indicating a blanket effect on the core. We anticipate that such tidal heating, balanced against convective cooling, maintains this layer over the course of the lunar tidal history.

Keywords: the Moon, core-mantle boundary, low-viscosity zone, tidal heating