The rheological structure of moon interior and the mechanism of deep moonquake.

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Apollo program installed some seismometers on the moon and the seismic data provided us the much information about the moon interior. Analysis of moonquake data supports the following: The moon interior is differentiated, and the crust and mantle are composed mainly of plagioclase and olivine, respectively (reviewed by Wieczorek et al., 2006). Although we have considered the moon interior based on moonquake data, the mechanism of moonquake is debatable problem. Moonquakes is categorized into shallow moonquake, deep moonquake, thermal moonquake, and moonquake by meteoroid impact. We discuss the mechanism of deep moonquakes, which occur at a depth of 800-1200 km, based on the rheological structure of moon interior. Unraveling the mechanism of deep moonquakes is key to understand the heterogeneity and evolution of moon interior.
We calculate the rheological structure of moon interior. In this calculation, thermal structure of moon interior is calculated using the equation suggested by Kuskov et al., (2002). Pressure was calculated using the crustal density of 3000 kg/m^3 and mantle density of 3300 kg/m^3. Moho depth is assumed to be 60 km depth (Hood and Zuber, 2000). Based on the above assumptions, Byerlee's law is applied to determine the rock strength in brittle deformation regions, and the flow laws are applied to calculate the rock strength in plastic deformation regions. Crustal deformation is calculated by flow laws of plagioclase (Rybacki and Dresen, 2000; Rybacki et al., 2006), mantle deformation is calculated by flow laws of olivine (Karato and Jung, 2003). Strain rate is assumed to be 10^{-14} or 10^{-19} (s^{-1}).
The calculated rheological structure suggests that the deep moonquakes occur in plastic deformation region, where the fracture and slip are generally not occurred. We verified the possibility that the thermal runaway instability causes the deep moonquakes in plastic deformation region (e.g., Karato et al., 2001). The key issues in thermal runaway instability are (1) the strain rate should be large and (2) the degree of thermal feedback must be large (Karato et al., 2001). We calculated the strain rate that produced by the tidal stress in lunar interior under dry and wet conditions, and the degree of thermal feedback (a degree of softening of material). We found it difficult that the thermal runaway instability causes the deep moonquakes under dry conditions because small tidal stress (~0.1 MPa) cannot produce the large strain rate under dry conditions. On the other hand, the large strain rate is produced and the thermal runaway instability can be occurred in moon interior under wet conditions (500-1000 ppm H/Si). It suggests that the water exists heterogeneously in moon interior, and this heterogeneity of water may cause that the deep moonquakes occur in localized regions (clusters).

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