The heterogeneities in Lunar interior: Role of High Titanium materials

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Tomographic images of the lunar mantle have been reported by Zhao et al. (1) using the Apollo seismic data. They reported existence of P and S-wave anomalies in the lunar mantle which could relate also to the epicenters of the deep moonquakes. There is a possibility that the cause of the lunar P and S-wave anomalies is completely different from that of the Earth’s mantle. In the Earth, slow seismic anomalies are the signature of hot plumes ascending in the Earth’s mantle. On the other hand, the seismic anomalies in lunar mantle may be caused by compositional heterogeneities. Elkins-Tanton et al. (2) presented a model of solidification of the lunar magma ocean. In their model, titanium rich cumulates were formed in the later stage of its solidification, and gravitational overturn occurred in the early Moon. This overturn provided titanium rich regions in the lunar deep interior. Some of these materials might have stagnated and could have produced chemical heterogeneities in the lunar mantle. Titanium enriched materials are denser and slower in seismic wave velocity compared to that of the normal lunar mantle, which causes slow seismic velocity anomalies. Previous measurements of density and sound velocity of Ti-rich materials and magmas (3) indicate clearly that the Ti-rich materials which are remnant of the early overturn can cause slow velocity anomalies. Igrashi et al. (4) measured the solidus temperature of the Ti enriched materials at around 3-5 GPa corresponding to the base of lunar mantle, and showed the solidus temperature is lower than the lunar geotherm, i.e., the partial melting occurs in the lunar lower mantle generating dense magmas at the depths (3). Thus, the molten high Ti melts can cause high attenuation and slow seismic velocity regions at the base of the lunar mantle. More precise seismic tomography studies of the moon and mineral physics studies of the lunar materials are essential to clarify the heterogeneities of the lunar mantle in the future lunar exploration. It is very important to separate the chemical and thermal heterogeneities in the lunar mantle and to compare the difference from those of the Earth’s mantle.

References: (1) Zhao et al. (2008), Chinese Sci. Bulletin, 53, 3897-3907, Zhao et al. (2012), Global Planetary Change, 90-91, 29-36, (2) Elkins-Tanton et al. (2011), EPSL, 304, 326-336 (3) Sakamaki et al. (2010), EPSL, 299(3), 285-289, (4) Igarashi et al. (This meeting abstract)

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