Long-wavelength magnetic anomalies of the Moon observed by Kaguya: implications for the lunar crustal magnetism

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The magnetic field around the Moon has been successfully observed by the lunar magnetometer (MAP-LMAG) onboard SELENE (Kaguya) in a polar orbit at a nominal altitude of 100 km since October 29, 2007. The main objectives are to investigate (1) the lunar magnetic anomaly features and their sources, (2) magnetic field environment of the Moon and the interaction with the solar wind plasma and (3) electrical conductivity structure of the lunar interior. Here we report the initial global mapping of the lunar magnetic anomaly based on the observations during November 2007 to November 2008. Since the solar activity has been very low during this period, an effect of the external field fluctuation was often small enough to detect weak signatures of the lunar magnetic anomalies at about 100 km altitude.

A few tens of the lunar magnetic anomalies have been observed by Apollo and Lunar Prospector. One of the characteristic features is that most magnetic anomalies show a spotty pattern or a cluster of several spotty ones unlike the lineation pattern of the Earth's marine magnetic anomalies. This feature may evoke a single dipole-like source corresponding to each of the lunar anomalies.

Our initial global map of the magnetic anomalies currently covers about 95 % of the lunar surface. The anomaly intensities are smaller than 4 nT. Distinctly identified are the Crisium antipode anomaly, the Serenitatis antipode anomaly and the Apollo crater anomaly on the farside, and the Descartes anomaly and the Stofler anomaly on the nearside. However other magnetic anomalies observed at the lower altitudes (15-40 km) by Lunar Prospector are less clearly or hardly recognized on our map. In particular, the Imbrium antipode anomaly on the farside is observed to be a few scattered anomalies although it shows a cluster of several strong anomalies on the lower altitude vector maps and the surface intensity map by Lunar Prospector. Hence there is a significant difference in altitude dependence of the intensity among the lunar magnetic anomalies.

We examined the altitude dependence of the intensity for 11 major anomalies observed by both of Kaguya and Lunar Prospector. Some of the anomaly intensities are steeply attenuated in lower altitude range (about 15-40 km), which is possibly explained by a single magnetic dipole. However, their attenuation rates are moderate at higher altitudes (about 40-100 km). Similar to this moderate trend, a few anomalies show nearly exponent-like decrease in the intensity through the observed altitudes (about 15-100 km). These two typical attenuation rates indicate that the distributions of the lunar magnetic anomalies are represented by two components of about 100 km and 300 km horizontal wavelengths. It is inferred that anomaly sources of the shorter and longer wavelengths may be attributed to the near-surface rocks disturbed by impacts and the deeper and undisturbed crust, respectively.

The long-wavelength anomalies are observed in wide region of the lunar highland. The most striking feature is stripe-like magnetic anomalies of radial and north components in the farside highland region. These stripe-like anomalies consist of three or more pairs of positive and negative bands of 200-300 km width and about 1000 km length elongating nearly in east-west. These anomalies may have recorded the ancient global magnetic field of the Moon with reversals at the formation of the lunar crust as thermal and/or shock remanent magnetizations.