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かぐや搭載ガンマ線分光計による月全球の鉄・チタン分布地図

Iron and Titanium Distribution Maps of the Moon Observed by Kaguya Gamma-Ray Spectrometer

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Gamma-Ray Spectrometer onboard Kaguya (KGRS) successfully conducted the observation of lunar gamma rays with a Ge detector [1]. With a high energy resolution, the KGRS has succeeded in identifying a number of elements constituting the lunar surface; they are O, Mg, Al, Si, Ca, Ti, Fe, K, Th and U in lunar subsurface down to ~60 g/cm2.
The obtained energy spectra of gamma rays from the global lunar surface with energies from 0.2 to 12 MeV were accumulated for the three different conditions from December 14, 2007 to February 17, 2008 (Period 1), from July 7 to December 8, 2008 (Period 2), and from February 10 to May 28, 2009 (Period 3). In the observation modes for Period 1, Period 2 and Period 3, the high voltages of 3.1 kV, 2.5 kV and 2.5 kV were applied to a Ge detector, respectively. During Period 1 and Period 2, the Kaguya spacecraft moved around the Moon in a circular orbit at an altitude of about 100 km. During Period 3, the Kaguya spacecraft was placed into a relatively low altitude orbit of about 50 km. In December 2008, the annealing operation was conducted in order to anneal the Ge detector whose energy resolution was degraded by radiation damage due to cosmic radiation. After the annealing (Period 3), the energy resolution of the Ge detector was improved by about 7 keV at 1461 keV, comparable to that at the initial observation phase of the mission.
The maps of natural radioactive elements such as U have been already reported based on the observed data [e.g. 2]. This report presents the initial results of iron and titanium maps acquired during the Period 3.
We conducted a standard analysis of two Fe lines (doublet at 7631.1 and 7645.5 keV) and Ti line (6760.1 keV), including corrections such as dead-time and the spacecraft altitude variations. The spectra were not corrected for the variations of galactic cosmic ray (GCR) flux, because the variation of GCR flux seems stable enough to be neglected in that period. The Fe and Ti background gamma-ray line emitted from structural body of KGRS and spacecraft will be reevaluated in the future, but in this work that correction was not applied.
The estimated gamma-ray intensities of Fe and Ti were corrected for neutron number density variations among the lunar regions. The analyzed Fe and Ti gamma-ray lines are actually produced from the neutron capture reaction, thus the linear relation is not confirmed between the counting rate and the abundances. That correction was done following the recommendations from

Lawrence et al. [3]. The neutron number density map has been calculated with the Lunar Prospector Neutron Spectrometer data [4].
Finally, the resulting data can be benchmarked to existing datasets from previous missions (Apollo, Luna, Clementine and Lunar Prospector). Here, a linear regression was applied between KGRS and ground truth data of regolith and soil samples returned by Apollo and Luna missions [5] to convert the counting rates into concentrations.
The KGRS Fe and Ti maps are in good agreement with the Lunar Prospector maps reported by Prettyman et al. [6]. For example, high iron abundances are seen in the nearside maria, the South Pole-Aitken (SPA) basin, and Mare Australe. The highest iron concentration (about 16 %) is found in a region that includes western Procellarum and extends into Imbrium. However, KGRS abundances of Fe and Ti estimated in this study are lower than abundances of those elements reported earlier [6]. To develop a method to create concentration maps independently of previous mission data such as Lunar Prospector neutrons and ground truth for calibration would be necessary.

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