Improved distribution of iron in the lunar surface obtained by Kaguya Gamma-ray Spectrometer

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The iron distribution in the lunar surface is essentially important for lunar science. It was determined by the observation data of Kaguya gamma-ray spectrometer (KGRS). The KGRS employed high purity germanium detector (HPGe) which had an excellent energy resolution. Its excellent energy resolution enables us to obtain gamma-ray count rates in the complex energy peaks such as iron gamma-ray line at 846 keV.

The count rates of iron gamma-ray lines produced by inelastic scattering (at 846 keV) and neutron capture (at 7.631 and 7.646 MeV) are derived by peak fitting analysis. The neutron correction of inelastic scattering gamma-ray was conducted by the fast neutron flux derived from sawtooth peaks in gamma-ray spectra, and that of neutron capture was conducted by the thermal neutron flux obtained by Luna Prospector (LP). The sawtooth peek spectrum, which has a high energy tail, is produced by the direct injection of fast neutron toward detector crystal. Therefore, the iron distribution of inelastic gamma-rays is obtained by KGRS dataset without any other instrument dataset. This is first time to obtain elemental distribution by only KGRS gamma-ray observation.

The inelastic scattering gamma-ray was statistically superior to the neutron capture gamma-ray in spite of some contamination peaks around the inelastic scattering line. It is considered that this superiority in statistics is due to the detection efficiency since the emission rates of these gamma-ray lines by two neutron reactions are similar according to those in Reedy (1978). By the use of inelastic gamma-ray and sawtooth neutron correction, the accuracy of KGRS iron map was improved.

Comparing the KGRS iron map with the LP iron map, the general distribution trends was similar, rich in mare and depleted in highland. On the other hand, some low-middle FeO regions (3-15 wt%) such as the South Pole-Aitken and the Tycho crater show different features. These difference is achieved by the lower detection limit of KGRS (~ 3-4 wt%). The average FeO concentration in highland, north farside, was ~ 4.6 wt%, which is consistent to that of lunar samples.

The KGRS map shows two high FeO areas in the SPA where correspond to the Mare Ingenii and the area between the SPA central depression and the Apollo basin. The enhancement of FeO concentration in these regions implies that eruption of mare basalts apparently occurred as a result of these basin impacts at around the thinning crust by the previous SPA impact.

Chang'E-2 GRS team suggested the existence of Orientale ejecta at south west of Orientale basin. They reported basaltic composition with high concentration of potassium as evidence of the ejecta. However, we cannot find any significant FeO content implying the basaltic composition at that region. This discrepancy is explained by the internal background of $LaBr_3$(Ce), Chang'E-2 GRS detector. Radioactive La nuclides emit 1.436 MeV gamma-rays which make the statistical accuracy of Chang'E-2 counts of potassium gamma-ray line (1.461 MeV) low.

According to spectral measurements by Clementine, Kaguya, and Chandrayaan, the tycho crater is considered to be composed of mafic materials dominated by high-Ca pyroxene. However, the LP GRS map reports low abundance of FeO (~ 5 wt%). On the other hand, the KGRS map shows ~ 8-9 wt% FeO in that region. This result supports the results of the spectral measurements.

Our results show not only the KGRS high quality iron map but also present a possibility of gamma-ray spectroscopy by HPGe, which determine elemental concentration without neutron spectrometer.

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