High energy gamma-ray distribution on the Moon observed by SELENE Gamma-Ray Spectrometer

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The Japanese lunar explorer SELENE (KAGUYA) launched on Sep. 14, 2007 has been observing the Moon to understand its origin and evolution. The high precision Gamma-Ray Spectrometer (GRS) on SELENE employs a large Ge detector and measures gamma rays with energies of 0.2 - 13 MeV from the Moon with high energy resolution to determine elemental compositions of lunar surface material. Particularly, it is noted that the SELENE GRS also measures gamma rays with energies higher than 8 MeV for the first time in lunar missions [1].

Lunar gamma rays over 8 MeV are mainly dominated by continuous gamma rays from electron bremsstrahlung [2]. These gamma rays are considered to be mostly produced in the Moon by electromagnetic cascade shower initiated from pi-0 decay, and pi-0 is produced by nuclear reactions between cosmic rays (CRs) and the lunar surface materials. Therefore, the intensity of high energy gamma rays is influenced by the variation of CR intensity and the compositions of the lunar surface material. This work firstly shows a global distribution of high energy gamma rays in 8 - 13 MeV (HE gamma rays), in which a careful correction for the CR intensity was made. Then, regional differences of the HE gamma-ray intensity are discussed.

There is a good correlation between the intensity of HE gamma rays obtained by the SELENE GRS and neutrons obtained by a neutron monitor at Thule Station on the Earth [3], both of which are produced by CRs. The intensity variation of HE gamma rays reaches up to about 10 % during the observation period from Dec. 14, 2007 to Oct. 31, 2008, while that of neutrons is a few % or less. This means that the temporal fluctuation of CR intensity has much effect on the HE gamma-ray intensity. Therefore, the global map of counting rate of HE gamma rays was made after the correction for the temporal fluctuation of CR intensity. The intensity map shows that the counting rate in mare regions is basically higher than that in highland regions. In particular, the Procellarum KREEP Terrane (PKT) [4] shows a much higher counting rate than any other regions.

The abundances of heavy elements such as Fe and Ti in maria are higher than those in highlands, and therefore the average atomic mass in maria is also heavier [5]. Generally, the heavier an atomic mass of target material is, the higher the production cross section of pi-0 and the reaction cross section of bremsstrahlung and electron pair production are. Therefore, HE gamma rays are easier to be produced in the region with an average mass heavier and the intensity of those also gets higher there. The result of this work confirms this idea.

However, when the intensity maps of HE gamma rays and the average mass [5] are compared in details at PKT, there is a clear difference that the highest intensity region of the HE gamma rays is not corresponding to the heaviest region of the average mass. The highest HE gamma-rays region and the region with especially high concentration of Th are corresponding. However trace elements such as Th, which are heavier than Fe, do not influence the HE gamma-ray distribution, since the concentrations of these trace elements are ten thousand times lower than those of major elements such as Fe and Ti [6]. More detailed discussions are necessary about this difference.

[1] Hasebe et al., EPS 60, 299-312 (2008).
[2] Armstrong T.M., JGR 77, 524-536 (1972).
[3] Bartol Research Institute Neutron Monitor Data
http://neutronm.bartol.udel.edu/~pyle/bri_table.html.
[4] Jolliff et al., JGR 105, 4197-4216 (2000).
[5] Prettyman et al., JGR 111 E12007 (2006).
[6] Heikin et al., Lunar Sourcebook Cambridge University Press (1991)