New maps of natural radioactive elements on the lunar surface obtained by KAGUYA Gamma-Ray Spectrometer

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The elements of potassium (K), thorium (Th) and uranium (U) are geochemically very characteristic i.e., radioactive, incompatible and refractory (K is moderately volatile). The distribution and abundance of K, Th and U on the global lunar surface is a key constraint on the mode of crystallization of a magma ocean and the bulk-Moon abundance of the heat-producing elements. The formation and evolution of Procellarum KREEP Terrane (PKT) named by Jolliff et al. [1] must be closely connected to the characteristics of K, Th and U. In addition, the problems about the South Pole-Aitken Terrane (SPAT) [1], such as the maximum digging depth and the thickness of the crust, would be also clued by the well calibrated K, Th and U maps together with Fe and Mg maps. It is to know their abundances at the global surface that the first step for studying the Moon is in this context. The best way to measure the abundances of K, Th and U is a gamma-ray remote sensing.

In order to determine precisely the abundances of K, Th and U as well as other seven major elements, the gamma-ray spectrometer (GRS) onboard SELENE (KAGUYA) [2] was carried to the Moon in 2007. KAGUYA-GRS has successfully measured characteristic gamma rays from the natural radioactive elements [3]. The most excellent feature of KAGUYA-GRS is the high energy resolution, which is more or less ten times superior to that of GRS aboard Lunar Prospector (LP). The excellent energy resolution makes it possible clearly to discriminate gamma-ray peaks of K, Th and U, and to push the detection limit to those elements down.

The global maps of K, Th and U were preliminary produced by analyzing the spectrum data obtained at 100 km altitude from Dec. 14, 2007 to Oct. 30, 2008 by obtained KAGUYA-GRS. The lunar surface was pixilated by 150 km x 150 km quasi-equal areas or equal latitude/longitude spacing with 6 degree interval and gamma-ray spectra were accumulated in each pixel. The intensities of line gamma rays from K, Th and U in a pixel were determined from the accumulated spectra based on Covell method [4] that is a simple and quick way to obtain a net intensity of a peak. The intensities were converted to absolute abundances by multiplying factors which were determined by physically obtained coefficients, ex. the detection efficiency, the solid angle of KAGUYA-GRS and etc. The systematic error caused by the simplification of spectrum analysis, incomplete analysis of the detection efficiency and uncorrection of the spacecraft altitude is +- 30% in current analysis and it will be reduced in next version. New maps of the abundances of K, Th are nearly consistent with those by LP-GRS in a few hundred kilometer scale in which those elements are high in PKT and SPAT regions and are low in Imbrium basin. In PKT region, Th abundances in Fra Mauro and Apennius regions and highlands northwest of Imbrium basin measured by KAGUYA-GRS are clearly elevated.

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