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Possible detection of water ice in the lunar polar regions by the gamma-ray spectrometer onboard SELENE

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The neutron spectrometer onboard Lunar Prospector showed a certain decrease in neutron counting rate in the polar regions. This fact suggests a possible enrichment of light elements in the regions, one of which is supposed to be water [1].

According to the neutron capture reaction of hydrogen, 2.223 MeV gammas are emitted [2]. On the other hand, there are a lot of line gammas from major elements. They will contribute background events. In particular adjacent line gammas from ^{27}Al and ^{30}Si are isolated; 2.211 MeV and 2.235 MeV, respectively. The gamma-ray spectrometer (GRS) onboard SELENE comprises a germanium spectrometer that has resolution of 3 keV at 1.33 MeV. Therefore, the GRS of SELENE is expected to isolate the 2.223 MeV line between both the adjacent lines, provided that the intensity of 2.223 MeV gamma is considerable [3].

At present it is not clear how water is located beneath the moon surface. Monte Carlo works were done by assuming two cases that water existed near the moon surface; one was the case that water was homogeneously distributed in the soil (homogeneous distribution model, HDM) and the other case that water was layered in dry soil (water layer model, WLM).

We evaluated gamma-rays emitted from the moon using the Monte Carlo code, Geant4 [4]. The lunar surface was assumed to be made of the ferroan anorthosite (FAN) containing water, which is representative of lunar highland rock. Two cases, HDM and WLM, were considered as lunar soil. In HDM, gamma-ray spectra from the surface were calculated at various concentrations of water (0, 0.1, 0.2, 0.5 and 1 wt%). In WLM, a 10 cm thick water layer was located in FAN at 10, 30, 50 and 70 cm from the surface. For each case, the lunar surface was irradiated by GCR protons with a flux of 0.72 $cm^{-2}s^{-1}$. Then the energy spectra of gamma ray at the surface were calculated. The intensities of gamma-rays were multiplied by a factor of 1.5 because of the effects of heavy ion in the GCR [5].

For the case of HDM, the intensity of hydrogen line is shown in Figure (A). It is found that the intensity is proportional to the water content. The increase of concentration of water in the soil induces effective moderation for fast neutrons produced by GCR. Since the cross section for neutron capture with hydrogen is larger with lowering the energy neutron, the capture reaction and the emission of the 2.223 MeV line is much enhanced.

For the case of WLM, the intensity of hydrogen line is shown in Figure (B). The gamma-ray flux decreases exponentially with respect to the depth of water layer. In the water layer, the secondary neutrons due to GCR are immediately thermalized and then the gamma rays are generated. The volume production rate of 2.223 MeV is almost independent of the depth of water layer. Therefore, the flux of hydrogen gamma-ray (I_{WLM}) is determined by the attenuation in the dry soil. The results is consistent with the form of I_{WLM} = a exp(-bt), where t is the thickness of dry layer, i.e. depth of the pure water layer, b is the attenuation coefficient of FAN and a is a constant.

The adjacent lines of ^{27}Al and ^{30}Si are probably detectable for SELENE-GRS since they are major elements in the lunar soil. For the cases that the concentration of water more than 0.3 wt% in HDM and that the pure water layer is shallower than 40 cm in WLM, the intensity of hydrogen line is comparable to the adjacent lines (~0.04 $cm^{-2}min^{-1}$). Therefore, it is concluded that SELENE-GRS can detect hydrogen lines at the above cases.

[1] W. C. Feldman et al., Science 281 (1998) 1496.
[2] R. C. Reedy, Proc. Lunar Planet. Sci. Conf. 9th (1978) 2961.
[3] M. Kobayashi et al., Nucl. Inst. and Meth., A548 (2005) 401.
[4] S. Agostinelli et al., Nucl. Inst. and Meth., A506 (2003) 250.
[5] N. Yamashita et al. Doctor thesis, Waseda Univ., 2006.

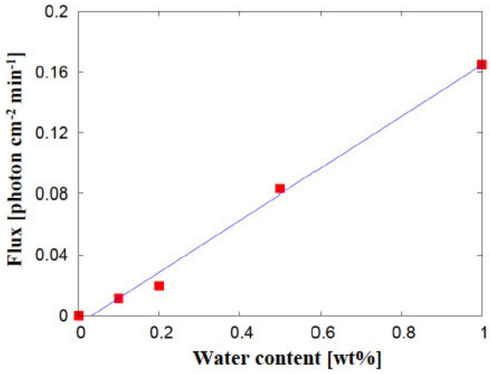

Fig. (A) Relation of γ-ray flux of hydrogen and water content (HDM). It is found that the intensity is proportional to water content.

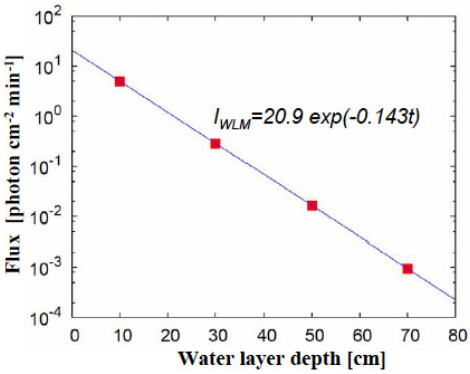

Fig. (B) Relation of γ-ray flux of hydrogen and water layer depth (WLM). The results show that the gamma-ray flux decreases exponentially with the depth of water layer.