Gamma-ray and Neutron Emission from the Surface of Martian Moons

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Mars has two moons "Phobos" and "Deimos" which have never been explored. Japanese mission to Martian moons "Mars Moon eXploration (MMX)" is planned to obtain some evidences for determining the origin of Martian moons. This mission will pick up rock and soil sample from Phobos to the Earth to analyze in detail by laboratory techniques. There are two influential scenarios about the origin of the Martian moons, captured asteroid origin and giant impact origin. However, any previous studies have never succeed to explain the origin of the Martian moons completely.
The chemical composition of the Martian moons which is essential information for planetary science has not been observed before. Gamma-ray and Neutron Spectrometer (GNS) is proposed as one of the mission payloads in order to determine elemental compositions of two Martian moons by remote sensing. The captured asteroid origin indicates Martian moons of primitive chondritic composition which enriches with volatile elements (H, S) and depleted with Si and Ca [1]. On the other hand, Martian materials ejected by the giant impact made the moon if they have similar composition to Mars which is considered to be rich in Si and Ca [2]. Moreover, volatile elements are depleted because of evaporation by impact heat. Therefore, the ratios of Si/Fe, Ca/Fe and H concentration will be important indicators to give a constraint to the origin of Martian moons.
In this work, we have investigated gamma-ray and neutron emission depending on chemical composition and H concentration to support the potential to distinguish sample compositions by the GNS. The elemental composition of Martian meteorites and some types of chondrites were assumed as the giant impact origin and the captured asteroid origin, respectively. H concentration in these elemental compositions were varied in the range of 0-20000 ppm. Production and transportation of gamma-rays and neutrons produced by galactic cosmic rays (H and He; 10 MeV/n-100 GeV/n) were calculated by using the Monte Carlo simulation code PHITS (Particle and Heavy Ion Transport code System) [3] and the INCL (Intra Nuclear Cascade of Liége) nuclear interaction model [4].
The Si/Fe and Ca/Fe ratios of gamma-rays emitted from Martian composition showed high values while that from chondrite composition showed low values. There are some differences in the shape of neutron energy spectra between Martian and chondritic samples. The neutron energy spectrum from chondrite shows a peak at the energy range of thermal neutron < 0.5 eV and a low flux of epithermal neutron energy from 0.5 eV to 500 keV comparing to that from Martian meteorite. In contrast, the shapes of fast neutron flux > 500 keV almost correspond. It is considered that the differences of H concentration in the sample composition caused this differences in neutron spectra since H atoms moderate neutrons effectively. The neutron fluxes were significantly varied depending on H concentration. Fast and epithermal neutron fluxes decreased with H concentration while thermal neutron flux increased until 2000 ppm of H and decreased above the value. Epithermal neutron flux is effective to determine H concentration since the change of epithermal neutron was larger than that of thermal and fast neutrons. By combining the ratios of Si/Fe and Ca/Fe and H concentration determined by gamma-rays and neutrons, the GNS will give an important constraint to the origin of the Martian moons.
The simulation results of the Martian moons will be presented and discussed.

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