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Laboratory experiments of X-ray fluorescence at rough surface and its implications to lunar and planetary missions

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Solar X-rays excite X-ray fluorescence (XRF) radiation characteristic to elements on atmosphere-free planetary surfaces. Major elemental mapping of the planetary surfaces can be carried out with concurrent observation of X-rays from the Sun and the planet. In laboratory experiments, we usually use polished flat samples or compacted powders whose particle size is typically less than 10 micrometers.

However, the planetary surfaces are often covered with soils and breccias called regolith whose average diameter ranges ten to hundreds micrometers and sometimes covered with rugged rocks, in both cases far from the ideal surface for detailed analysis. It is generally believed that the XRF intensities decrease gradually with increase in particle size of powders. Such trend is more remarkable for the lager phase angle between incident and emission angles(e.g., Kuwada et al., 1997). Therefore, understanding the effects by particle size of planetary surface is important for quantitative elemental analysis through remote XRF spectrometry of planetary surface.

This study aims at thorough investigation of angular dependency of XRF intensities at rough surface and its implications to data analysis for planetary missions. Then we prepared the specimens by crushing rocks and sieving them into different sizes. Those specimens used here include basalts, granites, anorthosites, and peridotites. We developed an apparatus for this experiment equipped with a chamber. It has functions of changing the angles of X-ray incidence and emission. The powdery specimen is mounted on the holder inside the helium filled chamber. The holder can incline up to 30deg.

Fluorescent X-rays from the specimen are excited by irradiation of X-ray tube generated primary X-rays and are observed with the PIN photodiode based spectrometer. The detector has energy resolution good enough to discriminate XRF of each major element and simultaneously observe them.

In this experimental study, we attempted 1) getting detail data of XRF under a variety of incidence angle and constant emission angle (e=0deg) aiming at observation by the XRS onboard the lunar polar orbiter SELENE, 2) understanding of behavior of XRF under such condition that phase angle is almost 90deg as performed in the NASA's NEAR Shoemaker asteroid mission, and 3) applying to a phase function of XRF that once investigated in the Apollo 16 observation. Further information on the method and the results of this study will be reported in detail.