（ ※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。）

MLF Experimental Report	提出日 Date of Report 2012年5月28日
課題番号 Project No. 2011B0032 実験課題名 Title of experiment: Development on analysis of planetary materials by using negative muon capture 実験責任者名 Name of principal investigator Kentaro Terada 所属 Affiliation Osaka University	装置責任者 Name of responsible person Yasuhiro Miyake 装置名 Name of Instrument/(BL No.) D2 instrument 実施日 Date of Experiment 9-11/2/2012 13-15/2/2012

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

SiO_2 plate (76mm × 51mm × 1.5mm)
Graphite plate (75mm × 50mm × 1.0mm)
Boron Nytride plate (78mm × 51mm × 1.5mm)

2. 実験方法及び結果 （実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

Since the pioneering work of Rosen (Rosen et al. 1971), Muonic atom spectroscopy has been developed over about four decades. Recently, the intense pulsed Muon source, J-PARC MUSE (Japan Proton Accelerator Research Complex, the Muon Science Fasility) has been constructed, providing the decay muon rate of 10^6 cps for 60 MeV/c (up to 10^7 cps for 120MeV/c) that is most intense pulsed muon beams in the world (Miyake et al. 2009). Because the stopping distance of both negative muons (～ tens of MeV/c) and muonic X-rays (more than several tens keV) are approximately mm orders, this analytical method could potentially enable us to obtain the 3-D elemental map from the near surface to the interior of the rocky sample by changing the momentum of muon beam.

Here, we report on the first trial of the depth profile analysis of the four-layered sample that consists of SiO_2, C (graphite), BN (boron nitride) and SiO_2 using the D2 beam line at J-PARC MUSE. The negative muon beam was collimated to approximately 2.7 cm diameter and focus on

2. 実験方法及び結果（つづき） Experimental method and results (continued)

the 50mm*75mm*4mm sample that was oriented at 45 degree to the beam (Figure 1). Changing the Muon's momentum from 37.5MeV to 57.5MeV/c, the generated high energy X-rays were measured by two Ge detectors (LEPS-**low energy gamma spectrometer** and Loax). Figure 2 shows the X-ray spectra obtained by LEPS.

At the momentum of 32.5MeV/c of which mean penetration depth of Muon bean is about 0.5mm, the μ Si-Lα (76 keV) and μ O-Kα (133 keV) signals are detected from the first layer with bgd μ Al- Lα (66keV). At the momenum of 42.5 MeV/C, μ Si-Lα and μ O-Kα peaks disappear and μ C-Kα (75keV) signal from second layer (Graphite) are detected through SiO2 plate of which apparent thickness is 1.4mm × $\sqrt{2}$. At the momentum of 50.0 MeV/c, μ C-K peak disappears and both μ B-Kα (52 keV) and μ N-Kα (102 keV) signals from third layer (boron nytride) are detected through SiO2 and graphite layers. Finally, at the momentum of 57.5 MeV/C, the peaks from μ B-Kα and μ N-Kα disappear and μ Si-Lα (76 keV) and μ O-Kα (133 keV) signals are again detected from the fourth layer (quartz) through totally 4mm × $\sqrt{2}$ depth. Thus, our preliminary result successfully demonstrates that non-destructive 3-D elemental map including light element such as B, N, C, and O would be possible. Expected depth resolution is about 10 % uncertainties of mean penetration depth.

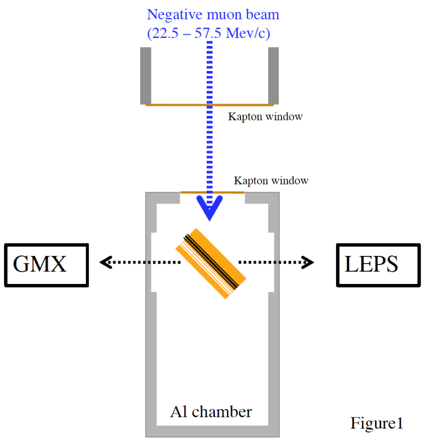

Figure1

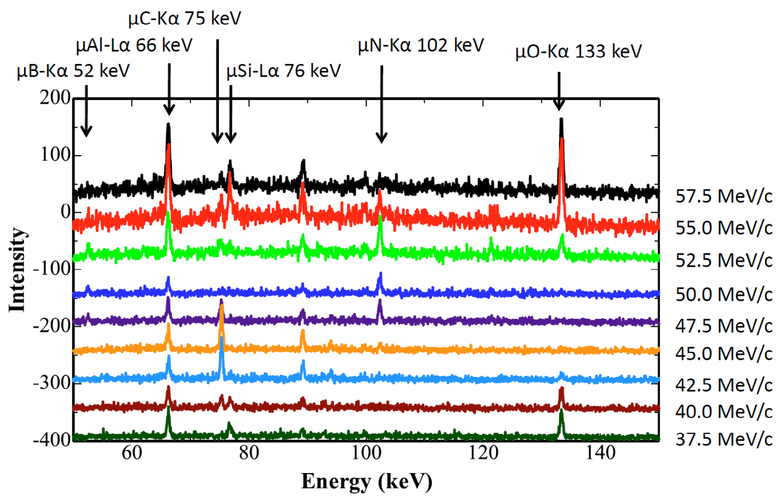

Figure 2

1st layer SiO_2: depth= 1.5mm ρ =2.2 cm^3

2nd layer graphite: depth= 1.0mm ρ =1.9 cm^3

3rd layer BN: depth= 1.3mm ρ =2.2 cm^3

4th layer SiO_2: depth= 1.5mm ρ =2.2 cm^3