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 MLF Experimental Report	提出日 Date of Report
課題番号 Project No. 2012B0065 実験課題名 Title of experiment Development on non-destructive elemental 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 2013/1/14-2013/1/16

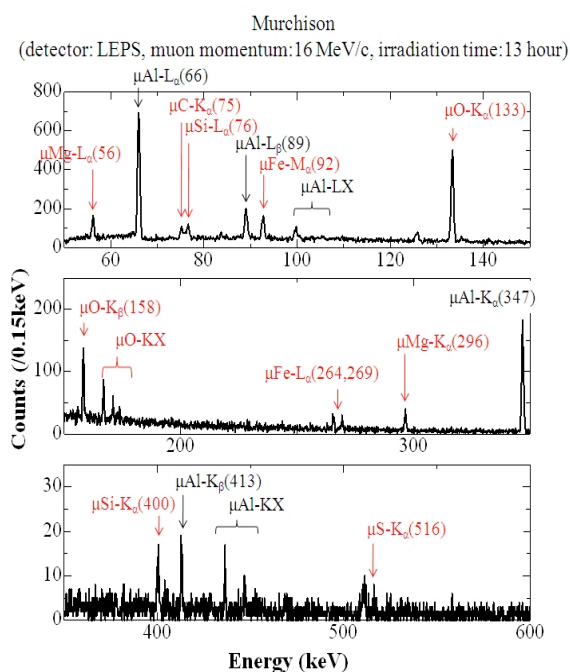
試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。(適宜、図表添付のこと)
 Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form. Murchison Meteorite (610 g) Allende Meteorite (4cm * 5 cm * 0.5 cm) Glass tube (φ 6mm * 5 cm)

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 et al. (1972), 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 Facility) has been constructed, providing the decay muon rate of 10^6 cps for 60 MeV/c that is the most intense pulsed muon beam in the world (Miyake et al. 2009). The stopping distances of both negative muons (about tens of MeV/c) and muonic X-rays (more than several tens keV) are approximately mm orders, which 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 incident muon beam. In our previous analysis [2011B0032], we successfully demonstrated that non-destructive depth-profile analyses of light element such as B, N, C, O and Si were possible using the D2 beam line at J-PARC MUSE [4]. We also confirmed that properties of the momentum-controlled muon beam (32.5 ~ 57.5 MeV/c) are suitable for several mm-sized terrestrial samples of which density is about 2.
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2. 実験方法及び結果(つづき) Experimental method and results (continued)

In this study, we measured the muonic X-ray spectra of primitive meteorites, Murchison and Allende. Figure shows the observed X-ray spectra of Murchison, where exposure time is about 13 hours and incident muon momentum is 16 MeV/c corresponding to penetration depth of 70 μm . As shown in Table, significant counts of fluorescent X-rays of Mg, C, Si, Fe, Ca, S from Murchison and those of Mg, Si, Fe, K, Ca from Allende were detected. On the other hand, those of K from Murchison and C and S from Allende were not detected. This indicates that detection limit of muonic fluorescent X-ray in this analytical condition is about 1 weight percent in concentration. It should be noted that the signal of Al are background signal from vacuum chamber and/or sample holder.



	Murchison 13 hours	Allende 10 hours
Ca(4-3) 55 keV		53 ± 23
Mg(3-2) 56 keV	896 ± 66	183 ± 23
Al(3-2) 66 keV	10796 ± 130	136 ± 30
C(2-1) 75 keV	626 ± 52	6 ± 27
Si(3-2) 76 keV	824 ± 58	175 ± 32
Fe(4-3) 94 keV	1310 ± 63	265 ± 39
O(2-1) 133 keV	4785 ± 111	800 ± 38
K(3-2) 140 keV		94 ± 27
Ca(3-2) 156 keV	213 ± 41	83 ± 28
Al(2-1) 346 keV	9542 ± 100	359 ± 27
S(2-1) 516 keV	121 ± 33	

Finally, we tried the measurement of 610 mg Murchison powder sealed in glass tube as a simulant of Hayabusa 2 samples collected from C-type asteroid. Significant Mg and small Fe and marginal C signals are detected via a glass of which thickness is 1 mm, using 37 MeV/c muon beam. For optimization of the analytical conditions (S/N ratios, spatial resolution, so on) for small amount of samples, further experiment should be required.