LIBS FOR MARTIAN MOONS EXPLORATION (MMX). S. Kameda[1], M. Horiuchi[2], Y. Cho[3], K. Ishibashi[4], K. Wada[4], T. Mikouchi[5], T. Nakamura[6], and S. Sugita[5], , [1]Rikkyo University (3-34-1 Nishi-Ikebukuro, Toshima, Tokyo 171-8501, Japan, kameda@rikkyo.ac.jp). [2]Rikkyo University, Tokyo, Japan. [3]NASA Marchall Space Flight Center, AL. [4]Chiba Institute of Technology, Chiba, Japan. [5]The University of Tokyo, Tokyo, Japan. [6]Tohoku University, Miyagi, Japan.

Introduction: JAXA's Martian Moons Exploration (MMX) is planned to be a sample return mission from Phobos, one of the satellites of Mars. The nominal instruments have been selected: a telescopic camera, wide angle multiband camera, near infrared spectrometer, gamma-ray and neutron spectrometer (GNS), ion mass spectrometer, dust monitor, and LIDAR. Because one or two additional instruments may be acceptable, we propose adding a laser-induced breakdown spectrometer (LIBS).

One of the scientific objectives of MMX is to determine the origin of the two martian moons. Phobos and Deimos seem to be asteroids captured by Mars' gravity according to the result of spectroscopic observation of the surface reflectance. Conversely, they also seem to have been formed by a large impact of a body with Mars and subsequent accretion [1]. Elemental analysis is necessary to clarify the origin of the moons.

The MMX mission will acquire more than 10 g of regolith on the surface of the moon. A coring unit will be installed with a core diameter of 10–20 mm. Assuming that the sample is representative of Phobos, we will be able to clarify the origin of the moons. To test this assumption, we should determine suitable landing sites and identify the uniformity or nonuniformity of the distribution of surface material. Though we can obtain the globally averaged elemental compositon using the GNS, the distribution of the elemental compositon cannot be obtained by the selected instruments with a resolution of ~10 mm.

Laser induced breakdown spectroscopy (LIBS): LIBS is widely used for chemical composition analysis. A high-intensity pulsed laser is focused to ablate the surface of the target material in order to form a light-emitting plasma. The composition of this ablated material can then be analyzed using atomic emission spectroscopy. This technique has already been successfully used in ChemCam onboard Mars Curiosity [2,3]. The result clearly shows the emission lines of the major elements—Mg, Si, Ca, Fe, Ca, Na, K, and Al—and the light elements—H, C, and O. This new technique will be the standard for future planetary exploration. We can also expect an innovative performance of LIBS on the surface of Phobos because in principle, it can be used in vacuum as well.

The rotation period of Phobos is 7.65 hours. In the nominal plan, the spacecraft has to take off from the surface before dusk. Thus, the operation time is limited to be approximately 1 hour. We conducted an experiment to demonstrate that we can determine whether the surface composition resembles that of Martian meteorites or that of a carbonaceous chondrite in a short time with an instrument similar to that designed for MMX. Figure 1 shows the obtained LIBS spectra in vacuum for NWA1068 and Zagami, (Martian meteorites), and Allende (a carbonaceous chondrite). The emission lines of major elements are clearly detected. Figures 2 and 3 show the differences between the Martian meteorites and the carbonaceous chondrites. It is known that Allende is Mg-rich and Martian meteorites are rich in Al and Ca, and our result shows that we may distinguish Martian meteorites from carbonaceous chondrites using LIBS. The required observation time is ~30 minites including the time for focusing and shifting the field of view, which is within MMX operation time on the surface.

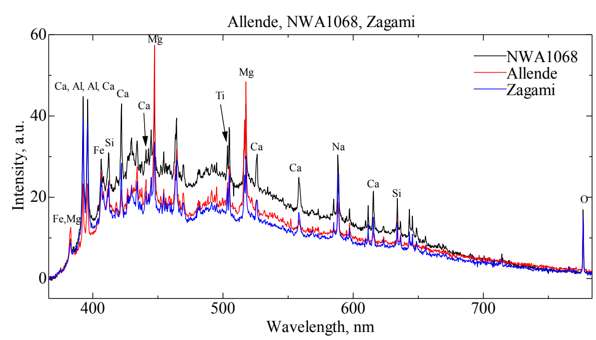

Figure 1: LIBS spectra for NWA1068, Zagami and Allende

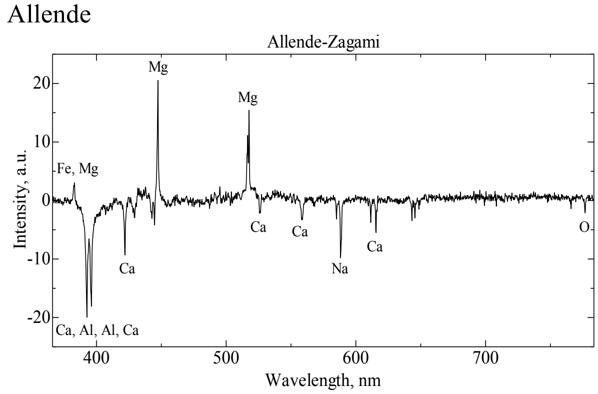

Figure 2: Difference between LIBS spectra of Allende and Zagami.

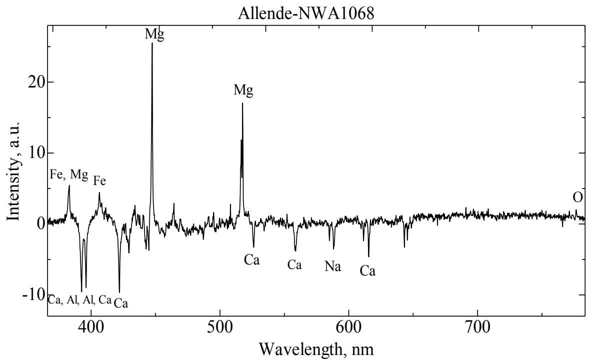

Figure 3: Difference between LIBS spectra of Allende and NWA1068

References: [1] Rosenblatt et al. (2016) Nat. Geosci., 9, 581–583. [2] Maurice, S. et al. (2012) Space Sci. Rev., 170, 95–166. [3] Wiens, R. C. et al. (2012) Space Sci. Rev., 170, 167–227.