SCG61-P13 Room:Convention Hall Time:May 22 18:15-19:30

In-situ elemental analysis with laser-induced breakdown spectrometer (LIBS)

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Elemental and mineral composition of rocks is important information for classifying rocks and clarifying their origins. Elemental and mineral composition is usually measured in laboratories. In-situ elemental measurement, however, enables us to conduct a field research with gaining a better comprehension in real time. Furthermore LIBS would be a powerful tool for selecting appropriate samples to bring back to laboratories for more detailed analysis. Now we are developing a laser-induced breakdown spectrometer (LIBS), which is able to measure elemental composition of rocks in the field.

The measuring principle of LIBS is as follows: Samples are irradiated with pulsed laser beams in order to generate plasma plumes of a small amount of a sample. When atomic and ionic species excited in the plumes are deexcited, the emission of lights occurs according to the difference in energy levels before and after the deexcitation. These lights are measured with a spectrometer as emission lines on spectra. The wavelength of emission lines is unique to each element, and the intensity of emission lines is correlated with the elemental abundance. Both qualitative and quantitative analyses, such as elemental abundance determination and mineral classification, are carried out by analyzing the acquired spectra.

LIBS has several advantages such as (i) capability of remote analysis, (ii) rapid data acquisition, (iii) ability to analyze almost all elements including light elements, (iv) high spatial resolution, and (v) unnecessity of sample preprocessing.

On the other hand, LIBS have a weak point of slightly worse determination precision than other elemental analysis methods usually used. However, recent studies show that the use of multivariate analysis methods such as partial least squares regression (PLS) as a spectral analysis method improve the determination precision.

In this study we made a small portable LIBS, and carried out a field measurement test with it at Mount Mihara on Izu-Oshiam island. The LIBS we made is for a short range measurement and has a fifty-millimeter fixed focal length. Standard elemental-composition-known igneous rock samples have been measured with the LIBS in the laboratory in advance to make PLS regression models for quantitative elemental analysis. In the field we measured many samples such as bounding stones and lava flows under the Sun and obtained spectra with high signal-to-noise ratio. The elemental compositions determined with those spectra shows reasonable values for basalt.

We are going to improve the device in accordance with the intended use, such as extending the measurement distance to measure the samples at inaccessible places and mounting a micro imager to observe textures around the measuring point on the samples. We are also going to prepare more standard samples with various elemental compositions to determine elemental compositions with much higher precision.

Keywords: elemental composition, elemental analyzer, field research