Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC54-P01 会場:コンベンションホール 時間:5 月 20 日 15:30-17:00

可視分光顕微鏡を用いた珪酸塩ガラス中の鉄の二価・三価比の局所分析：マグマ・マントルの酸化還元状態の理解へ向けて
Microanalysis of ferric-ferrous ratio of silicate glasses by visible microspectroscope

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Ferric-ferrous ratio of magma reflects source mantle and evolution of redox state during magma ascent to earth surface (e.g., Kelley and Cottrell, 2009 Science; Burgisser and Scaillet, 2007 Nature). A direct method to determine the redox state is to investigate the ferric-ferrous ratio of quenched glasses in volcanic rocks. The synchrotron micro XANES technique, which has high spatial resolution down to 10 um (Delaney et al., 1998 Geology), has been applied to the measurement of ferric-ferrous ratio of volcanic glasses, but the major disadvantage of this method is the limited number of facilities. Here, we develop a visible microspectroscope to measure ferric-ferrous ratio of silicate glasses in in-house laboratory and report preliminary results.

The visible microspectroscope consists of a microscope, a halogen lamp unit, and a monochromator. In this system, the intensity of the monochromatic light through a sample thin section is measured using a digital camera with the raw mode. Because we use the monochromatic light and digital camera, two dimensional data can be obtained, which is expected to have high spatial resolution.

We synthesized standard glasses with different chemical compositions (JA3 and JB3) and different ferric-ferrous ratios to calibrate the relationship between ferric-ferrous ratio of the glasses and the transmittance of visible lights. The glasses were prepared by melting powder samples using a Pt wire-loop method, at a temperature of 1300 deg C under CO_2-H_2 mixed gas flow. On the basis of the CO_2/H_2 ratio, the oxygen fugacity was controlled to be deltaNNO-1 to deltaNNO+3, and the ferric-ferrous ratio was calculated from the mixed CO_2/H_2 ratio. The quenched glass was doubly polished to thin sections with thicknesses of approximately 60 and 110 um. The visible light image of the glasses was obtained using some different wavelengths (420, 440, and 520 nm). The greyscale intensity in 8 bit was measured in different points in the glass and normalized by the background intensity. For the analytical condition of this study, the transmittance of 420 nm shows a good correlation with the ferric-ferrous ratio without intensity saturation. Hence, there is a possibility that the ferric-ferrous ratio and redox state of basaltic to andesitic glasses can be determined using the visible microspectroscope.

We will apply the method established in this study to melt inclusion in pyroclasts to investigate the change in redox state of magma before volcanic eruptions and to examine the relationship between redox state of magma and the injection of fluid into magma chamber which has been recently proposed in many volcanoes (e.g., Blundy et al., 2010 EPSL).

キーワード: 珪酸塩ガラス, 鉄の二価・三価, 可視分光法, マグマ, マントル, 酸化還元
Keywords: silicate glass, ferric-ferrous ratio, visible spectroscopy, magma, mantle, redox state