Textural analysis of obsidian lava flow in Shirataki, Northern Hokkaido, Japan

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Formation process of obsidian is poorly understood and it is thought that gas loss (outgassing) plays an important role. Glass formation needs the high-effective supercooling resulted from a high ascent and decompression rates, and this process increases magma viscosity. The ascending process of such a highly viscous magma is also unclear. In this study, we conducted textural and chemical analyses for Tokachi-Ishizawa (TI) obsidian lava one of Shirataki rhyolite lava, Hokkaido, northern part of Japan, in order to elucidate the magma ascent and outgassing process.

In Shirataki rhyolite lava area there are monogenetic volcanoes composed of 10 obsidian lava flow units, which were erupted at 2.2Ma. Rhyolite lava area with well-exposed outcrops allow us to observe the internal structure of obsidian lava flow. The TI lava is 50 m in height and stratigraphic sequence from the bottom is a brecciated perlite layer, obsidian layer (7m), banded obsidian layer, and rhyolite layer. In this study, we define the obsidian and rhyolite based on the difference in appearance of specimen and rock texture, especially crystallinity. Rhyolite has perlitic cracks on glass, and contain the crystalline materials (i.e. spherulite and lithophysae). Banded obsidian layer which is located at the boundary between the obsidian and rhyolite layer, is composed of obsidian and rhyolite. Volume fraction of the crystalline materials in rhyolite layer is up to 40 vol.%.

Obsidian in TI lava is almost aphyric, composed of glass (>98 % in volume), rare plagioclase phenocrysts, plagioclase microlites, magnetite phenocrysts, oxide microlite, and rare biotite. Chemical compositions of obsidian glass, plagioclase and magnetite were analyzed by electron microprobe.

The maximum depth of magma chamber is estimated as <300MPa from the rhyolite-MELTS (Gualda et al., 2012) and petrographic characteristics. Magmatic temperature is calculated as T= 800 –820 [℃] from the plagioclase-melt geothermometer (Putirca, 2005). Magma viscosity is estimated as log μ= 4.9 –8.7 [Pa s] (Giordano et al., 2008).

We measured length, width and number of oxide microlite based on three-dimensional measuring method (Castro et al. 2003), and oxide microlite number density (N_v [/m^3]) was obtained. N_v of oxide microlite is $2.1\times10^{13} – 1.4\times10^{14}$. Water exsolution rate and ascent rate are inferred as 4.0×10^{-8}–2.2×10^{-7} [wt.%/s], and 6.8×10^{-5}–5.6×10^{-4} [m/s] respectively, from N_v and glass chemical compositions (Toramaru et al., 2008). These results means that obsidian and rhyolite experienced the same degassing rate, that is, ascent rate. This constraint provides an insight into the formation process of obsidian.