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Decompression experiments for sulfur-bearing hydrous rhyolite magma: Redox evolution during magma decompression

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Abstract

We performed decompression experiments on sulfur-bearing hydrous rhyolite magma at a temperature of 800 °C to investigate redox evolution during magma decompression. The magma was continuously decompressed from 100 MPa to 10–50 MPa at rates of 10 and 100 MPa h^{-1}. The evolution of the ferric to total iron ratio (Fe^{3+}/Fe_{total}) during decompression was investigated using XANES, and redox evolution was determined based on a thermodynamic calculation and measured Fe^{3+}/Fe_{total}. Before decompression, the sample was buffered from NNO to NNO+1, and the pre-exsolved fluid phase and sulfide crystal coexisted. Sulfide crystals were found in all decompressed samples, and Fe^{3+}/Fe_{total} showed a slight decrease with decompression. It was confirmed that the sample in a gold capsule was not influenced by the change in redox conditions outside of the capsule for the timescale of the decompression experiments; thus, the decompressed sample reflected the redox evolution in magma during decompression.

Our experiments indicated that magma decompression causes a slight reduction when it includes water and sulfur. This evolution is qualitatively explained by sulfur degassing and fluid-melt redox equilibria. During the fluid-melt redox equilibria, magma is reduced if the existence of a pre-exsolved fluid phase is assumed, while the model calculation shows that magma is oxidized when it contains only water or no pre-exsolved fluid phases. This is because sulfur buffers the oxidation of magma through a reaction with oxygen in the fluid phase. Therefore, we inferred that the redox condition of magma is not oxidized during explosive volcanism with a pre-exsolved fluid phase and closed-system degassing. In contrast, if magma experiences open-system degassing, it may be oxidized, resulting in the breakdown of sulfide crystals as observed in some pyroclasts and lavas.

Keywords: Rhyolitic magma, decompression, redox evolution, sulfur, water