Constration of pre-eruptive process using crystal clot: A case study of Unzen 1991-95 eruption

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1.Introduction

Magma mixing is thought to be the major eruption triggers of arc volcanoes. This process can control whether magmas will erupt or stall in the crust. However, magma mixing processes have not been revealed well. Therefore, it is important to reveal mixing process at magma reservoir.
For this purpose, we focus on Unzen 1991-95 eruption. This eruption is characterized by continuous growth of dacitic lava domes and pyroclastic flows caused by collapse of the lava domes. During the eruption, two vulcanian eruptions were recognized. Previous studies proposed that magma mixing between nearly aphyric, mafic and crystal-rich, silicic end-members occurred in the magma chamber (e.g., Sato et al., 1999). Because there are lots of geophysical and geological studies, this eruption is suitable for getting more detailed information about pre-eruptive processes.
Recent studies demonstrated that igneous amphiboles are powerful tools to constrain pre-eruptive magmatic conditions (e.g., Ridolfi and Renzulli, 2012; Putirka, 2016). For example, empirical equations relating temperature and SiO_2 content of co-existing melt with amphibole composition were proposed by Putirka (2016). By using these equations, we can constrain physicochemical conditions of melts in which individual phenocryst crystallized.
Our previous results suggest that the 1991-95 magma was formed by three-component mixing, in which contribution of the newly-recognized 3rd endmember magma (MT magma) (Iwahashi et al., JpGU2018). Products of 1991-95 eruption often contain crystal clots. They consist of amphibole, plagioclase and Fe-Ti oxides. Because magma reservoir of Unzen volcano is thought to be mushy (e.g., Nakamnura et al., 1995), crystal clots are possible to be part of mushy magma reservoir. Therefore, in this study, we expect to get more detailed information about pre-eruptive process of 1991-95 eruption using crystal clots in addition to amphibole phenocrysts.

2.Methods

We used 11 dacitic samples erupted at different times during the 1991-95 eruption. All of these samples contain crystal clots. They are composed of amphiboles, plagioclases, Fe-Ti oxides and interstitial glass. The major element compositions of amphibole phenocrysts and constituent minerals and glasses in crystal clots were measured by using EPMA at ERI, University of Tokyo.

3.Results

Amphiboles in crystal clots are classified into four types; Type A, Type B, Type C, Type D. Amphibooles of Type A has zonal structure, Type B has reaction rim, Type C has both zonal structure and reaction rim and Type D is almost homogenous. These amphiboles are classified magnesiohornblende and tchermakite based on their compositions. There is an apparent compositional gap between these two clusters. Crystallization temperatures are estimated to be ~750-800ºC and ~850-950ºC for magnesiohornblendes and tchermakites, respectively. Amphiboles in crystal clots reveal temperatures of ~750-800ºC. Estimated SiO_2 contents of melts coexisted with amphiboles (SiO_2^{melt}) are ~66-73wt.% and ~60-67wt.% for magnesiohornblendes and tchermakites, respectively. On the other hand, SiO_2 contents of interstitial melts are ~68-72wt.%. Almost all plagioclases in crystal clots have oscillatory zoned texture. An content (=100*Ca/Ca+Na) of these rim are 60-75.

4.Discussion

H_2O saturation depth estimated for the interstitial melt compositions are consistent with that of main magma chamber in which the silicic endmember magma was thought to be stored.
On the other hand, zonal texture of amphibole often cut by other crystals and this implies that MT magma reservoir may present before 1991-95 eruption. In addition, comparison of temperatures estimated by amphiboles with phase diagram by Noguchi et al.(2008) indicate that there may be almost no plagioclases in MT magma reservoir.
In addition to these results below, we plan to present some new picture of pre-eruptive process at 1991-95 eruption and MT magma reservoir.

Keywords: pre-eruptive process, crystal clot, amphibole

