An EBSD study of plagioclase glomerocrysts in Aokigahara lava flow from Fuji volcano, Japan: Implication for their formation process

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Introduction Plagioclase phenocryst has wealth of information about magmatic process in their textural and chemical features. To decipher such information, we have to understand the growth history of plagioclase crystals. Plagioclase is often found as glomerocryst in natural magmas; perhaps, glomerocryst is more common than non-aggregated single crystal for natural plagioclase phenocryts. However, the formation process of plagioclase glomerocryst is not well understood. In this study, we performed EBSD mapping analyses, as well as microscopic and BSE image observations, for plagioclase glomerocrysts in a basaltic lava flow from Fuji volcano, Japan to understand forming process of plagioclase glomerocryst.
Sample and methods We used a basaltic lava sample erupted at AD 864-866 from Fuji volcano, Japan, called as Aokigahara lava. The lava has ca. 32 vol.% of plagioclase phenocrysts and most of them are glomerocrysts. Hereafter, we call a continuous region of crystal with the same crystallographic orientation as “domain”. Plagioclase glomerocryst is composed of a number of domains. We performed EBSD mapping analyses for plagioclase glomerocrysts to identify inter-domain boundaries and quantitate Euler angles of each domain. Then, relative orientations between neighboring domains are calculated, which is described by a combination of direction of symmetric axis and rotational angle around the axis. In addition, we observed microscopic and backscattered electron (BSE) images of inter-domain boundaries. We analyzed 1060 pairs of neighboring domains in 25 plagioclase glomerocrysts.
Results and discussions 911 (86%) pairs show rotational angles of 180 degree. Their symmetric axis directions are concentrated to [100], [010], [001] and [h0l]. We classified the pairs with a symmetric axis of [100], [010], [001] as Type-I and [h0l] as Type-II, respectively. Other 149 (14%) pairs do not show systematics between their symmetric axis and rotational angle around the axis. We call these pairs as Type-III. Domain boundaries of Type-I pairs often cut across the concentric compositional pattern of plagioclase without melt and/or other mineral inclusions. These observations as well as the crystallographic orientation relations indicate that Type-I pair is twin. The pairs with [010] and [001] axes are characterized as Albite and Carlsbad twins. The pairs with [100] axis are explained by combination of Albite and Carlsbad twins. These domain boundaries are formed during crystal growth of plagioclase single crystals. Domain boundaries of Type-II pairs with symmetric axes parallel to (010) are often found at the contacts of independently-grown crystals. Impurities are rate along the boundaries. Concentration of the symmetric axis directions to [201] and [102] is observed. These observations indicate that Type-II pairs are not twin but are controlled by crystal structure of plagioclase. The relation is explained by 180 degree rotational axes of [201] or [102] on the (010) plane. This orientation relation is relatively stable due to superlattice-like bonding of neighboring domains on (010) plane. We think that Type-II boundary is formed by repetitive collision of plagioclase crystals when they are suspended in liquid magma. Relative orientation relations of Type-III pairs are random. In addition, melt and other mineral inclusions are often found along this type of boundary. Type-III boundaries are also found at the contacts of independently-grown crystals. These features may suggest that Type-III boundary is formed when plagioclase crystals are cumulated. Coexistence of all types of inter-domain boundaries in large glomerocrysts suggests that they are formed by crystal growth followed by collisions in liquid magma and also in crystal mush before re-entrainment into the erupted magma. Our results demonstrate that EBSD analysis of inter-domain boundary is a powerful method to clarify the formation processes of

glomerocrysts and also cumulate rocks.

Keywords: plagioclase, glomerocryst, EBSD, magma, Fuji volcano, crystal growth