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Petrological features related to magma ascent rate -A case-study from the historic activity of Usu volcano, Japan-

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Usu volcano, located on southwestern Hokkaido, started the historic activity in AD 1663. Its eruptive style show wide variations: plinian eruption, pyroclastic flow, and formation of lava dome, whereas the whole-rock compositions of the ejecta show roughly homogeneity: rhyolite to dacite. We focused on the summit and flank eruptions (the end of the 17th to 19th and the 20th centuries, respectively). They're similar in the eruption sequence: the tephra eruption and the formation of dome in the early and late stages, respectively, although they are different in not only vent location but also the duration of the formation of lava dome (few months for summit lava, two years for flank one). In this study, we focus on the petrological features of tephra and lava to reveal the effect of the magma ascent rate based on the recent studies.

Phenocryst abundance of tephra and lavas are ca. 5-22 and 12-18 vol.%, respectively. The phenocrystic minerals of lavas consist of plagioclase, orthopyroxene and Fe-Ti oxide. Tephra also includes hornblende, quartz and clinopyroxene. The groundmass of tephra is composed of clear glass, plagioclase, orthopyroxene and Fe-Ti oxide. The groundmass of lavas is well crystallinity and has some silicate minerals as a microlite. The crystal size of microlites in the flank lava is larger than those in the summit one. Focused on core compositions of plagioclase phenocrysts, we can found high-Or plagioclase in lavas, whereas absent in tephra. They are composed of the phenocryst with resorption core and the clear phenocryst (˜microphenocryst). The amount of the former is much larger than that of the later in the summit lava. In the flank lava, however, the amount of them is much larger than those in the summit one and the number of clear phenocryst increases. Moreover, all the plagioclase phenocrysts in lavas have higher-Or rim compositions than those in tephra, and rim compositions in the flank lava show higher Or content than those in the summit one.

As magma rise quickly during the eruption of tephra, tephra retains the petrological features in magma chamber. During the effusion of lava, however, the magma ascent rate is so small that its petrological feature can be changed by decompression and degassing. The absence of the minor phenocrystic minerals in lavas probably reflects on the breakdown by decompression and degassing. Recent experimental study also indicated that crystallinity of groundmass become high and silicate minerals crystallized during the multiple-decompression at low pressure (Hammer & Rutherford, 2002; Martel & Schmidt, 2003). This result agrees with the high crystallinity of groundmass and the existence of silicate minerals in lavas because magma rise slowly and keep near the surface temporally during formation of lava dome. Moreover, high-Or rim of plagioclase crystallization requires the move of the position of the plagioclase + liquid (PL + L) curve toward anorthite. Previous study implied a change in the position of PL + L curve induced by degassing and a reduction of water content (e.g. Nekvasil, 1992). Therefore, crystallization of high-Or plagioclase commenced at the edge of the pre-existed plagioclase by degassing. High-Or core of plagioclase with resorption core can be explained by the similar process.

Martel & Schmidt (2003) indicated that the crystal size of microlite increased with the length of the decompression and post-decompression equilibration durations. Therefore, the large microlites in the groundmass of the flank lava is consistent with this result. The high-Or compositions of clear plagioclase in the flank lava can also interpret as crystallization by the long duration on the syn- and post-decompressions. This interpretation agrees with the recent experimental study (Suzuki et al., 2006: MSD-144). The higher-Or rim of plagioclase in the flank lava can be explained by the highly degassing, resulted in the large change in the position of PL + L curve toward anorthite.