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Numerical simulation of plagioclase rim growth during magma ascent at Bezymianny volcano, Kamchatka

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A mathematical model of plagioclase crystal growth is developed. Plagioclase is one of the main rock-forming minerals. Plagioclase is composed of molecules of two types: anorthite and albite. Crystallization occurs as a result of component (albite and anorthite) diffusion to the boundary of the growing crystal. The model is based on multicomponent diffusion equations with the real dependencies between crystal and melt compositions, pressure and temperature. Based on this model the growth of rims on plagioclase crystals related to magma ascent during dome building eruptions on Bezymianny volcano (Kamchatka) is simulated. Bezymianny Volcano supplies material to the Earth surface about every half a year. Eruptions of 2000, 2006 and 2007 were selected to determine the magma ascent conditions as the most typical for the last activity cycle.
The problem is considered both in equilibrium and non-equilibrium formulations. In the case of equilibrium the diffusion rate is assumed to be infinity. The inverse problem of determining of the pressure and the liquidus temperature changes for known anorhite profile across the rim is solved. The system temperature was calculated independently according to the assumption of the crystallization latent heat release. Result of simulations show that the temperature changes are overestimated by equilibrium formulations and growth of plagioclase is far from equilibrium.
In the non-equilibrium case the influence of initial conditions, the crystal growth rate, the ratio between anorthite and albite diffusion coefficients and ascent conditions on the crystallization process is investigated. The ascent conditions of magma for Bezymianny Volcano eruptions were reconstructed. Simulations suggest ascent from a pressure of about 100 MPa to atmospheric during 15-20 days. That for known discharge rate helps to estimate conduit cross-section area.