Modeling of oscillatory zoning of plagioclase: A relation between condition of the crystal surface and the growth velocity

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Although the oscillatory zoning (OZ) of magmatic plagioclase has been mathematically studied, the origin still remains unsolved. In order to understand the origin of OZ, we need to quantitatively clarify the factors controlling characteristics of OZ such as amplitude and wavelength. In this paper we propose a model for the formation of OZ and give an insight into the controlling factors.

We build upon the qualitative model proposed by Sibley et al. (1976), in which coupling between crystal growth and diffusion plays an important role. In the model presented here, we assume that the growth velocity drastically changes depending on the roughness of crystal surfaces. We include the transition between rough and smooth states of crystal surfaces into the formulation of the crystal growth problem. From a simple geometrical model of crystal surface we found that the growth velocity varies by twice due to the transition of crystal surfaces. Based on this result, we simulate the oscillatory growth of plagioclase crystal by numerically solving the diffusion equation coupled with the crystal growth kinetics. As a result, we obtain the amplitude and the wavelength of compositional oscillations as functions of degree of supersaturation. The ranges of calculated characteristics agree with those of natural plagioclases, in which the amplitudes take values of 1 to 10 mol.% as anorthite mole fraction and the wavelengths of 1 to 10 microns (Pearce and Kolisnik, 1990).