Positive correlation between crystal size and chemical composition of core; numerical simulation of the crystallization of plagioclase

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The plagioclase microlite sometimes show positive correlation between their size and chemical composition of core as shown by some studies (e.g. Noguchi et al., 2006, 2008). We analyze crystal size and An# (Ca / Ca + Na) of plagioclase microlites witch were ejected by Shinmoe-dake 2011 eruption. Crystal size is positively correlated with An#. An# of microlites range in 0.65 – 0.57, for the smallest size (10 μm) and increase with size converging to 0.65 for the largest size. They are distributed within upper and lower bounds. This correlation can be explain the continuous nucleation and growth process including the evolution of melt composition, namely high and low An# evolution series.

In order to quantitatively interpret this correlation, we develop a simple model. We assume that growing surfaces of nucleated crystals are in local equilibrium with adjacent melt in their compositions, namely the effective partial coefficient is defined. We calculate An# with software package Rhyolite-MELTS (Gualda et al., 2012). We denote the rate of nucleation and crystal growth, as J [$m^{-3}s^{-1}$] and G [ms^{-1}] respectively. In the case that rate of crystallizing change P is constant, if we set J as constant, G is automatically calculated, because G depends on the total crystal surface area S and P = SG. In our calculation, G is decrease with time, because surface area is increasing. Crystals that nucleate at earlier stage grow by large G. We calculate final crystal size distribution and An# with as a varying parameter J.

The correlation between crystal size and An# become tight with increasing J, and round with decreasing J. When J is high, crystals mostly crystallize at early stage and later growth is few. When J is low, crystals grow later stage. High An# evolution series can be explain cooled at high J, and low An# evolution series can be explain cooled at low J condition. As a result of simulation, it is found that a relatively higher value of J and vice versa, corresponds to low An# evolution series in size vs. An# trends.