Computer simulation of reaction-limited Ostwald ripening in magmatic systems: effect of ripening on crystal size

Sanghyun Park, Hyung Shik Kim & Youngdo Park
Dept of Earth & Environmental Sciences, Korea University, Seoul, Korea 163-701

We have studied the effect of Ostwald ripening on the crystal size distribution (CSD) of igneous rocks using numerical computer simulation. In the computer simulation it is assumed that 1) single species of crystals are present in the system, 2) the crystals are spherical in shape, 3) temperature and composition of magma are fixed and 4) Ostwald ripening is rate-limited by reaction. The simualtion of crystal growth and dissolution by Ostwald ripening involves the following steps. 1) The mean size of all crystals in the system is calculated. 2) The crystals smaller than the mean size are selected, and dissolved by amount calculated by the Gibbs-Thompson equation. 3) the total mass dissolved in the step 2) is added to crystals bigger than the mean size. The algorithm of Ostwald ripening is checked with the steady-state CSD patterns. The normalized CSDs remain constant (i.e. steady-state), and the linear relation exists between the square of mean crystal radii and the time during testing simulation. The steady-state of CSD and linear power-law relation accord with the theory of Ostwald ripening well.

With the verified algorithm of Ostwald ripening, simultaneous crystallization and Ostwald ripening are performed under the following assumptions; 1) The nucleation rate used in simulation is calculated from published CSD study, 2) The growth rate is size-independent. When the residence time is short, the number of very small sized crystals are larger than what expected by the CSD theory increases because dissolution of small crystals by ripening inhibit the growth effect. With long residence time, however, tiny newly-crystallized crystals can not survive after some unit time steps. Therefore, The resulting CSDs show absence of small crystals. Also the additional simulations of Ostwald ripening effect of post-crystallization explain that the lack of small crystals in published studies is caused by Ostwald ripening after crystallization.

Although this simulation have many assumptions, it is possible to estimate the residence time and cooling rate of natural magmatic systems if the simulation is with real data for ripening kinetics.