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Experimental study of CSDs of clinopyroxene produced at the temperature oscillations around liquidus

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Crystallization of clino-pyroxene from the melt of Ab55Di45 composition at P=2 kbar and water content 3.3 wt.% was studied. Experiments with constant undercooling and oscillating temperature were performed. Oscillations (totally 1-8) have rectangular shape (in T-t space) with period in the range 4 min- 3 hours. Temperature varied between 1155 and 1135C (+5 above and 15 below Cpx liquidus temperature, respectively). At the quenching stage of experiments significant part of crystallization had place. All runs products have homogeneous stochastic spatial texture and were characterized by Cpx Crystal Size Distributions (CSDs). We separate quenching tails of CSDs based on the quantitative analysis of distributions.
We find that the time of the dissolution of the largest crystal (t1) is a main controlling parameter. This diffusion defined time was estimated to be 15-20 min for crystal radius 5 mkm based on the published experimental data for diffusion. In the experiments with half-period w1/2 < t1 in the hot stage partial dissolution of crystals occurred while in the cold half-period dissolved material is reprecipitated. At this regime initially exponential CSD were ripening with reducing number of crystals and increase of their sizes as predicted in the theoretical model (Simakin and Bindeman, 2008).
Second controlling parameter is time of relaxation of the subcritical clusters to the equilibrium state corresponding to the applied weak superheating (t2). In the experiments with half-period satisfying the condition t1 < w1/2 < t1+t2 in the hot stage all crystals dissolve, however excessive clusters survive thus facilitating fast homogeneous nucleation of Cpx in the cold half-period. In this regime the largest crystals were synthesized. These crystals are characterized by up to 16-18 mkm core width (45-50 mkm full width with quenching rims). In the experiment with w1/2 > t1+ t2 pure glass was formed at the quenching after two oscillations. High superheating to 1200C even for 2 minutes was sufficient to inhibit homogeneous nucleation in the melt exposed to DT=150 for 5 hours.

We propose quantitative model for extraction of the kinetic data from the observed CSDs. Basic idea is to track back in time CSD and use it in the calculation of the supersaturation, growth and nucleation rates. Growth rate equation with one free parameter (accounting for variable viscosity and supersaturation) was calibrated at the consideration of the quenching tail of the run with known thermal history satisfying certain criteria. Variations of the growth and nucleation rates in experiments were calculated and successfully compared with published data.
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References.
Simakin AG and Bindeman I. (2008) Evolution of crystal sizes in the series of dissolution and precipitation events in open magma systems. JVGR 177 (4), 997-1010.