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Experimental study of plagioclase rim growth around anorthite seed crystals in rhyodacitic melt

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ABSTRACT

The purpose of this study was to replicate experimentally the growth of new rims around highly anorthitic plagioclase "core" phenocrysts, analogous to the incorporation of xenocrysts into a silicic magma body through magma mixing. Aniakchak rhyodacite forms the bulk starting composition, and phase-equilibria experiments constrained the pre-eruption magma conditions to be ~110 MPa and 870–880 °C. The experimental runs were seeded with Great Sitkin anorthite (An_{91-95}) crystals. New rim growth of An_{28-38} plagioclase occurred at rates between 3.5 (±0.3) × 10^{-10} to 60.6 (±20.0) × 10^{-10} cm/s at pressures and temperatures from 50 to 150 MPa and 825 to 880 °C. The values in parentheses are ±1σ standard deviation. Microlite crystallization (An_{27-41}) occurred in all experiments within the plagioclase stability field, and their growth rates varied from 4.4 (±1.3) × 10^{-10} to 65.7 (±10.1) × 10^{-10} cm/s. The rim and microlite growth rates are similar to one another within each experiment, and microlite number density (N_V) is correlated approximately inversely with rim growth rates. Microlite crystallinities increased from 4.2 to 49.7 vol% as a function of increasing ΔT_{eff} up to 95 °C. The results indicate growth-dominated crystallization at low ΔT_{eff}, and nucleation dominated crystallization at high ΔT_{eff}, in agreement with previous studies. Assuming the experiments apply to nature, the rim growth rates can provide a minimum estimate on how fast magma mixing can occur. Rims that are 10 to 100 μm wide can grow in ~10 days to 4 months, recording fast mixing timescales as long as eruption occurs shortly after mixing. The growth rate estimates presented here generally agree with those derived from sodic rims growing around anorthite cores after mixing between basalt and andesite prior to the 1996 eruption of Karymsky volcano, Kamchatka.