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Reaction rim growth on olivine in silicic melts: Implications for magma mixing

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ABSTRACT

Finely crystalline amphibole or pyroxene rims that form during reaction between silicic host melt and cognate olivine xenocrysts, newly introduced during magma mixing events, can provide information about the timing between mixing and volcanic eruptions. We investigated rim growth experimentally by placing forsteritic olivine in rhyolitic and rhyodacitic melts for times between 25 and 622 h at 50 and 150 MPa, H_2O-saturated, at the Ni-NiO buffer. Rims of orthopyroxene microlites formed from high-silica rhyolite and rhyodacite melts at 885 ˚C and 50 MPa, and in the rhyolite at 150 MPa and 885 ˚C. Rims of amphibole with lesser orthopyroxene formed in the rhyolite at 150 MPa and 800 ˚C and in the rhyodacite at 150 MPa and 885 ˚C. Irregular, convolute olivine edges and mass balance between olivine, melt, and rim phases show that olivine partly dissolved at all conditions. Iron-rich zones at the exteriors of olivines, which increased in width parabolically with time, show that Fe-Mg interdiffusion occurring in olivines was not outpaced by olivine dissolution. Linear increases of the square of rim widths with time suggest that diffusion within the melt is the rate-controlling process for olivine dissolution and rim growth. Rims grew one-half to one order-of-magnitude faster when melt water contents were doubled, unless conditions were far above the liquidus. Rim growth rate in rhyolite increases from 0.055 ± 0.01 μm^2/h at 885 ˚C and 50 MPa to 0.64 ± 0.13 μm^2/h at 800 ˚C and 150 MPa. Melt composition has a lesser effect on rim growth rates, with growth rate increasing as melt SiO_2 content decreases. Pyroxene rims on olivines in andesite erupted from Arenal volcano (Costa Rica) grew at a rate of 3.0 ± 0.2 μm^2/h over an eleven-year period. This rate is faster than those of the experiments due to lower melt viscosity and higher temperatures, and suggests that a magma mixing event preceded the start of the eruption by days.