

Eruption dynamics of high silica rhyolites inferred from pyroxene and feldspar microlites

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The eruption dynamics of magmas can be linked to the microlite textures and assemblages found in the eruptive products. Previous studies have successfully related natural microlite textures with those generated by decompression experiments, thus constraining ascent rates. But, those studies have focused on feldspar microlites, which are not always present in high silica rhyolites. In fact, Fe-Ti oxides and pyroxene are more common in most high silica rhyolites. We identify microlite phases and quantify microlite number density (MND) in samples from 10 Central Plateau Member Rhyolites from the Yellowstone caldera. Those flows comprise a suite of ~20 high silica rhyolite lavas that erupted from 170-70 ka. Eruption volumes of individual units range from 0.01-70 km³, and maximum flow distances range from 0.13-22 km. Phenocryst compositions, phase equilibria experiments, and geothermometry indicate similar storage conditions for all of the flows. Thus, differences in microlite assemblages and textures are likely to have been caused by variations in eruption dynamics. Fe-Ti oxides are the principal microlite phase in all samples. They are morphologically consistent in all samples, occurring as roughly equant crystals, 1-10 μm across, as well as high-aspect-ratio needles, 3-40 μm long. Fe-Ti oxide MND ranges from 10^{8.1}-10^{9.4} cm⁻³. Pyroxene is the second most common phase, occurring in 8 of the 10 flows we examined. Pyroxene occurs as overgrowths on Fe-Ti oxides and as prismatic crystals. When present, pyroxene MND varies from 10^{7.3}-10^{8.7} cm⁻³. Feldspar microlites were identified in only 2 of the 10 flows. They occur as individual high-aspect-ratio prisms, 5-20 μm long, often with swallowtail extensions. Hopper and skeletal forms were not observed. Feldspar MND range from 10^{5.9}-10^{8.1} cm⁻³. Feldspar microlites only occur in samples that also contain pyroxene. The average total MND of individual flows varies from 10^{8.1}-10^{9.5} cm⁻³. Thicker flows and those with longer flow lengths have the highest number densities, but the relationship between microlites and flow characteristics is seldom straightforward. For example, there is no correlation between eruptive volume and microlite assemblage. In addition, variations of MND from different portions within individual flows may exceed an order of magnitude, whereas others are steady. The variability of assemblages and MND within all of the flows and across individual flows implies eruption dynamics were also variable. Toramaru et al. (2008) developed a model that links MND to decompression rate. According to that model the flows studied here were fed by magmas that underwent decompression rates of 0.02 to 0.2 MPa/hr. At such slow rates, all of the lavas should contain feldspar microlites according to previous experimental work. In contrast, most of the flows do not have feldspar, suggesting the model is not yet calibrated for high silica rhyolites. Furthermore, all previous experimental work was calibrated for feldspar microlites. Our dataset suggests that pyroxene, rather than feldspar, may be the most sensitive indicator of eruption dynamics in high silica rhyolites. We have designed a set of decompression experiments to target the nucleation and growth of pyroxene microlites. When completed, those experiments will allow us to place quantitative constraints on the eruption dynamics of high silica rhyolite lavas.

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