

EVOLUTION OF SILICIC MAGMAS IN THE UPPER CRUST:
AN EXPERIMENTAL ANALOG

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The evolution of silicic magmas in the upper crust is characterized by the establishment of chemical and thermal gradients in the upper portions of magma chambers. Chemical and fluid dynamic models indicate that cooling of a silicic magma body from the top and sides can result in formation of a chemically and thermally stratified, as well as highly fractionated and water-rich roof zone above a convecting region. Crystallization experiments with Na_2CO_3 solutions were performed in a 40 x 30 x 10 cm plexiglas tank. Top and side cooling of a homogeneous Na_2CO_3 solution results in crystallization along the top and sides and upward convection of bouyant Na_2CO_3 -depleted fluid. A stably stratified roof zone, which is increasingly water-rich and cooler upwards, develops over a thermally and chemically homogeneous convecting region. Crystallization at the top ultimately ceases, and continued upward convection of water-rich fluid causes slight undersaturation adjacent to the roof despite cooler temperatures.

By analogy, crystallization at the margins of a magma chamber and bouyant rise of the fractionated boundary layer into the roof zone can account for the chemical evolution of the magma system at Twin Peaks, Utah. The chemical changes during the development of the zoned rhyolite magma at Twin Peaks can be modeled exactly for all major elements and closely for most trace elements by the crystallization of quartz (17.8%), sanidine, (40.5%), plagioclase (10.1%), orthopyroxene (-0.5%), clinopyroxene (4.9%), magnetite (2.2%), and ilmenite (0.1%). Liquid-state differentiation may be important for certain trace elements such as REE whose distribution cannot be accomodated by crystal-liquid equilibria. Because of the low diffusivity of ions in silicic melts, diffusive regime convection, rather than stable gradients, is to be expected in silicic magmas; this could substantially facilitate liquid-state differentiation.