Caldera resurgence during magma replenishment and rejuvenation at Valles and Lake City calderas

Ben M Kennedy[1], John Stix[2], Jack Wilcock[2]

[1]University of Canterbury, New Zealand, [2]McGill Uiversity, Canada

E-mail: ben.kennedy@canterbury.ac.nz

A key question in volcanology is the driving mechanisms of resurgence at active, recently active, and ancient calderas. Valles caldera in New Mexico and Lake City caldera in Colorado are well-studied resurgent structures which provide three crucial clues for understanding the resurgence process. (1) Within the limits of $^{40}Ar/^{39}Ar$ dating techniques, resurgence and hydrothermal alteration at both calderas occurred very quickly after the caldera-forming eruptions (tens of thousands of years or less). (2) Immediately before and during resurgence, dacite magma was intruded and/or erupted into each system; this magma is chemically distinct from rhyolite magma which was resident in each system. (3) At least 1 km of structural uplift occurred along regional and subsidence faults which was closely associated with shallow intrusions or lava domes of dacite magma. These observations demonstrate that resurgence at these two volcanoes is temporally linked to caldera subsidence, with the upward migration of dacite magma as the driver of resurgence. Recharge of dacite magma occurs as a response to loss of lithostatic load during the caldera-forming eruption. Flow of dacite into the shallow magmatic system is facilitated by regional fault systems which provide pathways for magma ascent. Once the dacite enters the system, it is able to heat, remobilize, and mingle with residual crystal-rich rhyolite remaining in the shallow magma chamber. Dacite and remobilized rhyolite rise buoyantly to form laccoliths by lifting the chamber roof and producing surface resurgent uplift. The resurgent deformation caused by magma ascent fractures the chamber roof, increasing its structural permeability and allowing both rhyolite and dacite magmas to intrude and/or erupt together. This sequence of events also promotes the development of magmatic-hydrothermal systems and ore deposits. Injection of dacite magma into the shallow rhyolite magma chamber provides a source of heat and magmatic volatiles, while resurgent deformation and fracturing increase the permeability of the system. These changes allow magmatic volatiles to rise and meteoric fluids to percolate downward, favoring the development of hydrothermal convection cells which are driven by hot magma. The end result is a vigorous hydrothermal system which is driven by magma recharge.