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Factors controlling volcano-dynamic of large active calderas

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Calderas have been much studied during the last century since they are generally the result of large and catastrophic ignimbrites eruptions with high related volcanic risk.
A fundamental difference between large calderas and central volcanoes is represented by their thermal state; active calderas are commonly “hotter” than central volcanoes. Large calderas are generally associated with crustal extensional regions. Extension is normally correlated with the crust thinning, producing passive upwelling of hot asthenosphere with block faulting and subsidence. Both the upwelling of asthenosphere and the extensional regime promote the conditions for large volume magma storage at shallower levels (5-10 km). For these reasons thermal state of large active calderas is commonly characterised by high geothermal gradients and migration of brittle-ductile transition towards the surface. Hydrothermal activity can accompany the magmatism, becoming dominant late during caldera evolution and maintaining a quite-steady high thermal state of the shallow permeable rocks. When the crust is subjected to the stress (due to magma pressure) and high temperature, viscoelastic processes become dominant in respect to the elastic one. In this case viscous flow is enhanced and fracturing processes are inhibited, thus dike injection and eruptions are improbable.
Keeping constant other parameters, such as magma volume and magma feeding rate, the possibility of eruption or magma storage is controlled by the thermal state and thus viscosity of wall rocks, the higher is the temperature the lower is the viscosity. When high viscosity wall rocks are subjected to magma pressure, rock failure and magma injection (eruption) are enhanced. The above assertion can be generalised as: “rocks beneath colder active volcanoes can be fractured more frequently than those beneath hotter active calderas” and, as actually occur, central volcanoes can erupt more frequently. This is true for active volcano erupted during the last century like Unzen (Japan) and Vesuvius (Italy). In fact, unexpected low temperature were recorded within deep wells of Unzen (50-60°C/km) and Vesuvius (30°C/km). On the contrary high temperature have been recorded in calderas which erupted large volume of magma thousand of years ago, like Campi Flegrei caldera, Italy (150°C/km) and Long Valley caldera, CA USA (100°C/km). Furthermore, after large ignimbrite eruptions forming caldera, the VEI (Volcanic Explosive Index) of the subsequent eruptions within caldera decreases (from moderate to small), while their frequency increases. It is know that this behaviour is correlated with different processes such as progressive cooling of large magma chamber, reduction of eruptible volume, increasing of gas content and pressure, decreasing of wall rocks temperature and increasing viscosity. Eruptions are rather controlled by the tectonic regime of the area, magma rate influx and temperature/viscosity of wall rocks. We highlight that tectonic extension and temperature/viscosity of wall rocks play a fundamental role in caldera eruption and/or magma storage. An example is applied to the Campi Flegrei caldera (Southern Italy).