

Residence times of silicic magmas associated with calderas

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In the last two decades there has been a large wealth of geochronological information produced at caldera related volcanic systems. This contribution explores what systematics can be extracted from it and how the magma residence times may be related to other parameters such as cooling times of igneous bodies, or process durations determined from chemical zoning in crystals and diffusion models. Magma residence times are obtained from the difference between the eruption age and the age obtained by radioactive clocks and phases that may be a closed system at high magmatic temperatures (*e.g.*, U-Pb system in zircon).

Large ranges of residence times between different systems are found. The shortest are those of Oruanui and Rotoiti magmas (Taupo Volcanic Zone) with 4 ky and 9 ky of residence, respectively, followed by the Dry Creek (7 ky) and Lava Creek (19 ky) Yellowstone magmas. There is not a good correlation between magma volume and residence time, although most eruptions $< 10 \text{ km}^3$ have residence times $< 100 \text{ ky}$, and those $> 100 \text{ km}^3$ have residence times of up to ca. 400 ky (Fish Canyon Tuff). The residence times of some small ($< 10 \text{ km}^3$) pre-and post-caldera magmas reflect that they are batches extracted from the same caldera-forming reservoir because they fall on the same time evolution line (*e.g.*, Long Valley, Taupo). In contrast, the residence times of other small volume magmas may be the result of crystals being recycled from previous cycles of caldera-forming magmas (Yellowstone), or from plutonic rocks of the same caldera cycle with or without erupted equivalent on the surface (Crater Lake, Taupo, Long Valley) or even from not completely solidified caldera-forming magma reservoir (Taupo). These interpretations are in agreement with cooling rates and solidification times obtained from simple thermal models of magma reservoirs. Magma production rates were calculated from the ratio of erupted volume and residence time, and they vary between $< 0.001 \text{ km}^3 \text{ y}^{-1}$ for small deposits ($< 10 \text{ km}^3$) to ca. $0.1 \text{ km}^3 \text{ y}^{-1}$ for the Oruanui eruption (530 km^3). Estimates for most eruptions $> 500 \text{ km}^3$ are within $2 \pm 2 * 10^{-2} \text{ km}^3 \text{ y}^{-1}$, values that are comparable to global eruptive fluxes from basalts (*e.g.*, Hawaii). Most residence times are of several thousand years or more, which is much longer than the durations of processes obtained from the reequilibration of chemical gradients in minerals, which are more on the order a few hundred years. This difference may be explained by considering that the residence times could record the entire history of the system whereas some of the diffusion data only the last event that leads to the eruption.

Petrology and phase equilibria of Ti-andradite and titanite in alkaline ultramafic rocks of the Tamazeght complex, Morocco

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The elliptical ($5 \times 15 \text{ km}$) Tamazeght (syn. Tamazert) alkaline igneous complex (High Atlas Mountains, Morocco) was emplaced during the middle Eocene and intrudes Jurassic to Cretaceous limestone. It comprises numerous intrusive phases that document a progression from ultramafic to felsic magmatism. A wide range of lithologies are present, including ultramafic rocks, shonkinites, gabbroic to monzonitic phases, and feldspathoidal syenites, which predominate. Moreover, carbonatites and lamprophyres occur as diatremes and dykes.

This study focuses on the petrology, paragenesis and phase equilibria of the ultramafic lithologies (pyroxenite and glimmerite). Pyroxenite is dominated by cumulus clinopyroxene (aluminous diopside) and garnet, with the latter locally rimmed by mica (phlogopite) and/or titanite. Olivine, nepheline, apatite and interstitial calcite are minor phases. In glimmerite, large poikilitic mica predominates ($\leq 65 \%$), along with minor cumulus pyroxene-I (Al-rich), garnet, perovskite (rimmed by titanite), Fe-sulphides and apatite. Occellar textures, consisting of clinopyroxene-II (Al-poor), calcite and mica, occur throughout. Garnet occurring in the ultramafic rocks have TiO_2 contents of between 5 and 11 wt. %. It is therefore Ti-andradite. Where present in some of the more evolved units (*e.g.*, syenites) garnet occurs only as an accessory phase and TiO_2 concentrations are uniformly lower (around 4 wt. %).

Here we present petrological, electron probe and LA-ICP-MS data, and will focus on the paragenesis, phase equilibria and stability relations between the phases present in order to track the evolution of intrinsic parameters (such as T , $a(\text{SiO}_2)$, $f(\text{O}_2)$) during the formation of these rocks.