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Generation of large magma reservoirs in the upper crust and their ability to differentiate

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Models of large-scale magma differentiation and/or magma mixing in the upper crust require the presence of large-volume magma reservoirs at shallow crustal levels. Most shallow magma bodies grow through the incremental emplacement of discrete sheets of melt. However, long-term average emplacement rates of plutons are too low to create large magma chambers because successive sheets will solidify before the emplacement of the next sheet. Emplacement rates that are at least one order of magnitude higher than the average emplacement rates of plutons are necessary to accumulate large volumes of magma that are hot and hence molten enough for processes of fractional crystallization or magma mixing.
Numerical simulations show that sizable crustal magma chambers can be generated in periods of higher magma fluxes although the long-term average emplacement rate is low. The models involve conductive heat transfer between repeated sheet intrusions and the country rock as well as heat production from radioactive decay and phase changes. Different modes of emplacement rate fluctuations for a given intrusive volume are simulated by varying the time interval between subsequent injections. Regarding the whole duration of the model run, the long-term average emplacement rate is the same for the different modes of emplacement rate fluctuations that are simulated. Results show that the mode of emplacement of successive intrusion sheets is crucial to form high amounts of mobile magma. Up to 20% more mobile magma is generated with an intrusion mode where the time interval between consecutive sheets decreases during the duration of the simulation compared to a mode where the inter-sheets time interval is held constant. Consistently, a higher average emplacement rate is needed to build a magma chamber of a given size when the time interval between subsequently intruded sheets increases with time.
The modeling results also give insight into the ratio of eruptive to intrusive rocks and suggest that this ratio is small when the time interval between injections of magma decreases during the whole emplacement period of the magma. This implies that the emplacement interval is the controlling factor for the construction of large magma chambers and plutons and that average intrusion rates can be smaller than previously thought to create large magma reservoirs.
Substantial magma chambers with magma hot enough and above solidus that differentiation processes can occur only build up during periods when magma fluxes are significantly above the long-term average emplacement rate. The fact that magma fluxes do not stay constant but may in fact vary with time over several orders of magnitude needs to be considered in the discussion about the relationship between plutonism and volcanism.