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Physical constraints of the evolution of felsic magma chambers: implications for the evolution of granite magmas

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Igneous petrologist working on mafic magmas generally agree that magmas are stored and frac-tionated in crustal reservoirs called magma chambers. The current fashion among granite petrologist, on the other hand, is to minimize the importance of such reservoirs assuming that the huge granite bodies found in many crustal segments grew incrementally, due to the sequential addition of small magma batches. This idea is mostly based on the existence of cryptic contacts and isotope heterogenities inside a single pluton. However, these features can be as well explained by the crystallization dynamics of a viscous magma filling a km sized magma chamber, which is additionally consistent with field evidence. Magma chambers are transient structures that change by loosing and replenishment of magma and volatiles, that but also evolve as a whole due to the crystallization dynamics induced by cooling. The evolution of a given magma chamber depends on the ratios between (1) the rates of magma extraction/replenishment and (2) heat loss. To understand the complexity of magma chamber evolution, here we studied the evolution of an isolated magma chamber (no extraction/replenishment) during cooling, by coupling an internally consistent rheological dataset with the laws of fluids dynamics and heat transfer. Without regional stress, the evolution of the magma is dominated by top-down convection due to negative density gradient in the upper part of the body caused by crystallization. If the melt density is so low that permits fast melt-crystal segregation, the above-described mechanism is inhibited, and melt diapirs formed in the lower crystallizing zone can detach and ascend through the magma chamber producing so differentiation. Convective heat-loss leads most of the magma chamber to critical crystallinity in a few thousands years, which stops all magmatic dynamics except residual melt extraction due either to gravity-driven compaction, which produces short-range differentiation series. The situation is complicated if the chamber crystallizes during regional deformation. In this case, no significant fractionation occurs until the critical crystallinity is reached, when the residual melt can be efficiently segregated by filter pressing caused by differential stress leading so to long-range differentiation series