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The stability and spacing of crustal magma chambers

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The development of discrete volcanic centers reflects a focusing of magma ascending from the source region to the surface. We suggest that this organization occurs via mechanical interactions between the magma chamber, volcanic edifice and dikes, and that the stresses generated by these features may localize crustal magma transport before the first eruption occurs. We develop a model for the focusing or "lensing" of rising dikes by magma chambers, and show that it dominates focusing by volcanic edifices in most cases. We then test the stability of chambers that grow through dike lensing, by dynamically simulating the thermal evolution of basaltic composition magma chambers in country rock composed of either tonalite or amphibolite, as end member proxies for arc and continental crustal magma chambers. These simulations allow us to map out the parameter space in which magma chambers erupt, freeze out, or exist stably in a geothermal gradient, as well as the averaged bulk melt fraction and degree of country rock assimilation in each scenario. We find that for reasonable lower crustal melt flux ($10^{-4} - 10^{-2} m^3/m^2/yr$) there is a regime of stable magma chambers, as well as the possibility for rapid but stable chamber growth. This model suggests a general framework for the formation of volcanic centers and for the incremental growth of large crustal intrusions.