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Transition to chaos and implications for time-scales of magma hybridization during mixing processes in magma chamber

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In this contribution numerical simulations of magma mixing are performed with the aim to understand the physico-chemical conditions triggering the development of chaotic mixing dynamics.
The mixing process is simulated in a magma chamber where a less evolved magma underplates a more evolved magma and the 'chaoticity' of the system is quantitatively estimated calculating the finite-time Lyapunov exponents. It is shown that magma chambers dynamics are strongly controlled by the Rayleigh number (Ra), whereas other parameters, such as buoyancy ratio and viscosity contrast, play a subordinate role.
Results indicate that magma chambers with Ra of the order of 10^6 are dominated by non-chaotic behaviour. Increasing Ra shifts the system towards an increasing chaotic state and, in particular, above Ra=10^7 chaotic dynamics are fully developed in the magma chamber. It is also shown that chaotic dynamics may characterise most magma chambers subjected to the constraints of the proposed model in both plutonic and volcanic environment.
Estimates of possible time-scales of hybridization of magmas during chaotic mixing are also performed. It is shown that large degrees of hybridization can be rapidly achieved possibly generating large volumes of hybrid magmas in time-scales much shorter than possible life-times of magma chambers.