Numerical modeling of granitic intrusion mechanisms

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The idea of generation of granitic magma by partial melting of lower crust due to temperature anomalies is well accepted. These anomalies can be caused either by intrusions of mantle-derived magmas or by underplating of the lower crust by hot asthenospheric material. However, it is still not clear which physical mechanisms are responsible for this magma to rise and form intrusions in the middle and upper crust.

In order to understand magma ascent and emplacement processes we used a 2D Cartesian, visco-elasto-plastic, finite difference numerical model (code I2ELVIS) with a length of 1100km and a depth of 200km. The model is self-consistent and includes source regions for both crustal and mantle magmas.
We assume a magma reservoir of mafic magma in the sub-lithospheric mantle which is connected with the bottom of the lower crust by a pre-defined vertical magmatic channel. Starting with a positive temperature-anomaly in the lower crust we study the ascent and emplacement of granitic magma in the upper crust. Results of numerical experiments suggest that crustal magma rising is triggered by a spontaneous income of overpressurized mafic magma from the sublithospheric source into the region of the crustal temperature anomaly. Depending on the rheological properties of the crust, the amount and temperature of the lower crustal magma it either erupts to the surface or intrudes into the upper crust. Magma chambers of different size and shape develop in the upper and lower crust.

In a next step we plan to implement more realistic properties of the magmas, in particular a temperature-pressure-composition-dependent rheology and include processes like degassing of the magma due to lower pressure at shallower depth. Degassing and cooling of the magma chamber will be studied at high resolution on a magma chamber scale.