Density control on formation of crustal magma storage system

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Magma reservoirs probably grow by repeated sill-like intrusions. We investigate the conditions for repeated crustal intrusions at the same depth by a feeder dike before a permanent molten reservoir can form. Sill formation requires that magma within a dike develops an overpressure large enough to overcome the strength of surrounding rocks. An efficient mechanism to achieve this involves ascent through layers with decreasing density, such that magma becomes negatively buoyant above some structural interface. To significantly affect dike ascent, the density change in country rock must occur over a thickness of the order of the length-scale for the inflated nose region that develops below the dike tip. This characteristic length depends on the elastic properties of the host rocks, on magma buoyancy and on the flux of magma. It is usually around 1 km for basaltic magmas, comparable to the typical thickness of sedimentary strata and volcanic deposits. The overpressure that develops at the density inversion level is determined by the vertical extent of the inflated dike nose region above that level, and hence is related to the volume of magma in that region. Thus, sill formation also requires that the total volume of magma available in an individual intrusion event exceeds a threshold value.

Pressure variations in metamorphic rocks: Implications for the interpretation of petrographic observations

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During mineral reaction, the overall mechanical state of a rock is very important. Rock strength may control the reaction progress from 0 to 100% which may result in the development of stress, and therefore pressure, variation on all scales. Hence, considering the interplay of metamorphic reaction and mechanical properties is critical for correctly interpreting microstructural observations in metamorphic rocks and correct quantification of the processes.

Stresses that develop during deformation of geologic materials can be responsible for the formation and preservation of GPa-level pressure variations. Considering that the typical value of the lithostatic pressure at the base of the continental crust is ~1 GPa, GPa-level variations make the interpretation of depth from pressure problematic for crustal metamorphic rocks. Such pressure perturbations are more apparent on a small scale (nm to mm), where, in some cases, they can be directly measured by spectroscopic methods. However, the non lithostatic pressure variations can also be relevant to larger (crustal) scales. Schmalholz and Podladchikov [1] have recently shown that even when rocks are deformed in a "weak" crustal- scale shear zone, force balance across the shear zone requires that pressure will not be smoothly varying with depth but it will be paradoxically higher within the shear zone.

The recent microstructural observations and mechanical models question our current quantification approach in metamorphic petrology based on the lithostatic assumption. The recent data have therefore opened horizons for new approaches and new physically rigorous and geologically realistic interpretations of our petrographic observations. Such approaches would contribute to our better understanding the processes in the Earth interior.

[1] Schmalholz & Podladchikov (2013), *Geophys. Res. Let.*, 10.1002/grl.50417

DOI:10.1180/minmag.2013.077.5.20