Millennial storage of near-Moho magma

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It has recently been shown that storage timescales in shallow silicic systems can be 10^3-10^5 years [1], either in near-solidus conditions of so-called cold storage [1-2] or in an eruptible high melt-fraction state [3]. In contrast, little is known about storage times in the mafic systems that dominate magmatism at mid-ocean ridges, ocean islands and in the deeper part of arc volcanoes. Observations of U-series disequilibria in basalts and their crystals indicate that their total crustal storage times cannot exceed several thousand years. However, making the link between these timescales and specific portions of the magmatic history has proved challenging. Direct storage times in the lower crust have been notoriously difficult to estimate by diffusion chronometry as shallow and mid-crustal processing act to obscure lower crustal signals through crystal re-equilibration and resorption. Here we provide the first direct estimate of magma residence times in the lower crust, and for basaltic mushes in general, by studying ultramafic nodules found in a primitive Icelandic basalt from Borgarhraun, which underwent crystallisation near the Moho. Thermodynamic modelling suggests that spinels encased in clinopyroxene began to re-equilibrate with local melt pockets during cooling in the mush environment. We combine 2D finite-element models of Cr-Al exchange in spinels with a nested sampling Bayesian inversion to estimate the storage time associated with this re-equilibration. Of the 7 spinel crystals modelled at 1215 °C, the median time was 1418 years, with 95% of retrieved timescales being less than 4092 years. In each tectonic setting, punctuated magma storage and rapid transport is likely a prominent feature, meaning that packets of magma fresh from the mantle melting region could take thousands of years to traverse the crust, but with storage accommodating most of that time.

References

[1] Cooper and Kent, 2014
[2] Rubin et al., 2017
[3] Barboni et al., 2016