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First data on magma ascent and residence times retrieved from Fe-Mg and trace element zonation in olivine phenocrysts from Kamchatka basalts

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Compositional zonation in olivine phenocrysts and diffusion modelling have been used in the last ten years to estimate magma residence times and the duration of magma ascent. The fundamental assumption is that mixing with newly injected magma into a reservoir triggers diffusional exchange between mafic olivine crystals and more evolved magma and that this magma mixing eventually triggers eruption. If depth of mixing is known, this translates to ascent rates of magmas to the surface. We applied this approach to a series of different arc basalt lavas from Kamchatka to constrain the rates of magma ascent and magma resident in what is one of the most active subduction zones in the world that is also dominated by an abundance of unusually mafic magmas. Our sample collection cover the principal modes of arc magmatism in Kamchatka: from different volcanic complexes (strato-volcano, dikes, summit eruptions, monogenetic cones), of different age (from Late-Pleistocene to Holocene and recent eruptions), from different magmatic regimes (long-lived volcanoes vs. monogenetic eruptions) and different major element composition (from basalt to basaltic andesite of different geochemical character including LILE enrichments). We analyzed and modelled zonation profiles for a range of elements with different diffusivities (e.g. Mg-Fe, Ca, Ni, Mn, Cr) to assess the role of variable diffusivities as a function of major and trace elements in the olivines from different P-T conditions. First data were obtained on samples from the Klyuchevskoy, Shiveluch and Tolbachik, including recent most eruption in 2012/2013. These data show that for some samples the zonation patterns are much more complex than is usually observed: high-Mg olivines at different volcanoes have very different zonation patterns, including normally, reversely zoned grains or even show highly complex repetitive zonation that indicate large compositional changes in the surrounding magma at very short time scales (years). Thus in some Kamchatka basalts, we observe unusual Mg-Fe zonations that are linked to complex mixing, possibly resorption and subsequent crystal growth processes that are generally not preserved due to fast diffusion of Mg-Fe. Based on a first assessment of our measured profiles, the values for diffusion times in Fo-rich olivines (88 to 92% Fo) vary from only a few months to years and thus magma ascent from deep magma sources must have been fast.