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Plagioclase crystals tell magma dynamics and the feeding system geometry beneath Avachinsky volcano (Kamchatka, Russia)

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Sampling of the basaltic andesite of the 1991 eruption at Avachinsky volcano allowed the investigation of feeding system dynamics. The low-K (tholeiitic) affinity along with major and trace elements are within the compositional range of other Kamchatka volcanic rocks of similar evolutionary degree. The role of crystal removal prior to the eruption was verified through MELTS. The starting melt composition was taken from an average of the less evolved basaltic andesites of the entire Avachinsky volcanic succession, assuming that the primary basaltic magma (s.l.) rose up at crustal levels and underwent slight differentiation after its generation. The chosen parameters reproduce an isobaric crystallization process into a magma chamber located at ∼5.5 km (150 MPa) with temperature ranging between 1150°C and 1000°C. The initial content of dissolved H_2O was set at 2.0 wt.%, whereas fO_2 at the QFM+1 buffer. Results show that the 1991 basaltic andesites can be explained by fractionation of plagioclase ∼An70–82 (3–27 wt.%), augitic clinopyroxene (10–12 wt.%), orthopyroxene (1–4 wt.%) and opaque oxide (2–6 wt.%). Rayleigh fractionation for trace elements is also consistent with removal from the poorly evolved basaltic andesite of an assemblage constituted by plagioclase, clinopyroxene, orthopyroxene and opaque oxide with the same proportions as for major oxides. More complex differentiation dynamics have been unravelled through the integration of textural and compositional features recorded by plagioclase crystals (high-resolution BSE images and core-to-rim profiles). Several texture types were found: 1) small and large-scale oscillation patterns; 2) disequilibrium textures at the crystal core (patchy zoning, coarse sieve-textures, dissolved cores); 3) disequilibrium textures at the crystal rim (strongly sieve-textures); 4) growth textures consisting of melt inclusion alignments at the rim. Disequilibrium textures found at the cores testify episodes of destabilization at variable decompression rates and dissolved H_2O contents, which suggest different pathways of magma ascent from the deep portions of the plumbing system. At shallower levels, plagioclase textures and compositional profiles indicate that crystallization continues in reservoir/s not affected by important chemical and physical perturbations (oscillatory zoning develops). This may be evidence of either scarce magma replenishment from depth or that a large volume of magma is able to buffer minor, new magma pulses. The occurrence of distinct patterns of oscillation, even within the same crystal, is evidence that crystals can encounter different dynamic regimes throughout their growth history. A similar behaviour suggests that some convection should take place at shallow levels, implying the presence of at least one magma body of considerable size. The sole occurrence of strongly developed sieve-textures or thin alignments of melt inclusions that cut the oscillatory zoning patterns at the plagioclase rims is indication that crystals undergo rather common histories at shallow levels, favouring the hypothesis of a large magma reservoir whose top is at ∼5.5 km of depth, more than several separated batches. The presence in a hand-size sample of these two types of textures, which are sometimes not coupled, implies that crystals have the chance to mix mechanically at very shallow levels after ascent through distinct pathways. This may confirm the existence of a small, superficial magma reservoir at ∼1.8 km of depth, where crystals that record different growth histories finally meet.