Do olivines faithfully record magmatic events?

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Reconciling the archives preserved by different minerals in a same sample has proven to be difficult. In the case of plagioclase- and olivine-bearing basaltic-andesites from Volcán Llaima (Chile), it is surprising to see how zoning of olivine phenocrysts is always simpler compared to An-zoning of plagioclase. The general model is that Llaima basaltic andesites stall at the base of the edifice, where they crystallize to large extents and form mush bodies. Frequent magma inputs from a deeper reservoir remobilize these crystal mushes, maintain them in a rheologically viable state, and trigger eruptions. Magmas are stored in a plexus of dike-like reservoirs, which implies that individual magma batches experience variable frequencies of replenishment and reach different degrees of magma differentiation. This model explains a number of chemical and textural features observed with melt inclusions and olivine and plagioclase phenocrysts. However, it raises the question of why plagioclases record a series of recharge events whereas olivines systematically record one only? In this study we examine major and trace element zoning patterns of olivine phenocrysts, measured by electron microprobe (profiles and maps) and laser ablation ICP-MS (profiles), within a theoretical framework of crystal growth and element diffusion. We show that combining elements recording changes in magma composition (i.e. magma recharge or mixing: Fe, Mg, ±Ca, Mn, Ni) with elements recording disequilibrium crystallization (i.e. rapid growth: P, ±Al, Ti, Sc, V), while bearing in mind their individual diffusivities and partition coefficients, enables the recovery of a much more complex history than could be inferred from Fo-zoning alone. It is only after such a detailed analysis that the olivine archive could be reconciled with the plagioclase archive of magma reservoir processes at Volcán Llaima.