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Changes in open-system crystal-mush evolution and mobilization dynamics in concert with shallow magma-reservoir migration beneath historically hyperactive Llaima Volcano (38.7°S, Chilean Andes)

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Many basaltic to basaltic-andesitic historic and pre-historic eruptions from the main cone of Llaima volcano are phenocryst-rich (up to 70%). The products of eight of these are well preserved (1640-2008/09). Olivine-hosted melt inclusions (MIs) with very low CO_2(four young tephra deposits) indicate that pre-eruptive magma reservoirs were shallow (40-140 Mpa). MIs contain low H_2O for arc magmas (1 to 2-2.5 wt.%), also due to shallow degassing. Plagioclase and olivine compositions document temporal-spatial changes in the nature of crystal cargoes that are poorly coupled with small differences among whole-rock (WR) compositions. A solid block of vesicular crystal mush serves as a reference state for less-solidified, hence eruptible mushes (Fo_{73-68}). A relatively primitive lava with a rare 'native' phenocryst assemblage (Fo_{84-79}) is the proxy for mafic recharge magmas. Extremes of An- and Fo-contents in crystal-populations generally conform to these limits, and both populations are commonly present as core compositions. These results are the basis for proposing scenarios that address how the thermal-chemical evolution of an early-prehistoric magma reservoir differed from younger, more northerly systems. An abrupt change occurred during the 1780-90 eruption. WR compositions of the voluminous and homogeneous 1751 magma, and early pahoehoe flows of the heterogeneous 1780-90 eruption from the same southerly vent area, are identical. Olivine core plateaus in 1751 lavas and 1780 pahoehoe are Fo_{74-71}. Rare Fo_{84-80}grains were contributed by recharge magmas. Low-Fo grains, which are not in equilibrium with melts of WR composition, were comprehensively reconstituted by diffusive equilibration with interstitial liquids prior to eruption. The Mg gained by interstitial melts may have increased solidus temperatures, thereby 'extending the lives' of these magmas. The second phase of the 1780 eruption is characterized by Fo-rich olivine (Fo_{84-72}). Post-1790 lavas manifest significant fractions of olivine grains contributed by recharge magmas, highly varied olivine-core compositions, and spectacularly contrasting zoning profiles. Relatively ephemeral, heterogeneous, variably phenocryst-rich, and vertically distributed conduit/reservoir systems, in which recharge and resident magmas mixed extensively during eruptions, are implied. Early-prehistoric, sensibly homogeneous, crystal-mush magmas probably evolved in a sill-like body maintained by heat and volatile transfer from underplated recharge magmas, but with minimal mixing.