Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.22187

Causes of Chemical Variations in Monogenetic Eruptions: The Magmatic Evolution of Xitle Volcano, Mexico

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Understanding volcanic systems, including processes and timescales of pre-eruptive magma evolution, is essential for evaluating and mitigating volcanic hazards. Monogenetic volcanoes, despite their small eruptive volumes, have recently become more widely recognized to pose significant hazards and as such, a better understanding of their petrogenetic evolution and eruption-triggering mechanisms is particularly important.

Xitle volcano, a monogenetic volcano located in the southern part of present-day Mexico City, erupted ~1700 years ago, uprooting a pre-Hispanic civilization. The eruptive products of Xitle exhibit complex temporal-chemical variations, which could result from the evolution of a single magma batch by fractional crystallization and crustal assimilation (AFC), multiple magma recharge events from a heterogeneous mantle source ± magma mixing, or a combination of these processes. In order to further investigate the potential pre-eruptive magmatic processes, we have analyzed 40 samples, representing all lava flows and multiple stratigraphically constrained tephra samples from two interlaying tephra units, for bulk-rock and crystal-scale major and trace elements, coupled with Sr, Pb, Nd, Os, and O isotopic data.

Our preliminary findings reveal a non-monotonic change in SiO_2 through time, with multiple reversals in bulk-rock Mg#, indicative of multiple magma recharge events. Variations in Sr-Nd-Pb-Os isotopic signatures occur throughout the eruption sequence but do not correlate with SiO_2 or Mg#, arguing against simple AFC processes and suggesting the involvement of multiple melts generated from a heterogeneous mantle source. Disequilibrium textures in minerals (e.g., dissolution structures), zoned olivines with variable $\delta^{18}O$ between cores and rims, as well as olivine-hosted melt inclusions exhibiting variable SiO_2, K_2O, and Na_2O contents distinct from the matrix glass, all further support this interpretation. Sr-Nd-Pb isotope systematics and elevated olivine $\delta^{18}O$ values relative to MORB mantle suggest that Xitle magmas were derived from a heterogeneous subduction-metasomatised mantle source dominated by sediment-derived fluids. The evolution of the Xitle eruption, involving multiple magma batches and recharge events rather than simple evolution of a single magma batch by progressive AFC, holds importance for the timescales and mechanisms of melt ascent from source to surface, with implications for geophysical monitoring and hazard mitigation.