Popocatepetl's plinian versus vulcanian behavior: Melt inclusions hold clues to fundamental differences in eruption dynamics

CARLOS ANTONIO ANGELES DE LA TORRE[1*], JULIE ROBERGE[1], CELESTINE N. MERCER[2], PAUL J. WALLACE[3]

[1] Instituto Politécnico Nacional, ESIA-Ticomán, DF, México
[2] U.S. Geological Survey, Denver, CO, USA
[3] University of Oregon, Eugene, OR, USA

Popocatepetl volcano, located in the central part of the Trans-Mexican Volcanic Belt, has had at least 7 plinian eruptions in the last 23,500 years, but since it reawakened in 1994 it has been the site of volumetrically smaller, effusive (dome building) and explosive (vulcanian/strombolian) activity. What is the difference in Popocatepetl's magmatic system between the historical plinian eruptions and the present styles of eruption?

To address this question, we have characterized olivine- and pyroxene-hosted melt inclusion and mineral chemistry from Popocatepetl's first plinian eruption (~23,500 yr BP) and last plininan eruption (~1,100 yr BP). We have compared these data with olivine-hosted melt inclusion and mineral chemistry from the ongoing vulcanian and occasional strombolian eruptions [1]. In particular, we have focused on new estimates of pre-eruptive volatile contents and thermobarometric estimates to determine the key differences in the magmatic plumbing system controlling these contrasting styles of eruptions.

Our results indicate that there is a more restricted range of entrapment pressures for the older plinian eruptions (~100-200 MPa), which suggests the presence of a shallow, closed system, magma reservoir at ~6 km depth. Our hornblende barometry results are consistent with such a reservoir. In contrast, current eruptions are a result of variably degassed melts over a wide range of pressures (~1-400 MPa) implying continuous magma ascent and degassing from ~11 km to the surface via a network of dikes[1]. The similarity in major element compositions of melt inclusions from the plinian eruptions and those from the current eruptions show a remarkably homogeneous magma composition over time. This suggests that the melts from current eruptive events come from the same mafic parental melts that have resupplied and thermally sustained Popocatepetl's magmatic system for the past 23,500 years. Thus, we conclude that shallow magma pathways (dikes vs. reservoir) and open- versus closed-system styles of degassing are the primary controls on the volcanic eruptive style.

[1] Roberge et al. (2009). Geology, 37(2), 107-110.