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Along-arc variations in magma chamber depths of large explosive eruptions in Central America: constraints from fluid inclusions and mineralogy

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Large volcanic eruptions pose a threat to an increasing number of people, and thus a better understanding of magma chamber processes leading up to criticality is important for hazard mitigation.

We have applied a combination of fluid inclusion and amphibole thermobarometry to felsic tephras from highly explosive volcanic eruptions along the Central American volcanic arc (CAVA) from Guatemala through Nicaragua in order to constrain pre-eruptive magma storage conditions. We note that this is the first time a combination of pressure estimates from fluid inclusions and amphibole chemistry have been used to quantify multi-stage magma chamber processes and magma ascent velocities of large eruptions.

We found that all analyzed tephra samples contain magmatic fluid inclusions in plagiclase, demonstrating the presence of a separate fluid phase at pressures of 100-300 MPa, corresponding to 4-8 wt% water dissolved in the melts. Microthermometry reveals a typical fluid composition of 90 % water, 5% CO_2 and 5% NaCl, and fluid inclusion densities in the range between 0.15 and 0.75 g/cm^3. Amphibole thermobarometry confirms 80-200 MPa, i.e. 3-8 km depth, as a regionally occurring pre-eruptive storage level of the felsic melts, but also identifies deeper magma storage levels. Magma storage occurs down to depths of 25 km in Guatemala and Nicargua, where the crustal thicknesses are about 45 km and 30 km, respectively.

All together the fluid inclusion and mineral-barometric data document a stepwise ascent of magmas though the crust, involving one or more storage levels, prior to residence in a shallow reservoir where degassing generates the overpressure needed for highly explosive eruptions.