Petrogenesis of antecryst-bearing Mexican arc basalts: insights into along-arc variations in magma ponding depths, H_2O contents, and surface heat flux

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The Trans-Mexican Volcanic Belt (TMVB) is known for the chemical diversity in its erupted products. We have analyzed the olivine, pyroxene and plagioclase mineral chemistry of30 geochemically well-characterized mafic eruptives from Isla Maria at the western end of the arc to Palma Sola in the East. The mineral major oxide data indicate the dominance of open system processes such as antecryst uptake, and the scarcity of mineral-mineral and mineral-melt equilibria suggest that erupted melts do not significantly crystallize during ascent. A combination of plagioclase antecryst chemistry and MELTS thermodynamic modeling of H_2O-saturated isobaric fractional crystallization is employed to develop a pressure sensor that allows determination of ponding depths of the co-genetic magmas from which the erupted plagioclase crystal assemblage originates. We show that the depth of magma-mush reservoirs increase eastwards along the TMVB.

We suggest that magma ponding is triggered by degassing-induced crystallization during magma ascent, and that the pressure sensor can also be regarded as a degassing sensor, with more hydrous melts beginning to degas at greater depths. Modeled initial magma H_2O contents at the Moho range from ~4 to ~9 wt%. Magma ponding depth variations fully explain the observed westward increase of average surface heat flux along the TMVB, supporting a new model of mafic arc magma ascent, where rapidly rising, initially aphyric melts pick up their antecrystic crystal cargo from a restricted crustal depth range, in which small unerupted batches of co- genetic magmas typically stall and solidify. This implies that globally, mafic arc magmas may be used to constrain the depths of degassing and mush zone formation.