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Slab controls on the redox state of primitive arc magmas: a case study from the Trans-Mexican Volcanic Belt

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Geochemical data indicate that arc magmas are typically more oxidized than other voluminous magma types on Earth, such as mid-ocean ridge and intraplate basalts. In addition to having a significant impact on magmatic phase equilibrium, the higher oxidation state also leads to a variable fraction of sulfur being present in oxidized form in arc magmas, which has a significant impact on ore-forming process and volcanic degassing. Despite its significance, the processes controlling the redox state of arc magmas are poorly understood, and even the initial oxidation state of primitive magmas generated in arc settings is highly debated.

Silicate melt inclusions (SMI) trapped in early crystalized minerals (e.g. olivine) allow direct determination of the undegassed composition and redox state of primitive arc magmas. In this study, we present data from the Trans-Mexican Volcanic Belt (TMVB), which is a unique continental arc because of the high abundance of monogenetic volcanoes delivering primitive mantle melts to the surface without significant interaction with the crust. The concentrations of volatile (S, Cl), major and trace elements, including the highly siderophile Au and Pt were determined in olivine-hosted melt inclusions by LA-ICP-MS to assess if magma oxidation is induced by slab-derived components.

Results show that basaltic primitive melts in TMVB have high V/Sc ratio and fO_2 value, indicating an oxidized state. The S and Cl concentrations in SMI show wide variation and reach rather high values. Sulfur positively correlates with Cl, fluid-mobile elements (Ba, K) and Th/Yb ratio, suggesting a significant contribution to the total S budget from both slab-derived fluids and subducted sediments. Importantly, Cl increases with increasing V/Sc and fO_2. This implies that the slab fluid is responsible for the oxidized state. Moreover, Pt and Au concentrations are higher than those in mid-ocean ridge basalts. In some cones, Pt and Au show positive correlation with V/Sc ratio and fO_2 value. This indicates that the Fe^{3+} is an important component in slab fluids, because only Fe^{3+} has capacity to oxidize the mantle wedge beyond the sulfide/sulfate buffer, a prerequisite for the release of Au and Pt into mantle melts.