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Olivine Ca as Proxy to Mantle Wedge Depletion in the Trans-Mexican Volcanic Belt

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The composition of the background mantle wedge – i.e. the mantle without subduction components - is a critical parameter when calculating the recycled material flux from slab to arc. The composition of the background mantle beneath arc front volcanoes, however, is difficult to assess. Here we use Cr-spinel bearing olivine phenocrysts and xenocrysts from high-Mg# basalt to dacites in the Trans-Mexican Volcanic Belt (TMVB) in order to infer the composition of the mantle wedge beneath the arc front volcanoes. Olivine+Cr-spinel data from arc-front small-volume (<1 km^3) monogenetic volcanos and composite volcano (Popocatepetl, ca. 500 km^3 eruptive volume) were compared to data from olivine +Cr-spinel from TMVB reararc magmas that are not affect by the slab flux [1, 2].

Rear-arc olivines have both mantle-type $^3He/^4He$ and $\delta^{18}O$, which contrasts with the arc front olivines investigated which have high mantle-type $^3He/^4He$ (5-8 R_a) but elevated crustal-type high $\delta^{18}O$ values (+5.5 to +6.6 ‰ SMOW). The arc front He-O isotope signature has previously been attributed to source contamination that affects all of the highly diverse arc front magmas (calc-alkaline, OIB-type and high-K arc magmas) [3, 4]. Remarkably, despite the considerable compositional diversity of the magmas investigated, we find that all arc front and rear-arc olivines display a strong and an inverse correlation between olivine Ca and spinel Cr# which ranges from 'enriched' (rear-arc olivines with high Ca ~2000 ppm and Cr# ~spinel 0.1) to 'depleted' (arc front olivines with low Ca ~1000 ppm and up to spinel Cr# ~0.7). Because the low Ca olivines are found in hydrous (calc-alkaline, high-K) and low-H_2O (OIB-type) arc front magmas alike, we propose that the low-Ca arc front olivines reflect low Ca host melts that originate from a mantle wedge that becomes progressively depleted by serial melting that in turn is triggered by the slab flux.

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