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New insights into slab flux driven processing of mantle wedge from the trace element systematic of Cr-spinel-bearing olivines in the Trans-Mexican Volcanic Belt

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Early-crystallizing forsteritic olivines and their Cr-spinel inclusions capture compositional characteristic of primitive mantle-derived magmas, which in turn have bearing on the composition, lithology and evolution of their mantle sources. This potential is particularly valuable in hybrid arc magmas where forsteritic olivines are the only remnants of mafic mantle melts that were fed into the transcrustal magmatic system. We tested the potential of the trace elements in arc olivines to trace the slab-flux driven processing of mantle wedge, using a series of primitive high-Mg# basalts and andesites at the Transmexican Volcanic Belt (TMVB). These include calc-alkaline and OIB-type arc front magmas that have variably strong subduction signatures as well as TMVB rear-arc magmas that lack a subduction influence.

Bulk rock and He-O isotope systematics of the olivines constrain their crystallization in mantle-derived melts, which at the arc front are produced in a mantle that has been variably modified by the slab flux [1, 2]. The origin of the melts from different mantle sources is reflected in the Ca, Al, Ti, Na, Cr, Ni, Mn and Zn variations of the olivines. While the trace element concentrations of the rear-arc olivines resemble those of olivines from fertile tholeiitic basalts, arc front olivines have lower Ca, Al, Na, Ti, Zn and Mn and higher Ni and Cr which are indicative of melts from depleted mantle sources. Combined olivine+Cr-spinels and bulk rock systematics show that the mantle wedge depletion is driven by the slab flux. We infer that the slab flux supplies greater amounts of some elements (e.g. Si, Na), and combines with low-Fe and Ti-melts from depleted mantle to form hybrid calc-alkaline arc magmas. Overall, the olivine trace elements complement the bulk rock variations and thus help unravel subduction-related mantle wedge processing in greater detail than possible from bulk rocks alone.

[1] Straub SM et al (2015a) Geochim Cosmochim Acta 166: 29-52; and [2] Straub SM et al (2023) J Petrol 64(12)