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Geochimica et Cosmochimica Acta

Volume 75, Issue 1, 1 January 2011, Pages 213-241

Magmatic diversity of western Mexico as a function of metamorphic transformations in the subducted oceanic plate

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https://doi.org/10.1016/j.gca.2010.09.029

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Abstract

This geochemical study of the Mexican subduction zone elucidates how metamorphic and dehydration reactions affecting the subducted oceanic plate at different depths can influence magmatic diversity. In the western Trans-Mexican Volcanic Belt, there is a narrow potassic volcanic front running in parallel to the Middle American Trench that becomes replaced by intraplate-like high-Nb rocks to the north, and by more typical calc-alkaline products to the southeast. Potassic rocks have high MgO and are enriched in incompatible trace elements, but have lower heavy rare earth element contents than more evolved calc-alkaline and high-Nb magmas, and slightly more enriched Sr, Nd and Pb isotopes. Potassic magmas also have higher Rb/Cs and Ba/Cs ratios than the calc-alkaline and high-Nb suites, and extend to unusually high Nb/Ta ratios that correlate positively with Rb/Ta, Zr/Ta, La/Ta and Gd/Yb. These chemical variations are inconsistent with different extents of melting of a peridotitic source, but are also incompatible with melting of a phlogopite-rich mantle (vein-plus-wall-rock relationship), unless mica is totally consumed during melting, and a titaniferous phase such as rutile remains in the residue together with garnet. This assemblage is unlikely in the source region of primitive hydrous magmas, but it is what would be expected during dissolution of phengite and monazite/allanite in the subducted slab, with the concurrent formation of an anhydrous rutile-bearing eclogite. The magmatic diversity of western Mexico can thus be explained by invoking contributions of chemically different subduction agents as a function of slab depth and residual mineralogy: a low-pressure/temperature aqueous fluid would induce melting of the peridotitic mantle wedge and form typical calc-alkaline volcanoes, whereas a deeper and hotter slab-derived melt (or supercritical liquid) would contribute to the formation of potassic magmas due to phengite/monazite/allanite disintegration. In this context, intraplate-like magmas derive from decompression melting of the upper mantle as a natural consequence of subduction geodynamics.

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