Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 863

A View of Mantle Metasomatism Versus Crustal Contamination from the Trans-Mexican Volcanic Belt, Mexico

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The Plio-Quaternary volcanic rocks of the Trans Mexican Volcanic Arc in central Mexico provide suitable samples to evaluate the role of crustal contamination and mantle metasomatism on the ultimate chemical composition of arc magmas. The Trans Mexican Volcanic Arc contains both calc-alkaline and alkaline rocks, including a basalt-basaltic andesite-andesite series and a hawaiite-mugearite-benmoreite series. The arc is underlain by terranes of different age and composition that were accreted at different times in the Phanerozoic. The westernmost terrane - The Guerrero terrane - is one of the largest juvenile terranes of the north American Cordillera and was probably accreted in early Cretaceous time. The central and eastern terranes, known as the Sierra Madre and Maya terranes, are underlain by Proterozoic rocks of Grenvillian age.

We have initiated a Re-Os isotopic study of these calc-alkaline and alkalic suites across the Trans-Mexican Volcanic Belt in an effort to distinguish the relative roles of subduction, mantle and overlying crust on the final chemistry of the magmas. Here, we present the results of samples with minimum MgO concentrations of 8 wt%. We also present data on the Re-Os isotopic composition of the lower and upper crust in the region.

The characteristics of the lower crust in all these terranes is fairly well understood since exposures, or xenoliths, of lower crustal lithologies are found within each terrane. Exposures of the westernmost Guerrero terrane indicate that the lowermost crust consists of basalt with mid-ocean ridge affinity. Overlying these rocks is a sequence of meta-sedimentary rocks that originated from a Proterozoic terrane. These rocks were then intruded by Cretaceous and younger intermediate magmatism. Lower crustal xenoliths found in the central Sierra Madre terrane, include two-pyroxene, pyroxene-plagioclase and pelitic granulites. The metapelites consist of garnet, quartz, feldspar and pyroxene. The model Nd ages for the exposed basement rocks range between 1.3 and 1.6 Ga, although some orthogneiss xenolith model ages are younger.

The present day $^{187}Os/^{188}Os$ ratios of the measured lower crustal meta-sedimentary and granulite lithologies from both accreted terranes and in nuclear Mexico range between 0.3 and 5.0. The meta-basalts of the accreted terranes have $^{187}Os/^{188}Os$ values between 1 and 2. The Os concentration of all lower crustal lithologies ranges between 10-160 ppt. Upper crustal granitoids have $^{187}Os/^{188}Os$ between 0.8 and 1.2 with Os concentrations between 1-10 ppt. The data presented here indicate that the lower crust has high Os concentrations and can be radiogenic. These data also indicate that the lower crust is a significant contaminant in the evolution of arc-derived magmas.

Osmium concentrations for the volcanic rocks range from about 0.5-70 ppt for the whole-rock powders to over 500 ppt for an olivine separate. Rhenium concentrations vary from 200-500 ppt for whole-rocks and olivine separates to several ppb for magnetite-rich separates. The $^{187}Os/^{188}Os$ initial ratios for the basaltic andesites and hawaiites range from ca. 0.13 to 0.41.

The $^{187}Os/^{188}Os$ of the samples correlates with Os concentration and indicators of fractionation, such as Ni or MgO. The Re-Os characteristics of these rocks cannot be easily explained as products of a metasomatised mantle or metasomatic processes. These data also cannot be explained by fractionation alone or assimilation of lithospheric mantle or upper crustal granitoids. In the latter case, between 50 and 90% granitoid would have to be assimilated to satisfy the Os isotopic values of the most evolved samples; this is unreasonable because it violates heat balance requirements and the resulting liquids would not be andesitic. On the other hand, assimilation of 25 to 40% of lower crustal material after melting satisfies heat balance requirements and is consistent with major element trends for the most evolved basalts. And even the most primitive basalts require assimilation of 5 to 10% of lower crustal material to explain the Os isotopic data.

In conclusion, the Re-Os data for the Trans Mexican Volcanic belt can be satisfactorily explained by assimilation of a lower crust that has been rejuvenated through time by addition of mantle derived magmas. The contamination of these arc-derived magmas occur very early in the evolution of these melts, with significant contamination occurring in primitive (10-8% MgO) lavas.