Crustal Recycling by Subduction Erosion in central Mexico

S.M. Straub[1], A. Gomez-Tuena[2], I.N. Bindeman[3], L.L. Bolge[1], P.A. Brandl[4], R. Espinasa-Perena[5], L. Solari[2], F.M. Stuart[6], P. Vannucchi[7], G.F. Zellmer[8]

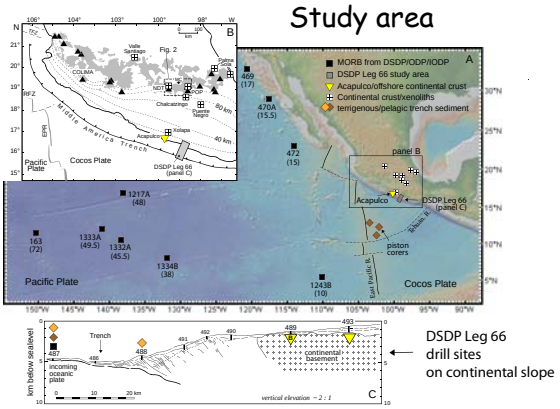
[1]Lamont NY U.S.A., [2]CGEO UNAM MX, [3]U Eugene OR U.S.A., [4]ANU Canberra AUS, [5]CENAPRED MX, [6]SUERC UK, [7]RH London UK, [8]U Massey NZ

The recycling of the upper plate crust in subduction zones ('subduction erosion') has been recognized as important mechanism of crustal recycling at convergent margins.

Detailed studies of olivine-phyric, Ni-rich high-Mg# basalts and andesites in the Quaternary central Mexican Volcanic Belt (MVB) provide new constraints for recycling by subduction erosion. These arc magmas that include calc-alkaline (dominant) and Nb-enriched (subordinate) series are near-primary mantle melts that escaped crustal contamination during ascent through the ca. 45 km thick crustal basements [Straub et al. 2008, 2011, 2013, 2014, 2015].

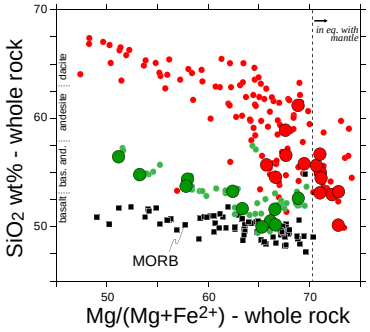
He-O isotope ratios of high-Ni olivines constraints the ubiquitous presence of a slab-derived crustal component. However, Nd-Hf isotope systematics rule out the pelagic trench sediment as crustal end member, and imply a crustal component that has been eroded at the trench from the overlying continental crust.

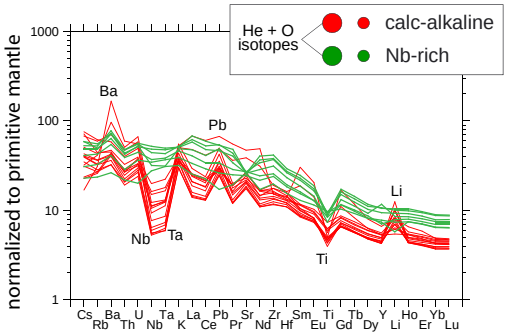
Study area

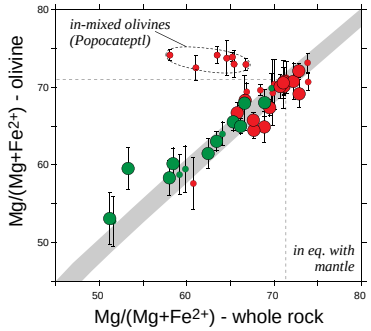


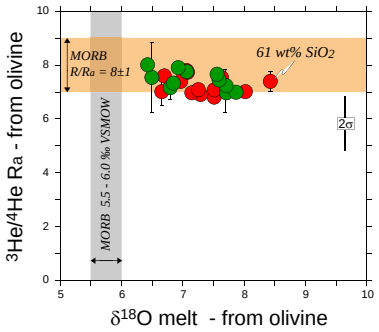
DSDP Leg 66 drill sites on continental slope

Central MVB arc magmas are hybrids of mantle and recycled slab components





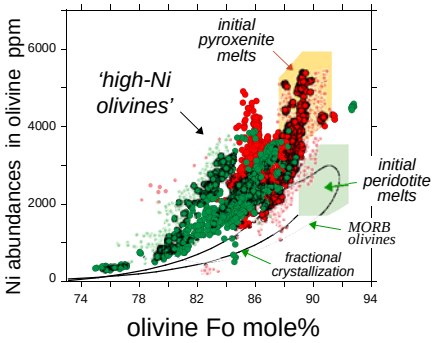




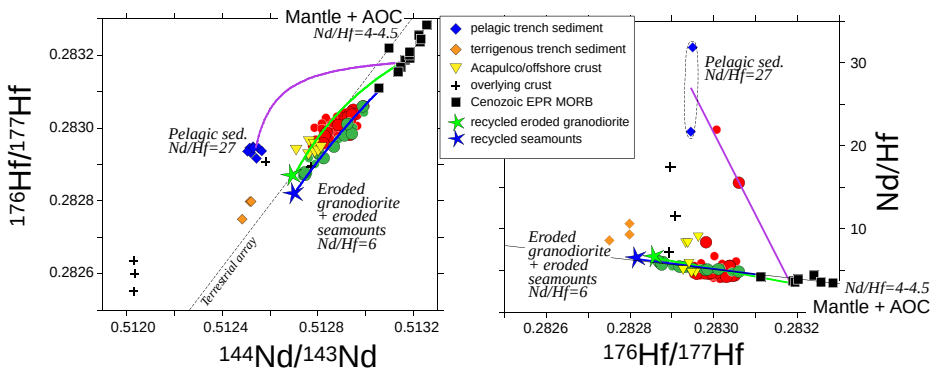
Central MVB basalts and andesites commonly contain high-Ni forsteritic olivine phenocrysts that combine high $^3He/^4He$ = 7-8 Ra of mantle melts with high $\delta^{18}O$ (melt +6.3-8.4‰) of crustal compositions (left).

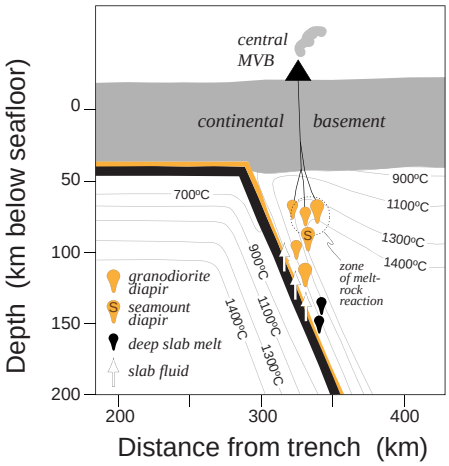
This combination rules out signficant crustal contamination and implies the presence of a crustal component from slab, and not from the overlying crust.

We tested this inference through comparison of the Sr-Nd-Pb-Hf isotope ratios of MVB magmas with crustal compositions of the incoming slab (Straub et al. 2015, GCA).



Nd-Hf isotopes imply recycling of eroded continental crust, and not of trench sediment





A 3-component mixture of subarc mantle, AOC and pelagic trench sediment fails to reproduce the trend of the MVB magmas. However, a mixture of subarc mantle, AOC and granodiorite crust from the Mexican fore-arc reproduces the calc-calc-alkaline arc series. We propose that that granodiorite forearc crust was entrained by either landward surface erosion, or by abrasion of the underside of the upper plate. A subducted seamount cluster may create locally Nb-rich arc magmas. At an estimated flux of 79–88 km3/km/Myr and thickness of 1500–1700 m, the eroded granodiorite may buoyantly rise into the mantle melt region and impose its trace element signature (e.g., Th/La, Nb/Ta) on the arc magmas.

This study is funded by NSF-EAR grant 12-20481. O. Pérez-Arvizu, WY Hsu and E. Knapp are thanked for lab assistance. Special thanks to V. Loreto Becerra, S. Nuño Licona, J. Valenzuela Gonzalez and HS Herrera Fernandez for help in the field.