Volcanism along the eastern margin of the Salton Trough: Constraints on the kinematics of initiation of the southern San Andreas transform fault system

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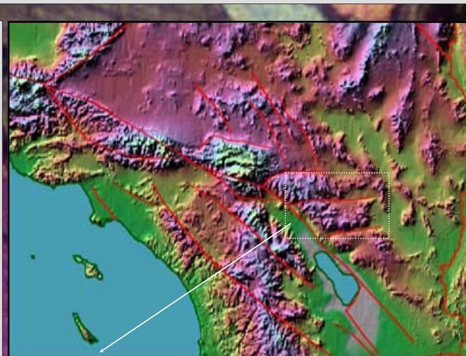
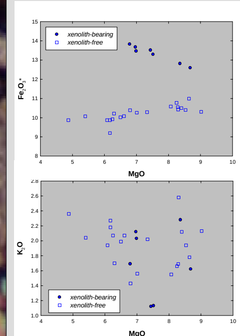
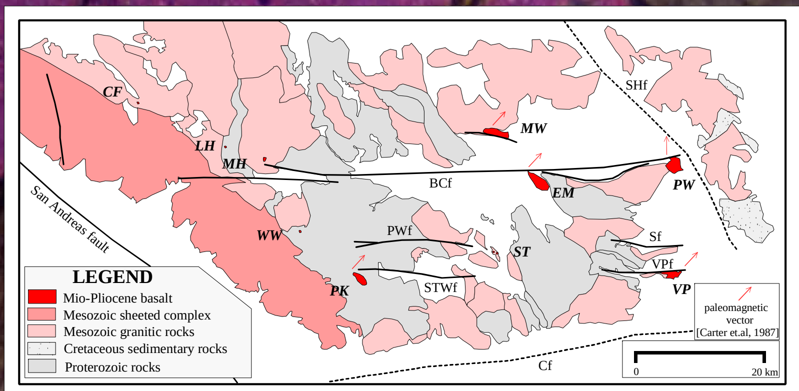
ABSTRACT

Late Miocene to Pliocene alkali basalts in the eastern Transverse Ranges of southern California erupted along the eastern Salton trough margin, near to the southern San Andreas fault and adjacent sinistral faults. Previous paleomagnetic studies and new $^{40}Ar/^{39}Ar$ geochronology suggest that these volcanic centers were temporally and spatially associated with early Gulf rifting and transrotation on a series of sinistral faults connecting the evolving San Andreas transform to the eastern California shear zone. Although these basalts erupted on Proterozoic continental crust, compositional variations suggest mantle sources across the western edge of Proterozoic lithospheric mantle, where it abuts oceanic lithosphere accreted in early Cenozoic time. We hypothesize that early Gulf opening and initiation of slip on the southern San Andreas fault between about 5.3 and 4.5 Ma was associated with rapid block rotation along sinistral transform faults along this pre-existing mantle lithospheric boundary. This hypothesis can constrain the magnitude and timing of kinematic linkage between the Gulf of California, the evolving San Andreas fault, and the eastern California shear zone, and may reconcile widely divergent estimates of net slip on the southern San Andreas fault.

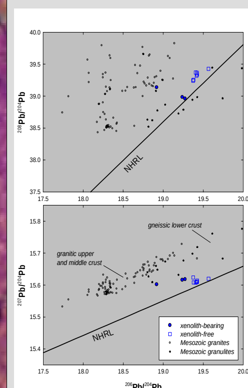




Xenolith-bearing and xenolith-free basalts comprise two geochemically distinct suites among alkali basalts on the eastern margin of the Salton trough. Xenolith-bearing sites nearer the southern San Andreas fault are more iron-rich, but are comparably alkali-enriched to xenolith-free sites further to the east. Xenoliths are predominantly granular to foliated harzburgite and lherzolite (Hughes, Probst and Barth, in preparation) and therefore Fe-enrichment observed in the xenolith-bearing suite is not due to interaction with xenoliths. Potassium contents describe two styles of compositional variability at individual eruption sites: positive covariation of K_2O with MgO characterizes the Eagle Mountain volcanic center, whereas other centers show more typical negative covariation. Xenolith-bearing sites overlap both MgO-K_2O trends.

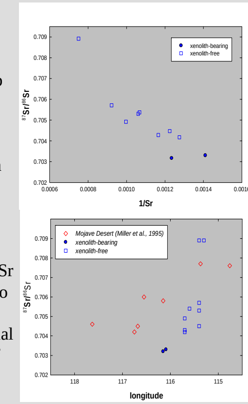


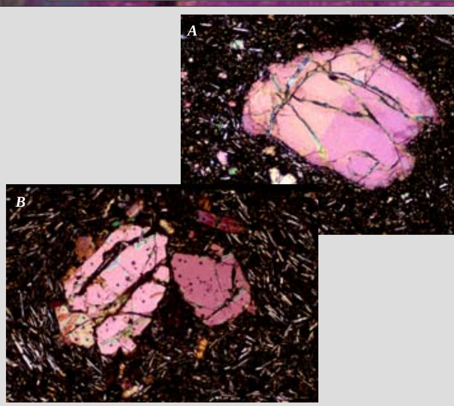
Late Miocene to Pliocene alkali basalts in the eastern Transverse Ranges erupted along the Salton trough margin, near to the southern San Andreas fault and adjacent sinistral faults. Paleomagnetic vectors suggest eruptions bracketed ca. 40 degrees of clockwise rotation between 5.5 and 4.5 Ma. Transrotation occurred on a series of sinistral faults connecting the early southern San Andreas fault to the eastern California shear zone.



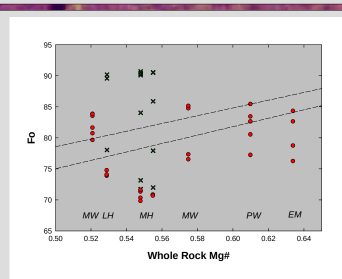
Pb isotopes are more radiogenic than expected for melts of depleted mantle (NHRL; Hart, 1984), but less radiogenic than local continental crust in $^{207}Pb/^{204}Pb$ for observed $^{206}Pb/^{204}Pb$ (crust values from Barth and others, 1992, 1995, and Wooden and Barth, unpublished data). These data suggest crustal contamination was limited in causing isotopic variation in the alkali basalts.

Xenolith-bearing basalts are less radiogenic than xenolith-free basalts. Negative covariation of initial Sr with 1/Sr suggests that initial Sr ratios are related to isotopic variability in mantle sources, rather than to crustal contamination. Initial Sr and Pb ratios increase abruptly east of 116E, as observed in the Mojave Desert immediately to the north.

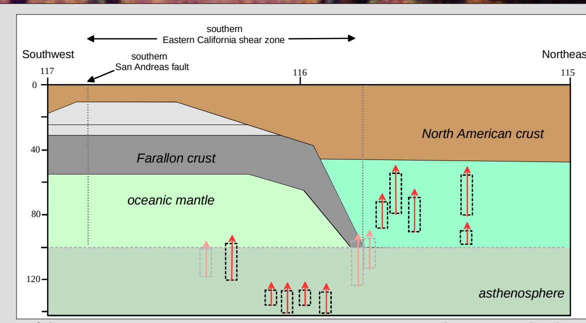




Photomicrographs of typical alkali olivine basalts. A. Kink-banded olivine xenocryst, xenolith-bearing basalt at Malapai Hill. B. Olivine phenocrysts surrounded by aligned plagioclase in flow-banded matrix, xenolith-free basalt at Pinto Wells. Width of field of view is about 3 mm.



Comparison of measured olivine compositions to equilibrium mineral-melt Fe-Mg partitioning at low pressures (Roeder and Emslie, 1970). In xenolith-bearing basalts, xenocrystic olivine cores (X) fall above the equilibrium field, with rims zoned toward compositions in equilibrium with phenocryst olivine (circles). Olivine phenocrysts fall near to or below compositions predicted for equilibrium partitioning, probably indicative of minor olivine accumulation during eruption and flow.



Cross section of the eastern Transverse Ranges in Late Miocene time, with juxtaposed Paleoproterozoic North American continental crust, thickened Farallon crust resulting from Laramide orogenesis, and underplated slab window asthenosphere. The superimposed mantle melting profile is based on compositional ranges of alkali basalt suites projected onto the line of section; boxes with red arrows show estimated magma source columns (model and additional data from Wang and others, 2002). Increase in Pb and Sr isotope ratios east of 116E implies the existence of a compositional boundary in the mantle, modeled here as the boundary between North American lithospheric mantle and Farallon oceanic mantle or asthenosphere. Grey vertical dotted lines show the boundaries of the eastern California shear zone, which formed along this boundary as basalt magmatism waned.