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Contrasting mantle xenoliths hosted in oceanic and continental alkaline lavas: Implications for the Martian mantle

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The petrogenesis of alkaline magmas is commonly driven by processes within the subcrustal lithosphere (SCL), including partial melting, mantle metasomatism, and fractional crystallization. If mantle xenoliths are present in alkaline lavas, they can represent samples of the source region and provide direct evidence for these processes. While mantle xenoliths have not been identified in Martian lavas, discoveries of alkaline magma compositions at the surface [1] and in regolith breccia meteorites [2] have implications for the planet's interior and suggest subcrustal fractionation and(or) metasomatism within the mantle. Here, we present data from mantle xenoliths from two alkaline suites representative of two endmember petrogenetic models – metasomatism and fractional crystallization: (1) Mount Taylor Volcanic Field (MTVF), NM, where magmas associated with continental rifting interact with SCL that has been metasomatized by long-lived subduction off the west coast of North America, and (2) the island of Hawai'i, HI (Maunakea, Kohala, Hualālai) where oceanic hotspot magmas fractionate at depth beneath oceanic stagnant lid lithosphere.

MTVF xenoliths comprise a diverse assemblage of lithologies, including lherzolites, websterites, clinopyroxenites, harzburgites, dunites, and wehrlites, suggesting disequilibrium within the mantle source region. Metasomatism is evident in the form of replacement and overgrowth textures, including reaction rims, symplectites, and sieve textures. Disequilibrium is further demonstrated by a wide range in mineral chemistry, including olivine Fo57-95 and pyroxene Mg#72-93 (enstatite to diopside). MTVF pyroxenes range from 0-0.23% TiO_2 and 0.02-1.38% Al_2O_3. In contrast, Hawai'ian xenoliths comprise dunites and wehrlites with an equigranular cumulate texture, suggesting formational equilibrium due to extensive fractional crystallization. This is reinforced by a narrow range in mineral chemistry, including olivine Fo79-88 and pyroxene Mg#79-91 (predominantly diopside). Hawai'ian pyroxenes range from 0.36-0.63% TiO_2 and 1.8-2.26% Al_2O_3, reflecting greater Tschermak substitution than MTVF pyroxenes.

Although the bulk composition of Mars differs from that of Earth (i.e., more Fe-rich and volatile-rich), terrestrial xenoliths are accessible proxies for investigating subcrustal processes on Mars. Future work will include further analysis of mineral chemistry and cation order-disorder in these samples, as well as in xenoliths from additional geological settings.

[1] Stolper et al. (2013), *Science* 341.
[2] McCubbin et al. (2016), *JGR:P* 121.