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The Hydrated Nature of the Colorado Plateau Mantle Lithosphere

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Hydration of mantle lithosphere reduces its viscosity while increasing its susceptibility to melting, and can incite instabilities and lithospheric foundering. In the southwestern USA, lithospheric hydration during Late Cretaceous subduction of the Farallon slab could have contributed to the high-standing nature of the Colorado Plateau as well as to volcanism and attenuation of lithosphere at the plateau's margins. To better quantify the amount and origins of mantle-hosted water in the evolution of the Colorado Plateau, we investigated Miocene to late Quaternary near-primary basalts erupted at its western margin (WCP).

The WCP basalts exhibit considerable spatiotemporal chemical and isotopic heterogeneity, including large variations in Nd and Hf isotopes (e_{Nd} = -10 to +4 and e_{Hf} = -13 to +11, respectively) and in subduction-related proxies like La/Nb (0.7 to 5.7) and Ba/La (11 to 49). Water contents obtained by Ca-in-olivine hygrometry [1] are 1 to 4 wt.%, and are consistent with results for one field based on olivine-hosted melt inclusions [2]. When normalized to Ce, comparably incompatible during melting, these values yield H_2O/Ce ratios from 90 to 1200, with most being <300. Source water contents are estimated to cluster regionally at ~150 and ~600 ppm and, because hydrated mantle should be predisposed to melting, should be upper limits at the depths of melting.

We relate much of the chemical and isotopic heterogeneity of the WCP basalts to the variable effects of subduction-related silicate melt and hydrous metasomatism, and protracted radiogenic ingrowth in the mantle lithosphere. Contributions from a depleted mantle source are also present in younger basalts, possibly derived from the convecting upper mantle. The H_2O/Ce values of the WCP basalts resemble those of warm subduction zones, consistent with evidence of silicate melt metasomatism. Such a setting is at variance with shallow subduction of a >100 Myr old Farallon slab beneath the region. Therefore, we do not find a smoking gun linking hydration of the mantle under the WCP to Late Cretaceous subduction. The mantle is nonetheless hydrous, a feature that may have been longstanding in this region.

[1] Gavrilenko et al., J. Pet 2016
[2] Plank and Forsyth, Gcubed 2016