Cenozoic topographic and climatic change in the western U.S. from a paleosol carbonate record in Montana and Idaho

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Oxygen, carbon, and strontium isotope records from a Paleocene to Pliocene paleosol carbonate stratigraphy in southwestern Montana and eastern Idaho show evidence that significant changes in topography occurred between ~50 and 47 Ma. $\delta^{18}O$ values of calcite decrease by 7-10‰, while $\delta^{13}C$ increases by ~3‰, and strontium shifts to more radiogenic values. These changes reflect a reorganization of drainages with an increase in elevation of 2.5-3.5 km. This rise in elevation is roughly contemporaneous with the emplacement of the nearby Challis Volcanics, and the formation of metamorphic core complexes in the hinterland of the Sevier thrust belt. Moreover, when compared to previous oxygen isotopic studies that show oxygen isotopic shifts of similar magnitude occurring later (in the late Eocene to early Oligocene in northeastern Nevada, and late Oligocene to Miocene in southern Nevada), the results of this study add to a growing body of evidence for a spatial and temporal migration of high surface elevations from north to south in the Great Basin of the western United States. This surface uplift history supports tectonic models calling for north to south removal of the Farallon slab or delamination of the mantle lithosphere. Superimposed on this tectonic framework we find a high-resolution climate record with evidence of rapid Cenozoic climate fluctuations. Oxygen and carbon isotopes show major climate fluctuations at the Eocene-Oligocene boundary, and pulses of Pliocene cooling and Pleistocene warming. This adds to a growing body of literature that shows spatial variability in how global climatic changes are expressed in the terrestrial record. Understanding the larger tectonic framework is essential to making interpretation of climate based on these isotopic records.

Th/Nb evolution of the Archean mantle

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Values of Nb/Th in komatiites and basalts have been used as proxies for extraction of continental crust from the mantle. Ratios of 8-16 for ~ 2.7 Ga Yilgarn komatiites and basalts were interpreted either as large scale extraction of the continental crust early in Earth history, or extensive extraction of crust from small mantle domains, where bulk Archean crust has Nb/Th=2 [1]. In an alternative model, the ratio evolved from near primitive mantle values of 8 in the early Archean to MORB like values of 19, reflecting progressive crustal extraction. A new compilation of high precision data for komatiites of the Superior Province gives a range of 7-11 at 3 Ga but 7-21 at 2.7 Ga. Associated basalts span 5-13. These results are interpreted as large scale extraction of continental crust, as TTG, from melting of oceanic crust in convergent margins post 3 Ga, and recycling of the high Nb/Th residue into the mantle source of plumes from which the komatiites and basalts later erupted.

In the Neoarchean Wawa subprovince, oceanic plateau basalts are characterized by near-flat REE patterns, and Nb/U and Nb/Th ratios generally greater than primitive mantle values, consistent with positive ε_{Nd} values. They are associated with komatiites, the association being interpreted as an ocean plateau sequence erupted from a mantle plume. High Nb/U and Nb/Th ratios of plateau tholeiitic basalts are interpreted as a complementary reservoir to arc magmatism (low Nb/U and Nb/Th), hundreds of millions of years prior to recycling of oceanic lithosphere through a subduction zone (high Nb/U, Nb/Th), and its incorporation into a mantle plume from which 2.7 Ga plateau tholeiites erupted.

References

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