Relation of flat subduction to magmatism and deformation in western USA

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Flat subduction beneath western USA is largely responsible for the region's deformation, uplift and magmatism since ~100 Ma. Initial slab shallowing and rapid westward motion of North America were caused by low pressure in the western USA asthenosphere resulting largely from an inhibited asthenospheric flow toward the subduction zone, which was blocked by the cratonic root. Final slab flattening resulted from oceanic plateau subduction, which ripped beneath southern California.

Flat subduction compressed the continental interior, creating Laramide uplifts. NE motion of the Colorado Plateau shortened Proterozoic lithosphere in central Colorado and New Mexico; upper mantle seismic images suggest weakening of a 200 km-thick lithosphere in the shortened areas. In contrast, the widely spaced uplifts in Archean lithosphere suggest a lower crustal decoupling above a strong lithosphere (also imaged at ~200 km thick). Flat subduction also cooled and hydrated the base of the lithosphere. This largely amagmatic hydration made the lithosphere buoyant and fertile, preparing it for the Cenozoic. The current base of North America is a westward thinning wedge, which may have been planed into this shape by the subducting Farallon plate or it may represent a westward flow of compositionally buoyant basal North America following slab evacuation.

Progressive slab removal is revealed by the mid-Tertiary ignimbrite flareup, which propagated NW out of Sonora and SSE out of the Pacific Northwest, converging on southern Nevada. The southern California Transverse Ranges “drip” is the last of this slab removal. Exceptionally voluminous magmatism occurred where the hydrated mantle was fertile (outboard of the Paleozoic hingeline); the lithosphere weakened by this compositionally guided thermal event is now the Basin and Range.

Uplift of the western USA continues as the Farallon slab sinks and as continued magmatism both heats the lithosphere and creates buoyant residuum. Forces driving western USA extension result from (1) high gravitational potential energy of the elevated interior, (2) southern Cascadia rollback and (most intreastingly) (3) craton root drag, which shields western USA from ridge push compression. The occurrence of significant deformation rates in the western USA result from the thermally-controlled weakness of this region.