Flat-slab (horizontal) subduction occurs along ~10% of subduction margins, forms magmatic gaps, causes upper-plate deformation to migrate inland, and is thought to have caused the Laramide Orogeny. We investigate bulldozing of basal continental mantle lithosphere (CML) by the flat Farallon slab, using 2D numerical thermal-mechanical models. We vary CML density and strength to understand controls on the bulldozing process. Flat-slab subduction begins when an oceanic plateau, which makes the slab buoyant, enters the trench. The dense slab ahead of the plateau detaches and continues to sink, and subduction erosion of the continental margin begins. A slab hinge is quickly re-established at the front of the flat slab. The advancing flat slab erodes (bulldozes) the basal ~25-50 km of continental mantle lithosphere (CML), thinning it. Buoyant (depleted) bulldozed CML can accumulate ahead of the slab hinge, in a growing, migrating wedge up to ~200 km thick, that is wider (up to ~700 km) if bulldozed CML is weak, or narrower if CML is strong. We suggest that bulldozed wedges transmit contact stress into the upper plate, driving crustal deformation ahead of the flat slab itself. Dense bulldozed CML, especially if also strong, is entrained with the sinking slab, so would be imaged with it in seismic tomography. It is probable that bulldozed CML also may accumulate along one or both sides of the contact zone between slab and upper plate. Whether buoyant or dense, bulldozed CML fills the asthenospheric wedge, which would end arc-type melting during flat-slab advance. Flat-slab rollback reopens the asthenospheric wedge, renews melting, and leaves a step and/or a thickened keel in the CML at/ahead of the farthest slab extent.

Most modern South American flat slab segments coincide with subducted ocean ridges, have correspondingly narrow contact zones with the upper plate, and are bounded laterally by sagging or torn ocean lithosphere. Recent geodynamic models of subduction under North America suggest that the contact zone between Farallon and North America plates also was narrow, much more so than typically envisioned in older literature. This contact zone probably was bounded in southern Arizona - New Mexico by a slab tear, because arc volcanism farther south continued much closer to the coast. We interpret two geophysical anomalies under the western U.S. as fossil basal CML steps/wedges that define the limit of flat-slab advance. An upper-mantle fast-velocity anomaly below southeast New Mexico and west Texas is probably a keel now “dripping” into the asthenosphere. CML below southwest Colorado thickens northeastward across a step that probably defines the northeast limit of the Laramide flat-slab contact zone. If correct, then Farallon flat-slab contact ended hundreds of kilometers southwest of the Laramide front in Wyoming. Most Laramide-age magmatism was northwest or southeast of the contact zone, but some occurred above it: The Colorado mineral belt probably was above a slab tear and Laramide magmatism in western Arizona and southeastern California probably reflects petit-spot type melting where the slab was flexed concave-up. Modern examples of active flat-slab bulldozing probably exist in South America.

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Laramide, flat-slab subduction, magmatism, deformation

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