# Decoupling near the moho: weakening beneath rigid mantle or lower crustal layers in thickened mountain roots and extensional zones

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Continental deformation which changes crustal thickness results in decoupling near the crust–mantle boundary (MOHO). Decoupling results from rheological weakening of distinct lithologies, and thermal structure, and can occur above or below the MOHO.

The depth and width of a continental collisional orogenic belt depends upon the forces of plate convergence, the distribution of rheological layering in the lower crust, and the brittle to ductile rheological evolution in the subMOHO ultramafic mantle. Immediately after continental collision, the mantle below the thickened continental root (from 70 to ~100 km depth) is significantly colder and consequently stronger (~1500 MPa) than adjacent mantle. This indicates that sub-root mantle represents a first order rheological boundary during the later stages of convergence.

The stability of the deepened MOHO depends upon the geothermal gradient and rheological state just before thickening, and whether the lower crust is felsic (diorite) or mafic (diabase <35 km, eclogite >35 km). For average geothermal gradients and continents doubled from 35 km thickness after nearly 20 Ma of incubation, the root mantle and adjacent shoulder mantle have similar strength. After this time the root mantle layer supporting the thickened continent is no longer rigid and strong. For thinner continents, and more so for those still thermally softened during extension just before thickening, the weakening of the rigid upper most depressed root mantle occurs in less than 10 Ma.

The evolution of thermal structure in an orogen during continuous convergence is responsible for changes of strength distribution. Therefore, stress transmission through the orogen changes from an early strong wedging stage, towards a thickened-root weak stage. Such a strength evolution may play an important role in the possible mechanical behavior of forelands.

# A lithospheric buckling model for the Laramide orogeny

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During the Laramide orogeny (75–50 Ma) in Western North America, foreland deformation in the form of arches or antiformal uplifts occurred throughout the eastern Rocky Mountains region. The same structural style developed east of the foreland in the midcontinent region, and extends from the Gulf of Mexico to approximately the US/Canadian border (49° N). Initiation of foreland and mid-continent arches appears generally to be older in the south and younger in the north. We attribute the deformation in the Rocky Mountain foreland and continental interior to folding of the entire lithosphere (lithospheric buckling). The observed wavelength of arches in the western United States is ~150–190 km, a spacing consistent with a lithospheric buckling interpretation. Where late-stage Laramide deformation has not obscured early Laramide structures, arches show a tightening from an initial wide uplift to a narrower, greater amplitude antiform; this observation is also consistent with scaled lithospheric models for buckle development.

The earliest of the Rocky Mountain foreland arches are NS oriented, at a high angle to ENE oriented Precambrian boundaries (e.g., Archean Wyoming province vs. Proterozoic Colorado terranes), that might be expected to control arch geometry. Although some evidence exists for reactivation of old (Precambrian to Paleozoic) crustal structures during Laramide foreland deformation, the overall style of deformation of the uplifts seems to be more strongly controlled by buckling geometry than by pre-existing structure.