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Mountain building long after plate collision. Possible mechanisms

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It is commonly believed that mountain building occurs synchronously to plate collision. However, it was well known long ago that in most cases mountain building began 10-100 Ma later. For example, in the Middle and Southern Urals collision occurred from the Late Devonian and until the Early Permian. The shortened regions remained covered by a shallow sea. High mountains began to form rapidly 10 Ma after the termination of collision. The Verkhoyansk Range in Northeastern Asia was strongly shortened at mid-Cretaceous time. It remained at a low altitude for 100 Ma and rose by 2 km in the Pleistocene.

Compressive stresses most probably were acting in the Urals during all the epoch of collision. Strong shortening however occurred only as several impulses 1-2 Ma long. This can be explained by temporary weakening of the lithosphere due to a change in the mechanism of creep under infiltration of fluids from the mantle.

To sustain a thickened crust at a low altitude, a density increase in the lithosphere was necessary. A possible cause could be metamorphism in crustal rocks, both mafic and felsic, under a pressure increase during collision.

Rapid uplift of the shortened crust long after collision and establishment of a new temperature distribution indicates a density decrease in the lithosphere. Thus, on the Precambrian cratons which cover about 70% of continental areas collision terminated $\geq$ 500 Ma ago. However, during the last several Ma most of them underwent the uplift ranging from 100-200 m to 1000-1500 m. This occurred on the African continent, in central and eastern Australia, East Siberia, East Antarctica and in many other regions. Preservation of thick mantle roots precluded delamination of the lowermost lithosphere as a mechanism for the uplift. Due to a strong denudation of cratons deeply metamorphosed rocks of the lower crust emerged to a shallow depth. Under dry conditions for a long time they remained metastable. Recent inflow of fluid from the mantle ensured a new phase of metamorphism with the formation of hydrous minerals and rock expansion. Possible density changes at different levels and the corresponding crustal uplift are calculated using phase diagrams for the main types of crustal rocks. Expansion of rocks within the crust is also indicated by numerous slopes tens of kilometers wide that formed during the recent uplift.

Strong thinning of mantle lithosphere occurs under many Phanerozoic mountain ranges, e.g., in the Alpine Belt which underwent intense recent uplift. This can be attributed to rapid replacement by the asthenosphere of the lower mantle lithosphere. Its strong weakening by infiltration of mantle fluid was necessary to ensure such a replacement with the isostatic crustal uplift after a long period of relative stability. Strong lateral variations of the uplift indicate a large input in it of metamorphism within the crustal layer. Thus, infiltration of mantle fluids into the continental lithosphere appears to be a trigger for strong shortening of the crust and mountain building.