d27 Sierra Nevada < trapdoor fault >

Clarence King (1842-1901) The use of topographic maps with contours, rather than hachure shading, to indicate topography for plotting geology was a method he introduced when, at the age of 25, he command a pioneering five-year mapping project (scale 4 miles to the inch, and a contour interval of 300 feet) from the Sierra Nevada across the Rocky Mountains.

WANTED / Young wiry fellows / not over eighteen. / Must be expert riders, / willing to risk death / daily. Orphans pre- / ferred.—Pony Express advertizement.[1]

Pliocene and Miocene volcanoes dot the Sierra Nevada (originally mapped by pioneer geologist **Clarence King**)[2] that is otherwise a vast block of erosionally exposed batholithic granite and granite-intruded metamorphics. The Sierra Nevada block (***Figure d27.1***) was uplifted during the Pliocene as is evidenced by the cool, semiarid, temperate climate in its rain-shadow region to the east having changed drastically during that time (as fossil plants there record) from a warm, humid, subtropical climate.[3] The uplift was by tilting of its peneplaned surface (a relect landscape with moderate relief now its western slope north of 37°N and a south-declining upland south of 37°N)[4] by a great normal fault that bounds its eastern side. There, today, the eroded-back fault escarpment elevation averages 4000 m high above the floor of the Great Basin desert of Owens Valley with its interior drainage and salt lakes.[5] Central vent volcanos, as Mt. Whitney, its peak at 14,494 ft (4418 m), and flows with an aggregate thickness in places of 1000 m, are nonconformable on the eroded upper surface of Sierra Nevada granites and metasediment remnants of its once batholith roof. Geobarometry (study of pressure recorded by minerals when they crystallized) indicates that the granite top was formerly at a depth of 15 km. The batholith itself is a complex of granites intruded episodically during the Cretaceous.

Granitic magma is generated by wet partial melting of the deep parts of continental orogens.[6] Some volumes are produced at geologically slow rates by radiometric and conduction heating but most is likely produced there when additional heat is advected in from the underlying (hotter) mantle by basaltic magma. Then, to two-thirds of the basalt's thickness, an overlying magma of granite magmas at a temperature up to 950°C can form in a scant 200 years, H. E. Huppert and A. W. Woods calculate.[7] Upon its generation, granite magma is prone to become segregated rapidly, not by settling-compaction of phenocrysts, which its viscosity inhibits, but by a kneading of the source rock by directed orogenic-deformation that also focuses the melt flow. Ascent of crystal-poor (<30% of volume) granite magma can be rapid, either through relatively thin conduits or where channeled along shear zones. Emplacement is typically in tabular intrusions (***Figure d27.2***). Room for the incoming magma, which arrives in small batches, is made by a combination of lateral and vertical displacements: for laccoliths, the roof is lifted by flotation; for plutons, the floor is lowered as a result of the decreasing volume of the magma source.[8] The extraction of granite leaves a "basic behind."[9] From below Sierra Nevada, this has sloughed off to the west and its sinking draws in asthenosphere from the east.[10] Dynamically the (sediment accumulating) Tulare Lake basin of San Joaquin Valley is pulled down and the (eroding) Sierra Nevada is tilted up to the east.[11]

Magmatism is not associated with the end phase of the Late Cretaceous Laramide orogeny. Its absence suggests that lower crust and mantle part of the continental lithosphere were melt-drained and had become infertile when, 100-120 million years ago, central Sierra Nevada experienced a "flare-up" of granitoid (about 60% SiO_2) magma emplacement of more than a thousand plutons with regional aggregation thicknesses of 25-30 km.[12] This peak of lower lithosphere en masse magmatism occurred 15-25 million years after the early phase of the Laramide orogeny (documented in datable metamorphic foliation exposed terrains) had fold thickened the California arc. That delay is consistent with estimates by A. F. Glazner and J. M. Bartley in 1985 for geotherms to rebound after initial thrust thickening and later in their rise to cause melting[13] (of what Mihai Ducea in 2001 reasoned must also have been very “melt fertile” lithosphere, “possibly because of an abundance in volatiles”[8]). ❏

Figure d27.1 [14]
The Sierra Nevada (shown in east-west cross section) exposes a granite batholith. Uplift was by tilting. The eastern margin is a great normal fault escarpment which extends 400 kilometers along the eastern edge of the state of California. The western margin is not fault defined but there Cenozoic sediments of the Great Valley of California lap over the eroded upper surface of the Sierra Nevada granite.

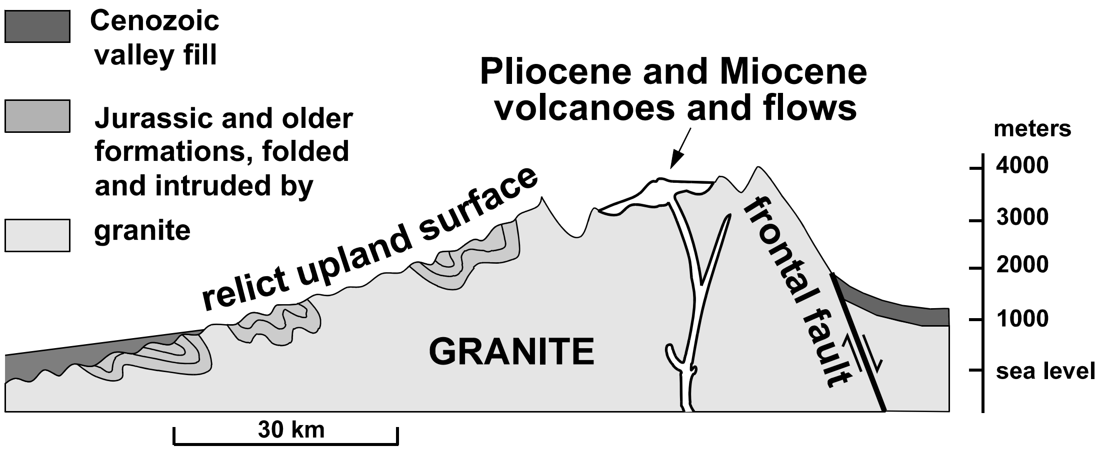
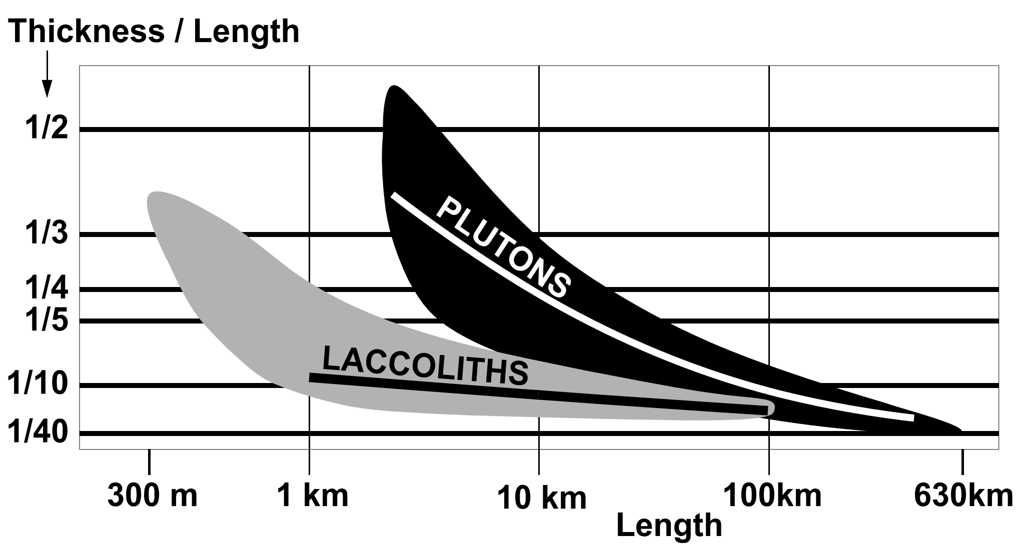


Figure d27.2 [15]
Ranges (shown by shaded fields) of measured thickness to length ratios of some 100 laccoliths and 50 plutons.



Footnote d28.1 The lowest continental elevation on Earth is in the eastern hemisphere where, in the Jordan rift valley, the shore of the drying Dead Sea is 355 m (1,200 ft) below sealevel.