d30 Rocky Mountains

< Neogene epeirogeny, Rocky Mountain peneplain, Laramide orogeny>

The Rocky Mountains (***Figure d30.1***) were raised to their present dramatic heights by epeirogenic uparching during the Neogene. The mountainous scenery is due to differential erosion of the rocks that have been raised. During the uplift, large rivers maintained their courses by rapid downcutting and now flow through mountain ranges in water gaps. Still nearly horizontal Cenozoic sediments and more ancient, underlying, folded and thrust faulted sediments and crystalline basement rocks are exposed in cross section in the valley sides of these rivers. From them, subsequent streams have opened out wide valleys in the more easily eroded parts of the Rocky Mountains.[1] Wind gaps in the mountain ranges have resulted from river piracy by the subsequent streams of major river headwaters.

In the Central and Southern Rocky Mountains, Neogene elevation involved tensional basin and range faulting that is not aligned with previous rock structures. Badland scenery is developed in elevated, but otherwise little deformed, Cenozoic basin-fill sediments.[2] Where Cenozoic sediments have been eroded off the high central portions of the ranges, rocks bearing the stamp of the Laramide orogeny, crop out in exhumed Early Paleogene and Late Cretaceous sceneries.[3]

In Yellowstone National Park, Wyoming, active hydrothermal activity (world famous for Old Faithful) continues today where rhyolitic and some basaltic volcanism erupted in the Quaternary and earlier in the Late Pliocene. Before, and throughout the area of the Cordilleras, great volumes of andesitic lavas and pyroclastic debris erupted during the Oligocene and the Late Eocene. These volcanics in the Yellowstone area (Lamar Valley exposures in the Absaroka Range) buried a succession of petrified forests of a humid subtropical type flora. W. J. Fritz in *Roadside Geology of the Yellowstone Country*, 1985, describes the in-place stumps at Specimen Ridge (27 successive fossil forest layers) and at nearby Specimen Creek (over 50 such layers).[4]

During the Early Eocene, Paleocene, and late Cretaceous, the Laramide orogeny (concluding disturbances of the Mesozoic Cordilleran orogeny) produced several low elevation mountains sceneries in the Rocky Mountains area. Where not exhumed, Laramide mountain scenery is buried by Eocene lake deposits and shed debris (continental alluvial-backfill graded to the coast of the Gulfward retreating Zuni epeiric sea).

In the area of the Central and Southern Rocky Mountains, Laramide compressional basement-buckling created basins, and intermittently raised and maintained blocks of basement above the level of basin-accumulating sediments (***Figure d30.2***).[5] Varicolored river and lake deposits of the Eocene Wasatch Formation are spectacularly exposed in Bryce Canyon National Park, Utah.

To the north and south of this area, the style of the Rocky Mountain Laramide orogeny was a continuation of earlier disturbances. Here, eastward-directed compression, stacked old strata and basement rocks above younger rocks in overfolds and thrust sheets (***Figure d30.3***). On the northeastern flank of the Front Range, eastward Laramide displacement on basement thrust-faults transform, **Eric Erslev** finds, into folds in the overlying sediments.[6]

Uplifted Paleocene volcanic rocks have been carved into the rugged Absaroka Range of Wyoming and Montana, San Juan Mountains of Colorado and New Mexico.

The Paleocene climate of the region was warm and wet overall. Deep weathering, produced bauxites and allowed erosion to mostly keep pace with uplift. Intermountane basins accumulated economically important fossil fuels. For example, the Green River basin is famous for its lake-fish fossils and 600 meter thick lacustrine oil-shales (actually a kerogen-rich limestone) with alternating light and dark colored laminations.[7] These couplets, if they are varves, record summer followed by winter yearly accumulations. If so, counting has shown that over 6.5 million years of undisturbed accumulation is recorded. Natural oil and gas is extracted from the Eocene Wasatch Sandstone formation which at top interfingers laterally with the Green River beds and underlies them.[8] The Powder River basin is famous for the Paleocene Fort Union Formation with its vast reserves of sub-bituminous coal.[9]

Beginning-Paleocene scenery was of rivers meandered across a plain without regard to structures in resistant crystalline basement rocks. This plain, named the Rocky Mountain peneplain by pioneer geomorphologist William Morris Davis (1850-1934), was then everywhere at low elevation except for a few monadnocks.[10] ❑

Figure d30.1 [11] (*see over*)

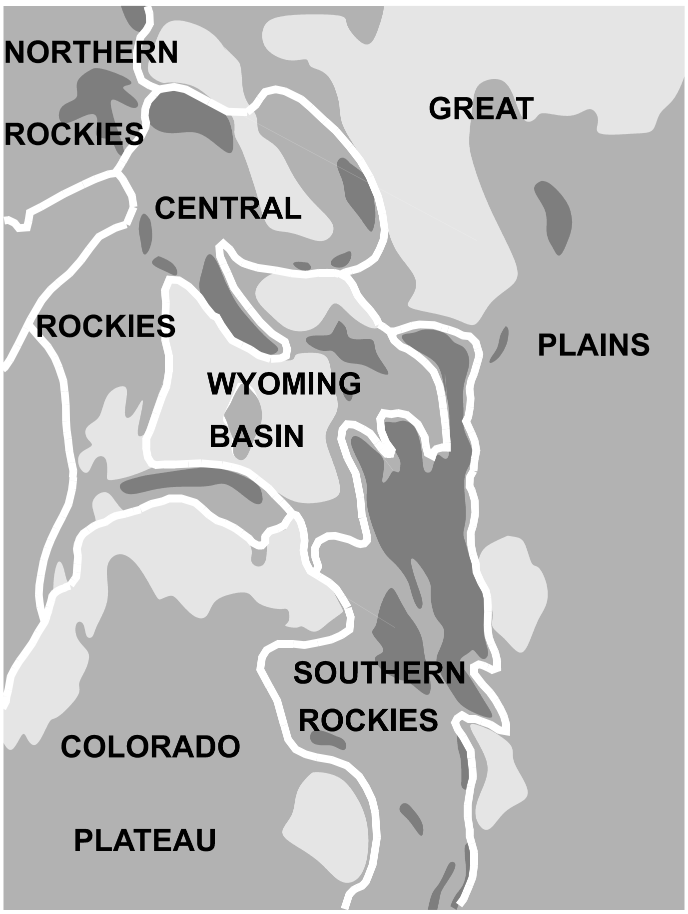

Figure d30.2 [12]
The present topography (the physiographic provinces outlined by white lines) of the Central and Southern Rocky Mountains is due to river erosion of the Rocky Mountain peneplane, which was epeirogenically uparched in the Pliocene. At high elevations are exposures of Precambrian rock (dark gray). These are erosionally truncated crests of Laramide-orogeny raised fault blocks. Early Cenozoic sediments accumulated in basins (pale gray) between.

Figure d30.3 [13] **Cross section of the Northern Rocky Mountains**.
Sedimentary rocks have been folded and thrust eastward by thin skinned tectonics upon a basement of crystalline Precambrian rocks.

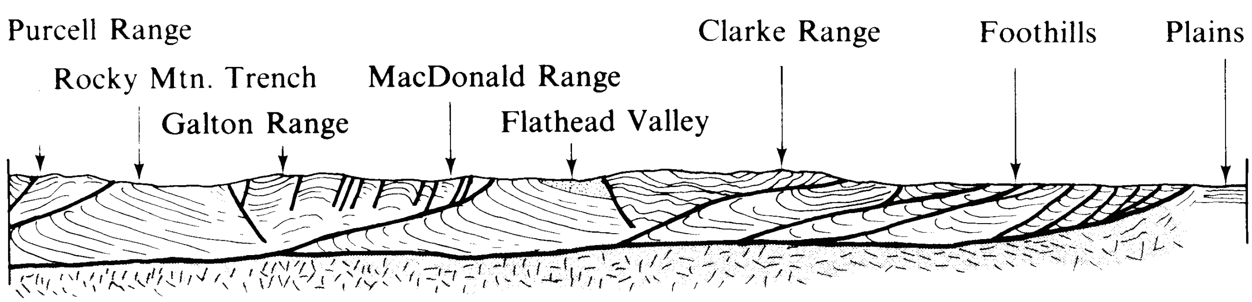

Figure d30.1 **Unraveling the prehistory of the Rocky Mountains**

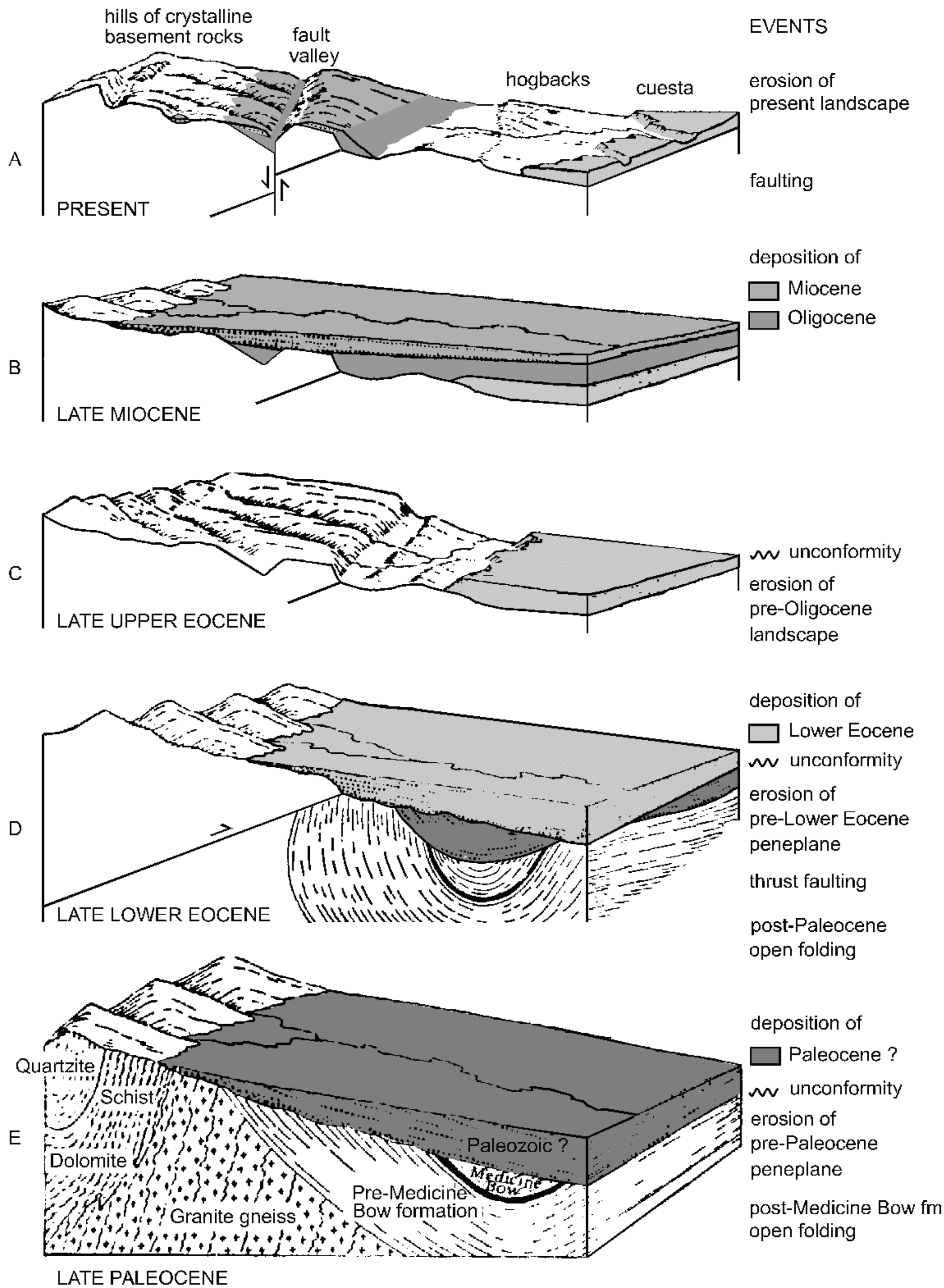

Figure d30.1 cont.

(A) The present erosion cycle is the result of post-Miocene rejuvenating epeirogenic uplift.

To either side of a north trending fault-strike valley are remnant Miocene alluvial sediments. The fault's upthrow on its east has a vertical displacement a little greater than the thickness of the Miocene sediments downthrown on its west. These sediments dip shallowly east on either side of the fault in accord with rejuvenation that tilted the region up toward the west. To this movement, the fault displacement is antithetic.

In the western upland of crystalline rocks, erosion is sculpting east-west valleys across a north-trending line of hills of crystalline basement rocks.

Centrally, erosion is exhuming an earlier lowland scenery with hogbacks of east-dipping strata.

In the east, stream erosion has exhumed a landscape with a west-facing cuesta of Lower Eocene sediment. The river that flows in a water gap east through the cuesta can be judged to be antecedent. River capture, possibly by this river, has left to its south a wind gap through the cuesta.

(B) The Late-Miocene scenery (reconstructed using the principle of lateral continuity) is an alluvial plane built of alluvial sediments prograding east from the range of hills to the west.

(C) A pre-Oligocene erosion cycle of partial exhumation (as is being repeated today) is occurring. In the upland to the west, erosion sculpts hills and east-draining valleys in basement-rock. In the lowland to the east, erosion is working to strip away Lower-Eocene sediments by eroding back the scarped western edge of these. Between upland and lowland, is an eroded-back east facing thrust fault scarp.

(D) The late Lower-Eocene landscape (reconstructed using the principle of lateral continuity and an assumption that the Lower-Eocene alluvial sediments were thick enough to overlap the thrust-fault escarpment) is an alluvial plain prograding east from the ridge of hills to the west. Eastward displacement earlier on the thrust fault, at the beginning of the Early Eocene as a final phase of the Laramide orogeny, could have increased the elevation of the hills of crystalline basement rocks to its west. East of the thrust-fault escarpment, Lower-Eocene sediments bury an angular unconformity.

Pre-Eocene deformation was by folding (Laramide orogeny). A last fold event is recorded by an open fold of sediments of possibly Paleocene age. (The truncated western limb of a syncline of these that plunges shallowly north, is exposed today in the central lowland as the east-dipping hogbacks).

(E) The Paleocene(?) sediments are unfolded and using the principle of lateral continuity an alluvial plain is restored with hills of exposed basement rocks to the west. Paleocene(?) sediments are separated by an angular unconformity from sediments that had been involved in even more pronounced folding (early phase of the Laramide orogeny). This pre-Paleocene folding is recorded by an open syncline (known from oil and gas play drill-core data) of a thick sequence of sediments (the Medicine Bow formation, its basal conglomerate and the conformable underlying Pre-Medicine Bow formation), and the nonconformity on which they rest. The crystalline basement complex is a metasedimentary synform in granite gneiss. The synform has a quartzite core and an outward sequence of schist and dolomite. The erosionally resistant quartzite crops out to build the highest hills in the west.

Reprise

The story of the Rocky Mountains in the Cenozoic is one of repeated uplift of basement complex blocks and times of erosion of lowlands between and infill of these lowlands. The present elevation of the Rocky Mountains is due to post-Miocene epeirogeny. Thrust and open fold mountain building (Laramide orogeny) ceased early in the Paleogene. Hills of erosionally resistant quartzite in the west have been persistent features of successive landscapes.