Geologic Setting of Table Mountain Boulder County, Colorado

Table Mountain is a plateau of approximately two square miles. It rises about 250 feet (~75 meters) above lands to the east, and 100 feet (~30 meters) above lands west of the plateau. Whereas it appears to be flat-topped, there is a gentle 0.85° tilt at the surface (1 foot vertical in 66 feet horizontal) from SW to NE. Table Mountain is the remnant of an erosional surface and an alluvial fan, called a pediment, which formed from an older alignment of Left Hand Creek when it exited the mountains west of Niwot/Nebo Road in glacial times. It is an example of inverted topography.

Table Mountain

Figure 1

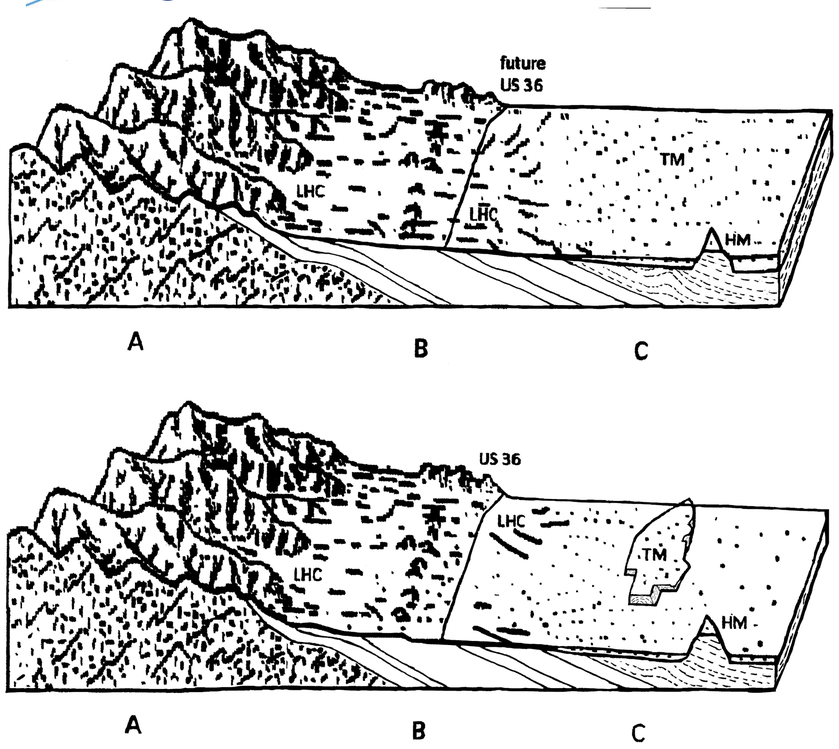


Figure 1. Generalized elements of pediment formation and local cross section: A) Dissected zone, here the Rocky Mountain Front Range; B) Pediment with residual reliefs, here are near US 36; C) Mantled pediment and beginnings of alluvial fan, here Table Mountain (TM) and other nearby surfaces. HM = Haystack Mtn. LHC = Left Hand Creek at mouths at mountains and Front Range. Dotted lines suggest drainage directions. Hatched lines under HM represent Pierre Shale. Figure is not to scale. (Modified after Gutiérrez (2005) Figure 15.7 and Braddock, *et al,* (1988) B-B' profile)

Underlying Geology

The Laramide Orogeny (~65 mybp) uplifted the core of the modern Rocky Mountains, exposing Precambrian crystalline rocks and leaving overlying Paleozoic and Mesozoic sedimentary rocks exposed as the dipping outcrops (hogbacks) of the Front Range. There is some normal faulting visible west of Table Mountain. The sedimentary rocks dip to the east an average of 20° into the Denver Basin (**Figure 1**); however, there are numerous folds and faults which can change local dips exposed at outcrops. For example, the Cretaceous Niobrara Formation outcropping near the intersection of US 36 and Neva Road dips about 70°. The brown sandstone commonly used as building stone in the area (warehoused at the intersection of US 36 and Plateau Road, and at US 36 and CO 66) is the Permian Lyons Sandstone. The upper Cretaceous Laramie Formation, which surfaces miles east of Table Mountain, was a major source of shallow coal. Its mining gave birth to cities such as Erie, Lafayette, and Louisville. There was Paleocene intrusive activity, as witnessed by the vertical Valmont Dike in east Boulder, and some bedding-plane sills a mile west of US 36, just west of Table Mountain.

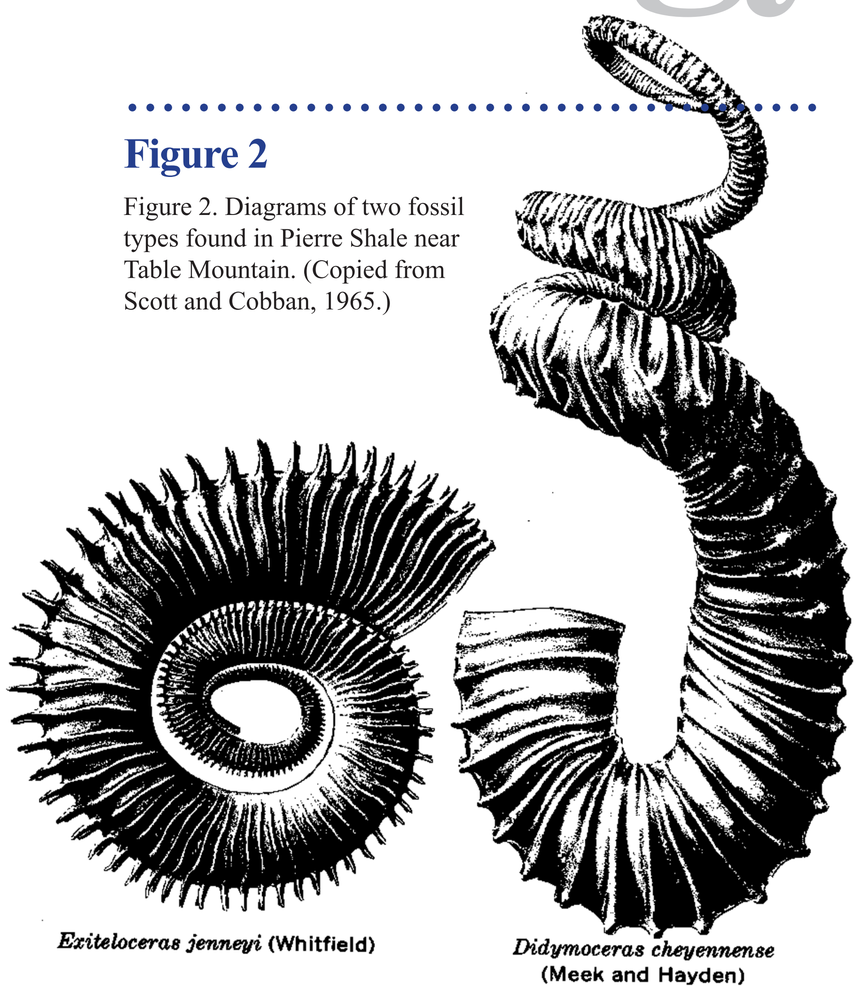
The upper Cretaceous Pierre Shale Formation immediately underlies the pediment material of Table Mountain, in particular the Middle Shale member and the Hygiene Sandstone member. The Hygiene member outcrops north of the Table Mountain north gate at Nelson Road. The Pierre Shale is an olive-gray shale with interbedded sandstone layers, locally with ironstone concretions and limestone concretions. The Pierre Shale formed in the shallow seas of the Western Interior Seaway, and it is a very thick formation (~8000 ft ≈ 2400 m), internally mapped biostratigraphically. Numerous ammonites have been discovered, notably genera Baculites, Inoceramus, and Didymoceras (**Figure 2**). Some were found along the east and north edges of Table Mountain. Other plant and animal (e.g. clams) fossils have also been found. The ironstone may have formed in bogs or under the sea, and was the basis for some historical foundries (e.g. Eldorado Springs area).

The south edge of Table Mountain is over the north end of the Haystack Mountain Anticline which runs southward to the Boulder Reservoir. Ironically, Haystack Mountain is not over any part of the anticline. This anticline is likely only in the Pierre Shale.

The Pierre Shale—named for the city of Pierre, South Dakota—has low permeability (tight to water) in its buried state. However, exposed to weathering, its clays (bentonite) can swell significantly, and it will erode easily. The shale under Table Mountain (probably the Hygiene Sandstone member) is protected from most weathering and remains stable, whereas in surrounding areas, the shale, which was originally the uplands, has eroded to levels below Table Mountain (inverted topography).

Figure 2

Figure 2. Diagrams of two fossil types found in Pierre Shale near Table Mountain. (Copied from Scott and Cobban, 1965.)



Surficial Geology

Left Hand Creek, and it tributary James Creek, drain the local mountains in roughly an easterly direction (oddly oblique to major, mapped faults) at a latitude corresponding to Niwot or Nebo Road. When it reaches the valley west of the Front Range (Olde Stage Road corridor), the creek diverts north and exits mountains just west of Plateau Road (after merging with Geer Canyon Creek). It is believed the major drainage did not divert, but rather emptied into plains just north of the old Ball Aerospace facility.

During the melting of various glacial advances during the Pleistocene, large amounts of rock and sediment (mostly of crystalline origin) were eroded from the mountains and transported eastward. The current creeks are mere vestiges of their glacial versions. After the creeks exited hard crystalline rocks of the mountains, they eroded the Pierre Shale and other local sedimentary rocks to a sub-planar surface (i.e. the pediment). Alluvial fans formed within the valleys of the paleo-topography, generally east of the pediment (see **Figure 1**). The distributary channels in a fan shift (horizontally) frequently to dump their sediment load most easily. A thin layer (~10 to 30 feet thick) of these sediments was also left atop the pediment rocks. The resulting sediments are generally unsorted with respect to grain (or cobble) size, although there will be limited areas of well-sorted material, such as from a sandbar. During inter-glacials, when the semi-arid climate returned, calcium carbonate precipitated out of stream or rain waters and formed a weak cement between the sand grains, called caliche. The resulting pediment is very porous, permeable, and weakly cemented. Subsequent rain waters quickly drain through the material while eroding very little of it. As mentioned above, the pediments remain stable, while weatherable rocks forming the valley walls erode, leaving the pediments as inverted topography.

Other local pediments left as mesas include Table Mesa (NCAR) and Kohler Mesa (behind the Department of Commerce facility) in Boulder, Table Top Mountain north of Hygiene, and the flat areas north and west of Table Mountain. There are at least five pediment levels mapped locally. Haystack Mountain represents the highest and oldest level (Nebraskan glaciation). It is the highest, since the surrounding geology had yet to erode down. Table Mountain represents the second oldest level (Kansan glaciation). Note that the two Table Mountains east of Golden are capped with volcanic rock and are not pediments.

In May 1993, two wells were drilled at the Table Mountain Geophysical Observatory, which this author logged. Cuttings are available. The top 15 feet were dry sand and gravel. The next 10 feet were moist sand and gravel. These 25 feet are the pediment at this site. It is expected that the thickness of the pediment can vary ±10 feet elsewhere on Table Mountain.

During the spring of 1993, there was a great deal of rain. The 10 feet of moisture was a perched water-table, not always present on Table Mountain. Gravimeter readings were high that spring, reflecting the added mass of the ground water. Typically, rain water (and snow melt) drain into the pediment, hit the aquiclude of the shale, and move off horizontally, coming out as temporary springs, or going into perimeter canals. In the well, from 25 feet to 36 feet, a brown, sandy shale was encountered. This shale may have been the bottom of the Hygiene Sandstone member or a weathered section of generic Pierre Shale. From 36 feet to the bottom of the well at 100 feet, dry Pierre Shale was encountered.

Compiled by D. Winester, NOAA-NGS, August 2009.

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Surficial Geology