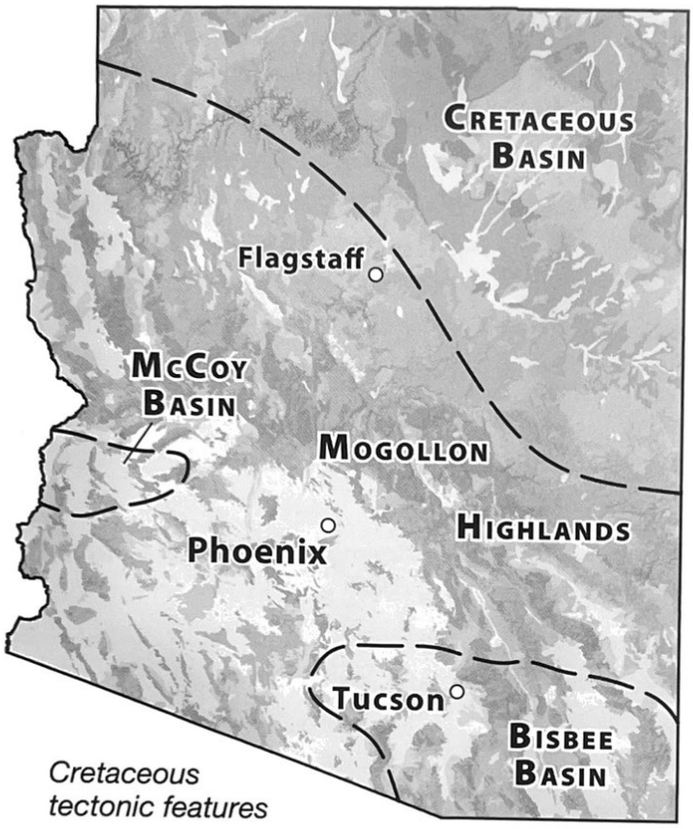
Cretaceous History

The Cretaceous Period, from 145 to 66 million years ago, was a time when basins formed in three different parts of the state (▾). In the latest Jurassic and Early Cretaceous, the Bisbee Basin formed in southeastern Arizona, likely in response to rifting that accompanied the opening of the Gulf of Mexico far to the southeast. The resulting unit, the Bisbee Group, contains nonmarine rocks as well as the marine-deposited Mural Limestone in the middle of the sequence. Formation of the basin was accompanied by faulting that uplifted the flanks of the basin. Steep mountain fronts shed coarse debris along the flanks, as represented by the Glance Conglomerate, the oldest unit of the Bisbee. The broad, northwest-trending Mogollon Highlands likely represented uplift on the flanks of the rift due to thermal effects and normal faulting in the basin.



Cretaceous tectonic features

In west-central Arizona, an east-west basin formed and accumulated miles of sediments that formed the McCoy Mountains Formation. The upper part of the formation is Late Cretaceous, but the lower parts are not as well dated and could overlap in age with the Bisbee Group and reflect similar events. An unconformity separates these two parts. The middle part of the McCoy consists of a thick, cobble-bearing conglomerate that is interpreted to be deposited in front of the Maria fold-and-thrust belt (discussed later in this introductory section).

In middle Cretaceous time, a third basin formed in northeastern Arizona as part of the Western Interior Seaway that connected the Arctic Ocean to the Gulf of Mexico. Marine and shoreline-related rocks were deposited across most of northeastern Arizona, barely reaching parts of east-central Arizona. They are best exposed around Black Mesa, south of Kayenta.

The Bisbee Group is latest Jurassic to Cretaceous and consists of four main formations (from bottom to top): the Glance Conglomerate, Morita Formation, Mural Limestone, and Cintura Formation. The fossil-rich, marine Mural Limestone (▾) is the most easily recognized unit from the highways because it produces gray cliffs and ledges. The Mural contains abundant marine fossils, like bivalves. The Morita and Cintura are dominated by fine-grained sedimentary rocks and sandstones. They can be hard to tell apart from a distance, unless the Mural is nearby to indicate if the unit is above or below the limestone.

Mural Limestone, Mule Mountains near Bisbee

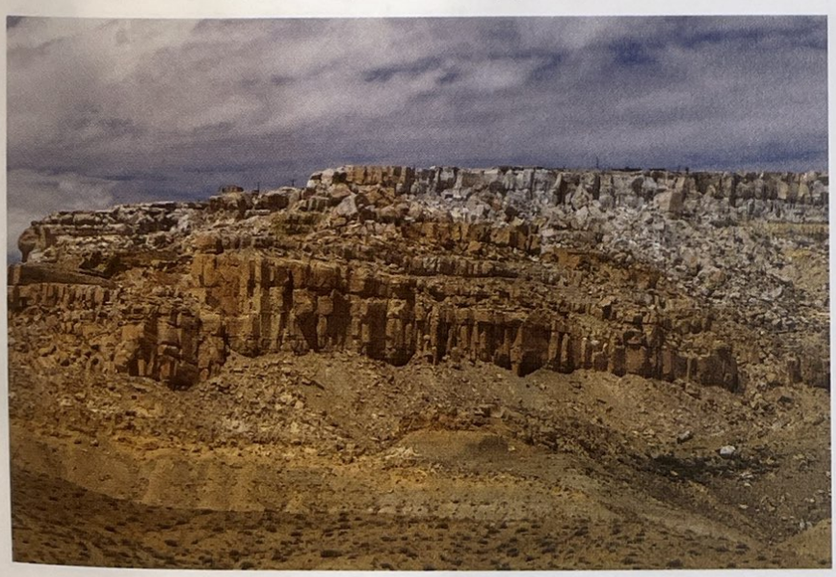
The thickest post-Jurassic unit in the region is the McCoy Mountains Formation, which is only exposed in west-central Arizona (▾). This section of highly deformed clastic rocks is up to 4 miles thick and is mostly sandstone and siltstone with a thick conglomerate in the middle. The formation composes nearly all of the central Dome Rock Mountains and nearby Livingston Hills, and equivalents are exposed elsewhere. Lower parts of the formation are poorly dated and are possibly Late Jurassic, but the upper parts are Late Cretaceous.

McCoy Mountains Formation, Livingston Hills near Quartzsite

The oldest Cretaceous unit on the Colorado Plateau is Dakota Sandstone, which was deposited along shorelines as the Western Interior Sea advanced across the land. The sandstone forms brownish-tan cliffs, such as the one capping this ridge (◂). The underlying lighter-colored sandstones are the Jurassic Morrison Formation. The contact between the two units is a major unconformity, probably formed during uplift of the Mogollon Highlands to the south. The upper Morrison was eroded away prior to deposition of the Dakota.

Dakota Sandstone over Morrison Formation, US 160 milepost 386

On the Colorado Plateau, the youngest Cretaceous unit is the Mesaverde Group, which caps Black Mesa and the Hopi Mesas (▾). The units are mostly tan- and brown-weathering sandstones that form ledges, in addition to gray shale and coal. The Mesaverde Group is Late Cretaceous and represents sediment deposited on either side of the shoreline of the Western Interior Sea as it withdrew from the region. Below the ledges are gray slopes formed by Cretaceous Mancos Shale, which represents marine muds deposited by the shallow sea.

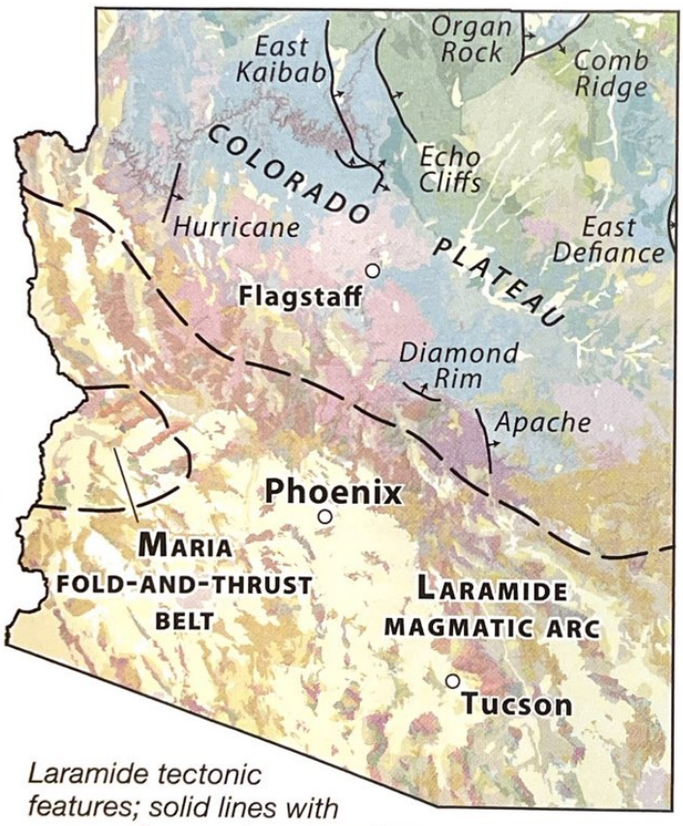


Mesaverde Group and Mancos Shale, AZ 99 milepost 383

Latest Cretaceous–Early Cenozoic (Laramide) History

In latest Cretaceous time, global tectonic events caused an increase in the rate of convergence along the west-coast subduction zone. This and other aspects of the down-going plate caused the angle of subduction to progressively decrease with time from 80 to 45 million years ago. This time interval was marked by widespread magmatism and regional compression of the Laramide orogeny. The magmatic arc entered southwestern Arizona at about 80 million years ago and had swept eastward across the state and into New Mexico by 55 million, eventually reaching west Texas.

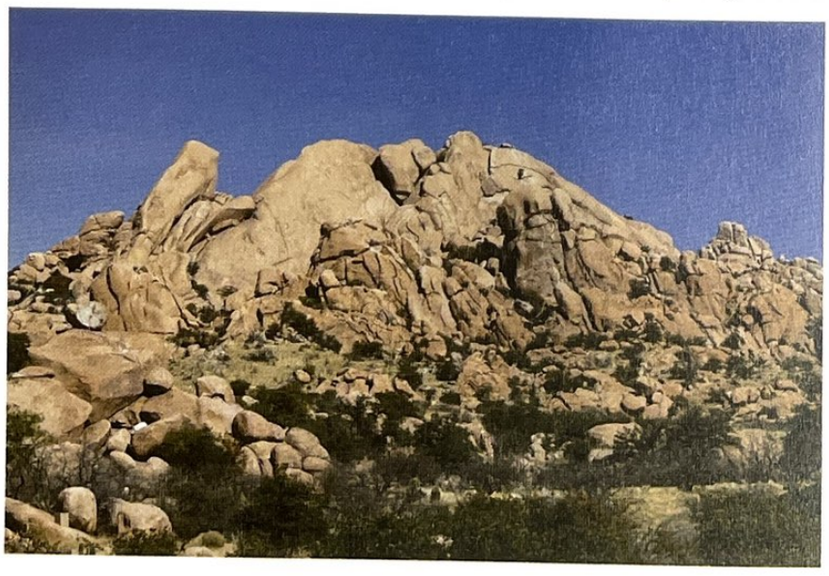
In Arizona and New Mexico, Laramide magmatic intrusions brought with them copper and other metals that formed large copper deposits. Laramide volcanic rocks are also present, especially in southeastern Arizona. Western Arizona was uplifted relative to other parts of the state, so the volcanic cover was stripped away, exposing the underlying plutons. One cause of this uplift was probably the Maria fold-and-thrust belt, an east-west zone of thrust faults, folds, and metamorphosed rocks in west-central Arizona (◂). Compression on the Colorado Plateau formed monoclines and other folds as layers draped over the edges of fault-bounded basement blocks that were uplifted or down-dropped. Arrows on the monoclines show the dip direction within each fold.



Laramide tectonic features; solid lines with arrows show major monoclines

Laramide sedimentary rocks exist in southern Arizona but are largely absent on the Colorado Plateau and Transition Zone. The Transition Zone and nearby parts of the Basin and Range were part of an uplifted area that was higher in elevation than the Colorado Plateau. Streams flowed from the Transition Zone and Basin and Range onto the plateau.

A major pulse of subduction-related magmatism occurred during the Laramide orogeny. The resulting intrusions form large parts of mountain ranges in southwestern and southeastern Arizona and are widely exposed because a major episode of uplift accompanied and followed the Laramide orogeny. Such plutons commonly form landscapes with rounded masses (◂). A distinct series of late Laramide, muscovite- and garnet-bearing granites were formed when the subducted slab beneath Arizona was nearly horizontal, causing lower parts of the continental crust to melt and produce these unusual granites.



Texas Canyon pluton near I-10 milepost 319

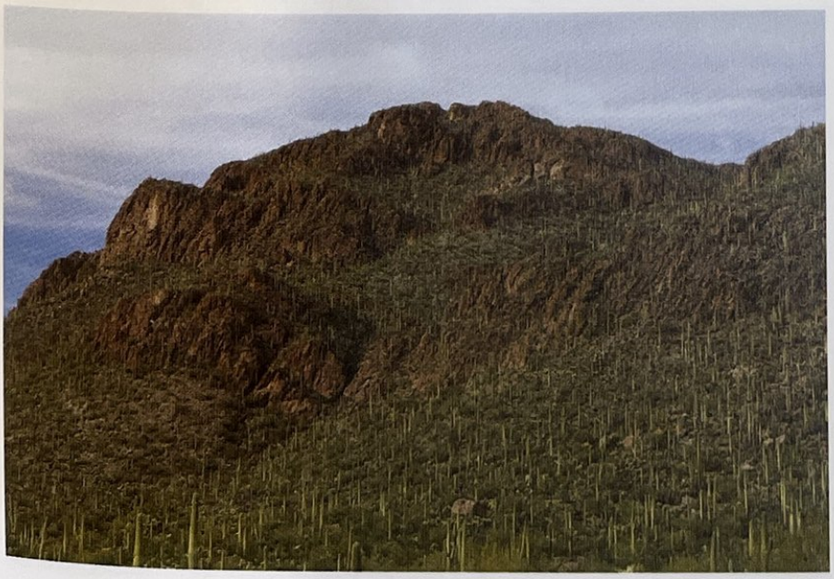
An important component of many Laramide igneous systems are porphyries, igneous rocks that have larger crystals in a fine-grained matrix (▾). The texture in a porphyry reflects growth of some crystals at depth followed by rapid cooling of the remaining magma, which solidifies as the matrix surrounding the already well-formed crystals. Porphyries are associated with Arizona's largest copper mines, which are called porphyry copper deposits because of this close association. Porphyries are exposed as dikes along some southern Arizona highways.

Porphyry in the Copper Creek deposit near San Manuel

Associated with many Laramide intrusions, especially those near copper mines, were hot fluids that carried copper and other metals, in addition to sulfur. Flow of such hydrothermal fluids was channeled along fractures, causing pyrite and other sulfur-bearing minerals to be deposited within or adjacent to the fractures. Later oxidation of the minerals produces staining in shades of orange, red, and brown, or the blue-green colors of oxidized copper minerals. Here (◂), such stains are concentrated along several fractures.

Mineralized intrusion, Copper Creek deposit near San Manuel

Many Laramide magmas reached the surface, producing Laramide-age volcanic units. The oldest Laramide volcanics are generally dark-gray andesite. Younger than the andesites are tuffs, with both welded and nonwelded versions. Thick sequences of tuff accumulated in large calderas, as in the Tucson Mountains (◂), and in thinner sheets outside the calderas. Within the calderas, ash infilled fractures in the underlying andesites and in blocks of various older rocks that fell into the caldera from caldera walls.



Cat Mountain Tuff, Tucson Mountains from Gates Pass Road