UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

COLORADO PLATEAU PROJECT
TRACE ELEMENTS MEMORANDUM REPORT 301

STRUCTURAL SETTING OF THE COLORADO PLATEAU
By E. M. Shoemaker

The accompanying map was compiled to show the major structural features of the Colorado Plateau, in order to obtain a better understanding of the structural environment of the uranium deposits of the Colorado Plateau. The work was done as part of a program conducted by the Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

The main structural features of the Colorado Plateau may be classified into two types: (1) deep seated structures reflecting deformation in the basement rocks and (2) shallow structures caused by movement and intrusion of plastic materials in the layered sedimentary mantle. To the first group belong the great monoclinal upwarps and intervening basins, the large domes surrounding stock centers of the laccolithic mountains, and also volcanic plugs, calderas, and explosion vents. Shallow structures are represented by laccolithic anticlines and by salt anticlines. Extensive faulting and jointing is associated with all of these structures.

Monoclinal deformation has taken place at different times and has been due probably to different systems of stress on the west and east sides of the Colorado Plateau. Monoclines on the west side of the Plateau were developed mainly, if not entirely, before deposition of Eocene formations. Their folding appears to have involved crustal shortening, and therefore they were produced probably under lateral compressive stress. Monoclines on the east side of the Plateau are of diverse nature and probably have undergone repeated deformation. Folding along the Grand Hogback has involved Eocene formations, and uplift of the Uncompahgre positive element has been repeated probably as late as the Pleistocene. Low-angle thrust faulting is known along the Gunnison uplift; whereas the steep west front of the Uncompahgre is characterized by systems of grabens. With minor exceptions, monoclines on the west side of the Plateau dip eastward and monoclines on the east side of the Plateau dip westward.

Each of the laccolithic mountain groups on the Plateau occupies a broad structural dome 5 to 20 miles in diameter. These domes are distributed without apparent regard for the other major structural features of the Plateau. The volume increase accompanying development of the mountain domes can be accounted for by the volume of the stocks at their centers. It seems likely, therefore, that the domes were developed by the vertical thrust of the intruded stocks. Deformation probably involved doming of the basement rocks as well as the overlying sedimentary rocks.

Small anticlines radiating from the stocks have been produced by laccolithic injections on the flanks of the mountain domes. These injections range from 1 to 4 miles in length and half a mile to 3 miles in width. Both linear bulges and dikes on the roofs of the laccoliths radiate from the central stocks. The laccoliths are generally concordant but gradually cut upward in the section toward their distal ends, where on some laccoliths the roofs are faulted upward to form bysmaliths.

Volcanic plugs, calderas, and explosion vents are represented best in northeastern Arizona. Volcanic plugs are of two types, feeders composed of dense igneous rock, and crater fillings composed of tuff-breccia. The plugs are surrounded by cone sheets, arcuate vertical dikes, radial dikes or are alined along parallel dikes. Calderas or caldron subsidences are small, ranging from half a mile to 2 miles in diameter. Explosion vents are localized areas injected with fragments of basement and sedimentary rocks from depth rather than igneous rock; they range from small clusters of rootless dikes to elliptical areas of complex faulting half a mile across.

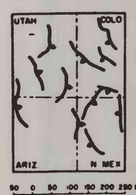
Between the eastward-dipping monoclines on the west side of the Plateau and the westward-dipping monoclines on the east side of the Plateau lie the northwest-trending salt anticlines. Masses of salt, gypsum, and shale from the Paradox member of the Hermosa formation of Pennsylvanian age have intruded Pennsylvanian, Permian, and Triassic sedimentary formations. These intrusive masses were formed in the Permian, but their upward movement continued until late Jurassic time. The resulting structures also localized post-Cretaceous regional deformation, which accentuated the old structures and developed broad anticlines in the overlying Jurassic and Cretaceous rocks. The crests of the anticlines subsequently collapsed because of the removal of salt by solution and of the flow of the plastic rocks in the intrusive masses during a late Tertiary to Recent epoch of canyon cutting.

Concentric patterns of folds in the intrusive salt-gypsum masses and the trends of arcuate collapse faults in the rocks above the intrusive masses show that in places the salt, gypsum, and shale were intruded as roughly circular and elliptical plugs. Individual plugs range from half a mile to about 4 miles across. Large intrusive masses underlying Sinbad Valley and Paradox Valley are composites of several distinct plugs. Some of the salt masses have a vertical dimension of at least 10,000 feet.

Along the Sinbad Valley-Fisher Valley anticline, Salt Valley anticline, Moab Valley anticline, and the Castle Valley-Paradox Valley anticline, individual plugs and composite masses of salt and gypsum are strung out like beads on a string. These masses are probably connected at depth to an elongate roll of salt and gypsum along the length of the anticline. The separate intrusive masses may be thought of as cupolas extending up from the underlying salt-gypsum roll.

The probable sequence of Cenozoic structural events is as follows:

1. Pre-Eocene monoclinal folding on the west side of the Plateau.
2. Anticlinal folding in the salt plug region, possibly contemporaneous with monoclinal folding on the east side of the Plateau.
3. Normal faulting in the central part of the Plateau along northwest trends contiguous with the salt anticlines.
4. Injection of stocks and laccoliths. Injection of sheetlike plugs and dikes in the extreme northern and western parts of Arizona may be contemporaneous with the laccolithic period of volcanism.
5. Late Tertiary volcanism and faulting on the borders of the Colorado Plateau, and epirogenic uplift of the entire Plateau.
6. Renewed uplift and faulting during the Pleistocene, as along the Uncompahgre uplift. Excavation of valleys along the salt anticlines accompanied by faulting along the crests and flanks of the anticlines.



INDEX MAP SHOWING TREND AND DIRECTION OF DIP OF MAJOR MONOCLINES

EXPLANATION

Source of map data

Structure contours

Baker, A. A., 1946, U. S. Geol. Survey Bull. 951, pl. 20

Babenroth, D. L., and Strahler, A. N., 1945, Geomorphology and structure of the East Kaibab monocline, Arizona and Utah: Geol. Soc. Amer. Bull., vol. 56, pls. 2,5, and 7

Darton, N. H., 1925, Arizona Bur. Mines Bull. 119, pl. 52

Compiled by E. M. Shoemaker from original work and published and unpublished maps from many sources

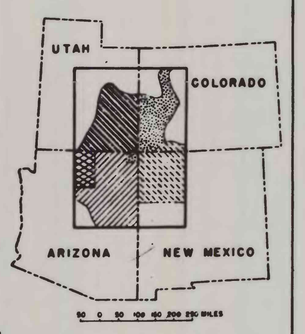
Silver, Caswell, 1950, Guidebook of the San Juan Basin, New Mexico and Colorado: New Mexico Geol. Soc., Pg. 6

Igneous rocks

Compiled from state geologic maps of Utah, Arizona, Colorado, and New Mexico

Salt structures

Compiled by E. M. Shoemaker mainly from original work



INDEX MAP SHOWING SOURCE OF STRUCTURE CONTOURS

EXPLANATION

Map

Tertiary volcanic rocks

Tertiary intrusive igneous rocks

Intrusive masses of salt and gypsum

Thickened rolls of salt and gypsum, not intrusive beyond normal stratigraphic positions

Structure contours dashed where approximately located

Fault, dashed where approximately located

Structure contour interval 500 feet
Datum is mean sea level

10 0 10 20 MILES

TECTONIC MAP OF THE COLORADO PLATEAU

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This map is preliminary and has not been edited for conformity with U. S. Geological Survey standards and nomenclature.