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GEOLOGY OF THE SEDIMENTARY ROCKS OF THE MORRISON QUADRANGLE COLORADO

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MISCELLANEOUS GEOLOGIC INVESTIGATIONS
MAP I-428

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The Morrison quadrangle is in Jefferson County, about 10 miles west of Denver, Colo. The rugged western one-third of the quadrangle along the eastern flank of the Front Range is underlain by Precambrian crystalline rocks. The eastern two-thirds, with which this account is concerned, lies in the Colorado Piedmont section of the Great Plains and is underlain by sedimentary rocks. Prominent topographic features on the plains include (1) the long sinuous hogback formed by the Dakota Group; (2) South Table Mountain, a broad relatively flat mesa at the north edge of the quadrangle; (3) Green Mountain, a broad gently rounded conspicuous eminence in the east-central part of the quadrangle; and (4) Mt. Carbon, a flat-topped remnant of a middle Pleistocene pediment south of Bear Creek. The principal streams—Clear Creek, which crosses the northwest corner of the quadrangle, and Mount Vernon and Bear Creeks—have cut deep canyons in the Front Range. Clear Creek and Bear Creek flow eastward from the mountain front across the sedimentary rocks of the Piedmont and into the South Platte River, but Mount Vernon Creek is diverted by the hogback formed by the Dakota and empties into Bear Creek at Morrison.

The author has benefited from many discussions with Richard Van Horn. Dr. H. D. MacGinitie of Humboldt State College contributed helpful suggestions concerning the Cretaceous-Paleocene boundary and identified fossil leaves from the Denver and Green Mountain Formations. The Cretaceous invertebrate fossils were identified by W. A. Cobban, and the zones of the Pierre Shale were mapped by G. R. Scott. Scott and Cobban collected most of the fossils by which the zones of the Pierre Shale were mapped.

Geologic observations in this area were made as early as 1869 by the Hayden Survey, but the earliest comprehensive geologic study was made by Emmons, Cross, and Eldridge (1896). More recent studies were made by Johnson (1931) on paleontology, Lovering and Goddard (1938) and Waldschmidt (1939) on the Table Mountain flows, LeRoy (1946) and Van Horn (1957) on general geology, Brown (1943) and Reichert (1954) on the Tertiary sedimentary rocks, Waagé (1955) on the Dakota Group, Scott and Cobban (1959) on the Pierre Shale, Maughan and Wilson (1960) and Hubert (1960) on the Fountain and Lyons Formations, and Berg (1962) on the Golden fault.

The bedrock of the Morrison quadrangle comprises Precambrian metamorphic and intrusive rocks, which were not mapped, sedimentary rocks of Paleozoic and Mesozoic age, and sedimentary rocks and interbedded volcanic flows of early Cenozoic age. These rocks are mantled by alluvium and colluvium of Quaternary age. The sedimentary rocks consist of 15 formations that range in age from Pennsylvanian to Tertiary (table 1) and have a combined thickness of about 13,000 feet. The contact of the Precambrian crystalline rocks with the overlying Fountain Formation is sharply unconformable, and locally the crystalline rocks beneath it are deeply weathered.

Paleozoic sedimentary rocks.--The Paleozoic is represented by the Fountain Formation, Lyons Sandstone, and part of the Lykins Formation. The Fountain and Lyons are resistant to erosion and form bold outcrops. The contact between them is gradational, the characteristic lithologies of the two formations interfingering within a 30-foot transition zone. The Lykins Formation was subdivided by LeRoy (1946) into three shale members separated by two thin limestone members. The uppermost or Strain Shale Member constitutes about two-thirds of the formation; its upper part is of Triassic(?) age. Most of the Lykins is not resistant to erosion, and, except for the Glennon Limestone Member, forms a broad valley. The Glennon forms a narrow sharp hogback. The basal contact of the Lykins probably is disconformable. The Lykins is the brightest red bed in the quadrangle.

Mesozoic sedimentary rocks.--Rocks of Mesozoic age include those from the upper part of the Lykins Formation to the lower part of the Denver Formation. The lower contact of the Ralston Creek Formation is not exposed but is disconformable in adjoining areas. The disconformity marks a hiatus encompassing Early, Middle, and part of Late Jurassic time. The Ralston Creek locally forms a low ridge. The Morrison Formation forms a steep smooth slope interrupted by small ledges of sandstone and limestone. A basal sandstone of the Morrison locally lies in channels in the Ralston Creek Formation and indicates a minor unconformity. Near Morrison, the formation has yielded many fossil bones of giant dinosaurs (Marsh, 1877).

The Dakota Group was divided by Waagé (1955, p. 18-19) into the Lytle and South Platte Formations, and the South Platte was subdivided into five members. Although all these units are recognizable locally in the Morrison quadrangle, they were not mapped separately. Almost the entire group is exposed along the Alameda Parkway, but elsewhere exposures are incomplete. The basal contact is disconformable, the lowermost conglomerate beds of the Lytle lying in channels cut into the Morrison. Sandstone units in the Dakota Group form a prominent hogback.

The Benton Shale contains recognizable equivalents of the Graneros Shale, Greenhorn Limestone, and Carlile Shale but was mapped as a single unit because of poor exposures. The Benton forms a broad eastward-sloping belt between the hogback of Dakota and one made of limestone at the base of the Niobrara Formation. The Benton is conformable and transitional with the underlying Dakota.

The Niobrara Formation is divided into the Fort Hays Limestone and Smoky Hill Shale Members. The Fort Hays forms a small sharp hogback, and chalk beds in the middle and at the top of the Smoky Hill form low ridges locally. The basal contact of the Niobrara is disconformable. Johnson (1930, p. 789) reported phosphatic nodules and other evidence of a disconformity near Pueblo, Colo., and Cobban and Reeside (1952, p. 1029 and chart 10b) showed that several fossil zones known in other areas are absent at the contact along the Front Range.

The Pierre Shale, by far the thickest formation in the quadrangle, is easily eroded and poorly exposed, although a part of the Hygiene Sandstone Member, in the middle part of the formation, locally forms a hogback. The Pierre grades into the underlying Niobrara. A persistent ledge-forming limestone bed is regarded as the top of the Niobrara, and nearly 100 feet of calcareous shale above it is assigned to the Pierre. Faunal zones within the Pierre Shale have been depicted on the map with the aid of W. A. Cobban and G. R. Scott. In order of increasing age, these zones are:

- Baculites clinolobatus Elias
- Baculites grandis Hall and Meek
- Baculites baculus Meek and Hayden
- Baculites eliasi Cobban
- Baculites cuneatus Cobban
- Didymoceras cheyennense (Meek and Hayden)
- Didymoceras stevensoni (Whitfield)
- Didymoceras nebrascense (Meek and Hayden)
- Baculites scotti Cobban
- Anapachydiscus complexus (Hall and Meek)
- Baculites gregoryensis Cobban
- Baculites perplexus Cobban
- Baculites asperiformis Meek (called B. obtusus in the broad sense in the adjoining Indian Hills quadrangle)

The Fox Hills Sandstone makes a low hogback at several places. Thick-bedded sandstone characteristic of the Fox Hills is transitional downward into the Pierre, which contains sandstone layers in its upper part. The Laramie Formation is well exposed in large clay pits and forms the most prominent hogback east of the Dakota Group. The basal contact is unconformable. In places where the formation is thin, claystone beds are missing from its upper part and evidently were eroded before the Arapahoe Formation was deposited.

The Arapahoe is well exposed only south of Green Mountain where the basal conglomerate beds make a low ridge. The upper beds are well exposed in a gully south of the Alameda Parkway. The basal contact is disconformable, conglomerate of the Arapahoe abruptly succeeding the claystone and sandstone of the underlying Laramie. The conglomerate is regarded as an orogenic deposit derived from the rising Front Range on the west. The Denver Formation is exposed only on steep slopes and in gullies. The base of the formation is selected at the base of the lowest bed containing andesite pebbles and probably is disconformable.

Cenozoic rocks.--Rocks of Cenozoic age consist of the upper part of the Denver Formation and the Green Mountain Conglomerate of LeRoy (1946). The upper part of the Denver Formation includes interbedded flows of latite, which form a gently sloping cap on South Table Mountain. To the north, in the adjoining Golden quadrangle, Van Horn (1957) distinguished three such flows, but only the two he designated as numbers 2 and 3 are present in the Morrison quadrangle. The Green Mountain Conglomerate crops out only on the upper slopes of Green Mountain. The base of the formation is marked by trees which grow there because water seeps from the conglomerate. The basal contact probably is conformable and is marked by a change in the composition of the gravel, from predominantly andesitic in the Denver to predominantly granitic in the Green Mountain.

The Morrison quadrangle is on the east limb of the large north-trending Front Range anticline. Sedimentary rocks therefore dip sharply eastward at the mountain front, but they flatten abruptly eastward and generally dip gently beneath the plains (section A-A').

The Golden fault.--The Golden fault, the most prominent in the area, crosses the quadrangle from northwest to southeast. It is a reverse fault that dips west at an angle of 45°, or more, and has a predominantly dip-slip component of movement. The fault locally includes wedges of sedimentary rock. Minor branch faults extend northwest from the main fault and one can be traced into the Precambrian rocks. Strata on both sides of the fault commonly are overturned.

Stratigraphic throw of the fault decreases from 8,000 feet where the Fountain is against the Pierre, at the north edge of the quadrangle, to 0 near Mt. Carbon, where the fault is in the Pierre and all the faunal zones of the Pierre are present. From Mt. Carbon northward, the fault roughly parallels the uppermost or Baculites clinolobatus faunal zone but cuts stratigraphically downward across the older faunal zones, and finally, across older formations.

The complicated nature of the Golden fault is shown on cross section B-B', which depicts the stratigraphic section penetrated in the S. D. Johnson, 1 Lillie Pallaoro well in sec. 7, T. 5 S., R. 69 W., and the Great Basins Petroleum, 1 Pallaoro dry hole in sec. 6, T. 5 S., R. 69 W. The S. D. Johnson 1 well was drilled 5,696 feet through a normal section from Pierre Shale to a fault in the upper part of the Fountain Formation. From there down to 8,140 feet the well penetrated overturned and faulted rocks including, successively, the Lykins, Ralston Creek, Morrison, Lytle, Morrison, South Platte, and Benton Formations. Below a fault at 8,140 feet it entered Pierre Shale, followed by Niobrara, Benton, and Dakota in normal sequence.

Although the Golden fault dies out southeastward in the quadrangle, a belt of steeply dipping or overturned strata continues to the southeast from the Mt. Carbon area (Scott, 1962). This fact and structural relations such as those of the Lillie Pallaoro wells and wells in the Littleton quadrangle suggest that a belt of complex structure may continue southward beyond the end of the fault for several miles in the subsurface.

Minor faults.--Several short northwest-trending faults, probably contemporaneous with the Golden quadrangle, cut the Fort Hays Limestone Member of the Niobrara Formation in secs. 26 and 35, T. 4 S., R. 70 W. These faults dip about 50° SW., and all show an apparent displacement of the southwest block to the northwest. They evidently die out northwestward in the Benton Shale, as they are not recognized in the hogback of the Dakota Group; they also die out southeastward in the shale of the Smoky Hill Shale Member.

The contact of the Fountain with the underlying Precambrian rocks is offset by a few faults, and a fault along the contact near the mouth of Mount Vernon Canyon is inferred from a narrowing of the Fountain outcrop and from slickensided strata in a clay pit a few hundred feet north of U. S. Highway 40.

Joints.--A joint pattern typical of the sedimentary terrane is well displayed in the large roadcut where Alameda Parkway crosses the Dakota hogback. There, a dominant joint set strikes N. 65° E. and dips vertically on the average, although the strike ranges from N. 50° E. to N. 70° E. and the dip from 80° SE. to about 70° NW. A set of weaker joints strikes from due north to N. 30° W. and dips either 40°-60° SW. or 70°-80° NE.

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