GEOLOGY OF THE CANON CITY-
TWIN MOUNTAIN AREA, FREMONT COUNTY, COLORADO

by

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ABSTRACT

The Canon City-Twin Mountain area lies along the western edge of the Canon City Embayment. Precambrian crystallines of the Wet Mountains and the Front Range bound the area on the west and northeast respectively. Sedimentary rocks of every geologic age except Cambrian, Silurian, Mississippian, and Triassic crop out in the area.

Two periods of strong deformation are recognized in the area, the Pennsylvanian Ancestral Rocky Mountain orogeny and the Cretaceous-Tertiary Laramide orogeny. Uplift and minor faulting are the principal features of the Ancestral Rocky Mountain orogeny; folding and high-angle thrust faulting are the common features developed during the Laramide orogeny. Tertiary and Quaternary terraces record epeirogenic uplift which occurred after the end of the Laramide revolution.

Economic mineral products of the area include oil, coal, refractory sand, ornamental stone, flux lime, fire clay, and sand and gravel.

INTRODUCTION

Interest in the Canon City Embayment dates back to the early 1800's when Lieutenant Pike, Captain Fremont, and other explorers were making expeditions into the Western Interior. Several of these expeditions worked their way up the Arkansas River to the present site of Canon City where they had to detour around the Grand Canyon of the Arkansas.

Oil seeps along Oil Creek attracted early notice, and in 1863, in Sec. 3, T. 18 S., R. 70 W. the first oil well west of the Mississippi River was completed for a barrel a day. Development of the first oil field in Colorado, the Florence oil field, was commenced in 1876. In 1926 the Canon City oil field was discovered and development commenced.

Initial development of the Canon City coal fields was started in the 1860's and maximum production was attained in 1917. Fire clay, sand and gravel, ornamental stone, refractory sand, building stone, and flux lime have played or are playing an important minor role in the regional and local development.

Although geologic interest in the Canon City Embayment has fluxuated with the economics of the region, little detailed mapping has been conducted in the area selected for study.

Location

The Canon City-Twin Mountain area lies along the western side of the Canon City Embayment, Fremont County, Colorado (Fig. 1). The area is included in Tps. 17, 18, and 19 S., Rs. 70 and 71 W. It is bounded on the west

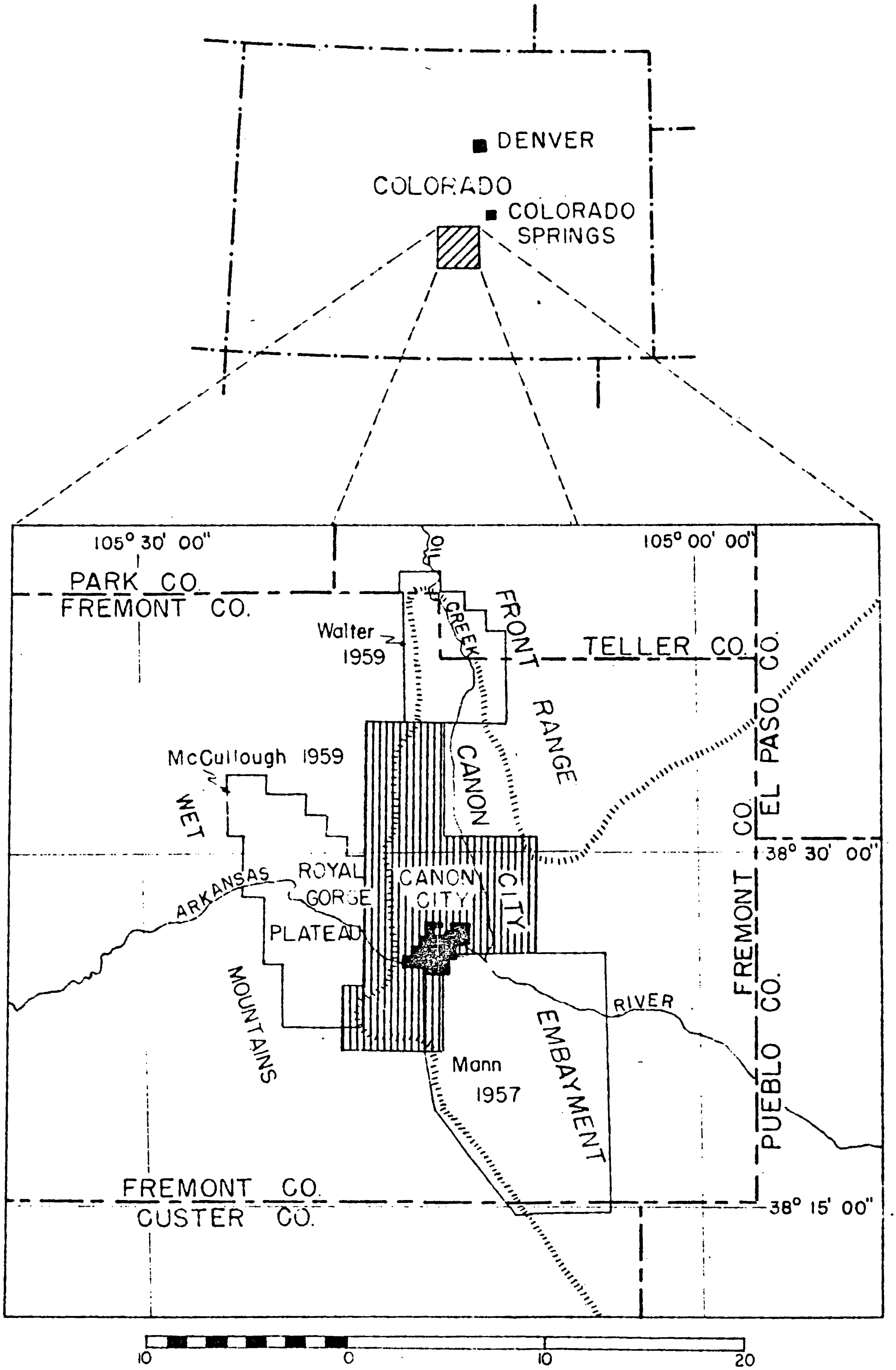


FIG. I. Index Map

by crystalline rocks of the Precambrian, on the south by the tear fault terminating the Wet Mountain thrust, and on the north and east by arbitrary section lines as a natural geologic boundary is not present. Approximately 94 square miles are included in the area mapped. U. S. Highway 50 extends from east to west across the area, roughly dividing it in half.

Purpose and Methods

The purpose of this study was to map and describe the geology of the Canon City-Twin Mountain area. Two months of field study were completed during the summer of 1958. U. S. Forest Service aerial photographs were used in the field mapping and U. S. Forest Service drainage maps were used as the base to establish horizontal control.

Previous Work

The general geology of the Canon City region was first described in the American Journal of Science (Hayden, 1868, pp. 322-326) and reports of the first surveys of the Western Interior (Hayden, 1869, pp. 147-149, 1873, p. 430; Endlich, 1874, pp. 215-220; Williams, 1876, pp. 249-251). Walcott (1892) made his classic study of the Harding and Fremont Formations one mile west of Canon City. Cross (1894) mapped a small part of the northwestern end of Shaws Park in his study of the Pikes Peak area. Darton (1906) mapped and studied the aquifers of the Arkansas Valley of eastern Colorado. Washburne (1910) mapped the Canon City coal fields. Blum (1944b) conducted a magnetic survey of the area south and west of Canon City. Heinrich (1948) described the pegmatites of Eight-mile Park. Boos and Boos (1957) studied the tectonics of the Front Range. Most of the published geologic maps of the Canon City Embayment and surrounding region are correct only in broad general aspects and lack detail.

After completion of the field study, four unpublished theses were found to have been completed in parts of the area covered by this thesis (Acharya, 1949; Miller, 1951; Ruley, 1952; Browder, 1958); however, less than half the area covered in this study has been previously mapped in detail. The four maps were checked in the field in April 1959 and found to be in error in part, particularly in detail.

Acknowledgments

The writer is indebted to Dr. Louis F. Dellwig who suggested the area of study and supervised the investigation and to Stuart Grossman who assisted in plane tabling a portion of Twin Mountain. Sincere appreciation is extended to the ranchers and residents of the Canon City-Twin Mountain area who gave free and ready access to their land.

PHYSIOGRAPHY

Physiography of the Canon City Embayment

The Canon City Embayment, a re-entrant of the Denver Basin (Fig. 1), is bounded on the north and northeast by the Front Range, on the west and south by the Wet Mountains, and on the southeast and east by the Colorado piedmont.

Elevation of the Precambrian cores of the bounding mountain ranges ranges from 2,000 to 4,000 feet above the embayment floor. Crystalline rocks of the Front Range and Wet Mountains are bordered by flatirons, hogbacks and ridges of resistant Paleozoic and Mesozoic sedimentary rocks.

Physiography of the Canon City-Twin Mountain Area

A hogback-strike valley topography dominates the western, northern and northeastern marginal regions of the area, bordering the Precambrian crystallines. Shales are soft and easily eroded to form valleys. Limestones and some sandstones are resistant and form hogbacks and flatirons.

North of the Arkansas River along the western side of the area the Manitou Dolomite and Fremont Limestone form prominent flatirons against the Precambrian mountain cores. Conglomerates of the Fountain Formation form flatirons and ridges in Red Canons Park (Fig. 2), Shaws Park, and Priest Canyon; however, the upper shaly part of the Fountain is easily eroded and a valley former (Fig. 3). The Dakota Sandstone forms a conspicuous hogback which rises over 500 feet above the embayment floor (Fig. 4). On the western side of the area the Dakota strikes north and dips east, to the north it swings across the axis of the northern extension of the embayment and on the eastern side of the area it strikes north and dips west (Fig. 5). The dip of the strata becomes considerably less in the northern extension of the embayment and the Dakota caps the dip slope of a long south dipping cuesta. Oil Creek cuts the cuesta in half.

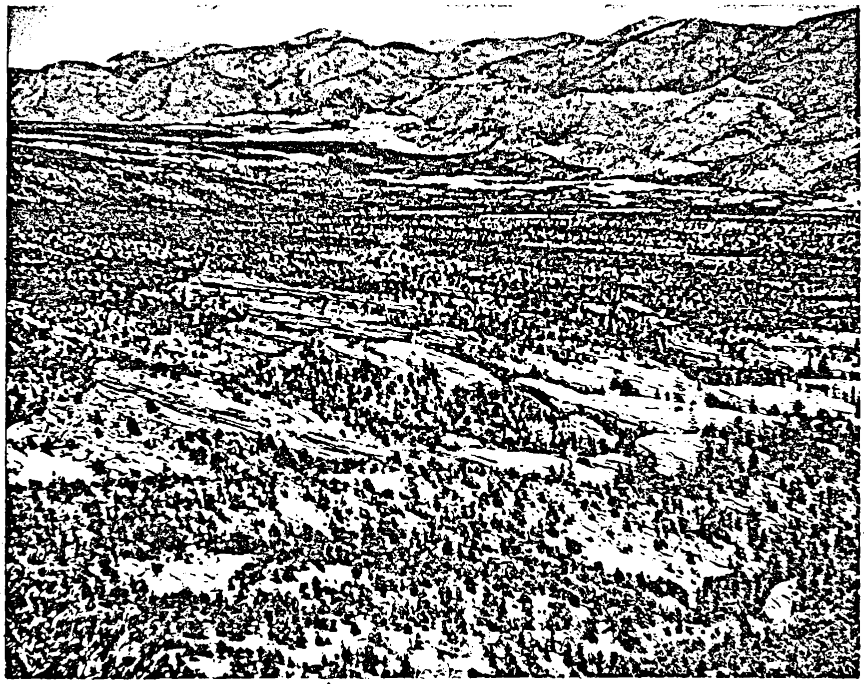


Fig. 2. Flatirons developed in Fountain conglomerates; view looking north across Red Canons Park. NW 1/4, SE 1/4, Sec. 7, T. 17 S., R. 70 W.).

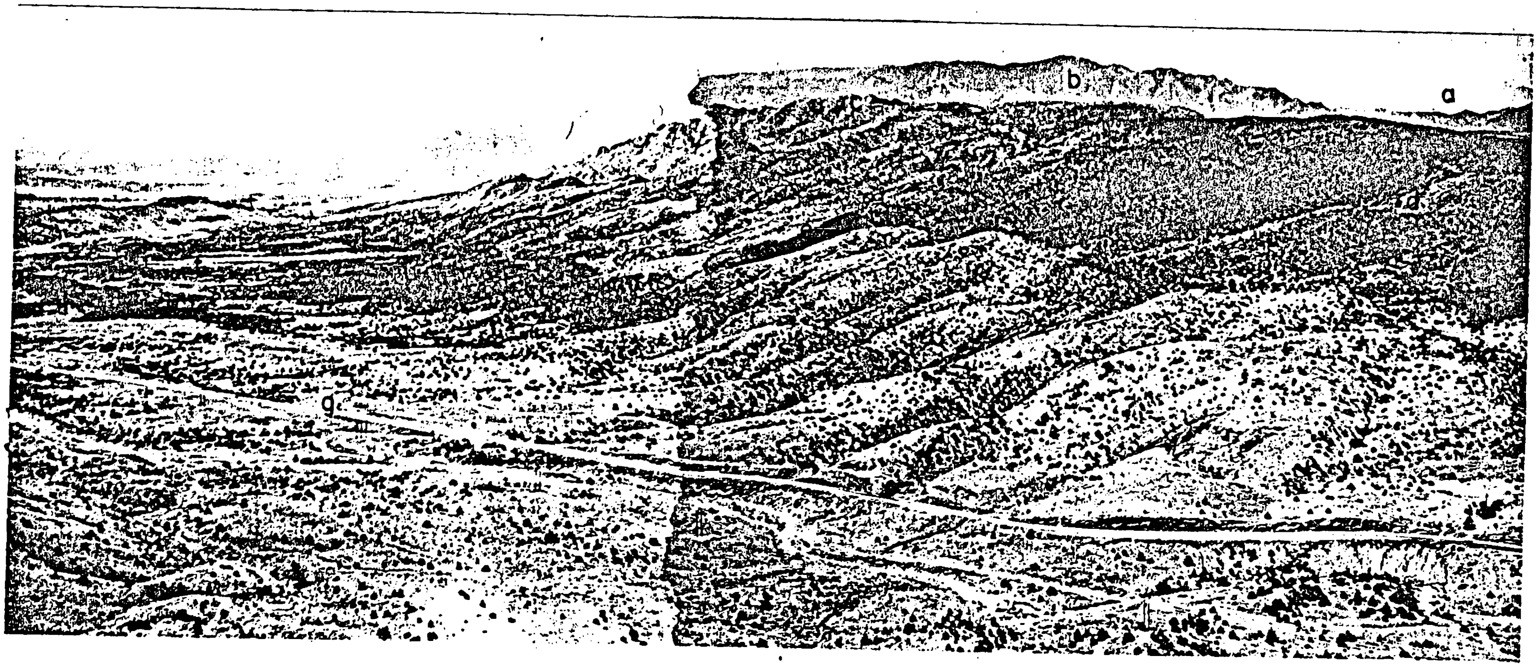


Fig. 3. Panoramic View showing: a. Sangre de Cristo Mountains; b. Wet Mountains; c. Fremont Peak; d. quarry in Eightmile pegmatite; e. Priest Canyon, watergap in Fremont Limestone; f. valley in Fountain Formation; g. U. S. Highway 50. Camera facing south from SW 1/4, NE 1/4, Sec. 12, T. 18 S., R. 71 W.

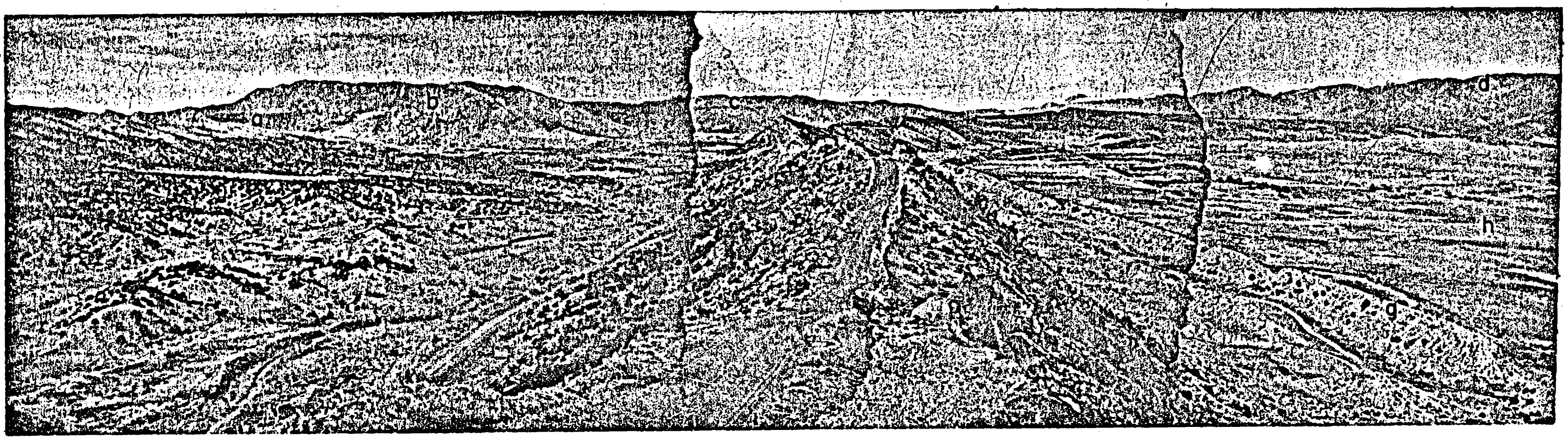


Fig. 4. Panoramic View showing: a. Devils Gap; b. Twin Mountain; c. Wet Mountains; d. Front Range; e. strike valley eroded in Fountain Formation; f. Dakota hogback; g. Codell-Fort Hays hogback; h. valley eroded in Pierre Shale. Camera facing northwest on left, north in center, and northeast on right from NE 1/4, SW 1/4, Sec. 29, T. 18 S., R. 70 W.

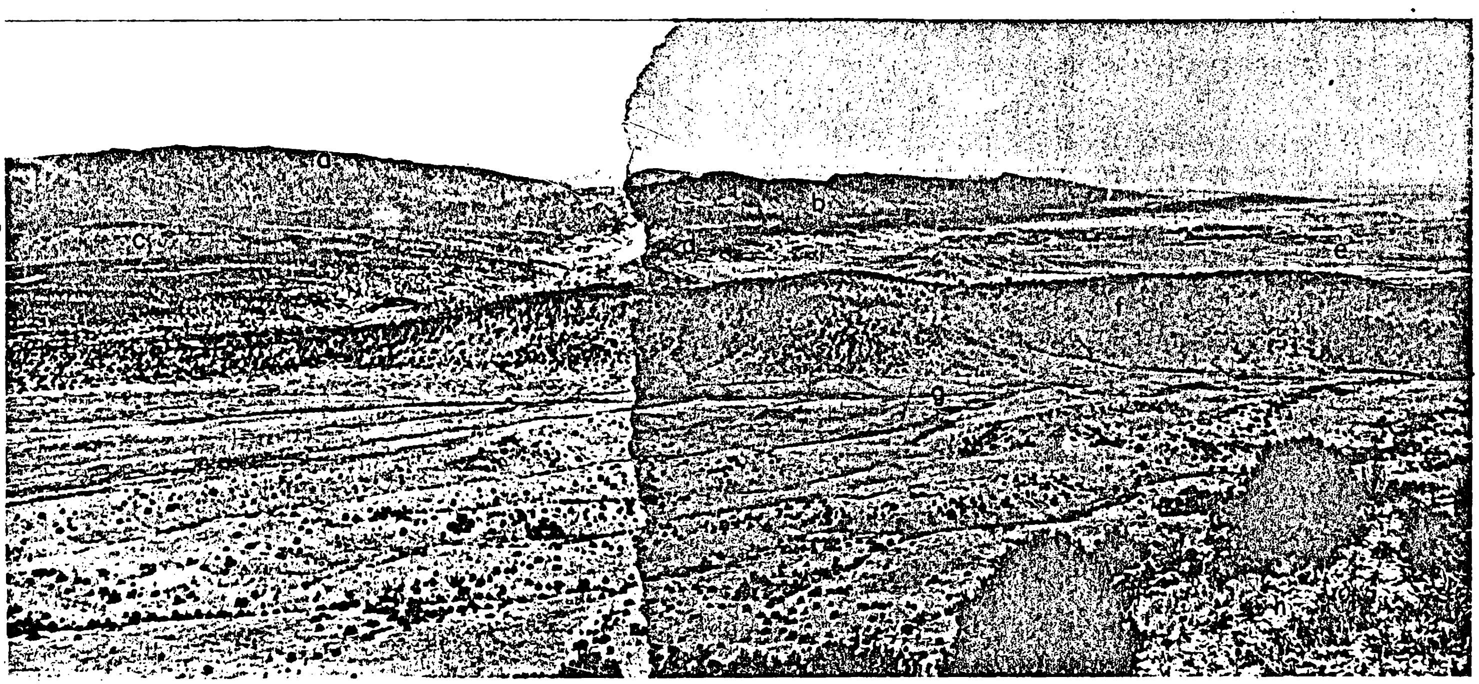


Fig. 5. Panoramic View showing: a. Front Range; b. Dakota hogback; c. Oil Creek water gap in Dakota cuesta; d. Codell-Timpas hogback; e. Pierre Valley; f. face slope of Dakota hogback; g. strike valley eroded in Fountain Formation; h. Fremont Limestone. Camera facing east from SW. 1/4, NE. 1/4, Sec. 12, T. 18 S., R. 71 W.

A small, though prominent, hogback is formed jointly by the Codell Sandstone member of the Carlile formation and the Fort Hays Limestone member of the Niobrara Formation. The Greenhorn Limestone in some places forms a low ridge or hogback. South of the Arkansas River, a noticeable hogback is held up by the Vermejo Formation.

Most faults are topographic lows, forming saddles or small valleys and in some places valleys of considerable magnitude. A few streams in the Precambrian display a marked lineation and are probably fault controlled.

All streams drain into the Arkansas River, which along with its tributaries Grape Creek and Oil Creek, are the perennial streams in the area. Wilson Creek is perennial to the Dakota hogback in Sec. 5, T. 18 S., R. 70 W. where its flow is absorbed by the sandstones of the Purgatoire and Dakota Formations. All other streams are ephemeral, carrying large volumes of water and sediment after heavy rains. Torrential rains have resulted in Precambrian boulders over two feet in diameter being transported more than four miles.

Where the Arkansas flows out of the crystalline rocks of the Royal Gorge it loses considerable velocity and cannot carry the sedimentary load previously maintained. As a result conditions are excellent for deposition. Six terraces, not including the present flood plain, are recognized along the Arkansas. The older terraces are of coarse unstratified materials, whereas, the younger terraces are composed mostly of sand, granules, and pebbles, and show some degree of sorting.

Powers (1935) recognized seven terraces (Table 1) in the upper Arkansas River Valley and Royal Gorge area. He dated the terraces by morainal and Cenozoic stratigraphic relationships.

Table 1. Correlation of terrace deposits. Height above present river level in feet.

Terrace	Powers 1935	Mann 1957	This report	Age
1	390	380-400	390-400	Pre-glacial
2	300	310-360	300-350	Pre-glacial
3		230-260		Pre-glacial
4	200	180-200	150-160	Earliest known glacial
5	120-150	120-130	90-100	Unrelated to known glacial moraines
6	80-100	50-75	40-75	First pre-Wisconsin
7	60	20-25	15-20	Wisconsin glacial
8	20	8-10	8-10	Post glacial, present floodplain

In the Royal Gorge plateau area (Fig. 1) Powers (1935, pp. 190-191) recognized two ancient erosion surfaces. The upper, at an elevation of 6,800 feet (1,100 feet above the present river), is recognized on Fremont Peak, Secs. 25 and

26, T. 18 S., R. 71 W., and the lower, at an elevation of 6,100 feet (400 feet above the river), is developed in Webster and Eightmile Parks. Both of these surfaces are post Laramide in age (Van Tyle and Lovering, 1935, p. 13; Powers, 1935, p. 199).

PRECAMBRIAN ROCKS

Precambrian rocks of the Wet Mountains and the Front Range bound the area of study on the west and northeast corner (Sec. 1, T. 18 S., R. 70 W.) respectively. A detailed investigation of the Precambrian is beyond the scope of this study and no division was attempted. Heinrich (1948, pp. 424-432) described three groups of Precambrian rocks in the Eightmile Park area: Idaho Springs Formation, Pikes Peak Granite, and injection gneiss. In addition, all have been intruded by sills and dikes of aplite, fine-grained granite, and diabase. The Idaho Springs Formation and Pikes Peak Granite are recognized further north in the Front Range.

STRATIGRAPHY

Introduction

Strata of every geologic system except the Cambrian, Silurian, Mississippian, and Triassic are present in the Canon City-Twin Mountain area (Plate 1). Outcrops are generally good and sections were measured and described (Appendix).

Ordovician System

All three series of the Ordovician are present in the area of study. They are, in ascending order: the Manitou Limestone, early Canadian; Harding Sandstone, late Champlainian; and Fremont Limestone, late Cincinnatian. Maher (1953b,

GENERALIZED STRATIGRAPHIC SECTION

PLATE I

p. 2478) correlated the Ordovician of Colorado with the Ordovician of Oklahoma and Kansas.

Manitou Limestone

The Manitou formation (Cross, 1894, p. 2) is light pink to maroon, fine to coarsely crystalline, dense, argillaceous, resistant dolomite. Irregular varicolored chert bands, 1/2 to 4 inches thick are abundant in the thin-bedded lower 25 feet of the formation (Fig. 6). The upper massive unit contains scattered chert nodules. The Manitou is normally a resistant unit, with pit and cusp weathering developed locally.

A nonconformity separates the Manitou from underlying Precambrian rocks and a 2 to 6 inch pre-Manitou weathered zone is found at the contact. An occasional Precambrian boulder of spheroidal weathering origin is left on the relatively smooth surface on which the Manitou was deposited. Although a paraconformity appears to separate the Manitou from superjacent Harding, a slight angular unconformity actually exists. To the west of Red Canons Park (Sec. 6, T. 17 S., R. 70 W.) 52 feet of Manitou were measured. To the south, successively lower units of the Manitou are truncated by the Harding, and the southern most outcrop of Manitou is found in Priest Canyon (Sec. 13, T. 18 S., R. 71 W.; Fig. 7). A mile to the south Harding overlies the Precambrian; however, fragments of Manitou can be picked up in talus slopes between these two localities.

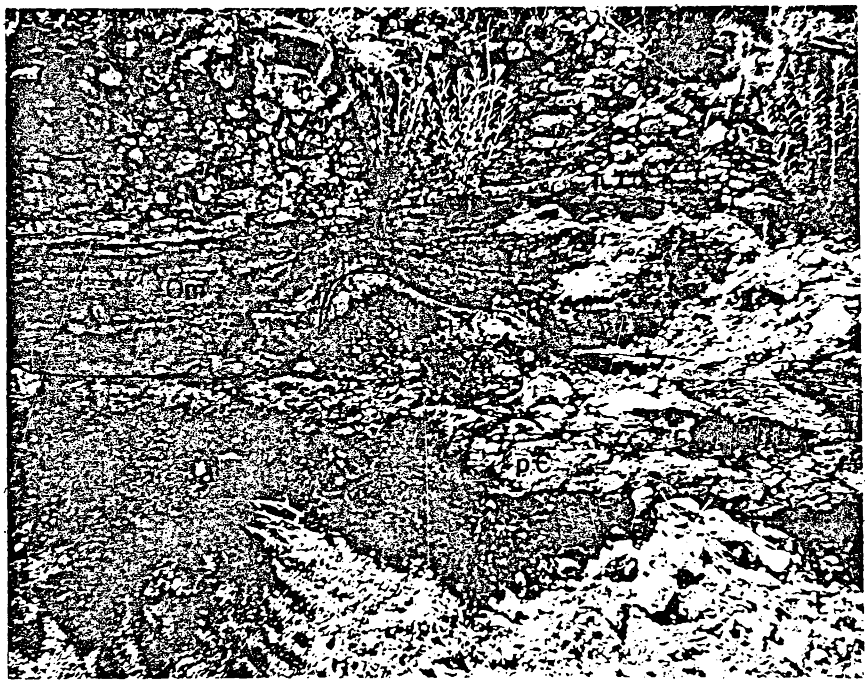


Fig. 6. Manitou- Precambrian contact. Note chert bands and compaction over Precambrian boulder. Photo taken along shelf road SW 1/4, SW 1/4, Sec. 27, T. 16 S., R. 70 W., looking west.

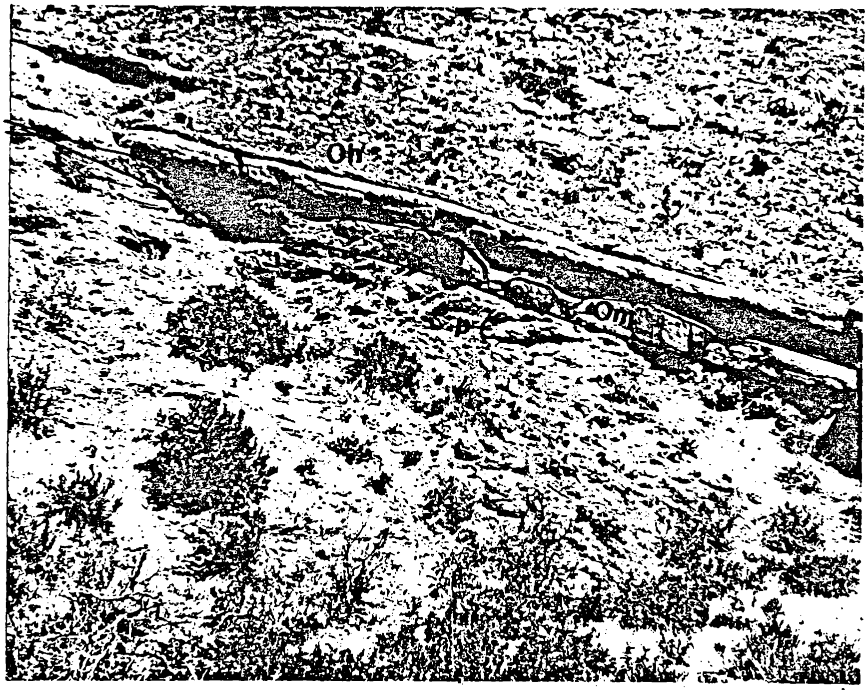


Fig. 7. Truncation of Manitou Limestone by Harding Sandstone: pC, Precambrian; Om, Manitou Limestone; Oh, Harding Sandstone. Photo taken in Priest Canyon, NE 1/4, SE 1/4, Sec. 13, T. 18 S., R. 71 W., looking north.

Harding Sandstone

The Harding formation was named and described by Walcott (1892, pp. 154-167) from exposures in the Harding quarries west of Canon City in Sec. 31, T. 19 S., R. 70 W. Harding may be divided into four units: (1) a resistant, white to light gray, unfossiliferous, silica cemented, basal conglomerate 3 to 4 feet thick; (2) an overlying 30 feet of thin-bedded, fine-grained, white to pink, soft sandstone and interbedded maroon, slightly fossiliferous shale; (3) 20 to 25 feet of maroon shale with abundant fossils; and (4) an uppermost 45 feet thick unit of thin- to thick-bedded, white to lavender, sandstone and interbedded maroon, fossiliferous shale. Except for the basal conglomerate, the Harding is poorly consolidated and easily eroded.

Fish plates are abundant in the shales. Lingula sp., Maclurites?, and worm trails are found in small numbers. The fauna and lithology indicate a shallow water near shore environment of deposition. Walcott (1892, p. 156) suggested a littoral environment for the Harding.

Sweet (1954, p. 295) measured 157.4 feet of Harding in Priest Canyon, the maximum observed thickness. The writer measured 129.8 feet west of Red Canons Park and 102.2 feet in Sec. 24, T. 18 S., R. 71 W. Walcott (1892, p. 156) measured 86 feet at the type section; however, Sweet (1954, p. 288) measured 120.5 feet when redescribing the type section. The above measurements indicate that the Harding is thickest in Priest Canyon and thins to the north and south.

Three outliers of basal Harding were mapped by McCullough (1959) in Sec. 10, T. 19 S., R. 71 W. The writer checked these with McCullough in the field and has included them on the geologic map (Plate 2).

Acharya (1949), Miller (1951), and Ruley (1952) erroniously mapped the basal Harding unit as Sawatch Quartzite, (Upper Cambrian) in the Grape Creek area, Secs. 10, 11, and 12, T. 19 S., R. 71 W. In this area the Harding formation lies nonconformably on Precambrian rocks, and the basal conglomerate may easily be mistaken for the Sawatch Quartzite. However, the basal unit can be traced across the Arkansas River to Priest Canyon where it is found to overlie the Manitou.

In general a paraconformity separates the Harding from overlying Fremont. In the Grape Creek area Fountain overlies Harding and a disconformity is apparent. A weathered zone is present at the top of the Harding where it is overlain by the Fremont.

Fremont Limestone

Walcott (1892, pp. 154-167) also named the Fremont f ormation and it is assumed, though not specified, that the type section is in the vicinity of the type section for the Harding. Sweet (1954, pp. 294-295) on faunal and lithological differences, divided the Fremont into a lower massive member and a thin-bedded upper member. The lower massive member is light gray to pink dolomitic limestone containing scattered dark gray chert nodules, numerous crinoid stems, and a dominant coral fauna. Abundant Receptaculites occur in the lower 30 feet. The upper Priest Canyon member has a dominant brachiopod fauna. Both members have been fractured and recemented and pit and cusp weathering is well developed on exposures.

Fossil preservation is poor and identification difficult. The following species were collected and identified:

Priest Canyon member:

Hebertella sinuata (Hall)
Zygospira modesta (Say)
Plaesiomys subquadrata (Hall) ?
Streptelasma sp

Lower Massive member:

Receptaculites sp
Halysites sp
Streptelasma corniculum (Hall)

Walcott (1894, p. 158) attributed the deposition of the Fremont to deepening of the Harding seas, as he did not recognize an unconformity separating the two formations. The relative ages of the faunas of the Fremont and Harding suggests a considerable period of nondeposition between the two formations and the presence of a weathered zone indicates some subaerial erosion. The fauna of the Fremont indicates a shelf environment. The fragmental texture of the limestone appears to have been caused by fracturing insitu and recementation, but it could have been caused by tectonic forces after lithification followed by cementation.

Walcott (pp. 156-157) measured 300 feet of Fremont at the type section, Sweet (p. 295) measured 283.5 feet along the old Royal Gorge road in Priest Canyon, and the writer measured 351.1 feet a mile south of Priest Canyon (Sec. 19, T. 18 S., R. 70 W.) and 126.3 feet west of Red Canons Park. South of the Arkansas the Fremont ranges from zero to 30 feet due to post Fremont erosion. In Sec. 12, T. 19 S., R. 71 W. erosional remnants of basal Fremont 10 feet in diameter are insitu as inclusions in the Fountain Formation.

Where Williams Canyon overlies the Fremont a 2 to 4 inch weathered zone is present in most places and a paraconformity is evident. A disconformity separates the Fountain Formation from Fremont strata across an irregular surface. The disconformity is well exposed in Secs. 13 and 24, T. 17 S., R. 71 W. and Secs. 11 and 12, T. 19 S., R. 71 W.

Devonian ? System

Williams Canyon Formation

The Williams Canyon Formation (Brainerd, Baldwin, & Kayte, 1933, pp. 381-396) is white to light gray, thin-bedded, unfossiliferous limestone in the lower part and arenaceous limestone interbedded with thin sandstone stringers in the upper part. A basal conglomeratic zone contains cobbles of Fremont. Pit and cusp weathering is found locally.

Age of the Williams Canyon is questionable as fossils have not been found; correlation is based on stratigraphic position and lithologic similarity. Brainerd, Baldwin, and Keyte (pp. 390-391) suggested that the Williams Canyon correlates with the Parting Quartzite member of the Devonian Chaffee Formation, on the west side of the Front Range. Maher (1953b, pp. 2481-2483) called the Williams Canyon Mississippian and suggested that it is lithologically similar to recognized Mississippian, Spergen and Warsaw Formations, of southeastern Colorado.

West of Red Canon Park 15 feet of Williams Canyon is present but it is faulted out or removed by erosion for 3 miles south of this locality. In the southwest corner of Sec. 19, T. 18 S., R. 70 W. 51.1 feet were measured; Sweet (p. 295) measured 25 feet in Priest Canyon.

The Williams Canyon is disconformably overlain by the Fountain Formation. Most of the thickness difference of the Williams Canyon may be attributed to pre-Fountain erosion.

Pennsylvanian System

Fountain Formation

The Fountain Formation (Cross, 1894, p. 2) parallels the Front Range from the Wyoming-Colorado line south to the Canon City Embayment. It consists of red to locally mottled white or green, arkosic conglomerates, sandstones, and shales. The lower 600 to 800 feet of the formation is mainly conglomerate and sandstone with an occasional shale; whereas, the upper part is characterized by fine conglomerate, sandstone, and shale. Graded bedding is common in many units of the Fountain and abundant fragments of older Paleozoic sediments are found throughout the section. Locally Fremont pebbles, cobbles, and boulders over one foot in diameter may compose more than 95 percent of the conglomerate. Calcareous cement is commonly present and in part may have been derived from solution of Manitou, Fremont, and Williams Canyon.

A nearby source is indicated for the material composing most of the strata of the Fountain in the Canon City-Twin Mountain area. Assuming increasing erosion or increase in erosion with concurrent uplift, erosion would cut into successively lower strata, thereby producing fragments of increasingly older age for deposition in higher and younger strata. Conglomerates of the Fountain

Formation west of Canon City indicate that this has occurred.

In Sec. 19, T. 18 S., R. 70 W. the basal conglomerate of the Fountain contains pebbles, up to 2 3/4 inches, of Fremont and Williams Canyon along with quartzite and other metamorphic and igneous pebbles. The igneous and metamorphic pebbles probably came from some distance to the west, whereas the Fremont and Williams Canyon pebbles were locally derived and transported short distances, probably less than a mile. Younger conglomerates contain pebbles of Manitou and Harding as well as Fremont (no Williams Canyon was found) and indicate a close source of sediments.

Southeast of Red Canons Park the basal part of the Fountain contains chert fragments with recognizable Mississippian fossils, indicating that Mississippian strata once covered part of the area mapped, or nearby areas.

Thickness of the Fountain is irregular. Almost 1200 feet were measured in Red Canons Park. A thickness of 1674 feet was measured a mile southeast of Priest Canyon; and 50 feet was estimated in the Grape Creek area. The thickness difference is probably due to local irregularities on the depositional surface and in part to post-Fountain erosion.

Finlay (1916, pp. 12-13) was the first to consider the Fountain Formation to be of Pennsylvanian age. He recognized Pennsylvanian plant fragments in Fountain coal lenses in the Colorado Springs area. Maher (1953a, pp. 918-921) correlated the Fountain with Kansas Pennsylvanian and Lower Permian. Moore (1958, p. 240) considers the Fountain to be Middle and lower Upper Pennsylvanian.

Tieje (1923, pp. 196-197) concluded that the Fountain is largely an alluvial fan or braided river deposit. LeRoy (1946, p. 21) postulates a continental, fluvial environment of deposition. A continental environment is indicated by channeling, trough cross-bedding, extreme vertical and latteral variations, coal lenses, and a lack of marine fossils.

A disconformity separates the Fountain Formation from superjacent strata. The Fountain is overlain by Jurassic Morrison strata in the Grape Creek area, and by Permian Lykins strata north of the Arkansas River, along the western side of the area. In the northeastern corner of T. 18 S., R. 70 W. the Jurassic Ralston Gypsum overlies the Fountain.

Permian System

Lykins Formation

The Lykins Formation (Fenneman, 1905, pp. 24-26) is white to medium gray, thinly laminated, dense, arenaceous, unfossiliferous, "crinkled" limestone. Thickness ranges from a featheredge to 3 feet. The limestone is resistant to weathering and forms a slope break or low scarp where it is present. The Lykins is absent in Sec. 1, T. 18 S., R. 70 W. and south of the Arkansas River.

In the Golden-Morrison area LeRoy (1946, pp. 30-42) divided the 400 feet plus Lykins into several members. He considers the "crinkled" limestones to be Permian and the overlying sandstones and shales Triassic. No Triassic Lykins crops out in the Canon City-Twin Mountain area.

Six miles east of the Canon City-Twin Mountain area a few evaporites are interbedded with the "crinkled" limestones. This suggests a lagoonal environment of deposition. The arenaceous and argillaceous inclusions in the limestone along Skyline Drive record influx of clastics during deposition. The clastics may have been derived from a relatively close source and the size (less than 0.5 millimeter) may indicate that the Ancestral Rocky Mountains had been eroded down and were a negligable source of sediment.

The Lykins is disconformable with superjacent Morrison strata. Part of the difference in thickness is probably due to pre-Ralston Creek and or pre-Morrison erosion as the Lykins is thought to have been deposited throughout the area of study.

Jurassic System

Ralston Creek

LeRoy (1946, pp. 47-57) named sandstones and shales exposed along Ralston Creek north of Golden, Colorado the Ralston Formation, recognizing at the same time a gypsum facies to the south of the Colorado Springs area. Van Horn (1956, pp. 755-756) suggested renaming the formation Ralston Creek as Ralston Formation was preoccupied.

Ralston Creek crops out only in Secs. 2, 11, and 12, T. 18 S., R. 70 W. A white to light pink, soft, massive, gypsum approximately 30 feet thick at the southeastern end of the outcrop is absent at the northwestern end. The pinch out is probably due in part to post-Ralston Creek erosion but may in part be due to nondeposition.

West of Canon City along U. S. Highway 50 (NW 1/4, NW 1/4, Sec. 32, T. 18 S., R. 70 W.) Fredrickson, De Lay, and Saylor (1956, pp. 2140-2142) considered 102 feet of sandstones and conglomerates, immediately overlying the "crinkled" limestone, as a clastic facies of the Ralston Creek. Heaton (1950, p. 1674) considered these same strata as lower Morrison. They grade upward from conglomerates and coarse-grained sandstones to fine-grained sandstones and shales of recognized Morrison sediments which they lithologically resemble. These rocks are not found elsewhere in the Canon City Embayment. The absence of clastic sediments within the gypsum outcrops in Secs. 2, 11, and 12, T. 18 S., R. 70 W. has influenced the writer to agree with Heaton in assigning a Morrison age to the strata in question.

Heaton (1950, p. 1689) correlated the Ralston Creek with the Toldilto Formation of New Mexico.

The Ralston Creek is disconformably overlain by the Morrison Formation. Channeling of the Morrison into the Ralston Creek is locally well developed.

Morrison Formation

The Morrison Formation was named from exposures two miles northwest of Morrison, Colorado (Emmons, Cross, and Eldridge, 1896, pp. 60-62; Waldschmidt and LeRoy, 1944, pp. 1097-1114).

In the Canon City-Twin Mountain area the Morrison consists of several lithologic units which are gradational between one another. They are, in order of oldest to youngest: (1), 50 to 100 feet of tan to red to light green, arkosic conglomerates, sandstones, and shales; (2), 80 to 100 feet of white to tan, resistant, slightly arkosic sandstones interbedded with light gray to green shales and a few thin-bedded, fossiliferous, fresh water limestones containing abundant ostracods and Aclistochara; (3), 50 to 60 feet of light green to chocolate brown, blocky shale; (4), 60 to 75 feet of light gray to tan, fine-grained sandstones interbedded with light green to chocolate brown shales; (5), 60 to 80 feet of tan to maroon sandstones interbedded with light green to brown, silty shales; and (6), 10 to 15 feet of white to light green, friable sandstone.

The Morrison is recognized over vast areas of the Central and Western Interior, however, lateral changes are extreme in the Morrison and few beds can be traced more than 200 yards along the outcrop. Lenses and channel fills are common.

Abundant dinosaur remains have been found in the Morrison in Garden Park, directly east of Shaws Park outside the area of study. Professors Cope and Marsh discovered and described several genera and species from this area in the late 1800's (Hatcher, 1901, pp. 332-341).

Emmons (1896, p. 23) thought the Morrison to be a lacustrine deposit. Heaton (1933, p. 161) suggested an area of fresh water lakes and swamps with a moist climate as the environment of deposition. Sedimentary structures and the fauna indicate continental lacustrine depositional conditions.

The Morrison is disconformably overlain by the Lytle Member of the Purgatoire Formation which was deposited on a very irregular surface.

Cretaceous System

The Cretaceous sedimentary rocks are mostly clastics with a few thin limestones. Strata are distinct and laterally persistant over large areas. Many of the formations may be traced by subsurface methods and correlated with the Cretaceous of western Kansas. Except for the Purgatoire Formation only Upper Cretaceous strata are present in the area of study.

Purgatoire Formation

The Purgatoire Formation (Stose, 1912, p. 3) has two members, the Lytle Sandstone and the Glencairn Shale, both named by Finlay (1916, p. 8).

The lower Lytle Sandstone member is a white cross-bedded conglomerate. It is distinct and easily recognized in the field. Pebbles of chert and quartz are scattered throughout the member but are particularly abundant along bedding planes, and make cross-bedding a prominent feature. Thickness ranges from 2 to 31 feet in the area of study with lateral variation extreme. Along Skyline Drive the Lytle ranges from 8 to 20 feet vertically with a horizontal distance of 50 feet.

The Glencairn Shale consists of white to tan, fine- to coarse-grained, thin- to massive-bedded sandstone with carbonaceous inclusions and scattered plant fossils interbedded with light to dark gray, carbonaceous, arenaceous, fissile shale and an occasional thin coal stringer. Locally the shale grades into high grade fire clay. Biped dinosaur tracks are found in the upper part of the Glencairn in the NE 1/4, SE 1/4, Sec. 12, T. 19 S., R. 71 W.

Thickness of the Purgatoire ranges from 98.8 feet south of Red Canons Park to 124.2 feet along Skyline Drive. The massive sandstones of the Glencairn are resistant and along with the Dakota Sandstone form a prominent hogback.

The Purgatoire is of middle Albian age. Cobban and Reeside (1952, chart) correlated the Purgatoire with the Kiowa Shale and the Cheyenne Sandstone of western Kansas.

The Lytle is transitional with the superjacent Glencairn, and the Glencairn is gradational into overlying Dakota Sandstone. Cobban and Reeside (1952, p. 1029) inferred a hiatus between the Purgatoire and Dakota in the Colorado Springs area.

Dakota Sandstone

The Dakota Sandstone (Meek and Hayden, 1862, pp. 419-420) is white to light tan, medium-grained, friable, massive, cross-bedded, limonitic sandstone in the lower part. The upper 20 feet is thin-bedded sandstone grading into gray to black clayey shale. Numerous fucoids and plant fragments are found at the base and top of the formation. Ripple marks are found at the top of the massive unit. Locally a high grade fire clay is developed in the upper unit. The Dakota is resistant and forms a prominent hogback (Fig. 4). Along Skyline Drive 79.7 feet of Dakota Sandstone were measured.

The Dakota of the Canon City Embayment is of early Cenomanian age; it correlates with the lower part of the Frontier Formation of Wyoming.

Upper and lower contacts of the Dakota are transitional. The Dakota and Purgatoire probably represent the transgression of Cretaceous seas into the area. Lithology and flora of the Dakota and Purgatoire suggest a continental near-shore environment frequently covered with shallow marine seas, as bivalve casts have been reported in the base of the upper sandstone (LeRoy, 1946, p. 74). The coal seams indicate that local swampy conditions prevailed.

Graneros Shale

In the Canon City-Twin Mountain area the lower 150 to 180 feet of the Graneros formation (Gilbert, 1896, p. 564) is light gray to black, fissile, platy shale with a cone-in-cone zone 50 feet above the base. The upper 50 to 60 feet of the formation is light brown to gray, calcareous, fissile, platy shale with stringers of argillaceous limestone. Along Skyline Drive 231.3 feet of Graneros were measured and described (Appendix).

A few marine pelecypods, Inoceramus sp., were found in the upper calcareous unit. No fossils were found in the lower part of the Graneros. The entire formation is of marine origin.

The Graneros is of late Cenomanian age. Cobban and Reeside (1952, chart) correlate it with the lower part of the Mancos Shale of New Mexico and western Colorado, and the lower part of the Frontier Formation of Wyoming.

The Graneros is conformable above and below and the upper calcareous part of the Graneros is transitional with the overlying Greenhorn Limestone.

Greenhorn Limestone

The Greenhorn Limestone (Gilbert, 1896, p. 564) is a widespread formation. It consists of thin-bedded, light bluish gray, finely crystalline, dense limestone interbedded with light gray, calcareous, platy, fissile shale. Abundant

Inoceramus sp. shells and fragments occur locally.

Along Skyline Drive the Greenhorn is 37.1 feet thick. It is easily eroded due to the thin-bedded character and interbedded shales, but it usually forms a low ridge or hogback where it crops out.

The Greenhorn is of early Turonian age, and correlates with part of the Mancos Shale of western Colorado. It is gradational into the superjacent Carlile formation.

Carlile Shale

The Carlile Shale (Gilbert, 1896, p. 565) contains three members in the Canon City Embayment: the lower Fairport Chalky Shale member (Rubey and Bass, 1925, pp. 16, 40), a light gray to black, fissile, calcareous shale with thin stringers of anhydrite; a middle Blue Hill Shale member (Logan, 1897, pp. 218, 225, 228, 229), a light brown to black, platy, fissile shale with scattered anhydrite crystals; and the upper Codell Sandstone member (Bass, 1926, pp. 28, 64), a light brown, fine-grained, calcareous sandstone which contains abundant sharks' teeth.

The Carlile was mapped as a unit; however, members are generally distinguishable in outcrops. Along Skyline Drive 143.5 feet of Carlile was measured as follows: 63.1 feet of Fairport Chalky Shale; 76.1 feet of Blue Hill Shale; and 4 feet of Codell Sandstone.

Cobban and Reeside (1952, chart) correlated the Carlile formation with the upper part of the Frontier Formation of Wyoming. The Carlile is of late

Turonian age, of marine origin, conformable with the underlying Greenhorn, transitional between members, and paraconformable with the overlying Niobrara Formation.

Niobrara Formation

The Niobrara Formation (Meek and Hayden, 1862, p. 419) contains two members, the Fort Hays Limestone (Williston, 1893, pp. 108-109) and the Apishapa Shale (Gilbert, 1896, p. 567).

Typically the Fort Hays member is thin-bedded, light gray, finely crystalline, argillaceous, fossiliferous limestone interbedded with light gray, platy to blocky, calcareous shale. Inoceramus sp. are locally found in profussion, and sharks' teeth are occasionally found in the lower five feet of the member. A thickness of 27.5 feet was measured along Skyline Drive.

In eastern Colorado the Fort Hays was formerly called Timpas Limestone (Gilbert, 1896, p. 566). Fischer (1953) showed a similar foraminiferal assemblage in the Timpas and Fort Hays. He traced the Fort Hays from the type section in western Kansas to the Timpas type section in eastern Colorado.

The Apishapa Shale member is light gray to buff, calcareous, splintery, to platy, fissile shale locally grading into marl and or argillaceous limestone. Over 500 feet of Apishapa Shale is found along the highway in Sec. 21, T. 19 S., R. 70 W., half a mile east of the southeastern limits of the map.

The Niobrara is of Coniacian and early Santonian age. Cobban and Reeside (1952, chart) correlated the Niobrara with part of the Mancos Shale of New Mexico and western Colorado.

The Apishapa is conformable with the subjacent Fort Hays. Although in outcrops no unconformity is recognizable, Cobban and Reeside (1952, p. 1029) inferred a hiatus at the top of the Apishapa as no Eagle and Telegraph Creek faunas are recognized in the Canon City Embayment.

Pierre Shale

The Pierre Shale (Meek and Hayden, 1862, pp. 419, 424) is divisiable into five recognized zones in the Canon City Embayment (Vanderwilt, et. al., 1948, p. 49): (1) the Barren zone at the base is void of fossils; (2) a Rusty zone contains limonitic concretions; (3) the Tepee Butte zone contains numerous, small, calcareous, fossiliferous aggregates which weather in the shape of small cones or "tepees"; (4) the Cone-in-cone zone is arenaceous with thin discontinuous cone-in-cone stringers; and (5) the Transition zone, consists of interbedded sandstone and shales, locally calcareous. The Pierre is soft and weathers easily; as a result outcrops are poor.

Thickness ranges from approximately 1,000 feet in the NW 1/4, Sec. 21, T. 19 S., R. 70 W., just east of the southeast corner of the area studied, to 3,500 feet in Sec. 35, T. 18 S., R. 70 W. Well records in the Canon City oil pool were used to determine the 3,500 feet thickness (Lavington in McCoy, and others, 1951, p. 1008).

The Pierre is dated as middle and late Campanian and early Maestrichtian by Cobban and Reeside (1952, chart). They correlate it with the Mesaverde Formation of the San Juan Basin.

The Pierre conformably overlies the Apishapa Shale and interfingers with the overlying Trinidad Sandstone.

Trinidad Sandstone

The Trinidad Sandstone (Hills, 1899, p. 3) is massive, light gray to buff, fine-grained, argillaceous, friable sandstone with limonitic staining. It is poorly exposed due to its soft character. A thickness of 56 feet was measured in the SE 1/4, Sec. 17, T. 19 S., R. 70 W.

Trinidad is of early Maestrichtian age. It is correlated with the lower part of the Lance Formation of Wyoming (Cobban and Reeside, 1952, chart).

Reeside (Vanderwilt, and others, 1948, p. 50) believes that the Trinidad is progressively younger to the north, and north of the Canon City Embayment it is in part correlateable with the Fox Hills Sandstone. Lovering, and others, (1932) believe that the Trinidad is a near-shore facies of the retreating Late Cretaceous sea.

The Trinidad is a marine deposit which interfingers with the subjacent Pierre formation and the superjacent Vermejo Formation.

Vermejo Formation

The Vermejo Formation (Lee, 1913, p. 531) is a thick sequence of thin- to massive-bedded, tan to buff, fine- to coarse-grained, friable sandstone interbedded with light to dark gray, soft, platy to blocky, arenaceous, lignitic shale and soft, black, argillaceous, arenaceous coal. Abundant plant fragments are scattered throughout the formation. Most beds of the formation are lenticular and few may be traced more than a few hundred yards laterally. The sandstones are resistant and form a prominent hogback.

Almost 1,000 feet of Vermejo were measured in the SE 1/4, Sec. 17, T. 19 S., R. 70 W. A late Maestrichtian and early Danian age is assigned to the Vermejo. Cobban and Reeside (1952, chart) correlated the Vermejo with the upper part of the Lance Formation of northern and eastern Colorado and Wyoming. The Vermejo is unconformable with the superjacent Arapahoe Formation.

Cretaceous-Tertiary

Arapahoe Formation

Only the lower 300 feet of the Arapahoe Formation (Eldridge, 1888, p. 97) are exposed in the area mapped, in the eastern half of Secs. 8 and 17, T. 19 S., R. 70 W. However, it is over 1200 feet thick a few miles to the southeast. The Arapahoe is the youngest formation in the area and it is composed of light brown to white, friable, thick- to massive-bedded, arkosic conglomerate and sandstone. There is graded bedding, cross-bedding, and channeling in many units. Fragments of almost all the older units of the area are identifiable in the conglomerates. Dakota and Fremont pebbles are particularly abundant.

Age of the Arapahoe is questionable. Dinosaurs have been reported in the lower part of the formation, and Reeside (Lovering and Goddard, 1950, p. 46) believed the Cretaceous-Tertiary boundary falls within the formation. Cobban and Reeside (1952, p. 1013-1014) placed the Arapahoe in the upper Danian, questionable Late Cretaceous.

In outcrops a disconformity is apparent between Arapahoe and subjacent Vermejo. Mann (1957, p. 41) suggests a slight angular unconformity is possible. The Arapahoe is of continental origin.

Tertiary

Igneous Pipes

Four igneous pipes are present in the Grape Creek area (Fig. 8). All are cylindrical in shape and were probably vents for extrusives although no remnants or evidence of extrusives are found in the area today. A petrographic study of thin sections of samples of each of the pipes showed a marked similarity of composition and grain size. An average slide analysis is as follows:

Mineral	Percent	Average Size	Maximum Size
Plagioclase An56	51	0.2 mm	0.5 mm
Augite	19	0.1 mm	2.0 mm
Uralite ?	17	0.1 mm	0.2 mm
Orthoclase	5	0.1 mm	0.3 mm
Magnetite	5	0.1 mm	0.2 mm
Calcite	1	0.1 mm	0.8 mm
Quartz	0.5	0.1 mm	0.3 mm
Pyrite	trace	0.1 mm	0.1 mm
Natrolite	trace	0.2 mm	0.8 mm

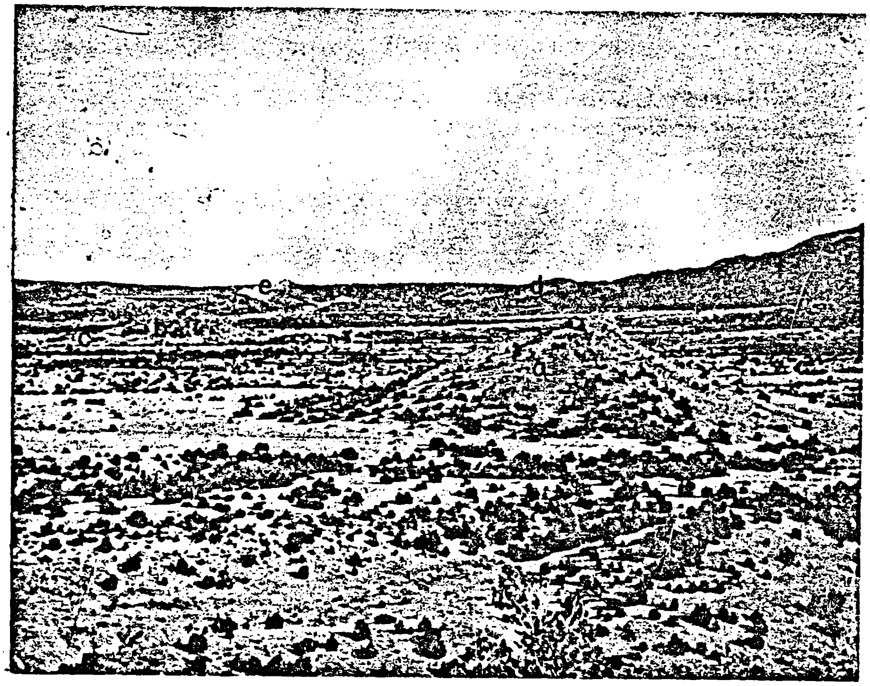


Fig. 8. View of igneous pipes: a. western pipe; b. double pipe; c. small northeastern pipe; d. Dakota hogback displaced by tear fault terminating Wet Mountain thrust; e. Vermejo hogback; f. Wet Mountains. Camera facing east, NW 1/4, SW 1/4, Sec. 7, T. 19 S., R. 70 W.

Phenocrysts are commonly augite and in places plagioclase, orthoclase, quartz, and magnetite. Vesicules are filled with calcite and natrolite and occasionally quartz. The uralite (?) is probably an alteration product of augite. The western most pipe contains almost 5 percent biotite, otherwise it is similar to the other pipes. Ground mass of all the pipes is holocrystalline plagioclase microlites embedded in a matrix of anhedral to subhedral augite and magnetite grains. The pipes are classified as tholeiitic basalt. They were undoubtedly derived from the same primary magna, and were emplaced at approximately the same time.

The western pipe has a metamorphosed zone approximately 6 to 10 feet wide encircling it. The matamorphosed rock is a yellow-brown hornfels containing quartz, muscovite, augite, and magnetite porphyroblasts up to 0.4 millimeter in diameter. Some of the magnetite is altered to hematite. Identification of the ground mass is difficult due to the extremely fine-grained texture. No apparent internal structure was observed. The hornfels is believed to be metamorphosed Apishapa Shale.

The southeastern pipe is a double pipe with a saddle of slightly metamorphosed terrace deposit between the two pipes. Metamorphism consists of slight alteration of the matrix but no alteration of the pebbles and cobbles. The contact region of the small northeastern pipe is covered.

The fine-grained texture of the basalt indicates a rapid rate of cooling. This would suggest the magma was either at or near the surface when it cooled.

The slightly metamorphosed conglomerate between the double pipes in the NE 1/4, NE 1/4, Sec. 18, T. 19 S., R. 70 W. is a Late Tertiary terrace deposit. This dates the pipes as Late Miocene or perhaps early Pliocene. Lovering (1929, p. 108) stated that all intrusives and extrusives of the Front Range were Miocene or older.

Travertine

Two small travertine deposits are located south and east of Twin Mountains. The name Twin Mountain Travertine is herein proposed for these deposits.

The northern deposit, SW 1/4, Sec. 7, T. 18 S., R. 70 W., averages 17 feet thick and is well exposed in a quarry. It is angularly unconformable on the Fountain Formation and may be divided into four units as follows: (1), 0.3 to 4.9 feet of red to orange calcareous weathered zone containing pebbles and granules of Fremont, Harding, and Fountain; (2), 0 to 14.2 feet of varicolored white to buff to pink, massive, vuggy travertine, locally arenaceous and containing encrusted plant fragments; (3), a 0 to 11.2 feet unit of pink to dark red, massive, vuggy travertine, locally conglomeratic containing quartz and Precambrian granules and encrusted plant fragments; (4), 0 to 8.3 feet of buff to light gray, massive, vuggy travertine containing plant fragments locally. At the southern extremety of the deposit encrusted plant fragments appear to be growing in situ in the upper unit.

The southern deposit, in the northeast corner Sec. 24, T. 18 S., R. 71 W., consists of 22 feet of varicolored buff to pink, soft, thin-bedded, vuggy travertine, arkosic in the upper five feet. It is angularly unconformable to subjacent Williams Canyon at the western end of the deposit and Fountain at the eastern.

The source of carbonate for the deposits is probably Fremont Limestone. The northern deposit lies on the plunging nose of South Twin anticline. Waters moving along the thrust fault breaching the anticline may have dissolved Fremont Limestone, carried it in solution, and upon reaching the surface deposited the travertine. The presence of encrusted plant fragments, some appearing to be in the position of growth, indicates a cool temperature of deposition. If the water was originally from hot springs it had cooled sufficiently to allow plant life at the site of deposition. Origin of the southern deposit was probably similar to that of the northern.

Both deposits dip 4 to 6 degrees southeast; the dip is probably initial, although it may in part be due to uplift after deposition. Age of the deposits is questionable but the writer believes they may be as old as Pliocene as they lie above the terrace level along Sand Creek and have been eroded considerably since deposition. Similar deposits were reported by Paul Johnston (personal communication) in the Red Creek area, north of Cotopaxi.

Tertiary-Quaternary

Terrace Deposits

Unconsolidated to loosely consolidated material of sand to boulder size forms terraces along the Arkansas River, Oil Creek, Wilson Creek, and Sand

Creek. Cobbles and boulders are uncommon. The older terraces contain a larger percentage of coarse material than the younger ones. Age and location of the terraces was discussed previously (see p. 12).

STRUCTURAL GEOLOGY

Major structural features of the Canon City-Twin Mountain area include the Canon City syncline; the tear fault terminating the Wet Mountain thrust; the thrust faults of the Grape Creek area; anticlines and associated thrusts and synclines of the Twin Mountain area; and the Twin Mountain thrust and terminating tear.

Canon City Syncline

The Canon City syncline is a broad structure plunging 10 degrees southeast. It is bounded on the east by the plunging southern end of the Front Range, and on the west by the monocline paralleling the Wet Mountains. In the southern part of the area the axis of the Canon City syncline lies between an anticline reported from subsurface data in Sec. 35, T. 18 S., R. 70 W. and the Dakota hogback three miles to the west. The axis bifurcates in the northern half of T. 18 S. with the western fork striking approximately N. 40° W. through Shaws Park and the east fork striking approximately north in the area east of Red Canons Park.

Tear Fault Terminating the Wet Mountain Thrust

The northern end of the Wet Mountain thrust is present in the southernmost part of the area mapped (Sec. 20, T. 19 S., R. 70 W.) where Precambrian crystallines are in contact with Morrison sedimentary rocks. Mann (1957, pp. 44-48) mapped the thrust south of the area and found the dip to range from 25° to 35° west, increasing to the south. The thrust is terminated on the north by a tear fault striking approximately N. 80° W. dipping from 85° south to vertical. In Secs. 14 and 15, T. 19 S., R. 71 W. the tear has Precambrian crystallines on the south faulted against sandstones and shales of the Dakota and Purgatoire formations; tracing the fault eastward, progressively younger sediments are in contact with the Precambrian. Maximum horizontal separation, over 16,000 feet, is in the Dakota Sandstone, from NW 1/4, SW 1/4, Sec. 14, T. 19 S., R. 71 W. to SE 1/4, NE 1/4, Sec. 20, T. 19 S., R. 70 W. Mann (1957, p. 48) suggested the tear continues a mile and a half east of the thrust. The south block of the fault displaced Precambrian crystallines upward and to the east.

Evidence of the tear is found in the center of Sec. 14, T. 19 S., R. 71 W., where drag in the upper Dakota formation is well exposed. A half a mile to the west in the Purgatoire and Dakota evidence of thrusting is well displayed in overturning of strata.

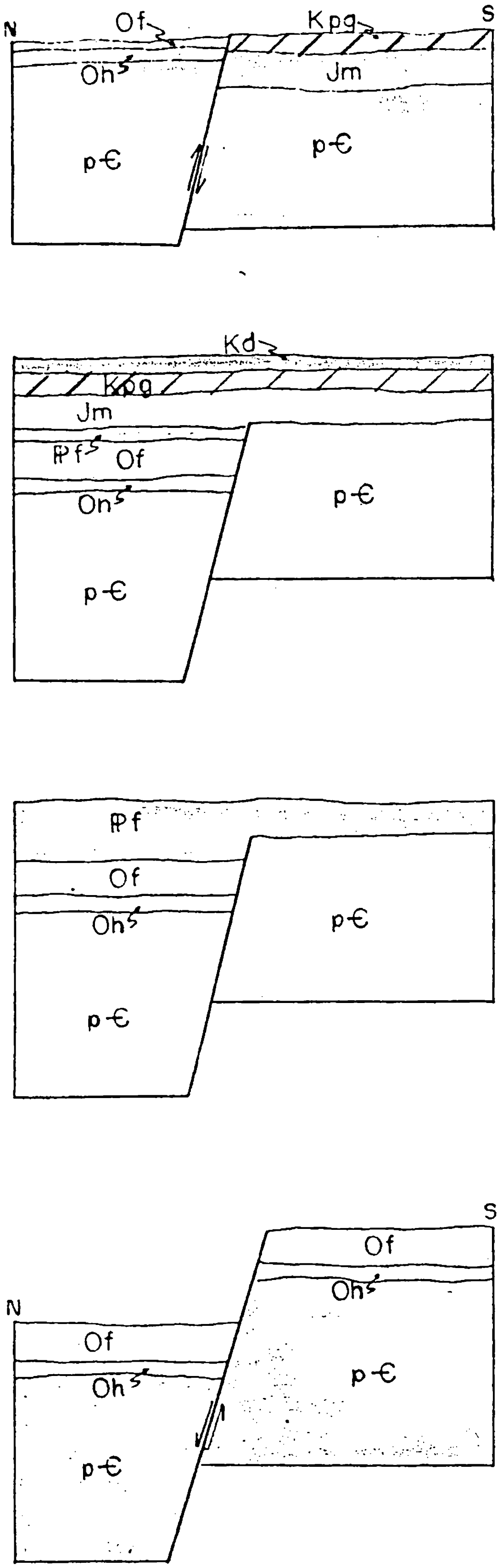
The author and D. L. McCullough investigated this fault and traced it west into Webster Park, where a prominent shear zone approximately 100 yards wide is present within the Precambrian. McCullough (1958, p. 29) traced the fault still further to the west where it changes to a thrust in the southern end of Webster Park.

Grape Creek Area

Thrust faults are the primary structural feature of the Grape Creek area. Two parallel high angle thrusts strike approximately S. 80° W. and dip from 83° north to vertical. These two thrusts are well exposed in Secs. 11 and 12, T. 19 S., R. 71 W.

The southern thrust has apparently had two periods of movement with a reversal of the direction of movement (Fig. 9). Initial gravity type faulting was post-Fremont and pre-Fountain, probably during early phases of the Ancestral Rocky Mountain orogeny, with the north block moved down relative to the south block. During the Laramide orogeny direction of movement reversed along the fault thrusting Harding and Fremont on the north block in contact with Morrison and Purgatoire on the south (Cross-section C-C', Plate 2).

Along the northern thrust Precambrian crystallines on the north side are in contact with Ordovician sediments in the northern half of Sec. 12, T. 19 S., R. 71 W. The fault changes strike to N. 29° E., in the SE 1/4, NE 1/4, Sec. 12, T. 19 S., R. 71 W. In the NE 1/4, NE 1/4, Sec. 12 Precambrian on the west side is in contact with Morrison on the east side. Tracing the thrust to the north the Precambrian is in contact with progressively older sediments and in the NW 1/4, Sec. 6, T. 19 S., R. 70 W. Ordovician sedimentary rocks overlying the Precambrian on the hanging wall are in contact with Fountain conglomerates of the footwall. On the south bank of the Arkansas River the fault is entirely in the Fremont Formation at the surface. It cannot be traced north of the Arkansas.



4. Reversal of direction of movement during the Laramide orogeny and subsequent erosion to Fremont Limestone on the upthrown block and to the Purgatoire Formation on the downthrown block.

3. Removal by erosion of all Fountain strata on the upthrown block and part of the strata on the downthrown block, followed by deposition of Cretaceous strata.

2. Removal by erosion of Ordovician strata on the upthrown block and deposition of Fountain strata over the area.

1. Initial gravity faulting during Ancestral Rocky Mountain orogeny.

Fig. 9. Diagramatic development of southern thrust in Grape Creek area.

Twin Mountain Area

Major structures of the Twin Mountain area, from southwest to northeast respectively, are: Devils Gap syncline; South Twin Mountain anticline: Twin Mountain syncline; and North Twin Mountain anticline (Plate 3). The area lies in Secs. 1, 2, 11, and 12, T. 18 S., R. 71 W.

Devils Gap syncline is a southeast plunging structure on the southwestern flank of the South Twin Mountain anticline. The limb common to both structures is highly faulted.

South Twin Mountain anticline is a breached structure plunging 30° southeast. A longitudinal high angle thrust breached the anticline and placed Precambrian crystallines in contact with Manitou, Harding and Fremont of the southwestern limb. Vertical displacement along the thrust is approximately 900 feet in the SE 1/4, SE 1/4, Sec. 2 and becomes progressively less to the east. The thrust is terminated by a small normal fault on the eastern end. In the SW 1/4, SE 1/4, Sec. 2, NE 1/4, Sec. 11, and NW 1/4, Sec. 12 the thrust bifurcates to include a large slice of Precambrian crystallines capped with Manitou Limestone and Harding Sandstone.

North Twin Mountain is a faulted overturned breached anticline plunging 25° southeast. As the anticline developed it was overturned to the southwest and the northeastern limb was thrust over the southwest limb. The high angle thrust dies out in the Twin Mountain syncline in the SE 1/4, Sec. 1, T. 18 S., R. 71 W. Displacement along the thrust increases to the northwest.

Twin Mountain syncline lies between North and South Twin Mountain anticlines. The axis of the syncline is well exposed in the valley of Twin Creek. The northeastern limb is overturned to the southwest and is thrust over the southwest limb.

Twin Mountain Thrust

The Twin Mountain thrust is a high angle thrust striking approximately N. 30° E. and diping from 80° west to nearly vertical. The Twin Mountain anticlines and associated thrusts are terminated by this fault. The western upthrown block has thrust Precambrian crystallines into contact with strata of Ordovician, Pennsylvanian, and Jurassic age.

A tear fault terminates the Twin Mountain thrust in the NW 1/4, Sec. 7, T. 17 S., R. 70 W. The north block of the tear moved east relative to the south block.

ECONOMIC GEOLOGY

In the Canon City-Twin Mountain area numerous abandoned pits and shafts attest the short lived and fruitless attempts of prospectors. Copper mineralization along major faults attracted the prospectors in the late 1800's. More recently noncommercial uranium deposits in the Morrison have attracted some attention.

Industrial minerals have been produced since the 1860's and are still an important aspect of the economics of the area. Sandstone, limestone, and clay are all actively quarried or mined today for a number of uses. Petroleum and coal have the longest production record in the area.

Coal

Coal has been extensively mined in the Canon City coal fields, southeast of Canon City (Washburne, 1910). The coals are in the Vermejo Formation and are thicker in the subsurface than in exposures. Large reserves are present, however, operating costs and lack of demand make them marginal. The coal does not coke, but does make an excellent domestic fuel. A few mines are currently active, mostly supplying local demand with a small annual production.

Oil

Oil seeps along Oil Creek mentioned in early reports of the Canon City area attracted the attention of a Denver prospector. Hayden (1869, p. 219) reported that four wells were drilled by the Denver man along the seeps, with the first one completed in 1863. Annual production for the four wells was only 4,000 gallons. The crude was analyized as follows:

Benzine	12%
Good clear burning oil	50%
Nitrogenous mass, containing much parafine and parafine oil	25%
Coke and refuse	13%

In 1876 the Florence field was discovered 6 miles southeast of Canon City, and 50 years later, the Canon City pool was opened one mile southeast of Canon City. De Ford (1929) listed both of these fields as permeability traps with production from fractures in the Pierre Shale. Lavington (McCoy, et. al., 1951,

p. 1008) showed the production to be from the Tepee Butte zone of the Pierre.

The fractures in the Canon City pool occur on the nose of the southeasterly plunging Oil Creek anticline, whereas the Florence field is on a terrace on the eastern limb of the Chandler syncline. The oil is probably indigenous to the Pierre and accumulated in fractures formed during the Laramide revolution (De Ford, 1929, pp. 86-87). No water is encountered in the wells and wells do not go to water with age. A few wells are still pumping in both fields today.

Ornamental Stone

Travertine is quarried at the Cowan Brothers' quarry in the SW 1/4, Sec. 7, T. 18 S., R. 70 W. The travertine takes a high polish, and is highly prized as an ornamental stone. Three colors are commonly found, light orange, mahogany, and gray and it is sold under trade names derived from the colors, Colorosa, Colorosa Mahogany, and Colorosa Gray, respectively.

In the NE 1/4, NE 1/4, Sec. 13, T. 18 S., R. 71 W. a conglomerate bed in the Fountain Formation is composed entirely of Fremont pebbles, cobbles, and boulders with a dolomitic cement. It is quarried by the Cowan brothers and sold under the trade name Royal Breche.

Fremont Limestone and Williams Canyon Limestone are quarried for use in making terrazzo. Both limestones are quarried in the NW 1/4, SW 1/4, Sec. 25, T. 17 S., R. 71 W.; in addition, Williams Canyon is quarried at two localities in the NE 1/4, Sec. 12, T. 18 S., R. 71 W. The quarries are worked 4 to 6 weeks each year, as material is needed.

Fire Clay

Fire clay is mined in the SW 1/4, SW 1/4, Sec. 4, T. 18 S., R. 70 W. The clay occurs in the upper part of the Dakota Sandstone, and varies from 5 to 11 feet in thickness. Several abandoned quarries and mines in the Glencairn Shale member and the Dakota Sandstone are located in Secs. 5 and 8, T. 18 S., R. 70 W. The clays are local, discontinuous, and too impure in places. Two plants in Canon City use the clays for manufacturing brick, tile, and tile pipe.

Sand and Gravel

A drag line operation in the Arkansas River, SE 1/4, Sec. 32, T. 18 S., R. 70 W., supplies all the sand and gravel required for construction in the Canon City area. Small pits are operated in Sand Creek, SW 1/4, NW 1/4, Sec. 29, T. 18 S., R. 70 W.; Wilson Creek, NE 1/4, NW 1/4, Sec. 10, T. 18 S., R. 70 W.; and Oil Creek, eastern half Sec. 10, T. 18 S., R. 70 W. These pits supply material to farmers, ranchers, and the County Highway Department for various uses.

Flux Lime

A large quarry in the NE 1/4, SW 1/4, Sec. 30, T. 18 S., R. 70 W. supplies Fremont Limestone to the steel mill of the Colorado Fuel and Iron Company in Pueblo, where it is used as a flux in the blast furnaces. Extensive reserves extend as far as 6 1/2 miles north of the quarry.

Refractory Sand

Quarries in the Harding Sandstone in the southern half of Sec. 30, T. 18 S., R. 70 W. have been worked since the turn of the century. The sand supplied by these quarries is used as refractory sand at the steel mill in Pueblo.

Pegmatites

Pegmatites of the Eight Mile Park area have been extensively mined in the past (Heinrich, 1948). Today mining is still active, although most of the mines are marginal. Quartz, feldspar, beryl, and mica are the primary minerals mined today.

Building Stone

The Dakota Sandstone has been quarried in the past as dimension stone. Several of the Colorado State Penitentiary buildings were constructed with Dakota blocks quarried within the penitentiary grounds. Another abandoned quarry is located in the NW 1/4, SW 1/4, Sec. 20, T. 18 S., R. 70 W.

Roofing Chat

The resistant nature of the chert and dolomite of the Manitou formation makes it useful as roofing chat when crushed. A small quarry is located in the SE 1/4, SE 1/4, NE 1/4, Sec. 11, T. 18 S., R. 71 W. The quarry is operated by a Denver contractor a few weeks each year to meet his construction demand.

GEOLOGIC HISTORY

A thick sequence of sandstones and shales were deposited during Precambrian time in the area that is occupied by the Front Range today. Injection of the Pikes Peak Granite metamorphosed the strata into the schists and gneisses of the Idaho Springs Formation. Later injections resulted in formation of the injection gneiss. A third period of intrusion was followed by uplift and erosion.

Middle Cambrian seas invaded the region from the east and in the Front Range, Sawatch Quartzite was deposited on a base-leveled Precambrian surface. No Sawatch is found in the Canon City Embayment; if it was deposited, it was removed by pre-Manitou erosion.

Early Ordovician seas spread over the region depositing Manitou Limestone. Retreat of the sea was accompanied or followed by a slight uplift on the southwestern side of the embayment. Minor faulting was associated with the uplift. A thick sequence of clastics was deposited by transgressing Middle Ordovician seas. Withdrawal of the Middle Ordovician seas was followed by a period of subaerial erosion which ended with transgression of Upper Ordovician seas and deposition of the Fremont Limestone. After withdrawal of Ordovician seas the area was low lying, and a period of quiescence prevailed through Silurian time.

Faunal evidence shows Devonian seas were present in western Colorado. Questionable Devonian sedimentary rocks along the Front Range are non-fossiliferous. If Mississippian seas covered the embayment, pre-Fountain erosion removed the Mississippian strata and considerable amounts of older Paleozoic strata along the western side of the embayment.

During Morrowian time uplift of the Ancestral Rockies was initiated. Pulsations of the uplift probably continued until early Missourian time. Some faulting in the Grape Creek area is thought to have been associated with the uplift.

The Lykins Formation records invasion of late Permian seas. In the Canon City Embayment the Lykins sea withdrew either at the end of Permian time or shortly after. Further north along the Front Range the Lykins sea did not withdraw until early Triassic time. If any Triassic sediments were deposited in the Canon City area they were subsequently removed by erosion.

Throughout Early and Middle Triassic time, the region around Canon City was probably low. During Late Jurassic, late Callovian and early Oxfordian time, a closed basin was evident in southeastern Colorado, extending into the eastern portion of the Canon City Embayment. Deposits of gypsum over 100 feet thick are present a few miles northeast of Canon City.

Upper Jurassic Kimmeridgian time was a period of continental lacustrine deposition. These conditions prevailed through early Portlandian time before erosion began leveling the area.

Early Cretaceous was a period of subaerial erosion with the area low and erosion of little consequence. During Albian time continental deposits preceeded the encroaching Late Cretaceous seas. Late Cretaceous seas covered the entire present Front Range. Several oscillations of the sea are recorded in the sandstone, shales, and limestones deposited during the Late Cretaceous. The first pulsations of the Laramide Revolution were during Pierre time (Lovering and Goddard, 1950, p. 58). Cretaceous sediments were quickly eroded from the rising Rocky Mountains and Upper Cretaceous deposits are continental, with abundant feldspar indicating intense mechanical weathering of the Precambrian rocks.

Continental deposition continued through Early Tertiary time and further pulsations of the Laramide Revolution folded, faulted, and uplifted the area. Vulcanism and intrusion terminated the Laramide Revolution.

Except for terrace deposits, deposition ceased in the Cañon City Embayment after Eocene time. Pliocene and Pleistocene were periods of relative quiescence except for epirogenic uplift.

REFERENCES CITED

Acharya, Ashutosh, 1949, Geology of the Grape Creek area, Fremont County, Colorado: Master's thesis, Colo. School of Mines.

Bass, N. W., 1926, Geologic investigations in western Kansas: Kans. Geol. Survey Bull. 11, p. 1-96.

Blum, V. J., 1944, A magnetic survey of the Canon City area: Am. Geophys. Union Trans., v. 25, p. 556-558.

Boos, M. C., and Boos, M. F., 1957, Tectonics of eastern flank and foothills of Front Range, Colorado: Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2603-2676.

Brainerd, A. E., Baldwin, H. L., Jr., and Keyte, I. A., 1933, Pre-Pennsylvanian stratigraphy of Front Range in Colorado: Am. Assoc. Petroleum Geologists Bull., v. 17, p. 375-396.

Browder, G. T., 1958, The geology of Shaws Park, Fremont County, Colorado: Master's thesis, Okla. Univ.

Cobban, W. A., and Reeside, J. B., Jr., 1952, Correlation of the Cretaceous formations of the Western Interior of the United States: Geol. Soc. America Bull., v. 63, p. 1011-1044.

Cross, Whitman, 1894, Description of the Pikes Peak quadrangle (Colorado): U. S. Geol. Survey Geol. Atlas, folio 7.

Darton, N. H., 1906, Geology and underground waters of the Arkansas Valley in eastern Colorado: U. S. Geol. Survey Prof. Paper 52, p. 1-90.

De Ford, R. K., 1929, Surface structure, Florence oil field, Fremont County, Colorado: Am. Assoc. Petroleum Geologists, Structure of Typical American Oil Fields, v. 2, p. 75-92.

Eldridge, G. H., 1889, On some stratigraphical and structural features of the country about Denver, Colorado: Colo. Sci. Society Proc., v. 3, pt. 1, p. 86-118.

Emmons, S. F., Cross, W., and Eldridge, G. H., 1896, Geology of the Denver Basin in Colorado: U. S. Geol. Survey Mon. 27, 556 p.

Endlich, F. M., 1874, Notes on surface features of the Colorado or Front Range of the Rocky Mountains: U. S. Geol. and Geog. Survey of the Territories Bull., v. 6, p. 183-240.

Fenneman, N. H., 1905, Geology of the Boulder district, Colorado: U. S. Geol. Survey Bull. 265, p. 1-98.

Finlay, G. I., 1916, Description of the Colorado Springs quadrangle (Colorado): U. S. Geol. Survey Geol. Atlas, folio 203.

Fischer, W. A., 1953, The foraminifera and stratigraphy of the Colorado Group: Doctor's thesis, Colo. Univ.

Frederickson, E. A., DeLay, J. M., and Saylor, W. W., 1956, Ralston Formation of Canon City Embayment, Colorado: Am. Assoc. Petroleum Geologists Bull., v. 40, p. 2120-2148.

Gilbert, G. K., 1896, The underground waters of the Arkansas Valley in eastern Colorado: U. S. Geol. Survey, 17th Ann. Report, pt. 2, p. 551-601.

Hatcher, J. B., 1901, Annals: Carnegie Museum, v. 1, p. 327-341.

Hayden, F. V., 1868, Remarks on the geologic formations along the eastern margin of the Rocky Mountains: Am. Jour. Sci., 2d ser., v. 45, p. 322-326.

______________, 1869, U. S. Geological Survey of the Territories, embracing Colorado and New Mexico: 3rd Ann. Report, v. 3, 261 p.

______________, 1873, Survey of the Territories: U. S. Geol. Survey Territories, 3rd Ann. Report, v. 7, p. 427-533.

Heaton, R. L., 1933, Ancestral Rockies and Mesozoic and Late Paleozoic stratigraphy of Rocky Mountain region: Am. Assoc. Petroleum Geologists Bull., v. 17, p. 109-168.

______________, 1950, Late Paleozoic and Mesozoic history of Colorado and adjacent areas: Am. Assoc. Petroleum Geologists Bull., v. 34, p. 1659-1698.

Heinrich, E. W., 1948, Pegmatites of the Eightmile Park, Fremont County, Colorado: Am. Mineralogist, v. 33, p. 420-448, 550-587.

Hills, R. C., 1899, Description of the Elmoro quadrangle (Colorado): U. S. Geol. Survey Geol. Atlas, folio 58.

Lee, W. T., 1913, Recent discovery of dinosaurs in the Tertiary: Am. Jour. Sci., 4th ser., v. 35, p. 531-534.

LeRoy, L. W., 1946, Stratigraphy of the Golden-Morrison area, Jefferson County, Colorado: Colo. School of Mines Quart., v. 41, no. 2, p. 1-115.

Logan, W. N., 1897, The Upper Cretaceous of Kansas: Kans. Univ. Geol. Survey, v. 2, p. 195-231.

Lovering, T. S., 1929, Geologic history of the Front Range: Colo. Sci. Society Proc., v. 12, p. 59-112.

______________, Aurand, H. A., Lavington, C. S., and Wilson, J. H., 1932, Fox Hills Formation, northeastern Colorado: Am. Assoc. Petroleum Geologists Bull., v. 16, p. 702-703.

______________, and Goddard, E. N., 1950, Geology and ore deposits of the Front Range, Colorado: U. S. Geol. Survey Prof. Paper 223, 319 p.

Maher, J. C., 1953a, Permian and Pennsylvanian rocks of southeastern Colorado: Am. Assoc. Petroleum Geologists Bull., v. 37, p. 913-939.

____________, 1953b, Paleozoic history of southeastern Colorado: Am. Assoc. Petroleum Geologists Bull., v. 37, p. 2475-2489.

Mann, C. J., 1957, Geology of Chandler syncline, Fremont County, Colorado: Master's thesis, Kans. Univ.

McCoy, A. W., III, Sielaff, R. L., Downs, G. R., Bass, N. W., and Maxon, J. H., 1951, Types of oil and gas traps in Rocky Mountain region: Am. Assoc. Petroleum Geologists Bull., v. 35, p. 1000-1037.

McCullough, D. L., 1959, Geology of the Parkdale area, Fremont County, Colorado: Master's thesis, Kans. Univ.

Meek, F. B., and Hayden, F. V., 1862, Descriptions of new Cretaceous fossils from Nebraska Territory: Phila. Acad. Nat. Sci. Proc., v. 13, p. 21-28.

Miller, J. H., 1951, Geology southwest of Canon City, Fremont County, Colorado: Master's thesis, Colo. School of Mines.

Moore, R. C., 1958, Introduction to Historical Geology: McGraw-Hill Book Co., Inc., New York, p. 240.

Powers, W. E., 1935, Physiographic history of the upper Arkansas Valley and the Royal Gorge, Colorado: Jour. Geol., v. 43, p. 184-199.

Rubey, W. W., and Bass, N. W., 1925, The geology of Russell County, Kansas: Kans. Geol. Survey Bull. 10, p. 1-104.

Ruley, E. E., 1952, The geology of a portion of the foothills belt on the southwest side of the Canon City Embayment Fremont County, Colorado: Master's thesis, Colo. School of Mines.

Stose, G. W., 1912, Description of the Apishapa quadrangle (Colorado): U. S. Geol. Survey Geol. Atlas, folio 186.

Sweet, W. C., 1954, Harding and Fremont Formations, Colorado: Am. Assoc. Petroleum Geologists Bull., v. 38, p. 284-305.

Tieje, A. J., 1923, The red beds of the Front Range in Colorado, a study in sedimentation: Jour. Geol., v. 31, p. 192-207.

Vanderwilt, J. W., and Others, 1948, Guide to the geology of central Colorado: Colo. School of Mines Quat., v. 43, no. 2, p. 1-76.

Van Horn, Richard, 1957, Ralston Creek Formation, new name for Ralston Formation of LeRoy (1946): Am. Assoc. Petroleum Geologists Bull., v. 41, p. 755-756.

Van Tuyl, F. M., and Lovering, T. S., 1935, Physiographic development of the Front Range: Geol. Soc. America Bull., v. 46, p. 1291-1349.

Walcott, C. D., 1892, Preliminary notes on the discovery of a vertebrate fauna in Silurian (Ordovician) strata: Geol. Soc. America Bull., v. 3, p. 153-172.

Waldschmidt, W. A., and LeRoy, L. W., 1944, Reconsideration of the Morrison Formation in the type area, Jefferson County, Colorado: Geol. Soc. America Bull., v. 55, p. 1097-1114.

Washburne, C. W., 1910, The Canon City coal field, Colorado: U. S. Geol. Survey Bull. 381, p. 341-378.

Williams, S. G., 1876, Notes on the geology of some localities near Canyon City, Fremont County, Colorado: U. S. Geol. and Geog. Survey of the Territories Bull., 2d ser., v. 1, p. 249-251.

Williston, S. W., 1893, The Niobrara Cretaceous of western Kansas: Kans. Acad. Sci. Trans., v. 13, p. 107-111.

APPENDIX

Measured Sections

Locality 1. Along line from NW 1/4, SE 1/4, Sec. 6, T. 17 S., R. 70 W. southeast through Red Canons Park to NE 1/4, SW 1/4, Sec. 8, T. 17 S., R. 70 W.

	Thickness Feet
Cretaceous	
Dakota Sandstone (35.1 feet, incomplete, top eroded)	
121. Sandstone, light tan, fine- to coarse-grained, friable. Grains subrounded. Loose calcareous cement. Massive with some cross-bedding....	10.4
120. Sandstone, light gray to tan, fine-grained, argillaceous, thin-bedded. Grains subrounded. Calcareous cement with some ferruginous staining....................................	6.8
119. Sandstone, light tan, fine- to coarse-grained, slightly calcareous cement locally. Grains subrounded. Thin- to massive-bedded. Small cross-bedding................................	10.8
118. Sandstone and conglomerate, white to light tan, fine- to coarse-grained, friable, loosely cemented. Grains subrounded. Cross-bedding well developed. Abundant wood and coal fragments. Numerous fucoids.............................	7.1
Purgatoire Formation (98.8 feet)	
Glencairn Member (67.1 feet)	
117. Sandstone, light tan, very fine-grained, well cemented. Grains subrounded. Ferruginous staining locally..............................	1.5

116.	Covered interval..................................	5.4
115.	Sandstone buff to light tan, very fine-grained. Grains subrounded. Thin- to massive-bedded with thin shaly partings. Ferruginous staining locally. Ripple marks on upper surface and fucoids throughout................................	14.3
114.	Shale, light gray to black, splintery to blocky, fissile, arenaceous. Carbonaceous inclusions. Ferruginous staining. Thin stringers, tan to buff, very fine-grained sandstone. Secondary gypsum along fractures...................................	9.1
113.	Sandstone, buff to light tan, very fine-grained. Grains subrounded. Ferruginous staining. Thin- to thick-bedded with thin shaly partings...........	12.9
112.	Shale, light gray to black, splintery to blocky, fissile, arenaceous. Carbonaceous inclusions. Ferruginous staining. Thin stringers, tan to buff, very fine-grained sandstone. Secondary gypsum along fractures.......................................	7.7
111.	Sandstone, tan to gray, weathers buff, very fine-grained, argillaceous. Grains subrounded. Ferruginous staining. Thin- to massive-bedded with discontinuous bedding planes.................	10.3
110.	Shale, dark gray, platy, fissile, arenaceous. Wood fragments scattered throughout. Gypsum stringers 0.25 to 0.5 inch thick in upper 6 inches. Thin stringers, light tan, very fine-grained sandstone.......................................	5.9

Lytle Member (31.7 feet)

109.	Conglomerate, white to light gray, friable. Pebbles of chert up to 1.4 inches. Matrix coarse-grained sand. Calcareous cement. Ferruginous staining. Cross-bedding well developed..................................	31.7

Jurassic

Morrison Formation (519.6 feet)

108.	Sandstone and shale, white to light green to purple massive. Calcareous cement. Laterally ranges from argillaceous sandstone to arenaceous shale................................	3.8
107.	Sandstone, white, fine-grained, friable massive. Grains subrounded. Calcareous cement..........	2.2
106.	Sandstone, white to purple, fine-grained, friable. Argillaceous, massive. Grains subrounded. Calcareous cement, loosely cemented. Ferruginous staining............................	17.2
105.	Sandstone, white to light pink, weathers same, fine- to medium-grained, friable, massive. Grains subrounded. Calcareous cement. Ferruginous staining. Calcite filled fractures. Cross-bedding well developed.................................	29.6
104.	Covered, interval..............................	320.1
103.	Sandstone, light gray to gray-green, very fine-grained, arkosic, massive. Grains subrounded. Calcareous cement..............................	4.2
102.	Sandstone, light gray to gray-green, very fine-grained, arkosic, friable. Calcareous cement. Thin-bedded. Thin stringers, light gray green, soft, blocky, arenaceous shale..................	4.0
101.	Covered interval...............................	13.7
100.	Sandstone, light gray to gray-green, very fine-grained, arkosic, friable, massive. Grains subrounded. Calcareous cement..................	4.4
99.	Covered interval...............................	22.1
98.	Sandstone, light gray to gray-green, very fine-grained, arkosic, massive. Grains subrounded. Calcareous cement..............................	2.8

97.	Shale, light green to chocolate brown, platy, to splintery, soft, fissile, arenaceous............	26.5
96.	Conglomerate, light gray to pink, arkosic massive. Pebbles up to 2 inches, angular to subrounded. Calcareous cement. Cross-bedding well developed..................................	4.9
95.	Conglomerate, light green to chocolate brown, arkosic, argillaceous, friable. Pebbles up to 0.5 inch. Thin wavy bedding....................	6.2
94.	Conglomerate, light green to chocolate brown, arkosic, argillaceous, massive. Matrix coarse-grained sand. Grains subangular. Calcareous cement...	7.4
93.	Sandstone, light green to chocolate brown, fine- to coarse-grained, arkosic, argillaceous, friable massive. Grains subangular to subrounded. Channeling into underlying conglomerate..................	2.9
92.	Conglomerate, light gray to pink, arkosic massive. Angular to subrounded pebbles up to 2 inches. Calcareous cement. Local cross-bedding..	3.8
91.	Sandstone, light green to chocolate brown, fine- to coarse-grained, arkosic, argillaceous, friable. Grains subangular to subrounded..................	4.1
90.	Conglomerate, light gray to pink, arkosic massive. Angular to subrounded pebbles up to 2 inches. Calcareous cement, loosely cemented. Cross-bedding well developed. Channeling at base..	17.7
89.	Sandstone, light green to chocolate brown, fine- to coarse-grained, arkosic, argillaceous, friable massive. Grains subangular to subrounded. Channeling at base............................	1.4
88.	Conglomerate, light gray to pink, arkosic massive. Angular to subrounded pebbles up to 2 inches. Calcareous cement. Local cross-bedding..	17.4

87. Sandstone, light orange to chocolate brown, fine- to coarse-grained, argillaceous, arkosic, friable massive. Calcareous cement, loosely cemented. Grains subangular to subrounded................ 3.2

Permian

Lykins Formation (0.2 to 0.5 feet)

86. Limestone, light gray-green, very finely crystalline, arenaceous. Wavy laminations............. 0.2 to 0.5

Pennsylvanian

Fountain Formation (1177.9 feet)

85. Sandstone, dark orange to chocolate brown, fine- to coarse-grained, arkosic, argillaceous, friable massive. Grains subangular to subrounded. Calcareous cement. Thin stringers, light gray-green shale................................. 54.2

84. Conglomerate, light gray to yellow-orange, arkosic, friable. Pebbles up to 2 inches. Calcareous cement.. 0.9

83. Sandstone, dark red-orange, very fine-grained, argillaceous, arkosic, friable massive. Grains subrounded...................................... 21.5

82. Conglomerate, light gray to yellow orange, arkosic, friable. Pebbles up to 2 inches. Calcareous cement... 0.6

81. Conglomerate interbedded with sandstone. Conglomerate, dark orange to maroon, arkosic. Subangular to subrounded cobbles up to 6 inches. Massive-bedded up to 15 feet thick. Cross-bedding well developed. Channeling common. Sandstone, dark orange, coarse grained. Grains subangular. Calcareous cement. Thin- to massive-bedded up to 3 feet thick. Cross-bedded locally... 192.9

80.	Covered interval..................................	34.0
79.	Conglomerate interbedded with sandstone. Conglomerate, dark orange to maroon, arkosic. Subangular to subrounded cobbles up to 6 inches. Massive-bedded up to 15 feet thick. Cross-bedding well developed. Channeling common. Matrix coarse-grained sand. Calcareous cement. Sandstone, dark orange, coarse grained. Grains subangular. Calcareous cement. Thin- to massive-bedded up to 3 feet thick. Cross-bedded locally..	158.8
78.	Covered interval..................................	17.4
77.	Conglomerate, dark orange to maroon, light gray locally, arkosic, well cemented. Grains subangular to subrounded. Calcareous cement. Cobbles up to 4 inches. Matrix coarse-grained sand. Massive-bedded with cross-bedding prominent.....	33.0
76.	Conglomerate, light gray to maroon, arkosic, friable, thick-bedded. Cobbles up to 3 inches. Calcareous cement. Grades into coarse-grained sandstone in the upper 3 feet. Channeling and cross-bedding common.........................	12.7
75.	Sandstone, dark orange to maroon, coarse-grained, friable, argillaceous, massive. Grains subangular. Calcareous cement............................	2.8
74.	Conglomerate, light gray to maroon, arkosic, friable, thick-bedded. Cobbles up to 3 inches. Calcareous cement. Channeling and cross-bedding common.......................................	11.3
73.	Conglomerate, light gray to maroon, friable, thick-bedded. Cobbles up to 4 inches. Matrix coarse-grained sand. Calcareous cement. Cross-bedding common.......................................	8.5
72.	Sandstone, dark orange to maroon, coarse-grained, friable, argillaceous, massive. Grains subangular. Calcareous cement....................	2.7

71.	Conglomerate, dark orange to maroon, friable, thick bedded. Pebbles up to 2 inches. Matrix coarse-grained sandstone. Calcareous cement. Cross-bedding and channeling common.................	7.4
70.	Conglomerate, light orange to dark red, arkosic, massive. Boulders up to 1.5 feet. Calcareous cement. Some gradational bedding with finer grained material towards top. Channeling and cross-bedding well developed. Some lensing.......	104.2
69.	Conglomerate, light orange to dark maroon, arkosic, well cemented. Calcareous cement. Cobbles up to 4 inches. Cross-bedding well developed.......................................	60.4
68.	Conglomerate, light orange to maroon, arkosic, massive. Boulders up to one foot. Calcareous cement, well to loosely cemented. Thin shaly partings. Some channeling at base................	2.1
67.	Sandstone, light gray-green to dark maroon, coarse-grained, argillaceous, micaceous, Calcareous cement, well to loosely consolidated. Irregular thin wavy bedded......................	11.7
66.	Conglomerate, light orange to maroon, arkosic, thick- to massive-bedded. Cobbles up to 4 inches. Calcareous cement, well to loosely cemented. Thin shaly partings. Some channeling at base..........	13.4
65.	Sandstone, light to dark red-orange, very coarse-grained, arkosic, thin-bedded. Stringers light gray-green shale. Small conglomerate lenses.....	27.6
64.	Conglomerate, light orange to maroon, arkosic, thick- to massive-bedded. Cobbles up to 4 inches. Calcareous cement, well to loosely cemented. Thin shaly partings. Some channeling at base..........	11.0
63.	Conglomerate, light gray-green to dark red-orange, argillaceous, arkosic, loosely cemented, massive. Cobbles up to 6 inches. Becomes coarser grained towards top. Cross-bedded locally................	12.4

62.	Covered interval................................	6.3
61.	Conglomerate, light to dark red-orange, arkosic, massive. Subangular pebbles up to one inch. Well consolidated, calcareous cement. Small cross-bedding.......................................	4.8
60.	Sandstone, light to dark red-orange, arkosic, micaceous, thin-bedded. Grains subangular to subrounded. Loosely to well consolidated. Locally conglomeratic. Well developed cross-bedding.......................................	15.7
59.	Conglomerate, light to dark red-orange, arkosic, massive. Subangular pebbles up to 2 inches. Well consolidated, calcareous cement. Small cross-bedding.......................................	7.4
58.	Covered interval................................	5.5
57.	Conglomerate, light to dark red-orange, arkosic, friable. Subangular cobbles up to 6 inches. Well to loosely cemented, calcareous cement. Massive bedded up to 16 feet. Small cross-bedding locally. Channeling at base.............	48.0
56.	Conglomerate, light to dark red-orange, friable, massive. Subangular cobbles up to 4 inches. Calcareous cement. Grades upward into coarse-grained sandstone..................................	9.0
55.	Covered interval................................	13.7
54.	Sandstone, light orange to maroon, coarse-grained, micaceous, friable. Grains subangular to subrounded. Calcareous cement, loosely to well consolidated. Conglomerate stringers and lenses................	15.2
53.	Conglomerate, light to dark red-orange, arkosic, massive. Subangular to subrounded cobbles up to 4 inches. Calcareous cement, well cemented......	7.8

52.	Covered interval................................	7.6
51.	Conglomerate, light to dark red-orange, arkosic, massive. Boulders up to one foot. Calcareous cement, well cemented. Prominent cross-bedding. Massive-bedding varies from 6 to 12 feet. Each unit is coarse conglomerate at the base and becomes finer grained towards the top of the unit.....	39.9
50.	Covered interval................................	4.5
49.	Conglomerate, light to dark orange, massive. Boulders up to one foot. Grades upwards into granule conglomerate. Calcareous cement, well cemented. Matrix coarse-grained sand...........	21.7
48.	Conglomerate, orange to dark red, arkosic, friable, thick massive-bedded. Cobbles up to 4 inches. Calcareous cement, well to loosely cemented. Cross-bedding small and poorly developed.........	16.6
47.	Conglomerate, orange to maroon, arkosic, friable, massive. Subangular to subrounded cobbles up to 4 inches. Calcareous cement, loosely cemented...	20.9
46.	Conglomerate, orange to maroon, arkosic, massive. Subangular to subrounded Fremont cobbles up to 4 inches. Calcareous cement, well cemented......	5.5
45.	Sandstone, chocolate red to maroon, fine- to coarse-grained, argillaceous, micaceous, arkosic, friable, massive. Calcareous cement, loosely cemented. Conglomerate lenses locally...........	4.1
44.	Conglomerate, orange to maroon, arkosic. Subangular to subrounded pebbles; cobbles up to 6 inches. Calcareous cement, well cemented. Thick massive-bedding up to 5 feet. Small cross-bedding. Argillaceous, sandstone partings up to 6 inches....	18.2
43.	Sandstone, chocolate brown to maroon, fine- to coarse-grained, argillaceous, micaceous, friable. Grains subrounded............................	1.7

42.	Conglomerate, orange to dark red, arkosic, massive. Cobbles up to 4 inches; subangular to subrounded pebbles. Calcareous cement; loosely cemented in upper 4 feet, well cemented in base....	24.2
41.	Sandstone, dark red to orange, weathers dark red, fine- to medium-grained, micaceous, friable, argillaceous, arkosic. Grains subangular to subrounded. Calcareous and ferruginous cement. Thin stringers red-orange, arkosic, well cemented, conglomerate with cobbles up to 3.5 inches........	30.1
40.	Conglomerate, reddish orange to maroon, arkosic, massive. Fremont cobbles up to 3.5 inches. Subangular to subrounded pebbles. Matrix coarse sand. Calcareous cement, well cemented.........	3.4
39.	Sandstone, dark red to maroon, fine- to medium-grained, friable, micaceous, argillaceous, arkosic, massive. Subangular to subrounded grains. Calcareous and hematitic cement....................	7.2
38.	Conglomerate, pink to orange, arkosic, massive. Pebbles subangular to subrounded; Fremont cobbles up to 6 inches. Calcareous cement, well cemented..	5.2
37.	Sandstone, dark red to gray, fine- to coarse-grained, argillaceous, thin-bedded. Grains subrounded. Ferruginous staining. Calcareous cement.	11.4
36.	Conglomerate, orange to maroon, thin-bedded. Calcareous cement, well cemented. Gradational, becoming finer grained at top. Small cross-bedding in upper 3 feet................................	5.2
35.	Sandstone, dark red to tan, fine- to medium- grained, argillaceous, loosely cemented, thin-bedded. Grains subrounded. Ferruginous staining..........	7.4
34.	Sandstone, dark red to orange, weathers dark red, medium- to coarse-grained, friable, massive. Grains subrounded. Calcareous and hematitic cement. Scattered iron nodules. Small cross-bedding....................................	3.0

33. Conglomerate, orange to yellow, massive. Williams Canyon and Fremont cobbles up to 4 inches. Well cemented, calcareous cement.................... 5.2

Devonian ?

Williams Canyon (15.8 feet)

32. Limestone, varicolored, white to yellow to gray to purple, weathers same, finely crystalline. Arenaceous in upper 5 feet. Thin-bedded with thin laminations................................ 15.8

Ordovician

Fremont Formation (126.3 feet)

31. Limestone, buff to gray, finely to coarsely crystalline, dolomitic, thin-bedded. Scattered chert nodules. Abundant crinoid stems and plates. Pit and cusp weathering........................ 39.6

30. Limestone, buff to gray, weathers buff, finely to coarsely crystalline, dolomitic, massive. Scattered gray to yellow chert nodules. Pit and cusp weathering. Vuggy porosity locally...................... 31.8

29. Limestone, buff to gray, weathers buff, finely to coarsely crystalline, dolomitic, massive. Gray to purple chert nodules. Discontinuous bedding planes. Pit and cusp weathering. Vuggy porosity locally. Abundant <u>Receptaculites sp</u>...................... 39.2

28. Limestone, buff to maroon, finely to coarsely crystalline, dolomitic, massive. Manganese zone in bottom one foot. Pit and cusp weathering. Vuggy porosity locally. Abundant <u>Receptaculites sp</u>............. 15.7

Harding Formation (128.5 to 129.8 feet)

27. Conglomerate, maroon, loosely consolidated. Harding and Fremont pebbles up to 2 inches. Appears to be highly weathered.......................... 0.6

26.	Sandstone, white to yellow to maroon, very fine-grained, friable, thin-bedded. Shaly partings. Abundant fish plates, particularly along the shale partings................................	6.8
25.	Covered interval................................	12.5
24.	Sandstone, white to yellow, very fine-grained, friable, slightly calcareous......................	2.4
23.	Covered interval................................	2.6
22.	Sandstone, white to light pink, weathers tan to pink, very fine-grained, friable, thin-bedded. Calcareous cement. Abundant fish plates, particularly along bedding planes.................	2.2
21.	Sandstone, light green to pink, very fine-grained, friable, argillaceous, soft, massive. Calcareous cement......................................	6.2
20.	Sandstone, white to pink, weathers pink, very fine-grained, slightly calcareous, friable, massive.....	10.0
19.	Sandstone interbedded with shale. Sandstone, pink, very fine-grained, slightly calcareous, thin-bedded. Shale, light pink, arenaceous crumbly.............	4.2
18.	Sandstone, white to pink to maroon, weathers tan to pink, very fine-grained, calcareous cement, thin-bedded. Shaly partings. Abundant fish plates along partings................................	10.5
17.	Limestone, white to purple, thin-bedded. Fish plates composed over 75 percent of unit...........	2.4
16.	Sandstone, white to light pink, weathers white, very fine-grained, massive, calcareous cement....	1.1
15.	Covered interval................................	26.5
14.	Sandstone, white, very fine-grained, calcareous cement, massive...............................	1.4

13.	Covered interval	2.3
12.	Sandstone, white to light pink, very fine-grained, calcareous cement, thin-bedded. Scattered iron nodules. Shaly partings	5.4
11.	Sandstone, light green to maroon, very fine-grained, friable, thin-bedded. Thin, maroon, arenaceous, shaly partings	1.2
10.	Sandstone, white to yellow to pink, weathers tan to yellow, very fine-grained, friable, calcareous cement, thin-bedded. Shaly partings	18.4
9.	Covered interval	9.3
8.	Conglomerate, white to light pink, weathers white, massive. Granules and pebbles subangular to subrounded. Matrix coarse-grained sand. Becomes finer grained towards top. Minor channeling at base	2.5 to 3.8

Manitou Formation (52.0 to 52.6 feet)

7.	Dolomite, purple to dark red to white, weathers orange to maroon, finely to coarsely crystalline, thin-bedded. Argillaceous and arenaceous in upper 6 feet. Wavy bedded in upper 5 feet. Scattered white to pink chert inclusions. Pit and cusp weathering locally	15.8
6.	Dolomite, purple to dark red to white, weathers orange to maroon, fine- to coarse-crystalline, massive-bedded. Scattered white to pink chert inclusions. Pit and cusp weathering locally	12.3
5.	Dolomite, purple to dark red, weathers orange to maroon, fine- to coarse-crystalline, thin-bedded, Irregular white to pink chert nodules	4.6
4.	Dolomite, purple to dark red, weathers orange to maroon, fine- to coarse-crystalline, massive. Irregular white to pink to purple chert stringers up to 3 inches thick. Few discontinuous bedding planes	13.1

3.	Dolomite, purple to dark red, weathers maroon, coarsely crystalline, argillaceous, arenaceous, massive. Irregular white to purple chert stringers and nodules up to 2 inches thick..............	6.2
2.	Soil zone, contains numerous weathered Precambrian fragments. Dolomitic cement locally....	0.0 to 0.6

Precambrian

1.	Precambrian, Pikes Peak Granite	

Locality 2. Section measured along intermittent stream bed from NE 1/4, SE 1/4, Sec. 24, T. 18 S., R. 71 W. to SE 1/4, NW 1/4, Sec. 19, T. 18 S., R. 70 W.

Pennsylvanian

Fountain Formation (274.2 feet, incomplete, top covered)

		Thickness Feet
61.	Conglomerate, orange, arkosic, friable, massive. Subangular to subrounded cobbles up to 5 inches. Calcareous cement, loosely cemented. Channeling at base. Cross-bedded locally..................	25.4
60.	Shale, orange, blocky, arenaceous, slightly calcareous, hematitic locally.....................	2.0
59.	Conglomerate, orange, arkosic, massive. Subangular to subrounded pebbles up to 2 inches. Calcareous cement, loosely cemented................	4.3
58.	Shale, orange, blocky, arenaceous, slightly calcareous, hematitic locally.....................	18.1
57.	Conglomerate, orange, weathers orange to gray, arkosic, thin-bedded. Subangular to subrounded pebbles up to 3 inches; mostly quartz and other Precambrian rocks. Matrix coarse-grained sand. Calcareous cement............................	6.2

56. Sandstone, light green to orange, coarse-grained, arkosic, micaceous, thin-bedded. Grains subangular to subrounded. Slightly conglomeritic locally. Calcareous cement. Small cross-bedding locally... 8.2

55. Conglomerate, light gray to orange to maroon, arkosic, massive. Cobbles of Fremont Limestone up to 6 inches. Matrix fine conglomerate. Calcareous cement, well to loosely cemented......... 19.5

54. Conglomerate, orange to light green, weathers orange, arkosic, thick- to massive-bedded. Fremont boulders up to 2 feet; cobbles of Precambrian rocks; pebbles of Manitou. Calcareous cement, well to loosely cemented. Small cross-bedding locally................................. 36.7

53. Conglomerate, light gray to orange to maroon, arkosic, massive. Boulders of Fremont Limestone up to one foot; cobbles of Precambrian rocks. Calcareous cement, well to loosely cemented...... 49.4

52. Sandstone, orange, coarse grained, friable, arkosic, massive. Subangular to subrounded grains. Locally grades into conglomerate. Channeling into underlying conglomerate. Cross-bedded locally................................. 5.8

51. Conglomerate, orange, arkosic, friable, micaceous, massive. Pebbles of Manitou, Harding (?), and Fremont up to 2 inches. Channeling into underlying sandstone. Calcareous cement.................. 1.7

50. Sandstone, light green to maroon, weathers orange, arkosic, fine- to coarse-grained, micaceous, friable, argillaceous, massive. Grains subangular to subrounded. Calcareous cement............................. 7.1

49. Conglomerate, orange, arkosic, friable, micaceous, massive. Pebbles of Manitou, Harding, and Fremont up to 3 inches. Sorted bedding with finer grains towards top. Calcareous cement. Cross-bedded... 7.7

48.	Covered interval................................	9.1
47.	Conglomerate, orange, arkosic, friable, micaceous, massive. Pebbles of Manitou, Harding (?), and Fremont up to 2 inches. Channeling at base. Well developed cross-bedding. Calcareous cement......	8.6
46.	Sandstone, white to maroon, fine- to coarse-grained, very argillaceous, micaceous, arkosic, friable, massive. Calcareous cement, loosely cemented....	34.9
45.	Sandstone, white to maroon, coarse-grained, friable, micaceous, arkosic, massive. Locally grades into fine conglomerate. Grains subangular to subrounded. Calcareous cement, loosely cemented. Cross-bedded..	17.2
44.	Conglomerate, white to maroon, friable, arkosic, micaceous, argillaceous, massive. Angular to subrounded pebbles of Fremont and Williams Canyon up to 2.75 inches. Calcareous cement, loosely cemented................................	12.3

Devonian ?

Williams Canyon Formation (51.1 feet)

43.	Limestone, light gray, cryptocrystalline, arenaceous, slightly dolomitic thin-bedded. Medium quartz grains are angular to subrounded. Calcite lined fractures and vugs. Pit and cusp weathering locally..	6.2
42.	Limestone, gray to pink, weathers buff to pink, finely crystalline, very arenaceous, argillaceous, thin-bedded. Some brecciation and recementation of the limestone................................	4.6
41.	Limestone, light gray, cryptocrystalline, slightly dolomitic, thin-bedded. Calcite lined fractures and vugs. Pit and cusp weathering locally.........	2.2

40. Sandstone, white to purple, weathers pink, fine- to medium-grained, calcareous cement, thin-bedded.. 1.9

39. Limestone, gray to pink, weathers buff to pink, finely crystalline, very arenaceous, argillaceous, thin-bedded. Some brecciation and recementation of the limestone.......................... 9.9

38. Limestone, gray to pink, weathers buff to white, finely crystalline to cryptocrystalline, dense, slightly dolomitic, thin-bedded. Wavy banding of colors. Pit and cusp weathering locally........ 22.5

37. Limestone, gray to tan to maroon, weathers buff to maroon, finely crystalline to cryptocrystalline, dolomitic, thin-bedded. Wavy color banding. Calcite filled fractures. Argillaceous partings. Pit and cusp weathering locally......... 2.8

36. Limestone, gray to tan to maroon, weathers buff to maroon, finely crystalline to cryptocrystalline, dolomitic. Cobbles of Fremont up to 8 inches. Pit and cusp weathering.......................... 1.0

Ordovician

Fremont Limestone (351.1 feet)

Priest Canyon Member (175.5 feet)

35. Limestone, gray to tan to light maroon, weathers buff to maroon, finely crystalline, very dolomitic, argillaceous, thin-bedded. Calcite lined vugs. Pit and cusp weathering.......................... 1.9

34. Limestone, light gray, weathers buff, cryptocrystalline to finely crystalline, very dolomitic, argillaceous, massive. Brecciated and recemented. Varigated chert inclusions. Pit and cusp weathering.. 15.9

33. Limestone, gray to tan to pink, weathers buff to pink, finely crystalline, very dolomitic, argillaceous, thin-bedded. Wavy color banding locally. Scattered varicolored chert inclusions. Few brachiopods. Pit and cusp weathering......... 11.7

32. Limestone, gray to tan to pink, weathers buff to pink, finely crystalline, very dolomitic, massive. Scattered varicolored chert inclusions. Few brachiopods. Pit and cusp weathering........ 13.5

31. Limestone, gray to tan, weathers buff, fine- to coarse-crystalline, very dolomitic, thin-bedded. Highly brecciated and recemented. Varicolored chert inclusions. Abundant crinoid stems, and few brachiopods. Pit and cusp weathering............ 11.7

30. Limestone, pink to white, finely crystalline, argillaceous, soft, thin-bedded. Wavy color banding locally. Varigated chert inclusions. Few brachiopods.................................... 7.6

29. Limestone, gray to tan, weathers buff, finely to coarsely crystalline, very dolomitic, thin-bedded. Highly brecciated and recemented. Varicolored chert inclusions. Abundant crinoid stems; few brachiopods, Receptaculites sp. and corals. Pit and cusp weathering............................. 113.2

Massive Member (175.6 feet)

28. Limestone, light tan, weathers tan to buff, finely crystalline, dolomitic, massive. Highly brecciated and recemented. Varicolored chert inclusions. Abundant crinoid stem and corals; few brachiopods and Receptaculites sp. Pit and cusp weathering.... 75.5

27. Limestone, light tan to pink, weathers buff, cryptocrystalline to coarse-crystalline, very dolomitic, massive. Highly brecciated and recemented. Varicolored chert nodules. Discontinuous bedding planes. Abundant crinoid stems; few corals, brachiopods, and Receptaculites sp. Pit and cusp weathering.................................... 60.8

26. Limestone, light tan, weathers buff, coarsely crystalline, very dolomitic, massive. Highly brecciated and recemented. Small quartz lined cavities. Manganese zone in the bottom one foot. Abundant Receptaculites sp., Halysites, and other corals.... 39.3

Harding Sandstone (98.3 feet)

25.	Shale, red to orange, weathers dark red, flaky to platy, arenaceous at base....................	2.2
24.	Sandstone, orange to pink, weathers orange, very fine-grained, argillaceous, calcareous, friable, thick-bedded. Scattered fish plates..............	3.4
23.	Sandstone, yellow to lavender, very fine-grained, friable, thick-bedded...........................	4.0
22.	Sandstone, orange, very fine-grained, argillaceous, friable, soft, massive............................	7.2
21.	Sandstone, lavender, very fine-grained, friable, massive. Calcareous cement, loosely cemented....	2.7
20.	Sandstone, white, weathers white to orange, very fine-grained, friable, thin-bedded. Calcareous cement, loosely cement............................	1.8
19.	Sandstone, white to pink, weathers gray to orange, very fine-grained, argillaceous, calcareous, fish plates, massive................................	2.0
18.	Sandstone, white, weathers gray, very fine-grained, calcareous cement, friable, massive..............	5.0
17.	Sandstone, white to light green, weathers light green to pink, very fine-grained, friable, thin-bedded. Argillaceous partings. Fish plate layer 0.3 foot thick. 2.4 feet from top. Calcareous cement....................................	6.4
16.	Sandstone, white, weathers gray, very fine-grained, friable, thick-bedded. Calcareous cement, poorly cemented.....................................	4.7
15.	Sandstone, white to light green, weathers light green to pink, very fine-grained, friable, thin-bedded. Argillaceous partings. Calcareous cement..	3.3

14.	Shale, maroon to light green, weathers maroon, splintery to flaky, fissile, arenaceous, soft. Abundant fossils, fish plates, Maclurites?, Leproditia?; fossils particularly abundant at top and base..	18.0
13.	Sandstone, light green, very fine-grained, friable, calcareous cement, fucoids, massive.............	6.4
12.	Sandstone, lavender to light green, weathers lavender, very fine-grained, friable, soft............	3.2
11.	Sandstone, light green, very fine-grained, calcareous, friable, thin-bedded. Argillaceous at top and base..	0.4
10.	Sandstone, lavender to light green, weathers lavender, very fine-grained, friable, soft...................	2.7
9.	Sandstone, alternating light green and maroon bands, very fine-grained, slightly calcareous, very argillaceous, massive......................	2.5
8.	Sandstone, white to orange, weathers gray to green, very fine-grained, calcareous cement, thick-bedded. Iron nodules. Algal structures??.................	5.5
7.	Sandstone, white, weathers gray to pink, very fine-grained, thin-bedded, argillaceous...............	1.1
6.	Sandstone, purple to light green, weathers purple, very fine-grained, calcareous, argillaceous, thin-bedded..	2.6
5.	Sandstone, light green, very fine-grained, friable, thin-bedded. Argillaceous bedding planes. Calcareous cement....................................	5.9
4.	Shale, light green, platy to blocky, fissile, brittle...	1.0
3.	Shale, light brown to maroon, platy to splintery, fissile, soft.................................	2.2
2.	Sandstone, white, weathers gray, fine- to coarse	

grained, friable, massive. Grains subrounded to subangular. Calcareous cement.................. 3.2

1. Shale, purple to light yellow, arenaceous, platy to nodular, fissile. Quartz grains subangular to subrounded.................................... 0.9

Locality 3. SW 1/4, NW 1/4, Sec. 32, T. 18 S., R. 70 W. across highway from prison farm.

Thickness Feet

Pennsylvanian

Lykins Limestone (0.4 feet)

6. Limestone, light gray, finely crystalline, thin-bedded, arenaceous. Thin laminations, varve like.. 0.4

Pennsylvanian

Fountain Formation (171.0 feet incomplete)

5. Shale, light green to yellow, platy to flaky, slightly arenaceous, fissile, soft.................. 0.7

4. Conglomerate, tan to light orange, weathers gray, calcareous cement. Pebbles up to 1.75 inches. Pebbles subangular to subrounded................ 0.9

3. Shale, light green to orange, weathers orange, platy to blocky, slightly calcareous, soft, crumbly....... 3.5

2. Conglomerate, orange, calcareous cement. Subangular to subrounded pebbles up to 2 inches. Thin-bedded, cross-bedding small............................ 3.6

1. Conglomerate, orange to light green, very argillaceous matrix. Subangular to subrounded pebbles up to 2 inches. Loosely consolidated. Small cross-bedding locally.. 162.3

Locality 4. SW 1/4, SW 1/4, Sec. 29, T. 18 S., R. 70 W., east side of U. S. Highway 50 back of Lamp House.

		Thickness Feet
Jurassic		
Morrison Formation (154.9 feet, incomplete)		
25.	Shale, gray-green, blocky, calcareous, soft.......	25.1
24.	Sandstone, light green, weathers light green to tan, fine-grained, calcareous cement, massive....	3.2
23.	Shale, gray-green, blocky, calcareous, soft.......	3.2
22.	Sandstone, light green, weathers light green to tan, fine-grained, calcareous cement, massive....	1.5
21.	Shale, light green, platy to splintery, fissile, arenaceous, arkosic............................	4.2
20.	Sandstone, light gray-green, fine- to coarse-grained, arkosic, calcareous cement, massive. Grains subrounded. Scattered granules of feldspar........	1.4
19.	Shale, light green, platy to splintery, fissile, calcareous. Granules and grains of feldspar.......	1.2
18.	Conglomerate, light green, weathers gray-green, very arkosic, friable, massive. Argillaceous in upper half. Gradational bedding, finer towards top. Calcareous cement, loosely cemented.......	4.2
17.	Shale, light green to maroon, platy, fissile, soft, arkosic granule inclusions..................	3.5
16.	Conglomerate, light green, argillaceous, friable, thin-bedded. Calcareous cement, loosely cemented...	0.3
15.	Shale, light green to maroon, platy, fissile, soft, arkosic granule inclusions..................	1.6

14.	Conglomerate, light green, argillaceous, friable, calcareous cement..............................	0.4
13.	Shale, light green to maroon, platy, fissile, soft, arkosic granule inclusions..................	4.2
12.	Conglomerate, light green, very arkosic, argillaceous, cross-bedded. Angular to well-rounded pebbles up to 2 inches. Calcareous cement, loosely cemented...	21.9
11.	Sandstone, dark maroon, weathers reddish tan, coarse-grained, very arkosic, argillaceous, thin-bedded. Interbedded with stringers of pink to light green conglomerate..............................	17.8
10.	Conglomerate, pink to light green, friable, very arkosic, thin-bedded. Cobbles of schist, granite, feldspar, and quartz up to 5 inches. Matrix coarse-grained sandstone. Stringers sandstone locally.....	9.1
9.	Sandstone, dark maroon, weathers reddish tan, very arkosic, argillaceous, friable................	1.2
8.	Conglomerate, pink to light green, friable, very arkosic, thin-bedded. Cobbles of schist, granite, feldspar, and quartz up to 5 inches. Matrix coarse-grained sandstone. Stringers sandstone locally. Well developed cross-bedding........................	25.9
7.	Sandstone, light green, fine- to coarse-grained, very arkosic, massive. Grains angular to well rounded. Few quartz and feldspar pebbles up to 1.5 inches. Calcite lined fractures...............	4.6
6.	Conglomerate, pink to light green, weathers light green, calcareous cement, thin-bedded. Angular to subrounded pebbles up to one inch. Small cross-bedding locally................................	3.7
5.	Sandstone, light green to pink, medium to coarse-grained, very arkosic, calcareous cement, thin-bedded. Conglomeritic locally with pebbles up to 0.5 inch. Ripple marks at top. Small cross-bedding well developed. Channeling locally........	15.2

4. Sandstone, light green, very argillaceous, friable, calcareous cement, wavy bedding.................. 0.4

3. Sandstone, light green to pink, medium- to coarse-grained, very arkosic, calcareous cement, thin-bedded. Cross-bedded locally. Conglomeritic locally....................................... 10.8

2. Sandstone, light green to pink, weathers light green, fine- to coarse-grained, very argillaceous, arkosic, calcareous cement, friable. Grains sub-rounded to well-rounded......................... 1.1

Permian

Lykins Formation (0.3 to 1.9 feet)

1. Limestone, light gray, weathers white, fine-crystalline, arenaceous wavy laminated bedding. Locally brecciated and recemented....................... 0.3 to 1.9

Locality 5. Along Skyline Drive road from NW 1/4, NW 1/4, Sec. 20, T. 18 S., R. 70 W. to SE 1/4, SW 1/4, Sec. 29, T. 18 S., R. 70 W.

Thickness
Feet

Cretaceous

Niobrara Formation (31.8 feet, incomplete)

Fort Hays member (31.8 feet)

105. Limestone, light gray, weathers white, to cryptocrystalline, finely crystalline, argillaceous, stylolitic, thin-bedded. Interbedded with light gray, blocky, calcareous shale. Abundant fragments of Inoceramus........................ 27.5

104. Shale, light gray, weathers buff, blocky to platy, very calcareous, soft........................... 1.4

103. Shale, light yellow tan, blocky to platy, arenaceous, calcareous, soft........................ 2.9

Carlile Shale (143.5 feet)

Codell Sandstone member (4.0 feet)

102. Sandstone, light brown to light gray, weathers tan, fine-grained, very calcareous, argillaceous, calcite crystals, carbonaceous material, thin-bedded. Thin discontinuous shale stringers. Sharks' teeth and fragments of brachiopods and pelecypods abundant............................ 2.1

101. Sandstone, light brown, weathers rust brown, fine-grained, calcareous, calcite crystals, carbonaceous material, thin wavy bedded. Sharks' teeth and other fossil fragments abundant.......... 1.9

Blue Hill Shale member (76.1 feet)

100. Shale, light brown to dark gray, weathers light gray, platy to blocky, fissile. Ferruginous staining. Anhydrite crystals..................... 21.0

99. Limestone, rust tan to light gray, weathers yellow white, nodular, finely crystalline, argillaceous, soft. Anhydrite crystals........... 0.6

98. Shale, light brown to dark gray, weathers light gray, platy to blocky, fissile. Ferruginous staining. Anhydrite crystals..................... 11.0

97. Shale, dark gray to black, weathers dark gray, platy to flaky, fissile, soft. Ferruginous staining. Anhydrite crystals..................... 43.5

Fairport Chalky Shale member (63.4 feet)

96. Shale, light gray to yellow-gray, weathers yellow-gray, platy to flaky to blocky, very calcareous, fissile, soft. Clayey locally. Stringers of anhydrite.................................... 63.4

Greenhorn Limestone (38.1 feet)

95.	Limestone, light bluish gray, weathers buff to white, cryptocrystalline to finely crystalline, dense. Interbedded with calcareous, gray shale. Abundant <u>Inoceramus</u> <u>sp</u>. fragments...............	38.1

Graneros Shale (231.3 feet)

94.	Shale, light gray-brown, weathers yellow-gray, platy, very calcareous, arenaceous. Stringers light gray, finely crystalline, shaly limestone......	36.6
93.	Limestone, light gray, weathers light blue gray, finely crystalline, arenaceous, blocky, argillaceous....................................	0.6
92.	Shale, light gray-brown, weathers yellow-gray, platy, very calcareous, arenaceous. Stringers light gray, finely crystalline, shaly limestone......	19.2
91.	Shale, light to dark gray, flaky to platy, fissile, soft, slightly calcareous..........................	42.5
90.	Limestone, light gray to dark gray, finely crystalline, arenaceous, argillaceous, thin-bedded.....	1.5
89.	Shale, light to dark gray, weathers light gray, platy to blocky, fissile..........................	12.9
88.	Shale, dark gray to black, flaky to platy, fissile...	24.4
87.	Shale, light gray to black, weathers light blue-gray, platy to blocky, fissile. Stringers of tan, ferruginous silt..............................	42.4
86.	Limestone, light yellow-gray, weathers rust brown, finely crystalline, argillaceous. Cone-in-cone structure..............................	1.3
85.	Shale, medium to dark gray, weathers light blue-gray, platy to blocky, fissile locally. Stringers of tan siltstone and gray clay.....................	10.2
84.	Shale, dark gray, weathers tan, very calcareous, blocky, brittle................................	0.8

83. Shale, dark gray to black, weathers light blue to tan, platy to flaky, fissile, carbonaceous, arenaceous locally, carbonaceous flakes, brittle. Ferruginous staining locally..................... 8.7

82. Shale, light to dark gray, weathers light gray, platy to blocky, fissile locally, soft............... 10.9

81. Shale, light to dark gray, weathers blue-gray, platy, fissile, arenaceous. Ferruginous staining... 19.3

Dakota Sandstone (81.2 feet)

80. Shale, light gray to black, platy to blocky, fissile, arenaceous. Interbedded with stringers of dark gray, argillaceous, hard sandstone........ 12.3

79. Sandstone, white to yellow tan, medium-grained, friable, calcareous cement, thin-bedded. Grains well rounded. Argillaceous partings. Ripple marks on the upper surface...................... 7.7

78. Sandstone, white to yellow tan, weathers light to dark brown, medium-grained, friable, massive. Grains well rounded. Ferruginous staining. Scattered small iron nodules. Small ripple marks at the top. Liesegang banding locally. Fucoids abundant near upper surface. Abundant plant fragments at base and top, few in the middle. Well developed cross-bedding......................... 59.7

77. Conglomerate, tan, weathers light to dark brown, friable, massive. Matrix coarse-grained, well rounded sand. Pebbles up to 0.5 inch............. 1.5

Purgatoire Formation (106.3 to 120.8)

Glencairn member (98.3 to 100.8 feet)

76. Sandstone, light gray to tan, weathers gray, fine- to medium-grained, ferruginous, well cemented, thin-bedded. Dark gray shale stringers locally. Few fucoids................................. 4.5

75.	Sandstone, light gray to tan, weathers gray with yellow-orange ferruginous staining, fine- to coarse-grained, argillaceous, well cemented, thin-bedded. Abundant fucoids. Scattered brachiopod molds.....	3.5
74.	Sandstone, tan to buff, weathers gray to tan, fine- to coarse-grained, friable, massive. Ferruginous staining. Calcite lined joints. Calcareous cement, loosely cemented. Ripple marks on the upper surface. Discontinuous limonitic and argillaceous partings. Scattered brachiopod molds. Cross-bedding well developed.............	11.3
73.	Sandstone, tan to buff, fine- to coarse-grained, thin- to thick-bedded. Ferruginous staining. Argillaceous partings. Calcareous cement, well to loosely cemented. Ripple marks on upper surface. Fucoids throughout......................	11.2
72.	Shale, light to dark gray, weathers light gray, platy, fissile, carbonaceous, brittle, calcareous. Stringers tan, fine-grained sandstone.............	3.5
71.	Sandstone, tan to light brown, fine- to medium-grained, thin-bedded. Ferruginous staining. Abundant fucoids. Shale partings.................	1.8
70.	Sandstone, tan to light gray, fine- to medium-grained, argillaceous, carbonaceous, well cemented, thin-bedded. Ferruginous staining. Fucoids......	4.5
69.	Shale, light to dark gray, weathers light gray, blocky. Stringers of argillaceous sandstone. Ferruginous staining.............................	4.0
68.	Sandstone, tan to light gray, fine- to medium-grained, argillaceous, carbonaceous, friable, thin wavy bedded. Ferruginous staining...........	2.0
67.	Sandstone, tan to buff, very fine- to medium-grained, friable, carbonaceous. Calcareous, ferruginous, and silicious cement; poor to well cemented. Thin discontinuous wavy bedding. Fucoids abundant, few poorly preserved brachiopod molds. Cross-bedding small and local...........	8.4

66.	Sandstone, buff, very fine-grained, carbonaceous, friable, massive. Ferruginous staining. Discontinuous shaly partings....................	6.1
65.	Sandstone, light gray, very fine-grained, argillaceous, carbonaceous, thin-bedded. Ferruginous staining..	1.5
64.	Shale, tan to dark gray, platy, fissile, arenaceous, carbonaceous. Stringers very fine-grained sandstone....................................	6.5
63.	Sandstone, buff to light tan, very fine- to fine grained, well cemented, thin-bedded. Liesegang banding locally. Grains well rounded. Fucoids....	8.0
62.	Shale, tan to dark gray, platy, fissile, arenaceous, brittle. Sandy stringers locally............	0.8
61.	Conglomerate, buff to light gray, weathers tan, well cemented. Angular to subrounded pebbles up to one inch..................................	1.0
60.	Sandstone, white to light gray, fine- to coarse-grained, friable, massive. Grains well rounded. Abundant fucoids and plant fragments.............	14.2
59.	Sandstone, white to buff, fine- to coarse-grained, friable, thin bedded. Graded bedding, coarser at base. Shale stringers. Fucoids and plant fragments abundant................................	2.0
58.	Shale, light gray brown to dark gray, chunky to platy, fissile in part, arenaceous. Plant fragments......................................	0.5
57.	Sandstone, white to light gray, weathers tan, fine-grained, friable, calcareous cement, massive. Abundant plant fragments.........................	1.0 to 3.0
56.	Shale, light gray to black, blocky, arenaceous, soft. Abundant plant fragments; locally lignitic. Ferruginous staining...........................	2.0 to 2.5

Lytle Sandstone member (8 to 20 feet)

55. Sandstone and conglomerate, white to light gray, weathers buff to white, loosely cemented, massive. Angular to subrounded chert pebbles up to 1.5 inches; cobbles of Morrison Sandstone up to 7 inches. Cross-bedding well developed. Abundant plant fragments in upper 3 feet. Channeling at base.. 8.0 to 20.0

Jurassic

Morrison Formation (313.1 to 316.3 feet, incomplete)

54. Sandstone, white to light green, weathers light green, fine- to medium-grained, very argillaceous, irregular bedding. Calcareous cement, poorly to well cemented.................................. 3.2

53. Sandstone, white, weathers buff, very fine- to coarse-grained, arkosic, iron nodules, massive. Grains subangular to well rounded. Calcareous cement, loosely to well cemented. Cross-bedded.. 10.5

52. Sandstone, light gray to green to tan, weathers tan to buff, very fine-grained, friable, thin-bedded. Argillaceous bedding planes. Ferruginous staining....................................... 9.8

51. Shale, chocolate brown to purple to light yellow green, weathers maroon to light yellow green, blocky, arenaceous. Stringers of sandstone....... 15.4

50. Sandstone, maroon to light tan, very fine-grained, well cemented, thick-bedded. Interbedded with light green to chocolate brown, blocky, silty shale.. 8.8

49. Sandstone, light green, weathers tan, very fine-grained, well cemented, thin-bedded. Ferruginous staining....................................... 3.6

48. Shale, light green to dark green, weathers light green, blocky to platy, arenaceous............... 11.2

47.	Sandstone, light purple gray, weathers maroon, very fine-grained, argillaceous, well cemented....	12.5
46.	Sandstone, light purple to tan, weathers purple, fine-grained, friable, argillaceous, blocky, thin- to thick-bedded. Grains subrounded to well rounded......................................	6.2
45.	Sandstone, tan, weathers buff, fine-grained, massive. Grains subrounded to well rounded. Calcareous and ferruginous cement......................	5.8
44.	Shale, light green to chocolate brown, weathers maroon to light green, blocky to platy, fissile, arenaceous, brittle. Interbedded with sandstone, light tan, very fine-grained, well cemented........	30.5
43.	Sandstone, light gray to tan, weathers tan, very fine-grained, argillaceous, calcareous cement, thin-bedded...	5.2
42.	Shale, light gray to green, blocky to platy, clayey, soft......................................	3.4
41.	Sandstone, light gray to tan, weathers tan, very fine-grained, well cemented, thin- to thick-bedded. Grains well rounded. Small cross-bedding....	5.1
40.	Sandstone, light gray, fine-grained, very calcareous, argillaceous, massive..........................	2.6
39.	Limestone, light gray, cryptocrystalline to finely crystalline, arenaceous, argillaceous, massive.....	2.3
38.	Sandstone, light gray-green, very fine-grained, calcareous, argillaceous, thin-bedded. Grains subrounded to well rounded. Light green to tan, platy, soft shale partings.......................	4.2
37.	Shale, light to dark green, blocky, arenaceous.....	13.4
36.	Shale, chocolate brown, weathers maroon, blocky to platy, fissile, soft...........................	2.7
35.	Sandstone, tan to light gray, fine-grained, argil-	

	laceous, calcareous cement, thin-bedded. Grains subrounded to well rounded. Weathers in nodular lumps....................................	5.2 to 6.7
34.	Shale, chocolate brown, weathers maroon, blocky to splintery, fissile, soft...........................	1.0
33.	Shale, light green, blocky, fissile, very arenaceous, soft....................................	1.0
32.	Sandstone, light gray to tan, very fine-grained, argillaceous, massive. Calcareous cement, loosely to well cemented............................	1.1
31.	Shale, dark green to chocolate brown, weathers maroon, blocky to platy, arenaceous, fissile......	2.7
30.	Sandstone, light green, fine-grained, thin-bedded. Grains subrounded to well rounded. Calcareous cement, loosely to well cemented. Weathers in nodular lumps..................................	1.5
29.	Shale, light green to maroon, weathers maroon, platy to nodular, arenaceous......................	0.6
28.	Shale, light green to chocolate brown, weathers light green to maroon, blocky to nodular, soft......	27.4
27.	Covered interval................................	8.8
26.	Shale, light green to chocolate brown, weathers maroon, blocky to platy, fissile, soft.............	21.9
25.	Shale, dark green, blocky, calcareous, brittle.....	0.7
24.	Limestone, white, finely crystalline, very arenaceous, soft. Grains of quartz and feldspar........	1.1
23.	Shale, light green, weathers maroon, very arenaceous, soft. Locally grades into shaly sandstone. Grains of quartz and feldspar.....................	8.7
22.	Shale, light green to yellow, weathers light green to tan, blocky to nodular, arenaceous, soft........	9.6

21.	Shale, dark green, weathers light green, blocky to platy to splintery, fissile, very calcareous......	1.7
20.	Limestone, light gray, weathers white, chalky, argillaceous, arenaceous........................	1.5
19.	Limestone, light gray, weathers light gray to white, cryptocrystalline, hard, arenaceous, argillaceous..	4.2
18.	Shale, light to dark green, weathers light green, platy to blocky, fissile in part, calcareous, soft....	13.5
17.	Limestone, light gray, weathers white, finely crystalline, dense....................................	0.7
16.	Shale, light to dark green, weathers light green platy to blocky, fissile, calcareous, soft..........	10.2
15.	Sandstone, light green, weathers purple to brown, very fine-grained, well cemented, arkosic, wavy irregular bedding. Grains subrounded...........	0.0 to 1.7
14.	Shale, light green, platy to blocky, fissile calcareous, arenaceous. Lenses of light green sandstone up to 1.5 feet....................	5.0
13.	Sandstone, light gray-green, weathers tan, very fine-grained, arkosic, calcareous cement, friable. Grains subrounded to well rounded..............	4.4
12.	Shale, light green, platy to blocky, fissile where platy, very calcareous, hard.....................	0.7
11.	Sandstone, light green, weathers off-white to light green, fine-grained, argillaceous, calcareous cement. Grains subrounded............................	0.4
10.	Shale, chocolate brown to light green, weathers light green, blocky to platy, slightly arenaceous...	1.5
9.	Conglomerate, light gray-green, weathers gray-brown, arkosic, calcareous cement, thick-bedded. Subangular to subrounded pebbles up to 0.25 inch......	0.7

8.	Shale, chocolate brown to light green, weathers light green, blocky, calcareous....................	1.5
7.	Shale, light green, blocky to splintery, fissile, calcareous, arenaceous. Locally grades into sandstone....................................	1.1
6.	Sandstone, light gray to tan, weathers maroon to light green, very fine- to coarse-grained, massive. Grains subangular to subrounded. Calcareous cement, well cemented..................................	0.7
5.	Shale, light green, blocky to splintery, arenaceous, fissile, calcareous. Locally grades into sandstone.......................................	1.3
4.	Sandstone, light gray to tan, weathers maroon to light green, very fine- to coarse-grained, massive. Grains subangular to subrounded. Calcareous cement, well cemented..................................	2.6
3.	Shale, chocolate brown to light green, weathers light green, blocky to splintery, calcareous, arenaceous..	3.4
2.	Conglomerate, light green to tan, weathers maroon, arkosic, calcareous cement. Angular to subrounded grains up to 0.5 inch...........................	0.7
1.	Shale, light green to maroon, weathers light green, blocky, calcareous, soft. Pebbles of quartz and feldspar up to 0.75 inch scattered throughout.......	9.6

Locality 6. SW 1/4, NW 1/4, Sec. 21, T. 19 S., R. 70 W. southeast side of Colorado State Highway 143.

Thickness Feet

Cretaceous

Pierre Formation (858.6 feet, incomplete)

20.	Shale, light gray to buff, weathers light gray, splintery to crumbly, fissile, arenaceous, slightly calcareous. Ferruginous staining.........	15.6
19.	Covered interval.................................	147.3
18.	Shale, light gray to buff, weathers light gray, splintery to crumbly, fissile, arenaceous, slightly calcareous. Ferruginous staining................	99.8
17.	Limestone, buff to light gray, fine-crystalline, argillaceous..................................	0.9
16.	Shale, light gray to buff, weathers light gray, splintery to blocky, fissile, arenaceous. Ferruginous staining.........................	44.6
15.	Covered interval.................................	182.0
14.	Shale, light gray to buff, weathers light gray, splintery to blocky, fissile, arenaceous. Ferruginous staining.............................	75.7
13.	Shale, light gray to light yellow, weathers buff, splintery, to platy, fissile. Ferruginous staining. Anhydrite stringers............................	92.4
12.	Covered interval.................................	65.0
11.	Shale, light to medium gray, splintery, slightly calcareous, ferruginous staining..................	23.4
10.	Shale, light gray to buff, weathers buff, flaky to splintery, fissile, slightly calcareous. Ferruginous staining..............................	82.5
9.	Shale, light to dark gray, weathers buff, splintery to platy, fissile, calcareous.....................	29.4

Niobrara Formation (529.9 feet, only Apishapa Shale member measured)

Apishapa Shale member (529.9 feet)

8.	Shale, light to medium gray to buff, splintery, to platy, very calcareous, soft. Locally grades into argillaceous limestone. Ferruginous staining. Thin anhydrite stringers........................	43.2
7.	Shale, light to medium gray to buff, splintery to blocky, slightly calcareous, soft...............	59.7
6.	Shale, yellow-orange to buff, flaky to splintery, fissile, very calcareous. Locally grades into argillaceous limestone. Thin anhydrite stringers. Few scattered brachiopods.......................	36.9
5.	Shale, buff to light yellow-gray, splintery to platy, fissile, very calcareous. Locally grades into argillaceous limestone. Ferruginous staining......................................	260.1
4.	Shale, light gray to buff, splintery to platy, fissile, slightly calcareous. Ferruginous staining. Thin anhydrite stringers...........................	38.4
3.	Shale, light gray to yellow, splintery to blocky, fissile, very calcareous, carbonaceous inclusions. Ferruginous staining and banding.................	10.5
2.	Shale, light gray, blocky to platy, very calcareous, fissile. Ferruginous staining....................	81.1

Fort Hays Limestone member

1. Limestone, light gray, thin-bedded, thickness not measured.

Locality 7. SE 1/4, Sec. 17, T. 19 S., R. 70 W. intermittant stream bed and water gap in Vermejo hogback.

Thickness
Feet

Cretaceous-Tertiary

Arapahoe Formation (336.7 feet, incomplete, top eroded)

67.	Conglomerate, buff to yellow, soft, friable. Subangular to well rounded pebbles up to 0.5 inch. Locally grades into coarse-grained sandstone......	11.0
66.	Covered interval................................	103.0
65.	Conglomerate, white to tan, massive. Subangular to subrounded pebbles up to 2 inches. Grades into coarse-grained sandstone in upper 10 feet. Calcareous cement, well cemented. Cross-bedded locally. Channeling at base. Ferruginous staining..	31.6
64.	Conglomerate, white to tan, massive. Subangular to subrounded cobbles up to 3.5 inches. Matrix coarse sand. Grades into coarse-grained sandstone in upper 8 feet. Calcareous cement, well cemented. Cross-bedded locally.................	27.7
63.	Conglomerate, white to tan, massive. Subangular to subrounded cobbles up to 4 inches. Cobbles mostly Precambrian; some Dakota and Fremont. Matrix coarse sand. Grades into coarse-grained sandstone in upper 5 feet. Calcareous cement, well cemented. Cross-bedded locally............................	25.2
62.	Conglomerate, tan to buff, massive. Subangular to subrounded cobbles up to 9 inches. Cobbles mostly of Precambrian rocks; some Dakota, Fremont, Lytle, and Greenhorn. Grades into coarse-grained sandstone in upper 15 feet. Well cemented, calcareous cement. Cross-bedding well developed......	52.9
61.	Conglomerate, white to tan, friable, massive. Subangular to subrounded cobbles of Dakota, Fremont and Precambrian rocks up to 7 inches. Matrix coarse sand. Grades into coarse-grained sandstone in the upper 10 feet. Calcareous cement, well cemented. Cross-bedded locally....	49.3
60.	Conglomerate, white to tan, massive. Subangular to subrounded cobbles up to 4 inches. Matrix coarse sand. Grades into coarse-grained sandstone in upper 6 feet. Calcareous cement, well cemented. Cross-bedding well developed........	36.0

Cretaceous

Vermejo Formation (973.7 feet)

59.	Sandstone, white to buff, weathers buff to tan, fine- to coarse-grained, friable, loosely cemented, thin- to massive-bedded. Grains subrounded. Calcareous cement. Limonitic staining and nodules. Liesegang banding locally. Small cross-bedding..................................	201.0
58.	Covered interval.................................	39.2
57.	Sandstone, white to tan, fine- to coarse-grained, friable, thick to massive bedded. Grains subangular to subrounded. Liesegang banding locally. Channeling common. Resistant to weathering. Limonitic staining and nodules. Plant fragments scattered throughout. Cross-bedded locally..................	232.0
56.	Sandstone, white to tan, weathers buff, coarse-grained, friable, calcareous cement, massive. Grains subrounded. Limonitic staining and nodules. Cross-bedded locally...........................	10.4
55.	Sandstone, white, weathers white to buff, fine- to coarse-grained, friable, thick-bedded. Grains subangular to subrounded. Limonitic staining and nodules. Abundant plant fragments. Small cross-bedding locally................................	7.8
54.	Covered interval.................................	50.7
53.	Sandstone, white to buff, weathers tan, fine- to medium-grained, friable, loosely cemented, thick-bedded. Grains subrounded. Limonitic staining and nodules. Small cross-bedding locally......................	5.3
52.	Sandstone, white to tan, weathers buff, medium- to coarse-grained, friable, limonitic cement, massive. Cross-bedded.........................	4.2
51.	Sandstone, white to buff, weathers tan, fine- to medium-grained, friable, loosely cemented, thick-bedded. Grains subrounded. Limonitic staining and nodules. Small cross-bedding locally.........	18.5

50.	Shale, light to dark gray, weathers light blue-gray, splintery to platy, fissile, arenaceous.......	2.8
49.	Covered interval.................................	22.0
48.	Sandstone, white to buff, weathers white to tan, fine- to medium-grained, calcareous cement, massive. Grains subrounded. Ferruginous staining. Cross-bedding well developed....................	21.7
47.	Covered interval.................................	15.4
46.	Coal, black to dark gray, very argillaceous and arenaceous, soft.................................	1.9
45.	Sandstone, light gray, friable, very argillaceous, calcareous cement, nodular, limonitic streaks, massive...	12.0
44.	Coal, black, very argillaceous and arenaceous, soft, bituminous.................................	2.4
43.	Sandstone, light gray to tan, fine- to medium-grained, friable, argillaceous, massive. Calcareous cement, loosely cemented. Limonitic staining..	5.5
42.	Shale, light to dark gray, blocky, crumbly, soft, carbonaceous, arenaceous.......................	5.4
41.	Coal, black, very argillaceous and arenaceous, soft, bituminous.................................	1.3
40.	Shale, light to dark gray, blocky, crumbly, soft, carbonaceous, arenaceous.......................	7.4
39.	Sandstone, light gray to tan, fine- to medium-grained, friable, argillaceous, massive. Calcareous cement, loosely cemented. Limonitic staining..	5.7
38.	Shale, light to dark gray, blocky, crumbly, soft, carbonaceous, arenaceous.......................	7.6
37.	Sandstone, light gray, to tan, fine- to medium-grained, friable, argillaceous, massive. Calcareous cement, loosely cemented. Limonitic staining...	7.2

36.	Coal, black, very argillaceous and arenaceous, soft, bituminous................................	1.5
35.	Sandstone, light gray to tan, fine- to medium-grained, friable, argillaceous, massive. Calcareous cement, loosely cemented. Limonitic staining..	7.0
34.	Shale, light to dark gray, blocky, crumbly, soft, carbonaceous, arenaceous.......................	3.6
33.	Coal, black, very argillaceous and arenaceous, soft, bituminous................................	1.3
32.	Shale, light to dark gray, blocky, crumbly, soft, carbonaceous, arenaceous.......................	3.1
31.	Covered interval................................	3.1
30.	Sandstone, buff to tan, fine- to coarse-grained, friable, massive. Grains subangular to subrounded. Liesegang banding locally. Ferruginous staining. Channeling locally. Cross-bedding well developed................................	15.4
29.	Coal, black, soft, bituminous...................	2.4
28.	Shale, dark gray to brown, splintery, fissile, arenaceous, carbonaceous......................	9.0
27.	Covered interval................................	5.6
26.	Sandstone, buff to tan, fine- to coarse-grained, friable, massive. Grains subangular to subrounded. Liesegang banding locally. Ferruginous staining. Channeling locally. Cross-bedding well developed................................	25.9
25.	Covered interval................................	8.0
24.	Sandstone, buff to tan, fine- to medium-grained, friable, massive. Grains subangular to subrounded. Liesegang banding locally..................	10.0

23.	Covered interval...............................	4.5
22.	Sandstone, light gray, weathers buff to light gray, argillaceous, fine- to medium-grained, thin-bedded. Grains subangular to subrounded. Calcareous cement, loosely cemented...........	4.9
21.	Coal, dark gray to black, very argillaceous, splintery, brittle. Locally grades into shale.......	7.8
20.	Shale, light gray, very arenaceous, blocky, crumbly, carbonaceous..........................	20.3
19.	Sandstone, light gray to buff, fine- to medium-grained, calcareous cement, massive. Grains subangular to subrounded. Ferruginous staining..	8.1
18.	Sandstone, light gray, fine-grained, friable, very argillaceous, thin-bedded..................	3.4
17.	Coal, black, soft, bituminous...................	3.0
16.	Covered interval..............................	55.2
15.	Sandstone, tan to buff, fine-grained, friable, massive. Grains subangular...............................	14.8
14.	Coal, black, argillaceous, brittle, bituminous.....	3.2
13.	Sandstone, buff to tan, fine-grained, friable, argillaceous, massive..........................	11.6
12.	Shale, light to dark gray, splintery, fissile, arenaceous, carbonaceous......................	20.1
11.	Coal, black, brittle, bituminous.................	0.4
10.	Sandstone, buff to tan, fine-grained, friable, argillaceous, massive..........................	19.4
9.	Coal, black, soft, bituminous...................	1.5

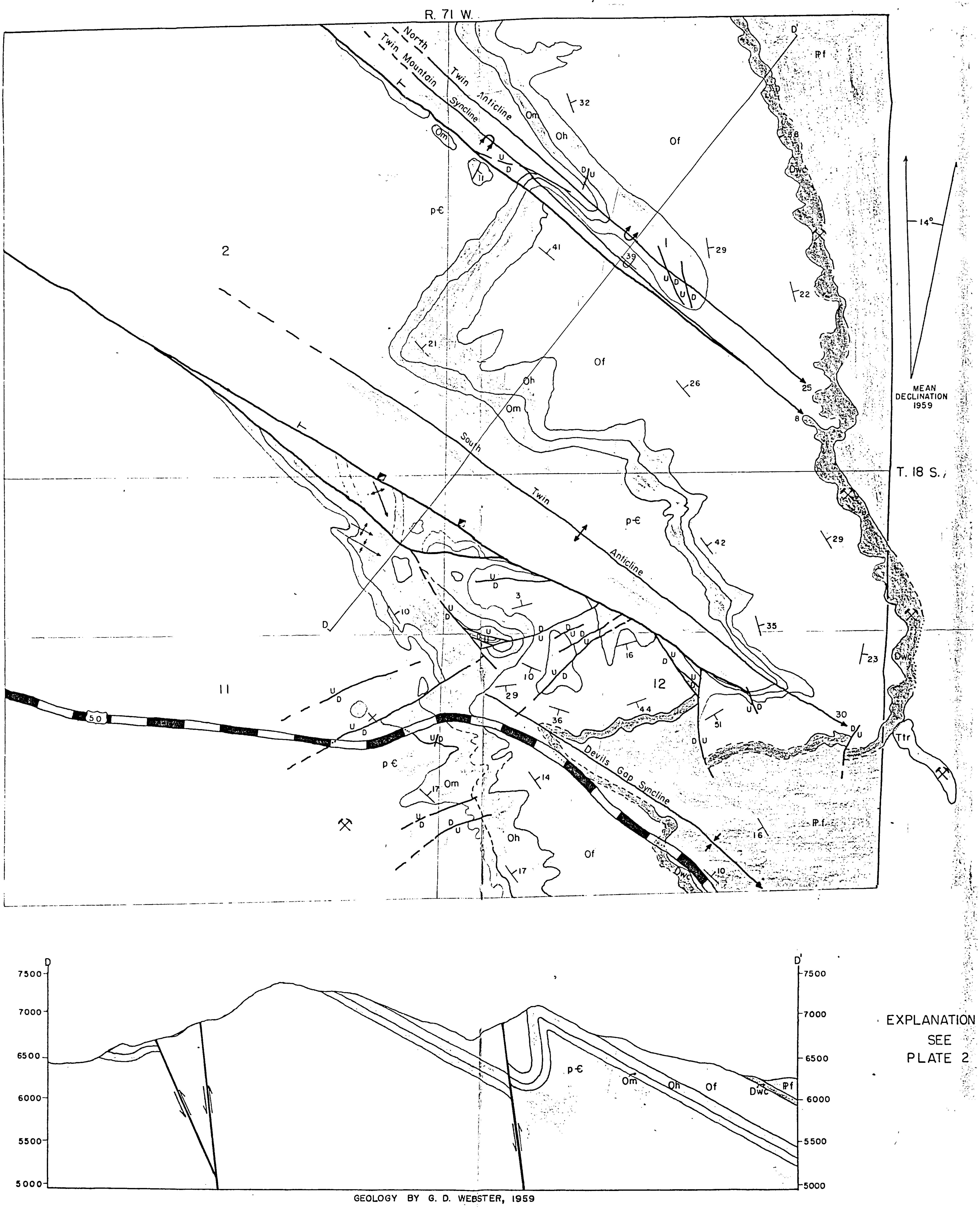
8.	Sandstone, buff to tan, fine-grained, friable, argillaceous, massive...........................	12.2

Trinidad Formation (56.0 feet)

7.	Sandstone, light gray to buff, fine-grained, very argillaceous, friable, massive. Calcareous cement, loosely cemented. Ferruginous staining..........	55.2
6.	Sandstone, buff, fine grained, calcareous cement, thin-bedded, cross-bedded.......................	0.8

Pierre Formation (234.1 feet, incomplete)

5.	Shale, light to dark gray, splintery to flaky, fissile, crumbly, arenaceous. Thin stringers of fine-grained argillaceous tan sandstone...........	58.6
4.	Sandstone, buff, fine-grained, calcareous cement, thin-bedded...	0.9
3.	Shale, light to dark gray, splintery to flaky, fissile, crumbly, arenaceous. Thin stringers of fine-grained, argillaceous, tan sandstone.........	48.8
2.	Shale, light to dark gray, to buff, weathers buff, flaky to splintery, fissile, arenaceous. Limonitic staining. Thin stringers of fine-grained, argillaceous, gray sandstone............................	125.0
1.	Sandstone, light gray, very fine-grained, argillaceous, calcareous cement.........................	0.8



GEOLOGY BY G. D. WEBSTER, 1959

GEOLOGIC MAP OF

TWIN MOUNTAIN AREA, FREMONT COUNTY, COLORADO

SCALE

0 1/4 1/2 3/4 1

MILES

PLATE 2

GEOLOGIC MAP OF

CANON CITY-TWIN MOUNTAIN AREA, FREMONT COUNTY, COLORADO

SCALE

0 ½ 1 1½ 2

MILES