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GEOLOGY OF THE GORE CANYON AREA, COLORADO

by

Marshall Clay Parsons

A thesis submitted to the Faculty and the Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT OF THESIS

Geology of the Gore Canyon Area, Colorado

By

Marshall Clay Parsons

The area investigated lies within the Gore Range in the vicinity of Gore Canyon, Colorado. It occupies a portion of southwestern Grand County and a part of northern Eagle County. Kremmling is the nearest large town.

The Gore Range is essentially a gentle arch which is steeply faulted on the western side. The top of the range is a broad, plateau-like surface of fairly uniform elevation. In the south, this range has been sculptured to the fretted-upland stage by glaciers, but still maintains a fairly constant elevation.

The plateau-like surfaces of the Gore Range are believed to represent the remnants of an exhumed pre-Permian peneplain. The peneplain has been faulted in the Gore Canyon area and has been previously misinterpreted as representing 3 different erosional surfaces.

There is a close relationship between the character of the sediments and the tectonic framework of sedimentation. The area lies on the boundary between a rising landmass (Front Range highland) and a sinking basin of deposition (Central Colorado basin). These features were in existence through the Paleozoic and most of the Mesozoic during which

time the landmass oscillated. As a result, the area near Gore Canyon is characterized by major unconformities and unsystematic overlaps.

The maximum thickness of the sedimentary section in the area is about 1500 feet.

The oldest unit mapped is the State Bridge formation of Permian(?) age. It consists of red siltstones and a basal graywacke conglomerate. The State Bridge overlaps the Pennsylvanian sediments 1 mile south of the area mapped; and is in turn overlapped by the Morrison (Jurassic) 1 mile north of the area.

The Triassic is represented by discontinuous red siltstones and shales of the Chinle formation and coarse sandstones and conglomerates of the Shinarump formation. These formations are overlapped by the Morrison formation in the north part of the area.

The Jurassic is represented by aeolin sandstones of the Entrada formation and by the sandstones and shales of the Morrison formation.

The presence of a thin conglomerate above the Morrison formation makes it difficult to draw the boundary between the Jurassic and the Cretaceous. The conglomerate is tentatively correlated with the Lower Cretaceous sediments of northwestern Colorado.

Only the quartzite and conglomerate members of the Dakota(?) are present in the area. The shale member which is present on the east side of the Front Range is missing.

The Benton and Niobrara formations are similar lithologically with the equivalent strata east of the Front Range.

River deposits of the North Park formation (Miocene) cover a large portion of the area. These sediments fill river valleys which apparently have been cut deeper than the valley of the present Colorado River; thus indicating that an ancestral Colorado River once flowed through the area in the Miocene.

Pediments of Pleistocene(?) age are present at the mouths of several canyons.

Two intrusives of late Tertiary age are present in the area. A rhyolite porphyry, tentatively correlated with the late white porphyry of the Leadville region, has intruded along several fault planes. Rhyolite agglomerate, which has intruded Miocene sediments, is correlated with similar intrusives in the Leadville region.

The only extrusive in the area is a basalt flow which caps the North Park formation.

The Pre-Cambrian rocks consist of granite gneisses and biotite schist which are intruded by pegmatites and granite. They are correlated with rocks of the Idaho Springs formation.

The structural complexity of the Gore Canyon region is attributed to the close proximity of the Williams Range thrust fault and the Mosquito fault. The Williams Range thrust is a westward dipping fault which defines the eastern side of the Gore Range. The Mosquito fault forms a high, steep scarp on the western side of the Gore Range and is interpreted by the author as an upthrust.

The earliest structure which can be deciphered is a series of northeast trending folds which were probably formed by the first movements on the Mosquito fault during the Paleocene. These folds were accentuated by northwest trending normal faults.

Northeast trending thrust faults truncated and deformed the earlier flexures and produced northeast trending overturned folds.

Northeast trending normal faults were apparently the latest faults since they offset Miocene sediments.

There is evidence that movement occurred along many of the faults during more than one period. Movement on the Mosquito fault was probably initiated during the Paleocene, but there is evidence of post-Miocene displacement.

The Gore Canyon area was emergent through most of the Paleozoic. All sediments earlier than Permian apparently have been overlapped south of the area. Since the overlaps are unsystematic, the Front Range highland probably oscillated.

At the close of the Pennsylvanian, the area was reduced to a broad peneplain upon which the State Bridge formation was deposited.

Despite the presence of intrusives and structure similar to those of the mining districts in the Mosquito and Ten Mile Ranges, there are no commercial ore deposits in the Gore Canyon area. The thin sedimentary section is extremely unfavorable for commercial concentrations of oil and gas.

This abstract of 850 words is approved as to form and content. I recommend its publication.

Date May 24, 1954.

Signed John R. Hayes
J. R. Hayes

GEOLOGY OF THE GORE CANYON AREA, COLORADO

Introduction

Location, Drainage, and Accessibility

The area constituting this thesis is located on the west side of the Gore Range (see Plate I) approximately six air miles southwest of Kremmling, Colorado. It occupies a portion of southwestern Grand County and a part of northern Eagle County.

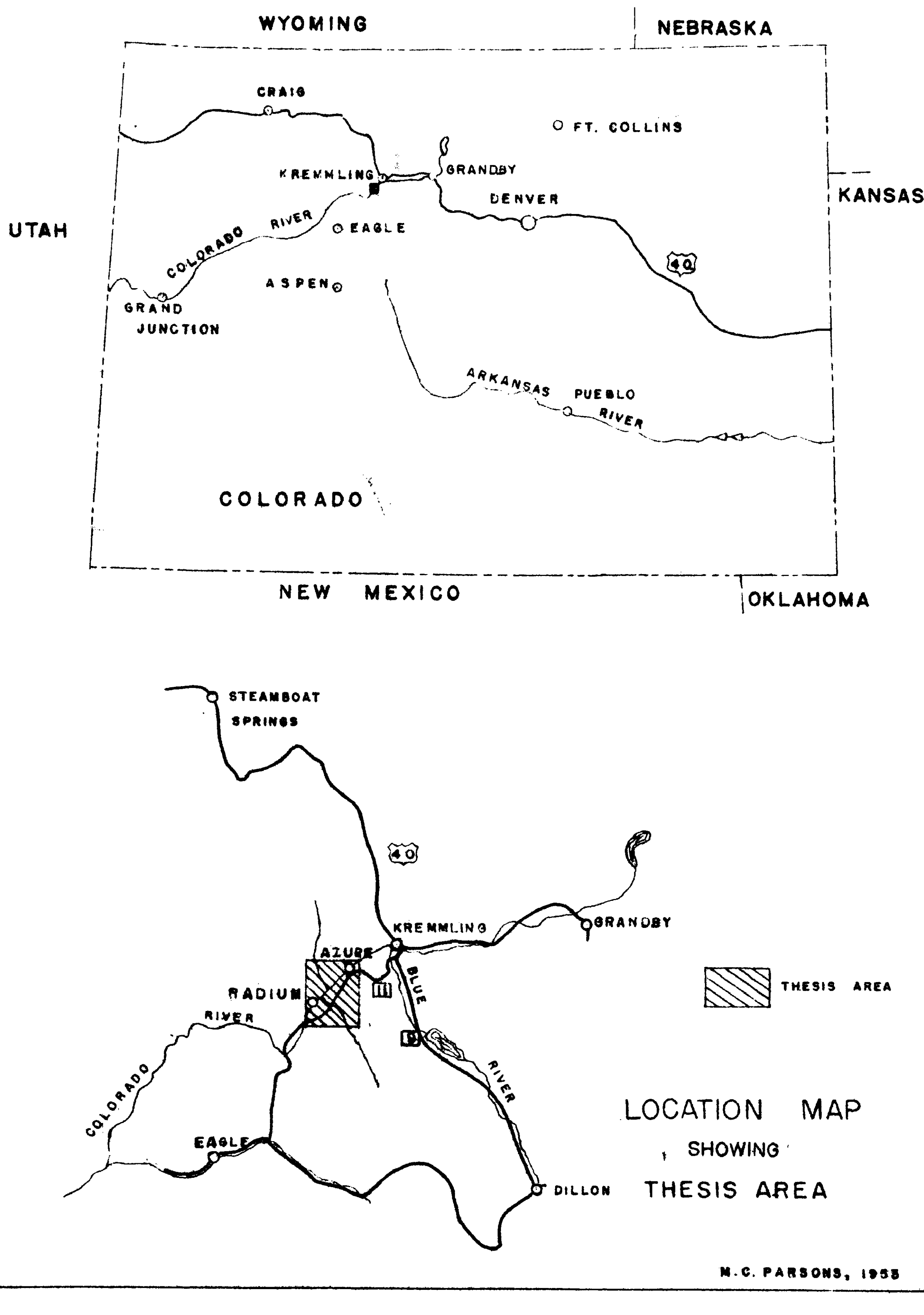
Approximately 25 square miles were mapped on both sides of the Colorado River between Sheephorn Creek and the western end of Gore Canyon. (See Plate I.)

Only four perennial streams flow within the area. The major one is the Colorado River, which flows from Middle Park through the Gore Canyon and divides the area. This river passes through three deep canyons within the area and contains numerous stretches of rapids. The other streams are considerably smaller, but provide nearly all of the irrigation water used within the area.

There are many other small, intermittent streams which carry off snow water and excess irrigation water. There are numerous springs which provide small amounts of water.

In general, the relief of the area is moderate. The maximum difference in elevation occurs in Gore Canyon,

PLATE I



LOCATION MAP
SHOWING
THESIS AREA

M.C. PARSONS, 1955

which is about 2,000 feet deep.

An improved gravel road, State Highway 11, connects the area with Kremmling and State Bridge. In addition, there are several county-maintained, all-weather, gravel roads within the area. Numerous trails permit access to the more rugged parts of the region.

The area is served by the standard gauge Denver and Rio Grande Western Railroad which operates over the tracks of the former Denver and Salt Lake Railroad. It passes through Gore Canyon and follows the Colorado River to Bond, Colorado, where it joins the main line to Salt Lake City.

Climate and Vegetation

With the exception of the high country to the south and west, the region is semiarid. The annual precipitation is about 16 inches; most of it falling as snow during the winter. The winters are usually severe and the summers mild. In January, 1953, the minimum temperature was -13°F. and the average was 26°F. In July, 1953, the maximum temperature was 92°F. and the average was 63.7°F.

The higher portions of the area are covered with aspen, lodge pole pine, Douglas fir, and some blue and Engleman spruce. Juniper, pinon, and sage brush grow on the lower slopes. The irrigated portions of the valleys grow hay, sunflowers, and grain.

Purpose and Method of Investigation

Because of its nearness to two major structural features--the Mosquito fault and the Williams thrust fault--there has been severe structural deformation in the Gore Canyon area. The main purposes of this investigation were:

1. To interpret this structural deformation and its relationship to the major structural features of the area.
2. To study the stratigraphy and its relationship to the tectonic framework.
3. To decipher the geologic history of the area.

Mapping was done in the field with the use of aerial photographs. This information was later transferred to a base map compiled from drainage maps of the U. S. Bureau of Land Management and township plats prepared by the General Land Office. Vertical control was provided by the Mt. Powell quadrangle map and a vertical profile obtained from the Denver and Rio Grande Western Railroad. Cross sections were made by using a stereocomparagraph.

Stratigraphic sections were measured with a Brunton compass and a tape along traverses shown on Plate VII.

Laboratory investigations included an examination under the binocular microscope of the various rocks of the formations and the preparation of thin sections of some of the igneous and sedimentary rocks.

Previous Publications

The first geologists to report on the area were with the Hayden Survey. Hayden (24, pp. 79-80) wrote a brief description of the area in "U. S. Geological and Geographical Survey of the Territories Annual Report for 1873".

In 1949, H. F. Donner (17, pp. 1215-1247) published an article on the geology of the McCoy area.

In 1950, Olcott Gates (20, 88 pp.), a graduate student at the University of Colorado, wrote a master's thesis on the stratigraphy and structure of the Radium area.

David Sheridan (58, pp. 126-147) published an excellent article in 1950 on the Permian(?), Triassic, and Jurassic stratigraphy of the McCoy area. He correlated stratigraphic units from the west and south up to the southern boundary of the thesis area.

Kenneth Brill (10, p. 1375; 11, p. 621; 12, p. 809) has done extensive field work and correlations in the central Colorado region. He attempted to correlate the numerous Permo-Pennsylvanian formations in Colorado and northern New Mexico.

Acknowledgments

The writer is indebted to all of the members of the Department of Geology for their helpful criticism and valuable suggestions; and especially to Drs. R. H. Carpenter and J. R. Hayes for supervising the thesis work, checking the field work, and reading the manuscript; to Dr. L. W. LeRoy for reading the manuscript; and to Dr. J. Harlan Johnson for aid in identifying fossils.

I wish to thank Mr. Mark Curry of Radium, Colorado for providing a cabin for my use and for taking me, by Jeep, to the more inaccessible parts of the region; Mr. Hanson of the Denver and Rio Grande Western Railroad for providing a profile of the railroad bed through the thesis area; and my wife, Jean, who typed the manuscript.

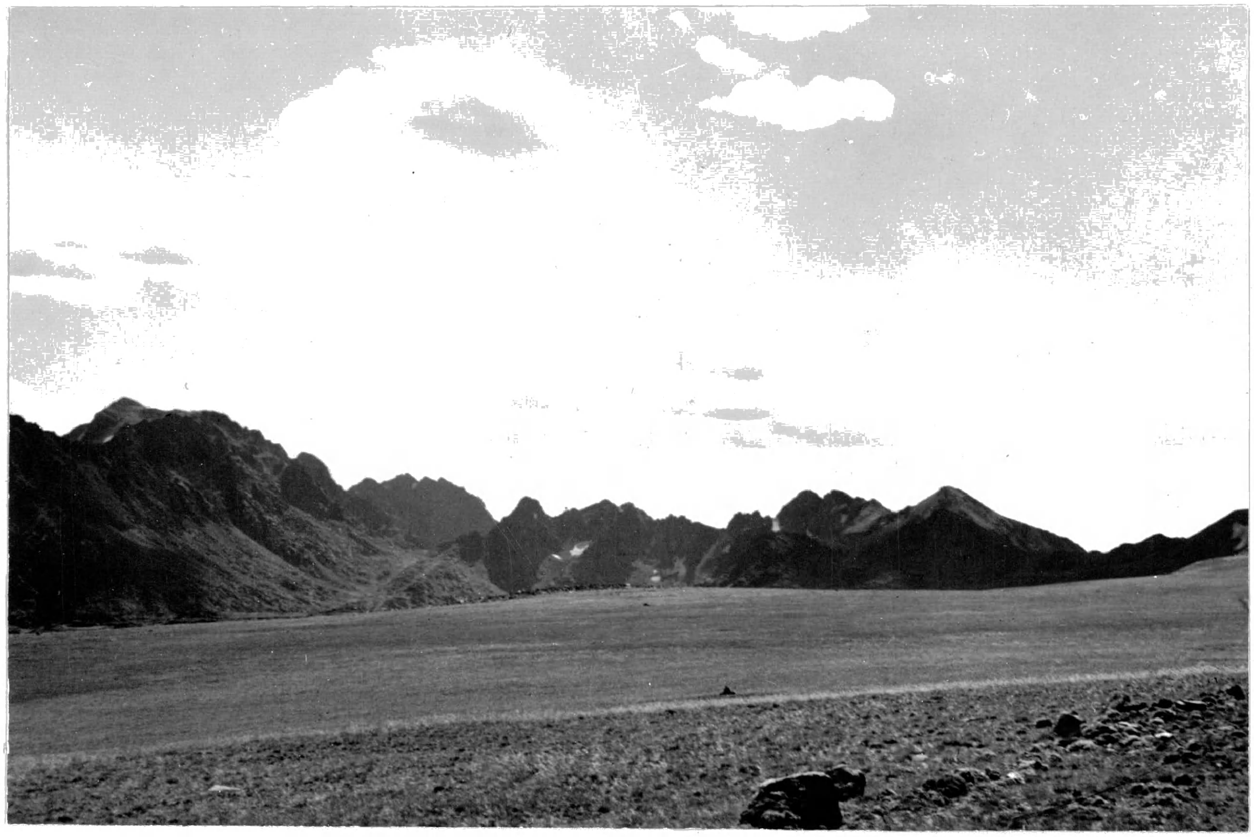
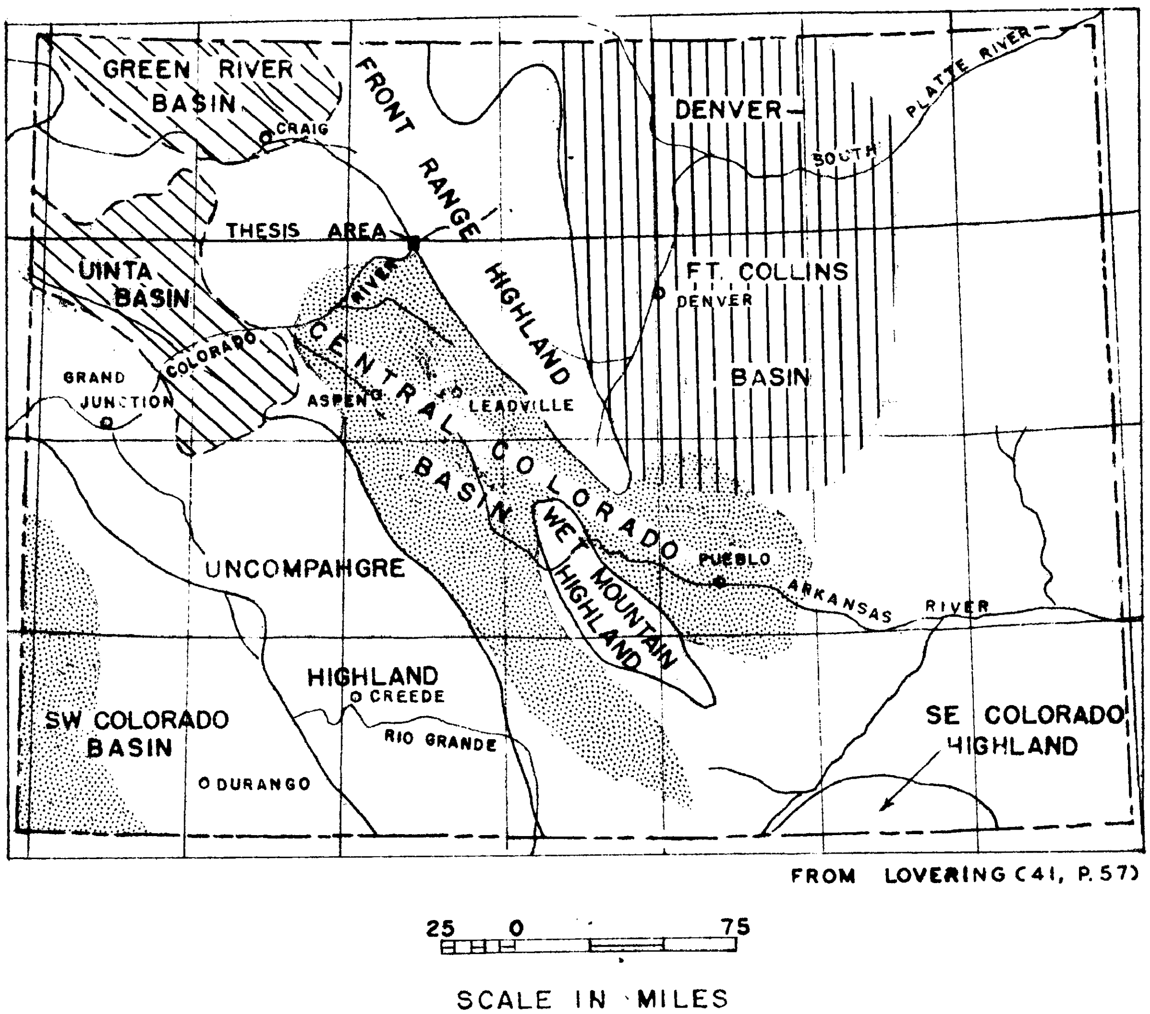


Figure 1. Peaks of the Gore Range dissected to the fretted upland stage. Flat surface in the foreground is 11,900 feet above sea level, and is possibly a remnant of a pre-Permian erosion surface. Closest peaks are five miles from the photographer. (See Plate VII for location.)



COMPOSITE PALEOTECTONIC MAP OF COLORADO

SHOWING ANCIENT POSITIVE AND NEGATIVE AREAS

DURING PALEOZOIC AND MOST OF MESOZOIC

M. C. PARSONS, 1953

Physiography

The area investigated lies within the Gore Range which is a southeastward-trending extension of the Park Range. Farther to the south it has a southerly trend and is called the Mosquito Range.

The Gore Range is essentially a faulted anticlinal ridge. The slopes on the east side of the Gore Range are gentle. There is a steep fault scarp on the western side of the range. At Gore Canyon the elevation is about 9,000 feet, but there is a gradual rise towards the south. About 15 miles to the south, at Eagles Nest Peak, the elevation has increased to 13,000 feet. With this increase in elevation a great change in the topographic character of the range has taken place. Whereas in the north it was a broad rolling ridge, in the south it has changed to a rugged, saw-toothed, glaciated ridge. (See Figure 1.)

Marvine, while investigating Middle Park in 1873, noted the uniform elevations of the Gore Range in his report to Hayden. He stated (47, p. 187):

> Looked at from the east, the general impression is received that all of the large ridges of the range have a similar structure. These rugged ridges, in their eastermost portions, present a pretty uniform general elevation, and as the northern ridge expands at its end into an even-surfaced table-like mass of rock, the impression is given that all of these sharp ridges are but the remnants left from the cutting away of a plateau-like step which once followed along the mountain face. These ridges also end quite similarly along a pretty straight line, and descend to rather a uniform level.

Marvine believed that it was fairly evident that the

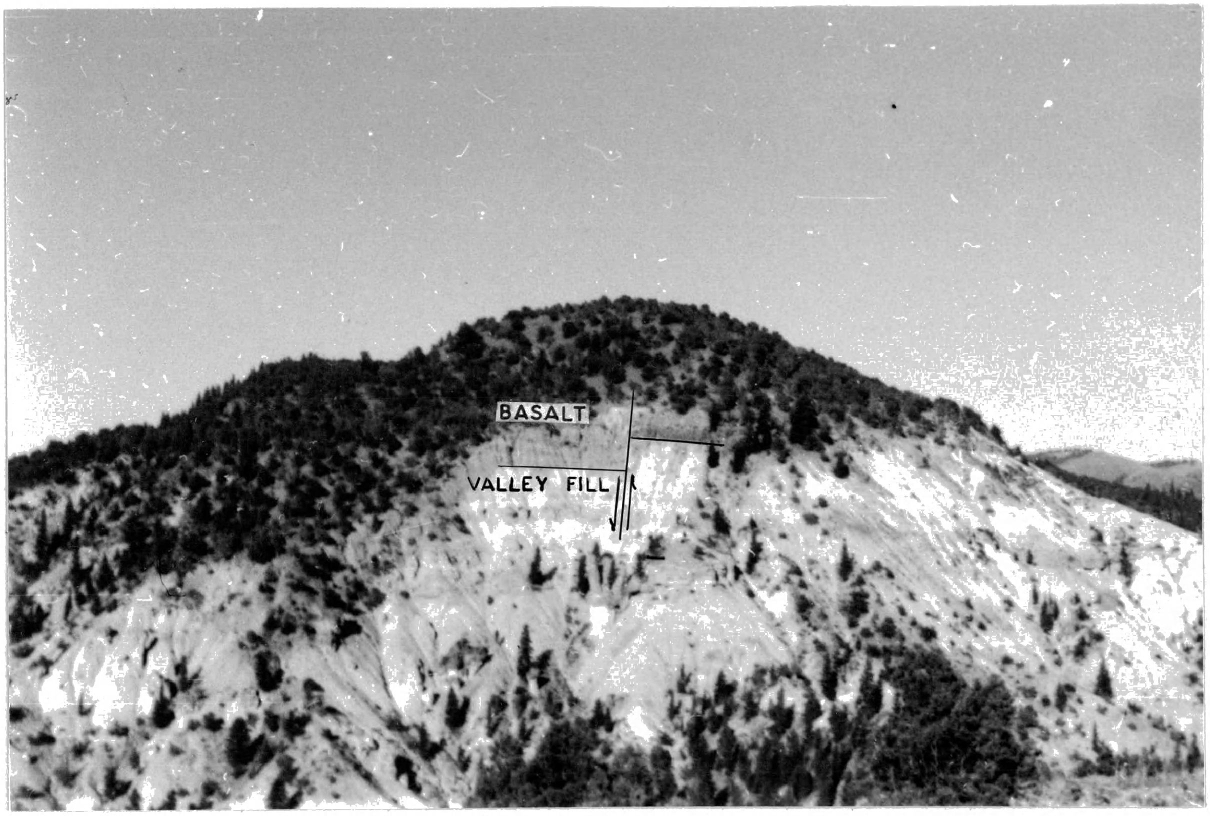


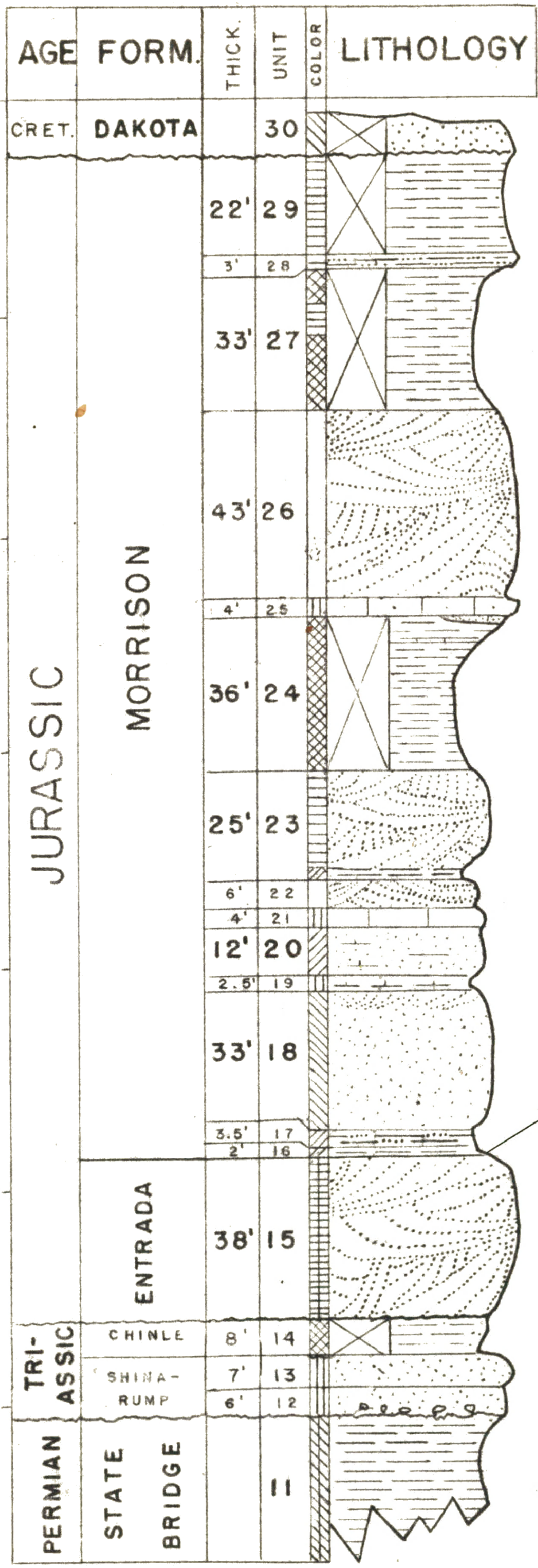
Figure 2. View of the North Park formation. Sediments are filling a valley cut into Cretaceous, Jurassic, and Pre-Cambrian rocks. Note the normal fault which cuts the basalt capping. (See Plate VII for location.)

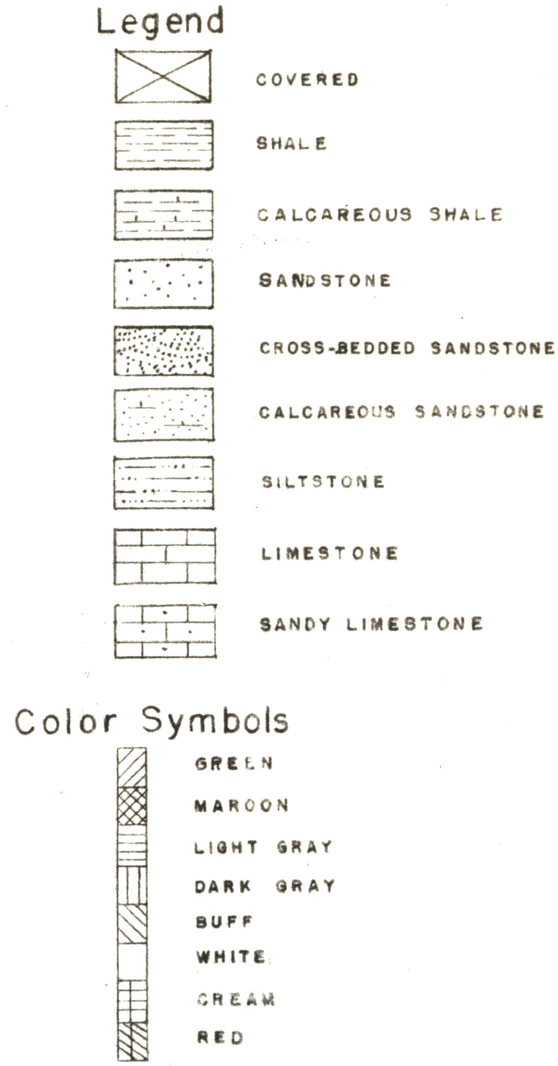
Cretaceous and Jurassic sandstones once covered this flat area and have since been eroded away. Fenneman (19, pp. 110-111) states that none of the plateau-like surfaces of the Park Range have definitely been correlated with either rne Flattop of the South Park peneplain. It appears likely that the plateau-like surfaces of the Gore Range do not represent a post-Laramide peneplain, but are instead, the relatively flat surface on which the Jurassic and Cretaceous sandstones were deposited.

This surface has been faulted down on the west side of the range, and still remains essentially level. The only difference between the upthrown surface and the down-thrown surface is that Permian(?) siltstones have been deposited on the latter surface. Farther to the south, the geologic map of Colorado shows that some Permian(?) sediments were deposited on the upthrown surface. It is reasonable, then, to assume that the age of a portion of this erosion surface is pre-Permian.

Several deep valleys have been cut into the pre-Permian erosion surface and were then filled with late Miocene sediments and lava flows. (See Figure 2.) There is evidence that one of these valleys was cut below the level of the present Colorado River. Although the deepest part of the Miocene valley exposed by erosion (sec. 26, T. 1 S., R. 82 W.) is only 200 feet above the level of the Colorado River, the great width of the valley at this level (1000 feet) indicates that the bottom of the valley is well below the present erosional surface. Such a valley could only have been formed by a major stream. The author believes that this stream was an ancestor to the present Colorado River.

PLATE-IV





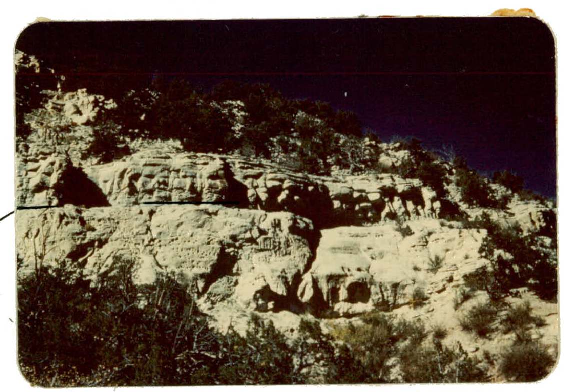


FIG. 3 MORRISON-ENTRADA CONTACT

DETAILED SECTION OF THE MORRISON FORMATION

SW$\frac{1}{4}$, SEC. 31, T.1S., R.81W.

M.C. PARSONS, 1953

Stratigraphy

The sedimentary rocks of the Gore Canyon area range in age from Permian(?) through Quaternary. They form a relatively thin veneer (maximum thickness is 1500 feet) over the Pre-Cambrian basement. There is a close relationship between the character of the sediments and the tectonic framework of sedimentation. The tectonic framework is a combination of two large landmasses and a rapidly sinking trough of deposition. (See Plate II.) The area mapped lies on the boundary between the Central Colorado basin and the Front Range highland. These features were in existence through the Paleozoic and most of the Mesozoic, during which time the landmass oscillated and was much higher in some periods than in others(46, p. 371). As a result, the area near Gore Canyon is characterized by major unconformities and unsystematic overlaps of the sediments. During the Paleozoic and most of the Mesozoic, the sediments varied from coarse arkoses to shales and limestones, depending upon the height of the adjacent landmass. There is clear evidence of cyclic deposition within the formations indicating repeated uplift.

Permian(?)

State Bridge Formation

History of Nomenclature

Brill (12, p. 810-811) lists about 45 different names for the Permo-Pennsylvanian of the Central Colorado basin. The outcrops are so discontinuous, fossils so rare, and facies changes so rapid that each worker applied his own formational nomenclature. It was not until Brill's excellent work (12, pp. 809-880) that successful correlations and separations of the Pennsylvanian and Permian(?) were made.

The Hayden Survey by Marvine (47, p. 187) and Peale (53, p. 100) was the first to study the thick red-bed sections. They recognized that the lower beds were Permo-Pennsylvanian and that the upper beds were Permian(?). In 1894, Emmons (11, p. 622), working in the Crested Butte area, proposed the term "Maroon conglomerate" for the red beds in the McCoy area. In 1936, Donner (17, p. 1223) extended the thickness of the McCoy formation and divided the overlying Maroon into two members: the "Rock Creek conglomerate" below and the State Bridge siltstone above. Brill (10, p. 1392) found that Donner's State Bridge member was persistent over a wide area and raised it to the rank of a formation. Sheridan (53, p. 129) noted that a limestone reported in the type section of the State Bridge formation was persistent and called it the Yarmony member.

Lithology

At the type section, the State Bridge formation consists of brick-red and yellow siltstone and shale. In the Gore Canyon area the siltstones are micaceous and slightly arenaceous. The lower beds are conspicuously rudaceous. There are occasional zones of violet to yellow-brown coloration which Sheridan (59, p. 134) interprets as a local influx of organic material that caused reduction of the iron oxide.

The following section was measured by the author on Sheephorn Creek.

Section of the State Bridge Formation

(Section 1, Plate VII)

SW$\frac{1}{4}$, Sec. 31, T. 1 S., R. 81W.
Eagle County, Colorado

Measured by M. C. Parsons, 1953

Section measured 250 yards north of Curry's ranch house.

Shinarump conglomerate (Upper Triassic)

Unconformity

State Bridge formation (Permian?)

Units		Thickness (feet)
11.	Shale: uniform brick-red; slightly arenaceous; micaceous; irregularly bedded to fissile; ferruginous cement..	45
10.	Covered. Probably red shales and siltstones................................	46
9.	Graywacke: gray; massive to irregularly bedded; conglomeritic, contains angular fragments of feldspar, quartz, and schist up to 2.5cm, average 1.2cm; calcareous cement; poorly sorted. Contains maroon and gray siltstone parting in center................................	8

8.	Shale: gray; fissile..................	2
7.	Limestone: dark-gray weathering to light-gray; dense; dolomitic; conchoidal fracture; thick-bedded; arenaceous, grains 0.1mm in diameter; micaceous............................	1
6.	Siltstone: red; laminated; arenaceous; micaceous; grains as much as 1.2mm in diameter; poorly sorted, subrounded quartz grains; calcareous cement.......	13
5.	Limestone: dark gray; dense to finely crystalline; dolomitic; calcite filling of joints; ledge-former; locally micaceous and fossiliferous....	2
4.	Siltstone: brownish-red; ripple marked; arenaceous, quartz grains are subrounded and 0.6mm or less in diameter; ferruginous and calcareous cement......	27
3.	Graywacke: gray; conglomeritic; phenoclasts are composed of angular fragments of quartz, schist, and feldapar which range from 1.2cm up to .3m in diameter, average is 7.5cm; dark color is due to biotite fragments 0.3mm in diameter; calcareous cement............	14
2.	Siltstone: gray; arenaceous, thick-bedded; conglomeritic along some bedding planes.........................	3
1.	Graywacke: gray; conglomeritic; contains sharp, angular fragments of feldspar, quartz and schist. There is evidence that the phenoclasts are derived from the underlying Pre-Cambrian. Average size of phenoclasts is 1.2cm...	12
	Total	173 ft.

Nonconformity

Pre-Cambrian

Thickness

Sheridan (59, p. 134) reports a rather constant thickness for the State Bridge formation throughout the

See pg 33-34
for page 23

is similar to the Hermosa fauna of southwestern Colorado, to the fauna of the lower Tensleep sandstone of Wyoming, and is approximately the equivalent of the Morgan formation of Utah.

Paleontology

Brill (11, p. 636) collected some poorly preserved internal and external molds of pelecypods from the Yarmony member at the type section. These were identified by Newell as:

Myalina sp?

Pleurophorus sp?

Aviculopecten sp?

Stratigraphic Relationships

In the Gore Canyon area, the State Bridge formation lies nonconformably upon the Pre-Cambrian gneisses and schists. About two miles north of Minturn, Colorado, Lovering and Johnson (46, p. 370) report local angular unconformities at the base of the Permian(?).

Sheridan (59, p. 134) found that some erosion had occurred at the top of the formation, but was unable to determine how much.

Overall, the surface upon which the State Bridge was deposited was level or gently rolling, but locally there is

Figure 4. High angle reverse fault which offsets color change between State Bridge and Entrada. (See Plate VII for location.)

a change of up to 20 feet in the relief within a very short distance. The fine red silts of the formation have penetrated several feet into fractures in the Pre-Cambrian; and even though the formation may have been completely stripped off by erosion, it is possible to map the former extension of the formation on the basis of the remaining fracture fillings.

The contact of the State Bridge with the overlying Shinarump is clearly marked in the areas where the massive conglomerate bed at the base of the Shinarump is well developed. In other areas the upper contact of the State Bridge is mapped on the basis of a color change from deep-red to light-yellow. This color change is evident in Figure 4.

Environment of Deposition

Plate II shows the essential paleogeographic features during the time that the State Bridge formation was being deposited. It should be noted that the area of deposition of the formation was on the northern edge of a rapidly sinking zeugogeosyncline. Although the zeugogeosyncline received deposition from both the Uncompahgre and Front Range positive elements, the source of the State Bridge formation was probably the Front Range landmass to the east. During State Bridge time, this landmass must have been reduced to a relatively low relief and had a warm, humid climate much like that of the southeastern States today. The abundance of mica would indicate that the rocks being eroded were metamorphic and igneous.

Sheridan (59, p. 141) believes that the basal graywacke present in the Gore Canyon area represents a type of fanglomerate deposited in a piedmont environment.

According to Brill (11, p. 635), the abundant ripple marks and the thin, arenaceous, algal limestone of the State Bridge formation indicate shallow-water deposition.

Triassic

Shinarump Conglomerate

History of Nomenclature

In 1876, Powell (54, pp. 54, 61) designated the red beds of eastern Utah, the Shinarump group, and placed them in the Triassic. Ward (71, p. 45) named the lower member the Moenkopi formation and called the conglomerate member the Lithodendron member of the Shinarump group. In 1917, Gregory (23, p. 42) named the upper shaly sandstone member of Powell's group, the Chinle. At present, the term Shinarump is restricted to the coarse sandstone and conglomeritic member of Powell's group.

Lithology

Lovering and Johnson (46, p. 357) report that the

Shinarump in the Glenwood Springs area consists of discontinuous conglomerates composed chiefly of quartz pebbles and a large amount of silicified wood. The latter is characteristic of the Shinarump everywhere. Ward (71, p. 45) called it the "Lithodendron member" because of these large silicified trees in the formation.

In the Gore Canyon area, the Shinarump usually occurs as a gray, weathering to light-gray, poorly sorted sandstone. There are many conglomerate lenses in the basal bed. The larger pebbles range from 6mm up to 65mm and are usually white quartz and chert. However, in one sample the pebbles (15mm in diameter) were light-brown, fine-grained sandstones containing sharp angular fragments of clear quartz. The Shinarump sandstones are cross-bedded, poorly sorted, and fine- to coarse-grained. The sand grains range from 0.2mm to 1.5mm and are subangular to subround.

Thickness

Lovering and Johnson (46, p. 357) report a thickness of 0 to 20 feet in central Colorado. Sheridan (59, p. 135) reports a thickness of 8 to 37 feet in the State Bridge-McCoy area. In the Gore Canyon area the thickness is extremely variable. Laterally, within 100 feet, it may range in thickness from 0 to 20 feet. A thickness of 13 feet was measured by the author on Sheephorn Creek. (See Plate IV.)

Age and Correlation

On the basis of fossil plants, Daugherty (16, p. 91) considers the Shinarump conglomerate to be of Upper Triassic age. This is supported by its position conformably below the Upper Triassic Chinle. Stokes (62, p. 91) considers it to be of Middle Triassic age, attaining its distribution during the period of erosion represented by the Moenkopi-Chinle unconformity.

Paleontology

The fossils found in the Shinarump conglomerate consist of bones of vertebrates, a few fresh-water gastropods, and numerous species and genera of plants. The following plants were identified by Daugherty (16, p. 22) in the Blue Forest area of Arizona:

Neocalamites virginiensis
Zamites powelli
Araucarioxylon arizonicum
Woodwortia arizonica

Stratigraphic Relationships

A major unconformity occurs at the base of the Shinarump conglomerate. Evidently, there was a long period of erosion, possibly lasting through the Middle Triassic, before the Shinarump conglomerate was deposited. In eastern Utah many stream channels cut into the Moenkopi and are filled with the conglomerate and coarse sandstone. In the Gore Canyon area, the contact between the State Bridge formation and the Shinarump is poorly exposed, but the complete change in lithology indicates a major unconformity.

The upper contact with the Chinle is gradational. There are several conglomerates and sandstones resembling the Shinarump in the lower beds of the Chinle. It is doubtful that an unconformity exists between the Shinarump and the Chinle.

Environment of Deposition

The rounded character of the pebbles in the lenticular conglomerates, as well as the cross-bedding, imply a fluvial origin for the Shinarump. Crickmay (15, p. 38) suggested that the Colorado Plateau area was an inland basin during the Upper Triassic and that the Shinarump and the Chinle were deposited by streams flowing northward and eastward from a landmass to the south (Jurosonora) and possibly from the "Ancestral Rocky Mountains".

Stokes (62, p. 92) suggests the possibility that the conglomerate represents gravel deposition on pediment surfaces. The rounded character of the pebbles and their nearly equal size, implies transportation for a considerable distance, which would seem to rule out Stokes' hypothesis.

The climate was probably tropical or subtropical with periodic heavy rainfall followed by distinct dry seasons. Daugherty (16, p. 29) reports evidence of numerous forest fires which would indicate that there were dry seasons.

Chinle

History of Nomenclature

In 1876, Powell (54, p. 41) described a section of strata in southern Utah and applied the name "Vermillion Cliff group." In 1917, Gregory (23, p. 42) designated the upper shaly sandstone member of Powell's group the Chinle. The type locality is at Chinle Valley, Arizona. Gregory divided the formation into four members, "A", "B", "C", and "D" in descending order. The "A" member appears to belong to the Glen Canyon group, conversely, there is a tendency to consider the Shinarump conglomerate an additional member because it grades upward into "D" (49, p. 89).

Lithology

Invariably, exposures of the Chinle in the Gore Canyon area are poor or concealed. On Sheephorn Creek, the formation seems to be predominantly yellow-brown, fissile shales and maroon, poorly consolidated, poorly sorted sandstones. The sandstones have subangular to subrounded grains which range in size from 0.1mm to 0.6mm, the finer size predominating.

Thickness

The total thickness measured on Sheephorn Creek was 8 feet.

Age and Correlation

According to Daugherty (16, p. 91) fossil plants seem to indicate an age of Upper Triassic and it has been assigned that age on the basis of vertebrate fossils.

Keyes (33, p. 61) believes that the Chinle correlates with the Dockum of Texas and the Dolores of southwestern Colorado.

Paleontology

Daugherty (16, p. 91) states that the same plant fossils found in the Shinarump are also found in the Chinle formation. The Chinle has yielded several groups of vertebrates, among them several genera of Stegocephlian.

Stratigraphic Relationships

The basal contact of the formation within the Gore Canyon area is concealed. Elsewhere (49, p. 91) it is reported that the contact with the underlying Shinarump is gradational.

The Entrada sandstone lies unconformably upon the Chinle. The contact is drawn at the top of the maroon sandstone. (See Figure 5.)

Environment of Deposition

The conditions of deposition of the Chinle formation were essentially the same as those under which the Shinarump was laid down. The area of deposition must have been a wide and low flood plain with meandering streams carrying material from highlands to the south and west.

Jurassic

Entrada

History of Nomenclature

The Entrada sandstone was named by Gilluly, et al. (22, p. 76) from the exposures at Entrada Point on the San Rafael Swell in Utah.

Lithology

The formation consists of a buff, massive, friable, fine- and medium-grained, quartzose sandstone. The grains

McCoy area. He measured a thickness of 384 feet at Radium, Colorado. The State Bridge is 173 feet thick at Sheephorn Creek and it thins rapidly towards the north and northeast as it approaches the area formerly occupied by the Ancestral Rockies. (See Plate II.)

Age and Correlation

Brill stated (11, p. 636): "Stratigraphic position and such lateral tracing as is possible from the White River Plateau to Moffat County indicate that the State Bridge formation is equivalent to the Phosphoria formation...although no diagnostic fossils have been found in the State Bridge, its fauna could be Permian."

If the South Canyon Creek dolomite member of the Maroon formation (4, pp. 1540-1551) correlates with the Yarmony member of the State Bridge formation, then the age of the State Bridge is fairly well established as Middle Permian. Brill (12, p. 837) suggests such a correlation and gives the age as Guadalupian.

Heaton (27, p. 1670) correlates the State Bridge formation with a portion of the Sangre de Cristo formation and the Embar formation of northern Wyoming.

There is a possibility that the State Bridge formation is equivalent to the Lykins formation east of the Front Range.

Johnson (31, p. 69) believes that the Maroon fauna

Figure 5. View of Entrada sandstone showing typical weathering characteristics; Entrada is about 38 feet thick at this locality. (See Plate VII for location.)

are well-rounded and frosted. The two predominating grain sizes are 0.2mm and 0.5mm with very few grains of intermediate size. The sandstone is cross-bedded and the weathered surface is usually cavernous. (See Figure 5.) The only accessory mineral is a very small amount of biotite. The grains are cemented by calcium carbonate.

Thickness

The thickness of the formation is variable. Lovering and Johnson (46, p. 357) report that it varies from 0 to 110 feet thick over central Colorado. In the Gore Canyon area, a thickness of 38 feet was measured on Sheephorn Creek.

Age and Correlation

The Entrada sandstone is placed in the middle Upper Jurassic on the basis of stratigraphic position (26, p. 1160).

Heaton (27, p. 1687) correlates the Entrada with the basal Morrison or Doctor Bond sandstone of the northern Front Range of Colorado, with the Exter formation of southeastern Colorado, with the lower La Plata of the San Juan Mountains, and with the upper "Nugget" of northwestern Colorado. In addition, Heaton (26, p. 1160) believes the Entrada is the approximate equivalent of the Preuss of southeastern Idaho, the "red zone" of the Sundance in

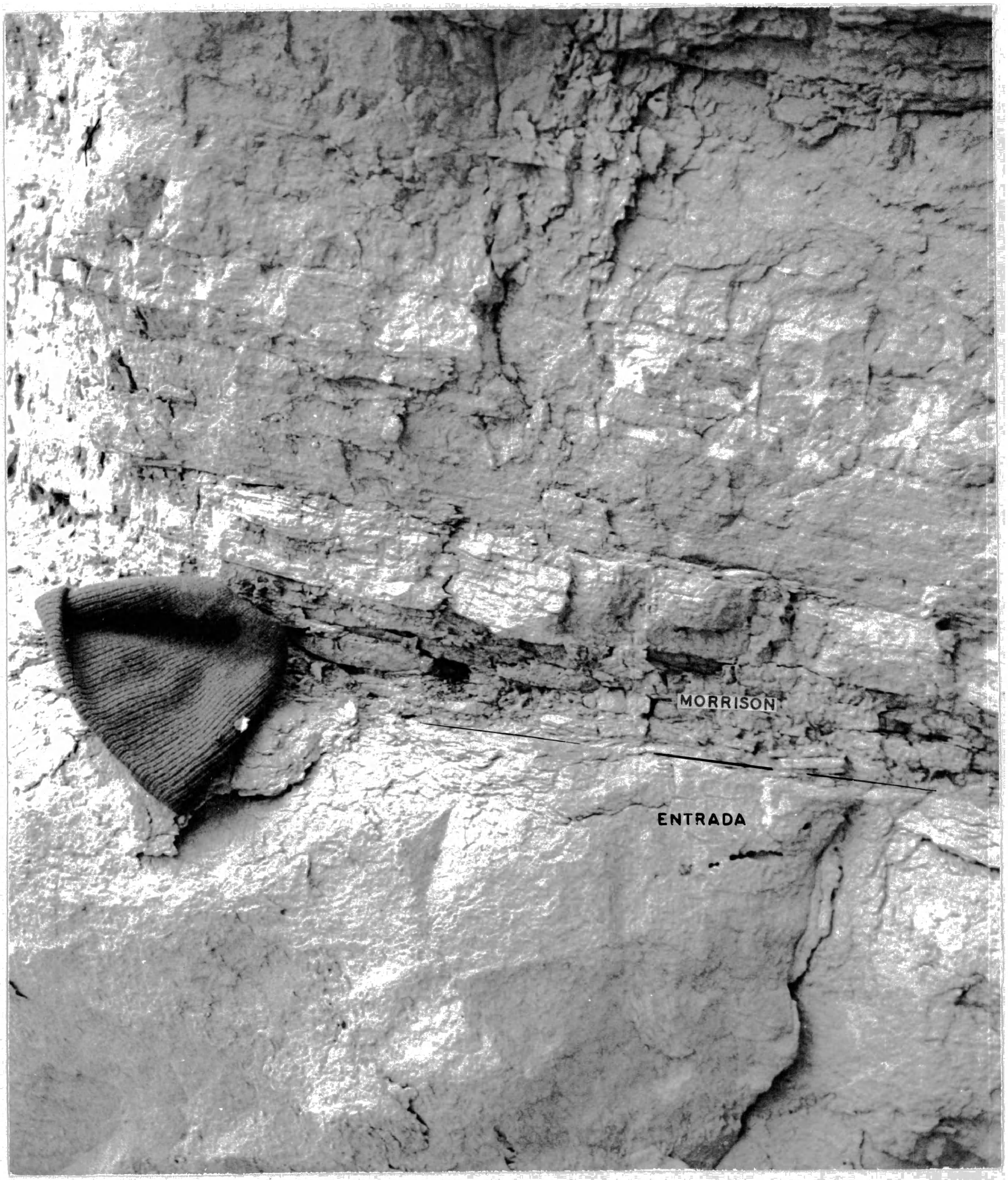


Figure 6. Entrada-Morrison contact; cap rests on top of Entrada. (See Plate VII for location.)

central Wyoming, and the Lak member of the Sundance formation in the Black Hills.

Paleontology

No fossils are known from the Entrada sandstone, except for a few dinosaur footprints (1, p. 8).

Stratigraphic Relationships

There is a distinct unconformity at the base of the Entrada. The evidence for this is the conglomerate in the basal bed and the slight discordance of dips between the underlying Chinle and the Entrada, which were measured by Sheridan (59, p. 143) in the State Bridge area.

The upper contact is marked by the change from the massive, buff Entrada to the green, thin-bedded Morrison. (See Figure 6.) There is some evidence of erosion at the top of the formation.

Environment of Deposition

Heaton (27, p. 1687) observed that the Entrada is doubtlessly aeolian and may have originated from the older Navajo, Wingate, or in earlier Carboniferous formations. The diverse and close cross-bedding as well as the frosted character of the grains seems to point toward an aeolian origin.

Morrison Formation

The Morrison formation was named by Eldridge (18, p. 60) from strata exposed near Morrison, Colorado. However, it had been described earlier by Hayden and Marvine.

In 1944, LeRoy and Waldschmidt (37, p. 1100) relocated the type section to a road cut on West Alameda Parkway, two miles north of the town of Morrison. They defined the Morrison as the interval of strata between the conglomeritic phase of the Dakota and the red, sandy shales of the Lykins formation.

Lithology

The Morrison formation is composed of discontinuous beds of green and maroon mudstones; soft, greenish-white, calcareous sandstones; and occasional thin beds of impure limestone.

The sandstones are composed of subangular to subround, fine- to medium-grained quartz grains, and usually exhibit aeolian cross-bedding.

The following Morrison section, shown graphically on Plate IV, was measured by the author on Sheephorn Creek north of Curry's ranch house.

Section of the Morrison Formation

(Section 1, Plate VII)

SW¼, Sec. 31, T. 1 S., R. 81 W.
Eagle County, Colorado

Measured by M. C. Parsons, 1953

Dakota Group (Cretaceous)

Unconformity

Morrison Formation (Jurassic)

Units		Thickness (feet)
29.	Covered. Probably gray shales with some green siltstones and sandstones. Green sandstone observed elsewhere at the Dakota-Morrison contact was found in the float. This sandstone is composed of sharp, angular quartz fragments 0.3mm in diameter cemented in a calcite matrix. The calcite material has coalesced to form crystals 15mm across......	22
28.	Siltstone: light-gray, thick-bedded....	3
27.	Covered. Probably gray to maroon shale and mudstone............................	33
26.	Sandstone: White, weathering to pink, fine- to medium-grained; massive to thinly-bedded, cross-bedded.................	43
25.	Limestone: dark-gray, arenaceous, sublithographic, massive. A ledge-former..	4
24.	Covered: Probably maroon and gray mudstones. A light-brown, cross-bedded, fine-grained sandstone lens is present at the top. A thin, argillaceous limestone bed is present 10 feet from the top................................	36
23.	Sandstone: light-gray, fine-grained, thick-bedded to massive, cross-bedded. Several green mudstone lenses are present in the lower part...............	25

22.	Sandstone: White, weathering to buff; fine- to medium-grained; cross-bedded..	6
21.	Limestone: dark-gray, weathering to gray; dense; argillaceous; 10% clay; arenaceous; sand grains are less than 0.1mm in diameter; conchoidal fracture; cut by thin calcite veinlets; weathers into ¼-inch blocks..................	4
20.	Sandstone: green, weathering to buff; fine-grained, very uniform in size (0.2-0.3mm); calcareous cement; some limonite between grains; friable.......	12
19.	Mudstone: gray, calcareous, small amount of biotite, small calcite veinlets 0.1mm across......................	3
18.	Sandstone: greenish-white, weathering to buff; fine-grained; well-rounded grains, 0.1-0.2mm in diameter; calcareous cement; friable. Upper 10 feet is a very white, poorly sorted sandstone; grains range from 0.2mm to 0.6mm in diameter and are subangular to rounded; cross-bedded...............	33
17.	Sandstone: greenish-gray; fine-grained; quartz grains appear to be reworked Entrada sandstone, are one size only, 0.2mm; calcareous cement; only dark mineral is biotite; laminations are irregular; thin-bedded.................	3
16.	Shale: green, thin-laminated..........	2
	Total	227

Unconformity

Entrada (Jurassic)

<u>Thickness</u>

The Morrison is 227 feet thick on Sheephorn Creek, but thins towards the east and northeast.

Age and Correlation

The Morrison is of late Upper Jurassic age(39, p. 953). It correlates with the Morrison of Colorado Plateau and Front Range, and the Zuni sandstone of western New Mexico (30, Chart 8-C).

Paleontology

Yen (73, p. 1214) reported finding a *Planorbia* sp? and a *Valvata*-like genus southeast of Grand Junction, Colorado.

The only fossils found in the area by the author were several poorly preserved, silica replacements of a pelecepod found in a limestone on Meyer's ranch. It was identified as:

Unio sp.?

Stratigraphic Relationships

The Morrison has overlapped the Curtis about 30 miles to the southeast of the thesis area. In the Gore Canyon area it rests unconformably upon the Entrada. (See Figure 5.) It is difficult to select the exact contact with the Dakota. In most of the area there is a 4-foot conglomerate bed of undetermined origin approximately 30 feet below the lowest conglomeritic bed of the Dakota(?) sandstone. This bed is separated from the Dakota(?) by a series of yellow-brown and maroon shales. Thomas (63, Chart 1) reported this conglomerate in northwestern Colorado and called it "beds of undetermined origin." He stated that Reeside had found Lower Cretaceous fossils in beds of similar lithology and stratigraphy, which would seem to indicate that the upper Morrison contact should be drawn at the base of the lowest conglomerate. In all but a few places within the area, this contact is covered.

Environment of Deposition

Crickmay (15, p. 39) summed up the conditions under which the Morrison was deposited when he commented:

> In the Jurassic, most of the area of the continent was without relief, and had only enough elevation to maintain its surface above sea-level--so low, indeed, as largely to inhibit subaerial erosion.... for what else but permanently low, flat surfaces could make possible the incursion, without notable erosion, of one epeiric sea after another, and the deposition of flood plain deposits over hundreds of thousands of square miles?

Nearly everyone who has dealt with the Morrison supports the theory that the Morrison formation represents deposits from rivers and lakes laid down upon a low, poorly drained surface. The flora and fauna found in the formation seem to indicate a warm, humid climate.

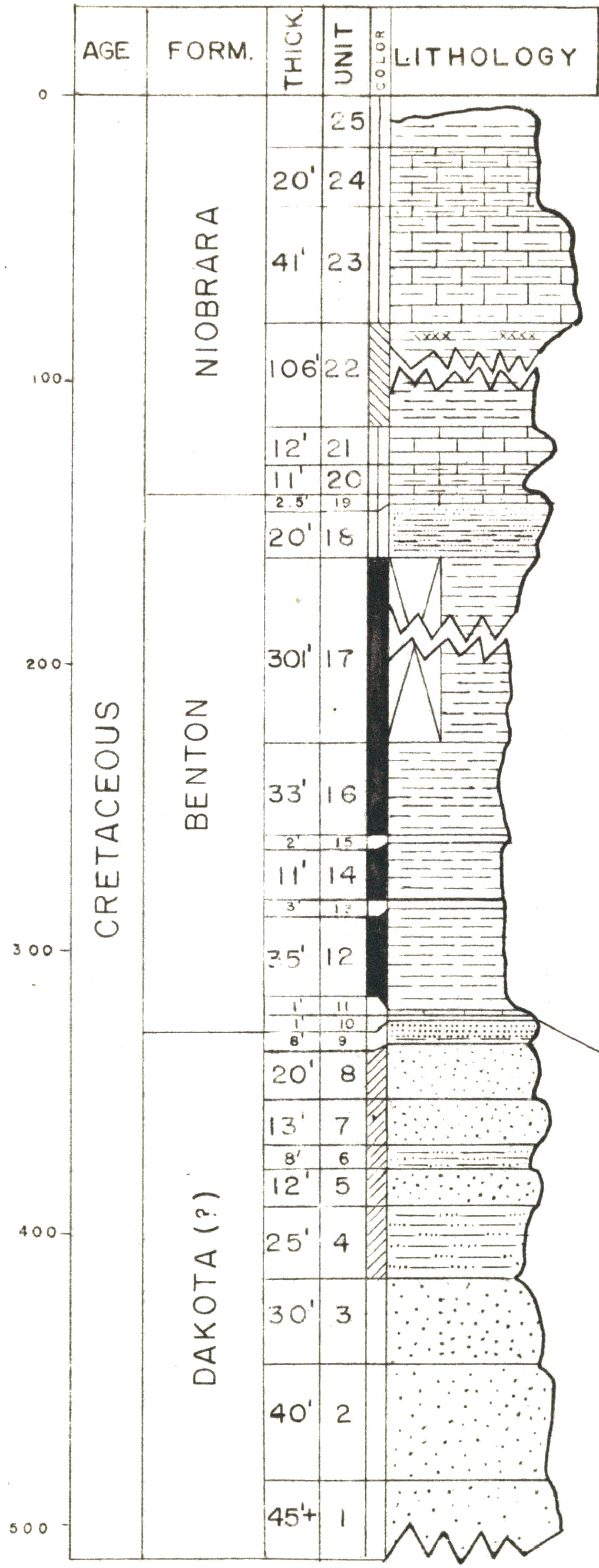
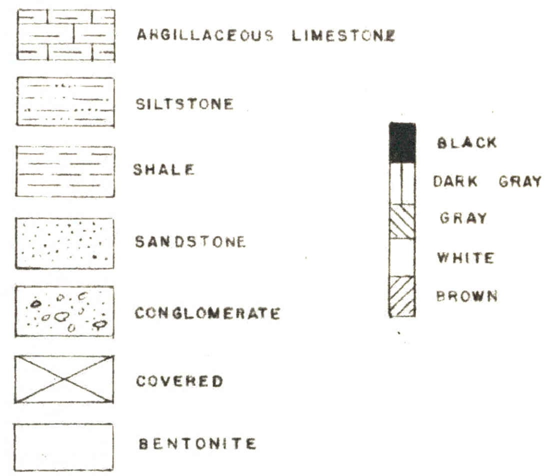


FIG. 7 DETAILS OF THE NIOBRARA LIMESTONE



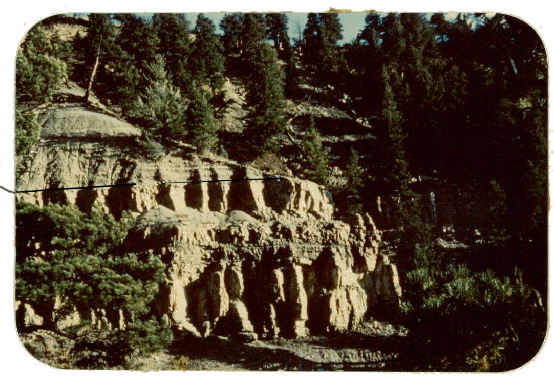


FIG. 8 DAKOTA–BENTON CONTACT

DETAILED COMPOSITE SECTION

OF THE

DAKOTA(?), BENTON, AND NIOBRARA

STRATIGRAPHIC SECTIONS 2, 3, 4, 5, PLATE VII

M.C. PARSONS, 1954

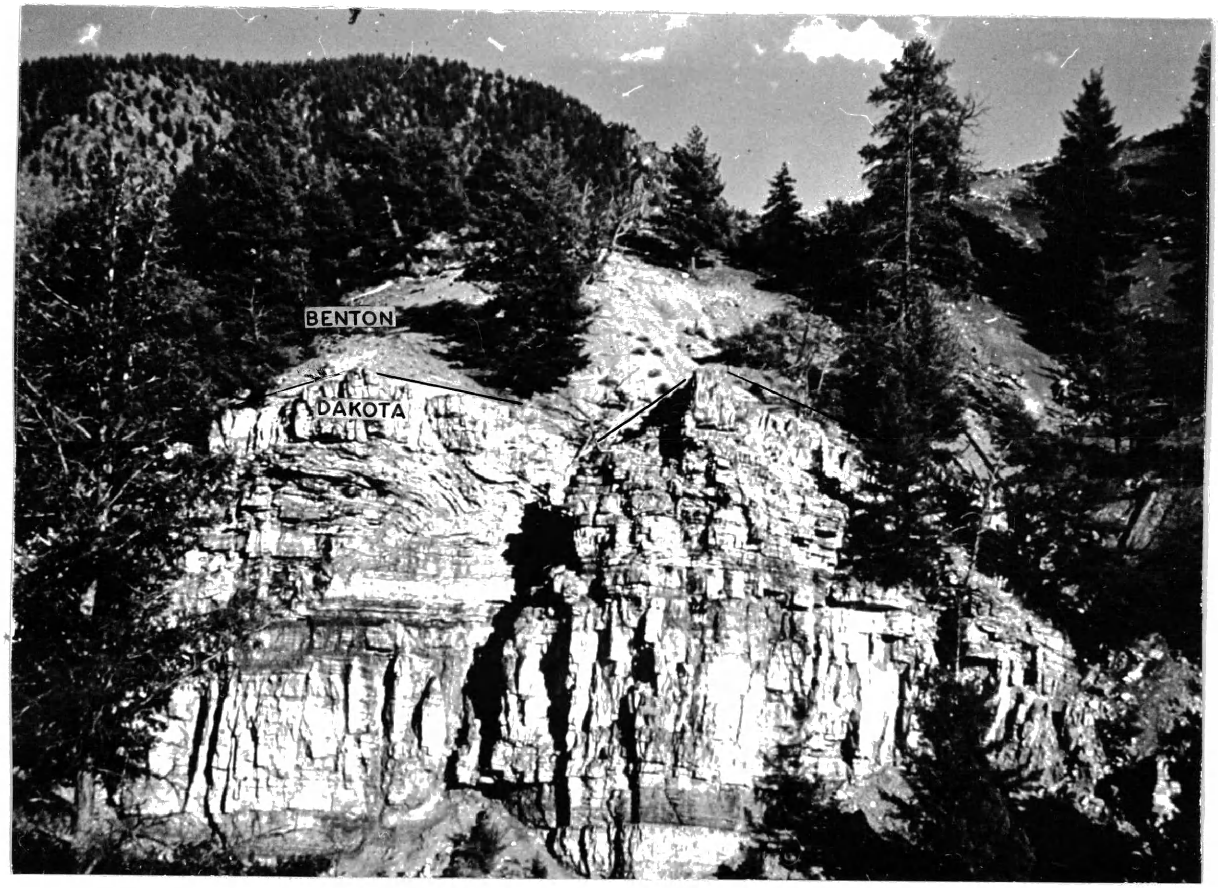


Figure 9. Dakota-Benton contact. Basal conglomerate of Benton occurs at top of sandstone strata. (See Plate VII for location.)

Cretaceous

Dakota(?) Formation

History of Nomenclature

The strata representing the Dakota group were first described and defined in 1856 by Meek and Hayden (50, p. 63), who designated them "Formation No. 1 of Cretaceous". They later renamed them the "Dakota Group" (51, p. 419). The U. S. Geological Survey restricted the name Dakota to the area east of the Front Range and the term Dakota Group or Dakota(?) is used for rocks of similar lithologic aspects in areas west of the Front Range and elsewhere.

Lithology

The Dakota(?) of the Gore Canyon area is usually composed of a coarse, conglomeritic, basal sandstone bed and thick beds of fine- to medium-grained, well-cemented sandstones with several thin beds of interbedded shale and siltstone. (See Figure 9.)

The following section was measured on the prominent hogback on Meyer's ranch near the mouth of Gore Canyon by the author. (See Plate VII for exact location.)

Section of the Dakota(?) Formation

(Section 2, Plate VII)

$N\frac{1}{2}$, Sec. 12, T. 1 S., R. 82 W.

Measured by M. C. Parsons, 1953

Top eroded

Dakota(?) Formation (Cretaceous)

Units		Thickness (feet)
9.	Sandstone: yellowish-brown, fine-grained, thin-bedded, mud cracks. Dark-gray, carbonaceous shale is present near the base..................................	8
8.	Sandstone: yellowish-brown, weathering to dark-brown, fine-grained, well-cemented with siliceous and ferruginous cement, ripple marked....................	20
7.	Sandstone: light-brown; fine- to medium-grained; quartz grains are sub-angular to subround, range in size from 0.1mm to 0.3mm in diameter with an average size of 0.25mm; poorly sorted; ferruginous cement; a ledge-former......	13
6.	Covered. Probably thin-bedded silt-stones or shale..........................	8
5.	Sandstone: tan, fine- to medium-grained, friable, massive to thick-bedded........	12
4.	Covered. Probably thin-bedded silt-stones or shale..........................	25
3.	Sandstone: white, weathering to tan and pink; medium-grained; subround grains of quartz range from 0.2mm to 0.6mm, average 0.45mm in diameter; friable, cement is limonite; massive.......................	30
2.	Sandstone: white, fine- to medium-grained, massive, few conglomerate lenses near base........................	40

1. Sandstone: white, weathering to light-brown; conglomeritic; pebbles consist of gray and white quartzite and are subrounded, range in size from 6mm up to 2.5cm; numerous pieces of silicified wood; massive. Bottom is covered.......	45+
Total	201+

Thickness

The measured thickness of the Dakota(?) formation in the northern part of the area is 201+ feet. A complete section is not present anywhere in the area. However, Gates (20, p. 49) measured an incomplete thickness of 232 feet near Radium, Colorado, which he thought was very near the total thickness. Therefore, the thickness of the Dakota(?) is probably about 250 feet, which would include the conglomerate and shale of doubtful Lower Cretaceous age.

Age and Correlation

The term Dakota has usually been applied to the quartzitic sandstone appearing directly beneath the Benton formation; thus the Dakota of one locality is not always the exact time equivalent of the Dakota of other localities.

Lovering (41, p. 39) states: "the Dakota group contains beds of Lower Cretaceous age, and only the upper sandstone should be classed as Dakota sandstone or quartzite of Upper Cretaceous age in most places." Formerly it was believed that all of the Dakota(?) formation on the western slope of the Front Range was of Upper Cretaceous age and that the top of the Morrison represented the boundary between the Jurassic and the Upper Cretaceous. As previously mentioned, several writers have noted the presence of a thick conglomerate below the proposed Morrison and Dakota(?) contact and have placed them in the Lower Cretaceous. Stokes (61, p. 958)proposed the name of Buckhorn conglomerate for the conglomeritic bed and Cedar Mountain shale for the Morrison-type shales above it.

The writer observed a conglomerate and shale of similar lithology and stratigraphic position in the northwest quarter of sec. 23, T. 1 S., R. 82 W and sec. 19, T. 1 S., R. 81 W. (Plate VII). The thickness of the conglomerate varied considerably over a short lateral distance. Because of the lack of more positive correlation it was mapped as part of the Dakota(?) formation.

A part of the Dakota(?) probably correlates with the Dakota east of the Front Range and the Purgatoire of southeast Colorado. Lovering (41, p. 39) also correlates it with the Cloverly formation of Wyoming.

Paleontology

The only fossils found in the Dakota(?) in the thesis area were pieces of petrified wood and fucoids.

Stratigraphic Relationships

The basal conglomerate present nearly everywhere, indicates that the Dakota(?) rests unconformably upon the Morrison. There is some doubt as to where the Dakota(?)-Morrison contact should be drawn. In this thesis it will be considered to be at the base of the lowest conglomerate.

A thin bed of conglomerate was found at the top of the Dakota(?), which indicates at least a local hiatus between the Dakota(?) and the overlying Benton formation.

Environment of Deposition

Lovering (39, p. 87) believed that the Dakota represented a beach of a slowly transgressing sea. This sea was spreading over a very gently sloping surface on an old piedmont plain, and as a result, widespread swamps developed.

Benton Formation

History of Nomenclature

As a result of their expedition to the Missouri Valley in 1856, Meek and Hayden (50, p. 63) named a series of gray clays the "Formation No. 2 of the Cretaceous." This term was used up until 1861, when they (51, p. 419) substituted a geographic term, "Fort Benton Group", after Fort Benton near Great Falls, Montana. The only modification since then has been to drop the name "Fort" and to divide into members.

Gilbert (21, p. 564) divided the Benton of eastern Colorado into three formations: the lower Graneros shale, the middle Greenhorn limestone, and the upper Carlile shale. In the Gore Canyon area, only the Graneros shale member and the Carlile shale member are recognized.

<u>Lithology</u>

A large portion of the Benton formation is covered in the thesis area. Only the bottom and top portions were exposed for detailed study.

<u>Graneros Shale</u>: A dark-gray shale containing numerous partings of bentonite and a thin, basal conglomerate.

<u>Carlile Shale</u>: This member is represented by thin-bedded, fine- to medium-grained sandstones and a bed of fossiliferous, petroliferous, arenaceous, flaggy limestone.

The following section was measured by the writer at three separate localities. The portion below the covered interval (See Plate V.) was measured on the east bank of the Colorado in the W½ of sec. 7, T. 1 S., R. 81 W. (stratigraphic section 3, Plate VII). The portion above the covered interval was measured in the SE¼ of sec. 13, T. 1 S., R. 82 W. (stratigraphic section 4, Plate VII). The total Benton formation thickness was measured in the

NW¼ of sec. 2, T. 2 S., R. 82 W. Since nearly all of the section at this locality was covered and the beds were nearly vertical, there is a possibility that the total thickness is incorrect owing to hidden strike faults.

Composite Section of the Benton Formation

(Sections 3, 4, 5, Plate VII)

Measured by M. C. Parsons, 1953

Niobrara Shale (Cretaceous)

Probable unconformity

Benton Formation (Cretaceous)

Units		Thickness (feet)
19.	Limestone: dark-gray; flaggy; petroliferous, distinct odor of petroleum on fresh surface; arenaceous, grains of quartz are subround and average 0.2mm in diameter; finely crystalline; very fossiliferous. Ledge-former	3
18.	Siltstones: brown; thin-laminated; arenaceous, largest visible grains are 0.25mm, average is 0.15mm.........	20
17.	Covered interval......................	30
16.	Shale: dark-gray; thin-laminated; fissile..............................	33
15.	Metabentonite: yellow, weathering to white; underlain by thin bed of dark-gray, weathering to brown mudstone....	2
14.	Shale: dark-gray; fissile............	19
13.	Same as unit 15......................	3
12.	Shale: dark-gray; thin-laminated; fissile; with a thin, dark-gray, weathering to brown, blocky mudstone.......	35

11.	Limestone: thin-bedded, blocky, argillaceous, dense..................	1
10.	Conglomerate: white and dark-gray, pebbles as much as 2 cm in diameter; pebbles are subrounded..............	1
	Total	419

Unconformity

Dakota(?) Sandstone.

Thickness

The thickness of the Benton formation appears to be fairly constant throughout the Gore Canyon area. The measured thickness is about 419 feet.

Age and Correlation

The Benton formation is of Upper Cretaceous age. Cobban and Reeside (14, Chart 10b) correlate the Carlile shale member with the Codell sandstone member of the Pueblo-Walsenburg region of Colorado and with the Frontier sandstone member of Wyoming. They also correlate the Graneros shale member with the Bell Fourche shale of the western Black Hills.

Paleontology

A large number of fossils were collected from the

Carlile member. They were identified as:

Prionocyclus wyomingensis Meek

Inoceramus sp?

Stratigraphic Relationships

The Benton formation lies disconformably upon the Dakota(?) sandstone. The evidence for this is the thin bed of conglomerate which occurs at the base of the formation. This probably represents a local hiatus, because the only other place where it is reported is in the valley of the Snake River east of Dillon, Colorado (41, p. 39).

The Benton is probably unconformably overlain by the Niobrara formation. The contact is marked by a thin, brown, fossiliferous bed of limestone which has a distinct petroliferous odor.

Environment of Deposition

According to Heaton (25, p. 166) the Benton was deposited in a shallow sea. Twenhofel (65, p. 1196) postulates that black shales are deposited in a near-shore environment in the region where aquatic plants hinder circulation, which would insure the deposition of black muds over the area of advance of a transgressing sea.

Niobrara Formation

History of Nomenclature

The Niobrara formation was first named "Formation No. 3 of Cretaceous" by Meek and Hayden (51, p. 63). In 1861, they substituted geographic names for the numbers of their stratigraphic divisions (50, p. 419). They called "Formation No. 3..." the "Niobrara Division."

East of the Front Range the Niobrara is divided into the Timpas limestone below and the Apishipa shale above. In the Gore Canyon area, a limestone closely resembling the Timpas limestone of the Pueblo region occurs directly above the Carlile member of the Benton formation. (See Plate V.) However, the "speckled shale" typical of the Apishipa member was not evident.

Lithology

The limestone tentatively correlated with the Timpas member of eastern Colorado is gray weathering to white, argillaceous and blocky, and weathers into thin slabs. It is thin-bedded; the beds never exceeding one foot in thickness.

Directly above the limestone is a thick section of gray, fissile shale containing numerous fragments of *Inoceramus deformis*(?). Secondary selenite occurs at the

Figure 10. Details of shaly limestone of Niobrara. Thickest bed is about one foot. (See Plate VII for location.)

top of this shale section.

A second series of limestones, similar to the Timpas limestones, is exposed above the shale (Figure 10).

The following stratigraphic section was measured about 100 yards northeast of the Hartman ranch house by the author. It is shown graphically on Plate V.

Section of the Niobrara Formations

(Section 4, Plate VII)

SE$\frac{1}{4}$, Sec. 13, T. 1 S., R. 82 W.
Grand County, Colorado

Measured by M. C. Parsons, 1953

Top eroded

Niobrara (Cretaceous)

Units		Thickness (feet)
25.	Shale; dark-gray, weathering to buff; calcareous; contains *Ostrea congesta*..	10+
24.	Limestone: dark-gray, weathering to white; contains few rounded grains of quartz averaging 0.6mm in diameter; and round marcasite concretions 6mm in diameter; dense; flaggy and blocky; fish teeth and scales are common......	41
23.	Shale: dark-gray, fissile, contains secondary selenite and *Inoceramus deformis(?)*.........................	106
22.	Limestone: dark-gray, weathering to light-gray; dense, argillaceous, thin-bedded, blocky........................	11
	Total	168+

Benton Formation (Cretaceous)

Thickness

The Niobrara in the area exceeds 168 feet.

Age and Correlation

According to Cobban and Reeside (14, Chart 10b), the Niobrara of the Gore Canyon area appears to correlate with the Niobrara of eastern Colorado and is of Upper Cretaceous age.

Paleontology

The following fossils were collected by the author:

Ostrea congesta Conrad
Inoceramus deformis (?) Meek

A complete specimen of *Inoceramus deformis* (?) was not found.

Stratigraphic Relationships

The Niobrara formation apparently lies unconformably upon the Benton formation. The contact between the two formations has been previously discussed. The upper portion of the Niobrara formation in the thesis area is eroded.

Environment of Deposition

The dense, impure limestones and dark-gray shales indicate deposition under shallow, agitated water and marine conditions.

Miocene

North Park Formation

History of Nomenclature

The geologists of the King Survey (34, pp. 431-434) applied the name North Park group to all the strata overlying the marine Cretaceous in North Park.

Beekly (6, p. 1514) restricted the term North Park to the white, calcareous sandstone and ashy beds present in that area.

Hayden (24, pp. 79-80) was the first geologist to describe the North Park sediments in the Gore Canyon area. In 1873, he made a brief exploration trip up the Grand River (Colorado River) and examined an outcrop of North Park sediments near the Radium post office. He dated them as Pliocene or later.

Lithology

The North Park formation of the Gore Canyon area

Figure 11. Hoodoos developed in North Park formation. (See Plate VII for location.)

consists of interbedded conglomerate; coarse- to fine-grained, arkosic sandstone; tuffs; shale; and lava flows. They show the typical cut-and-fill characteristics of river deposits. (See Figure 11.)

Thickness

The thickness of the North Park formation in the area is more than 800 feet. The bottom of the formation is not exposed in the locality where it reaches its greatest thickness.

Age and Correlation

Lovering (43, p. 41) places the North Park formation near Grandby, Colorado, in the lower Miocene. On the basis of vertebrate fossils, it is now considered to be of late Miocene or early Pliocene age (48, pp. 61-64).

Lovering (41, p. 41) correlates the North Park with the Arikaree sandstone of northeastern Colorado.

Paleontology

No fossils were found in the North Park formation by the writer. The local ranchers reported finding petrified trees in the formation, but this report could not be verified.

Stratigraphic Relationships

The North Park formation rests unconformably upon all of the older rocks of the area.

Environment of Deposition

The North Park formation is a river deposit. This fact is confirmed by the coarseness of the clastics and the cut-and-fill type of deposition. The region was probably subjected to heavy, torrential rains followed by periods of drouth during the Miocene.

Figure 12. Schist xenolith in granite. (See Plate VII for location.)

Igneous and Metamorphic Rocks

The igneous and metamorphic rocks of the Gore Canyon area include schists, gneisses, and granite of Pre-Cambrian age; white rhyolite porphyry dikes, rhyolite agglomerate, and basalt flows of Tertiary age.

Pre-Cambrian Rocks

The Pre-Cambrian rocks consist of biotite and amphibolite schists, and gneisses; all of which have been intruded by granite and pegmatites. The rocks appear to be similar to the Idaho Springs formation, and are shown as such on the Geologic Map of Colorado.

The intruding granite engulfed large slivers of schist. (See Figure 12.) The granite is schistose and its schistocity is developed in the same direction as that of the intruded country rock.

Tertiary Intrusives

White Rhyolite Porphyry

In secs. 15 and 22, T. 1 S., R. 82 W., white rhyolite porphyry has intruded along fault planes to form thick dikes. One of these dikes is shown in Figure 13.

An outcrop of the white rhyolite porphyry is typically white, weathering to cream, and often splits into thin,

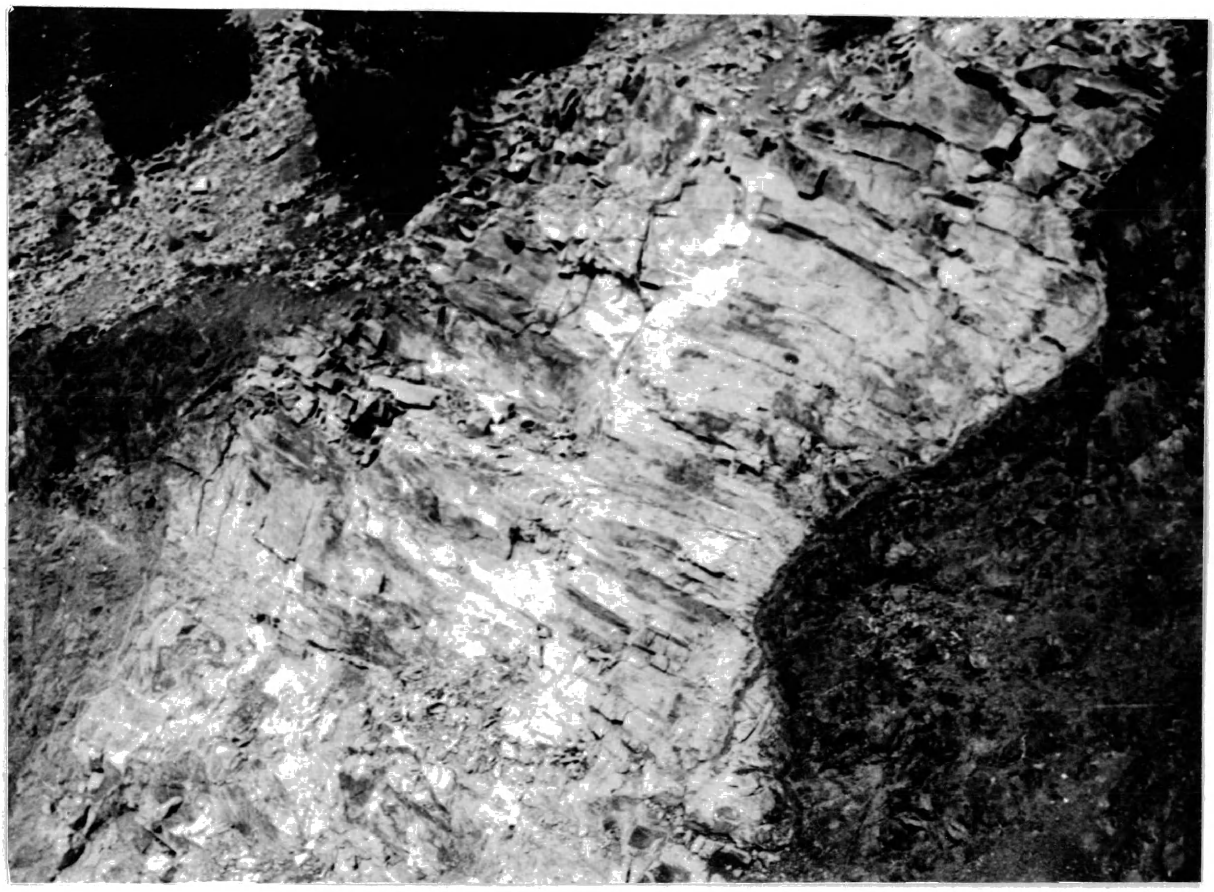


Figure 13. White rhyolite porphyry dike cutting Pre-Cambrian gneisses. Dike is 15 feet wide. (See Plate VII for location.)

platy slabs. A hand specimen of the same rock exhibits a dense, stoney groundmass containing a few euhedral feldspar phenocrysts 3mm across; fairly abundant euhedral biotite phenocrysts 1mm across; and rarely, euhedral quartz crystals 2mm across. There is a definite alignment of the biotite crystals.

A study of a thin section of the rock reveals that the groundmass is too fine-grained to determine its constituents, but the rock can be approximately classified as a rhyolite porphyry on the basis of its phenocrysts. The feldspar crystals are orthoclase and show considerable alteration to sericite and kaolin. There is no indication of reaction between the phenocrysts and the groundmass as the crystal outlines are sharp and distinct.

A rock very similar to the white rhyolite porphyry is described by Behre (8, p. 67) in his report on the geology of the west slope of the Mosquito Range. He stated that the rock was essentially a light-colored granodiorite porphyry.

It seems significant that the occurrence and description of the rock in both areas is nearly the same except that the principal feldspar in one case is orthoclase and in the other it is plagioclase. In both places the rocks are intruded into faulted areas adjacent to the Mosquito fault.

Figure 14. Rhyolite agglomerate.

Rhyolite Agglomerate

In secs. 26 and 35, T. 1 S., R. 82 W., the North Park formation is intruded by elliptical shaped masses of rhyolite porphyry and agglomerate. The hand specimen has a pink groundmass and a cryptocrystalline texture. It contains numerous anhedral phenocrysts of quartz 3mm in diameter and large, angular fragments of explosive breccia. (See Figure 14.) The breccia is composed of the same material as the matrix.

Behre (8, p. 67) reports a very similar intrusive, fifty miles to the southeast, in the Mosquito Range. The description, age, and occurrence appears to be almost identical with the rhyolite agglomerate of the thesis area. Behre describes it as follows:

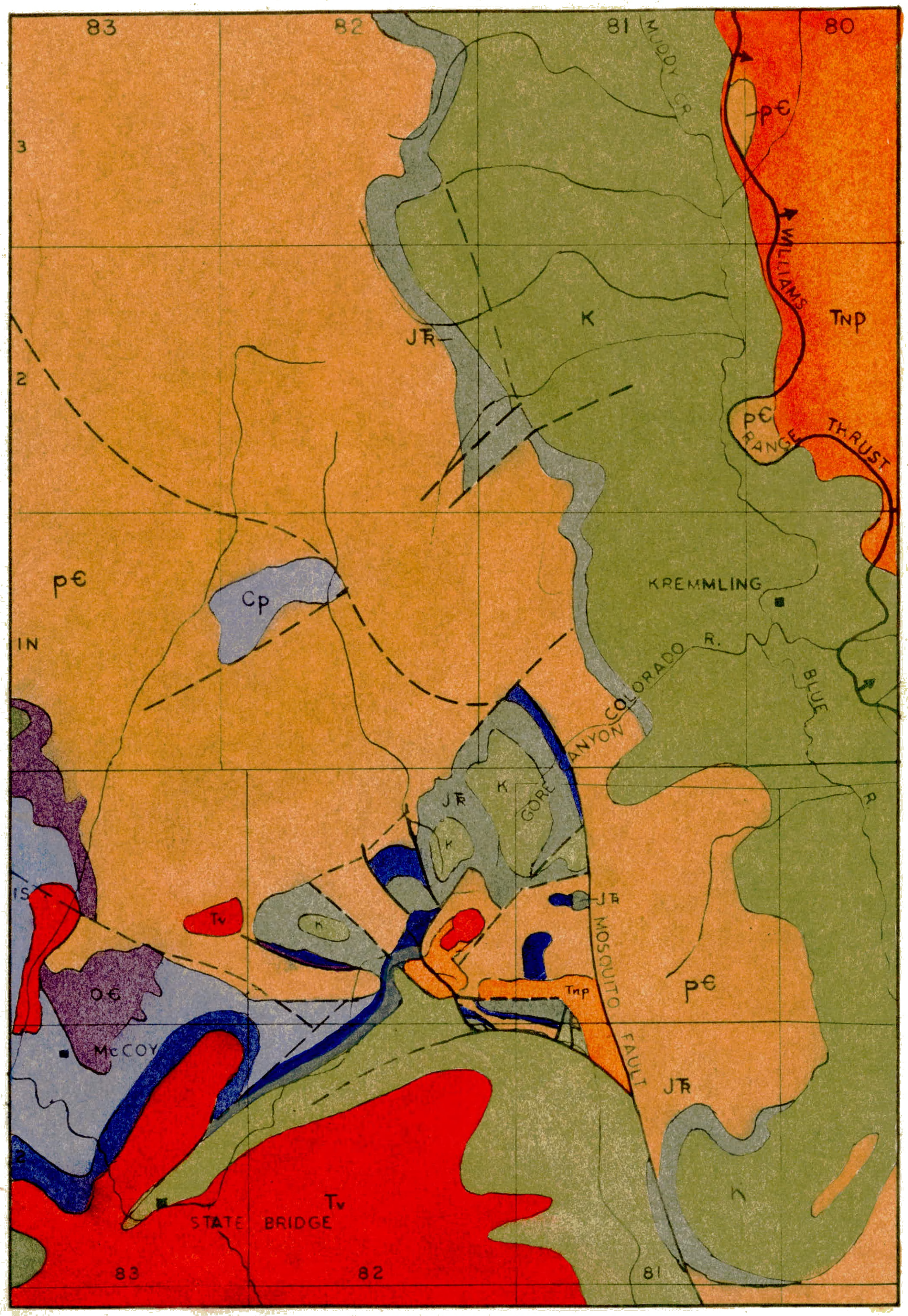
> The rhyolite agglomerate...follows faults and strongly resembles fault breccia, but flow lines can be seen which prove the pyroclastic origin...this agglomerate evidently is of late Tertiary age, for it contains fragments of definitely recognizable ore minerals which are believed to be of Miocene age.

Tertiary Extrusives

Basalt

The remnants of thick basalt flows are exposed in sec. 23, T. 1 S., R. 82 W. The basalt is a black, weathering to dark gray, dense to vesicular, aphanitic rock. In a thin section, it exhibits a pilotaxitic fabric with euhedral, lath-like crystals of plagioclase which show definite orientation. The plagioclase is extremely altered to sericite and kaolin and cannot be identified.

The age of these flows is probably Miocene since the lower flows are interstratified with the North Park formation. Figure 2 shows the relationship between the North Park formation and the basalt.



ADAPTED FROM U.S.G.S. GEOLOGIC MAP OF COLORADO

SCALE IN MILES

1 0 1 2 3 4 5 6 7 8 9 10

LEGEND

Tv	VOLCANIC ROCKS, UNDIVIDED
TNp	NORTH PARK FORMATION (MIOCENE)
K	CRETACEOUS
JTR	JURASSIC–TRIASSIC
Cpm	PERMIAN
Cp	PENNSYLANIAN
OЄ	ORDOVICIAN–CAMBRIAN
pЄ	PRE-CAMBRIAN

N

REGIONAL GEOLOGIC MAP

OF

GORE CANYON AND VICINITY

MARSHALL C. PARSONS

1954

Structural Geology

Regional

The major structural trend in the area is the Gore Range. This range is defined by the Williams Range thrust fault (which dips westward) on the east and by the high angle Mosquito fault on the west. (See Plate VI.) At Gore Canyon, these two faults are only 7 miles apart and therefore contibute to the complexity of the structure of this area.

The Williams Range thrust trends northwest from the vicinity of Breckenridge, Colorado, to the vicinity of Rabbit Ears Mountain. Principal movement on the fault occurred after the deposition of the Middle Park formation (late Cretaceous or early Paleocene) and before the extrusion of the Eocene volcanic material. Renewed movement occurred in the late Eocene (55, p. 1496).

The Mosquito fault is also a northwest trending fault. It is exposed for a distance of about 100 miles between Salida, Colorado, and Gore Canyon. It apparently dies out a short distance northwest of the thesis area. (See Plate VI.) This fault has been described as a reverse fault and also as a normal fault. Vanderwilt (68, p. 136) states that it is a normal fault where it is cut by the Climax workings. Behre (8, p. 49) believes that it is a high angle reverse fault at Leadville. In the Gore

Canyon area, there is evidence which seems to indicate that it is a reverse fault.

Local Structure

Folds

Within the thesis area, the major folding is parallel or nearly parallel to the axis of the larger regional fold, the Gore Range. Before the complex faulting took place, there was a series of gentle anticlines and synclines whose axes had a northwest trend. Cross section A-A' on Plate VII is probably close to and parallel to the original synclinal axis. Cross section B-B' probably lies on the original anticlinal axis. These gentle folds were accentuated by northwest trending normal faults and then partially obliterated and deformed by later northeast trending thrusts. This later faulting shifted the axis of the original folds and produced some northeast trending folds suon as the fold in sec. 18, T. 1 S., R. 81 W.

Faults

Faulting has produced most of the important structural features within the area. Each period of faulting has produced great changes and modifications in the earlier structure. In general, three periods of faulting can be recognized, with the possibility that movement occurred on many faults during more than one period.

Early Northwest Trending Normal Faults

These faults seemed to have accentuated and sharpened the earlier gentle folds. An excellent example of this is fault II in sec. 22, T. 1 S., R. 82 W. (See Plate VII.) The Morrison formation has been faulted down against the Pre-Cambrian and the resulting drag folding has produced a rather sharp syncline. The fault plane exposed near the railroad is vertical. The throw on this fault cannot be determined, but it tends to die out rapidly to the north.

The normal fault, IV, in sec. 15, T. 1 S., R. 82 W. has produced the deep Blacktail Creek canyon. The throw on this fault at the line of cross section C-C', is about 250 feet, but the fault dies out rapidly to the north.

Fault V in sec. 14, T. 1 S., R. 82 W. is illustrated in Figure 3. The throw, as measured in the offset sediments is about 50 feet. Since this fault passes into a fold in sec. 11, T. 1 S., R. 82 W., it is possible that the fault is a break thrust rather than a normal fault. However, the nearly vertical fault plane would seem to indicate that fault V is a normal fault.

Fault VI has produced a duplication of a portion of the Niobrara and Benton formations in secs. 12 and 13,

T. 1 S., R. 82 W. The fault can be traced for a considerable distance to the northwest where it brings the Morrison into cantact with the basal Dakota(?). The throw on the fault is probably about 350 feet. Several small northeast trending normal faults appear to terminate at fault VI in sec. 11, T. 1 S., R. 82 W.; thus indicating that fault VI antedates these northeast trending normal faults. Fault VI may have developed as a relaxation feature after the compression, which produced the flexures in sec. 11, T. 1 S., R. 82 W., was released.

Northwest Trending Reverse Faults

The most prominent feature in the area is the fault line scarp formed by the Mosquito fault system. (See Figure 17.) This fault extends for over a hundred miles to the south, but appears to die out a short distance north of the thesis area. Very little can be determined about the attitude of this fault except that it is a high angle fault. Elsewhere it has been described as a reverse fault and as a normal fault; evidence can be found within the area to support both arguments. The straightness of the scarp and the lack of overturning in beds adjacent to the fault are evidence in favor of normal faulting. Supporting evidence for thrust faulting is the fact that a branch of the Mosquito fault (Sheephorn Creek fault) is definitely a thrust fault.

The throw on the Mosquito fault within the thesis area is approximately 2000 feet, and it seems probable that this movement occurred during several periods.

The Mosquito fault divides in section 20. The eastern branch apparently dies out in the Pre-Cambrian, but the western branch can be traced for over a hundred miles to the south. The Sheephorn Creek fault joins the Mosquito fault southeast of the thesis area.

The Sheephorn Creek fault is apparently a branch of the Mosquito fault, which follows closely the valley of Sheephorn Creek. Drag folding in sec. 1, T. 2 S., R. 82 W., and an exposure of the fault plane in sec. 14, T. 1 S., R. 82 W. clearly indicate that this fault is a reverse fault dipping about 60° E. Throw on the Sheephorn Creek fault is about 800 feet. A large fault, extending southward, joins the Sheephorn Creek fault in sec. 1, T. 2 S., R. 82 W. This fault continues south toward State Bridge where it probably passes into the Yarmony Mountain monocline (17, map.)

Northeast Trending Reverse Faults

The Hartman Divide fault system forms the prominent fault line scarp shown in Figure 12. The fault plane is well exposed in a quarry in sec. 25, T. 1 S., R. 82 W. where the plane dips 60° E. Five cross sections: A-A',

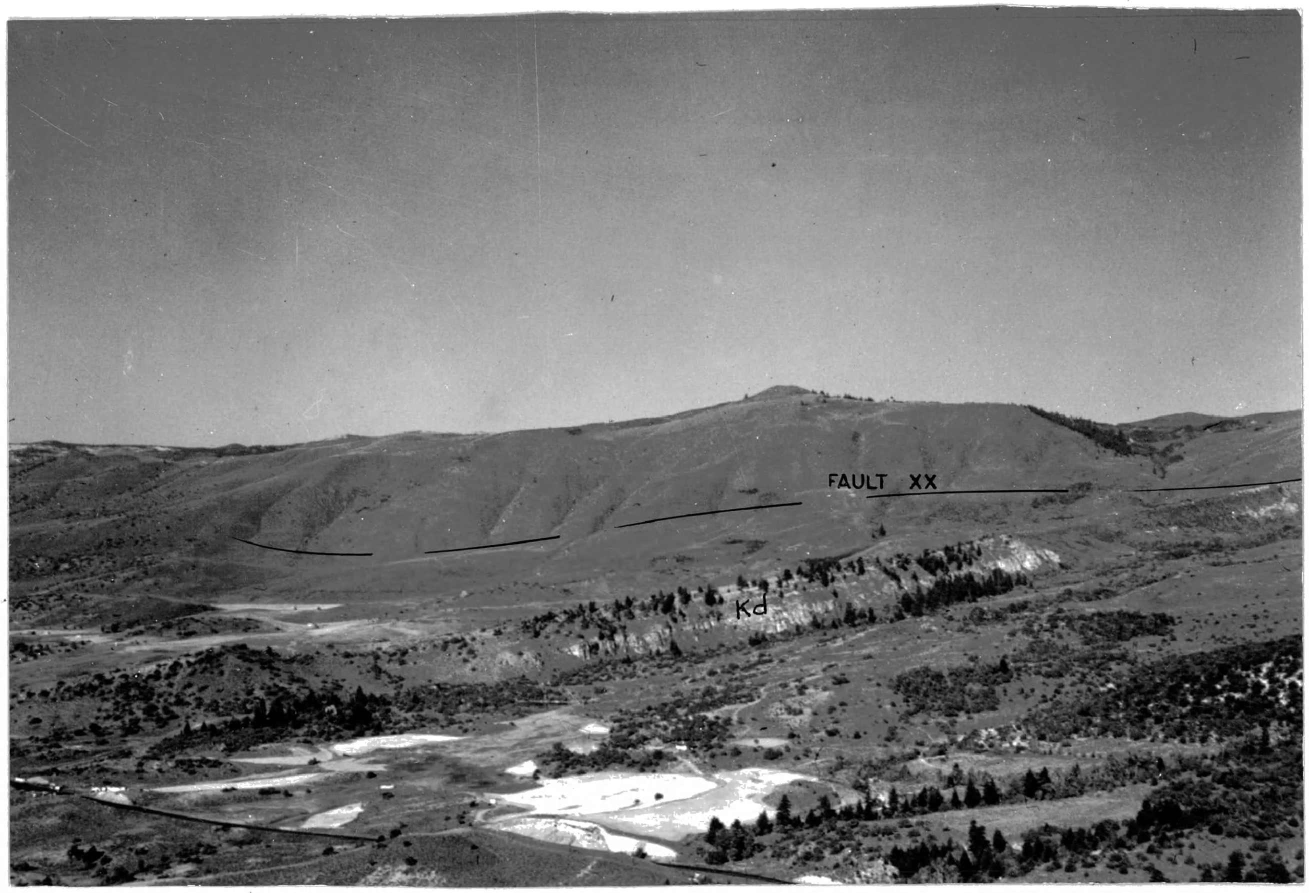


Figure 15. View of the fault scarp on the west side of the Gore Canyon area. Note the even altitudes of the mountains in the background. This probably represents an erosional surface. Hogback in the foreground is Dakota(?) sandstone. (See Plate VII for location.)

B-B', X-X', Y-Y', and Z-Z' (Plate VII) show how this reverse fault passes into a fold in sec. 18, T. 1 S., R. 81 W. The throw is approximately 500 feet.

The fault, XX, in sec. 11, T. 1 S., R. 82 W. is probably a high angle reverse fault as evidenced by the degree of tilting of sediments adjacent to it. It forms a high fault line scarp which is shown in Figure 15. This fault passes into a syncline in sec. 14, T. 1 S., R. 82 W. The amount of throw on the fault cannot be measured, but it is in excess of 800 feet.

Late Northeast Trending Normal Faults

Northeast trending normal faults are apparently the latest in the area and are usually short, although some have large displacement. They are too numerous to discuss separately so only the important ones will be covered. Faults X and XI are well exposed in sec. 31, T. 1 S., R. 81 W. The block between these two faults has rotated with the southern end rising and the northern end sinking. Some horizontal slippage has probably occurred along the fault planes.

Fault XII is exposed in sec. 36, T. 1 S., R. 82 W. where the Morrison is faulted down against the Pre-Cambrian. It is probably contemperaneous with or slightly later than the Sheephorn Creek fault. The fault probably developed as a relaxation feature after the compressive forces, which caused the reverse faulting, were released.

The scarp of fault XIV (sec. 19, T. 1 S., R. 81 W.) is shown in Figure 17. The fault probably resulted from the extension of the earth's crust when the compressive forces, which produced the Hartman Divide fault, were released. The throw is approximately 450 feet.

Fault XIII (sec. 26, T. 1 S., R. 82 W.) is shown in Figure 2. The fault clearly indicates that some of the northeast trending faults occurred after the deposition of the North Park formation.

The intrusion of white rhyolite porphyry along fault planes has practically obscured all structural detail in secs. 15 and 22, T. 1 S., R. 82 W. Only fault XV is well exposed and its fault plane dips 63° to the south.

Age of the Faulting and Folding

The earliest structural features-- those that originated in Pre-Cambrian time-- are too imperfectly known to be interpreted. It can only be noted that the general strike of the schistocity and linear elements in the Pre-Cambrian rocks is about northeast.

The earliest structural features about which there is any clear knowledge are the northwest trending folds which parallel the Mosquito fault and the axis of the Gore Range. These folds were formed after the deposition of the Niobrara formation. They were probably formed by the first movements on the Mosquito fault at the close of the Cretaceous or early in the Tertiary. Undoubtedly, there was movement along the Mosquito fault throughout the Laramide Revolution. Behre (8, pp. 49-79) pointed this out in the Leadville area.

The northwest trending faults probably were formed after the initial movements on the Mosquito fault. Faults I and II (sec. 35 and 36, T. 1 S., R. 82 W.) seem to form the boundaries for the North Park formation. This indicates that at least some movement occurred on these faults in post-Miocene time.

There is no indication that the Hartman Divide reverse fault extends farther south than where it is intersected by fault II in sec. 26, T. 1 S., R. 82 W. Therefore, it is believed that this fault and its associated faults are later than the northwest trending faults. One of the structures created by the Hartman Divide fault, the northeast trending fold in sec. 12, T. 1 S., R. 81 W., is truncated by the Mosquito fault indicating that there was movement on the Mosquito fault later than the northeast trending reverse faults.

The northeast trending normal faults seem to be the latest, although there is no evidence that they offset any of the earlier faults. Fault XIII shown in Figure 2, indicates that movement occurred along these faults after the Miocene(?) basalt was extruded.

Forces Producing the Structure

The predominate force acting in the area seemed to be compressive. Probably the same forces which produced the Williams Range thrust fault, only 6 miles to the east, were effective in the thesis area. The Williams Range fault is viewed as an underthrust by T. S. Lovering (45, p. 173). Since the greatest deformation occurs on the northeast side of the range, the compressive forces producing the Williams Range thrust and the related Mosquito fault, were probably from the northeast. Richards (55, p. 149) has shown that there was repeated thrusting on the Williams Range thrust fault; therefore the normal faulting in the area may have occurred during the periods of relaxation of the compressive forces.

The curving faults, such as the Sheephorn Creek fault which branches off the Mosquito fault, seem to be evidence that tangential forces were active in the area.

Vertical forces, in conjunction with compressive forces, were probably responsible for the high angle reverse faults in the area. The large Pre-Cambrian mass (sec. 6, T. 2 S., R. 82 W.) southeast of Radium seems to have been pushed up by vertical forces thus forming a large eastward plunging fold.

Intrusive forces may have played a part in forming the faults in secs. 15 and 22, T. 1 S., R. 82 W.

Geologic History

Pre-Cambrian

The Pre-Cambrian rocks of the region consist of a series of schists and injection gneisses intruded by batholiths of granite.

Lovering (39, p. 73) summarized the Pre-Cambrian history as follows:

1. The formation of a granite mass and its subsequent uplift and erosion. This was the source of the sediments for the marine shales and sandstones which make up the Idaho Springs formation.

2. Uplift and strong folding of the sediments with concurrent intrusion of granite batholiths.

3. Intrusion of many bodies of diorite, monzonite, and granite into this crumpled mass of sediments. The heat of the intrusive plus the emanations converted the sediments to gneisses and schists.

4. Two more intrusions of granite masses occurred.

5. The intrusion of the last series of granites was probably accompanied by uplift and a long period of erosion which left the Front Range as a highland in the latter part of the Algonkian.

6. This highland probably persisted through the remainder of Pre-Cambrian, Paleozoic, and most of Mesozoic time.

Paleozoic and Mesozoic Era

Plate II illustrates the general paleogeography of the Paleozoic era. The main features in central Colorado were the rapidly sinking zeugogeosyncline (Central Colorado Basin) and the two landmasses, the Front Range and the Uncompahgre highlands.

Lovering (39, pp. 75-76) believes that during the Cambrian, a shallow sea advanced over a base-leveled surface and deposited the thin quartzites of the Sawatch. Although these Cambrian sediments are not present in the thesis area, they do occur in the vicinity of Red Gorge, ½ mile south of the town of Radium. (See Plate VI.)

During the Ordovician, the seas again advanced across central Colorado, depositing sandstone, shale, and limestone. There is no evidence that Ordovician seas ever covered the Gore Canyon area. The nearest Ordovician formations (Plate VI) occur at McCoy, 13 miles to the southwest.

Colorado contains no Silurian sediments; so the area was probably emergent during this period.

The character of the Devonian sediments indicates that there was no landmass nearby undergoing active erosion. Because the nearest Devonian sediments are 25 miles to the southeast, it seems likely that the Gore Canyon area was emergent but relatively low lying during the Devonian.

Seas again advanced across Colorado in the early Mississippian time, but left no record in the thesis area. The Mississippian formations are calcareous at the base and pass through shaly horizons into coarser clastics (35, p. 78).

Figure 16. View of pre-Permian erosional surface. Flat surface in foreground has been faulted down from level surface in middle distance. This surface probably correlates with the erosion surface shown in Figure 1. A is the Hartman Divide fault scarp. (See Plate VII for location.)

Figure 17. View of Mosquito fault system. Notice syncline in foreground. Valley is formed by Colorado River. (See Plate VII for location.)

The nearest Mississippian sediments are represented by the Leadville limestone found at State Bridge, 10 miles south of the thesis area.

Thick Pennsylvanian sediments are present only 5 miles south of the Gore Canyon area, but are completely absent in the area. The sediments are extremely coarse clastics and have a bright-red hue. The feldspars are fresh and there is an abundance of coarse mica, which would indicate a source close by (39, p. 81). The rapidity with which the Pennsylvanian sediments thin as they approach the Gore Range indicates that the Gore Canyon area was relatively high, at least until late Pennsylvanian or early Permian time. There must have been a corresponding rapid sinking of the Central Colorado basin to permit the basin to receive the vast amount of Pennsylvanian sediments.

The erosion at the close of the Pennsylvanian reduced the region to what appears to be a peneplain. Remnants of this nearly flat erosional surface are still evident in the area. (See Figures 16 and 17.) The coarse, basal conglomerate, the fine silts, and the arenaceous limestone of the State Bridge formation were deposited on this level surface, which is the first clear evidence we have of any sedimentation within the area. These beds thin rapidly towards the north and northeast and disappear at the top of the Gore Range. During the Triassic, there was little erosion or diastrophism (39, p. 107). Keyes (33, p. 69) believes that the area was peneplained during the Middle Triassic, and on this erosion surface the Shinarump conglomerate and Chinle shales were deposited in Upper Triassic streams. The flora and fauna indicate that the climate was tropical during this period.

The region remained a land area during Jurassic and must have been arid through the middle Upper Jurassic, for during this time the Entrada dune sand was deposited. The Curtis sea of late Upper Jurassic approached to within 30 miles of the area, but is overlapped between Dotsero and State Bridge by the non-marine Morrison formation (22, p. 73). The Morrison sediments were probably deposited in fresh water lakes, in swamps, and on flood plains. They thin considerably in the Gore Canyon area and may pinch out a short distance to the northeast and east.

During the early Lower Cretaceous, the Ancestral Rockies were base-leveled (25, p. 161). In late Lower Cretaceous the land began to sink, and a slowly transgressing sea began to advance across the region, depositing a basal conglomerate and well-washed beach sand. The shore line of this sea advanced and retreated numerous times, which would favor the formation of widespread swamps.

While the Dakota was being deposited close to the margin of the advancing sea, the black shales of the Benton formation were being deposited a short distance off shore. In the Gore Canyon area, there was a local hiatus and the Dakota was elevated above sea level and eroded. This formed the basal conglomerate found at the base of the Benton formation.

Lovering (41, p. 39) reported that the most abundant pebbles in the conglomerate consisted of Dakota quartzite.

The marine seas remained in the area through the middle Upper Cretaceous.

During the late Upper Cretaceous, the Front Range highland was rising, and was exposed in some areas (29, p. 90). This was the beginning of the Laramide revolution.

Cenozoic Era

Tertiary

The general order of structural events in central Colorado during the Laramide revolution is essentially as follows (41, p. 58):

1. Noticeable arching of the Front Range highland shortly before Paleocene time.
2. Northwesterly folding and faulting began in early Denver time on the western border zone of the Front Range. The Mosquito fault may have been formed at this time.
3. Northwesterly trending thrust faulting and overfolding occurred at the end of Denver time. The Williams Range thrust fault (see Plate VI) was probably formed at this time.

4. East-northeasterly and northeasterly faulting occurred.

The Laramide orogenic activity continued through the Paleocene and probably culminated in early Eocene. The Rocky Mountains had probably reached their greatest height at this time and were being rapidly eroded. The resulting debris was washed into intermontane basins.

Eocene and Oligocene

Lovering, in his report on the Front Range (39, p. 95) states that a mature topography was developed in the higher parts of the Laramide uplift. The widespread Flattop peneplain developed over much of the Front Range in the Eocene, and in the Oligocene a second peneplain developed along the mountain edges. Neither of these peneplains have been correlated with erosion surfaces in the Gore Range.

There is no indication that sediments of these two epochs were ever deposited in the thesis area. However, on the east side of the Gore Range, in Middle Park, some Eocene sediments and volcanic rocks have been deposited. The Oligocene epoch was probably a period of non-deposition in the area.

Miocene

During the Oligocene, Miocene, and Pliocene there was a great deal of volcanic activity in the Rocky Mountains. In the Gore Canyon area vigorous streams were cutting deep valleys, which in some cases may be deeper than the canyons cut by the present Colorado River. (See Figure 2.) These valleys were filled with the soft sandstones, tuffs, conglomerates, and interbedded lava flows of the North Park formation (Miocene). The source of the volcanic material was probably to the south. Thick Miocene flows at Yarmony Mountain are reported by Donner (17, p. 1234).

The lithology of the North Park formation indicates that the Miocene climate was alternately arid and humid. During the arid periods, silts and other fine-grained clastics were deposited. During the humid cycle, the more vigorous streams deposited coarse conglomerates.

A rhyolite agglomerate (see Figure 15.) intruded the North Park formation during Miocene time. This intrusion was in the form of elliptical plugs and dikes.

Blackwelder (9, p. 229) suggests that the Colorado River did not exist in the Miocene and Pliocene time; that the region was too low and its climate too dry to generate a large river. The deep canyons cut into the hard Pre-Cambrian rocks imply that a rather large river flowed in the area during the Miocene, but not necessarily in the present course of the Colorado River. (See Figure 2.)

Where the Miocene valley is intersected by Sheephorn Creek in sec. 26, T. 1 S., R. 82 W., the lowest exposed portion of the Miocene valley is only 200 feet above the level of the Colorado River at Radium. The width of the Miocene valley at the deepest erosional level is still 1000 feet; therefore the valley can be expected to be considerably deeper than is now exhumed.

As the degradation of the Rocky Mountains continued during the Miocene, the deep river valleys slowly filled up with river sediments. Extrusion of large flows of basalt during the Miocene completely filled all of the drainage systems thus forcing the ancestral Colorado River to seek a new course. Such a course may be the present channel of the Colorado River.

Rejuvenation and active erosion occurred at the close of the Miocene.

Pliocene

The humid cycle which occurred at the close of the Miocene continued into Middle Pliocene according to Lovering (39, p. 103). This was probably a period of degradation and no deposition occurred in the thesis area.

Figure 18. Pediment gravel resting on sandstones of Morrison formation. This pediment was formed near mouth of Gore Canyon. (See Plate VII for location.)

Figure 19. Pediment developed at mouth of Blacktail Creek. (See Plate VII for location.)

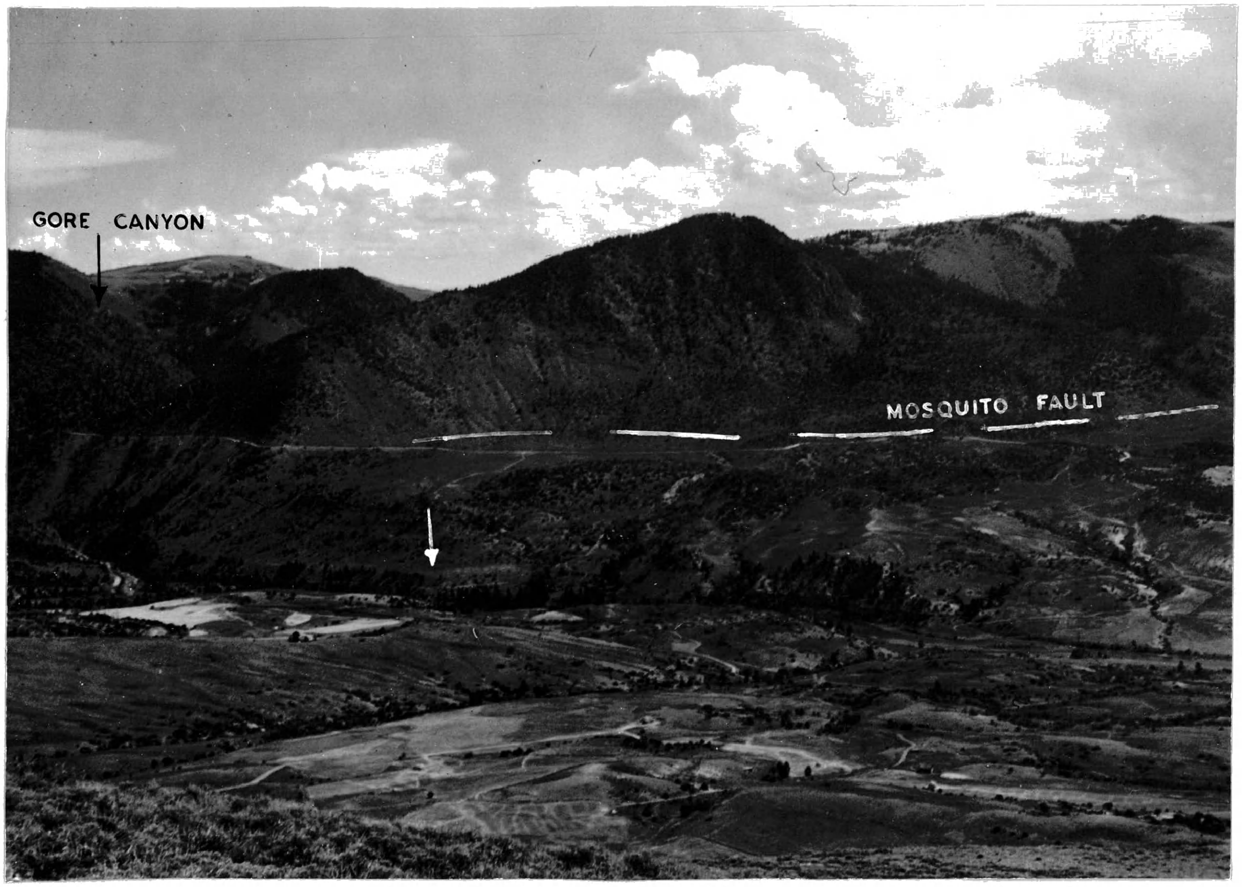


Figure 20. Gravel strewn terrace developed along Colorado River. (See Plate VII for location.)

Pleistocene

The arid cycle which began in late Pliocene continued into the early Pleistocene and it may have been during this time that the pediments, which were formed at the mouths of Sheephorn and Blacktail Creeks, were deposited. (See Figures 18 and 19.)

Rejuvenation occurred in the early Pleistocene and soon afterward the climate became cold and humid. Glaciation occurred in the higher portions of the Gore Range. (See Figure 1.) It was probably during this period of glaciation that the terraces shown in Figure 20 were developed.

Recent

The rejuvenated streams have been cutting down in their channels and wearing down the mountains ever since the Pleistocene uplift.

Economic Geology

The Gore Canyon area has been extensively prospected, but there is no report of ore in commercial quantities. There is a tunnel on the east side of Blacktail Canyon in sec. 24, T. 1 S., R. 82 W., but no indications of mineralization could be found.

Considerable prospecting has been done in Dry Gulch (Red Gore district), 2 miles south of the thesis area. The mineralization is reported to be malachite staining and nodules in a fractured zone in Paleozoic beds. Some development work is being done today, but no production is reported.

Mr. Andrew Henry, a rancher, told the writer that pitchblende had been found in a mine in Blacktail Canyon, but the ore was thought to be worthless and was dumped into the Colorado River. He stated that the tunnel opening had been covered when the railroad was built through the canyon. This occurrence was not reported in the literature.

A small gold placer was operated along the Colorado River (see Plate VII for location) north of Radium during 1934. The gold was extracted from pediment gravels. Evidently very little gold was recovered for no production figures are reported.

The area is extremely unfavorable for petroleum. The sedimentary section is thin and the closely spaced faulting has probably destroyed any trap which may have been formed in the past.

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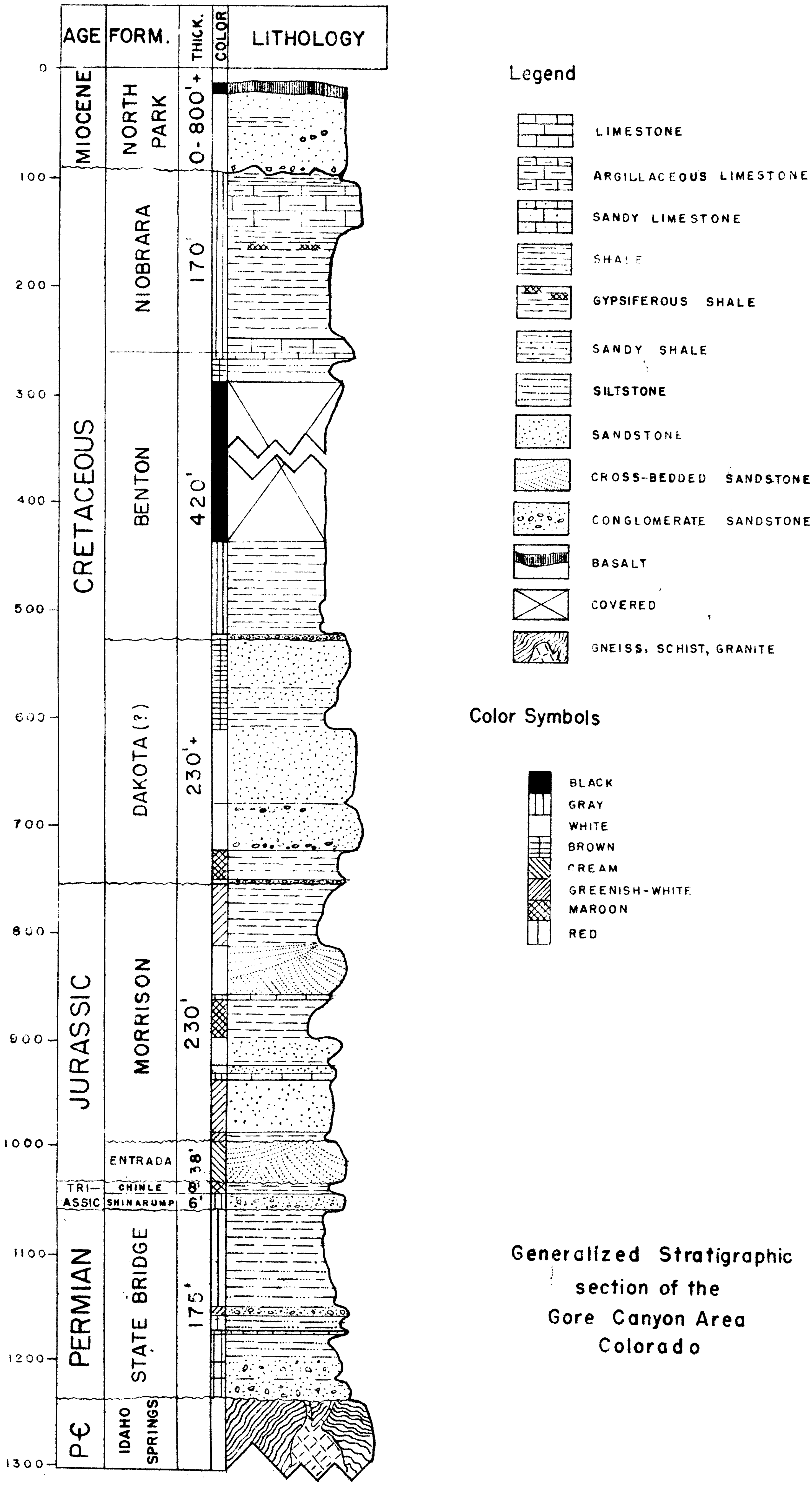

Generalized Stratigraphic section of the Gore Canyon Area Colorado

M.C. Parsons, 1953


PLATE
EXPLANATION
IGNEOUS
SEDIMENTARY
Qal ALLUVIUM
Qp PEDIMENT GRAVELS
Tnp NORTH PARK FORMATION
RHYOLITE AGGLOMERATE MIOCENE?
BASALT FLOWS MIOCENE
WHITE PORPHYRY LATE TERTIARY
Kn NIOBRARA FORMATION
Kb BENTON FORMATION
Kd DAKOTA(?) FORMATION
Jm MORRISON
State Bridge FORMATION
IGNEOUS & METAMORPHIC
PC GRANITE, SCHISTS, & GNEISSES
SYMBOLS
GEOLOGY
ANTICLINE
SYNCLINE
FORMATION BOUNDARIES
KNOWN
APPROXIMATE
FAULTS
KNOWN
APPROXIMATE
HYPOTHETICAL
THRUST
STRIKE SLIP
STRATA
STRIKE & DIP
OVERTURNED
VERTICAL
HORIZONTAL
VERTICAL
PHOTOGRAPHS
LINE OF SIGHT
CULTURE
IMPROVED ROAD
UNIMPROVED ROAD
RAILROAD
TUNNEL
BUILDINGS
MINE, PLACER OR PROSPECT
BENCH MARK
STRATIGRAPHIC TRAVERSES
BRUNTON AND TAPE TRAVERSE
R 82 W.
81 W.
T.1 S.
AREA COVERED BY PIEDMONT DEPOSITS
RADIUM
DENVER & RIO GRANDE WESTERN
COLORADO
GORE CANYON
SHEEPHORN
NORTH CREEK
HARTMAN DIVIDE FAULT
AREA SOUTH OF SHEEPHORN CREEK MAPPED BY RECONNAISSANCE ONLY
TO STATE BRIDGE
BASE MAP FROM BUREAU OF LAND MANAGEMENT MAPS & G.L.O. TOWNSHIP PLATS
to this
Reduce this line
N
SCALE IN FEET
HORIZONTAL= VERTICAL
1000 0 1000 2000 3000 4000 5000
Geologic Map Of The
GORE CANYON AREA
Grand and Eagle Counties, Colorac
SHOWING AREAL GEOLOGY, STRUCTURAL CROSS-SECTIONS, AND DRAINA
GEOLOGY BY MARSHALL C. PARSONS
1954