THE GEOLOGY OF SOUTHERN PERRY PARK
DOUGLAS COUNTY, COLORADO

By
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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.

Signed: Morad Malek-Aslani

Golden, Colorado
Date: August 2, 1950

Approved: F. M. Van Tuyll

Truman H. Kuhn
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ABSTRACT

The area covered in the present report comprises the southern part of the Perry Park, which is located about 11 miles southwest of the town of Castle Rock, Colorado. This area is situated on the western border of the Colorado Piedmont, and its relief features are characterized by typical foothill topography of the Front Range.

The rocks exposed in the Perry Park area range in age from pre-Cambrian to Eocene. The basement rock is Pikes Peak granite of pre-Cambrian age. The Paleozoic rocks are: Sawatch sandstone, Manitou limestone, Glen Eyrie and Fountain formations, Lyons sandstone, and Lykins formation. The Mesozoic is represented by Ralston and Dakota formations, Colorado and Montana groups, and Laramie formation. The only Cenozoic rock in the area is the Dawson arkose of Eocene age.

The structure of the area is a homocline modified by vertical faults, whose stratigraphic throw is several thousand feet.

Mineralization is not known to exist in the area. The only rock of the probable economic significance is the glauconite-bearing Sawatch sandstone, which outcrops at the mouth of the Gove Creek Canyon.
INTRODUCTION

Location of Area

The area covered in this report comprises the southern part of Perry Park, Colorado. This area is located about 11 miles southwest of the town of Castle Rock, Colorado, on the western edge of Douglas County in part of Townships 9 and 10 S., Ranges 67 and 68W. Plate 1 shows the location of the area studied.

Colorado State Highway 105 crosses the eastern edge of Perry Park. Several unimproved roads and trails extend westward through the area.

Purpose and Scope of Investigation

The investigation was undertaken with the following objectives in mind: (1) to study the general geology; (2) to interpret and map the local structure; and (3) to study thoroughly the stratigraphy of the area.

The simplicity of the local structure and the presence of good outcrops led the writer to concentrate on the local stratigraphy. In this report, an attempt has been made to corroborate on the stratigraphic nomenclature and correlation, referring to the literature on Front Range stratigraphy and using field data collected in the area.

Ample information has been presented on the local stratigraphy in order that readers can criticize the writer's
LOCATION OF AREA

Area mapped by M. Malek-Aslani
interpretations.

Field Procedures

The field work for this report can be divided into two parts:

1. The first part, which consisted of mapping the outcrops, studying the local stratigraphic section, and interpreting the structure, was undertaken by the writer during the months of August and September, 1949.

2. The second part was devoted entirely to the detailed measurement and sampling of the local sections. This phase of the work, which started in October, 1949, and ended in February, 1950, was performed in collaboration with J. V. Newhouser and F. W. Crubb.

The samples collected were studied under the microscope and a lithologic log was plotted which was used for correlation and other stratigraphic investigations.

Aerial photographs were used as a base for mapping in the field. The geological information plotted on these photographs were transferred onto a base map (6 in. = 1 mi.), prepared from the U. S. Geological Survey Castle Rock, Colorado, Quadrangle.

The sections were measured with the aid of the tape, plane table and alidade.
Acknowledgments

The writer is deeply indebted to the following members of the Department of Geology, Colorado School of Mines: Dr. L. W. LeRoy, for suggestions in connection with field work and stratigraphic studies, and for checking the field work; Dr. Truman H. Kuhn, and Dr. Warren R. Wagner for reading and correcting the manuscript; and Dr. F. M. Van Tuyl and Dr. J. Harlan Johnson for field and editorial assistance. Grateful acknowledgment is also given to Messrs. J. V. Kewhouser and F. W. Grubb for help in field work and permission to use the data collected in the field.
PREVIOUS PUBLICATIONS

The geologic features of Perry Park are discussed in the Castle Rock folio by G. E. Richardson (26), who summarized the literature up to 1915. A. E. Brainerd, H. L. Baldwin, and I. A. Keyte (2) described the pre-Pennsylvanian stratigraphy of the Front Range and redefined the pre-Fountain sediments found between Canon City and Perry Park.

W. T. Lee (20) correlated the geologic formations along the eastern margin of the mountains using Richardson's stratigraphy for the Perry Park area.

R. L. Heaton (16) discussed the Jurassic stratigraphy along the Front Range and gave a partial section for the Perry Park area.

The recent literature on the stratigraphy of central Colorado has been summarized in the "Guide to the Geology of Central Colorado," published in 1948 (19).

G. L. Robb (26) has recently investigated the geology of the northern part of Perry Park.
PHYSIOGRAPHY

The Perry Park area is located along the western border of the Colorado Piedmont (12, p. 30). The topography of this area is that of the typical foothills of the Front Range in Colorado, where the relief features are the result of differential erosion of the steeply dipping sedimentary strata.

Several parallel hogback ridges are developed on resistant strata separated by longitudinal valleys. Of these hogbacks the one developed on the outcrops of Dakota sandstone is most prominent. Dakota hogbacks are rather continuous along the strike, except where streams have cut water gaps or faults have displaced them.

Other formations which give rise to rather conspicuous hogbacks are the Timpas limestone and the Lyons sandstone. However, the Lyons hogback is not very persistent, and its presence is controlled by the nature of the cementing material, which considerably changes along the strike.

The erratic nature of the Fountain has resulted in a very irregular topography, characterized by typical pinnacles and discontinuous hogbacks. According to F. M. Van Tuyl (30, p. 27), the area was subjected to recurrent uplifts followed by peneplanations.

The consequent streams from the mountains flow transversely across the foothills, while the tributary streams have developed along the weaker strata resulting in the
development of valleys between the hogback ridges.

Wind gaps and stream gravel have been observed on the top of the Dakota -- center of the NE1/4, Sec. 23, T. 9S., R. 68W. -- and the Timpas -- SE corner of SE1/4, Sec. 14, T. 9S., R. 68W. These wind gaps suggest that a stream was flowing in a general northeasterly direction and confluence with Gove Creek somewhere in Sec. 13, T. 9S., R. 68W. This drainage seems to have been captured by a subsequent stream which was flowing westward and emptying into Bear Creek.

The Perry Park area, which lies in the Platte River drainage system north of the Palmer Lake divide, is drained by Bear Creek on the north and Gove Creek on the south traversing the area in a northeasterly direction and emptying into Plume Creek. The latter stream confluences with South Platte River near Littleton, Colorado.
Figure 1.-- A typical windgap developed on Timpas hogback.

Figure 2.-- Jointing in Pikes Peak granite.
INDEX MAP OF MEASURED STRATIGRAPHIC SECTIONS
STRATIGRAPHY

General Statement

The rock outcrops in Perry Park area range in age from pre-Cambrian to Eocene. The Paleozoic section of this area consists of Upper Cambrian, Lower Ordovician, Upper Pennsylvanian and Permian. The entire Mesozoic section, with the exception of Lower Cretaceous, is present. The Cenozoic era, in the area mapped by the writer, is represented by Eocene and Recent stream deposits.

The total thickness of the sedimentary section in Perry Park is about 12,500 feet, and includes the following rock-types: sandstone, siltstone, shale, limestone, dolomite, and gypsum.

Pre-Cambrian

Pikes Peak Granite

History and Name.-- The basement complex underlying the Perry Park area is the Pikes Peak granite. This granite is a part of the Pikes Peak Batholith which was first defined by W. C. Cross (4) in the Pikes Peak quadrangle, Colorado.

Lithology.-- The rock is a coarse-grained biotite granite composed predominantly of quartz and feldspar with subordinate biotite. Microcline and orthoclase feldspar
### Generalized Stratigraphic Section in Perry Park Area

#### Scale
- 1 inch = 100 feet
- 2000 feet

#### Plate: 3

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<th>Columnar Section</th>
<th>Description</th>
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<tr>
<td>Quaternary</td>
<td>Recent</td>
<td>Stream Gravel</td>
<td></td>
<td></td>
<td></td>
<td>Light-colored arkose (clay) sandstone, fragments of rhyolite at base. Coals masas in the plains. Unconformity.</td>
</tr>
<tr>
<td>Oligocene</td>
<td>Dawson</td>
<td>Arkose</td>
<td>300 Tur</td>
<td></td>
<td></td>
<td>Chiefly coarse varicolored arkose grits with lenses of conglomerate and shale throughout the formation. Conglomerate at base contains pebbles derived from the rocks of the foot hills Front Range, rhyolite lava and tuff interbedded near the top. A thin bed of andesitic sandstone in upper part expands NW and becomes Denver fm. Occupies most of the surface of the plains in the area, but is capped by rhyolite lava.</td>
</tr>
<tr>
<td>Cenozoic</td>
<td>Eocene</td>
<td>Laramie Formation</td>
<td>600 Ki</td>
<td></td>
<td></td>
<td>Drab silt with small nodules of clay ironstone and white, brown fine-grained sand and possibly workable beds of coal. Narrow belts. Unconformity.</td>
</tr>
<tr>
<td>Tertiary</td>
<td></td>
<td>The Top Shale</td>
<td>100 Kn</td>
<td></td>
<td></td>
<td>Upper part sand, silt, shale and clay near the top. The lower part predominantly shale &amp; few thin beds of limestone. Forms lowlands northeast of hogback ridges.</td>
</tr>
<tr>
<td>Cretaceous</td>
<td>Jurassic</td>
<td>Niobrara Formation</td>
<td>450 Kn</td>
<td></td>
<td></td>
<td>The upper part shale, The lower part white chalky, shaly limestone, forms low hogbacks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Timpa Shale</td>
<td>150 Kn</td>
<td></td>
<td></td>
<td>Shale interbedded with few thin beds of limestone, forms the lowlands between Dakota and Timpa hogbacks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Benton</td>
<td>120 Kn</td>
<td></td>
<td></td>
<td>Indurated quartzose sand, forms prominent hogback ridges.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lykins Shale</td>
<td>120 Kn</td>
<td></td>
<td></td>
<td>Black and varicolored shades, inner slope of hogback.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lyons Shale</td>
<td>120 Kn</td>
<td></td>
<td></td>
<td>Varicolored sh. &amp; shales, forms valley and low ridges.</td>
</tr>
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<td></td>
<td>Permian</td>
<td>Morrison Formation</td>
<td>400 Jf</td>
<td></td>
<td></td>
<td>Syste, forms inner slope of Morrison is ridge. Unconformity.</td>
</tr>
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<td>Ralston Shale</td>
<td>50 Jf</td>
<td></td>
<td></td>
<td>Brilliantly colored chiefly red sandy and clayey shales &amp; thin beds of gray &amp; white shales, forms low hills and valleys. Unconformity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lyons Shale</td>
<td>150 Jf</td>
<td></td>
<td></td>
<td>Varicolored (chiefly red) coarse-grained cross-bedded arkose sand. Lower part bricked-up upper part usually white, forms wall-like ridges and ledges.</td>
</tr>
<tr>
<td></td>
<td>Pennsylvanian</td>
<td>Fountain Formation</td>
<td>3000 Gt</td>
<td></td>
<td></td>
<td>Slate and shale. Covers Mantou &amp; slopes. Unconformity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manitou Shale</td>
<td>25 Jf</td>
<td></td>
<td></td>
<td>Gray to purplish silt, dolomite, sand lenses near the top, forms outer slopes of hogbacks. Unconformity.</td>
</tr>
<tr>
<td></td>
<td>Ordovician</td>
<td>Sawatch Shale</td>
<td>80 Bu</td>
<td></td>
<td></td>
<td>Fine-textured white quartzose sand, overlain by calcite, forms low hogback ridges. Unconformity.</td>
</tr>
<tr>
<td></td>
<td>Cambrian</td>
<td>Pikes Peak Granite</td>
<td>50 pC0</td>
<td></td>
<td></td>
<td>Massive, coarse-grained biotite granite, forms Front Range.</td>
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M. Malek-Aslani 1950
are commonly anhedral though the larger grains show imperfect crystalline faces. There are also small amounts of oligoclase and albite. The quartz is in irregular white anhedral grains.

In certain areas (Sec. 27, T. 98S., R. 68W.) three sets of well-developed joints are present in the granite. These joints seem to control the topography in that they coincide with the position of ravines.

**Age.**—The Pikes Peak granite is intruded into Algonkian quartzite, therefore this granite is of Late Archian age.

**Nature of Contacts.**—The Sawatch sandstone of the Perry Park area unconformably overlies the smooth, badly weathered granite surface of the pre-Cambrian basement.

**Paleozoic**

**Cambrian**

**Sawatch Sandstone**

**History.**—The name Sawatch was first given by G. H. Eldridge (8, p.7) to the Cambrian sandstone and quartzite, which occurs rather persistently in the Sawatch Range, central Colorado.

Richardson, (25, p.3) in his Castle Rock Folio, correlated the sandstone section immediately overlying the
granite basement and underlying a dolomitic limestone with the Sawatch sandstone of central Colorado. This correlation was based mainly on similarity of lithology and stratigraphic position.

**Distribution.**—Sawatch sandstone beds are confined to a narrow belt of outcrops paralleling the Front Range and dipping away from it to the east. The exposures are fairly persistent except where they are displaced by vertical faults. However, the best outcrop, which permits the study of the entire section, occurs only in Gove Canyon and Bear Creek Canyon. The latter location is west of the Perry Park ranch.

**Thickness.**—The Sawatch sandstone ranges in thickness from 50 feet in Bear Creek Canyon to over 80 feet in Gove Canyon. This variation in thickness can be attributed mainly to the conditions of deposition which prevailed during formation of the rock. However, one should not overlook the fact that the upper contact of this formation in Gove Creek is gradational, whereas in Bear Creek it is definitely unconformable. Therefore, it is logical to assume that at Bear Creek the upper part of the sandstone section has been removed by erosion.

**Lithology.**—The Sawatch is a bedded medium-grained, well-rounded, well-sorted, rather friable quartzose sandstone. Near the base it is slightly arkosic; toward the
Figure 3. -- Granite-Sawatch contact at Gove Creek Canyon.

Figure 4. -- The unconformable Sawatch-Manitou contact at Bear Creek Canyon.
top glauconite becomes progressively abundant. The top few feet in the Gove Creek section is very calcareous and dolomitic.

The color of the Sawatch varies from white and light gray to various shades of red.

Section of Sawatch Sandstone
(Pl. 4, sec. 1)
Location "1" on index map

Section in mouth of Bear Creek Canyon, in the W1/2 sec. 22, T. 93., R. 68W.

Thickness (Feet)

Manitou limestone

Unconformity

Sawatch sandstone

Sandstone, yellowish brown, medium-grained, friable, laminated sandstone with frosted and well-rounded grains of quartz and glauconite cemented by ferruginous material .......... 0.60

Sandstone, red to brown, fine-grained, thinly bedded, the upper part friable, lower part well-cemented ........................................ 6.3

Sandstone, pink to gray, medium-grained, well-rounded, jointed, bedded (3-inch and up) .... 15.0

Sandstone, maroon and gray, banded, thinly bedded to cross-bedded ......................... 6.6

Sandstone, maroon and gray, banded, thin-bedded ................................................ 6.0

Sandstone, light-gray with maroon patches, fine to medium, grains rounded and frosted, massive, upper part thickly bedded to cross-laminated ............................................. 4.7

Covered .................................................. 5.9
Sandstone, reddish brown, predominantly coarse (up to 5 mm.) with some medium larger grains well-rounded with smaller ones angular, friable, calcareous to ferruginous cement, massive, quartzose ......................... 1.0

Covered ................................................................. 17.7

Pikes Peak granite

Section of Sawatch Sandstone
(Pl. 4, sec. 2)
Location "2" on index map

Section at the mouth of Gove Creek Canyon,
in the W1/2NE1/4 sec. 2, T. 10S., R. 68W.

Manitou limestone

Sawatch sandstone

Dolostone, dark brown with green cast,
crystalline, sandy, very glauconitic ........ 10.0

Sandstone, brown with green cast, medium to coarse, rounded, thickly bedded, calcareous, well-cemented, glauconitic .............. 5.0

Sandstone, pinkish brown, medium to coarse, well-rounded, massive, friable, siliceous cement, quartzose, glauconitic .............. 11.0

Sandstone, brown to dark brown, medium to coarse, subrounded to well-rounded, thickly bedded, friable, siliceous cement, quartzose, glauconitic ........................................... 30.0

Sandstone, light pink, medium, subrounded, thickly bedded, friable, siliceous cement, some glauconite .............................................. 14.0

Sandstone, yellowish pink, medium, subrounded, thickly bedded, very friable, glauconitic .. 9.0
Pikes Peak Granite

**Nature of Contacts:** -- The lower contact is unconformable with the underlying granite. A conglomeratic sandstone with reworked material derived from the granite is typically developed near the base.

The upper contact with the overlying Manitou limestone is variable in nature. At Bear Creek, the contact is definitely unconformable and on which iron-stained clay with limonitic concretions have developed. The granule conglomerate in lenticular beds, resembling the channel fills, forms the base of the Manitou limestone. The top few feet of the Sawatch is glauconitic.

The upper contact at Gove Creek, on the other hand differs in that the Sawatch seems to grade into the overlying Manitou limestone with no erosional surface having been developed between them. However, glauconite suddenly disappears above the contact, a fact which indicates that the time interval between the end of the Sawatch and the beginning of the Manitou was a period of nondeposition.

**Environment of Deposition:** -- The Sawatch sandstone was deposited in a transgressing sea.
Figure 5.-- Sawatch-Manitou contact at Bear Creek Canyon. (Note the basal conglomerate.)

Figure 6.-- Sawatch-Manitou contact at Gove Creek Canyon.
Paleontology and Fossils.-- No fossils were found by the writer in the course of field work.

Correlation and Age.-- According to Brainerd, Baldwin, and Keyte (2, p. 379), "the age of the Sawatch sandstone has been placed as Upper Cambrian by the United States Geological Survey on the basis of the few fossils that have been found. This suggests a correlation with the Ignacio quartzite of southwestern Colorado, the Reagan sandstone of Oklahoma, the Bliss sandstone of the Franklin Mountains of west Texas, and part of the Deadwood formation of Wyoming, all of which are similar lithologically."

Cambro-Ordovician

Manitou Limestone

History and Name.-- The name "Manitou limestone" was first given by Whitman Cross (4, p. 2) to a reddish purple to gray limestone containing Lower Ordovician (Beekmantown) fossils which outcrops at Manitou Springs, Colorado. As a result of further investigations, Brainerd and associates (2, p. 380) came to the conclusion that the upper part of the Manitou limestone, as defined by Cross (4, p. 2), is actually younger than Ordovician. They subdivided the Manitou limestone, as exposed in the type locality, into Manitou of Ordovician age, Williams Canyon of Devonian age, and Madison of Mississippian age, and separated these three
units by unconformable boundaries.

The reddish purple and gray limestone section overlying the Sawatch in the Perry Park area was assigned by Richardson (25, p. 3) to Mississippian age and was correlated with the Millsap limestone. This assumption was based primarily on the fossils collected from chert nodules overlying the limestone. More careful investigation by Brainerd and associates (2, p. 388) proved that these chert nodules were derived from the Madison limestone and were deposited near the base of the overlying Glen Eyrie shale of Upper Pennsylvanian age.

Robb (26, p. 18) believes that the well-bedded magnesian limestone overlying the Sawatch in the Bear Creek section of Perry Park is of Devonian age and correlates it with the Williams Canyon limestone. He based his assumption on the following observations:

1. In the Bear Creek section, the top of the Sawatch is devoid of glauconite.

2. The insoluble residues of the limestone immediately overlying the top of the Sawatch in the Bear Creek section is different from those of the Cove Creek section.

Those two observations, according to Robb (26, p. 18) are evidence of a considerable erosional interval between the end of Sawatch time and the beginning of deposition of the overlying limestones. He believes that this long erosional cycle has removed the Manitou and therefore the limestone
sequence which overlies the Sawatch in Bear Creek is of Williams Canyon age.

The writer, as the result of careful study of the Bear Creek section, was able to identify glauconite near the top of the Sawatch, although this mineral is not as extensive as in the Gove Creek section. Erosion undoubtedly has removed the upper portion of the Sawatch. However, the removed interval does not exceed 50 feet, a fact which indicates only a local unconformity.

The lithologic character and sequence of the section immediately overlying the Sawatch in Bear Creek Canyon and Gove Creek Canyon was found to be alike. Therefore, it is the writer's contention that the Bear Creek section should be correlated with the basal member of the post-Sawatch beds of Gove Creek.

The limestones of the Gove Creek section, without doubt, are of Manitou age. This fact can be deduced from the gradational nature of the contact between it and the underlying Sawatch. This contact is very similar to the boundary between the Sawatch and Manitou in Manitou Springs, Colorado, the type locality of the Manitou limestone.

Considering the above-mentioned facts and the lack of definite lithologic breaks between the top of the Sawatch and the base of the Pennsylvanian Glen Eyrie in the Gove Creek section leads the writer to believe that the entire section in this locality is equivalent to the Manitou;
hence, the Bear Creek section is also of Manitou age.

This correlation is accepted in the present paper, tentatively, until a more detailed study of the pre-Pennsylvanian beds of the Front Range will throw more light on the problem.

**Thickness.**—The thickness of the Manitou limestone is extremely variable. This change in thickness can be attributed to the long period of erosion which preceded the Upper Pennsylvanian deposition and resulted in an irregular surface over which the Glen Eyrie shale was laid.

The thickness of the Manitou in the measured Gove Creek section is about 130 feet, while the Bear Creek section shows only 25 feet.

**Lithology.**—The Manitou limestone is composed of red, brown, purple, pink, and gray magnesian limestones, interbedded with calcareous sandstones and occasional layers of shale. The limestones near the base are dense, while higher up in the section they become more crystalline. The upper portion of the Gove Creek section shows considerable interfingering of limestones and calcareous sandstones. The sandstones are composed predominantly of well-rounded, frosted grains of quartz.

Following are a few examples of detailed sections of the Manitou.
PLATE-4

P A L E O Z O I C

D E T A I L E D  S T R A T I G R A P H I C  S E C T I O N S
O F
P R E - P E N N S Y L V A N I A N  F O R M A T I O N S

Scale
0 10 20 Feet
Section of Manitou Limestone
(Pl. 4, sec. 1)
Location "1" on index map

Section at the mouth of Bear Creek Canyon,
in the W1/2 sec. 22, T. 9S., R. 68W.

Thickness
(Feet)

Glen Eyrie shale

Shale and siltstone, red, with chert nodules near the base ........................................ 15.0

Unconformity

Manitou limestone

Limestone, dolomitic, dirty-pink, medium-grained, well-rounded to subrounded, frosted, massive, well-cemented with dolomite and calcite, grains predominantly quartz ................ 4.0

Limestone, dolomitic, pink, dense, bedded .... 3.0

Sandstone, dolomitic, dirty-pink, medium, subrounded with secondary facets, massive, well-cemented with dolomite, grains predominantly quartz ............................ 1.5

Limestone, dolomitic, purple to gray and red, dense, well-bedded, jointed ...................... 11.6

Limestone, dolomitic (with few thin lenses of clay), red to purple, dense, irregularly bedded .................................................. 2.4

Total 22.5

Unconformity

Sawatch
### Section of Manitou Limestone

(Pl. 4, sec. 2)

**Section at the mouth of Gove Creek Canyon,**
in the W1/2NE1/4, sec. 2, T. 10S., R. 68W.

**Thickness**

(Feet)

<table>
<thead>
<tr>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glen Eyrie shale</td>
<td></td>
</tr>
<tr>
<td>Manitou limestone</td>
<td></td>
</tr>
<tr>
<td>Limestone, dolomitic, yellowish purple, mottled, crystalline, fine, massive,</td>
<td>5.0</td>
</tr>
<tr>
<td>fractured</td>
<td></td>
</tr>
<tr>
<td>Limestone, dolomitic, yellow and purple, mottled, crystalline, fine, interbedded</td>
<td>1.0</td>
</tr>
<tr>
<td>with medium- to fine-grained sandstone</td>
<td></td>
</tr>
<tr>
<td>Sandstone, red, brown and white, streaked, medium-grained, subrounded, massi</td>
<td>14.0</td>
</tr>
<tr>
<td>ve, friable, cement calcite</td>
<td></td>
</tr>
<tr>
<td>Sandstone, interfingering with limestone, white-pink, medium-grained, subrou</td>
<td>25.0</td>
</tr>
<tr>
<td>nded, poorly sorted, friable, cement siliceous, composed predominantly of qua</td>
<td></td>
</tr>
<tr>
<td>rtz with some mica and feldspar</td>
<td></td>
</tr>
<tr>
<td>Sandstone, interfingering with limestone, white to light gray, grains coarse</td>
<td>17.0</td>
</tr>
<tr>
<td>and angular to subrounded, nonuniform, friable, cement siliceous, grains pr</td>
<td></td>
</tr>
<tr>
<td>edominantly quartz</td>
<td></td>
</tr>
<tr>
<td>Covered</td>
<td>9.0</td>
</tr>
<tr>
<td>Siltstone, white and red-brown, mottled, massive, ferruginous, with some we</td>
<td>3.0</td>
</tr>
<tr>
<td>ll-rounded quartz grains</td>
<td></td>
</tr>
<tr>
<td>Mudstone, red-brown, massive, ferruginous, with some well-rounded quartz gr</td>
<td>4.0</td>
</tr>
<tr>
<td>ains</td>
<td></td>
</tr>
<tr>
<td>Shale, sandy, red-brown streaked white, friable, ferruginous, with some we</td>
<td>7.0</td>
</tr>
<tr>
<td>ll-rounded quartz grains</td>
<td></td>
</tr>
<tr>
<td>Limestone, gray to pink, fine crystalline, thickly bedded, slightly vuggy</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Thickness (Feet)

Limestone, white to pink, very finely crystalline, dolomitic, thickly bedded, upper two feet brocciated ...................... 13.0

Limestone, white-gray, dense to finely crystalline, thin-bedded, dolomitic .......... 8.0

Sandstone, white to purplish-white, well-rounded, uniform, well-cemented with calcite and dolomite ..................... 5.0

Limestone, gray-purplish, very finely crystalline, dolomitic beds 1" to 5" thick .... 9.0

Limestone, light-pink, dense, dolomitic, sandy ........................................ 11.0

Total 131.0

Sawatch

Dolostone, sandy, dark-brown with green cast, crystalline, very sandy, glauconitic ....... 10.0

Distribution. -- The Manitou limestone outcrops in a belt parallel to the Front Range, and being resistant to erosion forms cliff slopes and flat dip slopes. It is best exposed in Gove Creek Canyon (in the W1/2NE1/4, sec. 2, T. 10S., R. 68W.) and Bear Creek Canyon west of the Perry Park ranch (in the W1/2 sec. 22, T. 9S., R. 68W.).

The outcrops of the Manitou are continuous except where they are displaced by vertical faults, or are covered with vegetation and granite wash.

Paleontology. -- The writer did not find any fossils from the Manitou limestone.
Figure 7.-- Sandstone lenses in the upper part of Manitou limestone at Cove Creek Canyon.

Figure 8.-- Typical pinnacle resulting from differential erosion of Fountain formation.
Age and Correlation.-- According to Brainerd and associates (2, p. 382), from the fossils collected in other localities, the age of the Manitou limestone has been established as Beekmantown or Lower Ozarkian (Lower Ordovician). The Manitou limestone is thus equivalent with the Arbuckle limestone of Oklahoma, the El Paso limestone of the Franklin Mountains of west Texas, the Pogonip of Nevada, and possibly the upper part of the Deadwood formation of Wyoming and Montana.

Nature of Contacts.-- The lower contact of the Manitou with the underlying Sawatch, as previously mentioned, is locally unconformable. For example, in the Gove Creek section, this boundary is gradational and closely resembles the Sawatch-Manitou contact at the Cave of the Winds. On the other hand, at Bear Creek the Manitou unconformably overlies the Sawatch. G. S. Lovering and J. H. Johnson (22, p. 361) mention the evidence of an unconformity between the Sawatch and Manitou on the east side of the Front Range. Field observation in the Perry Park area indicates that this unconformity is local.

The upper contact of the Manitou limestone with the overlying Glen Eyrie is unconformable and is marked by a sharp lithologic break, and the basal Glen Eyrie red shales contain reworked chert boulders from the Madison limestone.
Pennsylvanian

Glen Eyrie Formation

History and Name.-- A series of shales and sandstones which rest unconformably on the Madison limestone in the Manitou embayment was named by G. I. Finlay (10, pp. 586-589) the "Glen Eyrie formation". K. P. McLaughlin (23, p. 1942) refers to it as a separate cartographic unit.

In previous work, covering the Perry Park, no reference was made to the presence of the Glen Eyrie formation in this area. The writer believes that the red shales and siltstones, which immediately overlie the Manitou limestone in the Perry Park area, are equivalent to the Glen Eyrie formation of the Manitou embayment. This assumption is based on the following observations:

1. The lithologic character, which is persistent along the strike, making it a favorable cartographic unit.

2. The lithologic similarity of the section in Perry Park to that of the type locality.

3. The stratigraphic position.

Thickness.-- The thickness of the Glen Eyrie formation in the Perry Park area does not exceed 18 feet.

Lithology.-- The Glen Eyrie formation in Perry Park consists of red shales and siltstones with a few thin beds of sandstone. The basal part contains pebbles of chert.
derived from the Madison limestone.

**Distribution.** -- The Glen Eyrie formation forms a narrow belt between the Manitou and the Fountain. Being non-resistant to erosion, its outcrops are very scarce and when present form gentle slopes on top of the Manitou ridges. It is best exposed in Bear Creek Canyon just west of the Perry Park ranch and in Cove Creek Canyon.

**Age and Correlation.** -- According to McLaughlin (23, p. 1947), from the fossils collected, the age of the Glen Eyrie formation has been established as Des Moines or younger.

**Nature of Contacts.** -- The lower contact of the Glen Eyrie formation with the Manitou is unconformable. The upper contact with the Fountain is transitional.

**Fountain Formation**

**History and Name.** -- What is now known as the Fountain formation was first investigated by F. V. Hayden (15, p. 136) in Turkey Creek south of Morrison, Colorado. However, he referred to this formation as "red sandstone" of Triassic age. Cross (4) was the first to name the formation Fountain. The type section of the formation is located on Fountain Creek below Manitou Springs and at the head of the same stream in the northeastern corner of the Pikes Peak quadrangle.
The sedimentary beds composed of conglomerates, arkosic sandstones, and minor shales, overlying the Glen Eyrie formation, at Perry Park, were referred to by Richardson (25, p. 4) as Fountain. His correlation was based on the typical lithologic character of the Fountain formation which prevails through its entire extent, and the stratigraphic position of this formation.

Richardson (25, p. 4) assigned the entire section between the top of the Manitou and the base of the Lyons sandstone, to the Fountain. In this report, as previously mentioned, the first 18 feet of the above sequence has been correlated with the Glen Eyrie formation of Colorado Springs.

**Thickness.**—According to Richardson (25, p. 4), this formation in Perry Park is 2,000 feet thick. More accurate measurements have shown that the thickness of the Fountain in the Perry Park area is approximately 3,000 feet.

**Lithology.**—The Fountain formation is a complex mass of arkosic sandstone, conglomerate, and subordinate shale. The various lithic units are very irregular in shape and subject to erratic changes vertically and laterally.

The color of the formation is predominantly red in various shades, with brick-red being most common. But lighter colors and even white are also prevalent. The red discoloration is due to hematite films coating the sand grains, to the pink feldspars, and to red interstitial
argillaceous material.

The bulk of the formation consists of medium- to coarse-grained sandstone. Beds of conglomerate are not common and where pebbles are present they are interspersed in the sandstone in irregular layers. Interbedded with the prevailing coarse sandstone are thinner-bedded fine-grained sandstones and a few thin beds of shale.

The dominant mineral constituents are quartz and feldspar of various degrees of coarseness embedded in a matrix of finer grains of the same minerals. Mica is very subordinate, but muscovite, presumably in large part a decomposition product of orthoclase, is common in the finer-grained sandstones. The conglomeratic layers are composed of subangular and rounded pebbles. The large pebbles up to three inches in diameter, are chiefly of quartz, but some are also of granite, red sandstone, chert, and limestone, probably Manitou limestone. Cross bedding is common throughout the formation.

**Distribution.**—The Fountain formation, being almost 3,000 feet thick and having an average dip of less than 20 degrees, forms a very wide belt between the Glen Eyrie and the overlying Lyons sandstone, except where vertical faults have disturbed this normal relationship.

This formation in Perry Park, as in other places, weathers very irregularly. Wherever the ferruginous cement is present, it forms typical pinnacles and hogbacks. In
general, however, the outcrops are sporadic in distribution.

**Age and Correlation.**—According to C. S. Lavington and W. O. Thompson (19, p. 38), "The age of the Fountain formation can be fixed only approximately. The upper part of the Fountain interstratifies with the Ingleside formation of northern Colorado, to which a Pennsylvanian Virgil age is assigned. Interstratification with Glen Eyrie sediments in Colorado Springs embayment suggests a Des Moines or younger age for the lower part." The deposition of Fountain formation in Perry Park area, probably, started in Lower Pennsylvanian time and ended in the upper part of this period.

**Environment of Deposition.**—The nature of the Fountain suggests that this formation resulted from the deposition and coalescence of numerous rapidly formed alluvial fans whose source materials were derived from an ancestral range at or near the position of the present Front Range.

**Nature of Contacts.**—The lower contact of the Fountain with the underlying Glen Eyrie is conformable, but in the Perry Park area it is marked by a definite lithologic break. The upper contact of the Fountain formation with the Lyons is transitional through an interval of 5 to 20 feet, in some localities and sharp in others.

The writer of the present report applied screen analysis to differentials between the Fountain formation and Lyons sandstone. Study of the histograms shows that size distribu-
Figure 9. -- A typical outcrop of Fountain arkose.

Figure 10. -- View looking northeast showing the bluff-forming Lyons outcrop in the foreground and Dakota hogback in the background.
tion in the Fountain is irregular and remarkably different from that of the overlying Lyons sandstone, which shows a uniform distribution. (See pl. 6) This analysis also indicates that at the locality from which the samples were obtained the contact is very sharp and can be defined within one foot. In applying this technique to establish the Lyons-Fountain boundary one should keep in mind that this contact, in places, is gradational and the presence of conglomeratic lenses, which writer believes are channel deposits formed by the reworked materials derived from the underlying Fountain, may lead to an erroneous interpretation.

Permian

Lyons Sandstone

History and Name.-- The red and white cross-bedded sandstone overlying the Fountain formation along the northern part of the Colorado Front Range was recognized as a separate stratigraphic unit and was named by N. M. Fenneman (11, pp. 23-24) the "Lyons sandstone," after the town of Lyons, Colorado, where it is typically developed.

Richardson (25, p. 5) in the Castle Rock, Colorado, folio correlated the pink to white fine-grained, cross-laminated sandstones, which overlie the Fountain formation in the quadrangle with the Lyons sandstone of the northern Front Range.
Thickness.-- Measured sections show that the Lyons sandstone is about 400 feet thick, and seems to be fairly constant in thickness throughout its extent in Perry Park.

Lithology.-- The Lyons is entirely composed of brick-red to gray and white fine-grained sandstone, which is typically cross-laminated.

The brick-red color of the Lyons sandstone is the result of iron-staining of the grains' surfaces. In some outcrops, notably on the bluff just south of the Perry Park Ranch, the Lyons standstone is colored with alternating bands of brick-red and gray. In Perry Park area the brick-red color of the Lyons grades into white and light gray along the strike toward the south.

This formation is predominantly fine-grained and remarkably uniform in grain size distribution, both vertically and latterally. This conclusion was reached from the study of the histograms of the samples taken across the formation and at two thousand feet intervals along the strike.

The grains are subrounded to subangular, and predominantly composed of quartz. However, near the base of formation is slightly arkosic.

The Lyons is cross-laminated throughout its extent. Even the few members which appear to be massive from a distance when closely studied are found to be finely cross-laminated.

Lyons sandstone is cemented with ferruginous and cal-
DETAILED STRATIGRAPHIC SECTION
OF
LYONS SANDSTONE

Scale
0 20 40 Feet
Careous materials. This sandstone when cemented with ferruginous material forms pronounced ridges, the best example of which is the bluff just southeast of the Perry Park Ranch.

Along the strike, toward the southeast, the cement becomes progressively calcareous, and the outcrops more prone to erosion. Thus, two miles southwest of the Lyons bluff, near the Perry Park ranch, the outcrop is divided into two parallel low hogbacks separated by a shallow valley.

The clay content of the sandstone samples taken from the latter location is about ten percent and predominantly of kaolinite type.

Another characteristic feature of the Lyons sandstone is the presence of small limonitic concretions. The pitted surface of some outcrops is caused by removal of these concretions.

Section of Lyons Sandstone
(Pl. 5, sec. 3)

Section three-quarter of a mile east of Peary Park Ranch, in the W1/2SE1/4 sec. 23, T. 9S., R. 68W.

Lykins formation
Lyons sandstone

<table>
<thead>
<tr>
<th>Thickness (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covered</td>
</tr>
<tr>
<td>Lyons sandstone</td>
</tr>
<tr>
<td>Sandstone, light gray, fine-grained, friable, cross-laminated, pitted, the outcrop covered with criss-cross ridges or well-cemented sandstone veins</td>
</tr>
</tbody>
</table>
The FOUNTAIN-LYONS CONTACT

HISTOGRAM SERIES ACROSS

50 FEET

LYKINS FM.

LYONS SS.

FOUNTAIN FM.

LYONS SANDSTONE

PLATE-6
**Thickness (Feet)**

Sandstone, light brown, fine-grained, sub-rounded, friable, limonite concretions, quartzose 32.0

Sandstone, gray and red mottled, fine-grained, rounded, friable, argillaceous, cross-bedded 22.0

Sandstone, light brownish red, fine-grained, very friable, cross-bedded, quartzose 75.0

Covered 30.0

Sandstone, light brownish red, fine-grained, sub-rounded to subangular, argillaceous, very friable, grains predominantly quartz with some mica 9.5

Sandstone, with lenses or arkosic conglomerate 3.5

**Total** 406.0

**Fountain formation**

**Environment of Deposition.**—Different authors have expressed various opinions concerning the origin of the Lyons sandstone. Wind, wave action along the shore lines, and streams have been suggested as possible agents of deposition for this formation.

The latest hypothesis explaining the origin of the Lyons sandstone is the one suggested by W. O. Thompson (28, pp. 67-71), who believes that the dominant agent of deposition of Lyons sandstone is a shore process involving waves and littoral currents.

The structure and texture of the Lyons formation suggest that regardless of the nature of depositional agent,
Figure 11.-- Outcrop of Lyons sandstone (Note the cross-bedding).

Figure 12.-- Outcrop of Crinkled limestone member of Lykins formation.
the formation was formed in an environment which remained stable during the time interval represented by the Lyons sandstone.

Age and Correlation. -- The Lyons formation contain no fossils from which its age might be established. However, from the fossils found in formations which interfinger with the Lyons and the bed which immediately overlies it (28, p. 72), the age of the formation has been established as Middle Permian, and it is equivalent to the Leonard formation of west Texas.

Nature of Contacts. -- The lower contact of the Lyons with the Fountain, as previously described, is sharp to gradational. The upper contact with the Lykins is very sharp and is marked by a lithologic break.

Permo-Triassic

Lykins Formation

Name and History. -- The Lykins formation was first named and defined by Fenneman (11, pp. 24-26). He assigned the Lykins Gulch near the town of Lykins, Colorado, as its type locality.

In the Castle Rock folio the entire interval between the top of the Lyons and the base of the Morrison was assigned by Richardson (25, p. 5) to the Lykins formation.

Robb (26, p. 31) has correlated the top gypsum member
of Richardson's Lykins with the Ralston formation of the Golden-Morrison area (21, p. 47).

In this paper the correlation of Robb has been accepted and the name Lykins is confined to the interval between the top of the Lyons and the base of the gypsum beds.

**Thickness.**--The Lykins formation as defined here is about 200 feet thick.

**Lithology.**--L. W. LeRoy (21, p. 31) in the Golden-Morrison area has defined five members for Lykins formation. The Lykins exposures in Perry Park area being poor, no attempt was made by writer to carry these subdivisions into the area.

The lower part of the formation is essentially red shale, with four feet of sandstone and brownish gray limestone near the base.

The "Crinkled" member of the Lykins is present in the area. This member is composed of sandy, argillaceous, and magnesian limestone with wavy laminations. The stratigraphic position of this member correspond to Glennon limestone in Golden-Morrison (21, p. 36) area.

The interval between the top of the Crinkled and the base of the overlying Ralston, is a covered except the upper 30 feet. The exposed portion of this section consists of yellowish gray calcareous siltstone.
DETAILED STRATIGRAPHIC SECTION OF
LYKINS FORMATION

PERMIAN
LYKINS FORMATION

CRINKLED L. S.
MEMB.

TRIASSIC
LYKINS FORMATION

JURASSIC
RALSTON Fm.

SE1/4 sec.12, T.5S., R.70W.
Jefferson Co., Colo.
After L.W. LeRoy

Scale

0  20  40 Feet

MMalek-Aslani 1950
Section of Lykins Formation  
*(Pl. 7, sec. 3)*

Section a mile west of Highway 105,  
in the center of sec. 23, T. 9S., R. 68W.

<table>
<thead>
<tr>
<th>Thickness (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lykins formation</td>
</tr>
<tr>
<td>Siltstone, yellowish gray, massive, very calcareous, with minor amount of gypsum</td>
</tr>
<tr>
<td>Covered</td>
</tr>
<tr>
<td>Crinkled member</td>
</tr>
<tr>
<td>Limestone, pinkish white, finely crystalline, thickly bedded, vuggy</td>
</tr>
<tr>
<td>Limestone, green mottled with pink, laminated crinkly, very sandy, dolomitic, argillaceous</td>
</tr>
<tr>
<td>Covered (probably red shale)</td>
</tr>
<tr>
<td>Sandstone, gray to brown, massive, pitted, weathers irregularly</td>
</tr>
<tr>
<td>Shale and sandstone; white, green to buff; thinly bedded, calcareous</td>
</tr>
<tr>
<td>Siltstone, calcareous, well bedded</td>
</tr>
<tr>
<td>Shale, reddish brown, fissile</td>
</tr>
<tr>
<td>Covered</td>
</tr>
<tr>
<td>Limestone, brownish gray, crystalline</td>
</tr>
<tr>
<td>Sandstone, pale yellow, fine- to medium-grained, predominantly quartz</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

Lyons formation
Mesozoic

Jurassic

Ralston Formation

Name and History.-- The name Ralston was first introduced by LeRoy (21, p. 47) who believes that the sediments occupying the interval between the top of the Lykins and base of the Morrison, in the Golden-Morrison area, form a persistent cartographic unit and should be considered a separate formation.

Robb (25, p. 31) in his studies of the northern portion of the Perry Park area correlated the gypsum beds overlying the Lykins formation with gypsiferous facies of the Ralston formation of Golden-Morrison area. This correlation was based on stratigraphic position and lithologic similarity of those sediments with Ralston formation of Golden-Morrison area. No attempt has been made, as yet, to trace the Ralston formation from Golden-Morrison to the area under investigation. South of Perry Park this formation is present but is discontinuous in parts.

The writer of the present report agrees with Robb's correlation.

Thickness.-- Thickness of Ralston in Perry Park area is approximately 60 feet.

Lithology.-- This formation consists of massive to
fibrous gypsum and ranges in color from white to pale pink. In the lower half of Ralston formation grayish green shale interfingers with gypsum.

Section of Ralston Formation
(Fig. , Sec. 3)

<table>
<thead>
<tr>
<th>Thickness (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morrison formation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ralston formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum, pale-pink, slightly calcareous in parts, massive ........................................... 3</td>
</tr>
<tr>
<td>Gypsum, pale-pink, finely crystalline, massive, with few 3-in. stringers of fibrous gypsum ........................................... 18</td>
</tr>
<tr>
<td>Gypsum, snow white, massive, sugary ........... 3</td>
</tr>
<tr>
<td>Shale, greenish-gray, slightly calcareous, fissile, interfingers with thin stringers of fibrous gypsum ................................. 15</td>
</tr>
<tr>
<td>Gypsum, pale pink, finely crystalline to fibrous, quarter of an inch to 4 in. bands interbedded with grayish green siltstone .. 3</td>
</tr>
<tr>
<td>Shale with gypsum, pinkish brown, slightly calcareous, massive, with half of an inch stringers of crystalline gypsum ................................. 10</td>
</tr>
<tr>
<td>Gypsum, white to light gray, massive, slightly calcareous, with gray-green shale stringers ................................. 3</td>
</tr>
<tr>
<td><strong>Total</strong> 55</td>
</tr>
</tbody>
</table>

Lykins formation

**Age and Correlation.**-- The lack of paleontologic data makes the exact dating of Ralston formation impossible.
LeRoy (21, p. 55) believing that this formation is more closely related to the overlying basal Morrison strata than to the underlying Lykins, tentatively assigns the Ralston to Jurassic age. The Ralston formation of Perry Park area having the same stratigraphic position as in the Golden-Morrison area is also of probable Jurassic age.

Environment of Deposition. -- These beds are believed to have been deposited in shallow water environment in a closed aqueous body.

Nature of Contacts. -- The lower contact with underlying Lykins is transitional. The upper contact with Morrison is marked by a sharp lithologic contrast.

Morrison Formation

Name and History. -- The Morrison formation was first named and defined by G. H. Eldridge (8, p. 60), who assigned the outcrop of this formation near the town of Morrison, Jefferson County, Colorado, as its type locality.

W. A. Waldschmidt and L. W. LeRoy (31, pp. 1097-1114) redefined the formation and transferred the type locality to the road cut west of the Alameda Parkway, two miles north of Morrison.

The sediments lying between Ralston formation and Lakota sandstone in Perry Park, were correlated by Richardson (25, p. 5) with the Morrison formation of northern Colorado.
**Thickness.** -- The Morrison formation of Perry Park area is about 200 feet thick.

**Lithology.** -- The Morrison formation is composed of varicolored shale, siltstone, marlstone with some fresh-water algal limestone and sandstone near the base. Exposures of this formation are generally very poor and no detailed study of lithology is possible.

**Section of Morrison Formation**
(Pl. 7, sec. 3)

Section three-quarter of a mile east of the Lake, in the center of sec. 23, T. 9S., R. 68W.

<table>
<thead>
<tr>
<th>Thickness (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakota sandstone</td>
</tr>
<tr>
<td>Morrison</td>
</tr>
<tr>
<td>Shale, greenish-gray, slightly calcareous ..</td>
</tr>
<tr>
<td>Shale, gray to gray-green, calcareous, lower five feet silty .........................</td>
</tr>
<tr>
<td>Covered .........................</td>
</tr>
<tr>
<td>Siltstone, white to light gray, massively bedded, friable ........................</td>
</tr>
<tr>
<td>Shale, red, green, gray, mottled, calcareous soft.................................</td>
</tr>
<tr>
<td>Covered .........................</td>
</tr>
<tr>
<td>Siltstone, red-brown, calcareous, friable ..</td>
</tr>
<tr>
<td>Covered .........................</td>
</tr>
<tr>
<td>Limestone, light-gray, finely crystalline, flaggy vuggy, secondary calcite, with stringers of quartz .........................</td>
</tr>
</tbody>
</table>
Shale, greenish gray, soft, calcareous ..... 11

Limestone; gray finely crystalline, massive to bedded (fresh-water algal limestone ?) .. 1

Shale, greenish-gray, calcareous, fissile, sandy few 1/2 in. lime stringers ............ 14

Sandstone, white to light gray, fine-grained, massive, calcareous, grains predominantly quartz with some red chert ................. 2,4

Covered ........................................ 25

Total 201.4

**Ralston Formation**

**Distribution.**— The Morrison formation, being mostly composed of soft shales, rarely forms continuous exposures. It generally occupies the valleys between Dakota hogbacks and the Ralston formation. Only the basal member which contains some limestone and sandstone is fairly well exposed and forms minor hogbacks. The top portion of this information which forms the slopes of Dakota is also occasionally exposed.

The best outcrop of the basal member is on the eastern bank of the Perry Park lake.

**Age and Correlation.**— Although a number of continental faunas have been recovered from Morrison formation, the age of this formation is still open to question.

Lavington and Thompson (21, p. 46) classify it under
Jurassic Period, but do not discuss the age of Morrison formation.

Environment of deposition.-- The Morrison formation is believed to have been deposited in overloaded, slow-moving streams and broad, shallow lakes and swamps.

Nature of contacts.-- The lower contact with Ralston although very distinct is believed to be conformable (21, p. 66).

The upper contact with Dakota sandstone in Perry Park is generally covered, but from the study of literature, is believed to be unconformable.

Upper Cretaceous

Dakota Formation

Name and History.-- The definition of Dakota as originally described by F. B. Meek and F. V. Hayden (4, pp. 419-420) has since undergone considerable modification. The United States Geological Survey urges that this term should be restricted to areas east of the Front Range.

The interval between the top of the Morrison and base of the Colorado group in Perry Park area consists of two sandy members separated by a shale member, to which the name Dakota formation was applied by Richardson's predecessors. Richardson (25, p. 6) redefined this formation and restricted the name Dakota sandstone to the upper sandy mem-
ber and correlated the lower shale and sandstone with Purga-
atoire formation of Mesa de Maya quadrangle, Colorado. The
Purgatoire formation as defined by G. W. Stose (27) is of
Comanchian age, Lower Cretaceous, and of marine origin.

The lower sandstone member of the so-called Purga-
atoire formation in Perry Park area was carefully studied
by the writer. The physical character of this sandstone
strongly suggests that it was formed in a non-marine environ-
ment, therefore the writer believes that Richardson was not
justified in correlating the lower part of Dakota with the
marine Purgatoire formation.

Following the practice of previous reports submitted
to the Department of Geology, Colorado School of Mines,
the writer applies the names: Lakota sandstone for the
lower, Fuson shale for middle, and The Top sandstone for
the upper members of the Dakota formation.

The name "Lakota" was first introduced by N. H. Darton,
in 1899 (6, p. 327), who applied the name to coarse, buff
sandstones which overly the Morrison formation in the Black
Hills of South Dakota. He assigned these sediments to the
Lower Cretaceous age.

The varicolored shales and fine-grained sandstones
which occupy the stratigraphic interval between the base
of Dakota and top of the Minnewante limestone; in Fuson
Canyon, Black Hills of South Dakota; were first described
and named by N. H. Darton (7, p. 530) as Fuson shale.
DETAILED STRATIGRAPHIC SECTIONS OF DAKOTA FORMATION

Scale
0  20  40 Feet

UPPER CRETACEOUS

DAKOTA FORMATION

THE TOP SAND

DAKOTA FUSION SHALE

LAKOTA SANDSTONE

M. Malek-Aslani 1950
Thickness.-- The Lakota sandstone member in this area is fairly uniform in thickness, and is about 100 feet. Fuson shale member in Perry Park area is about 120 feet thick. The Top sandstone member is about 100 feet thick.

Lithology.-- The three members of the Dakota formation in Perry Park area are well defined and hence will be considered separately.

(1) Lakota sandstone: This member is essentially composed of medium-to-fine-grained sandstone ranging in color from white to yellowish brown. The lower half is cross-bedded and conglomeratic with scattered lenses of shale. The pebbles of conglomerate are aligned parallel to the cross-bedding. The upper half in some sections is thickly bedded, and in one location a lens of quartzite is formed near the top. The cementing material varies from ferruginous to siliceous. The characteristic feature of Lakota sandstone is the lenticular nature of its lithologic members which pinch out latterly.

Section of Lakota Sandstone
(Pl. 8, sec. 4)

Section quarter of a mile southeast of the Perry Park Lake on the flanks of Dakota hogback, in the NW1/4NW1/4 sec. 23, T. 9S., R. 68W.

Thickness
(Feet)

Fuson
Lakota Sandstone
Sandstone, yellow to buff, fine to medium-grained well-rounded to sub-rounded, bedding 2-3 feet thick, some intervening, thin bedded sandstone, jointed, cement ferrigenous, quartzose, limonite concretions ............. 39.0

Shale, yellow ........................................... 0.5

Sandstone interfingered with yellow to white clay ........................................... 3.0

Sandstone, gray-yellow to white, medium to fine-grained, massive to cross-bedded, limonite concretions. This sandstone down-wards becomes progressively conglomeratic and more cross-bedded ..................... 16.5

Conglomeratic sandstone cross-bedded with pebbles almost parallel to cross-bedding. One-foot bed of chert conglomerate near the center ........................................... 6.0

Conglomerate, gray-brown, massive, composed of big pebbles of chert (up to 1 in.) embedded in a sandy matrix ......................... 2.6

Sandstone, light-gray to yellowish-gray, fine to medium grained. The lower part strongly cross-bedded. Lenses of conglomerate near the center, composed of chert and few lime-stone pebbles ....................................... 17.2

Sandstone, gray to yellowish-gray and white, the upper half cross-bedded the lower half massive .............................. 13.0

Covered

Section of Lakota Sandstone
(Pl. 8, sec. 6)

Section northwest of the Lake,
in the W1/2SE1/4 sec. 15, T. 9S., R. 68W.

Fuson shale member
Lakota sandstone member

Sandstone, yellow to drab, thickly bedded, ripple marks on bedding surface, limonite concretions, quartzose .......................... 30.

Shale, purple to reddish-yellow, and drab, fissile ................................. 5.5

Sandstone, yellow to drab, massive, friable, quartzose, limonite, concretions very abundant .................................................. 6.

Sandstone, white to gray, fine-grained massive to cross-bedded, jointed, quartzose, some limonite concretions .................. 34.

Covered

Section of Lakota Sandstone
(Pl. 8, sec. 5)

Section at location "3" on index map, in the W1/2NE1/4 sec. 23, T. 9S., R. 68W.

Fuson shale member

Lakota sandstone member

Quartzite, light-gray ................................. 3.

Siltstone, light-yellow, sandy, massive .... 1.

Quartzite, light gray ................................. 3.

Siltstone, light gray, slightly calcareous, massive, soft, with a 6 inch reddish brown ironstone near the top ....................... 6.

Sandstone, light-gray to creamy, fine-grained, sub-rounded massive, very friable, cement argillaceous ....................... 8.

Sandstone, light-gray banded; fine-grained, subrounded, friable, massive, argillaceous .............................. 6.
<table>
<thead>
<tr>
<th>Thickness (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandstone, grayish-yellow to gray and green, fine grained, subrounded grains have frosted surface, very friable, cement argillaceous. 12.</td>
</tr>
<tr>
<td>Sandstone, pinkish-yellow to light brown, coarse, subrounded, cross bedded, argillaceous cement, friable 12.</td>
</tr>
<tr>
<td>Conglomeratic sandstone, yellowish gray, grains medium with pebbles up to half of an inch, grains have frosted surface, with some white clay lenses, cherty 3.</td>
</tr>
<tr>
<td>Sandstone, pinkish-yellow to light brown, medium, with frosted surface, argillaceous, friable 2.</td>
</tr>
<tr>
<td>Conglomerate 12.</td>
</tr>
<tr>
<td>Sandstone; grayish yellow to yellowish brown, fine-grained, subrounded, friable, massive, cement argillaceous 8.</td>
</tr>
<tr>
<td>Siltstone; yellowish gray to light brown, sandy, thickly bedded, argillaceous cement, with 2 feet gray shale near the top 10.</td>
</tr>
<tr>
<td>Sandstone, yellowish brown to grayish-yellow at base, fine grained, subrounded to rounded, very friable, thickly bedded, argillaceous cement 4.</td>
</tr>
<tr>
<td>Sandstone, pinkish white to pinkish brown, very fine-grained, subrounded, frosted, thickly bedded, the upper 4 feet well-cemented with siliceous material, weathered surface, cavernous, lower part very friable and cross bedded 9.</td>
</tr>
<tr>
<td>Siltstone, brownish-yellow, sandy, flaggy to thickly bedded, friable 4.</td>
</tr>
<tr>
<td>Total 103.</td>
</tr>
</tbody>
</table>
(2) Fuson shale: This member, being entirely composed of soft sediments, forms gentle slopes on the top of the Lakota sandstone ledges. Exposures of Fuson are generally covered with soil.

(3) The Top Sand Member: This member is a white to gray and fine-grained sandstone composed of subangular quartz grains cemented with silica.

Section of The Top Sand Member
(Pl. 8, sec. 3)

Section in location "3" on index map,
in the W1/2NE1/4 sec. 23, T. 9S., R. 68W.

Benton shale
Top Sand Member

<table>
<thead>
<tr>
<th>Sandstone, light gray, fine-grained, subangular, friable, glauconitic (?)</th>
<th>jointed, slightly cross-bedded, quartzose</th>
<th>18.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandstone, white to light gray, medium-grained, subrounded, friable, vuggy, jointed.</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td>Sandstone and breccia, light gray to yellowish brown, grains from 0.1 to 10 mm., subrounded, well-cemented with silica chert inclusions</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Sandstone, yellowish brown, medium-grained, stained with iron</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Sandstone, white to light gray, medium-grained, subrounded, friable, argillaceous, vuggy, siliceous stringers</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>Sandstone, light gray, medium-grained, friable, siliceous stringers form diamond-shaped ridges on outcrops</td>
<td>14.0</td>
<td></td>
</tr>
</tbody>
</table>
Siltstone, white, massive, sandy .................. 3.0

Sandstone, pale yellow, fine-grained, sub-angular to subrounded, massive, well-cemented with silica, quartzose ................... 9.0

Sandstone, silty, pale yellow and white mottled, very fine-grained, angular, well-cemented with silica, massive, jointed, quartzose .......................... 14.0

Siltstone, dark gray, indurated, massive to bedded ........................................ 0.5

Sandstone, silty, yellowish-brown, very fine-grained, well-cemented with ferruginous material, quartzose ....................... 5.0

Total 101.6

Fuson shale

Distribution. -- The Dakota formation where present forms prominent hogbacks, with the Top sand member forming the dip slope. Fuson shale being nonresistant to erosion gives rise to the gentle slopes between overlying Top sand member and underlying Lakota sandstone. The Lakota member generally forms the escarpment slope of the Dakota hogbacks. Owing to its variable cementing material, Lakota outcrops are not continuous. Immediately east of the lake, in the NE1/4 sec. 22, T. 9S., R. 68W., it forms a pronounced ledge on the flanks of Dakota hogback. Further east the ledge becomes inconspicuous and is divided into two small ledges separated by an eroded interval.

Age and Correlation. -- The Lakota sandstone and Fuson
Figure 13.-- A view looking east showing the escarpment slope of Dakota hogback. Kd: The Top sand member of Dakota formation. Kf: Fuson shale member of Dakota formation. Klk: Lakota member of Dakota formation. Jm: Morrison formation.

Figure 14.-- Outcrop of The Top sand member of the Dakota formation. Note the reticulated ridges developed on the surface of outcrop.
shale as defined by Darton (5, 1899, p. 387 and 6, 1901, p. 530) in the Black Hills, South Dakota, belong to Lower Cretaceous series. The present trend in the Front Range stratigraphy is to assign these two members to the Upper Cretaceous (14 and 18) and include them as members of the Dakota formation. Richardson (25, p. 6) reports the finding of fossil leaves in the Top sand member of Dakota formation at Perry Park area, which is typical of this formation in the other places.

Nature of Contacts. -- The lower contact with Morrison is generally covered and inaccessible for study, but is believed to be unconformable.

The upper contact with Benton formation is covered.

Benton Formation (Colorado Group)

Name and History. -- The lowest member of the Colorado group, which is composed of dark gray shales with occasional beds of light-colored limestones, was first described and named Fort Benton group by Meek and Hayden (24, pp. 419-421). For many years "Fort" has been dropped from the name, and Benton shale has been used.

In the Colorado Springs area the formation is subdivided into the Graneos, Greenhorn and Carlile, of which the first names is oldest (10, p. 8). Richardson (25, p. 6) did not distinguish these three members in the Benton formation of the Perry Park area. Lavington and Thomson (19, p. 47)
Figure 15.-- The intraformational conglomerate developed in The Top sand member of Dakota formation.

Figure 16.-- A view looking west showing the Timpas limestone hogback.
believe that the Greenhorn limestone thins toward the north and finally dies out as a recognizable formation a short distance north of Perry Park. R.C. Cutter (5, p. ) recently has shown that Greenhorn limestone is present west of Loveland in northeastern Colorado. A number of other workers (32) have traced this limestone both to the north and south of the Greenhorn found by Cutter.

The writer of the present report was able to distinguish the Greenhorn limestone in Perry Park area.

**Thickness.**-- The Benton formation in Perry Park is about 500 feet thick.

**Lithology.**-- The Graneros shale member is entirely composed of light to dark gray limy and fossiliferous shales. The Greenhorn limestone consists of 23 feet of gray fossiliferous limestone interbedded with gray limy shale. The Car- lile shale is very poorly exposed in the Perry Park area, but from scattered outcrops it seems to be composed of light gray limy shales, very sandy near the top.

**Section of Benton Shale**

*(Pl. 9, sec. 7)*

Section measured at the location "7" on index map, in the NE1/4SE1/4 sec. 15, T. 9S., R. 68W.

**Thickness**

*(Feet)*

Timpas limestone

Benton shale
DETAILED STRATIGRAPHIC SECTION OF BENTON SHALE
Scale
0 25 50 Feet
<table>
<thead>
<tr>
<th>Thickness (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carlile shale member</strong></td>
</tr>
<tr>
<td>Shale, grayish-yellow, sandy, fissile ..</td>
</tr>
<tr>
<td>Covered ....................................</td>
</tr>
<tr>
<td>Shale, light gray, limy, soft, contains fragments of megafossils</td>
</tr>
<tr>
<td>Covered ....................................</td>
</tr>
<tr>
<td>Shale, light gray to yellowish-gray, limy, fissile, some gypsum near top ....</td>
</tr>
<tr>
<td><strong>Greenhorn limestone member</strong></td>
</tr>
<tr>
<td>Limestone, gray, crystalline, vuggy, hard, fossiliferous (<em>Inoceramus</em>) ..........</td>
</tr>
<tr>
<td>Shale, yellowish-gray, contains some limy streaks, fissile .......................</td>
</tr>
<tr>
<td>Limestone, gray with yellow cast, dense, argillaceous, contains some microfossils</td>
</tr>
<tr>
<td>Shale, gray and yellow-brown, mottled, fissile, very calcareous ...................</td>
</tr>
<tr>
<td>Shale, yellowish-gray, very calcareous, contains microfossils, platy, hard, secondary calcite .................................</td>
</tr>
<tr>
<td>Shale, yellowish-gray, very calcareous, Platy, streaked with carbonaceous material, microfossils ...........................................</td>
</tr>
<tr>
<td>Limestone, dark gray, finely crystalline, thickly bedded .............................</td>
</tr>
<tr>
<td><strong>Craneros shale member</strong></td>
</tr>
<tr>
<td>Shale, light gray, dark gray and yellowish-brown, calcareous, fossiliferous ...</td>
</tr>
<tr>
<td>Shale, dark gray to yellow-brown, very calcareous, secondary calcite crystals ..</td>
</tr>
<tr>
<td>Shale, black, fissile, streaked with lime ............................................</td>
</tr>
</tbody>
</table>
Thickness (Feet)

Shale, gray, and yellow-brown, limy .... 26.0
Shale, white to light gray, very calcareous, platy ...................... 5.0
Shale, dark gray to black, limy, platy, fossiliferous ..................... 45.0
Shale, black and light gray, banded, fissile, carbonaceous ............ 23.0
Shale, black, platy to fissile, carbonaceous .................. 36.0
Covered ........................................ 155.0
Total 562.0

Dakota sandstone

**Distribution.**—The Benton shale, being composed of soft sediments, occupies the position of valleys between the Dakota and Timpas hogbacks. It is best exposed along the banks of Bear Creek in Sec. 12, T. 9S., R. 68W.

**Age and Correlation.**—The Benton shale is fossiliferous, with megafossils as well as microfossils. Richardson (25, p. 6) reported the presence of the following fauna in the Benton shale of the Castle Rock quadrangle:

**Ostrea** sp.

**Inoceramus** sp.

**Inoceramus fragilis** Hall and Meek

**Scaphites warreni** Meek and Hayden

This formation (19, p. 48) is of Upper Cretaceous age.
The top of the Carlile member is correlated with the Frontier sandstone of Wyoming, and eastward it grades into the Codell sandstone.

Environment of Deposition.-- The Benton shales are of shallow marine origin and are interpreted as having been deposited at some distance from the shore line (21, p. 79).

Niobrara Formation (Colorado Group)

Name and History.-- The name "Niobrara" was first proposed by Meek and Hayden (24, pp. 419-422) to designate the upper member of the Colorado group. G. K. Gilbert (13, pp. 551-601) in his stratigraphic works in the Arkansas Valley of south-central Colorado subdivided the Niobrara into two members. He named the lower limestone member "Timpas" and the upper shale member "Apishapa."

Thickness.-- The total thickness of the Niobrara formation is about 560 feet.

Lithology.-- The Timpas member of this formation consists of white to light gray, well-bedded, impure limestones interbedded with a few thin layers of calcareous shale. The Timpas is very fossiliferous and in the Ferry Park area is over 20 feet thick.

The overlying Apishapa shale member is entirely covered, and its lithologic character in this area is not known.
Distribution.— The Timpas member of the Niobrara formation, throughout its extent, forms conspicuous hogbacks parallel to the Dakota ridges.

Age and Correlation.— The Timpas member of the Niobrara formation is believed (21, p. 79) to be equivalent to the Hays limestone of western Kansas.

Environment of Deposition.— The Niobrara formation is of marine origin (21, p. 81).

Nature of Contacts.— Both contacts of the Niobrara formation in the Perry Park area are covered, but from a study of the literature they are believed to be conformable. The contact of the Apishapa member with the overlying Pierre, according to LeRoy (21, p. 79), can be defined by a change in microfauna.

Owing to the lack of exposures, the upper contact of the Niobrara with the Pierre shale was established only arbitrarily.

Montana Group

Eldridge in 1888 (8, p. 93) proposed the name "Montana group" to embrace the previously defined (24, pp. 415, 424) Pierre shale and Fox Hills sandstone. This group conformably overlies the Colorado group.

In eastern Colorado, Wyoming, and Montana this group is divisible into two formations, namely: Pierre shale and
Fox Hills sandstone. This division in the Perry Park area, probably is possible; but lack of adequate data and limited time forced the writer of the present paper to map the group as one stratigraphic unit.

**Thickness.**-- From the measurements made, the thickness of the Montana group in Perry Park seems to be over 4,500 feet. However, inadequate dip control and the possible presence of a strike fault make the accuracy of this figure rather questionable.

**Lithology.**-- The Pierre shale is very poorly exposed in the Perry Park area. The samples collected from sporadic outcrops suggest that the Pierre is essentially composed of gray shales, sandy shales, siltstones, and occasional beds of fossiliferous limestones.

In recent years several attempts have been made to break the Pierre into lithologic members or faunal zones, but this subdivision is beyond the scope of the present report.

The upper and lower contacts of the Pierre are both gradational. The lower contact, as previously mentioned, can be established on the basis of paleontology. The Pierre-Fox Hills contact, on the other hand, is paleontologically as well as lithologically transitional.

The Fox Hills sandstone, like the Pierre shale, is very poorly exposed. It is essentially composed of gray or brown argillaceous sandstones, siltstones, shales, and a few thin
beds of limestone near the top.

The contact of the Fox Hills with the overlying Laramie formation is not definite and was arbitrarily established in the field. According to Lavington and Thompson (19, p. 51), in many places along the Front Range evidence of unconformities between the Fox Hills and the Pierre have been observed.

Environment of Deposition.-- The nature of the Montana sediments and their faunal suite strongly suggest that this group was entirely formed in a marine environment. The Upper Cretaceous sea withdrew from the area at the end of the Fox Hills time.

Laramie Formation

Name and History.-- The Laramie formation was first described and named by King (17). Eldridge and Cross (4), in their geological studies of the Denver Basin, redefined this formation and restricted the name "Laramie" to the lower part of the previously described Laramie group, and placed the upper limit at the base of the Arapaho-Denver formation.

Richardson (25, p. 8) in the Castle Rock quadangle assigned the sediments occupying the stratigraphic interval between the top of the Fox Hills and the base of the Dawson arkose to the Laramie formation.

Thickness.-- The Laramie formation in the Perry Park
DETAILED STRATIGRAPHIC SECTION
OF LARAMIE FORMATION & UPPER
PART OF FOX HILLS SANDSTONE
area is about 600 feet thick. However, this figure may be inaccurate because of the indefinite boundaries of this formation.

**Lithology.** -- The Laramie formation is essentially composed of gray, yellowish-gray, and orange-brown, medium to fine-grained sandstones interbedded with siltstones. Three-to four-inch thick beds of ironstone transect this formation in various stratigraphic horizons.

Section of Laramie Formation  
(Pl. 10, sec. 8)

Section measured at the location "S" on index map, in the SW1/4 sec. 1, T. 9S., R. 68W.

<table>
<thead>
<tr>
<th>Thickness (Feet)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dawson arkose</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Laramie formation</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Siltstone, gray, sandy, quartz grains angular, some magnetite</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandstone, yellowish-gray, fine-grained, sub-angular, massive, well-cemented with argillaceous material, predominantly quartz with few magnetite grains</td>
<td>15.0</td>
</tr>
<tr>
<td>Siltstone, gray, massive, fissile, sandy</td>
<td>1.0</td>
</tr>
<tr>
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<td>20.0</td>
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<tr>
<td>Sandstone, pinkish-brown, fine to medium, sub-angular, ferruginous, quartzose</td>
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</tr>
<tr>
<td>Siltstone, gray, massive, slightly sandy, contains mica flakes</td>
<td>134.0</td>
</tr>
<tr>
<td>Thickness (Feet)</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td></td>
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<tr>
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</tr>
<tr>
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<tr>
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<td>Sandstone, yellowish-brown, fine-grained, subangular, massive, friable, grains are quartz, zircon(?), magnetite, and other minerals .... 31.0</td>
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<td>Siltstone, yellowish-brown, sandy, massive .................. 20.0</td>
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<tr>
<td>Sandstone, white to light gray, fine-grained, angular, massive, friable, argillaceous..... 145.0</td>
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</tr>
<tr>
<td>Sandstone, yellow to yellowish-brown, mottled, medium-grained, angular, very friable, ferruginous, argillaceous, grains are quartz, magnetite, and other minerals ................. 24.0</td>
<td></td>
</tr>
<tr>
<td>Sandstone, orange-brown, fine-grained, angular, cement argillaceous to ferruginous, grains are quartz, mica, and other minerals .............. 47.0</td>
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<tr>
<td>Sandstone, brown, fine-grained, angular, hard, ferruginous cement ................................ 0.5</td>
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</tr>
<tr>
<td>Sandstone, light gray, fine-grained, angular, very friable ................................. 43.0</td>
<td></td>
</tr>
<tr>
<td>Ironstone, dark brown, platy, thin-bedded, hard ........................................ 0.5</td>
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</tr>
<tr>
<td>Sandstone, light gray, very fine-grained, angular, poorly cemented ...................... 37.0</td>
<td></td>
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<td>Total 601.0</td>
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</tr>
</tbody>
</table>

**Fox Hills (?)**

**Distribution.** The Laramie formation in the Perry Park area is very poorly exposed. It is generally covered with debris from the overlying Dawson arkose. The best exposure
of Laramie is east of the Plume' Creek, SW1/4, Sec. 1, T. 9S.,
R. 68W.

Age and Correlation.-- The age of the Laramie, accord-
ing to Lavington and Thompson (19, p. 51), in Colorado is
definitely Cretaceous.

Environment of Deposition.-- The Laramie is of brack-
ish- and fresh-water origin.

Nature of Contacts.-- The lower contact with the under-
lying Fox Hills is transitional, but microscopic study of
the samples, taken across the formation, indicates the
presence of glauconite below a certain stratigraphic horizon.
This horizon also corresponds to the boundary below which
invertebrate fossils become abundant. Assuming a continental
origin for Laramie formation, one would not expect to find
many invertebrate fossils in this formation. This criterion
was, tentatively, used by the writer to define the Laramie-
Fox Hills contact.

The upper contact with the Dawson arkose was arbitrarily
established in the field.
Figure 17.— A view looking southeast showing the displacement of the Sawatch sandstone along the south dipping thrust fault. (Gove Creek Canyon)

Figure 18.— Drag and minor fault developed on the footwall of the thrust fault (Gove Creek Canyon).
STRUCTURAL GEOLOGY

The crustal deformation to which the present structure of the area owes its existence has involved the sediments of Early Tertiary age. This fact indicates that the existing structural features of the Perry Park area are the result of the Laramide Revolution.

The lack of angular unconformities between the pre-Tertiary strata shows that the older episodes of crustal unrest resulted only in broad arching and erosional unconformities rather than intensive orogenic movements.

The regional structure of the area is a homocline with beds striking about N 65°W and dipping 10°-15°N into the Denver Basin. Locally this simple structure is modified by a system of north trending vertical faults, which have displaced and dragged the beds. The intensity and direction of drag along the fault surface indicate that the strike slip of displacement is very large.

The easternmost fault enters the area in the sec. 1, T. 10S., R. 68W., and continues due north until it dies out in sec. 13, T. 9S., R. 68W. According to Richardson (25, p. 10), this fault trends along the Laramide-Montana contact. However, he does not cite any evidence to substantiate this interpretation. The writer of the present report failed to find any field criteria to support Richardson's idea. On the contrary, the microscopic study of the samples taken across the Montana-Laramie boundary indicate a grada-
tional rather than fault contact.

A sliver block in the NE1/4 sec. 36, T. 9S., R. 68W., and a minor fault which branches off to the northwest in the NW 1/4 sec. 30, T. 9S., R. 67W., are related to the major fault described above.

The presence of the sliver block was interpreted from the unusual stratigraphic relations brought about by structural deformations. Here the Lyons sandstone is in a fault contact with the Fountain formation on one side, and late Cretaceous sediments on the other. The fault contact of Lyons-Fountain is evinced by the absence of a part of the latter formation.

The branch fault, which joins the major one in the NW1/4 sec. 30, T. 9S., R. 67W., transects the formations at low angles. In the center of the sec. 24, T. 9S., R. 68W., this fault cuts across the Dakota sandstone, a fact which accounts for the absence of the Dakota hogbacks east of this location and dies out in the less competent beds of the Colorado group.

The second major fault in the area is west of the one previously described and separated from it by a two-mile strip of sediments. This fault is essentially parallel to the other. It enters the area in the SE1/4 sec. 34., T. 9S., R. 68W., where pre-Pennsylvanian beds are brought into fault contact with pre-Cambrian granite, and leaves the area under investigation in the sec. 15, T. 9S., R. 68W., where
the intensive drag along the fault causes the Lyons sandstone to form vertical hogbacks.

The westernmost fault in the area is parallel to the two previously mentioned and passes through the El/2 sec. 21, T. 9S., R. 68W. It brings the Fountain formation into a fault contact with pre-Cambrian granite. The granite-Fountain contact is characterized by the presence of vertical and overturned beds of the latter formation.

The only low-angle thrust fault noted in the area is at the mouth of the Gove Creek Canyon, in the NE1/4 sec. 2, T. 10S., R. 68W. The surface of this fault dips approximately 45 degrees to the south. The stratigraphic throw is about 60 feet. Considering the fact that some of the faults in the general area have several thousand feet of stratigraphic throw, it is obvious that the Gove Creek thrust fault is a minor structural feature.

W. H. Bucker (3, pp. 163-164) in the "Deformation of Earth's Crust" in discussing the foothills structures of the Front Range of Colorado, makes the following statement:

"Here then we see the crystalline core of the welt rise near the edge in slices that are forced upward differentially, overriding one another more or less."

Quoting Ziegler in the same page, he says:

"Here the front of the range, rising more abruptly, has bulged outward, locally overriding the sediments of the foothills zone along thrust planes dipping westward."

Based on the above-mentioned opinions and field observations, the writer of this report attempts to make
some speculations regarding the nature of the tectonism which resulted in the existing structures of the area.

The study of the Perry Park structure reveals the following facts:

1. The strike of the beds approaching the fault traces have a tendency to bend abruptly in a fashion that suggests horizontal drag.

2. The direction of drag on opposite sides of the fault indicates that each block has moved northward in relation to its eastern neighboring block.

3. The strata on the down-thrown side of the fault have been dragged into vertical dips.

These observations suggest that: (a) the existing structure of the area is the result of block faulting, and (b) that each block has moved upward and to the north in relation to its eastern neighboring one.

The writer believes that the present structure of Perry Park is the result of northward en bloc movement of the basement granite along the planes of thrust faults dipping due south. (See pl. 12) The tectonic force which caused the overthrust was acting along a north-trending line. The intensity of this force seems to have died out eastward, there resulting in a couple (See fig. A, pl. 12) which had a tendency to rotate the upper block around a vertical hinge line. Applying the strain ellipsoid to this problem, it becomes obvious that the direction of the maxi-
mum shear is essentially parallel to the strike of the existing faults. (See fig. B, pl. 12)
POSSIBLE MECHANICS OF FAULTING AT PERRY PARK AREA
HISTORICAL GEOLOGY

Pre-Cambrian

The basement complex in the Perry Park area consists of coarse-grained Pikes Peak granite intruded into the Algornkian rocks (Late Archean). A deep-seated origin for this granite is indicated by coarse texture. The events following this intrusion are (1) uplift and (2) extensive erosion.

Paleozoic Era

The pre-Cambrian surface on which the Sawatch sandstone was deposited is very even. Lower and Middle Cambrian sediments are not known in this area. Those two facts indicate that the erosional cycle that followed the Late Proterozoic uplift was active through Early and Middle Cambrian, leaving the area as a flat, featureless peneplane.

The Sawatch sandstone represents the beginning of a transgressing sea, encroaching from the east. The gradational nature of the Sawatch-Manitou contact, as at Manitou Springs or in Gove Creek Canyon, suggests that the end of the Sawatch was marked by a period of nondeposition. However, Sawatch was uncovered in some places, resulting in local unconformities.

In Late Cambrian and Early Ordovician time, the areas
supplying the clastic sediments for deposition of the Sa-
watch were aggraded by erosion and chemical precipitation
became more prevalent. During this period, limestones and
dolomites were deposited.

Middle and Upper Ordovician rocks are not found in
Perry Park, although they do exist farther south near Canyon
City; their absence in the Perry Park area may be due either
to nondeposition or to erosion, probably the latter.

According to T. G. Bartram (1, p. 1138), at the end
of Ordovician, the sea withdrew to the Cordilleran geo-
syncline. The interval during which the area was emerged
included the latter part of the Ordovician, the entire
Silurian period, and the Early Devonian. The diastrophism
which caused it probably was related to the important Late
Ordovician disturbances in Oklahoma which possibly resulted
in some warping and minor uplift in the southern part of
the Front Range area (22, p. 371).

In the Middle Devonian, the sea began to encroach
from the west, covering southwest and central Colorado (1,
p. 1138). The Williams Canyon limestone was deposited in
the Upper Devonian sea. This limestone is not believed to
be present in the Perry Park area; its absence may be due
to erosion or to nondeposition.

The expansion of the sea, which began in Middle De-
vonian, reached its maximum in Lower Mississippian time,
and it once more covered the entire Rocky Mountain region,
during which time Madison limestone and its equivalents were deposited in even layers. The Madison limestone of Lower Mississippian is not present in Perry Park. However, chert pebbles containing Mississippian fossils are found in the Glen Eyrie shale, a fact which indicates that Madison limestone might have been present in the area but was removed by erosion. With the end of the Lower Mississippian, the sea began to withdraw from Colorado, and the following erosional cycle removed a considerable thickness of sediments before the deposition of Pennsylvanian rocks.

During Early Pennsylvanian time, a positive land mass began to take form in Colorado. The alluvial deposits represented by the Fountain formation were laid on the flanks of these positive areas (1, p. 1140). The lower part of the Fountain in the Colorado Springs area interfingers with Lower Pennsylvanian marine beds represented by the Glen Eyrie formation, a thin tongue of which formation is extended as far north as Perry Park. The younger beds of the Fountain formation progressively overlap the older ones in a northerly direction.

The change from Pennsylvanian to Permian is not marked by a sharp break in the Rocky Mountain region. However, considering that the Lyons sandstone is of near-shore (26, p. 71) origin and that the overlying Lykins is a marine deposit, it becomes obvious that with the beginning of Permian time the sea began to encroach into the area.
A land mass existed in Colorado (1, p. 1142) which supplied material for deposition. The sediments surrounding this land mass seem to grade from continental to near-shore to marine. Heaton (16, p. 149) believes that the Lyons sandstone grades into the lower Lykins northward and southward, a fact indicating a limited extent for this formation and a possibility of the Lyons being the near-shore facies of the lower Lykins.

However, later in Permian time the site of Lyons deposition became deeper and the Lykins formation, which is a marine deposit, overlapped the Lyons sandstone. The Late Permian deposits in the areas to the east of the Front Range are believed to have been deposited in a restricted marine environment which favored chemical precipitation.

**Mesozoic Era**

By Triassic time the Colorado land masses being mostly eroded and buried in their own debris, were no longer of importance. However, conditions of sedimentation in the early part of the Triassic period were little different from those of Late Permian. The upper Lykins red beds are believed by A. J. Tieje (29, pp. 192-207) to have been deposited under deltaic conditions.

In Upper Triassic time the sea withdrew from the area, a fact which accounts for the absence of Upper Triassic sediments.
A part of Colorado was invaded from north by Jurassic sea. This sea, however, does not seem to have covered the Perry Park area because the Ralston gypsum was deposited in a shallow-water environment in a closed or partly closed aqueous body. The Morrison formation also is of continental origin.

During Upper Cretaceous time, the entire Rocky Mountains and Great Plains area was covered by seas. The Dakota formations, being of near-shore or brackish water origin, marks the beginning of the sea invasion. In this sea several thousand feet of sediments, representing the Colorado and Montana groups, were deposited. The end of the Upper Cretaceous sea invasion is marked by the top of the brackish-water sediments of the Fox Hills, which were followed by the continental coal-bearing deposits of Laramie age.

**Cenozoic Era**

The Laramide Revolution ended the Mesozoic era. This deformation, which was accompanied by orogenic movement and crustal deformation, began in Late Cretaceous and was active until the early part of the Cenozoic era. The character of the Dawson arkose, which represents the Tertiary sediments in the area, suggests that the Front Range was relatively high and the Pikes Peak granite the main contributor to sedimentation.

The faulting episode in the Perry Park area seems to
be contemporaneous with deposition of the Dawson arkose. This fact is shown by the local structural disturbances which have involved the Dawson arkose.
Mineralization is not known to exist in the Perry Park area. In the past, flour gold has been found in the streams to the east of the area. Several prospect holes in the granite testify to the attempts made at finding the source of gold.

Gypsum beds of Ralston formation may have some economic possibilities, and apparently few attempts have been made in past to exploit this deposit.

The rocks in the area are not suitable for large-scale exploitation as building materials. The granite is coarse-grained and contains biotite, therefore not fit for construction purposes. The Lyons sandstone in Perry Park area is cross-bedded but not flaggy enough to be suitable for building. The Dakota sandstone has been used as a construction material in past, but its lack of decorative value makes it unsuitable for modern architecture.

The Laramie formation has produced coal in other areas. In Perry Park area no outcrop of coal seams have been observed by writer.

The upper part of Sawatch sandstone in Cove Creek Canyon contains considerable amount of glauconite. The abundance of this mineral, which is used as water softener, in Sawatch may attach some economic importance to this formation.
BIBLIOGRAPHY


