Geology of the Platte Canyon Quadrangle Colorado

By WARREN L. PETERSON

CONTRIBUTIONS TO GENERAL GEOLOGY

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A description of metamorphic and igneous rocks of Precambrian age in the Front Range

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CONTENTS

ILLUSTRATIONS

TABLE

GEOLOGY OF THE PLATTE CANYON QUADRANGLE, COLORADO

By WARREN L. PETERSON

ABSTRACT

The Platte Canyon quadrangle is in Jefferson and Douglas Counties, Colo., on the eastern side of the Front Range. The area is an upland surface of low relief cut by deep canyons.

Most of the area is underlain by metamorphic and igneous rocks of Precambrian age. Metasedimentary rocks, the oldest rocks in the area, are migmatized biotite gneiss, amphibolite, sillimantic biotite gneiss, and calc-silicate gneiss. The Precambrian igneous rocks are quartz diorite, biotite-muscovite granite, Pikes Peak Granite, and mafic dikes. Sandstone of probable Cambrian age occurs in thin dikelike bodies in some fault zones; mafic intrusive rock of Cretaceous or Tertiary age occurs in thin dikes that cut the metamorphic rocks.

Very coarse gravel of late Tertiary age caps hills in the southwestern corner of the quadrangle, sparse alluvium occurs in the valley bottoms, and colluvial debris mantles many slopes.

Foliation and layering in the metamorphic rocks strike dominantly west-northwest and dip steeply north. Dominant lineations plunge steeply north-northeast.

Laramide faults and fracture zones are common in the quadrangle; the most conspicuous strike northwest and are nearly vertical. Healed breccia and sandstone dikes indicate that Precambrian or possibly Cambrian faulting established the lines of weakness followed by many of the Laramide faults.

INTRODUCTION

The Platte Canyon quadrangle has an area of about 56 square miles in Jefferson and Douglas Counties on the eastern side of the Front Range in Colorado (fig. 1). The quadrangle is accessible from the north by county roads that lead south from U.S. Highway 285 and Colorado Highway 124, from the south by a county road that joins Colorado Highway 67, and from the west by roads that join Colorado Highway 126.

The study of the Platte Canyon quadrangle was undertaken primarily to provide geologic information that is basic to planning

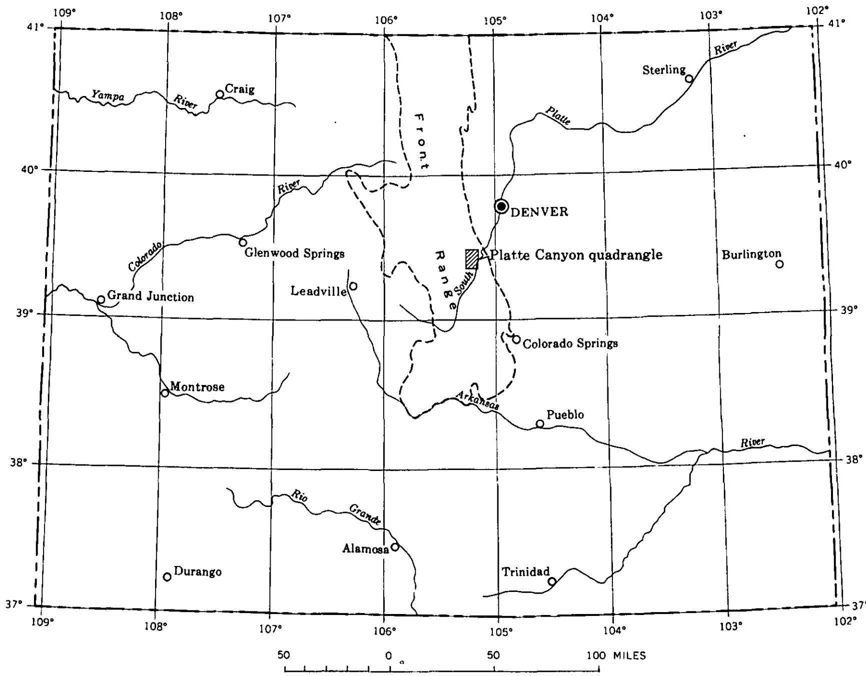

FIGURE 1.—Index map of Colorado showing location of the Platte Canyon quadrangle. Outline of the Front Range after Lovering and Goddard (1950, pl. 4).

engineering projects along the South Platte River and its north fork by the Denver City Water Board and the U.S. Bureau of Reclamation.

The quadrangle is characterized by broad upland areas of low relief, at altitudes of 7,500 to 8,500 feet, that are separated by the Platte Canyon and a network of tributary canyons. The valley walls are steep and rise locally as much as 2,000 feet above the South Platte River. The South Platte River flows northward across the southeast corner of the area and is joined from the west by the North Fork of the South Platte River at South Platte. Only the South Platte River and its north fork are perennial.

Geological fieldwork was done during the summers of each year from 1955 to 1959. I was ably assisted by the late John J. Halbert during the summers of 1957 and 1958.

I thank Glenn R. Scott and Douglas M. Sheridan of the U.S. Geological Survey for many helpful discussions. I also thank the many property owners who allowed access to their lands, especially Mr. Harry Graham of Foxton who provided field accommodations.

PRECAMBRIAN ROCKS

The Platte Canyon quadrangle is within the Precambrian core of the Front Range; it lies across the contact of a large batholith of Pikes Peak Granite with the Idaho Springs Formation. The batholith underlies the southwestern one-third of the quadrangle and extends 60 miles to the south; the Idaho Springs Formation lies to the north and east (Lovering and Goddard, 1950, pl. 1). The Precambrian rocks include metasedimentary rocks, migmatite composed of interlayered metasedimentary rock and granitic rock of unknown origin, granitic gneiss of unknown origin, and intrusive igneous rocks. The metamorphosed sedimentary rocks are the oldest rocks in the area. The igneous rocks include quartz diorite, biotite-muscovite granite, Pikes Peak Granite and pegmatite. Some mafic dikes are also of probable Precambrian age.

The metasedimentary rock, migmatite, and granitic gneiss form a gradational series. They have been subdivided according to the following system, modified from that of Harrison and Wells (1959, p. 49) : (a) nearly pure metasedimentary rock, containing as much as 10 percent interlayered granitic material, is called metasedimentary rock, (b) nearly pure granitic rock, containing as much as 10 percent interlayered metasedimentary rock is called granitic gneiss, and (c) all the rock between these end numbers is called migmatite.

Most contacts between Precambrian rocks are gradational. In general the contacts between units are drawn arbitrarily within gradation zones 10 to 200 feet wide and, in areas of poor exposure, as much as 500 feet wide.

The Pikes Peak Granite (pl. 1) is widely exposed but the other rocks are exposed mainly along the Platte Canyon and on the northeastern sides of valleys tributary to the Platte Canyon. The rocks underlying Russell Ridge, Sheep Mountain, and the long ridge that extends from the northwest corner of the map area southeastward to Turkshead Peak (pl. 1) are generally concealed by soil cover; those on the southwestern sides of the valleys tributary to the South Platte River are generally concealed by forest cover.

Names used in this report for some rocks differ from those used previously for the same rocks by Peterson and Scott (1960). The term "biotite gneiss" is used for biotite-quartz-plagioclase gneiss, "granitic gneiss" for gneissic fine-grained granite, and "sillimanitic biotite gneiss" for sillimanitic biotite-quartz gneiss.

METASEDIMENTARY ROCKS

The metasedimentary rocks of the northeastern two-thirds of the quadrangle were mapped as biotite gneiss, sillimanitic biotite

TABLE 1.—*Summary of*

[Major constituents: all percentages greater than 1.9 rounded to nearest whole number; minor constituents: avg, average; min, minimum;

Sample group	Rock type	Number of modes	Major constituents														
			Alkali feldspar			Plagioclase			Quartz			Biotite			Hornblende		
			Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min
1	Biotite gneiss	6	23.0	4.0	0	31	22	14	56	48	37	33	23.0	15.0	9	1.5	0
2	Biotite gneiss (from layers in areas underlain by migmatite).	7	9.0	1.4	0	56	36	8	53	41	27	29	18.0	7.0	2	.4	0
3	Hornblendic biotite gneiss (from layers in migmatite).	6	.4	Tr.	0	52	34	13	28	25	21	29	24.0	13.0	30	18.0	10.0
4	Amphibolite (from areas mapped as amphibolite and layers in areas mapped as migmatite).	7	0	0	0	65	42	25	7	2	0	3	.4	0	68	53.0	34.0
5	Microcline-bearing sillimanitic-biotite gneiss.	4	23.0	16.0	0	22	17	8	52	37	19	30	21.0	12.0	0	0	0
6	Granitic layers in migmatite.	7	50.0	33.0	22	42	33	15	42	31	16	7	1.4	0	0	0	0
7	Granitic gneiss	4	40.0	35.0	29	29	24	20	47	38	31	2	1.3	.6	0	0	0
8	Biotite-quartz diorite	2	0	0	0	54	49	44	23	20	18	27	24.0	20.0	Tr.	Tr.	Tr.
9	Biotite-muscovite granite from Casto Creek pluton.	5	42.0	37.0	34	30	26	23	35	32	27	3	1.1	0	0	0	0
10	Pikes Peak Granite, variety quartz monzonite.	4	54.0	38.0	25	32	24	13	28	26	20	10	9.0	5.0	5	4.0	.3
11	Pikes Peak Granite, variety granite.	7	58.0	49.0	41	23	17	12	35	28	24	6	4.0	3.0	3	1.2	0
12	Fine-grained alaskite dikes in Pikes Peak Granite.	3	41.0	35.0	27	41	28	19	37	35	31	4	1.3	0	0	0	0
13	Fine-grained alaskite associated with inclusions in Pikes Peak Granite.	4	54.0	46.0	36	52	24	14	46	28	6	4	1.5	0	0	0	0

gneiss, and amphibolite. Calc-silicate gneiss was observed in small areas but was not mapped. The relative ages of the metasedimentary rock units are not known. These map units are subdivisions of the Idaho Springs Formation as defined by Ball (1906) and mapped by Lovering and Goddard (1950, pl. 1) in the northeastern part of the Platte Canyon quadrangle.

Most of the metasedimentary rock in the quadrangle is intimately interlayered with granitic material and is classed as migmatite. Metasedimentary rock that contains less than 10 percent of interlayered granitic material is largely restricted to the northeastern corner of the quadrangle.

BIOTITE GNEISS (BIOTITE-QUARTZ-PLAGIOCLASE GNEISS)

Biotite gneiss crops out in the northeastern part of the quadrangle in a narrow irregular belt that extends west-northwest about 3 miles from the eastern edge of sec. 5, T. 7 S., R. 69 W., and in a small area along the northern border northeast of Critchell. It also occurs in innumerable thin lenses and discontinuous layers in the area underlain by migmatite, and grades along and across strike into migmatite.

modal analyses, in percent

any given thin section commonly contains less than 0.3 percent of each of listed minerals. Max, maximum; tr, trace (less than 0.3 percent)]

Major constituents—Con.						Minor constituents (maximum found)													
Muscovite			Sillimanite			Magnetite	Sphene	Apatite	Zircon	Allanite	Hematite	Chlorite	Clinozoisite	Fluorite	Carbonate	Pyrite	Garnet	Leucoxene	Clinopyroxene
Max	Avg	Min	Max	Avg	Min														
Tr.	0	0	0	0	0	0.7	1.3	0.4	Tr.	0.4	Tr.	0.4	0.7	0	0	0	2.4	0	0
1.6	0.3	0	0	0	0	1.1	Tr.	.9	Tr.	.6	Tr.	Tr.	Tr.	0	0	0	Tr.	0	0
0	0	0	0	0	0	.6	.3	.5	Tr.	.5	0	0	0	0	0	Tr.	0	0	0
0	0	0	0	0	0	.7	1.8	.3	0	0	Tr.	.9	0	0	0	Tr.	0	0	0.6
1.8	0.5	0	10	8	4	1.1	0	Tr.	Tr.	0	0	0	0	0	0	0	.3	0	0
4.0	1.1	0.5	0	0	0	Tr.	0	Tr.	Tr.	Tr.	0	1.0	Tr.	0	0	0	0	Tr.	0
1.4	.4	0	0	0	0	1.1	Tr.	Tr.	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1.7	.8	1.5	0	0	Tr.	.7	.4	0	0	Tr.	0	0	0
6.0	3.0	1.7	0	0	0	.8	0	0	Tr.	0	0	2.0	0	0	0	0	0	Tr.	0
0	0	0	0	0	0	2.7	1.5	1.0	Tr.	0	Tr.	Tr.	0	0	0	0	0	Tr.	0
Tr.	0	0	0	0	0	.4	0	Tr.	Tr.	.4	0	Tr.	0	1.0	Tr.	0	0	0	0
Tr.	0	0	0	0	0	.6	0	0	Tr.	0	0	0	0	.8	0	0	0	0	0
0	0	0	0	0	0	Tr.	0	0	Tr.	0	Tr.	Tr.	0	Tr.	0	0	0	0	0

The biotite gneiss is a fine- to medium-grained, medium- to dark-gray, well-foliated rock. The foliation is produced by planar arrangement of the biotite crystals and by a fine layering defined by light-colored minerals and biotite in alternating layers $1/32$ to $1/16$ inch thick. Thicker light and dark layers, 1 inch to 1 foot thick, exist in places but are traceable only a few feet.

The principal minerals are quartz, biotite, plagioclase (oligoclase-andesine), and, in places, hornblende and microcline. Accessory minerals are magnetite, chlorite, apatite, sphene, muscovite, sericite, clinozoisite, allanite (commonly inclosed in clinozoisite), zircon, garnet, hematite, and pyrite. Compositions of several samples from the northeastern part of the quadrangle are summarized in table 1. Sample groups 1 and 2 show that biotite gneiss in the migmatite is generally similar in composition to that in the mapped bodies. One sample in each of the two groups contains a large percentage of microcline whereas the other samples in the two groups contain none or a trace. The microcline-rich samples are megascopically similar to those containing no microcline.

AMPHIBOLITE

Amphibolite occurs in discontinuous concordant layers and lenses throughout the gneissic rocks, but most of the occurrences are too small to show on plate 1. Several large bodies crop out in the northeastern corner of the quadrangle, and three large bodies crop out in the southeastern part.

Most amphibolite bodies are surrounded by zones of interlayered amphibolite and granite a few feet thick. Contacts between the individual layers of amphibolite and granite are sharp. Contacts between amphibolite and biotite gneiss are gradational because of interlayering of biotite gneiss and amphibolite, or, less commonly, because of hornblende in the biotite gneiss adjoining amphibolite.

Amphibolite is a dark-green to black fine- to medium-grained well-foliated gneiss. The finer grained rock is finely laminated and has irregular light-gray layers of plagioclase and dark-green to black layers of hornblende. The medium-grained rock generally lacks lamination; the hornblende and plagioclase are segregated into irregular lens-shaped aggregates that give the rock a speckled appearance.

Much amphibolite consists almost exclusively of subhedral hornblende and anhedral plagioclase (andesine-labradorite), but some contains quartz and biotite. Accessory minerals are magnetite, apatite, sphene, chlorite (derived from biotite), clinopyroxene, hematite, and pyrite (table 1).

Most amphibolite contains little or no biotite, and most biotite gneiss contains little or no hornblende. Locally, biotite-bearing amphibolite grades gradually into hornblende-bearing biotite gneiss, but such intermediate rocks are not common. Modes of several samples of intermediate rocks (table 1, sample group 3) indicate that quartz is a major constituent and that the proportions of hornblende and biotite vary widely.

Amphibolite contains interlayered granitic rock in smaller quantity and in different pattern than does biotite gneiss. The granitic rock is typically in coarse layers along the borders of bodies of amphibolite and is absent near their centers, whereas in biotite gneiss it is more uniformly distributed in fine layers throughout the rock.

CALC-SILICATE GNEISS

Small bodies of calc-silicate rock are sparsely scattered through the migmatite in the Platte Canyon quadrangle, but none was mapped separately. The calc-silicate rock may be divided into two varieties: (a) fine-grained, strongly foliated layered gneiss, and (b) fine- to very coarse-grained unlayered and unfoliated rock.

Most of the fine-grained layered gneiss is interlayered with amphibolite in thin discontinuous layers that parallel the foliation. Notable amounts of calc-silicate gneiss are interlayered with amphibolite in the inclusion in the biotite-muscovite granite in the northwestern corner of the quadrangle. The principal minerals there are hornblende, clinopyroxene, plagioclase, and clinozoisite. Other minerals observed are sphene, quartz, calcite, biotite, magnetite, limonite, garnet, tremolite, microcline, apatite, and scapolite. Calc-silicate gneiss is commonly finely layered; very dark green layers composed predominantly of hornblende alternate with pale-green or greenish-gray layers composed mostly of plagioclase and clinopyroxene. In places, the dark layers are predominantly clinopyroxene and the light layers mostly plagioclase.

The fine- to very coarse-grained massive calc-silicate gneiss occurs in irregularly lens-shaped bodies which are conformable to the foliation. They are predominantly quartz, epidote, hornblende, and subordinate red garnet. Other minerals are clinopyroxene, feldspar, calcite, pyrite altered to limonite, actinolite, and amphibole asbestos.

SILLIMANITIC BIOTITE GNEISS

A small body of sillimanitic biotite gneiss was mapped near the northeast corner of the quadrangle, and several bodies too small to show on plate 1 were seen in other parts of the quadrangle. The sillimanitic biotite gneiss grades into biotite gneiss through zones in which layers of sillimanite-rich rock alternate with layers of sillimanite-poor rock.

The sillimanitic biotite gneiss is an interlayered mixture of dominant microline-bearing sillimanitic biotite gneiss and subordinate sillimanitic biotite gneiss, biotite gneiss, calc-silicate gneiss, and quartzite. The individual layers of these rock types are not shown on plate 1.

Microcline-bearing sillimanitic biotite gneiss is fine grained, very finely layered, and well foliated. The fresh gneiss is dark gray; the weathered gneiss is silver gray or blue gray. The foliation is produced by the parallel arrangement of platy biotite crystals and thin lenses, pods, and discontinuous layers of sillimanite which are less than 1 mm thick. The principal minerals are plagioclase (oligoclase), microcline, quartz, biotite, and sillimanite; accessories include magnetite, apatite, red garnet, muscovite, and zircon (table 1). Garnet crystals are sparse but conspicuous and occur singly and in clusters.

Biotite gneiss composes about 20 percent of the sillimanitic biotite gneiss. It forms discontinuous lenses and layers that are interlayered with the microcline-bearing sillimanitic biotite gneiss. Much of the biotite gneiss is sillimanitic and apparently grades into microcline-bearing sillimanitic biotite gneiss. The biotite gneiss is locally garnetiferous.

Layers of calc-silicate gneiss and closely associated gray quartzite are scattered throughout the area mapped as sillimanitic biotite gneiss. The layers are a few inches to 2 feet thick and comprise 1 or 2 percent of the map unit.

The curiously circular outline of the body of sillimanitic biotite gneiss shown on plate 1 has no known structural significance. It may have been an aluminum-rich lens in the original sediments.

MIGMATITE

Migmatite underlies most of the northern two-thirds of the quadrangle. It is composed of interlayered metasedimentary rocks, which are predominantly biotite gneiss, and light-colored granitic rock. There appears to be a complete gradation from pure biotite gneiss to pure granitic gneiss, and separation of migmatite from the metasedimentary rock and granitic gneiss must be made arbitrarily. Most of the migmatite contains 20 to 30 percent granitic rock. The origin of the granitic rock is unknown but it is presumably younger than the interlayered metasedimentary rock.

Granitic layers range in thickness from paper-thin to 3 inches and, rarely, to several feet. The thinner layers, less than one-half inch thick, generally can be traced only a few inches to a few feet; those more than 1 inch thick generally can be traced several feet. (See figs. 2, 3.)

Thin but persistent layers of nearly pure biotite commonly line the contacts between granitic material and biotite gneiss. The biotite layers range in thickness from $1/64$ to $1/16$ inch. Layers of biotite within some layers of granitic rock also parallel the contacts with biotite gneiss.

The granitic rock ranges from fine to coarse grained, but is mostly fine to medium grained. It is locally pegmatitic and has grains as much as three-fourths inch in diameter.

The granite layers are predominantly pink and are predominantly of microcline, plagioclase (oligoclase), and quartz. Some layers are banded pink and gray, reflecting the predominance of microcline and plagioclase, respectively. Biotite is sparse and variable in amount. Accessory minerals are muscovite, magnetite, chlorite (altered biotite), zircon, apatite, leucoxene, clinozoisite, and allanite (table 1). In places, magnetite is a major constituent in the pegmatitic parts of the granite layers.

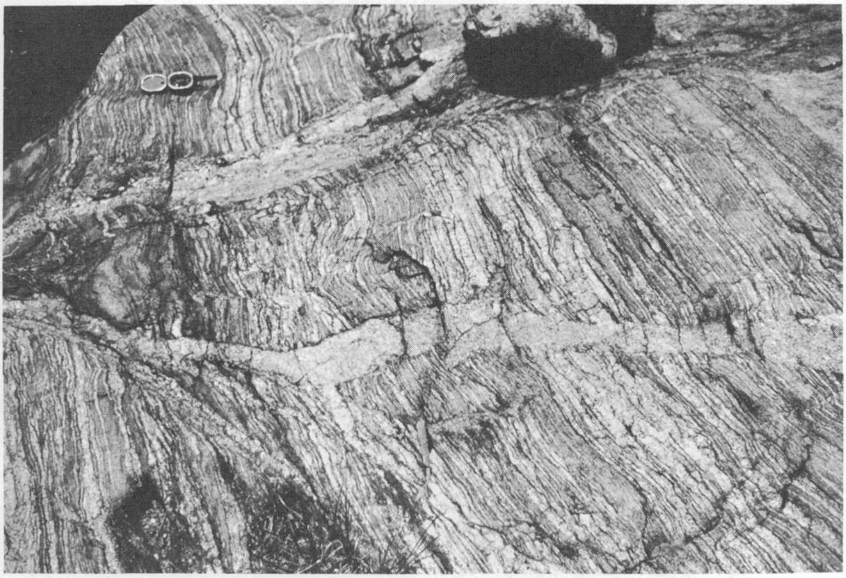

FIGURE 2.—Thinly layered migmatite composed of biotite gneiss and granitic rock. Migmatite is cut by granite dikes which fill faults of small displacement. Exposure is in the NE¼SE¼ sec. 8, T. 7 S., R. 70 W.

GRANITIC GNEISS

Granitic gneiss forms two large bodies in the northeastern part of the quadrangle and crops out in numerous small bodies throughout the area mapped as migmatite. The gneiss is of the same age as the granitic layers in the migmatite; its origin is unknown.

Some of the granitic gneiss contains no recognizable metasedimentary rock, but most of it contains wisps, knots, and thin layers of metasedimentary rock and grades along and across strike into migmatite and biotite gneiss. Where the content of interlayered metasedimentary rock exceeds 10 percent, the rock was mapped as migmatite.

The granitic gneiss is well foliated and pink where fresh and pale yellowish brown to pink where weathered. It is generally fine grained but locally is medium grained and, rarely, pegmatitic. Where uncontaminated, it is generally very light colored. The principal minerals are microcline, plagioclase (oligoclase), quartz, and biotite (table 1). Accessory minerals are magnetite, muscovite, apatite, sphene, and zircon.

The lightest colored granite gneiss is difficult to separate from fine-grained biotite-muscovite granite. Parts of the areas shown as granitic gneiss on plate 1 lack foliation and may in-

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clude some of the granite. Granitic gneiss in the extreme northeastern corner of the quadrangle is continuous with an area in the Kassler quadrangle mapped as biotite-muscovite granite by Scott (1963). There, the granitic gneiss has been intruded by biotite-muscovite granite.

BIOTITE QUARTZ DIORITE

A small body of biotite-quartz diorite is exposed at the northern edge of the Pikes Peak Granite batholith, near the western edge of the quadrangle. Its contacts with the migmatite are sharp or occupy a zone of gradation only a few inches wide, but evidence of crosscutting was not seen.

The biotite-quartz diorite is gray, medium grained, and foliated parallel to the foliation in the country rock. It is composed predominantly of biotite, quartz, and plagioclase (andesine) and contains accessory apatite, sphene, magnetite, hematite, clinozoisite, chlorite, and pyrite (table 1).

The diorite is cut by granite dikes that are presumably contemporaneous with the biotite-muscovite granite. It is probably younger than the migmatite and granitic gneiss but its age relative to the hornblende-quartz diorite discussed below has not been determined.

HORNBLENDE QUARTZ DIORITE

Several small bodies of speckled white and very dark green medium-grained hornblendic rock, having some contacts that crosscut the foliation, were observed in the area mapped as migmatite. This rock is similar to the quartz diorite and associated hornblendite of Harrison and Wells (1956, 1959). Only one of the bodies is of mappable size and is shown on plate 1. Parts of this body are weakly foliated parallel to the foliation in the country rock. As determined from one thin section, hornblende, biotite, microcline, quartz, and plagioclase are the major constituents.

The small body of hornblende-quartz diorite shown on plate 1 is crossed by dikes of fine-grained granite and pegmatite that are presumed to be the same age as the biotite-muscovite granite. The quartz diorite is probably younger than the migmatite and granitic gneiss.

BIOTITE-MUSCOVITE GRANITE

Biotite-muscovite granite was mapped in one large and several small bodies in the northern part of the quadrangle, and dikes and sills that seem to be related to it are abundant throughout the quadrangle. The granite is pale pink where fresh and light tan to pink where weathered.

Table 1 indicates that biotite-muscovite granite has the average composition of quartz monzonite. It is designated granite because of its appearance and because of previous usage, as by Boos and Aberdeen (1940), Harrison and Wells (1956; 1959), Peterson and Scott (1960), Scott (1963), and other writers.

The large body of biotite-muscovite granite on the northeastern side of Kennedy Gulch was mapped by Boos and Aberdeen (1940) who called it the Casto Creek pluton and considered it part of the Indian Creek Granite, which they correlated with the Silver Plume Granite. In the Casto Creek pluton the granite is medium grained and has variable amounts of tabular microcline phenocrysts that are commonly about 1 cm long but are as much as 2.5 cm. The phenocrysts are alined in some parts of the body, and some are alined parallel to the contact. The principal minerals are microcline, plagioclase (oligoclase), quartz, muscovite, biotite, and chlorite (table 1). Contacts of the Casto Creek pluton with the surrounding rock are either sharp or they are gradational as a result of interlayering. The southern part of the pluton is grossly conformable with the country rocks, but it is crosscutting in detail. The biotite-muscovite granite in sec. 35, T. 6 S., R. 70 W., is fine grained and contains widely scattered feldspar phenocrysts. Fractures that contain a very thin filling of epidote occur in most bodies of the granite.

Many small tabular or lens-shaped bodies of very light colored granitic rock crop out in the migmatite north and south of the Casto Creek pluton. The contacts of these bodies are sharp. The rock differs texturally from that of the Casto Creek pluton in being either coarse or fine grained, locally pegmatitic, and nonporphyritic but its composition and spatial relation to the pluton suggest that it is related to the biotite-muscovite granite of the pluton.

Thin dikes and sills of granite are abundant in the gneissic rocks (fig. 2). They are younger than the granitic layers in the migmatite but are not easily distinguishable unless they are crosscutting. They are fine to coarse grained and many are pegmatitic. They have sharp contacts with the country rock and many of the dikes occur in faults of small displacement. As far as known, these dikes and sills are younger than most or all of the small folds and crinkles found abundantly in the gneissic rocks. Though no direct relation with the biotite-muscovite granite has been proved, it seems probable that these dikes and sills were intruded at or near the same time as the Casto Creek pluton.

Biotite-muscovite granite is older than the Pikes Peak Granite, as shown both by field relations and potassium-argon age determinations. Dikes of granite presumably related to biotite-muscovite granite are cut off by the Pikes Peak Granite. Excellent exposures illustrating this relationship can be seen in the west-central part of the SW¼ sec. 9, T. 7 S., R. 70 W. Hutchinson (1959a, b; oral communication, 1960) has reported an age of 1,240 million years for biotite-muscovite granite in the Doublehead pluton, about 6 miles north of the Casto Creek pluton (Boos and Aberdeen, 1940), and of 1,080 million years for the granite in the northern end of the Pikes Peak batholith.

PIKES PEAK GRANITE

The Pikes Peak Granite, which contains both granite and quartz monzonite varieties, underlies the southwestern one-third of the quadrangle and is generally in sharp contact with the older rocks. A few small tabular bodies of the granite lie in the metamorphic rocks near the contact, and small scattered inclusions of metamorphic rocks lie in the batholith. The contact with the migmatite is well exposed at three localities. At two localities the contact is sharp. At the third, layers of Pikes Peak Granite 2 to 6 inches thick are interlayered with metasedimentary rock in a zone a few feet thick, but contacts between layers are sharp. The batholith is not bordered by a recognizable contact metamorphic halo. The contact dips steeply away from the batholith.

The Pikes Peak Granite crops out in smooth rounded masses. Locally, however, the rock is strongly fractured or sheared and does not crop out except along the very steep declivities, where it forms ragged angular outcrops.

The Pikes Peak Granite contains a platy flow structure formed by tabular microcline crystals, but the structure is obscure in the Platte Canyon quadrangle and was not mapped. The flow structure in the northern end of the batholith has been described briefly by Hutchinson (1960, pl. 1).

QUARTZ MONZONITE

The quartz monzonite variety of the Pikes Peak Granite crops out in the southwestern part of the quadrangle about 4 miles from the border of the batholith. The quartz monzonite grades into granite across a zone several hundred feet wide. As the quartz monzonite is approached from the granite, the rock darkens owing to increasing amounts of dark minerals, and scattered large pink crystals of microcline stand out against the darker gray medium-grained background.

The quartz monzonite is a medium- to coarse-grained rock of seriate or porphyritic texture. Where fresh, it is a faintly mottled light gray and light pinkish gray and is speckled with dark minerals; where weathered, it is light brownish gray. The principal minerals are plagioclase (oligoclase), microcline (in part perthitic), quartz, biotite, hornblende, sphene, apatite, and magnetite. Accessory minerals are zircon, hematite, and chlorite (table 1). Large euhedral crystals of gray plagioclase that are rimmed with colorless plagioclase are scattered through the rock. Much of the microcline occurs in large crystals that are 2 to 3 times larger than the average grains in the groundmass; these crystals give the rock a porphyritic appearance. The microcline crystals are as much as 4 cm long but average about 1.5 cm; they form a few percent to perhaps 75 percent of the rock and average about 10 percent. Biotite, hornblende, magnetite, sphene, apatite, and zircon tend to be clustered.

GRANITE

The granite variety of the Pikes Peak Granite underlies all the outcrop area except about 1 square mile in the southwest corner of the quadrangle. It is a homogeneous medium- to coarse-grained seriate-textured rock; rarely it is porphyritic. The fresh rock is pale pink; weathered rock is tan to pink. Principal minerals are microcline-perthite (and antiperthite), quartz, plagioclase (oligoclase), biotite, and hornblende. Common accessory minerals are fluorite, magnetite, allanite, and zircon (table 1). Biotite, hornblende, fluorite, magnetite and zircon tend to form aggregates and are not generally scattered singly through the rock.

FINE-GRAINED ALASKITE DIKES

The Pikes Peak Granite is cut by dikes of fine-grained alaskite. The dikes are less than an inch to as much as 10 feet thick, but most are less than 2 feet thick. Individually they are of uniform thickness and some are several hundred feet long. Most are nearly vertical, and many strike normal to the arcuate contact of the Pikes Peak Granite; others do not show a systematic orientation. The contacts are sharply gradational across 1/4 to 1/2 inch; the borders are not chilled. Some dikes are faintly layered parallel to the contacts. Some are parallel to nearby quartz veins, others contain quartz veins, and a few change along strike to quartz veins or pegmatite dikes. One dike cutting an allanite-rich layer in the granite was observed (p. C15).

The dike rock is fine grained and is light grayish pink where fresh and light brownish pink where weathered. The dominant minerals are quartz, microcline (rarely perthitic), and plagioclase. Dark minerals form less than 5 percent of the rock, in most places less than 1 percent. Accessory minerals include magnetite, fluorite, biotite, muscovite, and zircon (table 1).

PEGMATITE

Pegmatites are common in the Pikes Peak Granite, and several bodies of similar pegmatite have been found in the migmatite as far as 2½ miles from the contact with the Pikes Peak Granite. In plan, most of the pegmatite bodies are roughly circular or elliptical, but their shapes in depth are not known. They range in size from 1 to several hundred feet across but most are 5 to 50 feet in maximum dimension. Only those at least 5 feet across are shown on plate 1. The pegmatites are very coarse near the center and decrease in grain size toward their peripheries. Contacts with the Pikes Peak Granite are sharp and are defined by change in grain size or rock composition.

Several pegmatite zones have been recognized. From the center outward, they are:

1. Quartz or quartz and microcline-perthite core: Some pegmatites have a well-defined core that consists of white quartz alone, but in most the quartz of the core is accompanied by subordinate microcline-perthite segregated into large masses.
2. Microcline-perthite zone: Outward from the core, quartz decreases and microcline increases to a zone of nearly pure microcline-perthite. This zone has been removed by mining in several of the larger pegmatites. Some pegmatites have pale-green fluorite in this zone or between this zone and the core.
3. Biotite-quartz-microcline-perthite zone: Outward from the microcline-perthite zone is a zone composed of large euhedral biotite books, microcline-perthite, and minor amounts of quartz.
4. Biotite-graphic granite zone: Zone 3 grades into a zone consisting of biotite in thin narrow triangular crystals and quartz and microcline-perthite intergrown as graphic granite. This is the outer zone of most pegmatites.
5. Medium-grained granite zone: Locally the outer zone is a medium-grained granite containing triangular biotite crystals similar to those in zone 4. It is in sharp contact both with the rock of zone 4 and with the Pikes Peak Granite.

Purple fluorite occurs in most of the larger pegmatites. Amazonite and allanite have each been found in one pegmatite. Magnetite occurs rarely. Cyrtolite, columbite-tantalite, and xenotime have been identified by John W. Adams (oral communication, 1961) in pegmatites in the SE¼NE¼ sec. 33, T. 7 S., R. 70 W. Other minerals have been identified by Heinrich (1958) and Haynes (1958), who found some pegmatites to be rich in rare earth minerals.

Tabular pegmatite dikes are uncommon and can be traced only a few tens of feet. None more than 2 feet thick was observed.

Most of the tabular pegmatites have quartz cores and outer layers of microcline-perthite. Some contain biotite at the contacts with the Pikes Peak Granite. These zoned tabular pegmatites have been traced into pure quartz pegmatites and into fine-grained alaskite dikes.

ALLANITE-RICH LAYERS

In places, the Pikes Peak Granite contains thin, dark, curved layers (or veins) that contain abundant allanite as well as feldspar, quartz, biotite, and fluorite. The feldspar is reddened, and in outcrop, the layers show as gently curved reddish-brown bands 1 to 3 inches wide. The layers generally occur singly, but in places two or three occur together, spaced a few feet apart. Many layers have a zone ½ to 1 inch wide on each side that is free of dark minerals. The layers strike and dip in various directions and appear to be randomly oriented.

Thin sections of the allanite-rich layers show fractured grains of quartz and feldspar and bent crystals of biotite as if the rock had been sheared. The layers were probably formed by the deposition of allanite and fluorite along thin shear zones formed late in the consolidation stage of the Pikes Peak Granite.

INCLUSIONS AND ASSOCIATED ALASKITE

The Pikes Peak Granite contains many inclusions of metasedimentary rock and migmatite; most of the larger inclusions are intruded or enveloped by fine-grained alaskite. The inclusions range in size from equant bodies 1 inch in diameter to elongate bodies one-third of a mile long. Contacts of the inclusions with the alaskite and the medium- to coarse-grained Pikes Peak Granite are sharp. The bodies shown on plate 1 are composed of alaskite, migmatite, and metasedimentary rocks. The two largest bodies in sec. 4, T. 8 S., R. 70 W., are composed almost entirely of migmatite. The inclusions tend to be concentrated in two belts that parallel the contact of the Pikes Peak Granite with the metamorphic rocks.

The alaskite is generally pink to pale-red fine-grained sugar-textured rock and is rarely medium grained or porphyritic. It is composed predominantly of perthitic microcline, plagioclase, quartz, and biotite (table 1).

The pegmatites, the alaskite associated with the inclusions, the alaskite dikes, and the typical Pikes Peak Granite are mineralogically similar and are probably genetically related.

FOLIATED MAFIC DIKES

Several thin, closely spaced mafic dikes, shown as a single line on plate 1, crop out in a small area in sec. 5, T. 7 S., R. 69 W.

All the dikes strike about N. 70° W. and dip about 60° N. They crosscut the foliation and layering in the country rock, have sharp contacts, and are strongly foliated parallel to the walls. The rock is medium grained and very dark green to black. The grain size does not appear to change across or along the dikes. Principal minerals are biotite, hornblende, quartz, and feldspar.

The dikes are distinguished from younger mafic dikes by their foliation and are probably Precambrian in age.

CAMBRIAN(?) ROCKS

Sandstone and quartzite form vertical or nearly vertical dikelike bodies in some of the persistent fault zones. Outcrops and float of the sandstone have been found only in the faults in Bear Gulch, Willow Creek valley, and in the fault that extends southeastward from Kennedy Gulch along the contact of the Pikes Peak Granite. Sandstone is shown only where outcrops were found, although it is probably more widespread. Vitanage (1954) shows a continuous dike in the fault that extends southeastward from Kennedy Gulch. Though the dike may be continuous, it crops out in only a few places and is more reasonably interpreted as a series of isolated tabular bodies in the fault zone.

The dikes, which have been described by Vitanage (1954) and Scott (1963), are composed of well-sorted fine-grained sand but locally contain angular fragments of country rock near the walls. A faint layering parallel to and near the walls is noticeable in places. The dikes within the quadrangle are all red brown, locally spotted white.

Viewed in thin section, the larger grains are well rounded and the smaller grains are angular. Many grains appear to have been etched; some grains are embayed by others,—a feature that suggests solution at the contacts. The grains are cemented by silica, iron oxide, and an unknown green mineral or appear to be stuck together without cement. A mode of one thin section and an examination of others showed 98 to 99 percent of the grains to be quartz.

At one outcrop, one-fifth mile east of South Platte School (pl. 1), healed fault breccia encloses the dike and indicates that the country rock was faulted, healed, and then reopened prior to the emplacement of the dike. Contact with the enclosing rock was not observed elsewhere in the quadrangle.

Vitanage (1954) suggests that the Sawatch Quartzite of Late Cambrian age was the source of the sandstone. The sand was emplaced downward in fissures when the Sawatch was still unconsolidated.

CRETACEOUS OR TERTIARY ROCKS

Mafic dikes of Cretaceous or Tertiary age cut the Precambrian rocks. They are most abundant on Russell Ridge in the southeastern part of the quadrangle, but they do not cut the Pikes Peak Granite. The dikes are as much as 8 feet thick, have sharp contacts, and lie in various attitudes; dips range from horizontal to vertical. Most of the dikes do not follow recognized fault zones or the foliation. Though sparse fragments of dike rock were found in many places, the dikes are shown on plate 1 only where they crop out or where abundant float indicates the position of the dike.

The dike rocks are fine grained, dark gray or dark greenish gray, and have a diabasic texture. Some rocks are conspicuously porphyritic and contain euhedral phenocrysts of plagioclase 0.5 to 2.5 cm in diameter. All dikes have a very fine grained chill border a few inches thick. Viewed in thin section, the rock is composed dominantly of plagioclase and contains altered ferromagnesian minerals and magnetite. Plagioclase forms tabular euhedral phenocrysts and randomly oriented lath-shaped crystals in the groundmass. Ferromagnesian minerals fill the interstices between the plagioclase laths; in some specimens they can be recognized as pale reddish-brown clinopyroxene, olivine altered to serpentine or green hornblende, but in others, they have been reduced to a mixture of brown mica, chlorite, magnetite, and carbonate minerals. The accessory minerals are apatite and pyrite. Quartz was observed only as vug fillings.

LATE TERTIARY DEPOSITS

Gravel of probable late Tertiary age caps several hills in the southwest corner of the quadrangle (pl. 1) and probably once covered a large area. No measurements of thickness were made because no suitable exposures were available, but the gravel is estimated to be 25 to 100 feet thick. The contact between the gravel and the Pikes Peak Granite shown on plate 1 marks the limits of the slopewash of this gravel rather than the contact between undisturbed gravel and Pikes Peak Granite.

The gravel was not seen in cuts, but slopewash indicates that it is composed of boulders 6 inches to 6 feet in diameter and a small percentage of sand and fine gravel. About 95 percent of the boulders are of fine- to medium-grained alaskite similar to that associated with the Pikes Peak batholith. Few boulders of typical Pikes Peak Granite were found. Vein quartz, gray quartzite, and granitic gneiss also occur but commonly only in pebble sizes. The pebbles and cobbles are well rounded; the boulders are subrounded to rounded.

RECENT DEPOSITS

Alluvium is sparse within the quadrangle and is generally in deposits too narrow to be shown on the map. In the South Platte River valley, it is as much as 20 feet thick and is composed predominantly of pebbles and cobbles derived from local rock. The bottoms of the valleys of the ephemeral tributaries of the South Platte River commonly contain a few inches to a few feet of coarse sand and fine gravel.

Disintegrated granite that has been redistributed locally by running water covers large areas in the southwestern part of the quadrangle but is not shown on plate 1. It ranges in thickness from a few inches to a few feet.

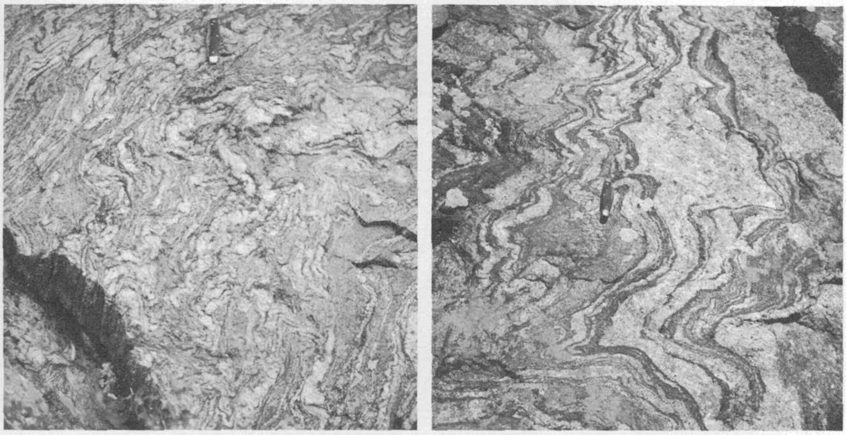
STRUCTURE

The foliation in the gneissic Precambrian rocks strikes generally north-northwest, almost parallel to the arcuate contact of the Pikes Peak Granite, and dips steeply northeast. The Precambrian rocks are broken by faults which trend dominantly northwest. All rocks are jointed.

WARPS, SMALL FOLDS, AND CRINKLES

Large folds are rarely seen in the quadrangle, but warps having wave lengths of 20 to 100 feet and amplitudes of a few feet occur throughout the gneissic rocks and form broadly arcuate outcrops. Two sets of small folds or crinkles at right angles to each other are superposed on these warps. The more conspicuous set, illustrated on figure 3, has axes that plunge down the dip of the foliation. Folds of this set commonly have amplitudes of ½ to 3 inches and wave lengths of 2 to 12 inches. Most of the lineations plotted on figure 4 are the axes of these small folds and crinkles. Folds of the other set are poorly formed; they have amplitudes of 3 to 12 inches and wave lengths of 3 to 6 feet; their axes tend to be horizontal. Small folds are most abundant in the migmatites. The metasedimentary rocks containing little granitic material are less crinkled and folded.

The foliation and the layering in both the metasedimentary rocks and the migmatite are involved in folds of all the kinds recognized;



A *B*

FIGURE 3.—Small-scale folding and contorted layers of granitic rock and biotite gneiss in the migmatite unit. The very thin dark layers consist predominantly of biotite. This type of minor folding is typical of much of the migmatite in the quadrangle. *A* is from SW¼SW¼ sec. 19, T. 7 S., R. 69 W.; *B* is from the SE¼NE¼ sec. 11, T. 7 S., R. 70 W.

consequently, they must either antedate the folding or be of the same age. The sills and dikes related to the biotite-muscovite granite are not folded, and granite of the Casto Creek pluton sharply crosscuts minor folds in one place. Most or all of the minor folding, therefore, occurred prior to the intrusion of the biotite-muscovite granite. The lineations in the gneissic rocks in the quadrangle do not generally indicate more than one period of folding.

LARGE FOLDS

Through the Platte Canyon quadrangle and the adjoining Kassler quadrangle to the east, the foliation strikes about N. 70° W. and dips about 60° NE. Peterson and Scott (1960) have suggested that this widespread orientation reflects major folds of northwest trend. No minor folds of this trend were observed; either none formed or they have been obliterated. The small-scale folds and warps described above all plunge northeast (fig. 4), and in small areas the foliation also strikes northeast (pl. 1). The northeast trend probably marks the dominant early structural orientation, in agreement with the orientation in the Freeland-Lamartine district (Harrison and Wells, 1956) 25 miles to the northwest. The minor folds may have been rotated into their present steep northeast plunge and the foliation into its steep northeast dip by the intrusion of the Pikes Peak batholith some time after the minor folds were formed.

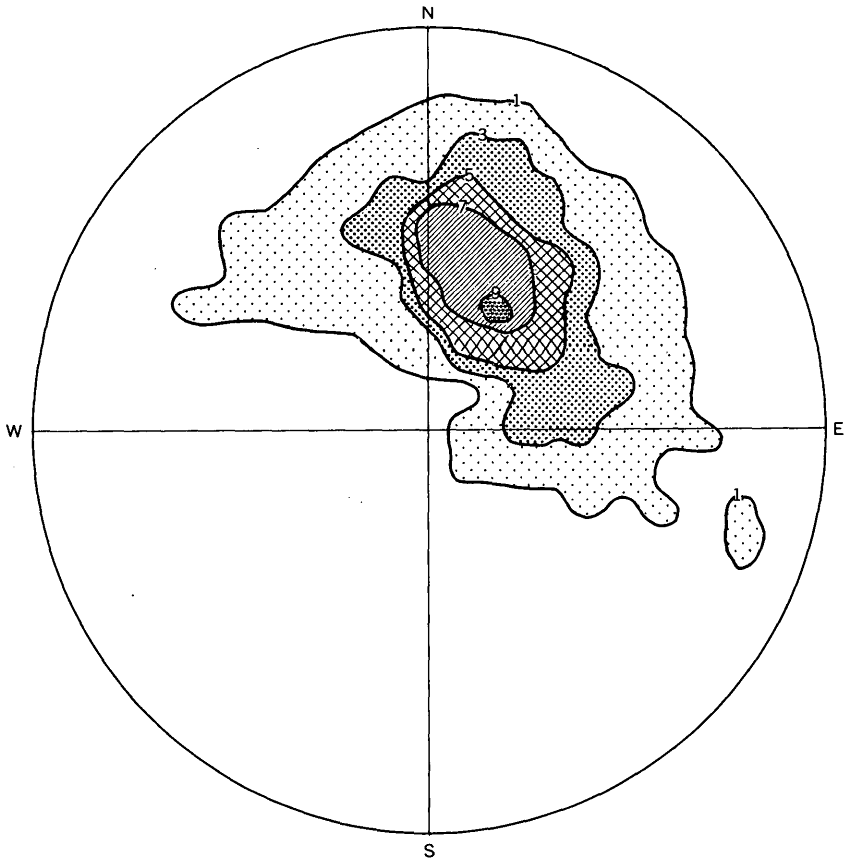


FIGURE 4.—Contour diagram of lineations; lower hemisphere plot of 696 poles. Contoured in percent of poles.

FAULTS

The faults shown on plate 1 have been identified on the basis of iron-stained zones, fracturing and brecciation, and alinement of topographic features. With two or three minor exceptions, offset has not been demonstrated.

The faults are characterized by broken, deeply reddened iron-stained zones that are typically 1 to 2 feet wide but locally much wider. Hydrous iron oxides fill fractures in broken feldspars and quartz and coat brecciated rock. Biotite is crushed and largely altered to a brown earthy mineral. Outward from the intensely fractured, deeply reddened zones, the rocks are broken and iron stained to a lesser degree in zones usually a few tens of feet wide but locally several thousands of feet wide (pl. 1). The iron staining in these zones is evidently a weathering feature. Fractured but otherwise fresh Pikes Peak Granite is exposed in road cuts beneath the iron-stained fracture zone at Longview, Vermillion, and South Platte (pl. 1).

Calcite, fluorite, hematite, and malachite have been found in some northwest-trending fault zones. Pitchblende was found in a fracture filling in SE¼SW¼ sec. 3, T. 7 S., R. 70 W. (Vance Haynes, oral communication, 1960.)

Where bedrock is well exposed, as in Platte Canyon between South Platte and Strontia Springs, many faults of small displacement are observed, as shown on plate 1. Such faults probably exist in other parts of the quadrangle but are not exposed.

Most of the faults in the Pikes Peak batholith (pl. 1) are approximately normal to the contact of the batholith. Hutchinson (1960, pl. 1) shows that the arcuate contact of the granite continues westward into the Pine quadrangle to form a near semicircle and that some fractures (the faults of this report) in the batholith form a radial pattern in the two quadrangles. He suggests that they are tension fractures related to cooling of the batholith and terms these features "primary tension joints." Thin zones of gouge and breccia, however, indicate that the joints underwent later fault movement. These radial faults are marked at the surface by conspicuous red-brown streaks 2 to 4 feet wide, and many are filled by thin quartz veins. All the radial faults appear to be vertical.

Faults range in age from Precambrian or Cambrian to Laramide and perhaps younger. The healed breccia containing the sandstone dikes (p. C16) indicates faulting in Precambrian or perhaps Cambrian, time; this movement established lines of weakness along which later movement occurred. The sandstone dikes indicate tension in the Cambrian Period. The wide belts of fracturing are probably related to Laramide faulting.

JOINTS

Joints are conspicuous in all rocks of the quadrangle. In the metamorphic rocks, a joint set (or rock cleavage) parallel to the foliation is invariably present, and two joints normal to the foliation are common. Within the Pikes Peak Granite there is a fairly conspicuous steep joint set parallel to the contact with the metamorphic rocks and another that is perpendicular to the contact. Joints in the northern end of the Pikes Peak batholith are shown by Hutchinson (1960, pl. 1).

GEOMORPHOLOGY

The topography of the Platte Canyon quadrangle is that of an erosion surface of low relief into which deep valleys have been incised. More than one old erosion surface may be present. Russell Ridge, Sheep Mountain, and the area around Raleigh Peak appear to be parts of the same surface (at 7,500 to 7,750 feet), but the long flat ridge extending from the northwest corner of the quadrangle to Turkshead Peak is much higher (8,000 to 8,750 feet) and may be a remnant of an older surface. A benchlike surface at an altitude of about 6,950 feet occurs along the Platte Canyon in secs. 19 and 30, T. 7 S., R. 69 W. This type of surface is common in valleys containing faults and may more reflect rapid weathering along the fault that traverses the bench than prolonged lateral corrasion by the South Platte River.

Most of the larger valleys follow faults, but the deepest part of a valley is generally located to one side of the fault plane (pl. 1).

The South Platte River valley above South Platte, where it flows through Pikes Peak Granite, is much broader than below—a feature that indicates that the granite is less resistant to erosion than are the metamorphic rocks. Generally, tributary valleys have steeper walls in the metamorphic rocks than in the granite.

ECONOMIC GEOLOGY

Granite.—The Pikes Peak Granite is an attractive and durable stone that was used in many buildings and for curbstones in Denver during the late 19th and early 20th centuries. It was quarried in sec. 29 and in the NE¼SE¼ sec. 17, T. 7 S., R. 70 W.

Feldspar.—Most of the larger pegmatites in the quadrangle, particularly those southwest of Raleigh Peak (pl. 1), have been quarried for feldspar. One pegmatite in the quadrangle was quarried for feldspar in 1958.

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