

THE GEOLOGY OF THE
BRECKENRIDGE, COLORADO,
DISTRICT.

by

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CONTENTS.

Introduction	page	I
General description of the district		2
History of the Breckenridge camp		4
Production of the Breckenridge camp		7
General Geology		10
Pre-Cambrian rocks		10
Sedimentary rocks		12
Wyoming formation		12
Dakota formation		16
Upper Cretaceous shales		20
Igneous rocks .		22
Monzonite porphyry		23
Quartz monzonite porphyry		25
Contact metamorphism		29
Quaternary deposits		33
Pleistocene deposits		33
Recent deposits		33
Structural geology		40
Ore deposits		44
Gold		44
Lead-zinc-silver ores		47
Deposits in Pre-Cambrian rocks		48
General mining conditions		49
The Lucky mine		49

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GEOLOGY OF THE BRECKENRIDGE, COLORADO, DISTRICT.

INTRODUCTION

The work used as a basis for this report was done during a part of the Summer of 1915 in connection with a geologic investigation carried on by a party from the University of Missouri, in charge of Prof. W. A. Tarr. The work included the mapping of the areal geology of the southern half of the Breckenridge, Colorado, mining district and a study of the structural geology of the region. The different igneous intrusions were studied, both as to the character of their rocks and their relation to and effect on the other rocks of the area. A good deal of time was devoted to the study of the economic geology and to the physiography of the district, with special emphasis on the processes and principles involved in each case. The glacial deposits and the part the ice played in developing the physiography of the region were studied to a considerable extent.

Much of the field work was done by groups of two, but the details were worked out individually. Acknowledgements are due F. W. Floyd of the University of Missouri and H. L. Griley of Denison University for cooperation in the field. All of the work was under the direct supervision of Prof. Tarr. Mr. F. L. Ransome's professional paper on the *Geology and Ore Deposits of the Breckenridge District has been of aid as a reference.

*Professional Paper 75, U. S. Geological Survey.

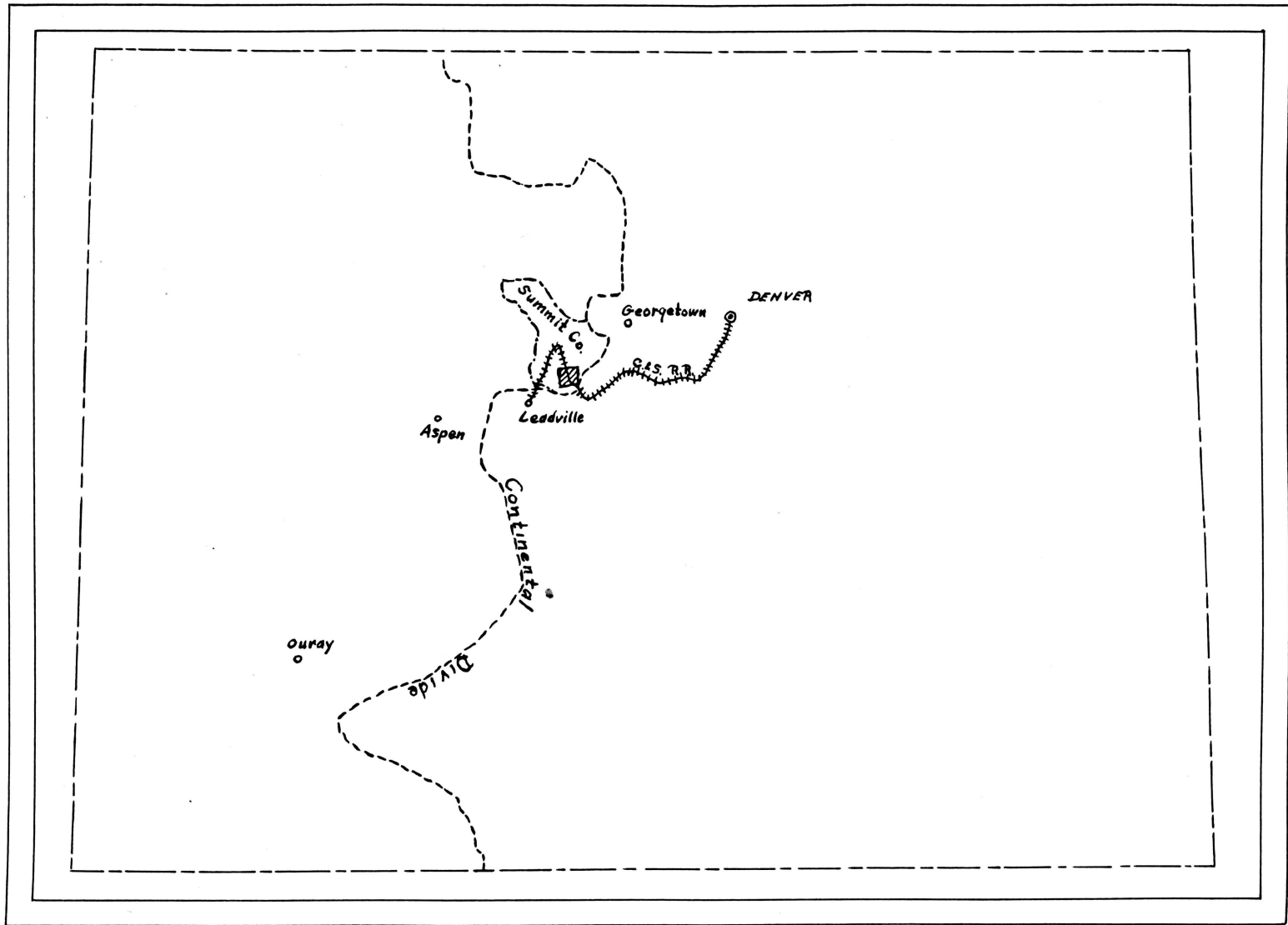


Plate I. Map of Colorado - showing location of Breckenridge district.

GENERAL DESCRIPTION OF THE BRECKENRIDGE DISTRICT.

The area studied includes most of the southern half of the Breckenridge Special Quadrangle, which is located in Summit County, Colorado, about sixty miles southwest of Denver. This region is just west of the continental divide which is formed by Bald Mountain, French Pass, Mount Guyot, and Georgia Pass. On the west the area is bounded by the base of the Ten Mile range. The altitude of the country mapped is from 9,450 ft. to 13,100 ft.

The whole country is in a mature stage of erosion and is very rough, being so completely dissected that there are practically no level upland stretches left. The only flat lands in the district lie along the larger streams. Almost all of the southern half of the area is occupied by the foothills of Bald Mountain and Mount Guyot, peaks which rise to 13,800 and 13,565 ft., respectively, just beyond the border. To the north of these foothills and just across French Gulch lie Gibson, Prospect, Mineral, Humbug, and Farncomb hills, which slope toward the Swan valley on the north. The slopes on both sides of French Creek are very steep except near its confluence with the Blue River just below Breckenridge.

The region is drained by the Blue and Swan rivers and their tributaries, the largest of which is French Creek. The only other tributaries of any size in this drainage system are Little French Creek and Illinois Gulch and Indiana Gulch. There is a large number of short, small gulches flowing into the larger streams.

but in most cases they are fed by rather limited watersheds and gain most of their water from melting snows. The gradient of all of these streams is very steep and they carry heavy loads, building up considerable accumulations of alluvial gravels in many places.

The Swan River lies to the north of the area studied and only a few of its tributaries play a part in the drainage.

The Blue River has a general south-north course, nearly parallel to the Ten Mile Range. The course of the Blue River and also that of the Swan is influenced by the contact of Pre-Cambrian crystalline rocks with the softer sediments.

The present topography is largely the expression of work done before the earliest glaciation recorded in the region, altho glaciation has wrought some minor changes. The main effects of Recent erosion have been in overcoming the modifications caused by the ice.

The only settlement of any size in the district is the mining camp of Breckenridge, which depends for its existence entirely on the ore deposits surrounding it. At various stages in the history of the region several large towns have thrived here but have disappeared with the decrease in mineral production. Mining is practically the only industry carried on, enough lumbering being done to supply the mines and town. Few dwellings outside of Breckenridge are permanent, as they depend entirely on the operation of nearby mines.

HISTORY OF THE BRECKENRIDGE CAMP.

The Breckenridge district first came to the notice of white men following the flood of immigration which was directed toward the Pike's Peak country in 1857. Some of the emigrants who succeeded in passing the first range of mountains in that year found gold in the gravels of Tarryall Creek, a tributary of the Platte. Placers were worked here and the settlement of Tarryall was established twelve miles south of Breckenridge

In 1857 a party of Georgians came over Georgia Pass and in Georgia Gulch found the rich placer ground north of Farncomb Hill. The town of Parkville, established at the mouth of the gulch, had as many as 1800 voters during the five years following the discovery of gold. During the five year period before the close of 1862, the production from Georgia Gulch approximated three million dollars.

Profitable placers were also operated at Jeff Davis along French Creek and in Nigger Gulch on the Lillian Vail claim. Other rich placers in Gold Run have yielded \$750,000. It is stated * that in 1870 there were 100 miles of ditches and flumes in the county, mostly around Breckenridge. In 1870 hydraulic methods were replacing the laborious hand washing and drifting methods that had been employed before. During these early years the few scattered placers represented the only scenes of activity in this wild country.

In 1869 lead ore was taken from the Old Reliable vein near Lincoln. This was the first lode mining in the
*Id. p. 17

Breckenridge district, altho silver lodes had been worked at Montezuma, twelve miles to the northeast of Breckenridge, as early as 1864. In 1869 the Blue Flag or Laurium mine began shipping lead ore to Denver and Golden by wagon. During the early '70's the Cincinnati mine on Mineral Hill at Lincoln was an active producer, yielding ore which contained 65% lead and 16 oz. of silver per ton. In 1873 a reverberatory furnace was constructed in French Gulch to treat this ore. Prior to the eighties the Lucky, Minnie, and Union mines were conspicuous producers.

Gold was not found in place in the district until 1880 when it was located on the Ontario claim, situated on Farncomb Hill. The late discovery was due to the extreme narrowness of the veins in the shale and to the deep layer of soil covering the rock. Very soon the famous Boss and Elephant mines and many others were obtaining a great deal of gold. For ten years pocket after pocket of finely crystallized wire and flake gold was opened up. In 1885 there were over a hundred men working on the north side of Farncomb Hill but by 1890 fewer large pockets were being found and mining activity began to decline. During the period of decline a mill was built in Georgia Gulch which worked on some of the low grade ores in some of the tunnels and from the dumps. About this time the Wapiti flume was built which furnished water used in washing almost the whole north side of Farncomb Hill.

During the eighties there were three mills operating in Lincoln, supplied largely by the Cincinnati, Oro, and Lucky mines. Other important producers in 1889 and 1890

5.

were the Iron Mask and Ohio Mines on the Blue River, the Washington, Dunkin, and Juniata, and the Puzzle, Country Boy, and Wellington. Most of these were lead mines. About 1898 the Mountain Pride was the leading producer of the district but its supremacy was short lived. Since 1896 there have been a few temporary revivals of activity as when work was resumed in the Puzzle and Gold Dust in 1909, but none of these have been very extensive. At the present time the Wellington is the conspicuous producer with the Dunkin, Carbonate, and a few others shipping some ore. Recent discoveries in the Dunkin have caused renewed activity on that property.

In 1895 Revett tested the gold bearing gravels along the larger streams by sinking a shaft in the valley of the Swan, and later by an experiment made with an oil drill, and a recognition of the gold-producing possibilities of the low-lieing stream gravels resulted. For several years following 1898 numerous unsuccessful experiments in gold dredges and hydraulic elevators were tried and abandoned. The most conspicuous and ambitious undertaking was the Gold Pan Mining Co., organized in 1899 with a capital stock of \$1,750,000. One million, five hundred thousand dollars in cash and stock was expended for equipment and excavation. Altho the anticipated profits were eighty million dollars, the hydraulic elevators failed to produce them and the com-

pany broke up. Most of the equipment was later used by Breckenridge and by the Tonopah Gold Dredging Co. Four successful gold dredges on French Creek, the Blue River, and the Swan River were built about 1908 and have been important producers continuously since that time.

Important advances in the district have resulted from the building of the Colorado and Southern Railway to Breckenridge in 1880 and its extension to Leadville in 1881, and the introduction of electric power in 1907.*

PRODUCTION OF THE BRECKENRIDGE CAMP.

Total mineral production.

<u>Year</u>	<u>Summit County</u>	<u>Breckenridge dist.</u>
-----1870	\$5,500,000	
1870--1875	407,500	
1875--1880	638,500	
1880--1885	475,000	
1889		\$100,850
1890		123,075
1904	739,995	
1905	582,359	280,000
1906	570,932	
1907	474,095	175,201
1908	355,815	129,173
1909	471,292	538,704
1910	973,725	755,356
1911	1,092,673	865,131
1912	1,372,749	1,250,544
1913	1,127,896	1,018,465
1914	1,028,395	982,329

*These notes on the history of the Breckenridge District have been taken largely from Ransome's Professional Paper No. 75 and from Mineral Resources of the United States, U. S. Geological Survey.

At the present time almost all of the ore production of Summit County comes from the Breckenridge District, the percentage in 1914 being 95.5 %. This represented but 2.8% of the total metal output of the state of Colorado. In the production of placer gold the district ranked first in the State, producing over 95% of the total amount. Summit County ranked as the third county in the state in the production of zinc in 1914, altho the output was very small compared with that of Lake County.

The great increase in the production of the district during the last few years has been due almost entirely to the successful operation of the four gold dredges and to the activity of the Wellington Mines. In 1914 the gold dredges were more important producers than at any time previously. The total production of the district in 1915 will probably be found to exceed that of any previous year.

The relative importance of the different metals obtained in this county in 1913 and 1914 was:

Year	GOLD		SILVER		COPPER	LEAD...		ZINC..	
	Placers	Deep Mines	Placers	Deep Mines		Pounds	Value	Pounds	Value
1913	\$386,196	\$76,032	\$2,645	\$98,519	\$2,816	3,944,268	\$173,548	6,931,074	\$388,140
1914	608,567	60,043	3,881	33,175	976	1,565,231	61,044	5,111,941	260,709

	PRODUCING MINES	SHORT TONS TOTAL	TOTAL VALUE	AV. VALUE PER TON
1913	45	40,630	\$1,127,896	\$18.31
1914	51	22,199	1,028,395	18.28

GENERAL GEOLOGY.

The rocks outcropping in the Breckenridge district range in age from Pre-Cambrian to Recent. Pre-Cambrian granites and metamorphic rocks form a base on which a thick series of Mesozoic sediments has been deposited. The sedimentary beds have been intruded by porphyries of Tertiary age and have been considerably distorted by the intrusions and subsequent faulting. To the east of the area a great fault along the western side of the Vasque range has lowered the whole series so that the sediments dip generally northeastward.

PRE-CAMBRIAN ROCKS

To the east and west of the Breckenridge district are large mountain ranges composed entirely of Pre-Cambrian rocks, but within the area only two small masses, from which the later sediments have been removed, outcrop. One of the areas is on the eastern side of Gibson Hill just north of Breckenridge, and the other is just ^{north} east of the Blue Flag or Laurium Mine in the central part of the district. The rocks consist mainly of schists and gneisses, cut by large masses of granite and by some dikes of pegmatite, basalt, and syenite. Study of the Pre-Cambrian formations is difficult because of the scarcity of unweathered outcrops.

One of the more common rocks of the series is a finely laminated, gray schist composed of quartz, biotite, and muscovite in the form of sericite. The relative amounts of biotite and muscovite and consequently the color of the rock, vary considerably. According to Ransome * this schist probably corresponds to the Idaho Springs Formation of Georgetown, Colorado, as described by Ball**.

Perhaps the most abundant of the Pre-Cambrian rocks is a gneiss of medium gray color, composed of feldspar with considerable amounts of biotite and muscovite and a little quartz. *

Outside the area at the head of the Swan River and along the Ten Mile Range are several other types of metamorphic rocks.

Cutting the gneisses and schists are large bodies of granite and dikes of pegmatite. The granite is usually pink or flesh colored due to the abundance of orthoclase. Muscovite and a little biotite are present in varying amounts. The texture is non-porphyrritic and medium grained, the grains averaging about 5 mm. in diameter. The pegmatite is light gray or white and consists of coarse grained quartz, feldspar, and muscovite.

A few dikes of basalt and syenite occur, but are of little importance. They are possibly complementary dikes associated with the granite intrusions.

* Id. p. 25.

**Ball, S. H. Prof. Paper, U. S. Geological Survey #63.

SEDIMENTARY ROCKS.

WYOMING FORMATION.

The oldest sediments in the district are the "red beds" of the Wyoming formation, which are probably of Triassic age. They directly overlie the Pre-Cambrian rocks, altho at Hoosier Pass eight miles south of Breckenridge, several hundred feet of Paleozoic sediments intervene between the Pre-Cambrian rocks and the Wyoming deposits.* The only Wyoming outcrops within the area are adjacent to the Pre-Cambrian masses on Gibson Hill and in the upper part of the Illinois Gulch basin.

The main body of the Wyoming formation is composed of bright red sandstones, with numerous conglomeratic layers, and of thin bedded, red, sandy shales. The sandstone is composed of fragments of quartz, feldspar, and a great deal of fine grained muscovite, which are cemented by silica, calcite, and hematite. In texture it varies from fine grained to a coarse grit. In the red beds occur many poorly defined layers of conglomerate, composed of quartz and feldspar pebbles in a matrix of red sandstone. The conglomeratic bands are of varying thickness, are discontinuous, and merge into the red sandstone above and below. The strata are rather thin bedded and many of the coarser beds are cross bedded. Ripple marks are common.

* Ref. Cit. p. 28.

At the contact of the Wyoming formation with the Pre-Cambrian there is a thick basal conglomerate, which is made up of large fragments of quartz, feldspar, and muscovite, with many pieces of schist and gneiss. Some of the fragments are over a foot in diameter but the average is much less. The color of the conglomerate is light gray.

The thin bedded red shales which are rather common in the Wyoming rocks do not make up a very large part of the formation. They are sandy and frequently grade into sandstone beds. Thin, lenticular beds of dark blue limestone are quite commonly interbedded with the sandstone and shale.

The Wyoming rocks exposed along the railroad in the southern part of the Breckenridge district are entirely red beds with irregular streaks of pebbly grit. Farther north, near the Pre-Cambrian outcrop in the Illinois Gulch Basin and near the base of the formation, the character of the rock is different. The beds are less constantly of the bright red color and present a more variegated appearance. They are often of a light gray or yellow color and are sometimes more or less mottled. Still farther to the north, near the Pre-Cambrian outcrop on Gibson Hill, where the Wyoming formation is much thinner, a large amount of the yellow, gray, and mottled sandstone and shale, with some almost wholly micaceous layers, occurs.

The Wyoming formation probably has its maximum thickness about six miles south of Breckenridge, between Boreas Pass and Red Mountain, where Ransome* gives it as 5000 ft. It thins out rapidly to the north to about 2000 ft. in the southern part of the Breckenridge District, and to 400 ft. or less at Gibson Hill, and is absent a few miles farther north at Barton Gulch, where the Dakota Sandstone rests on the Pre-Cambrian.

That the lower beds of this formation were laid down in shallow water close to the shore of a transgressing sea is shown by the presence of the coarse conglomerates at the base of the formation, by the occurrence of the coarse pebbly layers, the general coarseness of most of the red beds, and the presence of cross bedding and ripple marks. This is also evident from the progressive overlap shown by the occurrence of the Wyoming strata above Paleozoic sediments at Hoosier Pass and directly on the Pre-Cambrian at Breckenridge. As evidenced by the size and roughness of some of the units in the conglomerates, the transgression of the sea was rather rapid at times. The abundance of muscovite, feldspar, and fragments of gneiss and schist shows plainly the origin of the sediments in the incompletely weathered Pre-Cambrian rocks on or near this area. At the time the upper beds of the formation were being deposited, the streams were bringing finer material into this part of the sea than they had before.

* Id. p. 29.

Correlation of these strata is made difficult by the almost complete lack of fossils. Ransome * used the term "Wyoming formation" to apply to all the strata lieing between the Pre-Cambrian and the Dakota within the district. The term had been used previously in this sense by Emmons ** in the adjoining Ten Mile District. Altho it is not entirely satisfactory, we found insufficient stratagrap~~h~~ic evidence to warrant a change. Ransome remarks *** that the lower conglomeratic layers of the so-called Wyoming formation resemble lithologically the Weber and Maroon formations of Pennsylvanian age. But this has no value in correlation as the nature of the beds is due to the littoral conditions under which the sediments were laid down and the slow transgression of the sea lasting from Pennsylvanian into Wyoming time would give strata of the same nature at the base of the Wyoming formation as in the Weber and Maroon formations.

* Id. p. 31.

** Id. p. 31.

*** Id. p. 33.

DAKOTA FORMATION.

Altho the Dakota sediments are of wide extent in central Colorado, in the vicinity of Breckenridge they appear only as scattered remnants, greatly disturbed by igneous intrusions and faulting, and dissected by erosion. They are traceable in a more or less interrupted belt across the district from the south to the northwest, and small remnants are found scattered throughout the rest of the area. The maximum thickness is indeterminate on account of the porphyry intrusions and the lack of a complete section, but seems to be about 350 ft. There is no sharp line of distinction between the upper beds of the Wyoming and the lower Dakota. There is a possibility that the lower beds considered as of Dakota age, or the upper beds of the Wyoming may be of intermediate age and represent deposition in Jurassic or Comanchian time.

Ransome states that at Boreas Pass * the Dakota, 200 ft. thick, consists of three main parts: the lower member being a light gray or buff sandstone with pebbly streaks; the second, a thin bedded limestone; and the upper layers massive, fine grained sandstone. The character of the formation is greatly changed between Boreas and the southern part of the Breckenridge district and in the latter locality the three divisions are not shown.

*Id. p. 35.

The outcrops near Breckenridge are prevailingly quartzitic, but the formation is made up of many interbedded shale, sandstone, and quartzite members. The following section probably represents the maximum of irregularity in the Dakota strata of the district. It was taken near the southern border of the area and shows less quartzite than is typical in this vicinity. ^{Little} ~~is~~ limestone is represented in this section, altho ordinarily thin beds of it are a prominent feature of the formation. From top to bottom the succession is:

#17	Gray limestone- black and shaly at the top	19'
I6	Black shale with interbedded quartzite	32'
I5	Quartzite	3'
I4	Black siliceous shale	5'
I3	Massive gray quartzite	26'
I2	Black siliceous shale with sandstone at base	6'
II	Black shale	2'
I0	Gray, cross bedded sandstone	4'
9	Black, carbonaceous shale	9'
8	Quartzite, light gray	40'
7	Gray, thin bedded shale- weathers pink	44'
6	Thin bedded, hard, red, siliceous shale	61'
5	Fine grained, thin bedded, cross bedded s.s.	15'
4	Gray and red sandy shale	1'
3	Thin bedded red and white sandstone	33'
2	Gray, calcareous shale or shaly limestone	27'
I	Reddish calcareous shale	16'

The following section, made at Rocky Point by Ransome *, is more typical:

I4.	Thin bedded gray quartzite, conformably overlain by Upper Cretaceous shales.	18'
I3.	Gray quartzite.	3'
I2.	Thin beds of alternating gray quartzite and shale.	25'
II.	Quartzite.	12'
I0.	Dark shale.	1'
9.	Quartzite.	4'
8.	Thin, shaly sandstone and gray shale.	1'
7.	Massive quartzite.	15'
6.	Alternating thin bedded gray quartzite and gray to black shale.	18'
5.	Massive gray quartzite, disturbed and broken near base.	30'
4.	Disturbed red and green shale.	25'
3.	Thin bedded, light reddish sandstone and shale.	40'
2.	Buff, cross bedded sandstone with a few small quartz pebbles.	20'
I.	Brittle, gray shaly limestone, resting on porphyry sheet.	20'

On Little Mountain, Nigger Hill, and other places in the northern part of the district where the Dakota outcrops, the quartzite forms almost all of the exposures.

* Id. p. 36.

No unconformity is evident between the Wyoming strata and those of Dakota age, but the fact that the Dakota sea was a transgressing one, as indicated by the overlap on Pre-Cambrian rocks, shows the probability of a lapse of time between the deposition of the two series.

The lands from which the Cretaceous sediments were derived were subjected to rather complete weathering, so that the streams carried only quartz and clay sediments into the Dakota seas. This is in distinct contrast to the conditions during Wyoming time, and seems to indicate a long erosion interval between the two periods, in the nearby lands which furnished the material. The resulting rocks, except for the conglomeratic, arkosic layers sometimes occurring near the base of the formation, were free from the feldspar, mica, and fragments of crystalline rock that characterized the Wyoming formation.

A transgressing sea, overlapping the Wyoming formation and the Pre-Cambrian, covered the whole Breckenridge area during the Dakota. The presence of some ripple marks and cross bedding, together with occasional conglomeratic layers and the general coarseness of the rock, indicate shallow water deposition thruout most of Dakota time. At times the water cleared sufficiently to permit the formation of a rather impure limestone. Nowhere are the sediments as coarse and indicative of such shallow water conditions as in the Wyoming beds.

UPPER CRETACEOUS SHALES.

Resting conformably on the Dakota beds lie the black shales of the Upper Cretaceous system, and the contact between the two formations is poorly marked. The shales are restricted within the district mostly to the eastern and northeastern part, as the general dip is in that direction. The thickness is rather uncertain, and the top of the formation is not present, due to erosion, but 4000 ft. of the shales were measured. Mt. Guyot and nearby hills are composed largely of Upper Cretaceous shale capped by porphyry sills. Ransome states * that these black shales probably include the Benton, Niobrara, and part of the Montana series, as fossils representing all these groups have been identified with more or less certainty. Locally the strata are so nearly identical lithologically and so poor in fossils that no attempt at subdivision is justified.

The following fossils were collected by Ransome and identified by Dr. T. W. Stanton**:

<i>Ostrea lugubris</i> Conrad	Upper Benton
<i>Inoceramus fragilis</i> H. & M.	Upper Benton
<i>Scaphites warreni</i> M. & H.	Upper Benton
<i>Inoceramus deformis</i> Meek (?)	Lower Niobrara
<i>Inoceramus labietus</i> Schlotheim (?)	(Benton) (Montana)

* Id. p. 40

* Id. p. 41

These identifications are uncertain in the case of *Inoceramus labiatus* and less so in the case of *Inoceramus deformis*. The specimens identified as *I. labiatus* occupied a much higher position stratigraphically than some of the Benton forms which are characteristic of a later age, so they are ^{probably} of a Montana species which is very similar to *I. labiatus*. The supposition is made more likely by the thickness of the shales, which greatly exceeds that of the Benton and Niobrara in other sections of the state, and seems to indicate a part of the Montana here incorporated with the lower formations.

The Upper Cretaceous series is an almost homogenous mass of dense, black, thin bedded, carbonaceous shales containing some limestone layers and occasional lenses of quartzite near the base. As a rule the shale is soft and weathers readily into thin flakes, but in some places, especially on Farncomb Hill and in the Wellington Mine, it is harder, thicker bedded, and more siliceous owing to the intrusion of the porphyry. The color varies but little except when altered by exposure. With the leaching out and oxidation of the carbonaceous matter it is left with a dull gray, red or brown color. Some layers of fetid, highly carbonaceous, and occasionally fossiliferous shale beds occur, but are not characteristic of any particular horizon. Igneous intrusions have locally altered the shale somewhat, hardening or baking it to a hornstone.

The great thickness and uniformity of the black shales indicate deposition on a gradually and uniformly sinking ocean bed. The continent which supplied the sediment had evidently undergone rather complete weathering for the shales are free from any products of incomplete weathering. Cross bedding and other evidences of deposition in shallow water are absent. Occasionally the seas cleared for a short time and some limestone was laid down.

IGNEOUS ROCKS..

Porphyry intrusions of Tertiary age are numerous and outcrop widely in the district. They are of two general types with various gradations and intermediate variations. The usual mode of occurrence is as small dikes and sills which are seldom over a mile in length. A few of the sills are much larger, but the average length is only a few hundred yards, and the thickness seldom exceeds a hundred feet.

MONZONITE PORPHYRY.

Of the Tertiary intrusions, the rock having the most widespread outcrops is a monzonite porphyry composed principally of hornblende, feldspar, and biotite phenocrysts in a dense gray groundmass. The largest outcrop of the porphyry is found near the central part of the area, where it makes up a large part of Bald Mountain and the hills to the north. The same sill, which dips in a general way to the north and northeast at a varying angle, extends north as far as the placer workings on Gold Run. Other smaller dikes and sills are scattered widely over the whole area.

The phenocrysts are usually less than five millimeters in length and seldom make up as much as fifty percent of the rock, but variations in texture are rather wide and there are some facies in which the phenocrysts are larger and comprise sixty percent of the porphyry. Some phases are almost completely felsitic but are not common. One peculiar variation occurring in the Wellington mine is a diorite. Hornblende is the most conspicuous constituent megascopically, altho the phenocrysts of plagioclase feldspar are more numerous. Biotite is often abundant and is sometimes one of the principal constituents, but is not always present. Quartz is not found as phenocrysts. The phenocrysts of

these primary constituents are included in a light to dark gray, lusterless groundmass which the microscope shows to be made up mainly of plagioclase. On account of the extensive alteration which the rock has undergone at all exposures it generally has a dull greenish color resulting from the formation of chlorite and epidote.

The monzonite porphyry often shows some interesting segregation phenomena. Considerable amounts of hornblende and biotite are often found collected together into well defined masses containing practically no impurities. The border of such masses, which are usually only a few inches in diameter, is sharply defined and the surrounding rock contains a minimum of the ferromagnesian minerals.

The monzonite porphyry yields readily to chemical disintegration and the ferromagnesian minerals are usually the first to alter. Chlorite is a common alteration product, representing the first change in the breaking down of the hornblende and biotite. At the same time the iron in the ferromagnesian minerals oxidizes to magnetite and the calcium set free forms calcite. The chlorite formed is responsible for the prevailing green color of the rock. Small amounts of epidote often form during these changes. Colloidal silicic acid is always liberated in the alteration of the primary silicates.

More complete weathering gives kaolin and limonite or hematite as end products and the latter minerals color the extensively altered material brown or red. The magnesium liberated is removed in solution with the calcium in the form of the carbonate. The feldspars, upon breaking down, give kaolin, silicic acid,[?] potassium hydroxide, sodium carbonate and calcium carbonate as end products. The quartz is unaltered and only to a small extent dissolved. The kaolin, limonite, potassium hydroxide and part of the colloidal silica remain behind in the soil and the other end products are carried away in solution. Alteration near the metaliferous veins and under deep seated conditions results in the formation of a great deal of sericite, but the other products are mostly the same as in surface alteration.

QUARTZ MONZONITE PORPHYRY.

The other type of igneous rock, which outcrops more widely along the Swan River than within the area studied, is a quartz monzonite porphyry, which occurs only in small, scattered masses, representing sections of thin dikes and sills. Its outcrops are especially prominent in the shales of Farncomb and Humbug Hills. A rather large sill underlies the Dakota between Rocky Point and Bacon, and other small, isolated dikes and sills are widely distributed over the rest of the district.

In the quartz monzonite porphyry the phenocrysts are usually larger and make up a greater proportion of the rock than in the other type. The prominent phenocrysts are orthoclase and quartz and, in some facies, hornblende and biotite. They usually form about sixty percent of the rock and are surrounded by a dense ground mass of a dull gray color. The orthoclase commonly occurs as large, perfectly developed crystals which may be three inches in length, but is usually in small rounded masses or crystals. Twins and intergrowths are common. The orthoclase is the most conspicuous constituent of the rock on account of the large size of the crystals and the pink or flesh color which it has. Small, rounded, lusterless phenocrysts of plagioclase are characteristic and abundant, but are less conspicuous than the other feldspar. The quartz occurs as rounded grains and as double pyramids, which are sometimes 1 cm. in diameter.

In color the rock is light gray, changing to light red or brown on exposure. The presence of considerable hornblende and biotite in some facies makes the color a darker gray.

There are wide variations in texture and color. On the southeast slope of Brewery Hill there occurs a felsitic phase in which the ground mass comprises over ninety percent of the rock and few small phenocrysts of quartz and feldspar are present. On the other hand, some facies are made up of very large crystals and very little groundmass.

A striking variation, which is intermediate between this and the more basic porphyry, is found in several parts of the area. It contains numerous phenocrysts of hornblende and biotite, but quartz is also a prominent constituent. The large sill underlying the Dakota near Rocky Point is of this type, as is also an outcrop near the mouth of Little French Gulch. In chemical composition the intermediate porphyry is most closely related to the quartz monzonite type and has been mapped in with that formation.

The following composition is given by Ransome* for the quartz monzonite porphyry on Brewery Hill, at the northern border of the area studied:

Quartz	27.14	3
Orthoclase	22.67	
Andesine	39.61	
Biotite	3.46	
Hornblende	1.11	
Magnetite	3.02	
Titanite	.98	
Pyrite	.09	
Water	.72	4
Apatite, Zircon etc.	<u>.81</u>	
	99.61	3

The alteration of the acidic type of porphyry is much the same as that of the monzonite porphyry, yielding as end products: kaolin, colloidal silicic acid, iron oxide,

* Id. p. 48.

quartz, calcite and dolomite, potassium hydroxide, and sodium carbonate.

From the descriptions given it is evident that these two porphyries are closely related chemically and practically all gradations between the two are found in the vicinity of Breckenridge, suggesting a probable derivation from the same magma. But wherever the two are found together, the quartz porphyry seems to be intrusive into and cutting thru the more basic type. Field relations invariably indicate a slightly younger age for the quartz monzonite. These facts indicate a magmatic differentiation into the two types, one without quartz and the other containing it. The monzonite porphyry intrusions reached the sediments somewhat in advance of the silicic monzonite type and were cut by the later masses, or the whole mass may have been intruded and after some differentiation had taken place the silicic segregation was ejected thru the other part of the intrusion and the surrounding sediments. In support of both of these suppositions are the long dike of quartz monzonite porphyry cutting the great monzonite porphyry sill on Mineral and Prospect Hills, and also the relations of some of the smaller intrusive bodies on Humbug Hill.

The age of the porphyries cannot be determined within the Breckenridge district except that they are younger than the youngest Cretaceous sediments present. However, the relations of associated porphyries with strata in nearby districts indicate that their age is late Eocene or Miocene.

CONTACT METAMORPHISM.

The porphyry intrusions have had considerable effect upon the rocks which they cut, in addition to their work in the formation of the ore deposits of the camp. They have brecciated the rocks quite severely along many of the contacts and the shales have been more or less indurated near the porphyry, forming hornstone.

Where the porphyries have cut limestone lenses in the Cretaceous formations there are some typical deposits of contact minerals. In every case where the masses of metamorphic minerals occur there is a sill of one or the other of the porphyries intruded into the beds within a few feet of the deposits. In all cases it is probably the nearby intrusion that has produced the effects noted. Certain mineral associations are found which are formed only under conditions of high temperature and the presence of solutions such as come from igneous intrusions. Many of the minerals can only have been formed of material
? both from the igneous solutions and from the limestone.

Magnetite and garnet are especially abundant, the garnet being mostly of the andradite variety. Altho many crystals of the brown garnet occur, most of it is in the form of a dense, brown or green garnet rock. Epidote is commonly associated with the garnet, and specular hematite, actinolite, and augite are also present in varying abundance.

The limestone beds in which the contact deposits are formed contain considerable kaolin. The emanations from the intrusions which induced the changes were necessarily rich in silica, and the conditions of high temperature were favorable for the combination of the silica with the calcium of the limestone. The kaolin in the limestone furnished aluminum which was included in some of the new combinations, and some aluminum was also available from the magmatic solutions. Iron must have been an important constituent of the igneous emanations and a small amount was also present in the limestone. These elements being brot together under high temperatures and in the presence of certain "mineralizers" underwent new combinations and produced minerals typical of such conditions.

Calcium obtained from the limestone united with iron and silica which were in excess in the magmatic solutions, forming andradite garnet-- $\text{Ca}_3\text{Fe}_2(\text{SiO}_4)_3$ -- a mineral which is characteristic of the deposits. Calcium, silica, and iron were the most abundant elements present and such a combination would be expected to result and to form the most common of the contact minerals of the area.

Epidote, a hydrous calcium aluminum silicate, containing iron, is another of the typical contact minerals. The abundance of calcium available from the limestone was here again important, uniting with the iron and silica from the magma and with the aluminum from the clay impurities of the limestone or from the solutions. Some water, which probably came from the intrusions also went into the composition of the epidote.

The iron content of the magmatic emanations must have been greatly in excess of the amount required for the formation of the garnet and epidote and the small amounts of other minerals, for great masses of magnetite and some specular hematite occur in the contact deposits. Any excess of iron present would take the form of magnetite or specular hematite most readily under the existing conditions.

On the northeast slope of Bald Mountain occurs a metamorphic deposit which contains, besides the characteristic garnet, epidote, and iron oxides, considerable amounts of augite and actinolite. The augite is scattered thru some layers of blue limestone and the actinolite is deposited on the bedding planes of thin, calcareous shales. The new combinations which took place in forming the augite were much the same as those producing the epidote except that magnesium went with the calcium, iron, aluminum, and silica. Either the limestone

may have been locally dolomitic or some magnesium may have been present in the solutions from the intrusion. The formation of the actinolite was much the same as that of the augite except that no aluminum was involved. Considerable crystalline calcite and probably some dolomite accompany the silicates in every case. They represent the ? recrystallization of the limestone with the possible introduction of magnesium.

The sulfides, pyrite and chalcopyrite are also present in the contact masses, and must have resulted from the ? crystallization of iron, sulfur, and copper from the magma.

Prominent occurences of these contact metamorphic deposits are: in the limestone of the Dakota formation just above the Union Hill; at the Nebraska Mine, in the limestone of the Cretaceous shales; and near an old mine at the foot of the northwest slope of Bald Mountain, in a limestone lens of the Upper Cretaceous shales.

We see, thus, that while the general metamorphic effect of the porphyry on the sediments has not been great, certain peculiar and characteristic deposits have been formed in the most favorable places.

QUATERNARY DEPOSITS.

The Quaternary deposits which are widely scattered over this region may be referred to both the Pleistocene and the Recent periods. The glacial deposits of Pleistocene times can be shown to have been formed during two different epochs with a rather long interval of erosion between. The different deposits of the Quaternary belong to the following types: 1. terrace gravels, the remnants of the outwash plain of the earliest glacial invasion; 2. moraines--terminal, lateral, and ground, which belong to the latest stage of glaciation; 3. valley trains of the last ice advance; 4. lake bed deposits; 5. recent stream gravels; and 6. hillside wash, which has been collecting uninterruptedly since Tertiary times.

PLEISTOCENE DEPOSITS.

All of the glacial deposits within the area are found along the valleys of French Creek and Blue River except for a limited area in the Swan valley in the northeast corner. The glaciation in each of these valleys was independent of the others except in so far as they were influenced by the same climatic factors. That in the Blue valley has been the most extensive and has built up the most typical deposits.

Blue Valley. With the exception of some of the hillside wash, which may antedate the Pleistocene period, the terrace gravels along the Blue River are the oldest unconsolidated material in the area. They are found along both sides of the valley from Breckenridge north to the border of the district. They reach an elevation of 10,000 ft. on the ridge just northeast of Breckenridge and occur considerably higher across the Blue River. They were formerly continuous, representing the large outwash plain of the earliest ice invasion, but have been deeply dissected by subsequent erosion.

These gravels are stratified more or less roughly and consist of large and small boulders, most of which are sub-angular and rounded. Layers of sand and clay are present. Some striated and soled boulders are found. The material consists of shale and sandstone from the Mesozoic sediments, porphyry boulders, and a great many Pre-Cambrian fragments. The Pre-Cambrian boulders are much more abundant on the west side of the Blue than on the east.

Some unstratified beds are found associated with these layers and may be either hillside wash or morainic material of the glacier.

During the time when this great outwash plain was forming in the valley of the Blue, French Gulch was probably the scene of similar aggradation, either by swollen streams coming from a glacier up the valley, or by lacustrine sedimentation due to the damming up of the mouth of the valley. Another possibility would be that a French Creek glacier may have extended almost to the Blue valley so that no stratified deposits were formed in French Gulch. However, any deposits made then have been obliterated unless some of the gravels on Nigger Hill just northeast of Breckenridge were due to French Creek rather than the Blue River.

After the retreat of the glacier which caused this great aggradation in the Blue valley, there ensued a considerable time during which the outwash plain was severely eroded and greatly dissected.

The second glacial invasion left a large terminal moraine across the Blue valley about a mile south of Breckenridge. This moraine is very largely at a lower level than the older terrace gravels and still retains the typical knob and kettle topography. The existence of terrace gravels at a higher level than the surface of the moraine shows their earlier origin, for they could not have been deposited as outwash of the last advance without having covered the moraine. The kettle topography of

the moraine shows that its surface was never covered by outwash, so the older terrace gravel plain must have been dissected before the second glacier advanced. Thus, two distinct periods of glaciation must certainly have occurred here. These have been correlated with similar periods in the Leadville and Georgetown areas *.

The width of the moraine south of Breckenridge exceeds two miles and it is probably over 200 ft. in thickness. The main mass is located about two miles south of Breckenridge but its outliers extend to within a mile of the town. The Blue River has cut a meandering channel thru the eastern side. Extending down the valley from the moraine is a valley train between the higher terrace gravels. This valley train is not so extensive as that of the earlier glacier.

French Gulch .. Glacial and glacio-fluvial deposits are found along the whole course of French Creek except near the head of the valley. No evidences of the earlier stage of glaciation are present, unless part of the deposits on the northwest end of Nigger Hill belong here. Any material left in the narrow valley during the earlier epoch was subsequently removed by the swift streams.

From the head of the valley down to the mouth of Little French Gulch a considerable amount of drift is found at the sides and in the center of the valley. It consists of coarse, angular and sub-angular fragments, considerable amounts of which are found up as high as 11,000 ft. The upper limit

* Id. p. 74.

of the drift is obscure as the deposits are not thick and grade into the slope wash and detritus above. The material represents ground moraine and outwash with some remnants of small lateral moraines of the valley glacier.

Near the mouth of Little French Creek the amount of material is much greater, and the irregular topography indicates the existence of a small recessional moraine. The deposits reach higher levels on both sides of the valley here than they do above and below. This represents a halt of some duration during the retreat of the ice. From this point down to Lincoln the deposits are thinner but are continuous and extend up the southern wall of the valley as high as 10,250 ft. Many striated and faceted, sub-angular boulders are found along this upper level.

Near Lincoln occurs the terminal moraine of this short valley glacier and extensive deposits still remain on both sides of the valley. In Rich Gulch back of Lincoln the material is considerably more than fifty feet in thickness and extends up to the 10,600 foot level. The deposits are unassorted and are composed of intermingled coarse and fine fragments which are from Cretaceous shales, Dakota quartzite, and the two porphyries. A considerable amount of clay is present. On the opposite side of the valley in Weber Gulch is a still thicker deposit which is similar in all respects to the one back of Lincoln. A great deal of the material has been removed from the center of the valley, but the valley bottom is more filled in and more irregular than it is above and below.

Below the moraine the bed of the stream is filled with a great deal of very roughly assorted outwash representing the valley train of the glacier. This merges into the slope wash on the sides and no positive evidence of the ice is found from Lincoln down to the slope just northeast of Breckenridge, near the mouth of the valley. A great deal of the valley train has been removed. Some of the deposits have been reworked by French Creek during recent times so that a belt of recent alluvium is found along the stream from Lincoln down to the confluence with the Blue River.

Swan Valley .. Near the mouths of the American and Georgia Gulches considerable amounts of Pre-Cambrian boulders and other transported material occur. These can only have come from the Pre-Cambrian outcrops up the Swan River and represent a portion of a moraine across the Swan valley at this point.

RECENT DEPOSITS.

French Creek and Blue River have during Recent times deposited some material along the more level parts of their courses. This has given several long belts of Recent alluvium along the streams in the midst of older deposits.

The terminal moraine which formed in Rich Gulch back of Lincoln dammed up the headwaters of the stream so that for a time lacustrine sedimentation took place. The level plain known as Lincoln Park resulted from the filling up of this depression by lake bed deposits.

Similar conditions resulted from the damming up of the Blue River by the terminal moraine south of Breckenridge. Deposition in a lake back of the moraine formed the flats now known as the Goose Pasture.

During much of the present cycle of erosion in this region, rock fragments have been washing into and accumulating in many of the gulches and depressions. This has resulted in numerous extensive deposits of angular material such as are found in the old placer workings on Farncomb Hill, all classified and mapped as hillside wash.

Mechanical weathering on many of the steeper and more exposed hills has built up some very extensive talus slopes consisting of angular rock fragments of varying size and nature. On the gentler slopes thick masses of fine, weathered material have accumulated over the bed rock, making the study of the areal and structural geology unusually difficult.

STRUCTURAL GEOLOGY.

All of the sediments of the Breckenridge district with their associated igneous intrusions fill a long basin in the Pre-Cambrian rocks. The sides of this basin are formed by the Ten Mile Range on the west and the Vasque mountains on the east. To the east a great fault along the western side of the Vasque range has dropped the whole series of rocks down so that the Upper Cretaceous shales jut against the Pre-Cambrian of these mountains, and has given the sediments generally a sharp northeast dip. Local variations from this dip are due to the intrusions, to a great many faults- usually of small displacement, and in the Wyoming strata, to irregularities in the Pre-Cambrian floor.

The details of structure of the Breckenridge district are mainly an expression of the igneous activity which has taken place. The structure is complex, due to the abundance of small faults with the frequent repetition of beds, and to the many intrusions. The relationships are often very obscure due to the masking of outcrops by detritus and the impossibility of obtaining the dip of the beds in many places.

Since the Triassic red beds were laid down on an eroded land surface of Pre-Cambrian rocks this bottom sedimentary formation varies widely in dip, depending on the configuration of the land surface as well as on later changes. The general northeastward dip characteristic of the sediments does not hold everywhere in the Wyoming rocks.

Between Rocky Point and Bacon in the southwestern part of the area, a rather large sill of quartz monzonite porphyry occurs between the Wyoming rocks and the Dakota beds. This sill dips sharply to the northeast in conformity with the sediments into which it is intruded. The Dakota and Upper Cretaceous beds here form a syncline with the long axis northwest-southeast, extending from Indiana Gulch below Rocky Point to Bacon. The synclinal structure is probably due to the intrusion and to faulting on the northeast.

One of the most conspicuous structural features in the area is the large monzonite porphyry sill which forms a large part of Bald Mtn. and the hills to the north of that peak; It dips with the sediments which it cuts sharply to the east and north. On Bald Mountain the porphyry lies between layers of the Dakota sandstone. It is underlain by Dakota strata on the west side of the mountain, and on the eastern or upper border of the sill the upper beds of the Dakota dip sharply eastward under the Upper Cretaceous shales. Toward the northern end of the foothills of Bald Mountain, about three quarters of a mile south of French Creek, a series of faults has dropped this porphyry sill and the lower beds of the Dakota, with a lessening of the eastward dip. This causes the porphyry outcrop to extend farther west to Nigger Hill where the lower layers of the Dakota are again exposed. The numerous small outcrops of

45.

Dakota quartzite to the south of French Creek, surrounded by the monzonite porphyry, may be either remnants of the upper beds of the formation above the sill, or floats of the quartzite in the porphyry.

North of French Creek the sheet is cut by a long, narrow dike of quartz monzonite porphyry. This dike cuts the whole width of the monzonite porphyry from east to west and can be explained only on the supposition that the quartz porphyry represents a later stage in the intrusion than does the other type.

Some occurences of the Cretaceous shales in the western part of the area are at much lower elevations than in the eastern part in spite of the general eastward dip. This is due to the numerous faults and the variations in thickness of the formations beneath, with the configuration of the Pre-Cambrian floor possibly having some influence..

One of the most conspicuous results of faulting in the area is the location of the northwest-southeast belt of Dakota sandstone occurring in the southwest corner of the area. The fault dropped the beds on the southwest down so that the Dakota strata lie alongside of the Wyoming beds. The Dakota layers adjacent to the fault were crumpled and given a more or less synclinal structure by the movement. The fault extended northwest as far as Dry Gulch. At Dry Gulch the downward displacement

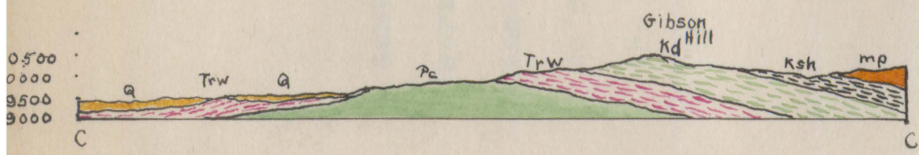
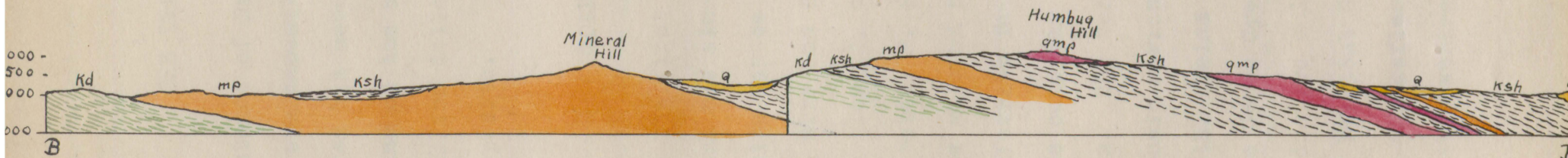
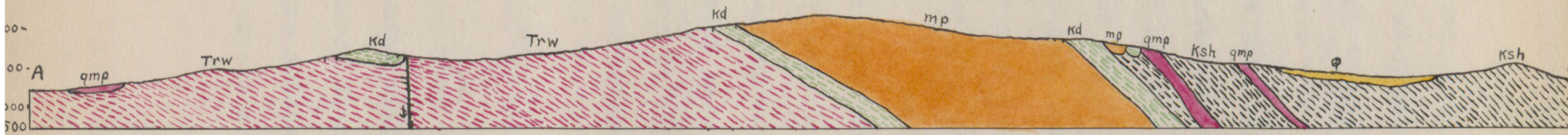
seems to have been on the north side for the Upper Cretaceous shale on the north of the fault is lower than the Dakota sandstone on the south.

Humbug Hill was formerly almost completely capped by a sill of quartz monzonite porphyry. Remnants of the sill remain over a considerable part of the hill and the whole surface of the ridge is covered by a thin mantle of the weathered porphyry. Due to the eastward dip this sill covered a large part of the eastern slope also.

In Rich Gulch Cretaceous shale outcrops occur below the adjacent Dakota outcrop on the east, a relationship which is probably due to faulting with a downward displacement to the west.

In the eastern part of the area the Cretaceous shales are cut by numerous small dikes and sills of both types of porphyry, without any important dislocations of the strata being produced.

These relationships and the details of structure are shown in the accompanying sections.



Structure sections
 across Breckenridge district, along
 lines indicated on the map.

ORE DEPOSITS.

The existence of Breckenridge is entirely dependent upon the ore deposits in the district and the surrounding area has been rather thoroly prospected. The annual value of the metal production amounting to over one million dollars shows the importance of the mineral deposits.

GOLD.

Gold was the first metal produced in the Breckenridge region and has always been the most important. The gold deposits may be grouped in the following classes: 1. crystalline wire and flake gold from the thin fissure veins in the shales; 2. gold associated with the sulfides in the larger veins; 3. placer deposits.

It is the gold of the first type that has made the Breckenridge district famous, altho the production from this source has come far from equalling that from the placer workings. The veins which carry the ore are remarkable for their narrowness, being usually less than an inch in width. Veins of this type are here restricted entirely to the Upper Cretaceous shales, and are found abundantly productive only in a very small area on the north slope of Farncomb Hill. Altho small, they are very persistent and are deflected little except by faulting and by separation into stringers on meeting harder rock.

The mineralization has probably been directly associated with the intrusion of the large, irregular mass of quartz monzonite porphyry which makes up a considerable part of the Farncomb Hill. All of the productive mines are located close to the porphyry-shale contact. Ransome states * that probably none of the ^{pocket of gold} larger nuggets have been found more than three hundred feet from the porphyry. The intrusion which injected the gold into the shale furnished practically no other metals. Besides the deposition of the gold little change was induced in the shales by the porphyry. The shale is somewhat hardened and a zone of breccia, cemented by igneous material and seldom mineralized, sometimes occurs along the border of the mass.

The metal occurs as nuggets of finely crystallized wire and flake gold, which are famous as museum specimens. The metal is very irregular and pockety in distribution, and many of the pockets are of extraordinary size and value. Farncomb Hill has now been almost completely worked out, altho some lessees are still operating on a small scale.

The gold associated with the sulfides is largely recovered in the treatment of the lead and zinc ores in which it occurs in small amounts. In a few of the mines it is concentrated enough to be worked alone, but it has never been a notable source of gold in comparison with

* Id. p. 154.

the veins of the Farncomb Hill type and the placers. Some of the mines on Humbug Hill operated on this type of ore exclusively but have never been successful.

The rich placer deposits of the district are of several different types. The gold first discovered here was in the slope wash of Georgia Gulch where extraordinarily rich deposits were worked for a number of years. Other similar accumulations of washed material in Dry Gulch, Gold Run and other localities have been very productive so that the total value of the workings has amounted to several million dollars. The gold in Georgia Gulch and Dry Gulch was derived from the rich veins of Farncomb Hill, while that in Gold Run came from veins on Gibson Hill.

The Terrace Gravels of the first glacial invasion have also been found to contain abundant gold and are worked on Nigger Hill and the sides of the Blue valley.

The present production of placer gold comes almost entirely from the low-lying stream and glacial gravels in French Gulch and the Blue and Swan valleys. The gold in these gravels was picked up by the ice and the streams from veins along the whole course of the valley. The only successful workings in the gravels are the present dredges two of which are operating in French Gulch, one on the Swan River, and one on the Blue.

Due to the activity of the dredges Summit County leads in the production of placer gold in Colorado. Altho the amount of gold to the cubic yard of gravel is small, averaging between twenty five and fifty cents, dredging on a large scale is proving very profitable, so that in 1914 the placer production of the district amounted to over \$600,000.

LEAD - ZINC - SILVER ORES

Following gold in importance of production in 1914 were zinc, \$260,709; lead, \$61,044; and silver \$33,175. These are found more or less intimately related, forming an important class of sulfide ores. The ore consists dominantly of galena and sphalerite with a great deal of pyrite and some gold and silver. Cerussite occurred extensively in the upper levels but has been practically exhausted.

The composition of the ores of the different mines varies widely. On the one extreme is the Country Boy Mine where much of the ore ran 43% zinc, without appreciable quantities of the other ore metals. The Minnie, on the other hand, produced ore running 67% lead, with 16 oz. silver, .03 oz. gold and no zinc. The ore of the Etigrade mine, while not strictly of this class, contained from 500 to 726 oz. of silver, .2 to 1.65 oz. of gold, and 4 to 13 % lead per ton. The other ores of the district

range between these extremes and even in a single mine the composition of the different veins varies widely. The Wellington Mine which is the largest producer at present, has shipped ore containing 50% lead, 5% zinc, and 10 oz. silver, and also another class of ore yielding 17% zinc and 1% lead.

The veins bearing the lead-zinc-silver ores have a general northeast-southwest strike. They are usually from three to ten feet in width and are rather persistent thru the different formations. They are almost always simple fissure veins showing varying amounts of replacement. The most common gangue minerals are siderite and pyrite with some barite and quartz.

The productive veins are always associated with the porphyry intrusions of either type, which furnished the metals. Faulting has been very extensive so that many of the veins have been considerably disturbed.

DEPOSITS IN PRE-CAMBRIAN ROCKS.

Some narrow, gold bearing fissure veins are found in the Pre-Cambrian rocks of the area but they have never been important. The Blue Flag or Laurium Mine was worked for some time on such veins, and other mines have operated in the Pre-Cambrian rocks for a short time.

GENERAL MINING CONDITIONS.

At present the only important producers in the camp are the Wellington Mine and the gold dredges, from which almost all of the production comes. The activity of the dredges has given the district first rank in the state in the production of placer gold. The Wellington Mine and the dredges will be able to maintain and possibly increase their present rate of production for some years. Prospecting and spasmodic production going on in numerous other properties may result in some new discoveries of more or less importance and will swell the total output of the district for some time.

THE LUCKY MINE.

As the Lucky Mine is more or less typical of the smaller lead-zinc mines of the district, a rather detailed description of it will be worth while. It is located on the northeast slope of Mineral Hill. It is one of the older producers of the district, having been worked since the 'seventies. No ore has been shipped from the Lucky during the past two years but active prospecting has been going on continually.

Three levels have been worked, the lowest of which is 180 ft. below the surface. Of these the first level was the most productive and furnished a considerable amount of high grade lead ore. Some high grade ore was

found on the second level and much stoping was done but the drifts were not pushed far. The vein has been drifted along for 405 ft. along the lower level but no workable quantity of ore has yet been found.

On the first level two veins have been worked. These have been called the Lucky and Paducah, as shown on the accompanying mine map. It is probable, in view of the relations of the veins on the first level and on the third, that the so-called Paducah vein is merely a part of the Lucky vein and that the vein worked to the south of the shaft on the first level is really the Paducah. It is possible, but not probable, that this latter vein may be a part of the Lucky vein which has been displaced southward by faulting. If the former be true, more ore might be expected in the unexplored country along the strike of the Lucky vein.

The ore encountered on the first level ran high in lead, with very little silver, zinc, or gold. Both galena and cerussite were present here. Some of the ore is said to have contained 70% lead. The gangue was mainly pyrite and siderite and quartz with some barite.

The veins are simple fissure fillings from four to seven feet wide and contain many pipes and stringers of ore. Slickensided surfaces and clay gouge are common along the whole length of the vein, and numerous small faults have cut across it. The dip of the veins varies little and is about 70° east and southeast. The faults seldom have a dip of over 25°.

The country rock on the first level is the Cretaceous shale which is unusually hard here. It has undergone no change from the intrusion of the associated porphyry except the mineralization and hardening. The second level is similar to the first except for a lessened amount of ore and a change in the country rock from shale to monzonite porphyry. This level is now inaccessible.

On the third level the vein has the same dip as on the first level and is continuous with the Lucky vein above. It is continuous along the whole lower level and varies little in strike or dip. It has been explored for 405 ft. on this level but little ore has been found. Small pockets, however, have assayed 22% lead, some zinc, 13 oz. of silver, and 16 oz. gold per ton. It is a question whether or not any of the rich shoots on the upper levels extend to this depth.

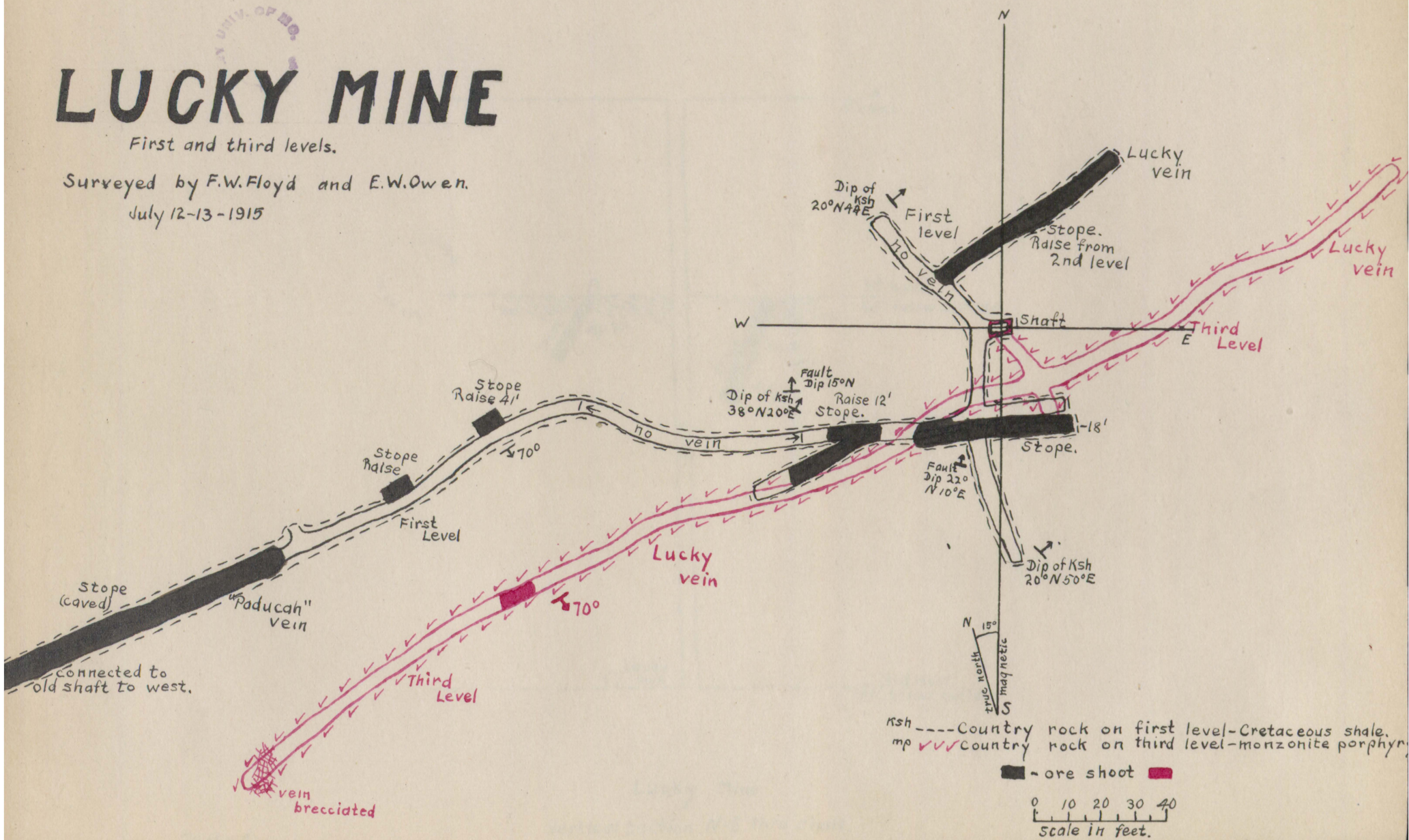
Explorations here may open up profitable shoots on the lower levels and locate productive, unworked parts of the vein above, but it is doubtful if much more ore remains on the Lucky property.

LUCKY MINE

First and third levels.

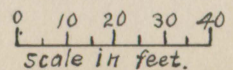
Surveyed by F.W. Floyd and E.W. Owen.

July 12-13-1915

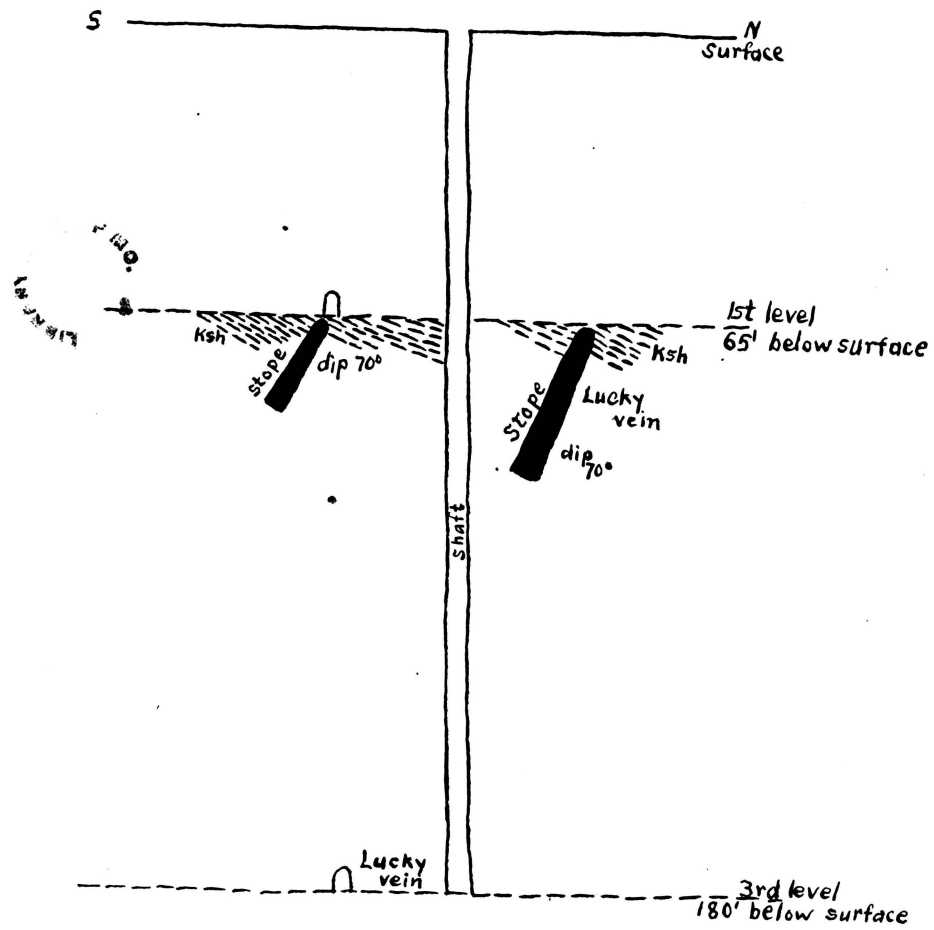


ksh --- Country rock on first level-Cretaceous shale.
 mp vvv Country rock on third level-monzonite porphyry.

■ - ore shoot ■



Directions of dip-angles are based on magnetic N.



Lucky Mine

Vertical section N-S thru shaft.

UNIVERSITY OF MISSOURI
COLUMBIA

DEPARTMENT OF CHEMISTRY

27:8:16

Dean Walter Miller,
Chairman, Graduate Committee

Dear Sir,

In accordance with your request I have rather carefully examined the dissertation of Mr. Edgar W. Owen.

I think it meets the general standard of this institution - but I think it might be improved.

For example, I ^{looked up} compared some of the references and found that they were as far as I could make out inaccurate. On page 10. "One of the areas of pre Cambrian rocks is said to be on the "eastern side of Gibson Hill" the map shows it on the western. Another area is said to be "just east" of a mine, the map shows it north. On page 11 There is a statement credited to Rausome. "according to Rausome" which as I read Rausome is not according to Rausome. On page 45 "larger nuggets" are credited to Rausome. Rausome says nothing about "nuggets".

There are a number of misspellings which I have noted and some other matters, trivial perhaps, with which I need not trouble you

Yours truly
W. A. Brown

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