C 11-9-14

COLORADO STATE GEOLOGICAL SURVEY
BOULDER
R. D. GEORGE, State Geologist

BULLETIN 2

GEOLOGY OF
THE GRAYBACK MINING DISTRICT

COSTILLA COUNTY
COLORADO

BY
HORACE B. PATTON
CHARLES E. SMITH
G. MONTAGUE BUTLER
ARTHUR J. HOSKIN

DOI: https://doi.org/10.58783/cgs.b02.qstp6655

GEOLOGICAL BOARD

LETTER OF TRANSMITTAL

State Geological Survey,
University of Colorado, May 1, 1910.

Governor John F. Shafroth, Chairman, and Members of the Advisory Board of the State Geological Survey,

GENTLEMEN:—I have the honor to transmit herewith Bulletins 1 and 2 of the Colorado Geological Survey.

Very respectfully,

R. D. GEORGE,
State Geologist.

CONTENTS

PAGE.

ILLUSTRATIONS AND MAPS

CHAPTER I.

INTRODUCTION.

ORGANIZATION.

The following pages are the result of six weeks of work in the field under the direction of the Department of Geology of the Colorado School of Mines during the summer of 1909. Most of the actual work in the field was done by students of the class of 1910, with a view to preparing graduation theses. This is more particularly true of the topographic map that had to be made before the areal geology could be undertaken. The party was in charge of the senior author, Horace B. Patton, assisted by Charles E. Smith and G. Montague Butler. Besides the above mentioned members of the geological department, the party comprised the following eighteen students: J. Courtenay Ballagh, Kent P. Campbell, Paul H. Carpenter, Charles E. Dyer, Russell J. Farrar, Samuel A. Feldman, Ronald P. Fitz Gerald, George T. Geringer, Charles M. Glasgow, Howard J. Hilton, Ernest F. Jones, Dana W. Leeke, Herbert B. Lesh, Glover S. McKay, Harlow D. Phelps, Harry M. Showman, Henry G. Skavlem, Otis W. Swainson.

After the preliminary work of triangulation was completed the territory to be mapped, embracing a little over thirty square miles, was divided into eight sections, a section being assigned to each squad of two for the purpose of completing the topographic map and for studying and mapping the areal geology. The topographic work, conducted under the direction of Mr. Smith, is described by him in chapter two. Mr. Smith has also prepared chapter three, on the Sedimentary Rocks. Chapter six, on the Ore Deposits, has been written by Mr. Butler, who conducted his investigations with the aid of two of the student members of the party. Finally, a description of the Mines and Mining Processes, chapter seven, has been prepared by Mr. Arthur J. Hoskin, Professor of Mining at the Colorado School of Mines, who joined the party for a short time for this purpose. To the senior author has fallen the task of the description of the Archaean, the igneous rocks and contact phenomena.

LOCATION AND HISTORY.

The area surveyed embraces about thirty square miles in the northern part of Costilla County, Colorado, lying due east of

Blanca Peak, the highest peak of the Sangre de Cristo Range. The Sangre de Cristo Range, which starts opposite Salida, runs approximately south until it culminates in Blanca Peak, which rises to a height of considerably over 14,000 feet. At Blanca Peak the range suddenly turns to the northeast, and runs for some fifteen miles at a much lower level, turning again to the southward at Sangre de Cristo pass, and finally merging into the Culebra Range. The county line between Costilla and Huerfano counties follows this lower portion of the Sangre de Cristo Range, and likewise forms the northern boundary of the mapped area. The southern, western and eastern boundaries have been taken somewhat arbitrarily, but so as to include the town of Russell, formerly called Placer.

Grayback Mountain, while not the highest peak of the district, is the most conspicuous one of the group as seen from the highway of travel along the La Veta-Russell road that has been built on the abandoned narrow-gauge right-of-way of the Denver and Rio Grande Railroad. On the map prepared by the U. S. Geological Survey in 1889, and designated the Huerfano Park Sheet, this mountain appears under the name of Iron Mountain, doubtless because of the iron mines on its western slope. The name Grayback, however, is the only name used by local residents. On this same sheet the name Grayback has been erroneously assigned to a much higher peak lying several miles to the west of Placer Creek. The name Grayback Gulch is applied by local residents only to the gulch that drains the west slope of Grayback Mountain and empties into Placer Creek from the east, as shown on our map, and not to the gulch draining southeastward from the above mentioned misnamed Grayback Mountain as given on the Huerfano Park Sheet. These same errors are to be found in the atlas prepared by the Hayden Survey of the Territories, which doubtless accounts for their occurring on the Huerfano Park Sheet.

The Trinchera Estate.—The northern boundary of the Grayback district also forms part of the northern boundary of the so-called Trinchera Estate, within which this tract lies. This estate, embracing some 450,000 acres, is the northern half of what was formerly a much larger private estate, known legally as The Sangre de Cristo Grant. This was an old grant made by the Mexican Government in 1843 to Luis Lee and Narcisso Beaubien. Lee, it appears, transferred his interest to Charles Beaubien, the father of his partner, who, through the death of his son and of

Lee at the hand of Indians, a few years later, came into possession of the entire grant.

When this territory was ceded by Mexico to the United States it was stipulated that this land grant should remain intact; accordingly congress, in 1861, confirmed the grant and conveyed absolute title to the land, including mineral rights. Subsequently the entire Sangre de Cristo Grant came into the possession of the late Governor Gilpin. Its boundaries were as follows: The southern boundary was the southern boundary of Colorado. The eastern and northeastern boundary was the Culebra-Sangre de Cristo Range as far as Blanca Peak. From here the line followed a southwestern course to the junction with the Rio Grande del Norte. From here it followed down the river to the state line.

Gilpin divided this Grant into two sections by an east-west line at latitude 37° 13′ 40″; the northern being designated as the Trinchera Estate, and the southern as the Costilla Grant.

CLIMATE AND VEGETATION.

Owing to the moderate elevation of the Grayback district—between 8,500 and 11,400 feet—the summer climate is mild and delightfully refreshing and the winters not excessively cold. The precipitation in the more mountainous portions is sufficient to form small but permanent streams in several of the valleys.

Most of the area is covered with a heavy growth of timber, especially on the northern slopes. Considerable portions are so thickly grown up with a second growth of young pine as to make it impossible to ride a horse through it. The timber consists of pine and spruce, with much aspen and some balsam. Logging operations have been conducted extensively in the past, and most of the large pine trees have been cut, but as these occur only as isolated trees in the midst of a forest of other firs the removal of timber has had no appreciable effect on the forested area.

The bottoms of the valleys and gulches are mostly open, as are also large spaces on the upper slopes, and furnish fine pasturage for cattle, many head of which are annually pastured in this portion of the Trinchera Estate.

PREVIOUS WORK.

Several brief notes bearing more or less directly on this region are commented on in succeeding chapters of this bulletin. In most cases they bear on the Sangre de Cristo range as a whole.

This is particularly true of what F. M. Endlich has to say in the Hayden Geological Survey of the Territories. In the report for 1873 (pages 323-334) he gives a general description of this range, confined mostly to the northern part. In the report for 1875 (pages 108-122) the general description is continued with additional reference to the southern part of the range. The carboniferous rocks along the Sangre de Cristo Creek from the pass of the same name westward to the crystalline schists are described under the name of the "Arkansas" sandstone, a few fossil forms are described and a vertical, but idealized section, from the pass westward is given. The igneous rocks of this district are referred to as trachyte. That portion of the Hayden Atlas, accompanying these reports, covering this limited area, is fairly accurate, except that the area covered by igneous rocks is too extensive and continuous.

ACKNOWLEDGMENTS.

The writer wishes to express his great obligation to Mr. R. C. Hills for the loan of many rocks and thin-sections of rocks from his splendid collection made in connection with his study of the rocks of the Spanish Peaks Quadrangle and of the Walsenburg Quadrangle; to Mr. E. C. Van Diest, Manager of the Trinchera Estate; to the Denver & Rio Grande Railroad Co., for numerous courtesies; and to many residents of Russell and vicinity for valuable information given. Further acknowledgments will be found in subsequent chapters.

CHAPTER II.

TOPOGRAPHY.

BY CHARLES E. SMITH.

DESCRIPTION.

The section under discussion has a general southwesterly drainage through the Sangre de Cristo Creek into the Trinchera Creek, thence into the Rio Grande River. Tributary to the Sangre de Cristo Creek, and cutting the section roughly north and south are Placer Creek, Middle Creek, Grayback Creek and Mill Creek, with numerous smaller tributaries.

There is a strong relief, shown by differences of elevation between 8,415 feet at Russell and 11,409 feet on Stearns Mountain.

The datum used was mean sea level, and the starting point was a bench mark near Russell Station, kindly furnished by the Denver and Rio Grande Railroad Company.

The level notes connecting this bench mark with the Grayback area follow.

Elev.	
8271.7	Top rail opposite mile post No. 217, D. & R. G. R. R.
8415.22	B. M. Post in front of Russell Hotel.
8440.22	B. M. Stump north of school house.
8461.93	B. M. on timber of old culvert.
8474.59	On top pipe in drill hole, placer prospect.
8520.65	On rock west side of road. Marked †36.
8523.50	Center of spile at north end of old R. R. bridge, west of road.
8577.09	Wooden stake west side of road, ¾ mile above placer.
8599.34	Wooden stake in mound of stones, east side of road above dredge.
8618.51	Rock, northeast corner of bridge, near old threshing engine.
8671.30	Top of stake, sta. C of base line, on hill above sawmill.
8729.74	Station B of base line. Small stake.
8729.37	Rock 26 paces north of Sta. B of base line; top of rock marked by chisel "†."

A base line was laid out in an open territory from which as large a number of prominent points as possible might be seen. It was measured and checked by two different squads.

The line of levels was carried up to each point on the base line, and a rough check made by calculating these points by means of measured distances and vertical angles. Here follow the base line field notes:

FIELD NOTES ON BASE LINE.

Sta. to	Sta.	Hor. Dist.	Elev.	Remarks.
	A		8792.05	West end of base line.
A	B	1198.56	8730.07	East of Sta. A.
B	C	1346.33	8671.37	East of Sta. B.
C	D	1075.82	8692.39	East of Sta. C.
D	E	1489.98	8876.02	East of Sta. D.
D	K	54.05	8883.62	East end of base line.

The total length of base line was 5164.74 feet.

The bearing, as determined by a solar observation, was N. 86° 13′ E.

PRIMARY TRIANGULATION.

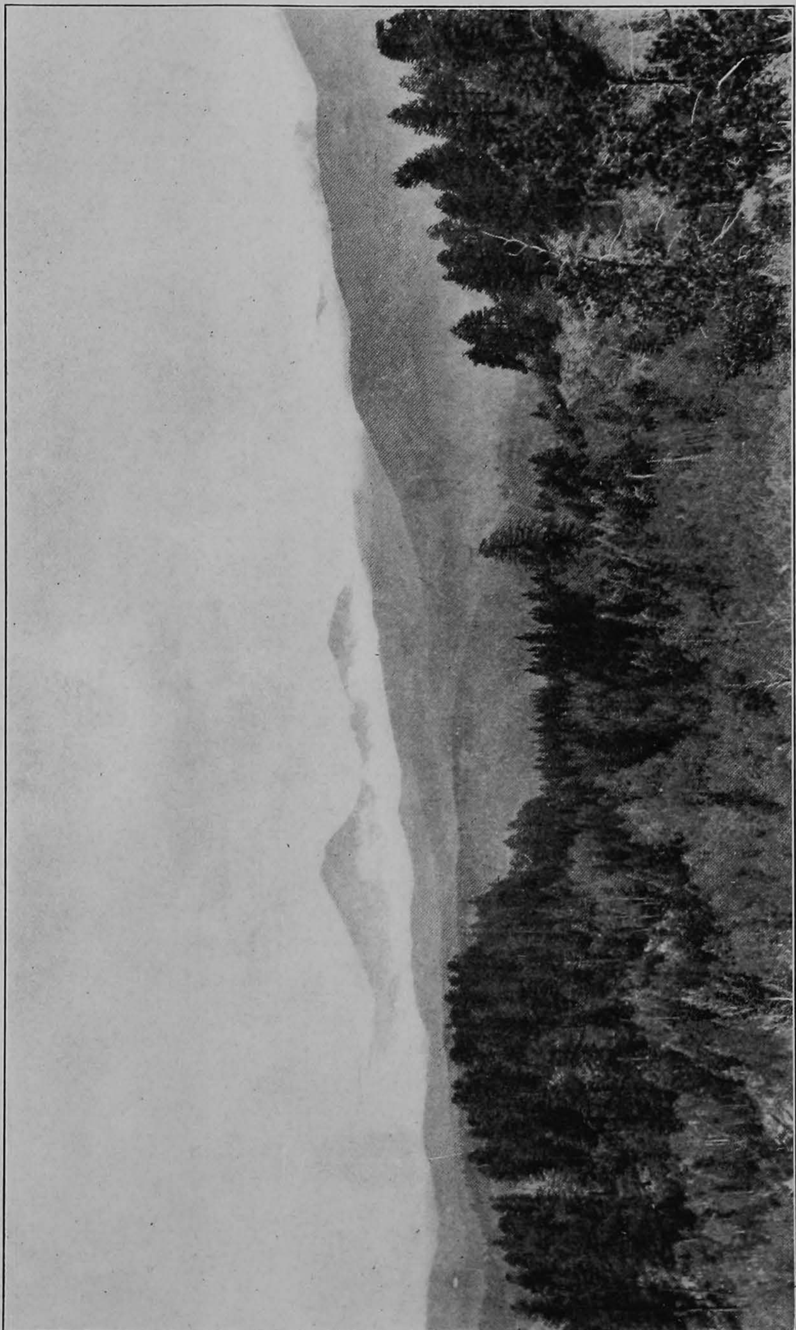
The base line was used as a foundation for triangulating in the main points in view from it, and high points not visible from the base line were triangulated by means of points and lines already determined from the base line.

This work was done with considerable care, two or more calculations being made for each point, and the average taken for the elevations of points. Angles were repeated and averaged which accounts for readings to seconds in the notes. Besides these precautions, two or more squads of students checked each other on the results.

Here follow the field notes with the calculations for all the more important points. All other points listed in the notes were carefully calculated, but it is not deemed necessary to present all the figures, as they were temporary points taken for the purpose of holding the contours.

Angles were uniformly read around to the right.

COLORADO GEOLOGICAL SURVEY PLATE IV



VIEW TO THE WEST FROM PARK MOUNTAIN, WITH MT. BALDY IN THE DISTANCE

Sta.	BS.	FS.	H. A.	V. A.	Hor. D.	Elev.	Remarks.
A	C				2544.89	8671	Sta. C is on base line.
		1	279°10′30″	+ 4°13′	2688.3	8954	Stripped tree, 40 feet high.
		2	279°15′15″	+ 2°57′	1994.2	8898	In front of 1 and same ridge.
		3	294° 3′15″	+ 4°20′	2442.2	8937	45′ tree on knoll above camp.
		3A	302°31′00″	+ 7°11′	12871.7	10393	26′ leaning dead tree on Park Mt.
		3B	313°44′00″	+ 6° 2′			Tripod on N end of Mt. Stearns.
		3C	316°00′30″	+ 6°25′	23401.7	11403	Monument on top of Mt. Stearns.
		3D	316°51′15″	+ 6°21′	23227.0	11381	Monument on S end of Mt. Stearns.
		6	329° 2′40″	+ 5°50′	13622.2	10180	5′ pole on cabin S slope of Grayback Mt.
		6A	327°22′15″	+ 6°48′	14962.5		Pole on top of Iron Mt. (Grayback Mt.)
		6B	344°34′15″	+ 5° 7′	6556.5	9381	Peak S. W. Mt. Stearns.
C	K				2619.9	8884	E end of base line.
		8	49° 1′15″	+ 2°13′	10821.1	9093	Lone Tree Peak.
		7	50°41′00″	+ 1°10′	7143.0	8821	Pole on ridge across creek from 8.
		6	322°31′00″	+ 7°33′	11514.5	10192	Located.
		6A	321°15′40″	+ 8°25′	12892.6	10575	Located.
		3A	291°57′00″	+ 8°30′	11702.2	10398	Located.
K	A				5110.69	8792	Sta. on base line.
		8	241°16′45″	+ 1°18′	9315.5	9095	Located.
		6B	123°31′15″	+13°26′	2092.3	9384	Located.
		7	250°58′15″	—0°33′	5845.6	8825	Located.
6B	A				6556.5	8792	Located.
		3C	141°21′45″	+ 6°30′	17919.4	11414	Located.

		2	17°34′00″—4°32′	6003.7	8902	Located.
		3	20°38′30″—4°19′	5346.9	8935	Located.
		1	24°12′20″—3°46′	5691.6	8952	Located.
3C	A			23401.7	8790	On base line.
		3B	118°52′00″—4°54′	1062.2	11326	Located
		G26	350°51′00″—7°00′	7375.0	10514	Top of Buckskin Mt.
3B	3C			1062.2	11410	
		G26	—5°47′	8072.7	10509	Located.
7	8			3015.0	9095	
		24	310°25′00″+ 5°35′		10291	Monument on top of Dump Mt.
8	7			3015.0	8822	Located.
		24	118°40′00″+ 5°18′	12941.0	10286	Located.

Calculations for "6B," which was used as a vantage point from which to triangulate other more important points.

Side A-K_1 = 5110.7 Measured.
Angle K_1 A-6B = 15° 25′ 45″
Angle A-K_1 6B = 123° 31′ 15″
Side A-6B = 6556.5 Calculated.
Side K_1-6B = 2092.3 Calculated.
Elevation calculated from A = 9381′.
Elevation calculated from K_1 = 9384′.
Average of Calculations, 9383′.

Calculations for "3C," Mt. Stearns.
Side A-6B = 6556.5 Calculated.
Angle 6B-A-3C = 28° 33′ 45″
Angle A-6B-3C = 141° 21′ 45″
Side A-3C = 23401.7 Calculated.
Side 6B-3C = 17919.4 Calculated.
Elevation calculated from A = 11403′.
Elevation calculated from 6B = 11414′.
Average of Calculations, 11409′.

Calculations for "6," Pole on Cabin, S. slope of Grayback Mt.
Side A-C = 2544.9 Measured.
Angle C-A-6 = 30° 57′ 20″
Angle A-C-6 = 142° 31′ 00″
Side A-6 = 13622.2 Calculated.
Side C-6 = 11514.5 Calculated.
Elevation calculated from A = 10180′.
Elevation calculated from C = 10192.
Average of Calculations, 10186′.

Calculations for "6A," Grayback Mountain.
Side A-C = 2544.9 Measured.
Angle C-A-6A = 32° 37′ 45″
Angle A-6-6A = 141° 15′ 40″
Side C-6A = 12893′ Calculated.
Elevation calculated from C = 10575′.

Calculations for Point "1."
Side A-6B = 6556.5 Calculated.
Angle 6B-A-1 = 65° 23′ 45″
Angle A-6B-1 = 24° 12′ 20″
Side A-1 = 2688.3 Calculated.
Side 6B-1 = 5691.6 Calculated.
Elevation of "1" calculated from A = 8954′.
Elevation of "1" calculated from 6B = 8952.

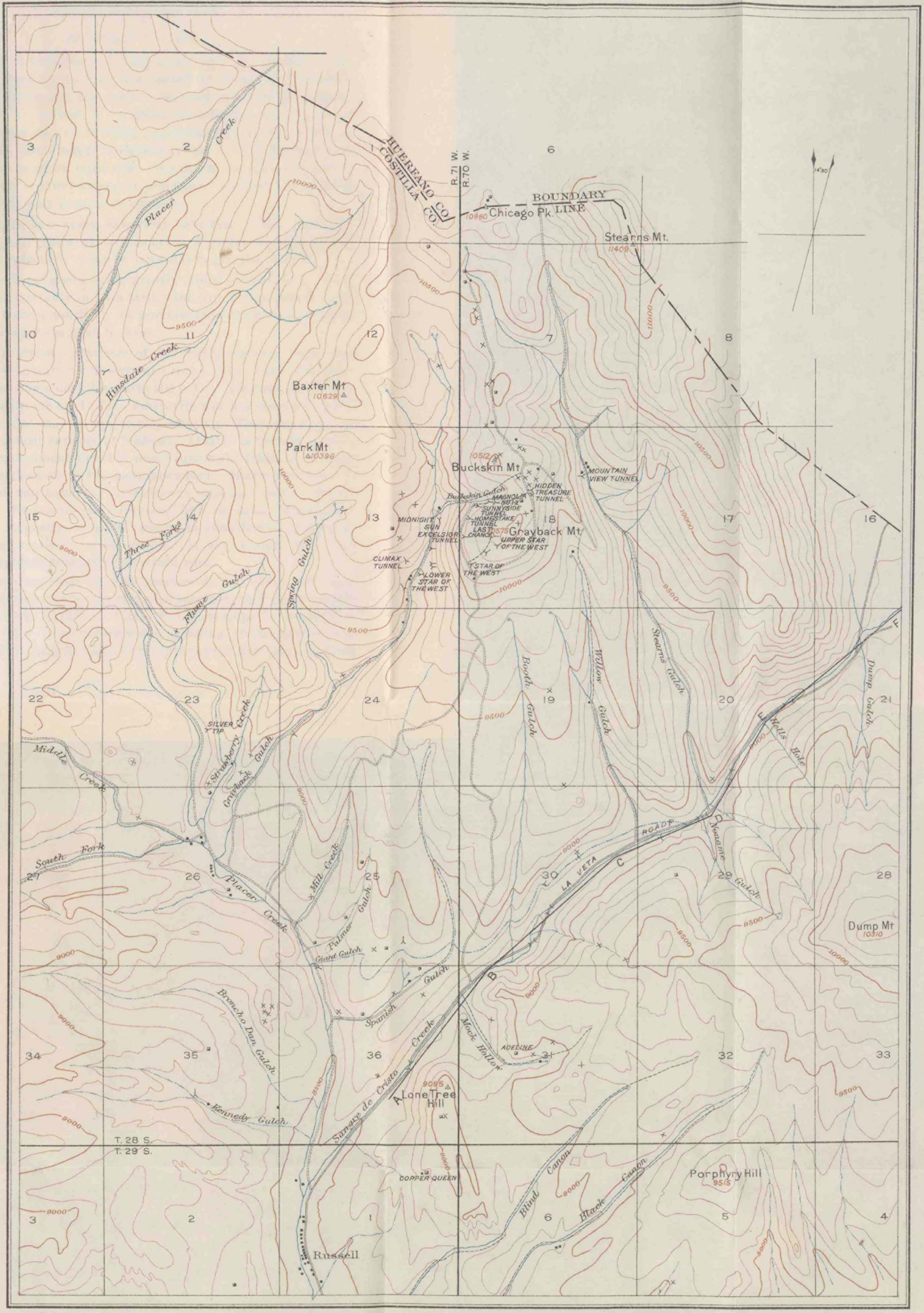
Average of Calculations, 8953′.
Calculations for "3A," Park Mountain.
Side A-C = 2544.9 Measured.
Angle C-A-3A = 57° 29′
Angle A-C-3A = 111° 57′
Side A-3A = 12871.7 Calculated.
Side C-3A = 11702.2 Calculated.
Elevation calculated from A = 10393′.
Elevation calculated from C = 10398′.
Average of Calculations, 10396′.
Calculations for "G-26," Buckskin Mountain.
Side 3B-3C = 1062.2.
Side 3C-G26 = 7375.0.
Side 3B-G26 = 8072.7.
Elevation calculated from 3C = 10514′.
Elevation calculated from 3B = 10509.
Average of Calculations, 10512′.
Calculations for "8," called Lone Tree Peak.
Side C-K_1 = 2565.8 Measured.
Angle K_1-C-8 = 49° 1′ 15″
Angle C-K_1-8 = 118° 43′ 15″
Side C-8 = 10821.1 Calculated.
Side K_1-8 = 9315.5 Calculated.
Elevation calculated from C = 9094′.
Elevation calculated from K_1 = 9095.
Average of Calculations, 9095′.
Calculations for "24," Monument on Dump Mt., 21 feet below highest point.
Side 7-8 = 3015 Calculated.
Angle 8-7-24 = 49° 35′ 00″
Angle 7-8-24 = 118° 40′ 00″
Side 7-24 = 14900 Calculated.
Side 8-24 = 12941.
Elevation calculated from "7" = 10291′.
Elevation calculated from "8" = 10286.
Average of Calculations, 10289′.

TRAVERSES.

Many valleys and slopes are quite heavily wooded, and because of this fact the triangulated points were of no use while in the timber. Happily, roads and trails traversed every portion of the territory, and along these roads traverses were run, connecting some known point on the base line below to some triangulated point above.

To all portions of the area these traverses were easily accessible, and proved very helpful in locating contours accurately. Some of the traverses were run by transit and chain, others with transit and stadia.

After the preliminary work outlined above was completed the field was divided into eight parts, the parts given to squads of students (two in a squad) to contour. The topographic map represents their work.



TOPOGRAPHIC MAP OF THE GRAYBACK MINING DISTRICT, COSTILLA CO., COL.

Topography by students of the Colorado School of Mines, under direction of the Geological department.

Scale $\frac{1}{36000}$ or 3000 feet to 1 inch

1 mile

Contour interval 100 feet

Datum is mean sea level

1909

A. HOEN & CO. BALTIMORE.

CHAPTER III.

ARCHAEAN GEOLOGY.

BY HORACE B. PATTON.

General Description.—A little more than one quarter of the area represented by the map is occupied by Archaean crystalline schists and gneisses. The contact between this and the carboniferous rocks to the east is a slightly sinuous one, running about north-northeast and conforming approximately to the course of Placer Creek, there being no Carboniferous west of Placer Creek except at the extreme upper end. The dip of the contact with the Carboniferous is always steep or practically vertical, but is sometimes westerly and sometimes easterly.

The rocks are never extremely schistose. They are very feldspathic, and represent various types of gneiss, with occasional lenses of hornblendic rocks or irregular pegmatite veins.

None of these gneisses are greatly folded or contorted. They fluctuate considerably in both strike and dip, but in general may be said to have a northerly to northeasterly strike and a steep dip fluctuating from east to west.

Granite Gneiss.—Gneisses of this character vary from very coarse- to comparatively fine-grained rocks. They very often have a reddish or even a dark brownish red color. They are inclined to be very poor in mica. In fact, muscovite was not observed at all, and biotite also may be practically wanting. They are made up mainly or almost entirely of feldspar. Quartz is usually present in considerable quantities, but never equals the feldspar. Of the feldspars orthoclase is the most abundant. Microcline is never lacking, and may equal the orthoclase in some specimens. Plagioclase may frequently be observed, but in quite subordinate amounts. Magnetite is often present in considerable quantities and in comparatively coarse grains. It may readily be picked out by a magnet from the pulverized rock.

In structure these granite gneisses do not ordinarily show any marked schistosity. In the hand-specimen they could readily be mistaken for granites. Under the microscope in thin-section they invariably show considerable crushing of the ingredients. These granite gneisses occur in all parts of the territory surveyed, but appear to be most extensively developed in the northern portion of the archaean area.

Biotite Gneiss.—Sometimes alternating with beds of granite gneiss and sometimes forming extensive masses are to be found other gneisses that have a varying but large amount of biotite. With the biotite may be associated some dark green hornblende, or perhaps chlorite and epidote. Here again magnetite in coarse grains is very abundant. These biotite or biotite-hornblende gneisses have usually a banded or bedded structure, in that beds of varying composition and from one to ten feet in thickness, alternate with each other.

Hornblende Schist and Amphibolite.—These rocks occur rather sparingly in the form of lens-like masses, conforming in strike and dip approximately to the adjacent gneisses. They are rarely more than fifty or one hundred feet wide.

Most of these hornblende rocks show a distinct schistosity, owing to the parallel arrangement of the constituents. A few, however, are massive amphibolites. The hornblende usually makes about one-half of the entire rock. Its color is dark green in the thin-section and almost black in the rock. With it are associated varying amounts of quartz, plagioclase and orthoclase. Accessory apatite, titanite and occasionally magnetite also occur. Microcline was not observed. Of the feldspars a basic plagioclase is the most abundant. Quartz may be entirely wanting, or, again, it may compose as much as one-quarter of the rock mass. In one case biotite formed a considerable part, but was lacking in all others examined.

Pegmatites.—A number of coarse-grained pegmatite masses fifty to one hundred feet wide and several hundred feet long were observed. They occur mostly in connection with the granite gneisses of the northern part. As they resist the weather better than do the gneisses they form more or less conspicuous outcrops. They consist of microcline and quartz in very coarsely granular aggregates or in the form of "graphic granite." A very little plagioclase was observed in one instance.

CHAPTER IV.

SEDIMENTARY ROCKS—CARBONIFEROUS.

(By Charles E. Smith.)

The sedimentary rocks described below and shown by their fossil contents to belong to the carboniferous are very well exposed in the Grayback District. They consist of a very complex series of alternating grits, sandstones, shales and limestones, and have a total thickness of over three thousand feet.

As a rule the sandstones and grits are barren except now and then a plant fragment. A calcite cement is most common, sometimes in excess, so that a thin lamina of limestone is found interbedded with the sandstone.

The limestones vary from impure shaly to compact blue beds, all of them fossiliferous, with the fossils in a fairly good state of preservation.

In the notes which follow it will be seen that, while fossils are generally distributed throughout the whole series, six especial zones are emphasized because of the predominance of some particular form of life contained.

In order, they are as follows:

The coral bed.
The floral bed.
The seminula bed.
The productus bed.
The aviculopecten bed.
The gastropod bed.

The writer is under special obligation to Prof. Junius Henderson of the State University of Colorado for his painstaking work in identifying the larger portion of the fossils collected and for his valuable suggestions as to correlations; also to Dr. Geo. H. Girty and Dr. David White, both of the United States Geological Survey. Some of the material, especially the corals and gastropods, was submitted to Dr. Girty and the flora was sent to Dr. White.

With no knowledge of the field notes on lithological characters Prof. Henderson tabulated the faunas reported from various sections in Colorado and checked the material sent him against this tabulation. His paleontological conclusions were that it most probably represents the Hermosa formation in the Pennsylvanian division of the carboniferous.

Dr. Girty coincides with Prof. Henderson and says: "The species examined indicate the Hermosa age of the beds with the exception of *B-4, which might possibly be Rico, so far as species are concerned," but adds, "I should hesitate to place this material in the Rico fauna and would suggest that it also might be Hermosa."

Dr. White, with a limited amount of poorly preserved plant remains, suggests: "It is probable that they (plants) are not younger than the middle of the Pennsylvanian."

There is, therefore, a unanimity of opinion on the part of these three gentlemen regarding the age of the rocks examined.

Notes on the lithological characters submitted herewith are a further confirmation of their determination, for it will be seen that the variety of beds and textures is so complex as almost to prohibit a detailed account of their occurrence. The formation is called the "Hermosa Complex" in the several folios dealing with areas containing it.†

Exposures and Choice of Section.

In the field under consideration a number of fairly good exposures may be seen. Nearly all of these exposures were worked to some extent by different members of the party, but owing to the complex character of the beds and the impossibility of correlating and checking the fossils collected from separated areas it was decided to work carefully one type section and let it stand for the field.

The best section available was found along the Sangre de Cristo Creek, parallel to which is an old railroad grade now used as the La Veta-Russell Road. This is the longest continuous exposure and is still further favorable inasmuch as it follows approximately the direction of dip.

Contact with the Archean is seen on this La Veta Road about three-fourths of a mile northeasterly from Russell.

Traveling along the road eastward from this contact one is passing over the nearly vertical beds composing the western limb of a syncline for about five-eighths of a mile, and in this distance there is hardly a bed which can not be easily examined.

*See faunal section B-4.
†See U. S. G. S., folios Nos. 120, 130, 131 and 153.

One small intrusion of felsite porphyry is to be seen about half way to the synclinal axis. It appears to have been a sill subsequently folded with the strata.

Dips change from 75 degrees and 80 degrees easterly to the same angles westerly, then back easterly and again westerly before the final gentle eastern dip near the synclinal axis.

These changes in dip, together with the fact that local faults occur near the Archean Contact, and that the westerly dips on the eastern limb of the syncline are comparatively gentle, probably indicate a fold recumbent to the eastward.

About three-fourths of a mile east of the synclinal axis the western end of a large intrusion of felsite porphyry is seen. It is exposed on both sides of the valley from this point for a distance of three-fourths of a mile eastward.

Dips and strikes are very much disturbed by this intrusion. A ledge of limestone was followed around its north contact. Its strike is parallel with the road. East of this intrusion the gentle easterly dips which persist for the next mile seem to indicate that beneath the aforesaid intrusion, or in the area occupied by it, a suppressed anticlinal fold must exist.

About one-half mile west of the eastern boundary of our territory the gentle easterly dip changes suddenly to a dip of 72 degrees easterly and then becomes vertical, in which condition it remains up to and one mile beyond the limits of our map.

For convenience in classifying the field notes and the collections made, the field was separated into A and B divisions. "A" division includes all beds to the west of the first synclinal axis, and "B" division includes those beds east of this axis. A and B divisions are arbitrarily subdivided into sections, each of which includes one or more fossiliferous beds, numbered A-1, A-2, etc.

Lithological Characters by Sections.

*The Archean floor is a granite gneiss of varying grain and composition, portions being composed of quartz and feldspar alone, while other portions approach a biotite schist. Directly beneath the sedimentaries it is granitic in character, fairly coarse grained.

A-1.

At contact the strike is N. 30 degrees W.

Dip is 75 degrees, with a direction of dip of N. 60 degrees E.

*Beds are described in order, always beginning with the lowest in a section

The earliest member of this series is a grit composed almost entirely of quartz and feldspar. The material is angular and varies in size of grain from fine sand to fragments one-quarter to one-half inch in diameter.

In the specimen collected there is included an occasional angular fragment of soft greenish material like serpentine or chlorite, the source of which is hard to conjecture, as the other material is decidedly acid in character. The cement is mostly silica, with a little hematite.

In the various descriptions of the Hermosa formation referred to above a bed of limestone has been found at the base. The absence of this lower limestone member, together with the specific character of the beds examined, led to the suggestion by Prof. R. D. George that the Sawatch Quartzite might be represented here.

S. F. Emmons *describes the Lower Quartzite, which is equivalent to the Sawatch, as follows: "A rock having a thickness of 150 to 200 feet, of which the lower 100 feet is composed of finely and rather thinly bedded white Saccharoidal Quartzites, while the upper fifty feet are shaly in character and more or less argillaceous and calcareous."

George H. Eldredge, †under the heading "Cambrian," gives the following description of the Sawatch Quartzite: "This formation so named because of its persistent occurrence around the flanks of the Sawatch range is the lowest sedimentary series in the region, and is of upper Cambrian age. * * *

The lower division, which is from 50 to 200 feet thick, is a white quartzite with a persistent conglomerate of white quartz at the base. The upper division, which has a maximum thickness of 150 feet, is red, ferruginous and somewhat calcareous sandstone, consisting chiefly of quartz and feldspar, with a small amount of mica. A green, glauconitic mineral occurs in both divisions, but more abundantly in the upper."

The lithological characters given for the upper division checks the description of the first 150 feet of the section under discussion, but in the sandstones having a calcareous cement carboniferous fossils were found; therefore if the Sawatch is represented here it must be by the conglomeratic grit alone.

The heavy grit grades into a thin bedded, micaceous, indurated sandstone, which contains a few fragments of car-

*Geology and Mining Industry of Leadville, Page 58.
†The Anthracite Crested Butte Folio, U. S. G. S. Folio No. 9.

bonized plant remains. The cementing material is now calcite. In some portions the lime predominates so that there are occasional thin beds of impure, fossiliferous limestone.

A-2.

A greenish grit with a calcareous cement contains chlorite. The main portion of the rock, however, is quartz with occasional fragments of pink feldspar.

The grit changes to limestone, the limestone to metamorphosed sandstone, and this higher up becomes coarse and gritty. Lime increases until the rock becomes a pure limestone. Toward the top of the section there is a sudden change to grit.

A-3.

This section comprises one bed of limestone. In its forty-five feet of thickness there are several small local faults. Dip has changed from 80 degrees eastward to 85 degrees westward. Strike is N. 36 degrees W.

A-4.

Calcareous, gritty shales, some of them purple in color, followed by a two-foot bed of limestone, and this by a green, tough, gritty shale of considerable thickness. The upper member of this section is a limestone, shaly at the base, solid and blue in color on top.

A-5.

A complex of sandstone, shale, limestone and grit. The different beds are rather thin. The sandstones have a lime cement.

A-6.

Limestone twenty-five feet in thickness, very fossiliferous. It is just shaly enough to allow the fossils to weather out in great abundance. As corals predominated here, it is called the Coral Bed.

Above this limestone is a variable, green, calcareous sandstone sometimes coarse and heavy bedded, and again fine and thin bedded.

A-7.

Gradual transitions from grit to limestone and back to grit. Two beds of each are included.

A-8.

A five-foot bed of sandstone about midway of the section is all that breaks the continuity of limestone from bottom to top. Very fossiliferous.

A-9

Five feet of shales containing some fossils is followed by ninety feet of very fossiliferous limestone, and this by a heavy bed of grit.

A-10.

The last heavy limestone bed on the western limb of the syncline is a seventy-foot bed at the base of A-10. It is fossiliferous, but so compact that the fossils are hard to collect.

In the sandstone members of this section, some of which are micaceous, a few fragments of carbonized plants are found.

A-11.

Sandstones, grits, graywackes and calcareous shales compose this section. On top of this western limb of the syncline is a two-foot bed of rather barren limestone.

About three hundred feet below the top is a bed of black, calcareous shales making what seems like a very definite horizon, and here emphasized because of its probable reappearance about one and one-half miles further east.

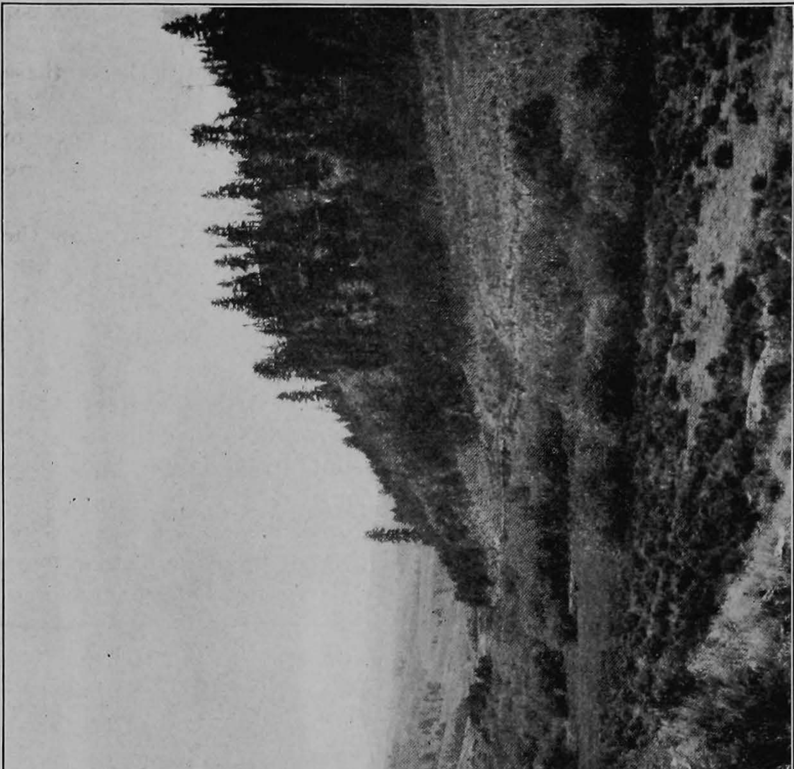
Section A-11 contains a bed of sandstone which is a mass of plant remains. This will be referred to as the *Floral Bed.*

The material was submitted to Dr. David White for identification. While disappointed over the fact that no good, diagnostic material was found, as it consists chiefly of Stigmariae, yet he adds: "The presence of these roots in place is interesting as showing contemporaneous shallowness of water, if not subaerial exposure at that point."

This floral bed is to be found just at the left side of a trail which turns north from the La Veta Road. The side hill slope at the intersection of the road with this trail is covered with weathered specimens from this bed. At this point the dip of the rocks is about 25 degrees easterly.

Near the base of Section A-11 the strike is N. 40 degrees W., and the dip is westerly about 85 degrees. There is here a sudden change from this westerly dip to vertical, then to easterly, back to vertical, and again to easterly about 60 degrees, with a

 PLATE V



PLACER GROUND ON PLACER CREEK

sudden drop to 25 degrees easterly, all within a space of seventy-five feet.

While there is no direct indication of faults here, these erratic dips suggest their probability.

Assuming the black calcareous shales mentioned above to be a definite and known horizon, further measurements were begun east of its second appearance.

The western exposure is about three hundred feet below the top of the syncline. Proceeding eastward on the eastern limb of the syncline the dips are very gentle to the west, and beyond the porphyry intrusion mentioned above the dips become permanently eastward for one and one-half miles.

About 1,000 feet southwest of Stearns Gulch the black calcareous shales appear again. Measurements downward (geologically) from the first syncline of about seven hundred feet and up again on this new syncline of about four hundred feet should give this horizon. Furthermore, the rock above this black shale about the Stearns Gulch region is a tough, shaly sandstone, very similar to the rock on top of the western limb of the first syncline.

The plant bed was not found in the sandstone; but two specimens from the black shales submitted to Dr. White prompted the following remark: "The two small fragments from locality No. 2 *belong to a stratum which will undoubtedly afford interesting and diagnostic material on further search."

A further confirmation of the correctness of measurements is found in the fact that the next limestone beds above Stearns Gulch, and presumably above any examined previously, contain faunas highly specialized and not found before in abundance.

10 degree and 20 degree dips to the easterly are found east of Stearns Gulch for about one mile.

B-1.

A bed of limestone two or three feet thick, decidedly shaly, and a mass of fossils largely of the genus Seminula. So abundant is this brachiopod that this is called the *"Seminula Bed."*

B-2.

Directly above the Seminula Bed, in fact a part of the same limestone bed, the genus Productus is just as abundant as Seminula was a few inches below. Logically, therefore, this is the *"Productus Bed."*

---

*See end of fossil list.

B-3.

About forty feet of sandstones intervene between the Productus Bed and the next fossiliferous limestone above. Again there has been a definite change in the fauna.

The genus Aviculopecten has been noted occasionally in former sections, but so abundant is this pelecypod here that it is called the *"Aviculopecten Bed."*

B-4

This section is simply the top of the limestone bed, which constitutes B-3, and while Aviculopecten is still quite abundant, it is diminishing and giving place to numerous gastropods. This youngest fossiliferous limestone is called the *"Gastropod Bed."*

B-4 marks the upper limit of limestone beds until the La Veta Pass is reached two and one-half miles farther east, and this is supposedly a recurrence due to folding rather than to a younger bed.

The remaining rocks within the limit of our map are sandstones, some fairly heavy bedded, but mostly thin bedded, tough and metamorphosed to various types of graywacks.

The color gradually changes from greenish and gray to maroon and red, the latter color becoming more pronounced as one proceeds eastward beyond the limit of the map.

As the above notes indicate, the whole section of sedimentaries has appeared to be rather complex, due to the endless variety of beds, and the consequent difficulty in correlating different parts of the field.

The following description of the Hermosa formation by Mr. Cross is found in the Rico Folio, page 3. It is quoted at some length because this description so nearly checks observations herewith submitted.

"The Hermosa formation is lithologically complex, consisting of interbedded limestones, shales and sandstones reaching a maximum thickness of 2,000 feet in Animas Valley. Individual beds of different lithological constitution are too thin and too variable in development to deserve special representation on the map, and groups of strata change so greatly in character from place to place that horizons cannot be definitely recognized in localities separated from one another by more than short distances. The name Hermosa is derived from a large creek entering the Animas River in the Durango Quadrangle, and was given to the formation in the Rico Report, in a chapter by A. C. Spencer.

"The Hermosa is composed of limestones, shales and sandstones, but all of these strata are more or less calcareous throughout. The limestones are of a blue gray color, rather dense in texture, and usually very fossiliferous. They are frequently more or less bituminous, sometimes so much so as to give a distinct odor when struck with a hammer.

"The shales vary from black bituminous clay shales, rather fissile, to sandy shales and sandstones of an olive green color.

"The sandstones are also of a greenish color, and under the microscope are seen to have an amorphous green cement. They are composed largely of quartz, but feldspar and mica are common. Cementing material is largely calcite. Sandy beds vary in grain from fine to coarse, and some are conglomeratic."

The Fossil Contents.

A-1.

Lophophyllum profundum.?
Rhombopora lepidodendroides Meek.
Productus inflatus McChesney.
Productus punctatus Martin.
Spirifer camaratus Morton.
Squamularia perplexa McChesney.
Allorisma terminale Hall.

A-2.

Rhombopora lepidodendroides Meek.
Productus inflatus McChesney.
Aviculopinna Sp.

A-3.

Rhombopora lepidodendroides Meek.
Productus inflatus McChesney.

A-4.

Productus inflatus McChesney.
Edmondia gibbosa Geinitz.

A-5.

Productus semireticularis var hermosanus Girty.
Productis inflatus McChesney.
Marginifera Sp.?

Spirifer camaratus Morton.
Seminula subtilita Hall.

A-6.

Campophyllum torquium. *Very abundant.*
Productus semireticularis var hermosanus Girty.
Seminula subtilita Hall.

A-7.

Campophyllum torquium.
Productus semireticularis var hermosanus Girty.
Marginifera Sp.?
Seminula subtilita Hall.

A-8.

Campophyllum torquium.
Productus punctatus Martin.
Spiriferina Sp.?
Spirifer boonensis Swallow.
Seminula subtilita Hall.
Pleurotomaria Sp.?

A-9.

Campophyllum torquium.
Marginifera wabashensis.
Productus inflatus McChesney.
Squamularia perplexa McChesney.
Schizodus cuneatus Meek.

A-10.

Productus cora d'Orbigny.
Seminula subtilita Hall.

A-11.

Spirifer camaratus.

Flora determined by Dr. White.

"Mostly Stigmariae, some showing rootlets passing radially into sandstones."

One fragment reveals a very distinct impression of the vascular axis.

One fragment may represent *Asterophyllites.*

Two fragments show poorly preserved branches of Lepidodenron, possibly brittsii Lesquereux.

Calamites cf. Roemeri.

Plant remains very abundant in one bed of this section.

B-1.

Lophophyllum profundum.
Productus cora d'Orbigny.
Productus semireticularis var hermosanus Girty.
Squamularia perplexa McChesney.
Seminula subtilita Hall. *Very abundant.*
Aviculopecten occidentalis Shumard.
Myalina Sp.?
Schizodus meekanus Girty.

B-2.

Lophophyllum profundum.
Rhombopora lepidodendroides Meek.

Productus cora d'Orbigny. Productus semireticularis var hermosanus Girty. Productus inflatus. Productus gallatinensis. Productus nebraskensis Owen.	*Very abundant.*

Spirifer rockymontensis Marcou.
Spirifer camaratus Marcou.
Squamularia perplexa McChesney.
Seminula subtilita Hall.
Aviculopecten occidentalis Shumard.

B-3.

Campophyllum torquium.
Fenestella Sp.?
Rhombopora lepidodendroides Meek.
Productus cora.
Productus inflatus.
Aviculopecten occidentalis. *Very abundant.*
Schizodus meekanus Girty.

B-4.

Campophyllum torquium.
Aviculopecten occidentalis.
Pleurophorus occidentalis? or immaturus?
Schizodus ovatus.
Soleniscus intercalaris?
Soleniscus: aff. fusiformis, and various gastropods with a few indeterminable pelecypods.

The fossils listed together without repetition are as follows:

Fauna.

Lophophyllum profundum.
Campophyllum torquium.
Fenestella Sp.?
Rhombopora lepidodendroides Meek.
Productus cora d'Orbigny.
Productus semireticularis var hermosanus Girty.
Productis inflatus McChesney.
Productus gallatinensis Girty.
Productus punctatus Martin.
Productus nebraskensis Owen.
Marginifera wabashensis.
Marginifera Sp.?
Spirifer boonensis Swallow.?
Spirifer rockymontansis Marcou.
Spirifer camaratus Morton.
Squamularia perplexa McChesney.
Seminula subtilita Hall.
Composita subtilita (may be same as above).
Aviculopecten occidentalis Shumard.
Myalina Sp.?
Aviculopinna Sp.?
Allorisma terminale Hall.
Pleurophorus occidentalis: or immaturus?
Schizodus ovatus.
Schizodus cumatus Meek?
Schizodus Meekanus Geinitz.
Soleniscus intercalaris.
Soleniscus aff. fusiformis.
Edmondia gibbosa Geinitz.
Pleurotomaria Sp.?

Flora.

Largely Stigmariae.
Lepidodendron brittsii?.
Asterophyllites op.?.
Calamites cf. Roemeri.

Material not listed in the sections given above. Found in the black calcareous shale near Stearns Gulch.

Neuropteris Sp.?

Two bodies belonging to Cardiocarpon? (probably seeds). Several minute fragments, very likely *Walchia.*

Determined by Dr. David White, who adds this comment: "Though this material is insufficient, both as to quantity and condition, it is fairly evident that it represents a horizon either near the top of the Pennsylvanian or possibly within the base of the Permian. The terrane is very interesting paleobotanically, and should be exploited further."

Here follows a columnar section of the sedimentary rocks examined. Plate III, in which the sections referred to in the notes above are represented with their thickness, and lithological characters.

Symbol.	Columnar Section.	Thickness in Feet.	Rock.	Notes.
		990	Sandstone,	Barren.
B-4		55	Limestone.	Aviculapecten diminishing. Numerous Gastropods on top.
B-3		70	Limestone,	Largely remains of Aviculapecten.
B-1-2		60	Limestone,	Productus Bed / Seminula Bed / Change from Seminula to Productus sudden.
		Unknown	Unknown,	East of Synclinal fold and of uncertain thickness. Character unknown.
A-11		652	Sandstone.	Last section on West Side of Synclinal Axis. Near the middle of this section is the plant Bed. Dip is about 23° Easterly.
A-10		695	Black Shale, Sandstone, Grits, Limestone	Contains lime concretions. Emphasized because of its probable reappearance east of large intrusive mass. Metamorphosed - containing occasional macerated fragments of plant remains
A-9		225	Grits, Limestone	Shaley at base
A-8		180	Limestone,	Very fossiliferous
A-7		280	Grits. Limestone	Gradual transition from Grit to Limestone, well shown in this section.
A-6		135	Sandstone, Limestone.	Partly thin bedded. Limestone - shaley enough to allow fossils to weather out. Many Brachiopods but designated as the Coral Bed.
A-5		304	Limestone, Grits Sandstone.	Lowest bed bluish gray. Sandstone - variable thin beds.
A-4		212	Limestone, Shale, Sandstone. Limestone.	Heavy bedded, blue in color. Gritty - Calcareous. Fossiliferous, hard to collect. Dip changes to westerly on account of a local fault.
A-3		45		
A-2		175	Grits Limestone. Sandstone.	Sandstone - greenish, metamorphosed at base, coarse and gritty at top grading into limestone above which contains in its base many grit pebbles.
A-1		150	Sandstone, Grits.	Metamorphosed, containing a few carbonized fragments of plants, occasional limestone stringers - fossiliferous - one specimen of Aviculapinna. Heavy. Strike N30°W Dip 75°E
		4228		

COLUMNAR SECTION OF CARBONIFEROUS ROCKS

CHAPTER V.

IGNEOUS ROCKS.

BY HORACE B. PATTON.

GENERAL.

With the exception of a very small area of diorite all the igneous rocks of this district are to be classified as effusives, of which there are two very distinctly marked types that differ in texture and in external appearance. The one, extremely acid in chemical composition, absolutely lacking in porphyritic texture and extremely fine grained and uniform, is described below as felsite, and has been given a distinctive color on the geological map. The other varies widely in actual mineral and chemical composition and in external appearance, but upon the whole has a more or less marked porphyritic texture, and, with a few exceptions, is neither extremely acid nor extremely basic in chemical composition. This second or porphyritic type forms the great bulk of the igneous rocks of the district, and has been mapped all with one color, designated by the letter P.

As will be seen later this porphyritic type really includes rocks that ordinarily would be mapped separately, as it is made to include, in addition to the prevailing so-called monzonite-porphyries, also quartz porphyries, andesites and a rock of greater basicity than the monzonite-porphyries. This grouping together of rocks of divergent types was due to several considerations. In the first place, owing to a thick forest growth covering a considerable portion of the territory and to a heavy covering of soil, the accurate tracing and mapping of a rather intricate complex of igneous rocks was extremely difficult, and, in fact, impossible. So numerous are the dikes of these rocks, and so intimately associated are rocks of different types, that it would have been impossible to have mapped them at all without greatly enlarging the scale of the map. Furthermore, the writer, who has made himself responsible for the mapping of the igneous areas, could not, within the time at his disposal, personally go over and satisfy himself of the correctness of all the work done. As stated above, most of the actual work was done by students of the Colorado School of Mines, whose experience in field geology was necessarily limited. Wherever possible their work was supervised or checked by the writer, who is satisfied that, in most cases, the map as here presented is reasonably accurate.

For the purpose of reducing errors of observation as much as possible, and especially where igneous dikes are too crowded to be capable of separate mapping, only the larger and most readily traceable masses of igneous rocks have been mapped as such. The surrounding areas—that is, the areas in which both sedimentary and igneous rocks occur under conditions unfavorable to accurate and detailed mapping—have been mapped as Carboniferous, but have been shaded differently from the rest of the Carboniferous, so as to indicate the presence of numerous but not definitely located igneous intrusions.

From the above it will be seen that the northern part of the area mapped really contains a larger proportion of igneous rocks than the map would at first sight suggest.

CLASSIFICATION OF THE ROCKS.

As will appear later, all the igneous rocks of the Grayback district are considered to be of Tertiary age. Following the long-established custom of many petrographers, the author would have preferred to have given names to the different rock types based in some degree on age distinctions, and would also have distinguished between porphyries with an alkaline feldspar and porphyrites with a more basic plagioclase. On account, however, of the close genetic connection and identity of most of the rocks here described with the igneous rocks of the region immediately to the east and southeast, it has been thought best to make the names here used conform to those used by Mr. R. C. Hills in his description of the igneous rocks of this adjacent region, more particularly as found in the U. S. Geologic folios Nos. 68 and 71; the Walsenburg and Spanish Peaks folios, respectively. In naming the rocks of these two quadrangles Mr. Hills has endeavored to conform to the present usage of the U. S. Geological Survey; has, therefore, discarded rock distinctions based on age, and has based his distinctions on differences of texture and degrees of alteration, and has made no distinction between porphyries and porphyrites.

Without discussing the advantages and disadvantages of this method of classification, it is obvious that conforming to the rock names already published by Mr. Hills will largely avoid confusion in the discussion of the same or similar rocks.

DESCRIPTION OF THE ROCKS.

Monzonite-Porphyry.—Rocks of this type form the great bulk of the igneous rocks in the northern half of the mapped district. They vary considerably in texture and in general appearance, some being fairly compact, others medium to rather coarse grained. They are light gray to dark gray in color, and always distinctly porphyritic in texture. In the hand-specimen the phenocrysts are not often very conspicuous to the unaided eye, as they are seldom more than one-eighth to one-quarter of an inch in greatest diameter. Occasionally, however, one meets with cases where the feldspar phenocrysts reach to half or three-quarters of an inch. With a magnifying glass, and especially in thin-sections under the microscope, these rocks are very markedly porphyritic, the phenocrysts being small and thickly crowded, but very sharply defined against a much finer groundmass. Feldspar is the most abundant phenocryst. It is almost always plagioclase—in rare cases also orthoclase—about one-eighth of an inch in average size. Of the dark-colored minerals among the phenocrysts there occur the following three, named in the order of their importance, namely: a dark green hornblende, a light green augite, that, in thin-section, appears almost colorless, and a brownish biotite.

The plagioclase of the phenocrysts has a medium to fairly basic composition, but is never extremely basic. Maximum extinction angles in sections perpendicular to the albitic twinning were observed up to about 27°, corresponding to labradorite, with a composition of Ab_1 An_1. The feldspar of the groundmass varies greatly in shape, size and character. In most cases both plagioclase and orthoclase appear to be present. The former is more apt to have definite lath form, or, at least, to be approximately rectangular in outline, while the orthoclase occurs in more irregular grains or fills the spaces between the plagioclase laths.

Hornblende, augite and biotite are to be seen among the phenocrysts in greatly varying quantities. Hornblende is present in nearly all of these rocks, and in many almost no other dark colored silicate is to be observed. Usually, however, a small amount of augite or biotite, or both, may be found if searched for. Biotite is much less abundant than augite, and only in a few cases is it of sufficient importance to be worthy of special mention. Through the biotite and augite the more typical of the monzonite-porphyries of the district become in places closely allied with rocks of quite different type.

The hornblende is almost always green and plainly pleochroic. It has typically a slender, prismatic habit, being several times as long as wide. It is usually about one-eighth of an inch in length, rarely a quarter of an inch or more. The vertical faces are usually very sharply developed. They are the unit prism and the brachy-pinacoid. The augite has also at times very sharply developed forms. The habit is short prismatic, with octagonal cross-sections through the development of the unit prism and the two pinacoids. Very frequently, however, the augite occurs in less regular shapes, and may at times show no trace of crystal form. They are not often abundant enough to be conspicuous or even visible in the hand specimen. In thin-section they are almost colorless, having, in fact, a very pale green color. Likewise, the biotite may occur either in very irregular grains or in more definitely defined crystal forms. In thin-section the characteristic habit is long and slender, the basal pinacoid being well developed. The color is brownish when fresh.

Magnetite and apatite form very constant accessory ingredients.

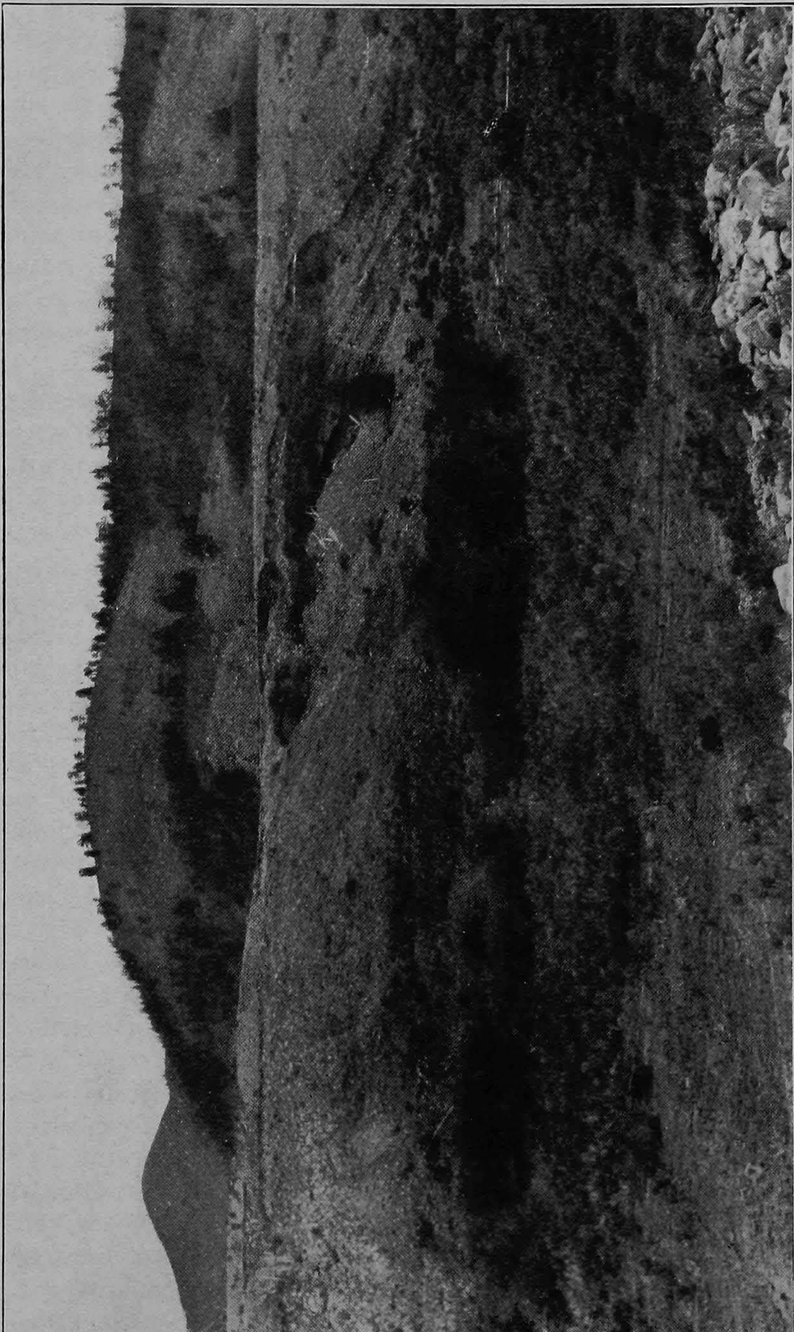
These monzonite-porphyries vary greatly in the fineness and texture of the groundmass. The finer grained varieties, of course, are to be found in the smaller dikes and at the margins of larger ones. As to texture, some have the plagioclase in distinct laths that may sink in size to microlites, while others show little or no trace of lath forms. Glass was not observed, except in the case of a few rocks that have been designated as andesites and that differ in other respects from the monzonite-porphyries. It is probable, however, that some of the finer grained groundmasses represent devitrified glasses.

While some of these rocks are very fresh and show but little alteration, most of the surface rocks show naturally a greater or less degree of alteration. The feldspars become clouded by the formation of kaolin and the ferromagnesian minerals change to chlorite with varying amounts of calcite. In not a few cases the hornblende crystals show granular magnetite rims owing to attack by the magma before final consolidation.

Inclusions of various sorts are very common features in most of the monzonite-porphyry masses. The most common and characteristic of these inclusions consists of angular black fragments varying in size all the way up to two or three inches, and sometimes extraordinarily abundant. They consist sometimes of nearly pure hornblende and have a coarsely granular texture.

COLORADO GEOLOGICAL SURVEY

PLATE VI



OFFICER'S BAR, AT THE MOUTH OF GRAYBACK GULCH

These dark colored inclusions are seen under the microscope to be composed of hornblende similar in character, but not in habit, to the regular hornblende crystals of the rock, also, to a much less extent, of plagioclase and the other more basic of the rock constituents. They are undoubtedly fragments of original basic segregations, broken up and scattered through movements of the rock magma. In other cases the foreign inclusions represent fragments of grit, sandstone, shale and limestone from the Carboniferous rocks through which the porphyries have forced their way. In such cases these inclosed fragments are likely to be more or less metamorphosed, the changes being such as are described later under the chapter on contact metamorphism. In still other cases fragments of other igneous rocks occur, such as monzonite-porphyries of varying texture, quartz porphyry, or both sedimentaries and igneous rocks combined. In a few instances the included fragments have appeared to make up one-half or more than one-half of the mass, so as to present the appearance of a breccia.

The more typical of the so-called monzonite-porphyries of this district, those with abundant small hornblende prisms and with blackish angular hornblendic inclusions, are identical with a type of rock named Silver Mountain monzonite-porphyry by Mr. Hills, who has recognized three more or less distinct monzonite-porphyry types in his study of the volcanic rocks of the Spanish Peaks and of the Walsenburg folios.* These he has named Early Monzonite-porphyry, Late Monzonite-porphyry and Silver Mountain Monzonite-porphyry. Through the kindness of Mr. Hills, the writer has been given access to all of the hand specimens and thin-sections collected and prepared by him in his study of the rocks of these districts, and has been enabled to make a careful comparison with the rocks of the Grayback district. In the absence of chemical analyses it has been difficult to arrive at altogether satisfactory conclusions as to the rocks studied. It has not been possible to find a parallel between some of the rocks of the Grayback district and those of the two districts named above. In fact, the writer has not been able to identify any of the monzonite-porphyries with the first two types of Mr. Hills'. It is possible that some of the rocks here included under the name of monzonite-porphyry may be of the same age and character as those designated as early monzonite-porphyry or late monzonite-porphyry. Be this as it may, there is no doubt

*R. C. Hills, U. S. Geol. Sur. Folio No. 71, p. 4; also Folio No. 68, p. 4.

of the identity of many or most of them with the Silver Mountain type.

Silver Mountain is a conspicuous peak situated in the Huerfano Park quadrangle and lies immediately east of the Grayback district and between this and the Walsenburg quadrangle. This mountain is composed of monzonite-porphyry and is described by Hills as being an independent center of volcanic activity. Silver Mountain lies to the east of North Veta Mountain, the two being composed of the same rocks. North Veta Mountain, which lies just east of the territory covered by the map of the Grayback District, sends out a long dike of monzonite-porphyry that extends into the Grayback territory and thus makes close connection with the rocks of this district.

Quartz Porphyry.—Quartz porphyry forms a comparatively small part of the igneous rocks of the district. They seem to be confined almost entirely to the extreme north or northeast portion of the territory mapped, and are intimately associated with the monzonite-porphyries. Whether they are older or younger than these latter has not been determined owing to insufficient exposures. They occur in masses of considerable size. For reasons stated above, no attempt was made to map them separately from the monzonite-porphyries.

These rocks are coarse-grained and very conspicuously porphyritic. The color is gray to brown, according to the state of weathering. As no very fresh exposures were observed, the character of the mineral components could not always be satisfactorily determined. Orthoclase in simple crystals and in crystals with Carlsbad twinning are very conspicuous as phenocrysts in sizes, ranging up to an inch and a half in greatest diameter. Quartz as a phenocryst is much more sparingly present and always in well rounded grains or in grains showing embayments due to magmatic resorption. The dark colored constituents are either biotite or hornblende, that is, sometimes one and sometimes the other, although the presence of hornblende cannot be asserted with great assurance, owing to alteration of the rock. An acid plagioclase is also present in varying but in comparatively small amount.

The groundmass is quite coarse-grained. It consists of orthoclase and quartz in more or less irregular grains, in one case showing a micropegmatitic intergrowth.

Andesite.—There are a few occurrences of igneous rocks within the Grayback district that differ markedly from monzonite-porphyries and other porphyries thus far described in their extreme freshness and, more particularly, in the presence of an abundant and fresh glass-base. Owing to these characteristics, the author feels justified in calling them andesites. The only occurrence noted of any prominence is to be found in the rock that forms the hill immediately west of the town of Russell. More particularly this rock may be designated as a hornblende-augite andesite. It covers an area of about 1,500 feet in diameter and is in the form of one or perhaps more sheets that may very likely have flowed out on the surface. The rock is medium-grained in texture, not markedly porphyritic in the hand specimen, and of a reddish brown color. It does not appear to be as fresh as the thin-section shows it to be.

The phenocrysts consist of numerous but small, short-rectangular, basic plagioclases, and also abundant dark reddish brown, slender hornblende and almost colorless, short-prismatic augite—both in perfectly sharply defined crystal forms. The augite is perfectly unaltered; the hornblende in one of the two studied is likewise unaltered. In the other case all the crystals have been altered by magmatic action into a fine black powdery aggregate consisting largely of magnetite. The groundmass consists of a fresh brown glass thickly crowded with plagioclase microlites and with a very fine black dust that is presumably magnetite. Flow-structure is very pronounced.

A somewhat similar andesite is to be found in one of the small exposures to the northeast of Russell and south of the Sangre de Cristo Creek. In this case the rock is a hornblende-biotite andesite, there being no augite present.

One more occurrence was observed in the shape of two small dikes, close together, and located close to Placer Creek, about 1,500 feet below the junction with Flume Gulch. Both of these are very fresh-looking black or nearly black, fine-grained rocks. One of the two appears glassy in the hand specimen. It is, in fact, perfectly fresh. It consists of a brown glass with plagioclase microlites, in which are imbedded small phenocrysts of plagioclase, and a greenish brown hornblende; likewise a few nearly colorless augites. The other rock may be considered as transitional to the hornblende monzonite-porphyry. It has a partially devitrified glass base containing plagioclase microlites. The phenocrysts are hornblende and plagioclase, there being no augite or biotite. The hornblende is green similar to the hornblende characteristic of most of the monzonite-porphyries of the district.

It would seem that these two small dikes furnish together a fairly complete transition between the more typical hornblende-augite andesite west of Russell and the normal hornblende-monzonite-porphyry. There is some evidence, however, as will appear later, that the andesite of the hill west of Russell may be later in time of eruption than the monzonite-porphyries.

Other Porphyries.—There remain to be described a few rather extensive dikes, found mostly near the summit of Buckskin Mountain, that are distinctly abnormal. They occur not on the very summit of the mountain, but partly to the southeast and partly to the north of this summit. Another occurrence is about one-half mile south of Chicago Peak.

These are dark gray, homogeneous, medium-grained and apparently non-porphyritic rocks. Some of them show a slight development of phenocrysts, but, in general, there is no marked distinction between groundmass and phenocrysts. The rock consists of basic plagioclase, augite and biotite, with comparatively abundant accessory apatite and the usual magnetite. In one or two cases a small amount of greenish hornblende with magnetite rims occurs. There is a strong tendency toward the development of an ophitic texture in that the plagioclase is the oldest of the silicates and occurs in well defined laths penetrating or enclosed within the augite and biotite. In some cases the augite and biotite form irregular grains that not only enclose the plagioclase, but that also mutually penetrate each other. In one particular case, however, both augite and biotite form, in part, sharply defined crystals. This is particularly true of the biotite occurring in thin tablets that appear as long strips in the thin-section. In this case, also, the biotite is extremely abundant.

The author is inclined to think that these abnormal types that may be designated as biotite-augite porphyries (porphyrites) may be the equivalent of what Hills calls lamprophyres in his description of the rocks of the Spanish Peaks and of the Walsenburg quadrangles. However, in spite of the fact that these lamprophyres of Hills' have a very great range in chemical and mineralogical composition, including orthoclase-bearing and orthoclase-free rocks, these rocks now under consideration do not agree very exactly either with the rock and slide specimens from the above mentioned quadrangles or with the descriptions given of these interesting rock types. They are more basic than the above described monzonite-porphyries, as the ferro-magnesian constituents are very abundant; orthoclase appears to be entirely wanting and the plagioclase shows on the average larger extinction angles.

Felsites.—Sharply contrasted with all the types of effusive rocks thus far described, all of which have been represented on the map under one color, and nearly all of which are more or less markedly porphyritic in texture. there remains to be described a type of rock that occurs mostly, but not entirely, confined to the southern half of the mapped area, and to which the name felsite has been given. All of these felsites are extremely light colored, varying, in fact, from a light gray to almost pure white, and except upon the closest scrutiny appear to be absolutely free from porphyritic development. They are extraordinarily uniform in texture and general appearance. The grain is very fine, that is, cryptocrystalline, or seemingly so, and may be, at the margin of a dike, flint-like.

Under the microscope most of these rocks are not so entirely free from porphyritic texture as an examination of the hand-specimen would lead one to infer. In fact, they may be said to be minutely porphyritic, that is, thickly strewn with very minute phenocrysts. These very small phenocrysts are almost entirely orthoclase, occasionally acid plagioclase and, possibly, quartz. Carlsbad twinning on these orthoclase crystals is very common. The shape in thin-section is mostly rectangular. The groundmass, so far as can be made out, consists only of orthoclase and quartz. It is not often coarse enough, however, to enable one to determine this absolutely. The texture of the groundmass is often like that of typical felsitic porphyries in that it is composed of ultra-fine grains or shreds of feldspar and quartz, almost or quite too small to be individually distinguished. In the case of large masses, as, for instance, the large mass exposed on both sides of Sangre de Cristo Creek near the center of the map, the groundmass may become much coarser grained and take on the appearance of a rather fine grained microgranite.

In no case was any structure observed suggestive of spherulitic or otherwise radiating structures. In one or two cases a hardly noticeable tendency was observed to form micropegmatitic intergrowths between the feldspar and the quartz. But it is altogether likely that some of these felsites do develop felsophyric varieties.

In a few cases absolutely no trace of any ferric mineral could be observed. But in most cases a very small amount of biotite may be observed in thin-section. They may be classed among the phenocrysts as they occur in very sharply crystallized, although very minute, plates. In fact, one can usually detect one or more of these biotite crystals in an ordinary sized hand-specimen if they are searched for with a pocket magnifying glass. These felsites often occur in very small dikes that may not appear in actual exposure, but that, because of their white color, may readily be traced for some distance. They are to be found in both the Carboniferous and in the Archaean rocks, but no case was actually seen in which they cut or were cut by the monzonite-porphyries. As will appear later, one such felsite dike west of Russell cuts an andesite breccia at the edge of the large andesite mass, and, possibly, cuts the andesite, too.

East of the territory here under consideration, in the Huerfano Park quadrangle, this rock forms much more extensive masses. The greatest of these is South Veta Mountain, a mountain that rises two thousand feet or more above its base and that is composed entirely of this material which, though somewhat coarser-grained, retains the other characteristics mentioned, and is astonishingly uniform. This rock also occurs sparingly in the Spanish Peaks quadrangle and at one locality in the Walsenburg quadrangle, and is given the name of granite-felsophyre by Hills, a name which will hardly apply literally to the occurrences within the Grayback district.

Igneous Breccias.—Breccias of igneous origin are by no means very common. As already mentioned, there are to be found at several points numerous inclusions of angular fragments of various porphyritic rocks, as well as of sedimentary rocks, within the mass of monzonite-porphyry dike, and that these fragments may be so thickly crowded as to resemble a true breccia, the cementing material being the solidified porphyry magma.

At several points breccias of the felsite have been observed covering a considerable area. Thin-sections of two of these breccias reveal a rock made of angular fragments of this felsite. There appears to be no cementing matter of consequence and all the fragments present practically the same appearance. It would seem, therefore, that the fragments could not have been derived from different sources, as would be the case in an ordinary surface breccia. In all probability these are cases of friction breccias, caused by the mashing of the rock in connection with orographic movements.

West of Russell, at the western edge of the andesite mass, occurs what appears to be a true volcanic breccia. The fragments are of various sizes and of differing character, but are all similar to the hornblende-augite andesite adjacent. The cementing material also is of similar nature, but composed of more dust-like particles. The rock shows its brecciated nature plainly, and disintegrates on exposure. It is not exposed on the surface, but has been opened up in a forty-foot shaft, at the bottom of which are two short drifts running in opposite directions. The shaft was sunk at the contact of the solid andesite with a felsite dike. It passes through several feet of the solid andesite, and then strikes the andesite breccia and the felsite, following down along the contact of these two to the bottom. One of the drifts cuts entirely through the felsite dike, which is ten feet wide, and discloses the andesite breccia on both sides of the dike.

This would seem to determine the relative ages of the felsite and andesite breccia, as the felsite clearly cuts the breccia. As the andesite sheet immediately east of this breccia, and composed of the same kind of rock material, must be considered to have been caused by the same volcanic activity, and, therefore, of the same age, we must conclude that both breccia and solid andesite are older than the felsite.

This andesite breccia is the only occurrence of what appears to be a true superficial volcanic breccia in the district.

Diorite.—The only exposure of a plutonic rock in the Grayback district occurs on the west side of Grayback Mountain. Owing to heavy wash the actual area covered by this mass can not be accurately determined. Apparently the surface exposure is very limited, but quite likely it has a much greater development beneath the surface. It is well exposed in the workings of the Homestake mine, as the main adit passes through this rock. It is a light gray, rather fine-grained rock, containing many very small (one-half mm. in diameter) black biotite specks. Under the microscope the feldspar is seen to be a fairly acid plagioclase. With this is associated not a little quartz and biotite, but no hornblende or pyroxene, and apparently no orthoclase. The texture is fairly normal hypidiomorphic, with the plagioclase tending to assume lath form.

It is evident that this rock is not the plutonic equivalent of any of the porphyritic rocks on the surface. It is more acid than the monzonite-porphyries, and, furthermore, lacking in both augite and hornblende. It has strongly metamorphosed the Carboniferous rocks with which it comes in contact.

GEOLOGIC STRUCTURES.

There are many evidences that the igneous rocks of the Grayback district are younger than the Carboniferous rocks with which most of them are associated. Among these evidences are the occurrence of dikes plainly cutting across the sedimentary beds, the enclosure of fragments of the Carboniferous sediments in the igneous rocks, and the marked metamorphism of the sediments at contact with the larger igneous masses. At the same time the absence of superficial phenomena, such as volcanic breccias and tuffs and scoriaceous or amygdaloidal structures indicate that all superficial accumulations, if such existed, have been removed by general erosion. The igneous rocks now exposed, therefore, represent intrusive masses that have forced their way upwards through the overlying rocks.

In a great many cases the monzonite-porphyries and other associated porphyries are plainly in the form of thin sheets that lie conformable with the sedimentary beds. This is best illustrated on the prominent ridge that runs southeasterly from the summit of Stearns Mountain. On this ridge there are to be seen within a distance of about one mile no less than sixteen of these sheets varying in thickness from a few to more then 200 feet. With but one or two exceptions these sheets are conformable to the sedimentary beds. Within this mile the igneous sheets make up approximately one-half of the rocks. How extensive laterally these sheets are it is impossible to say, as the thick wash covers them up, except on the ridge.

Not all the igneous intrusions are in the form of intercalated sheets. As already stated, dikes cutting across the strata occur along with the sheets. Furthermore, it is evident that the very considerable metamorphism of the sedimentary formations described in chapter five could only have been caused by very considerable masses of igneous rock. These may take the form of very heavy sheets or more probably the form of localities. That such laccolitic masses one or two miles in extent may exist may be judged from the distribution of the porphyries in the northern part of the district. It must not be supposed, however, that each separate color patch on the map necessarily indicates one single igneous intrusion, as many dikes or sheets may occur together, forming a continuous igneous area.

Mr. Hills refers to Silver Mountain in the Huerfano Park quadrangle as being the center of volcanic activity from which the Silver Mountain monzonite-porphyries originated. It is quite evident that a second center of eruption for this rock is to be found in and around Grayback Mountain.

As to the felsite intrusions, there is no evidence that they occur in the form of sheets, although there is no reason to suppose that they do not. The smaller masses are plainly in the form of dikes, and the larger ones have more the appearance of laccoliths. This is more particularly the case with the felsite mass near the center of the map, as this has considerable thickness. As will be seen in the section shown at the bottom of the map, and taken through this felsite mass, the strata are arched over this igneous mass as though they had been forced into an anticline by the up-welling lava. It is not likely, however, that the felsite intrusion is really responsible for this anticlinal arch, as the arch is much too extensive to be accounted for by so local an intrusion. Furthermore, as appears below, the felsite belongs to the latest period of volcanic activity manifested in the region. Doubtless the fold of the strata had been practically completed long before the date of the felsite intrusion.

AGE OF THE IGNEOUS ROCKS.

As to the relative age of the different igneous rocks, it is impossible positively to determine the order of their eruption from observations made within the confines of the area studied, except that the felsite must be among the latest intrusions, as it cuts in one case the andesite breccia. This also is in agreement with the observations of Hills, who finds that the "granite felsophyre"—the equivalent of the felsite—in the Spanish Peaks and in the Walsenburg quadrangles was erupted subsequent to all the dike rocks, with the exception of granite-porphyry and basalt.

The actual age of these igneous rocks can likewise not be determined by any evidence found on the ground, except that they are all younger than the Carboniferous. From evidence obtained by Hills in the above mentioned districts where the same or equivalent rocks cut much younger formations, the eruptive activity did not begin until the latter part of the Eocene, or possibly the early part of the Neocene. It is quite certain that a part, and perhaps most of the orographic movements that caused the uplift of the Sangre de Cristo Range, were completed before the eruptive period set in. But it is also certain that the intrusion of so large a quantity of igneous matter must have tended to raise to a still higher level the region affected, and to bring about many changes in the relative positions of the strata.

ROCK EXPOSURES.

One difficulty experienced in mapping the igneous rocks of the district is the scarcity of good exposures. Both the monzonite-porphyries and the felsite seem to break up under the action of frost with remarkable ease, so that solid continuous outcrops are exceptional. In nearly all cases the location of the igneous mass must be determined by means of loose fragments on the surface. In the case of the felsite these are mostly small and irregular pieces. The porphyry has a strong tendency to break up into roughly flat slabs that are large or small, according to circumstances. Where the exposed mass is large and outcropping on a steep mountain side, the fragments may be a foot or two in diameter, otherwise much smaller. But even in places where one would naturally look for extensive ledges of rock the solid porphyry will be found to be buried under several feet of loose fragments.

CHAPTER VI.

CONTACT-METAMORPHIC ROCKS AND IRON ORES.

(By Horace B. Patton.)

Contact-Metamorphic Rocks.

Contact metamorphism around the larger masses of igneous rocks is a constant and marked feature of this area. But on account of the thick timber or heavy soil and wash covering the rock formations the district is a very unsatisfactory one for the study of such phenomena. A number of instances were noted where the actual contact was exposed, but information as to the distance from the contact within which metamorphism is effective could not be obtained within the time available. Most of the specimens collected were obtained from dumps of old adits or mine workings, in cases where the mine workings themselves were caved in, or were too dangerous to justify examination.

It would seem, however, from the widely scattered float that a considerable portion of the carboniferous rocks in the vicinity of Grayback Mountain and north of this mountain have been, to a greater or less extent, metamorphosed or, at least, indurated by contact with igneous rocks. But from evidence in hand it is not probable that intense metamorphism, that is, complete recrystallization of the rock constituents, extends for more than fifty or one hundred feet from the actual contact. In case of smaller intrusive masses, of course, the zone of complete metamorphism is very much less than this, perhaps only a few feet.

With but two exceptions the observations were confined to rocks in contact with the monzonite-porphyries. These two exceptions were the large felsite mass in the Sangre de Cristo Valley, near the center of the district, and the very small diorite area on Grayback Mountain. No noticeable difference could be observed in these two cases except that the contact effects of the diorite are apparently more intense than elsewhere.

The effects of contact metamorphism will be described on, first, shales; second, sandstones; third, limestones.

Effect of Metamorphism on Shales.—Fine grained, calcareous shales alter into a greenish or greenish gray, very smooth, flint-like hornfels that consist of minute grains or sharp crystals of epidote, with a varying amount of irregular quartz grains and calcite. A little plagioclase may also be noted, but this is very likely an unaltered remnant of the original shale.

The non-calcareous shales become dark gray, fine grained rocks, with but a slight trace of bedding. They are entirely free from epidote and from calcite. They consist of biotite, quartz, orthoclase, and, where the clastic structure is still recognizable, a little plagioclase. The biotite is usually in irregular grains or shreds. It has a light brown color. Pleochroism is apt to be rather weak so that it seems to grade into a mica that is nearly colorless or that has a greenish color resembling chlorite, but with the birefraction of mica. A shale of this character in contact with the diorite of Grayback Mountain shows complete recrystallization and thorough crystalline texture. In this case the biotite occurs in sharply defined plates and there is also developed a small amount of greenish hornblende.

Effect of Metamorphism on Sandstones.—As would naturally be expected, sandstones are but slightly affected by contact with the igneous rocks. Except in cases of shaly or calcareous sandstones there appears to have been but little change produced on the sandstones over what has been effected by the partial consolidation of the sandstones of the district. This consolidation of the carboniferous sandstones has produced graywackes by the partial extension of the clastic grains of feldspar and of quartz and by the development of a chloritic cement. This regional process seems to have been further accentuated in close proximity to the igneous rocks in that the clastic fragments have been more plainly extended and may show a tendency to interlock and in that the chlorite is more distinctly crystalline. Occasionally, too, crystalline calcite enters as a cementing material.

The sandstones of the carboniferous in this district are extremely feldspathic and the grains usually show but little rounding. The feldspar consists of orthoclase and microcline and to some extent also plagioclase. The same ingredients remain in the contact rocks. Usually the clastic structure is plainly manifest, but in one or two cases the rock has a remarkably crystalline appearance.

Where a sandstone becomes more or less shaly biotite is developed, as in the case of the altered shales.

Effect of Metamorphism on Limestones.—At contact with the igneous intrusives pure limestones have been metamorphosed into a fine grained aggregate of white or nearly white crystalline calcite. As pure limestones are not very abundant in the district, this is the exception rather than the rule. In most cases the altered limestone consists of a coarse to fine grained aggregate of calcite, garnet and epidote, with varying, but usually small, amounts of quartz and chlorite. Different specimens differ greatly in relative amounts of these minerals and also in color and texture. Some are banded and extremely fine grained and represent transitions to the metamorphosed calcareous shales.

In the more coarsely crystalline masses the garnet, epidote and calcite are easily recognizable. The garnet has the trapezohedral form and is of a brown or reddish brown color. At times this form is pronounced, especially when the crystals lie imbedded in coarse grained calcite. Usually, however, this mineral occurs in more or less granular aggregates. These garnet grains do not often make solid aggregates, even to a limited extent, but each grain is as a rule separated from the others adjacent thereto by calcite or quartz or by a fine aggregate of several minerals, as, for instance, quartz and epidote, or quartz, calcite and epidote. There appears to be, further, a tendency to form parallel growing aggregates of garnet crystals immersed in a large skeleton-like grain of calcite or of quartz, after the fashion of pegmatitic intergrowths of quartz and microline. This would seem to indicate a simultaneous crystallization of these minerals. In a similar way, it may be stated, there commonly occur interpenetrating growths of quartz and calcite.

Epidote is not very abundant, at least it is not very conspicuous in the garnetiferous rocks. It occurs in small grains closely associated with quartz and calcite. It does not seem to be inclosed in the garnet nor to in any way interfere with the growth of this mineral. Chlorite occurs in small radiating aggregates that show in thin-section a vivid green color. Calcite often occurs in irregular, skeleton-like crystal grains a half inch to an inch in diameter, as shown by the simultaneous flash of the cleavage in the hand specimen.

Practically all of the specimens of metamorphosed limestone containing the above mentioned minerals came from the vicinity of the iron ore deposits on the west slope of Grayback Mountain. These specimens present many transitional forms between the garnet-epidote-calcite rocks and the pure iron ore. Both magnetite and hematite are to be seen in these transitional forms. They are variously intergrown with the other ingredients in coarse crystalline grains. Both of these iron oxides may be seen filling the spaces between garnet crystals and apparently replacing calcite and probably also quartz and epidote, but in no case does the iron oxide replace the garnet. In every case where magnetite or hematite comes in contact with the garnet the garnet form remains sharp and unaffected. Nor does the iron oxide occur inclosed within the garnet. From this it would seem that magnetite and hematite did not crystallize out simultaneously with the garnet, but subsequent thereto. It would follow, therefore, if it is admitted that garnet, calcite and quartz crystallized simultaneously, that the iron oxides must have been formed subsequent to these minerals also. The significance of this fact will appear in connection with the discussion as to the origin of the iron ores.

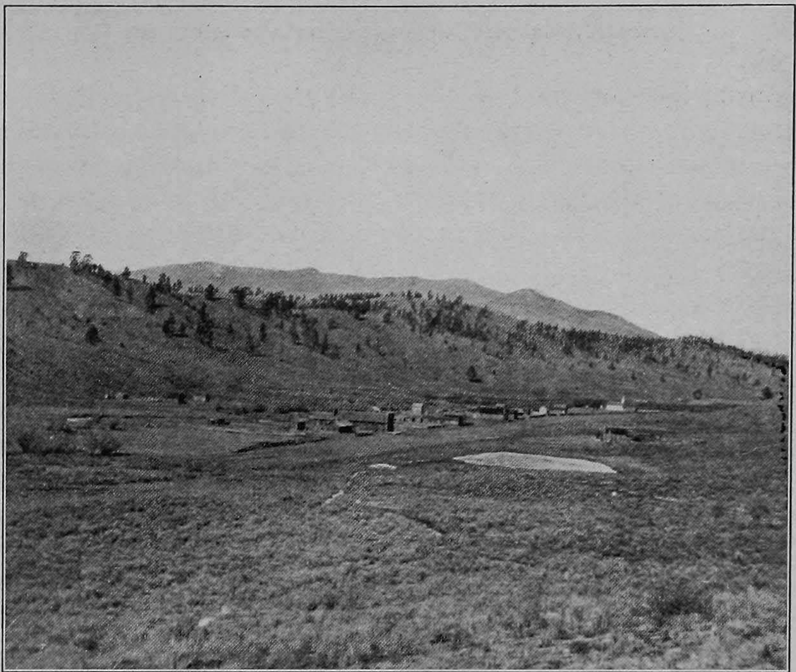
Iron Ores.

Character.—As will appear later in the more detailed description the iron ores occur as replacements of metamorphosed carboniferous limestone in which garnet is usually an abundant constituent, and are to be found at contact with monzonite-porphyry or close to such contact. They consist mainly of magnetite in more or less granular masses and show small, but greatly varying, amounts of calcite, garnet and other minerals characteristic of the altered limestone. In places hematite occurs either disseminated through the magnetite in coarse plates or in finer and purer masses. The original bedding of the limestone is commonly preserved more or less plainly in the iron ore. These ores have been developed on the western slope of Grayback Mountain in three mines that at present are known as the Upper Star of the West, Star of the West and Lower Star of the West.

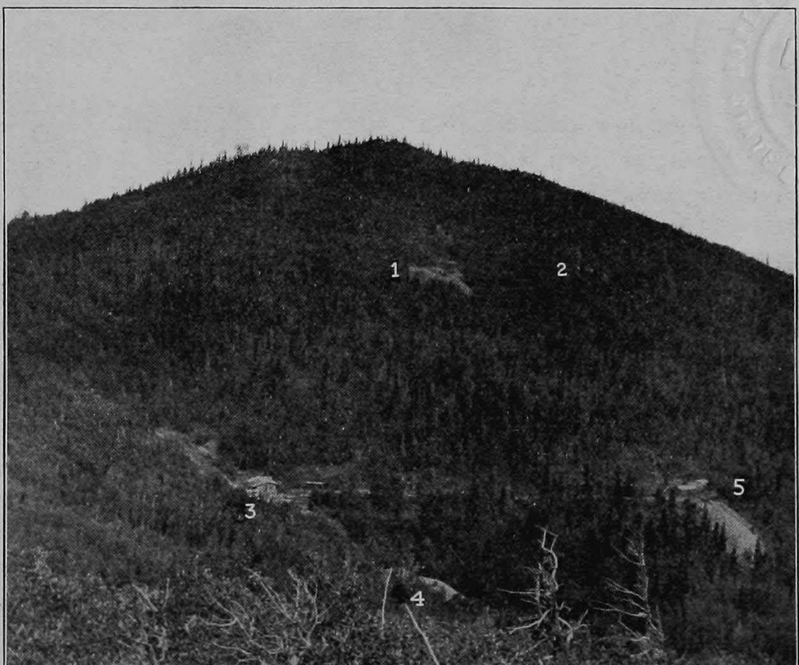
Detailed Description.—In the Tenth Census of the United States (volume 15, page 477) B. T. Putnam makes brief reference to the iron ore deposits on the east side of Grayback Gulch, that is, on the west slope of the mountain of the same name. He speaks of two mines, the Ainsworth, situated about 740 feet above the bottom of the gulch, and the Stoddard mine, about 180 feet above the gulch. These two mines correspond, doubtless, with what now goes under the name of the Star of the West and the Lower Star of the West, respectively. Mr. Putnam thinks that the two ore deposits may be really the same ore bed separated vertically some 560 feet by faulting. At the time the Tenth Census report was made but very little work had been done on the higher of the two mines, and the development of the lower mine was not sufficient to disclose the limited extent of the ore deposits and its close connection with local igneous intrusions. At least no mention of the proximity of such igneous rocks is made. From investigations of the writer it would seem that the fault mentioned by Putnam is probably not of great extent and that the two deposits are quite independent.

The Lower Star of the West (Stoddard).—The ore is composed of magnetite with varying amounts of hematite. It occurs very plainly replacing metamorphosed limestones at or close to the contact with monzonite-porphyry. The ore body is a bed some five feet thick conforming exactly in strike and dip with the overlying and underlying altered limestones, and containing to some extent the same minerals that make up the limestone. The strike is S. 80° E. and the dip about 25° to the south. The ore is cut off by a fault with a strike of South 40° East and a dip of 70° to the NE. A tunnel has been driven on this fault for a distance of 175 feet, beyond which the mine is caved in. The ore is found to the left, that is, northeast of this fault, the dip of the fault-plane being approximately at right angles to the dip of the ore bed. The ore has been worked out for a distance of 50 feet along the fault and for a width of about 25 feet. Beyond that nothing can be seen because of caving of the mine. At the end of the tunnel as far as now accessible monzonite porphyry occurs on the right of the fault instead of limestone, while ore continues on the left of the tunnel and fault. On account of the fault separating the two it is impossible to say whether the ore was originally in actual contact with the porphyry or not.

The Star of the West (Ainsworth).—This mine, located some 600 feet higher up the mountain than the Lower Star of the West, has been opened up from the surface in a sloping, cave-like stope that presents better opportunity for investigation. The ore is bedded six to eight or ten feet thick and conformable with the bedding of the metamorphosed garnetiferous limestone. The beds strike N. 80° E. and dip 35° S. That this ore body is a replacement of the limestone may be seen by the fact that a more or less gradual transition may be traced from solid ore to garnet-



TOWN OF RUSSELL, COLORADO, LOOKING NORTHWEST



GRAYBACK MOUNTAIN, FROM BUCKSKIN MOUNTAIN.
1. SUNNYSIDE. 2. EXCELSIOR. 3. MAGNOLIA. 4. LOWER MAGNOLIA.
5. HOMESTAKE.

nearing limestone in following along the beds in the direction of the dip. That is, the same bed continues uninterrupted from ore to limestone. Also the same minerals that form the metamorphosed limestone may be seen to some extent in the nearly pure ore. The following minerals occur in the altered limestone. Calcite, garnet (sometimes in recognizable trapezohedrons), epidote, amphibole, quartz, magnetite (in octahedral crystals), hematite (micaceous) and pyrite. Pyrite is also to be seen not very abundantly developed in portions of the iron ore.

This ore body occurs close to a mass of monzonite-porphyry located north of the ore. Actual contact with this porphyry does not occur here, as the ore has been cut off by a fault that strikes practically east-west and dips 70° south. The upthrow is on the north or foot wall side of the fault. The amount of the throw can not be determined, but it is sufficient to carry that portion of the ore body nearest to the monzonite-porphyry above the present level of the ground so that erosion has completely removed it. The direction of throw may be known from the fact that the iron ore has been dragged upward along the fault plane for some eight or ten feet. It should be noted that this fault differs from the one in the lower mine very greatly in both strike and dip.

Underlying this iron ore at one place occurs a whitish granular limestone having a very irregular line of contact with the overlying ore. Immediately at this contact the ore is limonite. It could not be determined positively whether the limestone had originally been replaced by magnetite which has later been altered to limonite or whether the limonite has directly replaced the limestone, but the impression made on the writer was that the replacement was originally by magnetite.

Upper Star of the West.—This body of ore is from one to four feet thick and lies bedded between an overlying garnet-bearing bed and an underlying bed of brownish crystalline limestone. The ore has replaced to some extent the upper part of this pure limestone bed. The dip of the beds is 45° S. The strike appears to be about the same as for the last described mine, which lies at a level some 150 feet below this mine, but owing to the strong magnetism of the ore the direction of strike could not be taken.

At this mine the iron ore and limestone come into sharp contact with monzonite-porphyry, the line of contact being approximately vertical. There is nothing at this place indicative of a vein of ore between the limestone and the igneous rock. In fact, no such veins of iron ore have been observed in the district by the writer. Mr. Hoskin, as stated by him in Chapter VIII, thinks he observed such a dike, and it is more than likely that such do occur.

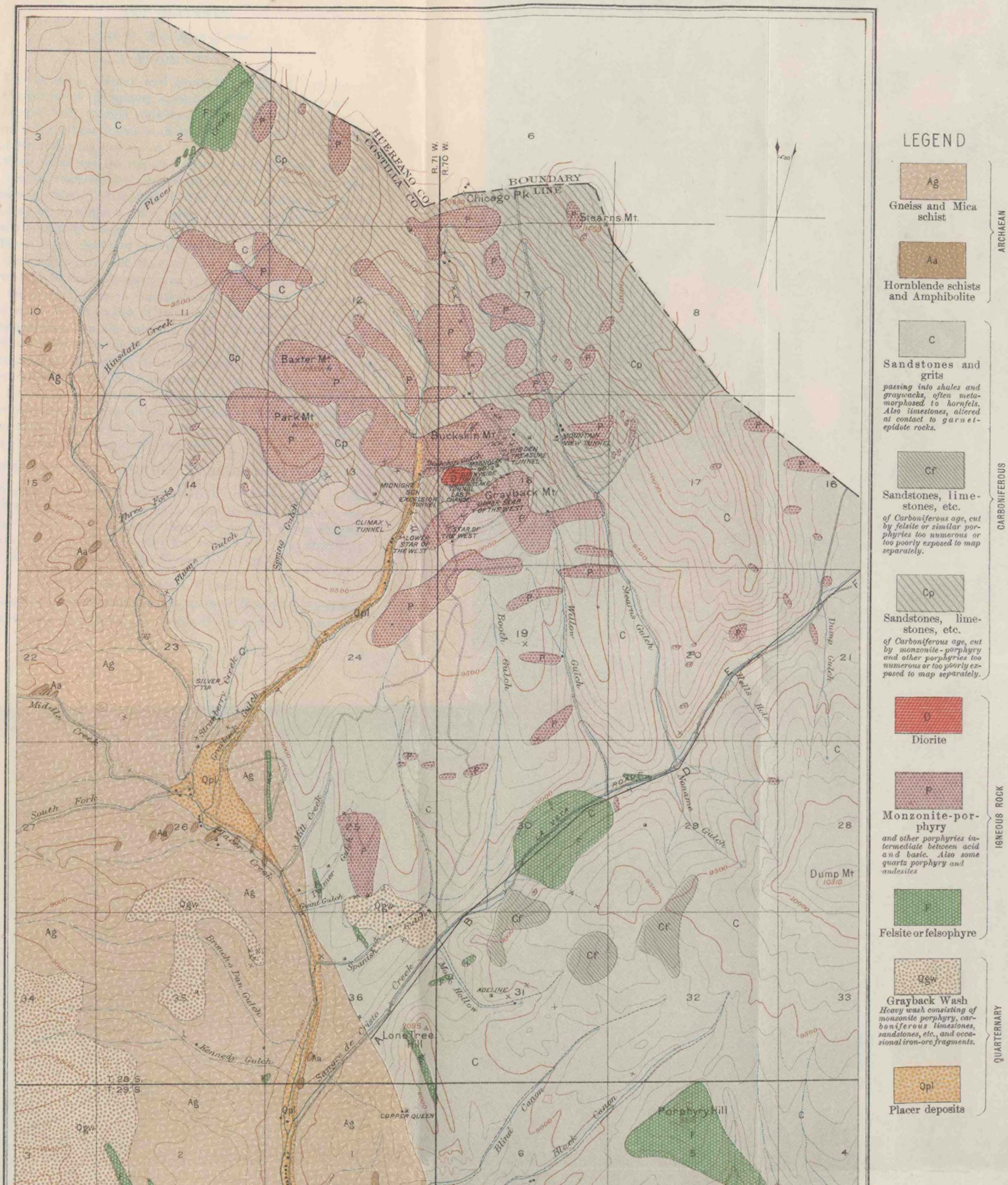
Origin of the Iron Ores.—In an extremely interesting and suggestive paper by Leith and Harder* on The Iron Ores of the Iron Springs District of Southern Utah these authors state that "it early became apparent to him (Leith), as it had been apparent to others, that the iron ore deposits of the West are prevailingly of a distinct and uniform type—an irregular replacement of limestone near the contact with igneous rocks, or a vein filling in both limestone and igneous rock—a type fundamentally different from that of the important producing districts east of the Mississippi River, and probably of different origin." In their investigation of the iron ores of the above named district Leith and Harder conclude that the ores are the direct or, rather, after-result of large igneous intrusions in limestone, and that the process may be summed up as the "entrance of hot ore-bearing solutions through fissures in the andesite into the adjacent sediments, depositing ore as dikelike masses in fissures in the andesite, as fissure fillings and replacements in the limestone, and as cements in breccias of andesite, limestone and quartzite."†

Owing to the extremely heavy covering of soil and forest on the western slope of Grayback Mountain and in the absence of more extensive mine workings a very good opportunity has not been afforded for investigating the origin of these iron ores. In the absence of positive evidence of iron ore veins it would seem that this form of deposit may be lacking in this district, although there can be no doubt that the ores are due directly or indirectly to the intrusion of the igneous rocks. The ore can hardly, however, be due to the metamorphosing of pre-existing limonite or other iron ore deposits, as such deposits are not found away from the igneous contacts. Furthermore, it has been shown in discussing the metamorphism of the limestones that the magnetite and hematite were not formed at the same time as the garnet—a very characteristic contact mineral—but subsequent thereto, mainly through the replacement of the calcite. We shall have

*C. K. Leith and E. C. Harder, U. S. Geol. Sur. Bull. 338, p. 11.
†loc. cit., p. 85.

to exclude also possible pyrite deposits as the original source of the iron ore unless we are prepared to admit that the same igneous intrusion can be responsible for three successive and very distinct processes of mineral formation: First, the direct contact metamorphism of the limestone; second, the circulation of waters carrying sulphides; third, the alteration of these sulphides to oxides.

It would seem that the only remaining alternative is the circulating of iron-bearing solutions, emanating from the igneous rocks during the later period of their consolidation or cooling and the differential replacement of the calcite in the metamorphosed limestones. As to the nature of the iron-bearing solutions there is no evidence at hand. Quite possibly the suggestion of Leith and Harder is correct, that ferrous solutions, such as the chloride or carbonate or sulphate, were partially oxidized by the breaking up of water at high temperatures.



GEOLOGIC MAP OF THE GRAYBACK MINING DISTRICT, COSTILLA CO., COL.

Topography by students of the Colorado School of Mines, under direction of the Geological department.

Scale $\frac{1}{36000}$ or 3000 feet to 1 inch

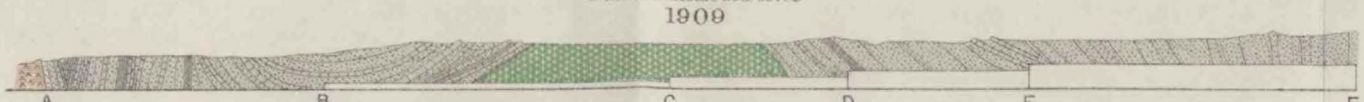
1 ¾ ½ ¼ ⅛ $\frac{1}{16}$ 0 1 mile

Contour interval 100 feet

Datum is mean sea level

1909

Geology by Horace B. Patton, Charles E. Smith and G. Montague Butler, assisted by students of the Colorado School of Mines



SECTION ALONG THE LA VETA ROAD

A. HOEN & CO. BALTIMORE

CHAPTER VII.

ORE-DEPOSITS.

(By G. Montague Butler.)

INTRODUCTION.

The location, history and general geology of this district and the nature of the mining operations which have been carried on here are fully treated elsewhere in this bulletin and some familiarity with these topics is desirable for a proper understanding of the following discussion.

Many years ago the region involved yielded placer gold and iron ore in commercially important amounts. Recently there has been a renewal of interest in the mineralization of the district, and an attempt is now being made to develop its placer deposits on a large scale.

There is no doubt of the presence of gold in the area, as it is an undisputed fact that several moderate fortunes were secured here in the early days, and it is now possible to pan gold from the stream beds in numberless places. This being true, the question of the source of the metal becomes one of interest and importance. In the solution of this problem the course of procedure followed involved careful testing, by panning, of all the stream beds and valley bottoms, together with several more or less extensive deposits of alluvium or wash now considerably above the water courses, but which doubtless represent, at least in part, old areas of alluviation. The result of this examination is summarized below and is followed by a discussion of the lodes from which the placer gold was derived.

PROVEN AND POSSIBLE PLACER DEPOSITS.

Three distinct periods of alluviation are represented in the area, the deposits resembling each other in many respects, but differing in location and height above the present water courses. Beginning with the highest, they are as follows: The Grayback Wash, the Terrace Gravels, the Recent Alluvium.

The Grayback Wash.

Location.—This is found a mile west of Russell and extends south and west far beyond the limits of the territory examined, and northward about one-quarter of a mile beyond Kennedy Gulch. There is a smaller T-shaped area on both sides of Broncho Dan Gulch, the nearest point being about a mile northwest of Russell, and this deposit is also found in Spanish Basin. All are at an elevation of approximately 9,000 feet and the bed seems to slope towards the southeast at a small angle.

Character.—This wash comprises well-worn fragments, varying from fine sand up to pieces several feet in diameter of all the rocks found in the immediate vicinity of Grayback Mountain, and also contains some material not now represented there. Porphyries, felsites, amygdaloidal basalt, granite-gneisses, wackes, grits, conglomerates, sandstones, limestones, hornfels, lime-silicate rocks, magnetite and hematite are mingled in great confusion. In some places one may predominate and elsewhere another, but the general character is everywhere strikingly similar.

The resemblance of most of the fragments to the rocks of the Grayback region is not merely superficial; they are *identically* alike. The limestones contain the same fossils as are found in the carboniferous sediments, and the igneous rocks are indistinguishable.

The proportion of Archaean material present is small and decreases towards the east, so it is almost lacking in Spanish Basin. Even where found scattered over the wash to the west it is probable that a considerable part is of extraneous origin, never having formed a part of the wash on which it lies.

Although the Grayback Wash is more firmly compacted than either of the other types of gravel deposits it may still be picked apart and shafts may be sunk therein without the use of explosives. It is too hard, however, to permit of excavation by means of bucket dredges or other automatic appliances. If the deposits west of Placer Creek contain gold it can hardly be extracted profitably by any method involving the use of water, since it is far above present stream levels, and to transport it down to water would be very expensive. The considerable degree of induration would also make it impossible to mine it profitably unless exceptionally rich, which it is not, as later statements will show.

Thickness.—The bed varies in thickness from almost nothing up to unknown figures, shafts fifty feet deep failing to reach the bottom of the gravel west of Placer Creek. It seems probable that in some places this figure is much exceeded.

Gold Content.—So far as known the Grayback Wash contains no gold west of Placer Creek; several pans of dirt from there were washed without obtaining a single color. It should be mentioned, however, that in no case was it possible to take the samples from the base of the gravel bed near bedrock, and it is quite possible that gold may be present there, although its profitable recovery seems out of the question, as previously stated.

Samples taken from this Wash in Spanish Basin yielded from three to ten coarse colors to the pan. As these colors were found to average a little above 1.5 mgs. in weight (worth .0975 of a cent with gold at $20.00 an ounce) and the pans averaged one hundred to the cubic yard, it is safe to assume that one "coarse color" is equivalent to 10 cents a cubic yard. Figured in this way it was determined that from grass roots to bedrock the whole averages 60 cents per cubic yard.

The Spanish Basin Placer Company, composed of R. M. Barnes, H. G. Nesper, G. C. Wrice and C. W. Frickey of Russell, Colo., controls one hundred and twenty acres in Spanish Basin and Spanish Gulch, which includes about all of the Grayback Wash suitably situated for profitable working. This company has leased the ground from the Trinchere Estate, paying 10% of the gross proceeds for the same. Water from the Sangre has been brought upon the property by means of a ditch two miles in length.

This same company, or one or more of the individuals of which it is composed, controls seventeen acres along Spanish Gulch, which opens into Spanish Basin from the south. Some of the ground is Grayback Wash, but the most of it is Recent Alluvium and will be discussed under that head.

The gold varies from fine to coarse and the particles are rather irregular in shape, scale-like or flake-like forms being the commonest, with some wire gold present. No large nuggets have been reported nor are rounded forms common, although most of the grains appear to have been somewhat smoothed by attrition or other means.

Age and Manner of Formation.—The total absence of fossils makes the ages of the various gravels somewhat indeterminate, but it is possible to fix their relative age with certainty and the conditions under which each was deposited seem fairly plain.

There is no doubt but that the Grayback Wash is the oldest and the character of its fragments proves that they had their origin in the Grayback Mountain mass and that the Wash was deposited after all the igneous rocks of the district had been formed, that is, some time after the Miocene Epoch of the Tertiary Period.

The intrusion of the youngest igneous rocks—mainly of felsitic type—was accompanied or followed by orogenic movements which may have been of considerable magnitude, and it is not unlikely that these occurred at the end of the Miocene, which was a time of notable mountain making movements elsewhere.

Possibly the Grayback Mountain mass was greatly elevated at this time and the Grayback Wash represents the remnants of an outwash deposit of fragments eroded from the mass soon after its elevation and carried to moderate distances from its base by torrential sheets of water.

The possibility of considerable outward as well as upward extension of the Grayback mass should be recognized, since the greater the magnitude of the former the easier it is to explain the observed facts without resorting to the assumption of a more than moderate upward extension of the mountain.

It has been suggested that this Wash may represent a great outwash deposit such as is formed around desert ranges at the present time, but the rounded, water-worn appearance of its constituents and their comparative freshness are unfavorable to this theory.

It is not necessary to assume that this Wash was originally continuous between the areas where it is now found, since it may have been confined to one or two very broad, flat valleys running southwesterly from the Grayback mass. It was probably originally a very thick deposit and subsequent differential erosion is responsible for differences of elevation of two hundred feet or more, such as are found at different parts of each of the existing deposits. This explanation assumes, of course, that there have been great changes in the topography and, possibly, slight crust tilting movements since the bed was formed.

The Terrace Gravel.

Location.—The Terrace Gravel constitutes a notable topographical feature of the area, but is not differentiated from the Recent Alluvium or from the Grayback Wash on the geological map accompanying the report.

It borders the present stream beds in several places, forming rather flat-topped mesas or terraces whose upper surfaces are about fifty feet above the streams. Officers' Bar (Plate VI) at the junction of Grayback and Placer Creeks is capped by one of these deposits, which are also extensively developed between the north and south forks of Middle Creek and along Placer Creek, particularly on the west side about a half mile north of its junction with Middle Creek and at several places on both sides south of this junction.

Character.—In the size of the rock fragments the Terrace Gravel resembles the Grayback Wash, but the nature of the materials of which it is composed depends upon its position. Between the north and south forks of Middle Creek it consists wholly of Archaean material; on the west side of Placer Creek above its junction with Middle Creek it is mostly of Archean fragments, and elsewhere its constituents are the same as are found in the Grayback Wash, with the addition of somewhat larger, although variable, proportions of Archaean rocks. As already mentioned, the Terrace Gravel is less consolidated than the Grayback Wash. It can be easily worked with picks and shovels and large amounts have been so handled.

The height above the streams is not so great but that in most cases water can be diverted to the top of the terraces or flats, and this has been done in several instances.

Thickness.—The deposit varies considerably in thickness, but averages at least fifteen feet.

Gold Content.—The Terrace Gravel proved to be absolutely barren where composed entirely or mainly of Archean material, and no beds rich enough to yield gold in paying quantities were found on the west side of Placer Creek below its junction with Middle Creek, although all these deposits contained well rounded magnetite and other heavy sand.

Auriferous Terrace Gravel is found capping a low triangular mesa near the junction of Grayback and Placer Creeks, on an extensive series of broken terraces east and south of this junction, and as small remnants of terraces at various points along Placer Creek between Grayback Gulch and the Sangre, principally on the east side.

The first of these localities, known as Officers' Bar and the Ebenezer Placer, is the richest and most extensive. It was worked many years ago by soldiers from old Fort Massachusetts, on Ute Creek, who left it a net-work of pits, and it is claimed that a great deal of gold was recovered, but figures are now unobtainable. There is still, however, probably as much as twelve acres of unworked ground, and this was sampled in many places.

The lower five feet was found to average about 90 cents and the upper thirteen about 35 cents per cubic yard. As high as sixteen coarse colors per pan (about $1.75 per cubic yard) were found near bedrock in a pit on this ground on the east side, which runs considerably higher in value than does the west side.

The Colorado Gold Dredging Company owns all this ground, but has made no attempt to work it, confining all operations to the Recent Alluvium, under which head these are discussed.

The gravel on the non-continuous terraces east and south of the junction of Grayback and Placer Creeks was also worked to some extent many years ago, but six samples show that it averages only about 20 cents per cubic yard. The bed is also thinner than on Officers' Bar and the topography is so broken that a great deal of wooden flume would have to be built to get water upon it. The greater part of this ground is owned by the Colorado Gold Dredging Company.

The Terrace Gravels further down Placer Creek are even less valuable than those last mentioned, with the possible exception of a small terrace on the north side of Miller Gulch, where it is claimed that Green Russell secured many thousands of dollars' worth of gold years ago. While there are abundant indications that work was some time done here, pans of the remaining gravel failed to yield a single color.

A small patch of this material on the west side of Placer Creek just north of the mouth of Kennedy Gulch was found to contain an unusually high proportion of large magnetite fragments and it was hoped that the gold content would also be high, but several samples failed to show a single color—one of many examples of the fallacy of the locally accepted idea that these two substances always accompany each other in this district.

Character of the Gold.—The gold found in the Terrace Gravel is identical in character with that described as occurring in the Grayback Wash in Spanish Basin, but it averages somewhat coarser, one flake weighing twelve milligrams.

Age and Manner of Formation.—After the formation of the Grayback Wash there evidently ensued a long period of erosion with high stream gradients and little or no alluviation in the area examined. This rough-shaped the topography of the present day and was ended or interrupted by the deposition of the

Terrace Gravel. When this occurred is almost purely a matter of speculation, but these high gravels plainly represent deposits from overloaded streams swollen to dimensions much greater than are possessed by any of the creeks now draining the district. As the Glacial Epoch was succeeded almost everywhere by an epoch—the Champlain—of heavy precipitation and swollen streams, it is at least possible that the Terrace Gravel was formed at that time. The deposit was doubtless originally continuous all around the junction of Middle, Placer and Grayback Creeks and extended for some distance up each of these as well as down Placer Creek. Evidently the gradients of the streams were so great above these points that there was little or no overloading and deposition of transported material, but near the junction referred to above the streams were close to base level, and the consequent decrease in velocity resulted in the deposition of a great part of their loads. The mingling and confusion of the currents may have had some influence upon this result, as it almost certainly did in the formation of the rich pockets on Officers' Bar.

The Recent Alluvium.

Location.—This comprises the material in the beds of all the permanent and intermittent streams. The most extensive deposits are naturally along the largest streams—the Sangre and Placer Creek below its junction with Middle and Grayback Creeks (see Plate VI).

Character.—The nature of this material necessarily varies with the different drainage areas. The alluvium in Kennedy Gulch, Broncho Dan Gulch and along Middle Creek is entirely Archaean, while that in Placer Creek and near the mouths of most of its tributaries north of Middle Creek is composed of mixed Archean, sedimentary and igneous debris. The creeks and valleys further east contain practically no Archaean rocks—all are sedimentary or igneous.

All are alike, however, in that they contain black sand (magnetite) in large quantities, this mineral being so widely distributed that a magnet drawn through the soil almost anywhere in the valley bottoms will pick up fragments which are usually well rounded excepting where their source was the Grayback Mountain mass.

Another point of similarity exists in the fact that most of the streams show evidences of at least two, and probably three, stages of deposition when conditions differed quite materially.

This is indicated by the division of the alluvium into usually two and sometimes three distinct layers. The lowest, of whose presence we have positive knowledge only in Grayback Gulch, in Placer Creek below Middle Creek and in the Sangre below Placer Creek, and whose existence is therefore only conjectural in other cases, is somewhat finer than the next overlying layer and contains fewer large fragments of magnetite than are found above it. It is locally, although erroneously, called the glacial bed. On top of this is a layer of coarser material which, in the streams draining the Grayback Mountain region, contains small and large rounded fragments of magnetite, occasional pieces weighing up to several hundred pounds. In general it does not appear to be quite as coarse as the Grayback Wash or the Terrace Gravel and is less consolidated than either. The uppermost layer is usually of loam and small, angular rock fragments. The permanent streams have cut their way through this and are flowing through the upper part of the underlying coarse gravel.

Thickness.—The lowest layer, where exposed, averages five feet thick, the middle varies from a few feet up to more than twenty feet, and the thickness of the top layer is so variable that it is hard to approximate to an average. Four feet is probably not far wrong.

Gold Content.—The Recent Alluvium was more carefully tested than either of the other types of deposits, as it was recognized that it contained the most recent record and was most likely to furnish the best means of tracing the gold back to its source. It should be noted, however, that lack of time made it impossible to dig pits down to bedrock, so complete data on the richness of the deposits is unavailable. Advantage was always taken, however, of natural or artificial excavations already existing and the figures may be regarded, therefore, as fairly reliable.

Kennedy and Broncho Dan Gulches and the north and south forks of Middle Creek for a distance of nearly two miles from the mouth failed to yield a single color. The same was true of Placer Creek and its tributaries above its junction with Middle Creek, and of Grayback Gulch above Buckskin Gulch, Spring Gulch, Mill Creek, Booth Gulch and the Sangre above its junction with Middle Creek, although it is claimed that some gold has been found on the Sangre below the mouth of Willow Gulch in pits now obliterated. The gulches south of the Sangre were also found to be barren.

This narrows down the gold-bearing Recent Alluvium to the following streams and gulches:

1. The Sangre from south of the southern limit of the area examined to the mouth of Placer Creek.

2. Placer Creek from its mouth to the mouth of Grayback Gulch.

3. Placer Creek from its mouth to the mouth of Buckskin Gulch.

4. Buckskin Gulch.

5. Willow Gulch.

6. Spanish Gulch.

7. Giant Gulch.

8. Stearns Gulch.

The first two of these are continuous and practically identical in character, so may be treated as one.

THE SANGRE-LOWER PLACER CREEK ALLUVIUM.

Many samples were taken at different points on both sides and in the creek bed at depths varying from the surface to bedrock, and these yielded up to sixteen coarse colors per pan, only three samples containing no gold.

The Colorado Gold Dredging Company drilled twelve holes to bedrock during the summer of 1909 and all yielded gold in paying quantities and proved that the deposit averages about twenty-two feet deep. The values were found, however, to be non-uniformly distributed vertically, the five-foot "glacial bed" containing the most gold—about 85 cents a cubic yard, which is present as coarse, uniformly rounded grains.

The lower three feet of the coarser gravel above averages about 65 cents a cubic yard, while the upper nine feet yields approximately 50 cents per yard. The gold in this horizon varies greatly in size and shape, some flour gold being present as well as a very few nuggets up to an ounce in weight. Round and flat grains one-eighth of an inch in diameter represent about the upper limit ordinarily to be expected.

Overlying these is about five feet of the fine surface Alluvium, which contains little or no gold.

The whole deposit from surface to bedrock may then be expected to run close to 50 cents a cubic yard.

All the workable ground above described is owned by the Colorado Gold Dredging Company, which is incorporated as a stock company under the laws of Wyoming, Mr. Frank N. Campbell of Breckenridge, Missouri, being President.

As this company owns nearly three miles of the placer ground just discussed and the average width of the workable deposit is at least three hundred feet it is a simple matter to figure that they have many hundreds of thousands of dollars in sight along the two streams.

Water level is struck at a depth of about five feet below the surface and there is a sufficient flow throughout the year to permit of continuous operation of dredges, one of which is now being installed and is expected to be ready for work before the summer of 1910.

GRAYBACK GULCH BELOW BUCKSKIN GULCH.

This is practically a continuation of the areas just discussed, but only in the first seven hundred and fifty feet is it sufficiently wide and of a low enough gradient to make successful dredging possible. Above this flat ground the gradient averages nearly 10%, the usual width is less than fifty feet and the average depth is about eighteen feet.

In the lower part of the gulch the water level is about five feet below the surface and there are four or five feet of the fine-grained, barren Alluvium overlying the auriferous gravel, so it was practically impossible to test the bed thoroughly. In every case where the coarse magnetite bed was exposed there could be obtained from one to two coarse colors per pan, and it is very probable that the yield would be considerably better nearer bedrock. As the distance from the mouth of the gulch increases the thickness of the fine, barren overburden decreases and the yield within five feet of the surface is from two to five colors per pan. Stull further up the barren Alluvium disappears and the deposit then pans well from the grass roots down.

The Last Chance Placer (Plate IX, B.) at and below the junction of Grayback and Buckskin Gulches is of this character. Each pan taken at from one foot to six feet from the surface contained two coarse colors, and below this the yield was from three to five colors a pan. Just above bedrock is a layer of sticky clay eighteen inches thick, which is very rich in coarse gold, three pans yielding, respectively, twenty-one, twenty-five and thirty-six coarse colors. Nuggets worth as much as $2.00 have been found in this clay, but it forms "sluice rubber" and is hard to handle. Values also are found in crevices in the bedrock, but are, naturally, difficult to recover.

The gold found here is coarse and is apt to be quite rounded, probably not by attrition, as later discussed. One peculiar and significant feature is the occasional occurrence of particles of gold telluride-calaverite—at this place. Sometimes a grain is part metallic gold and the rest telluride, bearing a strong resemblance to some of the particles contained in partially oxidized Cripple Creek ores.

Although the best values lie within three feet of bedrock it appears that the whole gulch will average 50 cents a cubic yard, although the amount of barren overburden at the lower end may somewhat decrease this figure.

The water supply is so limited that continuous operation is possible only in the spring, but by constructing reservoirs it would be possible to work intermittently all summer.

This placer is controlled by Mr. Wm. V. Casey of Boulder, Colorado, who has leased it from the Trinchera Estate on a 10% royalty basis. He spent the summer of 1909 in cleaning out old pits and testing the extent and regularity of the gravel, the work being conducted with a small giant. These operations are to be continued throughout the summer of 1910, and, if the results are satisfactory, reservoirs will then be constructed and large giants installed. Mr. Casey is well satisfied with the showing already made.

Most of the ground below the Last Chance Placer is owned by the Colorado Gold Dredging Company.

Buckskin Gulch.—This might be considered a continuation of Grayback Gulch, as it certainly is of the auriferous deposit found therein, not a trace of gold being found in Grayback north of Buckskin Gulch. The deposit in the Buckskin does not average more than six feet deep and is very narrow, but contains gold from grass roots to bedrock in quantities equal to or slightly greater than are found in Grayback. The very steep gradient—over 20%—and complete lack of water except in the spring would, however, effectually prevent the economical handling of this material.

Willow Gulch.—Here is located what is undoubtedly the richest placer deposit of any size in the district. At the upper end of the gulch the gold-bearing ground averages eight feet deep, yields from two to eight coarse colors at grass roots and twenty-five to ninety at bedrock. Most of the gravel is so rich that a lard pail cover filled with the finer stuff would give several colors. The presence of a barren or low grade overburden of fine Alluvium in the lower part of the gulch decreases the richness there, but gold is present, seemingly in paying quantities, clear down to the Sangre, a distance of about two miles.

The width of this deposit will hardly average fifty feet, however, so it was impossible to show it on Plate I because of the small scale there used.

The gold is all coarse and occurs in round and flat grains and as wires. Some faint indications of crystallization were noted, and grains of pyrite and calaverite were present. These, together with the sharpness of some of the grains, would seem to indicate that there has been little transportation of this material. Large quantities of magnetite, both as sand and large fragments, are present.

The richness of this deposit has been common knowledge in the district for years, and a small area at the head of the gulch has been worked by sluicing. A small giant was there installed, but never operated. The almost complete lack of water at any time but in the early spring explains the inactivity of those cognizant of the presence of the gold. There is, however, a permanent stream in Stearns' Gulch, and water could be brought to Willow Gulch through a ditch about one and one-half miles long. This has been attempted, but the gradient was not sufficiently high and little water was delivered.

The construction of such a ditch would be a rather expensive undertaking, as it is through thick, small timber most of the way, and there would doubtless be a great deal of seepage loss, so it is probable that the process ultimately adopted to reclaim the values will be some form of dry concentration. Enough power for this purpose could be generated from the Sangre or Stearns' Creek and the heavy sands could be shipped or the magnetite separated therefrom electro-magnetically.

A good road has been constructed to within one-half mile of the head of the gulch.

Spanish Gulch.—This Alluvium, which is found near the mouth of the gulch, was probably the first worked in the district, but the bed is narrow and shallow and the gulch is dry most of the year. Hence it is not a very attractive proposition, although it runs better than 50 cents a cubic yard. The gold is undoubtedly derived from the Grayback Wash in Spanish Basin.

The Spanish Basin Placer Company, which now owns or controls this ground, had solved the water problem by the construction of the long ditch already mentioned, but were confining their efforts to other richer or more extensive deposits.

Giant Gulch.—Near the head of Giant Gulch the Spanish Basin Placer Company is working a giant on gravel ten to twelve feet deep that averages 70 cents a cubic yard. (Plate IX, A.) As they have a good head of water and a large amount of auriferous ground, the width of the deposit increasing as the head of the gulch is approached, there seems to be no reason why successful operation should not be possible.

G. Jantz and G. A. Andrews worked the lower end of this gulch by ground sluicing during the summer of 1909. They used the overflow water of the Spanish Basin Placer Company above and worked by permission of this company, which controls the whole gulch. The sluices caught some coarse gold, but the steepness and narrowness of this part of the gulch and the narrowness of the bed made work difficult. It is doubtful if the work was very profitable, although figures were unobtainable.

The gold in Giant Gulch, like that in Spanish Gulch, was undoubtedly derived from the Grayback Wash in Spanish Basin. In fact, a finger-like projection of the Wash itself extends for some distance down the gulch.

Both fine and coarse gold is present and most of it is well rounded, but some is sharp-edged or flaky. A little calaverite was found and one particle was half calaverite and half metallic gold.

Stearns' Gulch.—Careful testing of this gulch yielded a single fine color from gravel three feet below the surface one-quarter of a mile above the Mountain View Mill.

Age and Manner of Formation.—After the formation of the Terrace Gravel there must have been a slight tilting to the southward or some other change which would cause the streams to cut their way down through these deposits to a point as low or lower than any previously reached. A slight northward tilting of the area or some other change which would decrease the velocity of the streams then ended this erosion and ushered in an epoch of deposition which has probably continued almost uninterruptedly up to the present time, resulting in the formation of the Recent Alluvium.

The three distinct layers into which this material is divided are doubtless due to changes in the amount of precipitation and consequent erosion, these being now at a minimum, since no grains of gold are now carried far from its source and large fragments of rock are transported only during brief periods of high water. The fine, barren Alluvium which covers much of the auriferous gravel is undoubtedly partially the result of sheet erosion of the hillsides during rainstorms, partially a wind deposit, and, to some extent, vegetable mold.

Source of the Gold.

That Grayback Mountain is the source of all the placer gold in the district must be evident to anyone who carefully considers the facts already stated. Not only do Grayback, Buckskin and Willow Gulches—all gold bearing—head in or near this mountain, but Stearns' Gulch is so situated that there is no doubt but that it carried some drainage from Grayback when the mountain was somewhat higher than at present. In fact, *all* of the larger streams or gulches draining the Grayback Mountain area, with the possible exception of Booth Gulch, are auriferous. Booth Gulch is broad and flat and contains so much fine Recent Alluvium that it was impossible to penetrate to the ordinarily auriferous coarser material. Its relative shallowness would indicate, however, that it is of recent origin, and it may, then, never have carried drainage from Grayback Mountain.

Not only is it a fact that all the larger streams or gulches which now drain the Grayback mass directly or indirectly, or which have recently done so, carry gold, but it is equally true that not another stream or gulch in the area does so, therefore the conclusion above stated appears inevitable.

The presence of the easily alterable telluride in the Grayback Wash may seem to indicate proximity to the source of the gold, but it is quite possible that the calaverite was brought thither in a fragment—since disintegrated—of the Grayback Wash which fills the head of the gulch and the basin above. That some proportion of the fragments contain thin auriferous veins is theoretically quite certain, although none were seen.

Fineness of the Gold.

All the gold recovered by panning was carefully saved in order that its fineness might be determined, but an accident scattered it beyond possibility of recovery before the analysis could be made.

The testimony of old residents of the district is uniformly to the effect that the gold is unusually pure, and the very low silver content of the lodes later discussed would seem to make this condition probable.

Explanation of the Size of the Grains.—The coarse, rounded gold grains and nuggets found in the "glacial bed" and, to a lesser extent, elsewhere, probably existed originally as particles no larger than those now found in the beds above, but have been enlarged by accretion, that is, by the deposition around them of other gold brought in solution throughout all the time since they were dropped in the stream bed. The rounded appearance of many of the smaller grains in localities near Grayback Mountain may quite possibly be due to the same agency, since they have hardly been transported a sufficient distance to be rounded by attrition.

The possibility of this "growth" of gold nuggets is well established, and this seems to be the logical explanation of the observed facts.

It is quite probable that this agency is active in enlarging the gold nuggets at the present time, but the heavy mantle and the unimportance of erosion and other mechanical processes of disintegration would tend to minimize the amount of gold now contributed in this way.

Heavy Sands.

A peculiarity of the Alluvium, excepting that along streams which drain Archean areas exclusively, is the high percentage of heavy minerals. These include not only the ever-present magnetite, but also garnet, epidote, spinal, highly ferruginous sandstone and other heavy minerals. This naturally greatly increases the difficulty of separating the worthless material from the gold that may be associated therewith.

THE LODES.

A brief examination of the geology of the district suffices to establish the probability of the presence of the following types of ore deposits:

(1) Contact Deposits.

(a) Archaean-Carboniferous contact.

(b) Sedimentary-igneous contacts.

(c) Archaean-igneous contacts.

(2) Fahlbands (impregnated schists).

(3) Fissure veins, sheeted zones, etc.

(4) Mineralized dikes.

(5) Metamorphosed bedded deposits.

(6) Miscellaneous deposits.

Contact Deposits.

Archaean-Carboniferous contact. This contact runs in a fairly straight line through the entire western half of the area examined, the strike approximating about N. 25° W.

In most places the contact is nearly vertical, and exposures show slickensides and thick streaks of gouge, indicating that faulting has made this a line of weakness and a passage-way for solutions—possibly ore-bearing.

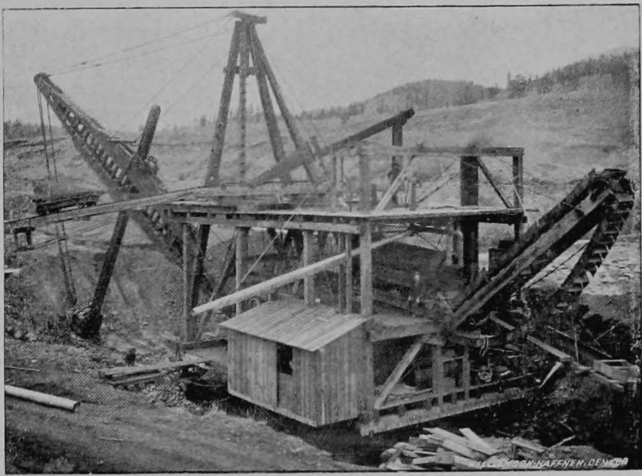
Prospectors early recognized the possibilities of this contact, and have worked upon it to a considerable extent. Beginning near the southern edge of the section and going northward, the best exposures are found in the Copper Queen and Blue Bird shafts, an open cut above the Silver Tip Mine, and in several shallow holes in, and north of Flume Gulch. The Blue Bird was the only one of these operated during the summer of 1909.

The investigation of the gold bearing character of the streams gave no grounds for expecting to find gold along this contact, but it was examined and carefully sampled in the event that it might contain copper, and perhaps silver and other valuable metals.

A mineralized zone exists apparently almost everywhere a few feet above (to the east) of the contact, in the Carboniferous rocks. Abundant slickensiding, numerous nearly vertical parallel cracks, and a thick layer of gouge (often black) indicate considerable faulting, as previously stated, and the sheeted zone thus formed varies from a few inches to several feet thick.

This zone is copper-bearing wherever exposed, malachite and iron-oxide staining the surface croppings, and chalcocite and chalcopyrite appearing in scattered patches at depths of twenty-five feet or more. Although occasional pockets yielding good assays for copper and some silver have been found, the amount of this high-grade ore is always so small that there is no possibility of mining it at a profit. No traces of any valuable metals but copper and silver are present.

COLORADO GEOLOGICAL SURVEY PLATE VIII A



PLACER MINING—STEAM SHOVEL. BADGER STATE PLACER MINING COMPANY. TRINCHERA ESTATE

COLORADO GEOLOGICAL SURVEY PLATE VIII B

UPPER STAR OF THE WEST (IRON MINE)

The copper minerals appear in the cracks of the sheeted zone, in the interstices of the porous sediments, and seem in some places to have replaced part of the ingredients of the latter. Exposures are not sufficiently numerous to make it possible to determine the influence that the varying Archean and Carboniferous below and above the contact may have upon the richness of the deposit, but a tendency toward a widening of the sheeted zone in the harder sediments was noted.

The cupriferous minerals were probably deposited from upward working aqueous solutions, and the presence of unaltered sulphides close to the surface leaves no grounds for hoping to find secondary concentration or enrichment with depth.

Sedimentary-igneous contacts. In many districts productive ore bodies are found at the contact of igneous and sedimentary rocks, and the variety and extent of the intrusions in the area examined, and particularly in the Grayback Mountain region from which the placer gold came, made it appear likely that ore-bearing contacts of this type would be found there. This possibility was long ago recognized by prospectors, and scores of prospect shafts or cuts are located on such contacts; in fact, few are found elsewhere.

Most of these contacts contain from a fraction of an inch to a foot or two of soft, oxidized, hydrated vein matter with some gouge, and are often slickensided on one of the walls, but, with one exception, not a vein of this character assayed more than a trace of gold or silver, and most of them are absolutely barren.

Several veins of this type are exposed at the contacts of monzonite-porphyry, or of felsite, and limestone in the Upper Magnolia, the Last Chance, and the Midnight Mine, which seem to have been opened mainly in the hope of finding ore in this position.

The one known exception to the statement that this type of vein is valueless is found in the Hidden Treasure mine on the eastern slope of Grayback Mountain. This vein is at the contact of limestone and monzonite-porphyry, is very ferruginous (hematite), and is fully three feet wide. A sample taken across the whole vein yielded $6.80 in gold and $.05 in silver per ton, and higher assays are said to have been obtained from other parts of the deposit. The country rock on each side of the vein was sampled, with the result that the hanging wall was found to contain a trace of gold, while the foot wall is barren.

Archaean-igneous contacts. While not as numerous as the last class, there are a number of these contacts in the western part of the area, but none were found to contain a trace of precious metals.

Illustrations of this type are to be seen in some abandoned adits on a felsite-gneiss contact on the hill north of Broncho Dan Gulch.

FAHLBANDS.

On the north side of Kennedy Gulch, an adit has been driven for one hundred and forty feet along a sheared zone of biotite schist, which is impregnated with limonite and calcite, and contains some plastic gouge, but not a trace of any valuable metal. While not a true fahlband, in that sulphides are absent, it is quite possible that these would appear at depth.

Of a similar nature are the copper impregnated amphibolite schists and gneisses on top of the small ridge northwest of the junction of Placer and Middle Creeks. Although heavily stained with malachite and containing numerous small particles of chalcopyrite, their copper content is too low to permit of profitable working, and they contain nothing else of value.

Copper stains are also present in the granite-gneiss on the southern exposure of the ridge between Kentucky Gulch and the small gulch to the southward.

FISSURE VEINS.

The exploration of igneous-sedimentary contacts has incidentally revealed a considerable number of fissure veins, many of which are barren, while some contain good ore. So far as is known, these fissure veins are present only in the Grayback Mountain region, but even there the outcrops are completely hidden under a thick cover of wash, and it is not unlikely that other veins, similarly concealed, exist elsewhere in the district. The distribution of the placer gold is, however, a convincing indication of the non-existence of precious metals in these possible veins.

Two distinct varieties of fissure veins are distinguishable: one steeply inclined and with oxidized filling, and another of blanket type containing sulphide ore.

The first are in general wider than the second, the maximum being about four feet, with a minimum of an inch or two. A sheeted zone is usually developed instead of one or two clean-cut fissures, slickensides show throughout the vein, gouge is often present along one wall, and the walls are sharply defined. The vein filling is thus largely fragments of country rock, much hydrated and softened and often iron stained.

In the breast of the adit of the Hidden Treasure Mine a four-foot sheared zone of this character is exposed. This contains only a trace of gold.

In the Homestake Tunnel there is a twelve-inch vein of this type which cuts the main tunnel and a cross-cut. This, together with a six-inch vein separated from the larger one by eighteen inches of barren rock, assayed $1.60 in gold and $.25 in silver per ton.

A vertical two-foot vein cutting monzonite-porphyry two hundred and fifty feet from the mouth of the Excelsior Tunnel is composed of very soft, somewhat calcareous material. This was sampled by panning and yielded several coarse colors to every pan.

Many other veins of this character were sampled, but all failed to give more than a trace of gold or silver, and most were shown to be absolutely barren.

The flat veins are not only narrower than those that are steeply inclined, but they are also decidedly less common. They are filled solidly with uncrystallized iron sulphide (FeS_2), which may be either marcasite or pyrite, the appearance suggesting the former. In some cases a single cleanly cut fissure without slickensiding, gouge, or other evidences of faulting is involved, while in other instances the forking of such a fissure has resulted in the formation of two closely contiguous veins. Occasionally small veinlets of the sulphide diverge from the larger vein, or form a network between two veins, but the wall rock is neither altered nor mineralized, and in every case shows a sharply defined junction with veins and veinlets. All these veins are marked by a noticeable uniformity of width.

The only deviation from the last mentioned statement that has been so far discovered was noted in a narrow streak exposed in the Upper Sunnyside Tunnel near the bottom of a winze connecting with the lower adit. At this point a pocket containing about a cubic yard of copper-stained galena was encountered. This yielded $22.00 in gold and $14.25 in silver to the ton, the percentage of lead being undetermined. This is the only reported occurrence of lead ore in the district. The silver content is unusual for this area, but is, of course, a common feature of lead ores.

Another interesting illustration of this type is shown in the Homestake Tunnel, where a one-half and a three-eighths-inch streak of sulphide are separated by two feet of limestone. It dips towards the west at a small angle. A sample taken from both veins contained gold and silver at the rate of $110.00 and $.35 per ton respectively, and the veinlet-pierced limestone between the two veins yielded $6.80 in gold and $.09 in silver per ton. The limestone below the lower and above the upper vein was sampled and proved to be barren. Basing the calculations on the above figures, it is seen that it is here possible to mine two feet of sulphide and limestone which would run better than $10.00 per ton.

At other points in this mine the vein just described traverses diorite instead of limestone, but its character and richness are unchanged.

A half-inch seam of this type exists in the Magnolia No. 1, but it was not sampled as it would be impossible to work such a streak at a profit unless it were phenomenally rich, and previous assays had proven that this is not the case.

Influence of the Wall Rock Upon the Veins.—So far as observed, the nature of the wall rock has no influence upon the size, appearance or richness of the included veins, one vein often traversing limestone, igneous rock and metamorphosed shale or other sediments without change in these respects.

Age and Genesis of the Fissure Veins.—The veins were observed to intersect all the varieties of the Carboniferous sediments excepting the felsite, and must therefore be younger than all these with the exception of the last, that is, Post-Eocene. No fissure veins in felsite were found, nor were any such veins truncated by felsite flows, so the relative age of the two could not be positively determined.

It seems certain that the two types of veins must have been formed in different manners and at different times, but no intersection of them and faulting of one by another was noted, so positive evidence of their relative age is also lacking. It seems possible, however, to fix the most probable age of at least one type by correlating it with other phenomena of known age.

The lack of all evidences of faulting in the flat veins points to a method of origin independent of orogenic movements, and we find such an agency ready at hand in the stresses that must have accompanied and followed the intrusion of the great masses of igneous rocks now found in the area—doubtless but a small part of those originally existing there. Just what the mechanics of the operation were is uncertain, but there is little doubt but that the fissures, perhaps originally vertical—the more common position, formed as an accompaniment of the intrusion and cooling of the magmas, and that the openings thus formed were subsequently filled with auriferous sulphide and small amounts of telluride, possibly brought upward from the still unsolidified rocks at greater depths. Pertinent to this point is the fact that the majority of the igneous rocks contain considerable quantities of primary sulphides. No attempt was made to detect gold in these rocks by any methods other than those used in ordinary assay operations.

The other type of veins is so evidently closely connected with mountain making movements that it is easy to place its age at either Post-Laramie or Post-Miocene, when such movements took place in this area. As to which of these epochs is the more probable, it is apparently impossible to say. The greater alteration of these veins as compared with the sulphide type may be due to greater age, but it may be, with equal probability, the result of their greater width and vertical position, which would permit of comparatively easy alteration by downward working surface water.

The positive solution of the problem must await the discovery of additional data, although a feature to be discussed later seems to point to Post-Miocene age as the most probable.

Enrichment With Depth.—Only the vertical, oxidized type of veins are of a nature favorable to the existence of secondarily concentrated deposits at depth, but the metals which often accumulate below the oxidized zone—copper, silver, lead and zinc—are rare or lacking here, so there is little probability that any material enrichment will be encountered below the present workings.

Mineralized Dikes.

Many of the igneous rocks of the district contain primary sulphide, as has been stated, and a few are so soft and hydrated as to indicate that they have been passageways for water. Several of those which appeared most promising were sampled and assayed, but proved to be barren.

Metamorphosed Bedded Deposits.

Under this head are included the iron mines, the geology of which has been discussed in another chapter of this bulletin.

The deposit, which averages perhaps six and one-half feet thick, has been found to contain (an average of four analyses) 53.78 per cent. of metallic iron and .931 per cent. of phosphorous.

In the Ainsworth or Star of the West mine a sample of a copper-stained streak two to six inches wide, and composed largely of calcite stained with iron oxide and copper carbonate, yielded assays of $9.92 in gold and $.08 in silver per ton.

A sample clear across the iron deposit yielded $2.90 in gold and $.10 in silver per ton, while similar samples from the Upper Star of the West and the iron vein above the Lucky Tunnel yielded $3.20 in gold and $.25 in silver, and $4.00 in gold and $.06 in silver per ton, respectively.

From this it may be seen that the whole iron deposit is gold bearing, but the low grade and peculiar character of the ore have combined to prevent its development as an ore of the precious metals. The large quantity available and its uniformly auriferous character should serve to stimulate experimentation with a view of using it as an ore of both iron and gold.

Miscellaneous Deposits.

Under this head may be placed the so-called "chimney" in the Mountain View Mine. The ore-shoot there is roughly funnel-shaped, with an elliptical horizontal cross-section. The stope from which ore has been removed is formed something like an old fashioned bee-hive, and measures thirty feet east and west, twenty-four feet north and south, and about forty feet high.

The ore body is a brecciated monzonite-porphyry, the fragments, which are several inches across in some cases, being cemented together by siderite and limonite, the latter carrying the gold. The whole mass runs somewhat better than $10.00 per ton in gold.

This deposit is at the intersection of two obliquely intersecting sheeted zones, which strike (magnetic bearings) approximately N. 74° W. and S. 26° E., respectively, the dips being 79° N. for the first and 86° S. for the second sheeted zone. Faulting along a large number of planes which intersect at an angle of about 48° has, perhaps, produced the brecciation which is more noticeable as the surface is approached, the lessened pressure and cohesion naturally tending to produce this result. Later, the gold bearing minerals, doubtless sulphides of iron, were deposited in the interstices between the fragments, probably from ascending solutions. Still later, descending surface water has oxidized the iron.

The richness of the deposit is said to decrease with depth, a condition which may be largely due to the smaller number of cracks and the consequent decrease in the proportion of limonite there found.

Conclusion.

Gold certainly exists in the region, but in most cases the deposits are either too limited or too low grade to be profitably worked; they must await improved and cheaper methods of mining and extraction before they can be handled to advantage. A few deposits might be worked now if milling and shipping conditions were more favorable or very small profits were acceptable.

Future activity should be confined to the Grayback Mountain region, as other portions of the area are almost certainly barren, and time expended upon them is practically sure to be wasted. The finding of larger or higher grade veins there is sufficiently within the bounds of possibility to make future search for them attractive, but the amount of work already done there without uncovering anything really attractive must tend to discourage such work.

The placer deposits are undoubtedly the chief immediate asset of the district, as they certainly contain large amounts of gold sufficiently concentrated to allow of profitable recovery, while at least along some of the streams conditions appear favorable for their development.

CHAPTER VIII.

MINES AND MINING PROCESSES.

By Arthur J. Hoskin.

The earliest knowledge of the presence of metals in this region was several years prior to 1875, when the Hayden Expedition traversed the southern part of Colorado. The report of that Survey makes mention of the recovery of gold from alluvials in Placer and Grayback Creeks. In those days of Indian outbreaks there was a government fort maintained at what is now the town of Fort Garland. The soldiers there stationed, it would appear, had knowledge of the values in the gravels mentioned and, for a time, a prominent bar or bench of this ground lying at the confluence of the two creeks was handled, in a very small way, for the recovery of gold. This piece of land is still known as "Officers' Bar." Later on the same ground was attacked by Chinamen, it is said, with very satisfying results.

Squatters were not, however, permitted to continue their operations very long, for in 1877 The Trinchera Estate authorities stopped all kinds of mining operations within its holdings. Up to this time the owners of the Estate had received no income from operations. Feeling that the ground was worthy of mineral development, it was deemed proper to devise methods whereby prospectors could locate and secure mining claims. Under certain restrictions, therefore, the domain was opened to location. These rules then inaugurated have undergone improvements until they now present features which are worthy of duplication by the Department of the Interior in disposing of the mineral lands of the National Public Domains.

Under the rules which now govern, the mining lands in The Trinchera Estate are open to location upon very much the same plan as prevails with similar lands upon the Public Domain. Lode claims are laid out 300 feet wide by 1,500 feet long. While there is no specific stated objection to the laying out of angular claims, a reference to the accompanying map will show that no lode claims have been laid out in such a form. This noticeable distinction prevails: a locator can claim only 1,500 feet of any vein or lode. When the claim is surveyed—and this part of the work is always performed by the Estate's engineers—so-called extensions are surveyed at each end of every lode location. These are retained by the Estate for subsequent sale or operation. Four such extensions have been sold.

Upon the completion of prescribed amounts of development work upon a lode claim, the claimant may request an official survey for patent. The engineer for the Estate performs the duties that correspond to those of the United States Surveyor-General; but, in addition, he has charge of the field work. This being the case, there are never any disagreements as to bearings and lengths of lines, nor any question as to overlapping claims. No apex controversies can ever arise. There are no excessive surveying fees possible. The disgusting delays due to "red tape" or to inefficient clerks—delays which nearly every mining man has experienced when patenting lands on Government Domain—are impossible in the Trinchera Estate.

Single placer locations are limited in size to 20 acres. The Estate retains no extensions of such claims. Locators may take up as many placer claims as they desire, and they may be contiguous or disconnected as desired. Locators may also file upon as many lode claims as they can develop, but these claims cannot, of course, lie end to end.

The Trinchera Estate, whose offices are in Colorado Springs, publishes a pamphlet detailing the Rules governing the Location and Purchase of Mining Claims, and copies may be had for the asking.

Upon the Map of the Mining Claims which accompanies this report, all patented claims are designated by either initials or their official survey numbers. Below are given the names of all claims so labeled.

Prior to the adoption of the present scheme of allotting and selling mineral rights, the few claims which were patented were designated merely by their location names. These claims are given upon the map by Initials, as follows:

H. T. Hidden Treasure.
HS. Homestake.
L. C. Last Chance.
M. Magnolia.
S. W. Star of the West.
SS. Sunnyside.

These pioneer claims are all located upon Grayback Mountain, in Section 18, Township 28 South, Range 70 West.

The other patented claims in this region all bear survey numbers, as follows:

Sur. No.	Name.	Sec.	Town.	Range.
4A	Badger State No. 1 Placer	26	28	71
5A	Badger State No. 2 Placer	26	28	71
6A	Badger State No. 3 Placer	25	28	71
7A	Badger State No. 4 Placer	36	28	71
8A	Badger State No. 5 Placer	36	28	71
10	Virtue	18	28	70
11	Excelsior	18	28	70
12	Double Standard	18	28	70
13	Rock and Rye	18	28	70
14	Magie E.	18	28	70
15	Golden Age	18	28	70
17	Climax	13	28	71
18	Monte Christo	25	28	71
20	Snow Flake	25	28	71
21	X. T. C.	36	28	71
22A	Otero No. 1 Placer	36	28	71
23A	Otero No. 2 Placer	1	29	71
24	Gold Bug	18	28	70
26	John Moore	13	28	71
27	Lucky	13	28	71
31	Mountain Pink	18	28	70
38	Star of the West No. 2	18	28	70
39	Climax No. 2	13	28	71
40	Midnight	18	28	70
44	Red Bird	18	28	70
45	Dewey	13	28	71
53	Copper King	7	28	70
54	Gertrude	7	28	70
55	Clorine	7	28	70
56	Mamarth	7	28	70
57	Last Chance No. 2	7	28	70
61	Millie G.	7	28	70
58	Copper	13	28	71
59	Pride of the West	18	28	70
60	Lucky Guss	7	28	70
63	Midnight No. 2	13	28	71
66	Barbara W.	7	28	70
67	Barbara W. No. 2	18	28	70
69	Midnight No. 3	18	28	70

Sur. No.	Name.	Sec.	Town.	Range.
71	Blue Bell	13	28	71
73	Independence No. 3	18	28	70
74	Lone Star of the West	26	28	71
83	Mountain View No. 1	18	28	70
84	Mountain View No. 2	18	28	70
85	Mountain View No. 3	18	28	70
88	Snow Drift	13	28	71
89	Lizzie G. No. 1	7	28	70
90	Lizzie G. No. 2	7	28	70
91	Lizzie G.	7	28	70
92	Paul H.	12	28	71
93	Daisy	12	28	71
101	Merrimac	18	28	70
105	Mountain View No. 4	18	28	70
113	Rossville No. 1	7	28	70
114	Rossville No. 2	7	28	70
115	Rossville No. 3	7	28	70
118	McPherson	12	28	71
119	Wishbone	18	28	70
120	Gilt Edge	18	28	70
124	Sunday No. 1	18	28	70
125	Sunday No. 2	18	28	70
126	Hub Hall	35	28	71
128	Russell No. 1	1	29	71
131	Rico	36	28	71
132	Blue Jay	36	28	71
133	Rico No. 1	36	28	71
134A	Alpha No. 1 Placer	36	28	71
135A	Alpha No. 2 Placer	36	28	71
136A	Omega No. 1 Placer	25	28	71
137A	Omega No. 2 Placer	25	28	71
138A	Beta No. 1 Placer	25	28	71
139A	Beta No. 2 Placer	25	28	71
140A	Denver Placer No. 1	26	28	71
141A	Denver Placer No. 2	26	28	71
142A	Denver Placer No. 3	26	28	71
143A	Denver Placer No. 4	26	28	71
144A	Denver Placer No. 5	23	28	71
145A	Denver Placer No. 6	36	28	71
146A	Denver Placer No. 7	1	29	71
147A	Denver Placer No. 8	1	29	71

Sur. No.	Name.	Sec.	Town.	Range.
151A	Eldorado No. 1 Placer..........	24	28	71
152A	Eldorado No. 2 Placer..........	13	28	71
153A	Lucky Seven Placer............	24	28	71
154A	Lucky Seven No. 2 Placer.......	23	28	71

Omissions in the numerical series are readily accounted for when it is remembered that the region under description is but a portion of the entire Trinchera Estate throughout which this system of numbering prevails.

The map shows, also, a number of claims bearing no labels. These are placers as well as lodes, and are held as locations, only. The placers can be distinguished from the lodes by the greater extents. No attempt is here made to give the names of these claims, since many of them will probably never complete the deeded title.

The lode claims which appear upon the map with broken boundary lines are so-called extensions. These claims are retained by the Trinchera Estate, and they effectually preclude any locator from obtaining more lode length than will be contained between his two ends, or practically, in all cases, about 1,500 feet. Should the development by an owner of a patented claim prove a worthy lode, the Estate receives a certain benefit in the shape of its possession of the lode's continuation, as is discussed elsewhere.

Some of the very early patented claims were allowed to be but 1,000 feet in length, the company retaining 500 feet at one end as its extension. This applies to the Last Chance, the extension of which is designated upon the map, L. C. Ex.

Gold Placers.

The washing of alluvials for gold has been, as already stated, one of the features of mining in this region for years, and promises to be a very prominent industry in the future of this country.

In 1898 The Badger State Placer Mining Company built the large steam shovel and gold-saving structure shown in Plate VIII, A. This machine, pretentious in its day, was intended to handle 1,000 to 2,000 cubic yards of gravel per day. There was little knowledge derivable from experience in such matters at that time, so it is little wonder that unforeseen defects in mechanical construction and gold-saving apparatus prevented continuous and successful operation of this machine.

The steam shovel, of dipper type, discharged each load into a revolving screen. Here the gravel was disintegrated and washed by jets of water, the undersize being conducted thence through a riffled sluice three feet wide and thirty feet long. As the shovel brought up about one cubic yard at a time, the apparatus would one moment be congested with the dirt, while a few moments later the screen and sluice would be running empty. Even under such conditions it is reported that this device treated about 2,700 cubic yards, from which was obtained an average yield of 24.6 cents per yard. The dirt averaged about 18 feet in depth. Naturally, in face of the inexperience of the operators and the shortcomings of the machine, the costs of operation were in excess of the recovery, and the closing down followed.

Iron Mining.

The most extensive mining operations ever conducted in this region were those of the early eighties, which were carried on by The Colorado Coal & Iron Company, the present Colorado Fuel & Iron Company. This company developed what was then called the Placer Mine, in some of its records, because of its location near the town of Placer, now changed to the town of Russell.

Operations were upon The Upper Star of the West claim, near the top of Grayback Mountain (see Plate VIII, B.). So extensive were the intended operations that the Denver & Rio Grande Railroad constructed a spur about two miles long from its line at the mouth of Sangre de Cristo Creek north along Placer Creek to the mouth of Grayback Gulch. The track continued up this gulch some two miles further, but the work of haulage on this section was performed by mules, the grade being too great for locomotives. The terminus of this road was directly down the mountain-side from the mine openings, and a gravity double-track tramway 1,566 feet long laid on a slope of 30°, conveyed the ore down to the loading bins in the gulch. The writer has endeavored to secure some pictures of this old system, which might have been taken years ago, but has not succeeded in finding any. Many relics of this transportation and haulage system remain in the shapes of graded roadbeds, rotted ties, rusty spikes here and there, and the ruins of the sheave and brake wheel at the mouth of the mine.

Mr. J. A. Writer, the Auditor of the Colorado Fuel & Iron Company, has informed the author of this report as to the pro-

SLUICING IN GIANT GULCH

THE LAST CHANCE PLACER, IN UPPER GRAYBACK GULCH duction made by this mine. He finds from old records that for the first two years, that is, from July, 1881, to July, 1883, the shipments amounted to 14,725 tons. Beyond the last date, records are not at hand. Royalties upon all shipments were paid to The Trinchera Estate. Mr. E. C. Van Diest, now Mineral Manager of the Estate, is of the opinion that the production must have been several times the tonnage stated above. The general statement of residents of the district is that no mining was done in this mine later than 1883. The extent of the underground chambers still remaining open to inspection would not seemingly have produced amounts greatly in excess of those reported by Mr. Writer; and, assuming that the mine did operate a few months later than July, 1883, it is safe to set the probable production from The Star of the West at a maximum limit of 20,000 tons.

The ore in this mine existed as a replacement of limestone. It was quite regular as to thickness, and had very smooth roof and floor. The accompanying photograph (Plate VIII, B.) gives an idea of this deposit, although the lapse of time has made it impossible to get views that show precise conditions that prevailed at the time of working. This picture of the upper workings shows plainly how close to the surface the ore was found. Above the upper workings the iron deposit may be traced to the top of the mountain where it is seen to abut against an east-west wall of limestone. The limestone measures have a strike which is also nearly east-west, and their dip is about 35° to the south.

The head of the incline already described was located at the portal of an adit which was driven N. 60° E. to develop the iron ore body one hundred feet below the lowest of the surface openings. This adit penetrated a very hard limestone, and must have been very expensive development work. At about 200 feet in from the mouth a right-angled turn to the right carried the adit some 50 feet farther where the iron body was reached and an upraise was made to connect with the open workings above. Most of the mine's production was delivered through this set of passageways to the ore bins at the portal. At about the elevation of the tunnel, the ore changed its character, objectionable sulphides occurring with the oxides which outcrop. No mining was ever done below the adit's level.

The stopes resemble open, sloping caves about 6 to 7 feet high. The roof and floor are of hard limestone, and no trouble was experienced with swelling or crumbling, so that the use of simple stulls has sufficed to keep the spaces open, even to the present time, or more than a quarter of a century. The ore was easily mined, and the writer is credibly informed that the total costs of mining and delivering the ore to the bins in the gulch at the foot of the incline did not exceed 50 cents per ton. Upon the dump at the mouth of the adit, specimens of the shipments made years ago may now be found. The iron occurred in the forms of hematite and magnetite. Specimens showing various stages of alteration of sulphides into the oxides are obtainable, and these show why operations were discontinued. It is reported that large samples of the ore taken from a copper-stained streak along the roof have run $2 per ton in gold and silver. Samples may now be taken which will assay better than this, but it is questionable if large shipments of this auriferous material could be produced.

This old mine is commonly spoken of now as the "Iron Mine."

From a point on the east side of Grayback Gulch, within the area of the Lucky claim (Sur. No. 26), an extensive and expensive adit has been run due easterly. This bore passes into the ground of the John Moore claim (Sur. No. 27), and was driven to penetrate the great iron deposit opened in the contiguous Star of the West claim. The bore was pushed through an exceedingly hard, dense, black rock (probably a metamorphosed shale) for about 450 feet. It is reasonable to assume that this driving was not done at a cost of less than $18 to $20 per linear foot. This is an instance of misguided effort. The perseverance which carried on this trying project would have been deserving of success if this commendable quality had been founded upon rational premises.

There are several adits a few hundreds of feet higher up the slope of Grayback Mountain from the Lucky Tunnel just described. These were successful in that they disclosed a deposit of hematite. These old, crooked workings are in bad condition, and an inspection of them entailed physical risks from falling ground, rotten timbering, bad air and treacherous sumps. At one stope it was possible to obtain a few data which tended to show that this ore occurred in a vein formation rather than as a replacement conforming with strata of the limestone. This stope showed that the extracted ore-shoot must have been some four feet thick, but the treacherous and already caved ground precluded any other measurements.

Upon the surface above this last set of chambers there is a pronounced depression, which has evidently resulted from the collapse of the ground. This depression is of a shape indicating the excavation of a tabular mass of ground. This point adds presumption to the existence of a vein, or some kind of elongated, thin ore body.

Discoveries of Metal Other Than Iron.

The region under consideration lies chiefly in sedimentary horizons. A pronounced, steeply dipping contact plane lying about three-quarters of a mile to the northeast of the town of Russell marks the limit of the Archean rocks in that direction. This contact has been recognized by prospectors, and two shafts have been sunk along it. The more southerly of these shafts is that of the Russell No. 1 claim (Sur. No. 128). This prospect opening is about 40 feet deep. The upper half is plumb, but the lower half follows on the dip of the strata, which here amounts to 75° to the northeast. The strike of the contact between the igneous and sedimentary rocks is approximately N. 20° W. The shaft does not actually expose the granite, but is rather within shales and grits a very short distance from the contact. The ore—if such it may be called—is about 12 inches thick, and is merely highly altered shale containing some slight amounts of metallic minerals, and conforms with the bedding.

The owners, though eventually disappointed, prosecuted their work of prospecting in a workmanlike manner, as is evidenced by the neat timbering.

A fifty-foot shaft has been sunk along the exact line of this same Archean-Carboniferous contact, in the Blue Jay claim (Sur. No. 132). This is the second opening to which allusion was made above, and it lies about 3,000 feet N. 20° W. from the Russell No. 1 shaft. Here the ore, or the material resembling ore, is really a very dark, somewhat altered grit, carrying small amounts of silver and copper. Here, as at the majority of prospect holes in the region, the work has been desultory.

Upon the western slopes of Grayback Mountain, and especially well up in Buckskin Gulch (which separates Grayback and Buckskin Mountains), a great deal of poorly directed prospecting has been performed. It would probably be stating the conditions too strongly to say that all of this work has been done in a haphazard fashion, for there are some prospect holes which have been warranted, at least so far as opening into solid formations is concerned. Usually the criticism, that the work was continued irrationally, will apply.

In the photograph of Grayback Mountain (Plate VII, B.), the cabins and dumps at several of these prospects are shown. This view is a southerly one, looking across Buckskin Gulch. The Star of the West—the Iron Mine—is around the right-hand side of the mountain at about the elevation of, or slightly above the dump of the Excelsior shown at 2. There are two adits upon this Excelsior claim (Sur. No. 11). No shipments have ever issued from this property. Low silver values are said to have been returned from samples of decomposed limestone taken in the lower adit. This adit runs in S. 50° E., and at 250 feet it discloses the vertical vein.

Just a short distance south of the Excelsior workings there is an incline whose dump is not shown in the photograph. This opening is upon the Last Chance claim. This discovery hole has a dip of 45°, and is along a body of iron ore somewhat resembling that in the Star of the West. The strike is east-west. Iron ore was not sought in the sinking of this discovery, and as no appreciable values in other metals were found in the hematite, the work of development has ceased. There is some reason to believe this ore body was genetically associated with that of the Star of the West, but this is not a place to enter into a discussion of the geology.

The Homestake tunnel, shown at 5, has been driven through a dike or sheet of diorite into blue limestone. Both rocks contain extensive, nearly flat, shear planes; and at places these crevices have permitted the blasting of the rocks to a naturally smooth roof. These cleavage fissures contain seams—not over one-half inch thick—of marcasite, which is found to yield high assay returns in gold and silver. At 525 feet from the portal a crooked lateral leads off to the east upon a grade conforming with the rise of one of these marcasite seams mentioned above. Despite the rich character of this seam, this work was unwarranted, for the output could never equal in value the expense of the development.

The main adit is driven in S. 40° E. for 700 feet, where it forks upon encountering a two-foot vein striking northeast and pitching southeast. The stuff in this vein is too lean to extract.

This set of workings passes from the Homestake claim into the Sunnyside claim, and was intended for mutual development. The tunnel opening from the Sunnyside surface (1) pierces the same two-foot vein found at the breast of the Homestake tunnel mentioned above. This Sunnyside adit has a course of S. 40° E., and is in 125 feet. The vein was too low-grade to warrant drifting upon it. The adit, after passing this worthless vein, was deflected to the southwest by a crooked drift some 80 feet in length, and again reached and followed the vein. A small lot of the material lies sacked in the shop at the mouth of the adit awaiting a deferred shipment. It is unlikely that this iron-stained, decomposed diorite will yield satisfactory results.

A few feet above and to the east of the portal of this last adit there is a shallow shaft connecting through a circuitous chain of drifts and stopes with the main workings of the adit. Near the base of this shaft there was extracted a small pocket—less than a cubic yard—of copper-stained galena. Specimens of this material may still be excavated. This is the only reported occurrence of lead ore in this mountain, and search failed to uncover any more of it, even in this set of workings.

The dumps at the portals of the adits on the Magnolia claim are shown at 3 and 4. The upper tunnel runs due east following a soft, eighteen-inch vein, which lies between walls of limestone and porphyry. This prospect work seemed rational, but it was continued too far. Nothing of value was uncovered. The lower tunnel, but a few feet from the upper, followed an entirely different and not so strong a vein.

The Hidden Treasure claim crosses the saddle of the mountain to the north of Grayback Mountain. A shaft has been sunk right on this ridge, on a contact between limestone and porphyry. The dip of this contact is 50° south, and the strike is east-west. A hematite deposit 30 to 36 inches in thickness has been deposited here, and it is found to run about $7 in gold. An adit has been driven toward this ore from the eastern side of the saddle near the head of Willow Gulch. Its course is S. 60° W. 153 feet; thence West 35 feet through a porphyry mass containing many thin seams of pyrite and hematite. At the breast there is an attractive but valueless sheared zone about 4 feet thick. Here a 35-foot winze was sunk vertically in this zone, and a 50-foot drift was driven from the bottom north along it. It has not yielded sufficient results to warrant further development.

The Mountain View group of claims (Surs. Nos. 83, 84, 85 and 105) lies in Stearns Gulch to the east of Grayback Mountain. Here may be seen the most pretentious surface and underground equipments in the district. In one building there are housed the following:

Ore bins, 2 Hendrie & Bolthoff automatic feeders, 2 Denver Engineering Works 5-stamp batteries, 2 amalgamation plates, 1 Pierce amalgamator, 1 Wilfley table, 1 American Well Works compressor (10″x12″ steam and 8″x12″ air), 1 Reliable 10″x12″ engine, belted to stamp shaft, 1 Sinclair drill sharpener, 1 16-foot return-tubular boiler, and carpenter's and machinist's benches.

Across the gulch from this mill building are the cabins occupied by the employes of the company, an incorporation.

An extension tunnel has been driven as follows: S. 60° W. 409 ft.; thence N. 65° W. 170 ft.; thence S. 65° W. 130 ft. From the first angle above, a branch runs S. 30° E. 54 ft.; thence S. 40° E. 35 ft.; thence S. 10° E. 30 ft.

At several points along these branches short drifts have been pushed in search of ore shoots. All drilling has been done with Sinclair drills. The greater part of this tunneling has been performed in a very hard, ringing, blue shale. In the second course of the left-hand branch the bore enters a light-colored, hard rock, whose texture is so fine that it resembles a very fine grit or a quartz-porphyry, despite the genetic differences in such rocks. These expensive workings were pushed blindly for the purpose of developing a peculiar ore body disclosed a few hundreds of feet up the mountain side.

At this upper point a shallow shaft and a short adit have opened up an interesting mass of brecciated porphyry. This body has been locally, though erroneously, called a "chimney." The excavation has produced a space resembling, in shape and size, a large bee-hive coke oven. From this stope a considerable tonnage must have been removed.

The fragments of porphyry are cemented together by iron oxides which carry a small content of gold. It was upon the showing in this one small stope that the sanguine owners erected the milling plant. The writer was informed by a gentleman in charge of operations here that a trial run of 6 tons put through the mill cleaned up $62. This mill now stands as but one of the many monuments throughout the world erected to men's credulity in matters pertaining to mining. Not only was this mill prematurely erected, but very poor engineering sense was exercised in permitting the tunnel to entirely miss its objective.

Generalites.

There are the following general features concerning this portion of The Trinchera Estate, which are of interest to the ordinary mining man.

The climate is very mild the year round. The winters are less rigorous than in most of the other Colorado mining districts. This area is well protected upon three sides by high mountains, Sierra Blanca being the highest peak in the state. The latitude is in favor of the climate, and operations of lode mining could continue without interruption from inclement weather. With the new installation of dredging on the placers, there is reason to expect continuous operations on the alluvials, summer and winter.

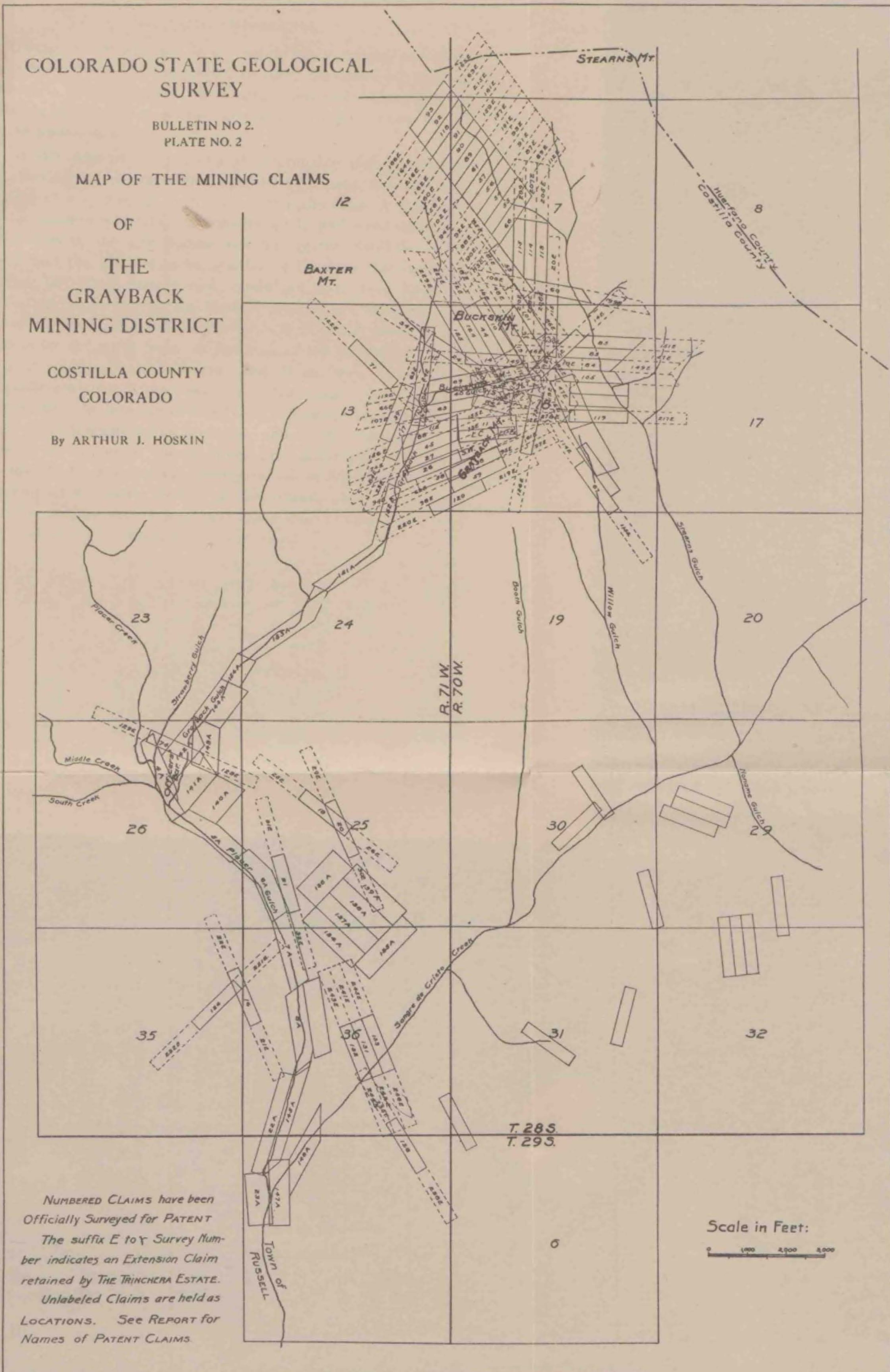
There is an abundance of fine water suitable for hydraulicking in the gulches (with the exception of Willow Gulch), and for milling purposes. Local treatment of ores would be possible.

Timbers for mining purposes are in abundance upon the mining claims, or they may be cheaply obtained from nearby points. These mountains have not been devastated of their forests as have the mountains in many mining districts.

Should smelting ores be produced, they can be easily marketed over the Denver & Rio Grande Railroad to Pueblo, or other smelting centers. The freight rates which have been paid in recent years upon a few shipments from Russell to Pueblo have averaged about $3 per ton.

The extensive coal fields just a few miles to the east of this Estate, in Huerfano County, assure a cheap fuel supply.

The writer desires to here acknowledge and to express his appreciation of the valuable information extended him by Mr. E. C. Van Diest, Mineral Manager of The Trinchera Estate; Mr. J. A. Writer, Auditor of the Colorado Fuel & Iron Company, and by Mr. Richard H. Hart, attorney for the same company.


COLORADO STATE GEOLOGICAL SURVEY
BULLETIN NO 2.
PLATE NO. 2
MAP OF THE MINING CLAIMS
OF
THE
GRAYBACK
MINING DISTRICT
COSTILLA COUNTY
COLORADO
By ARTHUR J. HOSKIN
STEARNS MT.
BAXTER MT.
BUCKSKIN MT.
GRAYBACK MT.
Huerfano County
Costilla County
Stearns Gulch
Boom Gulch
Willow Gulch
Placer Creek
Strawberry Gulch
Grayback Gulch
Middle Creek
South Creek
6A Placer
6A Gulch
Sangre de Cristo Creek
Noname Gulch
R. 71 W.
R. 70 W.
T. 28 S.
T. 29 S.
Town of RUSSELL
12
7
8
13
18
17
23
24
19
20
26
25
30
29
35
36
31
32
6
NUMBERED CLAIMS have been Officially Surveyed for PATENT
The suffix E to Survey Number indicates an Extension Claim retained by THE TRINCHERA ESTATE.
Unlabeled Claims are held as LOCATIONS. See REPORT for Names of PATENT CLAIMS.
Scale in Feet:
0
1,000
2,000
3,000

CHAPTER IX.

OROGRAPHIC MOVEMENTS AND BIBLIOGRAPHY.

Orographic Movements.

Owing to the absence of all sedimentary formations above the carboniferous it is impossible to trace the mountain-forming movements from a study of the limited area under investigation, but from a knowledge of the surrounding region these events may be understood.

At the close of the Laramie it is probable that the Sangre de Cristo Range, of which this area forms a part, was the eastern edge of a low lying continent. After the close of the Laramie the mountain-forming movements set in and were continued at intervals in the late Eocene and during the Neocene. It is known that the igneous rocks, similar to those in the Grayback District, but lying further east, could not have been intruded until after the middle of the Eocene, as they are shown to cut beds of the early and middle Eocene. It is quite possible that the eruptive activities began at the time of the orographic movements of middle or late Eocene, and, if so, they must have materially assisted in the elevation of the range. It is certain, however, that in late Eocene and early Neocene very extensive eruptions of igneous rocks occurred, and at the same time the deeper lying intrusive sheets, dikes and laccoliths must have been intruded. The present configuration of the mountains is the result of extensive erosion of the surface eruptives and of the thick sedimentary series that doubtless originally buried these igneous rocks thousands of feet deep.

It is more than possible that faulting of the rocks may have had some effect in the present configuration of the mountains, but there appears to be no evidence that fault movements have been very great. A number of faults have been observed at or near the contact of igneous with sedimentary rocks, or entirely within the igneous rocks and a few cases of apparently minor faults within the sedimentary beds, at some distance from the contact with igneous rocks, have been observed. It is almost certain, too, that the pressing in of so much igneous material must have resulted in more or less movement of the older rocks that would result in faulting or slipping one on the other, especially along the bedding planes. But in the absence of very extensive faults such minor slippings, no matter how numerous, would not produce any marked effect on the configuration of the topography.

Bibliography.

The following listed papers bear either directly or indirectly on the geology or history of the Grayback Mining District, and will be of service to those who may wish to look further into the subject:

Endlich, F. M.—

Ann. Rep. U. S. Geol. Sur. of the Territories for the year 1873; pp. 323-335.

The same, for the year 1875; pp. 108-122.

Girty, G. H.—

Carboniferous Formations and Faunas of Colorado. U. S. Geol. Sur., Professional Paper 16.

Hall, Frank—

History of Colorado, Vol. III.

Hills, R. C.—

U. S. Geol. Sur., Geol. Atlas, Folio 68. On the Walsenburg Quadrangle.

U. S. Geol. Sur., Geol. Atlas, Folio 71. On the Spanish Peaks Quadrangle.

Preliminary Notes on the Eruptions of the Spanish Peaks Region. Colo. Sci. Soc. Proc., Vol. 3, pp. 24-34.

Recently Described Tertiary Beds of the Huerfano Basin, Colorado. Colo. Sci. Soc. Proc., Vol. 3, pp. 148-164.

Additional Notes on the Huerfano Beds. Colo. Sci. Soc. Proc., Vol. 3, pp. 217-223.

Additional Notes on the Eruptions of the Spanish Peaks Region. Colo. Sci. Soc. Proc., Vol. 3, pp. 224-227.

Lee, W. F.—

Carboniferous of the Sangre de Cristo Range. Jour. Geol., Vol. 10, pp. 393-396.

Putnam, B. T.—

Iron Ores West of the 100th Meridian. Tenth Census Report on Mining Industries, Vol. 15, pp. 477-480.

Rolker, C. M.—
Notes on Certain Iron Ore Deposits of Colorado. A. I. M. E. Trans., Vol 14, pp. 266-273.
Stevenson, J. J.—
U. S. Geogr. Sur. West. of the 100th Mer., 1875, Vol. 3, Pt. 4, pp. 303-503.
Van Diest, E. C. and P. H.—
Geology of the Sangre de Cristo Range. Colo. Sci. Soc. Proc., Vol. 5, pp. 76-80.

INDEX

Page.

W.