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R. D. GEORGE, State Geologist

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GEOLOGY AND ORE DEPOSITS

OF THE

PLATORO-SUMMITVILLE MINING DISTRICT

COLORADO

By
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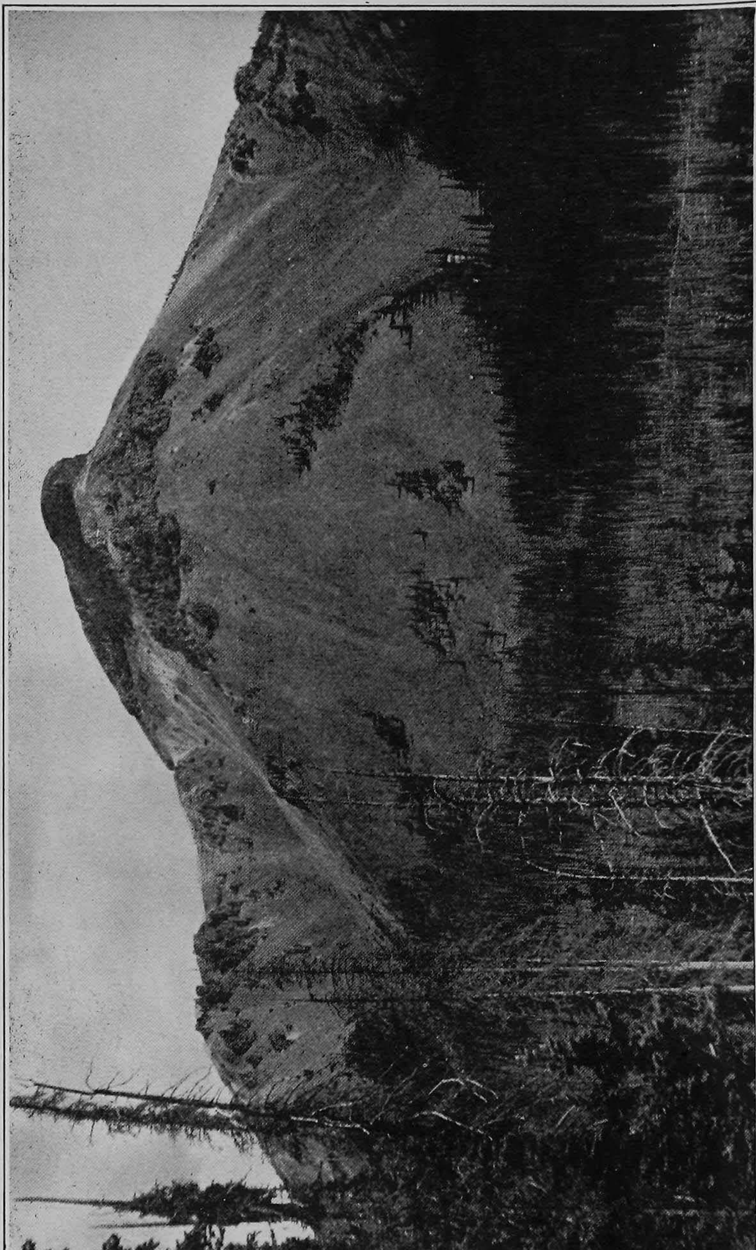

Lookout Mountain as seen from the southwest.

GEOLOGICAL BOARD.

LETTER OF TRANSMITTAL.

State Geological Survey,
University of Colorado, Jan. 26, 1918.

Governor Julius C. Gunter, Chairman, and Members of the Advisory Board of the State Geological Survey,

GENTLEMEN: I have the honor to transmit herewith Bulletin 13 of the Colorado Geological Survey.

Very respectfully,

R. D. GEORGE,
State Geologist.

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Geology and Ore-Deposits of the Platoro-Summitville Mining District, Colorado

CHAPTER I

INTRODUCTION

LOCATION AND EXTENT

The district covered by this Bulletin is located in the mountainous region that forms the southeasterly extension of the San Juan Mountains and at or near the head waters of the Alamosa and Conejos rivers. It lies in the southern part of Rio Grande county and in the northern part of Conejos county, the county line running a little north of the center of the mapped area, and is approximately forty miles west of Alamosa, the business center of the San Luis valley. It forms a small part of the Rio Grande National Forest. The area covered is something over fifty square miles.

Four mining camps lie within the district under consideration. These are Platoro, Summitville, Stunner, and Jasper. Platoro, situated on the Conejos river, lies in the southeast corner; Summitville in the extreme northwest, and Jasper in the extreme northeast corners of the mapped area. About midway between Platoro and Summitville is Stunner, located on the Alamosa river. All of these camps have been the scene of considerable prospecting and development work in the years past, and a number of mines of considerable extent have been opened, but only in the Summitville district have extensive shipments of ore occurred.

The district is difficult of access, because of its remoteness from the railroad and because of the difficult mountain roads that must be traveled. The nearest railway point to Summitville is Del Norte, which lies to the northwest twenty-eight miles by wagon road. For the first twelve miles out of Del Norte this road is in good condition and follows a very easy grade up the Pinos creek valley. From this point on, the grade is in places very steep and the road often in bad condition.

Jasper and Stunner both lie in the Alamosa valley and are easily accessible in good weather by means of the state road that runs from Alamosa and from Monte Vista, and that follows the course of the Alamosa river. By this road Stunner is approximately forty miles from Monte Vista and some six or seven miles further from Alamosa. To reach Platoro three roads are possible: first, up the Conejos river from Antonito; second, from Stunner over a six-hundred-foot divide; third, over the ridge running southeast from Cornwall mountain and joining the state road in the Alamosa valley. In the summer of 1915 the Conejos valley road was impassible and the two other roads nearly so, because of lack of repair.

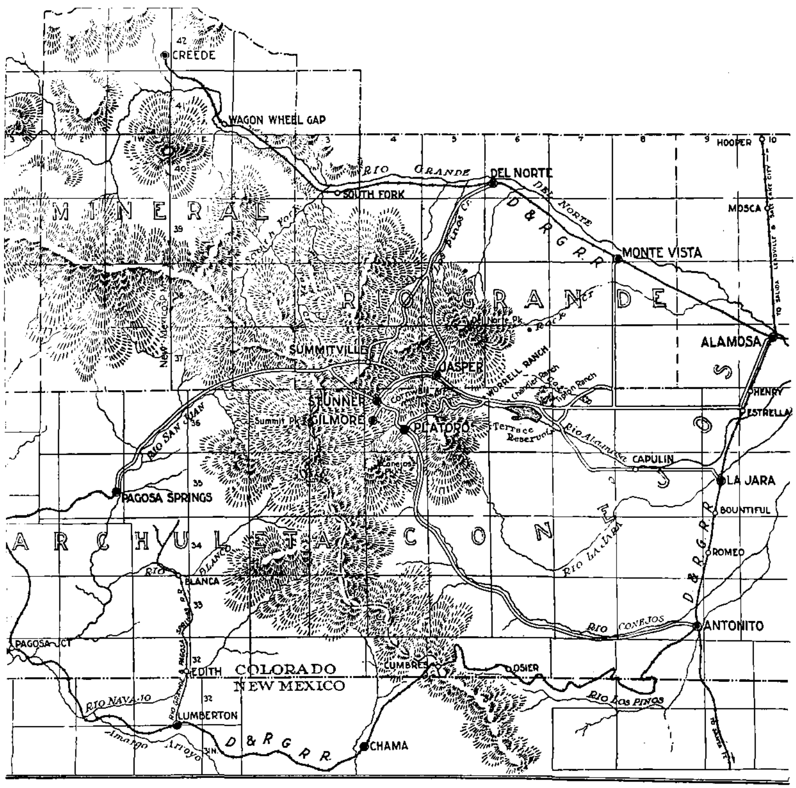

Fig. 1. Map showing the location of the Platoro-Summitville district.

GEOGRAPHIC DESCRIPTION

The section covered by this survey is confined to a fairly rugged mountainous area of great variety and of unusual beauty. Heavy forests cover a large part, but these are in places devastated by fire. The two highest peaks in this mountain range, namely Conejos Peak and Summit Peak, are plainly visible from any high point, but are not included in the area investigated. Both of these peaks rise to elevations of over thirteen thousand feet. The highest elevation within the boundaries of the area investigated is Cropsy Peak, a sharp-pointed, conspicuous summit a mile and a half south of Summitville, rising to a height of 12,557 feet. Other summits of somewhat less elevation are South Mountain, immediately south of Summitville and containing the ore deposits of that camp; Lookout Mountain, overlooking the Alamosa valley at Stunner, and Cornwall Mountain, a very broad, round-topped mountain that rises very precipitously on the south side of the Alamosa valley at Jasper. The lowest point is to be found at Jasper, and is a little under 9,200 feet in elevation. The extremes of elevation are about 3,400 feet.

As timber line is to be found at approximately 12,000 feet, the higher summits rise several hundred feet above this line and are bare of trees. This is conspicuously evident in case of the great dome-like top of Cornwall Mountain, whose bald upper slopes make a very prominent feature in the landscape as viewed from distant points.

This region is very well watered, as evidenced by the numerous running streams that endure through the summer and by the extensive snowdrifts that are to be seen on the higher summits and that do not melt away much before the storms of the autumn bring fresh snow supplies. The two principal streams, the Alamosa and Conejos rivers, have their sources at some distance south of the boundaries of this area and flow in deeply intrenched valleys above which the mountain slopes rise with unusual steepness to elevations above the valley bottoms of one thousand to twenty-five hundred feet. The Alamosa valley, two or three miles above Jasper, presents a superb display of wild and rugged mountain scenery such as is seldom excelled. The entire Alamosa valley from a point several miles below Jasper to and beyond the southern limits of the mapped area is, in fact, wonderfully attractive from a scenic point of view, and combines rugged topography with great beauty.

The state road passes up this valley as far as Stunner and then turns to the west and climbs up the valley of Iron creek along the southern base of Lookout Mountain.

A most beautiful and striking feature of the landscape in certain portions of the territory is the brilliant red, yellow and brown coloring of the mountain slopes that are nowhere more pronounced than on the southern slope of Lookout Mountain, along which the state road passes. The significance and origin of these red-painted rock formations is discussed elsewhere in these pages.

In the region between Platoro and Stunner, more especially south of Big Lilly lake, traveling on foot is rendered difficult and, on horseback, practically impossible over extensive areas because of down-timber, caused by both fire and wind. The same is true of other more or less extensive areas in different parts of the district.

The climate of the Platoro-Summitville district is like that of other high mountain areas in southern Colorado. In midsummer there is no more delightful climate than that found at and below timber line. The nights are usually cold and bracing and the days are often surprisingly warm, but not oppressive. The winters are necessarily severe and the precipitation of snow heavy.

ORGANIZATION OF PARTY

The topographic and geologic mapping of the Platoro-Summitville district was carried out in the main during a period of eight weeks in the summer of 1913. The work was done under the direction of the writer by a party from the Colorado School of Mines. This party consisted of thirteen students, who worked under the supervision and with the co-operation of Professor Carl A. Allen, Mr. I. I. Taylor, and Professor Charles E. Smith. The first of the above-named parties were at the time members of the faculty of the School of Mines, and the last-named had until very recently occupied the position of assistant professor of geology at the same institution. Mr. Taylor had charge of the topographic mapping. For the first month Professor Allen remained with the party and was jointly responsible with Mr. Taylor for the topographic work. During the second month his place was taken by Professor Smith, who, in addition to the topographic work, rendered some assistance in mapping the geological formations.

The following students were engaged in this work: Armistead F. Carper, Dah-Chun Cheng, Louis F. Clark, Edward W. Cowper-

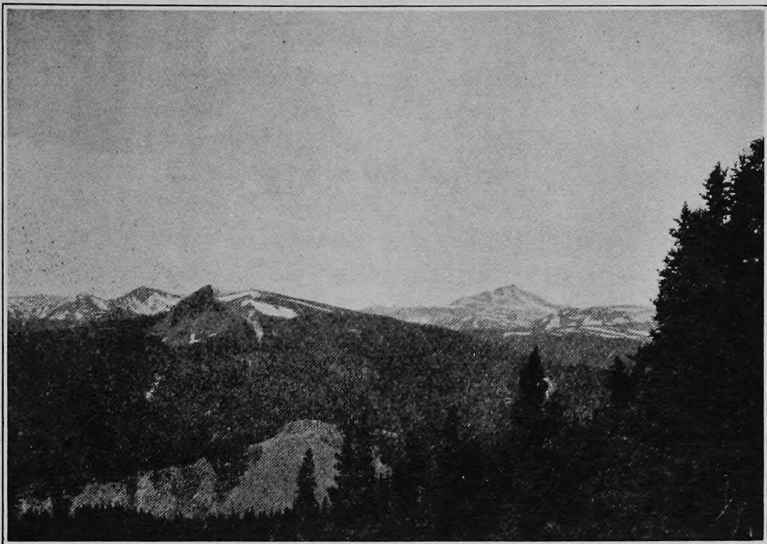

Fig. 1. View of the Summit Peak range, taken from near Cropsy Peak. The sharp-pointed rocky summit in the left middle view is Sheep's Head. Prospect Mountain is immediately back of it.

Fig. 2. Conejos Peak, taken from Cropsy Peak.

thwaite, Thomas T. Gow, Charles W. Hammen, Wallace H. Hayden, Merritt Hutton, Ralph W. Smith, Joe H. Woolf, Charles Ert Wuensch, W. T. Yang, and William G. Zulch.

As to the geological work, owing to the great difficulty of getting reliable mapping in a district of igneous rocks, especially where extensive alteration and strong original resemblances are the rule, it was not to be expected that this could be satisfactorily carried out by inexperienced observers. Only to a very slight extent, therefore, has the writer found it advisable to accept the conclusions of the other members of the party, but has himself gone over the ground.

DEGREE OF ACCURACY

As to the topographic map, claim cannot be made for very great accuracy. The difficulties involved, both in the triangulation and in the contouring, were unusually great, so that time could not be given for very accurate work in all parts of the territory covered. Special attention was paid to portions where mining operations have been carried on and comparatively little attention, especially in contouring to regions more remote from the mining camps. In particular the contouring will probably be found less accurate in the region between the summit of Cornwall Mountain and Jasper, and south of Cornwall Mountain towards Axell, also around Lake Fork and southwest of Iron creek in the vicinity of Sheep's Head and the Asiatic mine.

As to the mapping of the geological formations, in some cases it is extremely difficult in the field to make sharp distinction. This is due in part to the fact that rocks that are considered worthy of being mapped under different names may in place very closely resemble each other. This is true, for instance, in case of the intrusive monzonite porphyry as compared with some of the flows of the Summitville andesite. The resemblance in the field is often very close indeed, so that an accurate delimitation is hardly possible.

Owing to lack of time a careful mapping of the formations along the Conejos river below Platoro and in the vicinity of Lake Fork, likewise between the Asiatic mine and Sheep's Head, could not be made. In these regions, therefore, further field study would very probably result in some modifications of the geological map.

By far the greatest difficulty presented in mapping the formations is due to a profound alteration of the original rocks. This alteration in another chapter is more especially discussed and is shown to be due to several more or less different processes of alteration known as sericitization, kaolinization, and alunitization. By these alteration processes various rocks, such as andesite, monzonite, and latite have been changed into a soft, white or light gray material practically alike in appearance and composition, irrespective of the original difference in the rocks. Manifestly under such conditions boundary lines could not be drawn with any degree of certainty. These conditions prevail over large areas in the central portion of the district, more especially in the vicinity of Stunner. Such areas of intensive alteration have been mapped by a special pattern upon colors representing the rocks from which the present forms are presumed to have altered.

ACKNOWLEDGMENTS

The writer wishes to express his hearty appreciation of cooperation and assistance rendered in conducting this survey by numerous residents of the district and of other parts of the state, especially to Mr. L. G. Carpenter of Creede and to Judge E. T. Elliott of Del Norte for much valuable information; to Mr. A. E. Reynolds of Denver for free access to his office maps and for the privilege of reproducing some of them; also for numerous additional courtesies, to Mr. S. T. Penick of the United States Geological Survey for data as to elevations, to Mr. C. S. Barnes of Platoro for data and use of maps, and to Mr. Charles O. Axell for the use of his map of the mining claims of the Platoro-Summitville district.

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CHAPTER II

TOPOGRAPHIC SURVEY

INTRODUCTORY

At the time this work was undertaken no topographic map of the district had been published that could be of use as a base map for geological mapping. The maps of the Hayden survey were of course prepared on a very small scale. In the summer of 1913, the year that this survey was made, the U. S. Geological Survey had a party in the field under Mr. Stuart T. Penick engaged in making a topographic map, not only of the particular districts involved in this report, but of a much wider stretch of country. This map has now been published by the government under the name of the Summitville quadrangle. But this map was not available in. 1913 and had it been so the scale would not have been large enough to make possible such detail as the situation called for. It was necessary, therefore, for the party to prepare first a detailed topographic map. Fortunately Mr. Penick was able to furnish certain data of elevation from which a datum could be chosen for the work in hand. The elevations of several of the more prominent peaks were secured from Mr. Penick, among which was that of Cropsy Peak, about a mile and a quarter south of Summitville. As this elevation was considered by Mr. Penick the most reliable of all those given, it was taken as the datum for the map. This elevation is 12,557 feet above sea level.

BASE LINE

It was impossible to lay out a satisfactory base line within the district contemplated on account of the rough topography and heavy forest covering. The best that could be done was to lay out a 3,000 foot base line in the cleared land immediately north of Summitville. This had the advantage of being straight and of having several prominent high points visible from each end. It had the disadvantage of being located clear at one corner of the territory to be mapped.

The elevation of one end was obtained by triangulation from the summit of Cropsy Peak and by a line of levels run to that same summit. The base line was measured very carefully by a 300-foot steel tape, supported every fifty feet. Duplicate measurements were taken of all transit readings. The line as determined should be correct within an error of one inch to 20,000 feet.

TRIANGULATION

The triangulation of the district was the joint work of Professor Allen and Mr. Taylor. A very satisfactory triangulation net was laid out to cover all the nearer summits, but unusual difficulty was experienced in extending the triangulation to the more distant points on account of the lack of clear lines of sight. In order to extend the triangulation into the Platoro district it was necessary to make use of several very short calculated base lines. For this reason it is possible that some considerable error may be expected in the location and elevation of some of the points on this part of the map. In all transit work both horizontal and vertical angles were read to the nearest minute. All primary triangulation stations were occupied and check readings taken on from two to seven stations. A discrepancy of two minutes was allowed in the sum of the angles of each triangle and was adjusted among the three angles.

CONTOURING

Contouring was done under the direction of the writer and of Prof. C. E. Smith. Several methods were employed conforming to the requirements of the ground to be covered. Plane table work was made use of extensively in the higher and clearer portions of the territory. Traverse lines were run along the principal roads by means of stadia rods and steel tape. Stations established by these traverses furnished ready data for use in establishing contour lines.

CHAPTER III

GEOLOGY AND PETROGRAPHY

WORK OF THE HAYDEN SURVEY

The atlas published by the United States Geological and Geographical Survey of the Territories—more commonly referred to as the "Hayden Survey"—shows on map XVI the area covered by this report. The scale of the map is very small and the contour interval is 200 feet. Necessarily, therefore, the topography is indicated only in a general way. The course of the Conejos and Alamosa rivers is shown and also the two highest peaks of the neighborhood, Conejos and Summit Peaks. At the time of the publication of this map, in 1877, no mining operations had been begun except in the Summitville district. This district appears on the map under the earlier name "Summit District," and the road is shown leading to Del Norte.

As to the geology of this region only the vaguest suggestion is given under the two rock names used, "trachorite" and "trachytic breccia." No description of the rocks is to be found in the report accompanying this atlas except such general descriptions as apply to the larger area covered by the entire map.

WORK OF THE UNITED STATES GEOLOGICAL SURVEY

As already stated a topographic map of the Summitville quadrangle was under preparation by the United States Geological Survey at the time this investigation was begun, and was subsequently published under the name of Summitville Quadrangle. This topographic map was prepared in order that it might be available in the near future for the mapping of the great igneous complex of the San Juan Mountains that extends continuously in a southeasterly direction from those mountains to the Rio Grande river. This work has now been under way for some time under the direction of Dr. Whitman Cross.

It was the privilege of the writer to spend three weeks in the summer of 1915 with Dr. Cross's party in a study of the forma-

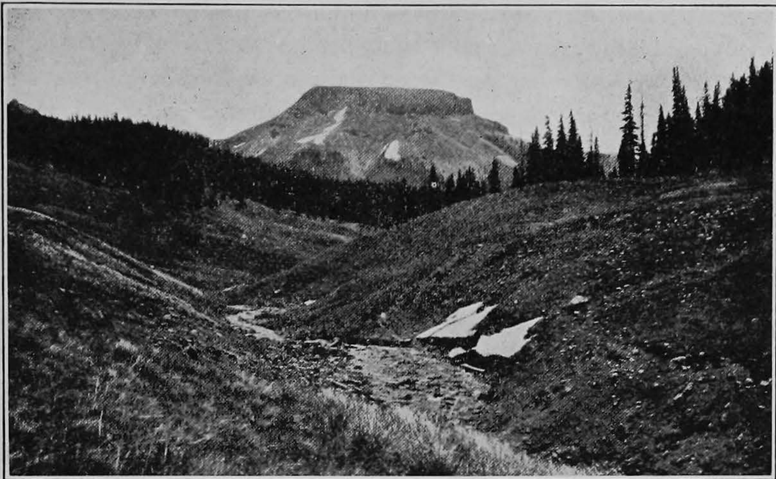


Fig. 1. View of Lookout Mountain, taken from the northwest. The flat capping-rock is a quartz latite.

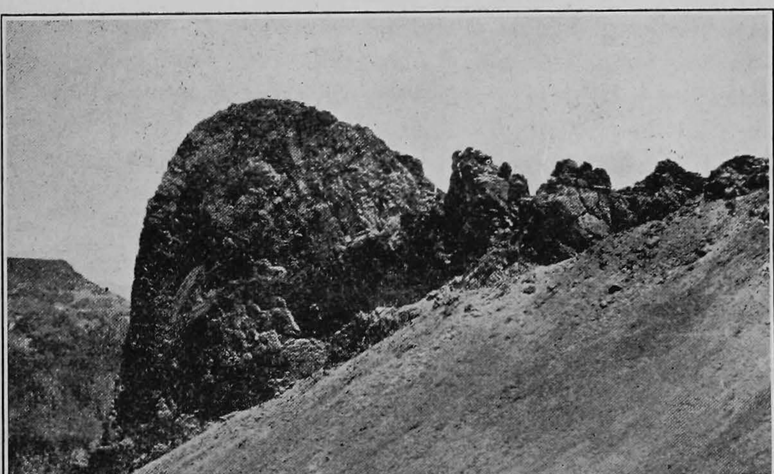


Fig. 2. View of Sheep's Head, a spur of Prospect Mountain, as seen from the north. The rock is a quartz latite, like that of Lookout Mountain.

tions lying to the north and west and southwest of the area at present under consideration, and to extend the information thus gained to a better solution of the problems involved in working out the geology of the Platoro-Summitville district. Without such information it would have been impossible to correlate the igneous rocks with the formations that have been described in the folios of the San Juan quadrangles. It will probably be some years before the results of the work being done by the United States Geological survey under Dr. Cross will be available to the public.

GENERAL CHARACTER OF THE GEOLOGY

The rocks of the district covered by this investigation are entirely confined to igneous formations. These igneous rocks are part of the great series so extensively developed in the higher portions of the San Juan Mountains and that form the mass of Uncompahgre Peak and Mount Sneffels as well as of others of the highest peaks of this superb mountain range. This igneous complex extends in a northeasterly direction from San Juan and Ouray counties on the west to and beyond the Gunnison river and to the northern end of the San Luis park. In a southeasterly direction it extends along the San Juan Mountain range to and beyond the boundaries of Colorado.

The rocks of this igneous series vary greatly both chemically and texturally. They embrace surface flows and associated breccias, also intrusive sheets, dikes, and bosses. While the andesitic and related types of rocks are prevailingly present, the siliceous rhyolites and subsiliceous basalts are also well represented. Even within the restricted area covered by the Platoro-Summitville district a great variety of igneous rocks may be found, varying from extremely siliceous to extremely subsiliceous types, and in texture varying from plutonic rocks to extrusive flows and breccias.

While most of the rocks of this district represent surface flows and breccias that were superposed one upon the other, there is abundant evidence that the series is broken by unconformities and by extensive faulting, so that the whole period covered by the volcanic activities was very considerable. The surface configuration has been greatly modified by glacial action and the rock formations have been deeply buried by glacial detritus over many square miles of territory.

FORMATIONS INVOLVED

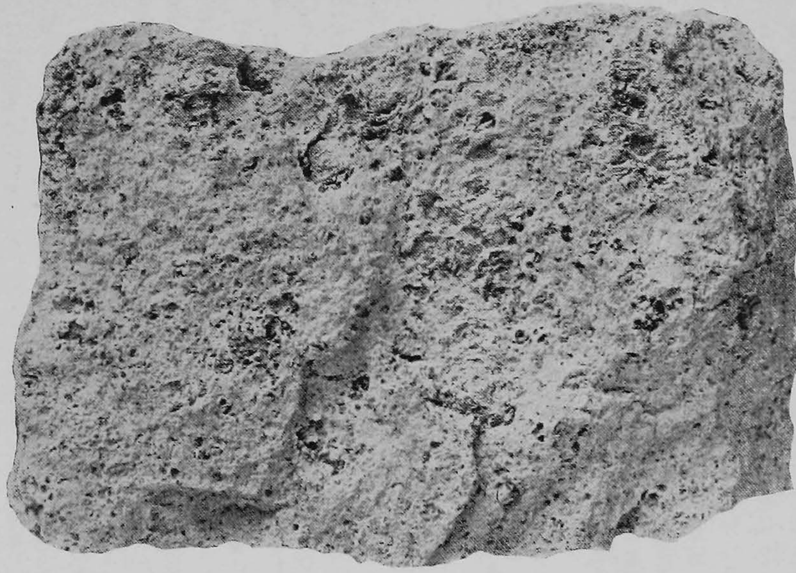
As stated above the igneous rocks of this district belong to the so-called San Juan igneous complex. From the very great extent of this complex and from the nature and structure of the rocks involved it is evident that there must have been several, possibly many centers of eruption. The work of the United States Geological Survey under Cross has also shown that this great series can be separated into a number of formations that represent successive periods of volcanic activity. Very considerable time intervals may be presumed to have occurred between the successive periods of activity during which erosion has been able to eat into the surface lavas and to develop a very uneven or even rugged surface over which later lava streams have been poured out.

Dr. Esper S. Larsen has kindly furnished a list of provisional and field names used by Dr. Whitman Cross and himself in connection with their study of the rocks of the San Juan volcanics. This list is given below. Some of these formations have already been described in the folios of the San Juan quadrangles. Others have only recently been worked out and have not yet been published. Most of them belong to the series of Tertiary volcanics described under the name Potosi Volcanic Series.* Doctor Larsen writes that the name Treasure Mountain formation is not altogether satisfactory and that the study of this formation to the East may make a change necessary. He also states that other names are not final, as further work in the field may make changes desirable.

PROVISIONAL AND FIELD NAMES FOR SUMMITVILLE QUADRANGLE

Provisional Name	Field Name
Hinsdale volcanic series	Same
Rhyolite	
Basalt	
Fisher quartz latite	Gap
Potosi volcanic series	
Piedra formation	Same
Huerto formation	Same
Alboroto formation	Same
Summitville formation	Same and Sheep Mountain
Treasure Mountain formation	Same
Conejos formation	Palisade

*Cross, Whitman, and Howe, Ernest.—Geologic Atlas U. S., folio 153, U. S. Geol. Survey, 1907, p. 9.



Rhyolite from Del Norte road. ×4/5. Lithophysae ¼ to ½ inch in diameter show on the face of the rock.

While most of the rocks of the Platoro-Summitville district are extrusives, that is, have been poured out over the surface as lava flows or consist of superficial volcanic breccias, this is not true of the entire series. There is abundant evidence of igneous rocks that have been intruded into these surface flows. Some of these intrusive rocks occur in well defined dikes. These dike rocks and others of more irregular form and of less certain relationships show more or less well defined porphyritic textures, and are not always to be distinguished in the field from the extrusive types. Still others have textures that are typically plutonic and that represent deeper lying intrusive masses that are closely related to corresponding effusive types and that were doubtless formed practically contemporaneously with the surface flows. Such plutonic rocks are to be seen mostly in the bottom of the deeply cut valley of the Alamosa river.

EXTRUSIVES

Extent and Distribution

The extrusive rocks cover perhaps nine-tenths of the area of the district, but they are extensively cloaked by a covering of glacial detritus and by the alluvium that forms comparatively narrow strips along deeper valleys, also occasional swampy meadows in higher ground. They embrace rocks of greatly varying composition from siliceous rhyolites to subsiliceous basalts, and include many rocks of intermediate types. Breccias are extensively developed in connection with the intermediate andesites, but are less in evidence in case of the rhyolites and basalts.

Rhyolite

Distribution and Megascopic Description—

The rhyolite belongs to the Hinsdale formation. From the occurrence of this rock in the country to the north and west of the area under consideration there is reason to believe that it must at one time have covered an extensive area. It undoubtedly covered a much larger territory than would appear today. At present, however, it is to be found only in one very restricted area that does not measure more than 1,600 feet wide and 3,000 feet long. It forms the summit of Elephant Mountain and extends down its southern slope to a point about 700 feet lower than the summit. The rock on the summit is part of a rhyolite flow. Lower down the slope rhyolite breccia is to be seen.

The nearest occurrence of rhyolite to that on Elephant Mountain is to be found about three and one-half miles to the north on the west side of the road from Summitville to Del Norte, at the point where the road crosses the divide. This rock forms the entire summit of the conspicuous mountain located at this place. The rock is closely similar to that of Elephant Mountain and the two form apparently remnants of a once continuous rhyolite formation.

The rock that forms the summit of Elephant Mountain is light gray in color. Its texture is fine grained, somewhat porous, and slightly scoriaceous. It frequently carries well defined lithophysae. (See Plate VII.) Owing to its porous character the rock breaks with a rough, harsh-feeling surface, and carries small, smoky-colored phenocrysts of quartz that measure about one millimeter in diameter and are easily visible to the eye. With a magnifying glass may also be seen white, glassy phenocrysts of sanidine of about the same size as the quartz.

Near the southern foot of this mountain the rhyolite assumes glassy forms which vary irregularly in color from light whitish gray to brown. The brownish portions have a more or less pitchy luster and may well be designated as pitchstone. Phenocrysts appear in the glassy portions of this rock and do not differ appreciably from those in the lithoidal rock at the summit of the mountain. Transitions between the glassy and lithoidal forms are much in evidence.

Microscopic Description—

Under the miscroscope this rhyolite presents the appearance of an extremely siliceous type of igneous rock. There is an apparent complete absence of all ferromagnesian silicates. Quartz and sanidine feldspar occur abundantly as small phenocrysts, and in addition to these two may be noted a small amount of sodic plagioclase. The feldspars are extremely fresh and disclose no tendency toward kaolinization or sericitization.

In the glassy portions of the rock the glass appears to be entirely free from crystalline matter and from alteration products. The colorless and brown colored portions of the groundmass often occur irregularly interwoven, the change in color being very sudden. The lithoidal portions of the groundmass appear to be more or less crystalline and to be composed in part of less irregular grains of sanidine and quartz. Opaque looking, dust-like particles abound in this part of the groundmass and give to the slide

Fig. 1. Quartz-biotite latite, South Mountain type, from a dike in Cropsy Gulch above the Cropsy mill. ×4/5. See page 24.

Fig. 2. Sericitized quartz-biotite latite, South Mountain type, from the Winchester tunnel on South Mountain. Natural size. See pages 24 and 46.

a dirty appearance. In some cases these dust-like particles appear to be grains of black and perfectly opaque magnetite. In other cases they may represent devitrification products of the glass.

Latite

EXTENT AND DISTRIBUTION—

Latite is represented in two very diverse types in the Platoro-Summitville district. These two types differ markedly in their physical appearance. They also belong to different formations. One of these types was identified by Dr. Whitman Cross in the field as belonging to the Fisher quartz latite formation that lies immediately beneath the Hinsdale formation; the other as part of the Treasure Mountain series. These two formations are separated in time by a very considerable interval, as the Piedra, Huerto, Alboroto, and Summitville formations, all lie above the Treasure Mountain and below the Fisher quartz latite. Of these four, only the Summitville formation appears to occur within the confines of this district. The other three are absent either through failure to cover this portion of the San Juan Mountain area or through subsequent erosion.

The younger of these two latites is to be found in the northwestern corner of the district, the older has an extensive development in the eastern and central portions. As they differ both in age and physical characteristics, these two latites will be separately considered.

FISHER QUARTZ LATITE—

The latite that belongs to the Fisher quartz latite formation has a very extensive development and covers many square miles of country to the west of Summitville, but does not extend very far over the area now under consideration. It forms the upper part of North Mountain immediately opposite to and north of Summitville, also the whole of South Mountain; and extends from here southward, forming the crest of Cropsy Peak and of Cropsy Ridge. It likewise forms the summit of Lookout Mountain and of Sheep's Head, a mile and a half to the west of Lookout.

The rocks as they occur in these rather limited localities are not identical in mineralogical composition. They differ, too, markedly in texture and state of crystallization. These differences would seem to make desirable a separate treatment of several of the representative types. They are, however, to all intents and purposes the same rock. That is, they represent a more or less continuous succession of latitic flows that poured out in successive sheets on the surface until they reached a total thickness of twelve or fifteen hundred feet or more. The two principal types are a quartz-biotite latite, developed principally on South Mountain, and a biotite-hornblende latite, such as forms the summit of Cropsy Peak and of Lookout Mountain. A further variation of the latter type is given below under the name biotite-hornblende-augite latite.

Quartz-biotite Latite. South Mountain Type—

Manner of Occurrence and Megascopic Description.—The rocks that form the mass of South Mountain above the underlying andesite and that carry the ore-veins of this mountain consist in the main of a quartz-bearing biotite latite that has a rather striking and characteristic appearance because of the presence of numerous large and very conspicuous phenocrysts of glassy sanidine. These sanidine crystals vary greatly in size and may in certain cases be only a quarter or half an inch in greatest diameter, but upon the whole they are very much larger and customarily reach a length of one or two or even more than two inches. They show well-defined Carlsbad twinning and have the general appearance of the orthoclase phenocrysts so characteristic of many coarse-grained granite porphyries. They have been subjected in many places, especially in the vicinity of the ore veins, to extensive alteration through the processes of silicification, kaolinization, and sericitization. But where such alteration has not taken place, these feldspars show a very unusual freshness, being glassy and transparent, like the sanidines of modern rhyolites and trachytes. (See Plate VIII, Fig. 1.)

There is no very essential difference between these coarsely porphyritic latites of South Mountain and other biotite latites of this mountain and of the district immediately to the south and west; but the abundance of this rock and the conspicuousness of the sanidine phenocrysts suggest the use of the name South Mountain latite for this type of rock.

In addition to sanidine these rocks also contain rounded grains of quartz that are frequently as large as five or six millimeters in diameter. They never constitute a large percentage of the rock and may be in place all but wanting or, at least, quite inconspicuous. Biotite also occurs abundantly in fresh, black phenocrysts of two or three millimeters diameter.

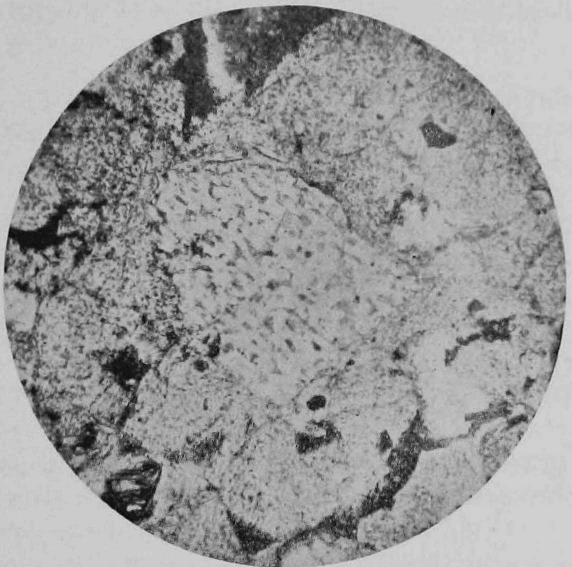


Fig. 1. Photomicrograph of glassy quartz-biotite latite, from the base of the cap on Sheep's Head. White light. ×45. Shows a broken phenocryst of plagioclase containing numerous glass enclosures. See pages 25 and 30.

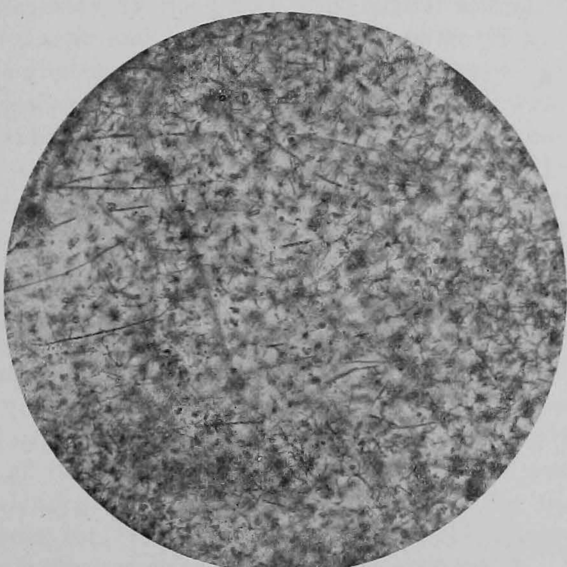


Fig. 2. Photomicrograph of glassy quartz-biotite latite, from Sheep's Head. Same slide as Fig. 1. White light. ×200. Shows a glass filled with minute, black, opaque microlites. See pages 25 and 30.

This rock is light to dark gray in color except where stained by iron oxides or where whitened by alteration to kaolin or sericite. Its fracture is usually rather rough.

Microscopic Description.—Among the phenocrysts sanidine appears only in large crystals and hence may be altogether missing in any given thin section. It is usually quite fresh except for secondary infiltrated calcite or other secondary minerals that may appear along the cracks. On the other hand, plagioclase is an abundant phenocryst, and, like the sanidine, is very fresh. In only two cases in the thin sections studied were symmetrical extinction angles noted. In each case the extinction angle was 5°. This observation, together with observations on crystals that show approximately symmetrical extinction angles, indicates a feldspar of the composition of oligoclase.

Biotite appears to be quite abundant and is mostly fresh. It has a brownish color in the direction of greatest absorption. It occurs to some extent in the groundmass.

Hornblende and pyroxene were not noted in this rock. But a study of related latites from other portions of this district lead to the conclusion that in all probability one or both of these minerals may perhaps have been originally present in small amounts. This is suggested by the presence of certain alteration products that in character and manner of occurrence would point to their having been alterations of hornblende or pyroxene. In one case, in fact (specimen, P. 44), a quartz-bearing latite, with fine large glassy sanidine phenocrysts, collected near the summit of South Mountain on the precipitous eastern slope, shows all the ferromagnesian minerals altered to an unrecognizable powdery mass but retaining the original shapes of the crystals. The shapes of both biotite and hornblende could plainly be recognized.

Apatite forms an abundant accessory mineral. It is usually in minute slender prisms, but occasionally in stour crystals of unusual size.

It is possible that the groundmass of these rocks was originally more or less glassy and that the glass has become devitrified. On portions of South Mountain latite vitrophyre is more or less strongly developed. (See Plate XI, Fig. 1.) But the relationship between the vitrophyre and the typically developed South Mountain latite porphyry could not be established. As will be shown later, the vitrophyre on Cropsy Peak passes gradually into the more crystalline latite. Such may also be the case with the latite of South Mountain. Quite possibly, however, the higher lying latite of Cropsy Peak may extend over and cover that of lower portions of South Mountain. Mr. R. C. Hills thirty-four years ago described the main rock* of South Mountain under the name of granular rhyolite, and the black glass he designated black rhyolite. Mr. Hills considers this black rhyolite glass to be a glassy sheet or layer that has been folded together with the granular rhyolite into a series of compressed folds. The writer comments on this supposed structure elsewhere in these pages. It is sufficient to call attention here to the fact that there is a more or less intimate association between glassy and non-glassy forms of the latite of South Mountain.

Occurrences in Dike Form.—The South Mountain latite, with its large glassy sanidine phenocrysts, has been found in several localities in dike form cutting other formations. These dikes probably represent fissures through which the latite magma flowed up toward the surface.

One of these dikes crops out in the bottom of Cropsy Gulch, just above the old Cropsy mill (location C2). It cuts diagonally across the creek and is exposed in the creek bed for a width of forty-five feet without disclosing either contact. It occurs not far from the contact of the Summitville andesite with the quartz-biotite latite of South Mountain, and appears to have andesite on each side.

Another such dike occurs in the bottom of Wightman's Gulch about a thousand feet below the ruins of the old mill near the point where Cropsy Gulch joins Wightman's fork. This dike is about twenty-five feet wide and strikes approximately parallel to the course of the stream, being exposed in or near the stream bed for a distance of two or three hundred feet. This dike cuts andesite breccia of the Summitville andesite formation. In the center it is exactly like coarsely porphyritic latite of South Mountain, but at the margin changes to a dark gray rock with coarsely felsitic groundmass and with small feldspar phenocrysts (location D2).

A third dike of similar rock of considerably greater extent both in width and in length is to be seen southeast of Lookout Mountain and west of Gilmore meadow (location C5). This dike has a north-south strike, and extends (with one break) for a dis-

*Ore Deposits of Summit District, Rio Grande County, Colorado, Proc. Sci. Soc., Vol. 1, 1883, pp. 20-36.

tance of 4,500 feet. It cuts through monzonite and monzonite porphyry.

Another almost equally great dike has an east-west strike and cuts the Summitville formation on the steep mountain side on the south side of the Alamosa river, nearly opposite Wightman's fork (location G4).

One more such dike occurs cutting the Summitville andesite on the south bank of the Alamosa below "The Nose" (location J3).

The occurrence of these widely scattered dikes would seem to indicate that the latite lavas of this type must at one time have extended over all of the territory as far east as the Alamosa river, if not further.

Chemical Analysis.—A chemical analysis of this rock was made in the laboratories of the University of Colorado by Messrs. George Roher and Esbon Y. Titus, and is given on page 30. The sample was taken from the dike in Cropsy Gulch, where the rock is unusually fresh in appearance. In spite of the fresh appearance, however, the presence of 3.75% of CO_2 that appears in the analysis, indicates a very considerable progress in the alteration of the rock. This alteration is largely confined to the materials of the groundmass where some calcite may be detected in thin section.

In a report on the geology of the Bonanza district, Saguache County, Colo.*—a region of similar rocks that belong to the San Juan volcanic complex—the writer has published a list of chemical analyses of three latites with which this analysis may be compared. While it shows a composition not dissimilar to those of the latites of the Bonanza district, it does not agree closely with any one. It is less siliceous than the so-called "Eagle Gulch latite," which is a quartz-bearing latite, and has a composition intermediate between the Eagle Gulch latite and the "Bonanza latite" which is free from quartz. The rather high percentage of MgO is accounted for by the abundance of biotite phenocrysts.

Alteration-Products.—This rock has undergone very extensive, and even complete alteration over rather large areas. Part of this alteration accompanies the deposition of ores and part of it does not appear to have direct connection with ore-veins. Such alteration, however, is not confined to the latite, but holds equally

*Patton, Horace B., Geology and Ore Deposits of the Bonanza District, Saguache County, Colorado, Bull. 9, Colo. State Geol. Survey, 1917, p. 44.

in case of andesite and of other rocks of the district. This extensive alteration will be discussed in another part of this report.

Quartz-Biotite-Hornblende Latite. Cropsy Peak Type.

Occurrence and Megascopic Description.—The rock that forms the summit of Cropsy Peak, of Lookout Mountain, and of Sheep's Head is a latite that varies greatly in physical characteristics, but that everywhere carries appreciable amounts of biotite and of hornblende. On the peaks just mentioned it forms the capping rock, including the exceedingly steep and often nearly vertical-walled portions. On Cropsy Peak it rests upon a floor of latite of the South Mountain type. On the southern extension of Cropsy Peak, to which the name of Cropsy Ridge has been given, and on Lookout Mountain and Sheep's Head it rests apparently on the Summitville andesite. This rock also covers a considerable but undetermined territory to the west of Cropsy Peak and of the summit of South Mountain and extends far beyond the boundaries of the mapped area.

It forms, therefore, the highest portions of the mountain summits in the region south of Summitville and would appear to be a surface flow that was poured out on top of the South Mountain quartz-biotite latite and spread out beyond the bounds of that rock over the adjacent andesite. Whereas the underlying quartz-biotite latite and the andesite usually show excessive alteration so that it is almost or quite impossible to determine the character of the rock, this Cropsy Peak latite is invariably fresh, except for superficial weathering.

This rock type differs from the South Mountain type mainly in the absence of or, at least, in the scarcity of the conspicuous phenocrysts of sanidine and of quartz, also in the presence of hornblende. But transitions to the South Mountain type are not lacking. It varies greatly in the appearance of the groundmass and in the relative abundance and size of the phenocrysts. Upon the whole groundmass is much finer grained than is the case with the South Mountain latite. It may be extremely dense and break with smooth surface, but it is more inclined to be rough and scoriaceous. But always it shows a strong tendency to crumble, so that it is difficult to trim it into a hand specimen, and it is impossible to break off a thin chip.

On all the mountain summits above mentioned the bottom of this flow is extremely glassy and may properly be designated as

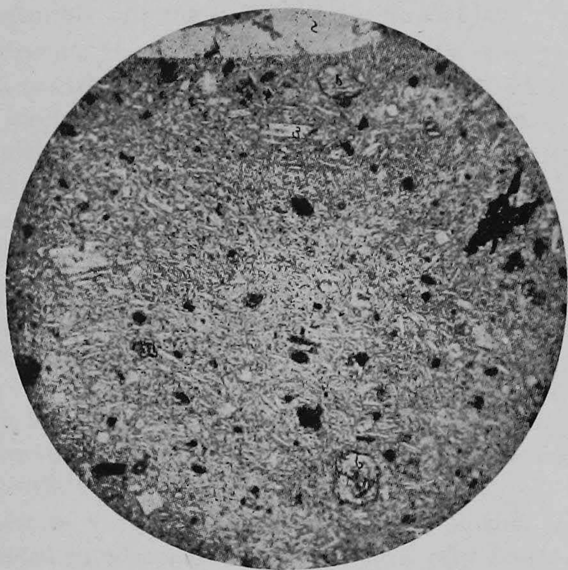


Fig. 1. Photomicrograph of biotite-hornblende-augite latite, from the west face of the cliff on Cropsy Ridge. White light. ×15. The figure shows orthoclase (2), plagioclase (3), hornblende with dark rims (5), augite (6), and magnetite (black).

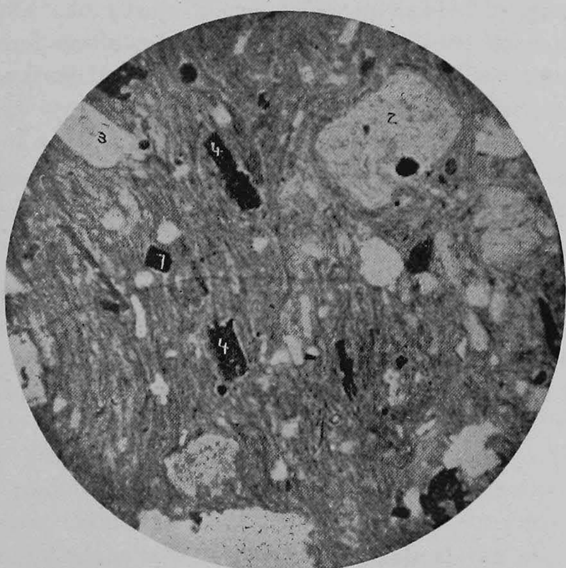


Fig. 2. Photomicrograph of biotite-hornblende-augite latite, from west face of Cropsy Ridge. White light. ×15. Shows the development of flow structure. The following minerals may be seen: orthoclase (2), plagio-

a black latite vitrophyre. This vitrophyric layer varies in thickness from a few feet up to twenty or thirty feet and passes more or less insensibly into the more normal lithoidal lava.

On Sheep's Head the lower glassy portion is very much jumbled and excessively scoriaceous. It appears to lie upon a bed of volcanic ejectamenta of similar character to the glassy latite, and to have picked up large amounts of this fragmental lava so as to present the appearance of flow-breccia.

In color this rock varies from black to various shades of gray and brown, according to degrees of oxidation and crystallization. On the west perpendicular face of Cropsy Ridge this rock is very well exposed and shows remarkable variation in color and texture. From the fragments that have been torn loose by the frosts and fallen to the bottom of the cliff it is possible to collect within the space of a few square yards ten or a dozen rock samples so different in physical appearance that one is almost inclined to take them for different rock types.

Quartz in visible grains is not entirely lacking in this rock. It was noted in conspicuous amounts in a very fresh, glassy, friable and scoriaceous portion of the flow at the foot of the north end of Cropsy Ridge.

Neither biotite nor hornblende are ordinarily conspicuous ingredients. In places hornblende can hardly be detected at all in the hand specimen. In the case of the scoriaceous, quartz-bearing latite from the north end of Cropsy Ridge just mentioned this mineral is very plainly visible and reaches dimensions of over a quarter of an inch.

Plagioclase is very abundant and forms usually more or less conspicuous phenocrysts that measure from one-eighth up to a quarter of an inch or more in greatest diameter.

Microscopic Description.—Owing to the comparative scarcity of orthoclase among the phenocrysts and to its relatively greater size, this mineral does not appear as a phenocryst in most of the thin sections. It is probably present to some extent in the groundmass, but, if so, it is not recognizable. Plagioclase is well and extensively developed. In most of the slides studied this mineral shows a rounded form due undoubtedly to magmatic resorption. The greatest extinction angle noted in section cut perpendicular to the twinning plane is 8°, which would indicate an oligoclase-andesine plagioclase. Very frequently the plagioclase phenocrysts are cellular or spongiform, showing inclusions of the glassy groundmass that may constitute apparently one-half of the bulk of the crystal. (See Plate IX, Fig. 1, opposite page 24.) These glassy inclusions are apt to be composed of nearly pure glass of a brown color, and to be free or nearly free from the crystalline constituents that, together with the glass, form the groundmass of the rock. In one case, however, (specimen P 8) the glass inclusions of the plagioclase contain hair-like trichites of exactly the same character as those that characterize the glassy groundmass. (See Plate IX, Fig. 2, opposite page 24.)

Biotite in most cases shows a yellowish or brownish yellow color in rays vibrating at right angles to the cleavage, and a black-brown color parallel to the same. In one case (specimen P 23) the colors were respectively greenish yellow and reddish brown. This mineral is usually quite fresh, but in some cases has been entirely removed by alteration. The biotite does not appear to have been subject to magmatic resorption.

Hornblende appears in sharply developed prismatic crystals that never show rounding by resorption. The crystal forms are usually (110) and (010). In some cases the macropinacoid (100) is developed in addition to the other forms (specimens P 9 and P. 23). The color is usually green and pleochroism strong. The colors are, $\mathfrak{a}$ yellow, $\mathfrak{b}$ dark brownish green, $\mathfrak{c}$ dark green. In one case reddish colors were noted, namely, $\mathfrak{a}$ greenish yellow, $\mathfrak{b}$ reddish brown, $\mathfrak{c}$ blood red. This occurs in the same rock in which the reddish brown biotite was observed (specimen P 23).

Apatite and magnetite are invariably present as accessory constituents.

The groundmass of these rocks in nearly all cases appears to consist to a considerable extent of glass. As already stated, extremely glassy types occur and form a well defined latite vitrophyre. These vitrophyric portions sometimes show delicate opaque or nearly opaque microlites (specimen P. 8, see also photomicrograph in Plate IX, Fig. 2). The trichites may occur in separate individuals or may be clustered in small bunches. In other cases the microlites are very minute straight prisms that are several times longer than wide, and are nearly opaque. Perlitic development is marked in case of the very glassy latite from Sheep's Head (specimen 8). Both striped and unstriped feldspars may be developed in the groundmass. They are mostly minute and customarily show a fluidal arrangement.

Chemical Analysis.—It was impossible to secure a specimen of the normal rock that was fresh enough to justify a chemical analysis. For this reason the analysis was made on a sample of the vitrophyre taken from fresh glassy material at the base of the latite flow that caps Lookout Mountain. It is not certain that this glassy rock has exactly the same chemical composition as did originally the lithoidal mass above it, but as the transition between the two is gradual, it may reasonably be assumed that the two must originally have had a nearly identical chemical composition.

The analysis of this vitrophyre is given below under the column marked P 39. The freedom from CO_2 indicates the extreme freshness of this rock. That it contains a higher per cent of water than does the much less fresh South Mountain latite given under column P 12 would seem to indicate that the glass is somewhat hydrous. In spite of the absence of visible quartz in this rock the higher percentage of silica shows that it is actually more siliceous than the quartz-biotite latite, P 12. The higher percentage of the alkalies and lower lime content also point to the same conclusion. Potash and soda are present in almost equal amounts, the former being only slightly in the lead.

CHEMICAL ANALYSES OF ROCKS OF THE PLATORO-SUMMITVILLE DISTRICT

	P 12	P 39	P 11	P 57
SiO_2	62.51	69.13	59.07	59.81
Al_2O_3	14.64	14.31	16.94	14.55
Fe_2O_3	.63	.64	3.82	5.10
FeO	2.93	1.10	1.92	3.03
MgO	1.88	.83	2.04	2.90
CaO	3.80	2.31	5.41	4.52
Na_2O	3.01	4.19	3.37	3.88
K_2O	3.78	4.55	3.13	4.17
H_2O-	.80	.06	.60	.09
H_2O	1.44	2.45	.97	.76
TiO_2	.73	.50	.98	.98
ZrO_2	.06	.10	.17	none
CO_2	3.75	trace	1.35	.04
P_2O_5	.36	.18	.11	.12
MnO	.08	.05	.13	.13
Cl	.02	.02	trace	.03
SO_3	.15	none	.26	none
S	trace	none	none	none
	100.57	100.32	100.27	100.11

P 12. Quartz-biotite latite, South Mountain type. From dike in Cropsy Gulch. Contains phenocrysts of glassy sanidine, plagioclase, quartz, and of biotite in a very fine crystalline groundmass.

P 39. Biotite-hornblende latite vitrophyre, Cropsy Peak type. From Lookout Mountain. Contains sanidine, plagioclase, biotite, and hornblende in a fresh black glass.

P 11. Augite-andesite, Summitville andesite. From creek bed of Cropsy Gulch. Contains plagioclase and augite phenocrysts in an altered groundmass that probably consisted of plagioclase, augite, and magnetite.

P 57. Monzonite. From near sawmill above Stunner. Contains orthoclase, plagioclase, quartz, pyroxene, and biotite.

The above analyses were carried out by Messrs. George Roher and Esbon Y. Titus in the laboratories of the University of Colorado.

Biotite-Hornblende-Augite Latite—

Occurrence and Megascopic Description.—Intimately associated with the biotite-hornblende latite of Cropsy Peak and Cropsy Ridge, and forming apparently part of the same eruptive series as that of the other rocks of the locality, are to be found rocks of somewhat greater basicity, but that present externally almost the same characteristics as have just been described. They are light gray in color, show a dense and sometimes scoriaceous groundmass, and contain numerous plagioclase and occasional larger sanidine phenocrysts. These rocks cannot well be distinguished from the others in the field nor in the hand specimen, but only when examined under the microscope in thin section. They probably were extruded as separate thin lava sheets upon or alternating with the flow or flows that constitute the main portion of the cap rock on these conspicuous summits.

Microscopic Description.—Under the microscope this rock shows the same minerals that compose the biotite-hornblende latite, but, in addition thereto, a rather limited amount of augite.

The plagioclase of the phenocrysts is more calcic than is the case in the biotite-hornblende latite. They show maximum symmetrical extinction angles of 18°, corresponding to andesine. In some cases they are rounded by magmatic resorption. In other cases they remain perfectly sharp in outline.

The hornblende of this rock is not as well preserved as in the main rock of Cropsy Peak. It has in part suffered resorption and in part has been altered by magmatic attack so that the margin of the larger crystals and the entire body of the smaller ones have been altered to a fine black granular aggregate, presumably of magnetite and augite. To some extent the biotite crystals have been similarly affected by the magma.

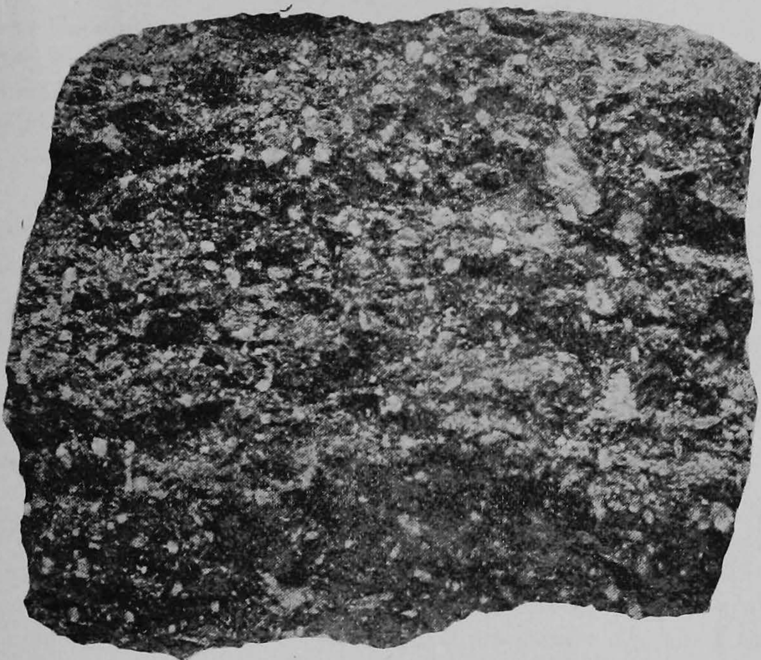


Fig. 1. Quartz-biotite latite vitrophyre, from summit of South Mountain. Natural size. The white crystals are mostly plagioclase. See page 25.

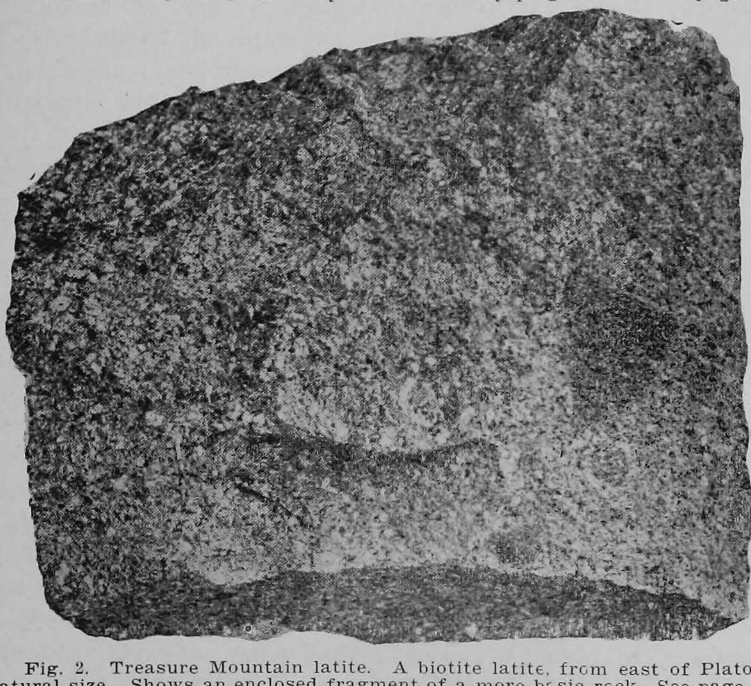


Fig. 2. Treasure Mountain latite. A biotite latite, from east of Platoro. Natural size. Shows an enclosed fragment of a more basic rock. See page 34.

The augite appears in nearly colorless crystals of mostly small size, and in cross-section shows the customary prism and two pinacoids. In some cases this mineral appears in two generations, an older one of relatively large, but actually small, stout crystals, and a younger one of very minute prisms.

The groundmass of these rocks contains much glass and usually shows very sharp and thickly crowded laths or microlites of plagioclase. (See photomicrograph in Plate X, Fig. 1.)

This latite appears to be most extensively developed on the west slope of Cropsy Ridge, and has also been identified on a low ridge two or three thousand feet west of Cropsy Peak.

TREASURE MOUNTAIN LATITE—

Biotite Latite—

Occurrence and Megascopic Description.—The latite that Dr. Whitman Cross has assigned to the Treasure Mountain formation, and that here will be designated as a biotite latite, differs in several material respects from the other latites of this district. Next to the Summitville andesite it forms the most extensively developed rock within the area of the Platoro-Summitville district. With the exception of the basalt that caps the summit of Cornwall Mountain it covers almost the entire country between Platoro and Jasper and extends for a long distance eastward. It also has an extensive development west of this district.

In color it varies from light to dark gray, but may locally assume light to dark brown shades, in accordance with the degree of oxidation. Its texture is invariably fine grained with a non-glassy groundmass and very numerous but minute and inconspicuous phenocrysts of whitish feldspar and of brown biotite. Owing to the almost universally altered condition of this rock the biotite may not be recognizable in the hand specimen, but in the comparatively rare cases of relative freshness this mineral is seen to be very abundantly developed.

Another characteristic of this rock is the development of flow structure. This may not be manifest in fresh-broken, sound rock, but is evidenced by a strong tendency to break up into thin slabs. This is particularly noticeable in talus slopes at the foot of steep declivities. As an instance of this may be noted the very steep mountain slope of Cornwall Mountain in the Alamosa valley opposite Jasper. At this place the entire slope for a thousand or more feet above the valley bottom consists of "slide rock" in which the rock fragments are composed of slabs of this material. Superficial weathering usually brings out the flow structure most conspicuously. Under the influence of the weather this latite may assume an apparent bedded structure like that of sedimentary rocks. This feature is very pronounced at a point about half a mile below Jasper where the road comes down close to the river. At this point is to be seen the contact between the Summitville andesite above and the apparently conformable biotite latite below. The contact appears to dip gently to the north. The latite just below the contact has been exposed to atmospheric weathering, which has developed the flow structure so that the weathered latite closely resembles a shale.

A further characteristic of this Treasure Mountain latite that has not been noted in any other formation in this district is seen in the inclusion of small angular fragments of other igneous rocks. This feature seems to be fairly constant wherever this rock occurs. The inclusions are mostly very small, varying in size from a quarter of an inch up to half or three-quarters of an inch. Only rarely do they reach dimensions of two or more inches. Sometimes these fragments are very sparingly developed and may easily escape observation. Then again, they may thickly crowd the rock so as to present a structure that the writer in connection with the description of a somewhat similar latite in the Bonanza district of Colorado has designated as rhyoclastic.* Such an occurrence has been frequently described by Cross under the term flow-breccia.†

These enclosed fragments vary in color from gray to brown. They are as a rule finer in grain than is the enclosing latite and have usually a minutely porphyritic texture. Owing to a lack of freshness a positive identification is not possible. They appear, however, to be partly andesite and partly latite.

The Treasure Mountain latite as developed within the boundaries of this district, as we have seen, are to be distinguished from other latites by three characteristics, namely, abundance of biotite, flow-structure, and the inclusion of foreign rock fragments. Not all of these three features may be in evidence in any one place, but usually one or more of them may be observed if searched for. (See Plate XI, Fig. 2.)

Microscopic Description.—The invariably altered condition of this rock is still more in evidence under the microscope than when examined macroscopically. From the distinctness of the flow-

*Patton, Horace B., Bull. 9, Colo. State Geol. Survey, 1917, p. 30.
†Cross, Whitman, Folio, U. S. Geol. Survey, No. 120, 1905, p. 7.

structure an original glassy groundmass may be reasonably inferred, but, if so, devitrification products have everywhere replaced the glass. This alteration of the glass of the groundmass is accompanied by a somewhat similar alteration of the phenocrysts. For instance, the biotite in nearly every case has been almost completely decomposed. The alteration products are hematite, magnetite, and a colorless mineral with strong, double refraction that has every appearance of muscovite. This last named mineral does not occur as a scaly aggregate, such as would be expected in the process of sericitization, but a single irregular muscovite individual associated with the iron oxides may be seen occupying part or all of the space of the original biotite. The magnetite and hematite appear in minute grains or in powder scattered through the muscovite or thickly crowding the margin of the same. In places the magnetite margin suggests the alteration of the biotite by magmatic resorption. Where fresh enough to be recognized the biotite has a brownish red color.

The visible feldspars are mostly, perhaps entirely, plagioclase. Maximum extinction angles in section at right angles to the twinning plane indicate oligoclase-andesine. Owing to the altered condition of the rock it is not possible to distinguish clearly between orthoclase and plagioclase, but some crystals that show no twinning striae and that have an index of refraction lower than Canada balsam may be presumed to be orthoclase. The identification of this rock as a latite is not, in fact, based on the identification of the feldspars, nor upon a chemical analysis, since the decomposed character of the rock did not justify the expense of a chemical analysis, but upon its general appearance and associations. Outside of the territory covered by this report this same rock formation occurs in comparatively fresh condition.

Summitville Andesite

AUGITE ANDESITE—

Occurrence and Megascopic Description—

The formation to which the name Summitville andesite has been given is so named because of its extensive development in the vicinity of Summitville. It is in fact more widely developed within the Platoro-Summitville district than is any other formation. With the exception of a not very extensive intrusive diabase in the valley of Wightman's Fork, this formation extends along the whole northern edge of the mapped area. Starting from Summitville it follows down Wightman's Fork to its junction with the

Alamosa and then along this stream to Jasper. It underlies the latite of Cropsy Peak and of Lookout Mountain and has a considerable development on Klondyke Mountain. It also underlies the latite of South Mountain.

It probably belongs to the Sheep Mountain formation of Cross' series of the Potosi volcanics, and lies, therefore, geologically above the Treasure Mountain latite formation. Between it and the higher lying Gap latite belong the missing formations designated as Alboroto, Huerto, and Piedra. The contact between the Summitville andesite and the Treasure Mountain latite in the Cornwall Mountain district is very sharply drawn and is due to a great structural fault that has brought up on the east side of the fault plane the underlying latite.

This formation consists of augite andesite flows and of interbedded breccias and agglomerates of like material. Both the solid and the fragmental rocks are very extensively developed. The breccias and agglomerates are well exposed opposite the mouth of Wightman's Fork on the exceedingly steep and deeply ravined side of Cornwall Mountain. The thickness of this andesitic series is not known, but to the north of the summit of Cornwall Mountain the entire mountain side consists of these rocks from the bottom of the Alamosa valley up to an elevation of not less than two thousand four hundred feet above the river. On the other side of the river the same formations rise to an even greater height. The Alamosa river has at this point cut its channel down through this andesitic formation to a depth of over twenty-four hundred feet without reaching the bottom of the formation.

The breccias have been very greatly consolidated, so that it is not always easy to distinguish the fragmental material from the solid flows except on the weathered surface.

The Summitville andesites are more basic than are the latites of the district. This is clearly indicated by the prevailing colors, which are gray or greenish gray to black. There is considerable variation in texture. The prevailing type is a rather dense grained rock with very minute and inconspicuous phenocrysts of lighter colored plagioclase. (See Plate XII, Fig. 1.) Another not uncommon type shows much larger plagioclase phenocrysts and discloses a marked porphyritic texture. Between these two extremes are many intermediate stages. Plagioclase is the only mineral that can be recognized. In the coarser porphyritic types this mineral may attain to three or four millimeters in length. In the finer grained varieties it sinks to less than one millimeter.

Fig. 1. Summitville andesite. An augite andesite, from the cliff on west side of Conejos river, opposite the Forest King mine. Natural size. See page 35.

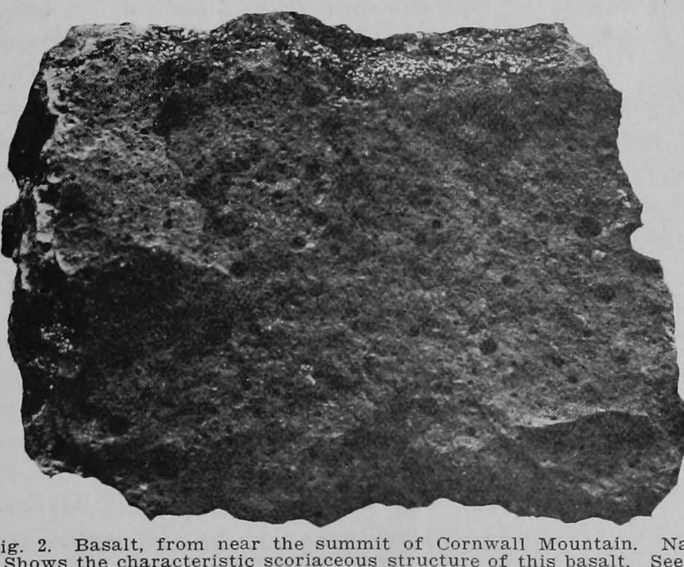


Fig. 2. Basalt, from near the summit of Cornwall Mountain. Natural size. Shows the characteristic scoriaceous structure of this basalt. See page 39.

The occasional development of amygdaloidal structure in the solid andesite flows attests to the superficial character of the rock. The amygdaloidal cavities are filled with chlorite and calcite.

This rock often appears to be very fresh, especially in case of the darker colored types, but even in such fresh appearing rocks a microscopic examination invariably discloses an advanced stage of alteration. Such alteration naturally is more pronounced in the breccias than in the solid flows. In the fragmental rocks greenish colors due to the formation of chlorite and epidote abound. But oxidation has often changed the color to browns and reddish browns.

Microscopic Description—

This rock is composed essentially of plagioclase and augite with very appreciable amounts of magnetite, and a varying amount of glass or of glass alteration-products. In a few cases hypersthene is very sparingly present. Hornblende and biotite are altogether wanting.

Plagioclase occurs in both the groundmass and the phenocrysts. The phenocrysts are very abundant and often show two generations. The older generation shows larger crystals of irregular outline and of more complex forms. They are not infrequently cellular or spongiform and contain enclosures of the groundmass material. The smaller and younger generation are more or less rectangular in cross-section. Symmetrical extinction angles of 27°, 28°, and 29° indicate a fairly sodic labradorite. Alteration is always well advanced through the development of sericite, chlorite, epidote, and calcite.

In all fairly fresh samples of this rock augite can be recognized sparingly developed among the phenocrysts. The size is invariably minute, as the crystals range from .08 millimeter to .6 millimeter in width and from .16 to 1.5 millimeter in length. The length in general is from one and a half to twice the width. In horizontal cross-section they show the presence of the prism and of the two pinacoids. Twinning parallel to the orthopinacoid was observed. In a thin section of normal thickness the augite is almost colorless. Alteration to chlorite, or epidote, or calcite, or to all of these secondary minerals is almost universal. In most of the thin sections studied the augite is completely altered and can be recognized only by the forms that the alteration-products take. (See Plate XIII, Fig. 1.)

It is more than possible that biotite may originally have been present in some of these andesites. But if so it has been completely altered to chlorite. As chlorite is also an alteration-product of the augite and is developed very extensively as an alteration-product of the groundmass, it is hardly possible to estimate how much of the chlorite represents altered biotite. Dikes of a rock of andesitic type cutting the augite andesite and the andesite breccias, also cutting rocks of different character within the Platoro-Summitville district, have been noted carrying a notable amount of biotite. To such dikes the name biotite andesite would seem to apply. Such dikes have been observed, for instance, on Klondyke Mountain. Whether these biotite-bearing dikes belong to the Summitville formation has not been definitely determined.

The mineral composition of the groundmass as it occurred in the original rock can only be inferred in the majority of cases. Everywhere chlorite and epidote abound as alteration-products. The plagioclase of the groundmass is, as a rule, sharply developed. The minute crystals have a rectangular or lath form and vary in length from .04 millimeter to .25 millimeter. The average length is between .06 and .08 millimeter. Flow lines in the groundmass are accentuated by the arrangement of the plagioclase laths. In a very few cases augite could be identified in the groundmass. The crystals are exceedingly minute. In width they measure from .005 to .008 millimeter, and in length from .01 to .02 millimeter.

Chemical Analysis—

On page 31 will be found a chemical analysis of a compact-grained, blackish colored augite andesite taken from the creek bed of Cropsy Gulch. This rock appears to be quite fresh, but the high percentage of CO_2 shows the presence of an appreciable amount of calcite. While the lime is higher and the amount of alkalies is lower than in the analyses of the latites given on the same page, it is interesting to note that potash is present in only slightly less amount than is soda. The contrast in composition between the latites and the augite andesite is not as great as would naturally be expected from their physical appearance and from the minerals present.

Palisade Andesite (Conejos Formation)

A dark colored andesite of compact texture and similar in appearance to the Summitville andesite occurs in a narrow strip on each side of the Conejos river beginning at Platoro and running down stream to the edge of the mapped area. Owing to insufficient time, this formation could not be studied in detail nor mapped with accuracy. A hand specimen of this rock was unfortunately lost before a thin section could be prepared. It is presumably an augite

Fig. 1. Photomicrograph of Summitville andesite. An augite andesite, from summit of cliff opposite the Forest King mine. A similar rock to that shown on Plate XII, Fig. 1. ×15. Polarized light. The figure shows plagioclase (3), augite of which a cluster of grains is seen around (6), and magnetite (black).

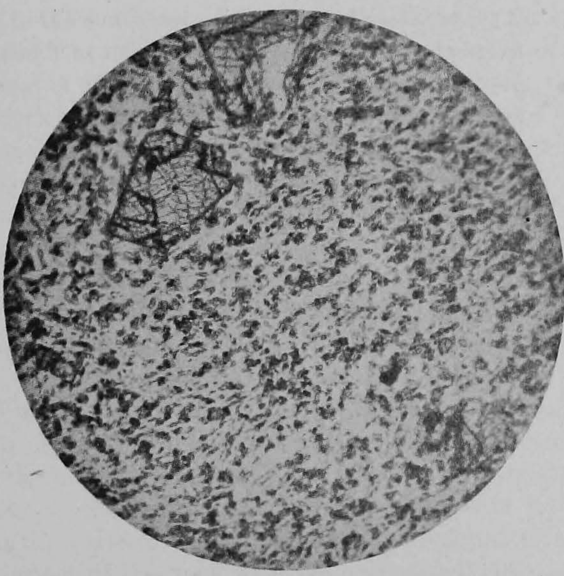


Fig. 2. Photomicrograph of basalt, from the east side of the Cornwall cap. ×45. White light. The large crystals are augite phenocrysts, as are also the dark colored grains of the groundmass. The white is plagioclase, the black magnetite. See page 40.

andesite. Geologically this andesite underlies both the Summitville andesite and the Treasure Mountain latite, and has been placed by Cross in the Palisade division of the Potosi series.

Basalt (Hinsdale volcanic series)

OCCURRENCE AND MEGASCOPIC DESCRIPTION—

The highest of the series of volcanic rocks in this district, the Hinsdale formation, contains both rhyolites and basalts. The rhyolite, which has been described above, is found only on the summit of Elephant Mountain. In similar fashion the basalt also forms a capping formation on two of the prominent peaks of the district. The great flat-topped, dome-shaped summit known as Cornwall Mountain is composed in the main of the Treasure Mountain latite. On top of this latite and spreading over a considerable portion of the summit of the mountain is a typically developed basaltic formation, which represents an erosion remnant of a once extensive basalt sheet. This rock extends from the summit in a southwesterly direction, following the gently sloping surface to the point where the mountain suddenly pitches towards the Conejos valley. A second, somewhat smaller mass of this basalt is to be found to the west and south of Kerr Lake. On the south side of the Conejos valley a similar basalt is to be seen capping the summit of Mammoth Mountain to the southeast of Platoro. Undoubtedly these separated areas of basalt at one time formed a continuous sheet of lava, only small remnants of which have survived to the present day.

This rock has an extremely fine-grained texture and is of a dark gray to black color, but has to a great extent, through oxidation, been changed to dark brown. (See Plate XII, Fig. 2.) On Mammoth Mountain it is massive and forms a precipitous cliff; on Cornwall it is very extensively scoriaceous. On the latter mountain this rock has broken up under the action of the weather into large and small rough-surfaced fragments that thickly strew the surface so that traveling on horseback is rendered very difficult. Only in a few places can the rock be found in place. This heavy accumulation of weathered fragments, together with the extremely scoriaceous character of the rock and the absence of basalt in place, gives one the impression that the material was originally composed of volcanic ejectamenta. The basaltic fragments have worked well down the sides of the mountain and obscured to a great extent the contact of this rock with the underlying latite, so that the boundary lines as drawn on the map are necessarily more or less conjectural.

MICROSCOPIC DESCRIPTION—

Under the microscope the minerals that are invisible in the hand specimen are readily recognized as plagioclase, augite, and magnetite. The plagioclase has the customary lath-form, with the longest dimensions about .2 millimeter. Augite and magnetite occur in grains of minute size. The former tends towards an elongated or prismatic form of about .04 millimeter in length. Both plagioclase and augite occur sparingly as phenocrysts too small to be visible in the hand specimen. (See Plate XIII, Fig. 2.)

In spite of the scoriaceous character of the rock, glass appears to be almost, if not entirely, absent from the groundmass, but flow lines are recognizable in the more or less parallel arrangement of the plagioclase microlites.

INTRUSIVES

Extent and Distribution

Near the central portion of the district, where the Alamosa river has eroded deeply into the igneous rock series, are to be found rocks of textures quite different from those found in the lava flows thus far described, and whose relationships to these lavas are such as to show that they are the result of magmas that have been intruded into the volcanic series. In addition to these centrally located intrusives are also two or three smaller intrusive masses near the northern edge of the mapped area.

These intrusive rocks, while described under different names, are more or less intimately related to each other. They are also chemically and mineralogically akin to the neighboring extrusive rock of the district. They must, of course, have been somewhat later in time of development than the volcanic series into which they have been intruded, but they undoubtedly represent deeper seated phases of the same magmas that supplied the surface flows, and were, therefore, formed almost simultaneously with these flows.

MONZONITE AND MONZONITE PORPHYRY—

Occurrence and Megascopic Description—

Very intimately associated with each other and showing frequent transitions from one into the other are two rocks that are intrusive in the surrounding effusive rocks and that have practically identical mineralogical composition. One of these two rocks is a typical monzonite and the other an equally typical mon-

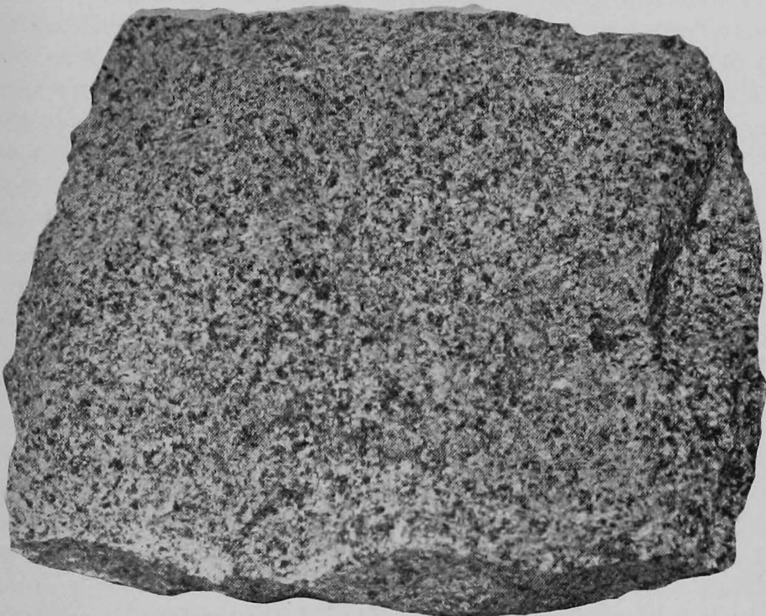


Fig. 1. Monzonite, from near the Gilmore mine on Klondyke Mountain. Natural size. See page 41.

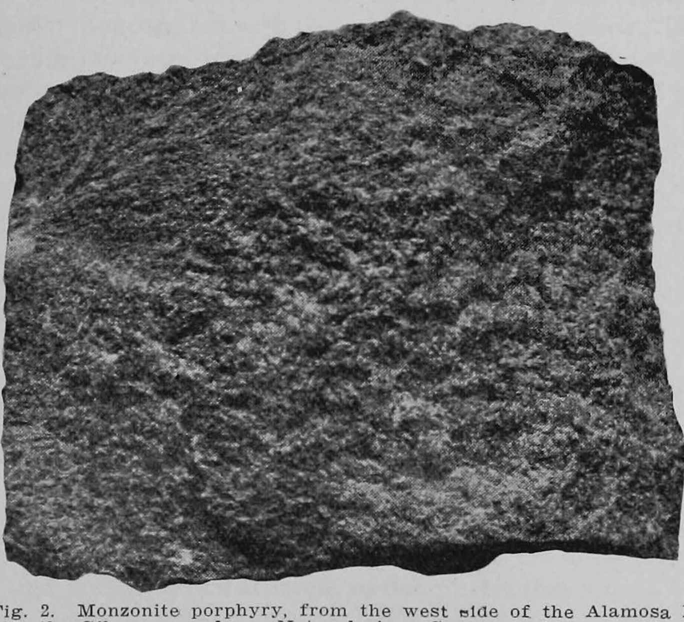


Fig. 2. Monzonite porphyry, from the west side of the Alamosa River, opposite the Gilmore meadow. Natural size. See page 42.

zonite porphyry. They have been mapped as one formation because in the field it is impossible to make a sharp distinction between them. The same difficulty of distinction is to a great extent met with in a microscopic study of the thin sections owing to the occurrence of textures intermediate between those of plutonic and effusive rocks. Undoubtedly they represent identical magmas crystallizing under somewhat different conditions of pressure or rate of cooling. As to the relative age of the two rocks, the evidence is contradictory. In some cases the monzonite porphyry is intrusive in the monzonite, in other cases the reverse is true. For all practical purposes, therefore, they represent one formation.

With the exception of a small area about two thousand feet long near Jasper, this intrusive rock is confined to a strip a mile to a mile and a half wide, occurring on both sides of the Alamosa valley in the vicinity of Stunner. The length of this mass is over four miles, but, as it extends to an unknown distance up the Alamosa valley beyond the boundary of the mapped area, its full size has not been determined. This rock is not altogether confined to the valley bottom, as it forms the entire mountain slope on the south side of the river below Stunner and builds conspicuous cliffs that rise to an elevation of 1,300 feet above the valley bottom.

The monzonite is a massive rock of grayish or greenish gray color in which biotite and both orthoclase and plagioclase feldspars can be recognized with the aid of a magnifying glass. Besides these minerals there is always much greenish colored material that cannot so readily be recognized and that consists in part of pyroxene and in part of chlorite or of partially chloritized biotite. (See Plate XIV, Fig. 1.)

The grain of this monzonite varies considerably in size. Normally the individual grain averages from one to two millimeters in diameter. Locally they may be somewhat larger than this, but still finer grain is more common. The finer grained portions of the rock lead naturally by transition stages into the monzonite porphyry.

Upon the whole this rock occurs in a fairly fresh condition, and in this case the orthoclase has a slightly pinkish cast and the biotite is of a rich bronze-brown color. Greenish colors in the rock are produced by the development of chlorite with perhaps some additional epidote. Complete alteration to white, earthy forms has been produced in this rock as is the case with the latite and andesite, and is treated in a separate section of this chapter.

The monzonite porphyry in color and general appearance may greatly resemble the monzonite and can with difficulty be distinguished from that rock. The groundmass is cryptocrystalline in varying degrees of fineness. In the finer gained forms the color is likely to be darker and the rock may then greatly resemble some of the andesites of the Summitville formation. Phenocrysts of plagioclase may usually be recognized, especially in the more pronouncedly porphyritic varieties. (See Plate XIV, Fig. 2.)

Microscopic Description—

These rocks vary in texture when viewed under the microscope from typically hypidiomorphic to equally typically porphyritic. In the plutonic types the principal constituents are plagioclase, orthoclase, biotite and pyroxene, named in the order of their relative importance. Also there is to be noted accessory quartz, magnetite, and apatite, and secondary chlorite and epidote. The plagioclase is distinctly older than the other silicates and the quartz occurs filling narrow spaces between the feldspars.

In the monzonite porphyry the plagioclase usually forms sharply defined phenocrysts. Even in the hypidiomorphic types this mineral has a pronounced tendency toward idiomorphic forms, and the development of a younger and an older generation is also manifested. Extinction angles in the zone perpendicular to the brachypinacoid reach a maximum of 19° to 20°, and are indicative of an andesine feldspar. Carlsbad twinning is greatly in evidence. The plagioclase resists alteration much better than does the orthoclase. In some cases it remains practically fresh alongside of orthoclase that has altered so as to assume a dirty gray appearance.

The orthoclase is only less abundant than the plagioclase. It is distinctly younger than that mineral and occurs in irregular grains of fairly large size. These grains of orthoclase usually partly surround the plagioclase. It is usually more or less clouded through kaolinization. Intergrowths with quartz of micropegmatitic character are frequent.

Quartz makes a relatively small part of the rock, but is always plainly visible in the plutonic types in the shape of small irregular grains filling the interstices between the other constituents of the rock, or forming micropegmatitic intergrowths with orthoclase. In one or two cases it appears that quartz has been formed as a secondary mineral in a process of silicification.

Pyroxene appears almost colorless in grains of fair size and of irregular form. They are nearly always fresh or nearly fresh, show

Fig. 1. Photomicrograph of monzonite, from the west side of the Alamosa River below Bitter Creek. ×15. Polarized light. The figure shows orthoclase (2), plagioclase (3), quartz (1), augite (6), and magnetite (black). See page 42.

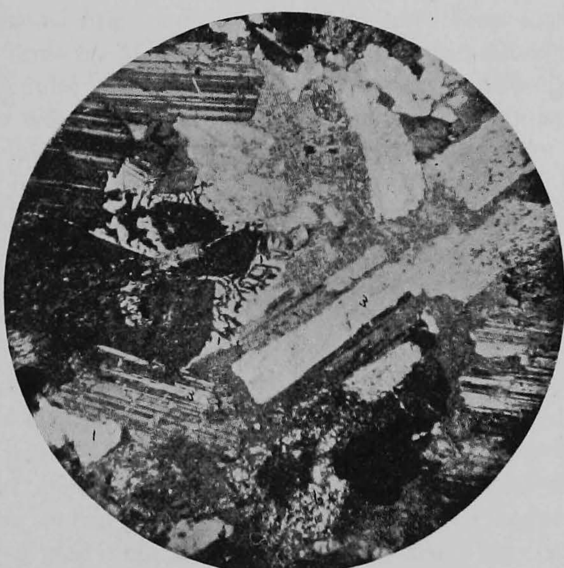


Fig. 2. Photomicrograph of monzonite, from top of cliff above the Eurydice mine at Stunner. ×15. Polarized light. The figure shows quartz (1), orthoclase (2), plagioclase (3). To the left of the center micropegmatitic texture is well shown. See page 42.

oblique extinction, and twinning parallel to the orthopinacoid. No orthorhombic pyroxenes were noted.

Biotite is usually much more abundant than pyroxene. When fresh it has a brown color, otherwise it is greenish through chloritization. This alteration may be only partial. The chloritization has progressed far enough to change the color from brown to green and almost to destroy the pleochroism, and the polarization colors have also been lowered, but not sufficiently to meet the requirements of chlorite. In outline the biotite is very irregular. (See Plate XV, Figs. 1 and 2.)

Geologic Relationships—

The monzonite and monzonite porphyry undoubtedly represent portions of the same magma crystallizing under slightly different conditions. It has not been possible to determine which of the two is the older. In some cases it would appear that the monzonite porphyry is intrusive in the monzonite; sometimes the reverse is true. It is more than likely that portions of the monzonite intrusions may have preceded the intrusion of the porphyritic type of rock, while other portions have come later. The porphyritic type is not nearly so extensively developed as is the hypidiomorphic type. It is mainly found around the margin of the latter.

The monzonitic magmas appear to have been intruded into both the Treasure Mountain latite and the Summitville andesite. But the definite relationship with these rocks is difficult to establish. This difficulty is largely due to the fact that intensive alteration has taken place in both rocks along the line where they come in contact north and west of the Alamosa river.

On the south and east side of the monzonite mass occur numerous dikes of monzonite porphyry and of andesite that so closely resemble each other that a field distinction is not feasible. This difficulty is enhanced by the heavy covering of glacial drift that completely obscures the rock formations over a large part of the ground where the contact between the andesite, monzonite porphyry, and latite formations is to be sought.

That portion of Klondyke Mountain that lies between the edge of the cliff above the Gilmore mine and the stream that drains through the central part of the mountain has been mapped as andesite after a study of thin sections made from only a few rock samples. In the field these same rocks were considered to be monzonite porphyry, and this region was provisionally so mapped. It is more than possible that both of these rocks occur on Klondyke

Mountain, and further study might necessitate a change in the map. The determination of its geological position was made solely on its petrographical character.

Chemical Analysis—

On page 31 is to be found a chemical analysis of this monzonite rock under the column headed P 57. The sample was taken from near the temporary sawmill above Stunner and is quite fresh, as is indicated by the small percentage of water and of CO_2.

QUARTZ MONZONITE PORPHYRY—

Closely related to the above described monzonite porphyry is a rock observed in the form of a few small dikes, too small to map, that were observed apparently cutting much altered monzonite to the west of Stunner. This rock contains the same mineral constituents as appear in the above described monzonite porphyry. It differs in the relative great abundance of quartz and in the greater coarseness of the groundmass constituents.

BIOTITE-AUGITE DIORITE—

Occurrence and Megascopic Description—

Among the distinctly intrusive masses that are to be found in this district is one that cuts the Summitville andesite formation and is apparently entirely surrounded by the andesite. It is in the form of a broad dike that occurs in the deep-cut valley of Wightman's Fork about midway between Summitville and the Alamosa river, just where the narrow rock-walled canyon suddenly widens out into a relatively broad and open valley. This dike has an approximate north-south direction and is about two thousand feet wide at the creek level. On the north side of the creek it narrows rapidly as it climbs the extremely steep canyon wall and is about 100 to 200 feet wide where it ends 800 feet above the creek level and at an elevation of 11,000 feet.

The western edge of the dike is sharply defined and well exposed, so that there is no difficulty in tracing it with accuracy. On the eastern side and on all sides to the south of the creek a heavy mantle of glacial drift covers the rock formations and renders an accurate mapping of the dike impossible. The dike appears to broaden out considerably to the south of the creek, but the boundaries as mapped are necessarily conjectural.

In general appearance this rock is somewhat intermediate between a rather fine grained gabbro and a diabase. In the field it

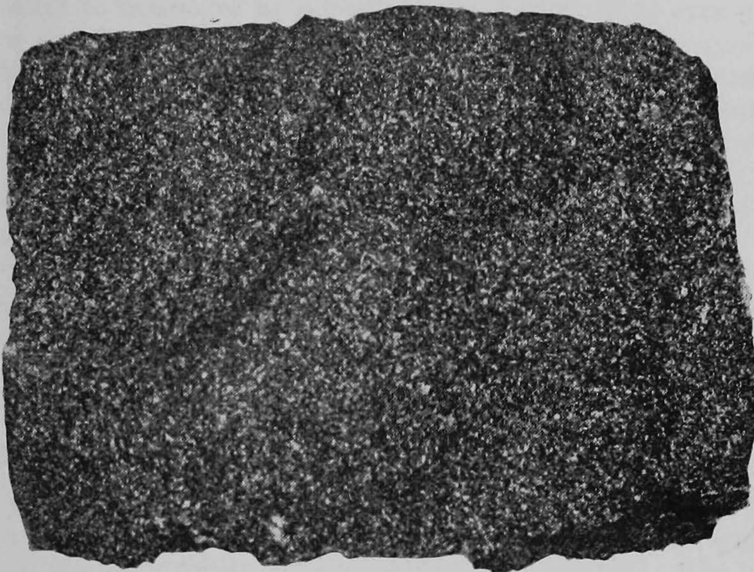


Fig. 1. Biotite-augite diorite, from a large dike intrusive in the Summitville andesite, Wightman's Fork. See page 44.

Fig. 2. Photomicrograph of biotite-augite diorite, from Wightman's Fork. The same rock as shown in Figure 1. ×15. Polarized light. The figure shows light-colored plagioclase strips, biotite (4), augite (6), and magnetite (black). See page 45.

was provisionally mapped as a diabase. But the composition and texture as revealed by a microscopic study indicates that it would better be designated as a biotite-augite diorite. It is dark gray or slightly greenish gray in color and has a uniform fine grained but not aphanitic texture. It may vary somewhat in coarseness in different parts of the intrusive mass. At the western contact of the dike near the upper end on the north side of the creek the rock developes a very distinct porphyritic salvage which so closely resembles the surrounding porphyritic andesite that a distinction between the two is difficult to make.

The plagioclase which forms the most abundant constituent is hardly to be recognized in the mass of the rock, but it also occurs in larger, very sparingly developed phenocrysts, and can then be readily identified. The other constituents of the rock cannot be recognized in the hand specimen. (See Plate XVI, Fig. 1.)

Microscopic Description—

Under the microscope this rock is seen to be composed of plagioclase, biotite, pyroxene, and magnetite, with accessory apatite and secondary calcite, chlorite, apidote, and leucoxene. The four thin sections prepared disclose considerable variation in texture and in the relative abundance of biotite and pyroxene. In one case (specimen P. 85) but very little biotite is present, and the rock has a texture very suggestive of the ophitic texture that characterizes typical diabase. In the other three cases biotite is more abundant than pyroxene, and the texture is not at all ophitic. (See Plate XVI; Fig. 2.)

Plagioclase occurs partly in lath-shaped and partly in more or less irregular rectangular forms. Extinction angles in sections perpendicular to the twinning plane reach a maximum of 30° to 32°, which indicates a labradorite of somewhat more basic composition than is found in the already described monzonites of this district. It is as a rule fresh, but alteration to carbonates is not uncommon.

The pyroxene occurs in irregular grains that appear almost colorless in thin section. It is easily recognized in spite of more or less alteration to calcite, chlorite, and epidote. In contrast to the pyroxene, biotite shows a strong tendency toward idiomorphism and discloses rectangular outlines. The color is green except in a very few cases where the brown color that originally characterized this mineral is still to be seen. Nearly everywhere the biotite has undergone a partial alteration through a process of chloritization.

This partial chloritization has changed the color from brown to green, has very greatly lessened the pleochroism, and has markedly lowered the double refraction. But in most cases the alteration process has progressed uniformly, so that the partially altered biotite crystals appear to have retained their homogeneity. The crystals are not frayed at the ends nor are there alternating streaks of chloritized and non-chloritized biotite.

Magnetite and accessory apatite are abundant.

The secondary minerals, chlorite, calcite, and epidote, appear to have been formed at the expense of both pyroxene and biotite, and also, to some extent, of plagioclase. Epidote is less abundant than are the other two. Leucoxene is fairly abundant in the form of excessively fine aggregates of grayish, highly refracting and strongly doubly refracting grains. These occur crystallized out in all the primary silicates of the rock.

In conclusion there should be mentioned the occurrence in part of the slides of a very little quartz and possibly also orthoclase that appear as an insignificant filling of some of the spaces between the plagioclase crystals.

Geologic Relations—

This diorite mass of Wightman's Fork is undoubtedly closely related to the intrusions of monzonite and of monzonite porphyry that have already been described. The resemblance in mineralogical composition is very close, as is also that in texture. The greater abundance of pyroxene and of magnetite, the absence of orthoclase, and the slightly more calcic character of the plagioclase present indicate a rock that crystallized from a somewhat more basic magma. The monzonite and diorite rocks represent intrusions that were not quite simultaneous in point of time or stages of differentiation in the consolidation of an originally homogeneous magma. Both rocks are intrusive in the Summitville andesite, but evidences of intrusion are not so pronounced in case of the monzonite as can be shown for the diorite.

DECOMPOSITION OF ROCKS

AREAS AND ROCKS INVOLVED

In the description of the various rocks of this district, attention has repeatedly been called to the intensive decomposition covering wide areas to which some of the rocks have been subjected. The alteration may be so extreme that hardly any resemblance to the original rocks can be seen in the alteration-product. The fin-

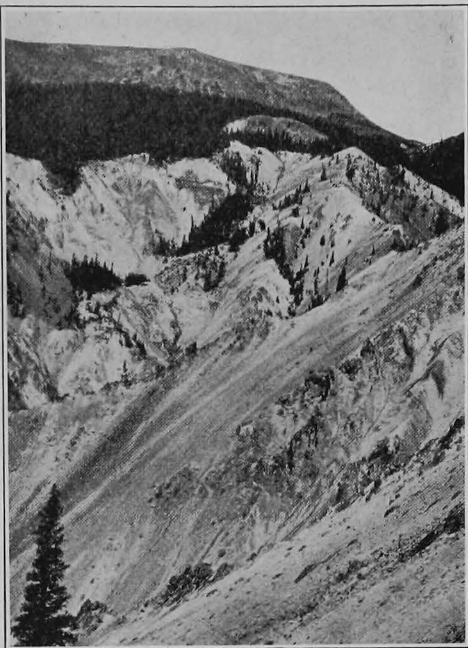


Fig. 1. Decomposed rock area in Alum Creek, near Stunner. The ridge in the background is Lookout Mountain.

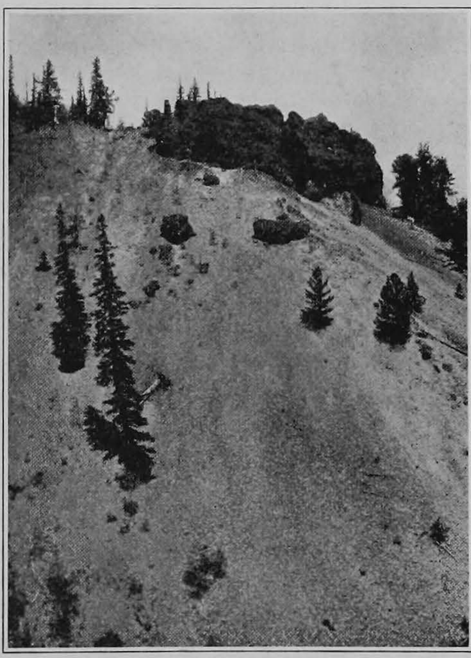


Fig. 2. Gravel cemented by limonite, capping a portion of the decomposed area of Alum Creek, near Stunner.

ished product of this extreme alteration is a light gray or nearly white, earthy looking, soft material. Where the original rock contained feldspar phenocrysts the outline of the feldspar may often be discerned, or where the unaltered rock was a breccia the angular outlines of the fragments may still be made out in the altered product, but in such cases nothing remains of the original mineral substances. Locally this whitish alteration material may be stained superficially and on the fracture and joint planes to brilliant red, yellow and brown colors, due to the deposition of a thin film of iron oxide; and extensive mountain slopes have assumed these brilliant hues, as, for instance, the south slope of Lookout Mountain.

Such decomposition is not confined to one kind of rock. Latite, andesite, monzonite and monzonite porphyry have been thus altered. For this reason it is impossible to give very definite and correct demarkation to the boundaries of these altered rocks. On the geological map accompanying this report (see Plate II in pocket) areas of alteration have been indicated by a color pattern. Over a very considerable area where there was little or no evidence of the character of the original rock, a special color pattern has been used to indicate decomposition irrespective of the nature of the rock involved.

The area covered by these altered rocks lies in the western half of the district with Lookout Mountain approximately in the center. Roughly speaking these altered rocks lie in a triangular area with Elephant Mountain, Sheep's Head and Gilmore at the three corners. The sides of this rough triangle measure respectively about 12,000 feet, 14,000 feet and 18,000 feet. An irregular extension to the northward from Lookout Mountain passes under Lookout Mountain and continues almost to South Mountain. Red Mountain and Little Red Mountain are altogether composed of such altered rocks. The cap rock of Cropsy Peak and of Lookout Mountain are not altered, but the base of both mountains has been subject to excessive decomposition, except apparently along the east side where the andesite is fresh enough to be recognizable.

MODES OF DECOMPOSITION

Although the effects produced by this extensive decomposition are apparently the same in nearly all cases, namely, the formation of a white, earthy rock looking like kaolin, there are really three quite distinct processes involved. These are customarily known as kaolinization, sericitization, and alunitization. In the laboratory investigation of these altered rocks it became evident that the samples collected in the field were not sufficiently numerous nor widely enough scattered to justify one in drawing very far-reaching conclusions as to the conditions under which these three processes have worked, or as to their relative importance.

Fourteen samples were subjected to a microscopic examination. Of these, six were andesite or andesite breccia; five were latite; one monzonite; one monzonite porphyry, and one of uncertain origin. Six of the fourteen contain kaolinite without sericite, one of them being practically pure kaolinite. Three contain sericite without kaolinite. Three are found to contain both of these minerals. Pure silica in the form of quartz, or chalcedony, or opal is present in abundance in all but three. Alunite was definitely determined in four of the fourteen. Of the four containing alunite, quartz or opal was present in all, kaolinite in two and sericite in none.

In addition to these fourteen altered rocks examination was made of three altered sanidine phenocrysts that came from different parts of a latite that occurs in the Winchester tunnel on South Mountain. Each of these crystals shows a greater or less alteration to sericite. The rock from which these phenocrysts came is also sericitized. It occurs in close proximity to the ore veins of South Mountain. One other rock showing sericitization came from the dump of the Iowa tunnel on South Mountain and is probably therefore found not far from ore deposits.

So far as one may be justified in drawing conclusions from these few cases, the proximity of ore veins has been favorable to the development of sericite rather than kaolinite. On the other hand all the altered rocks in which kaolinite has been developed are remote from ore veins. We are not, however, to infer that sericite is confined to rocks in proximity to ore veins, as it occurs in two other cases associated with kaolinite, and as it is a very common secondary mineral in all the rocks of the district outside of this area of intense decomposition.

The distribution of kaolinite appears to be much wider than sericite. According to Lindgren* kaolin, when it occurs in connection with sulphide veins, is likely to occur nearer the surface than does sericite and is formed under the influence of descending sulphuric acid solutions. It is most likely that the kaolin that appears to characterize much of this highly altered rock has been formed

*Waldemar Lindgren, Mineral Deposits, 1913, p. 457.

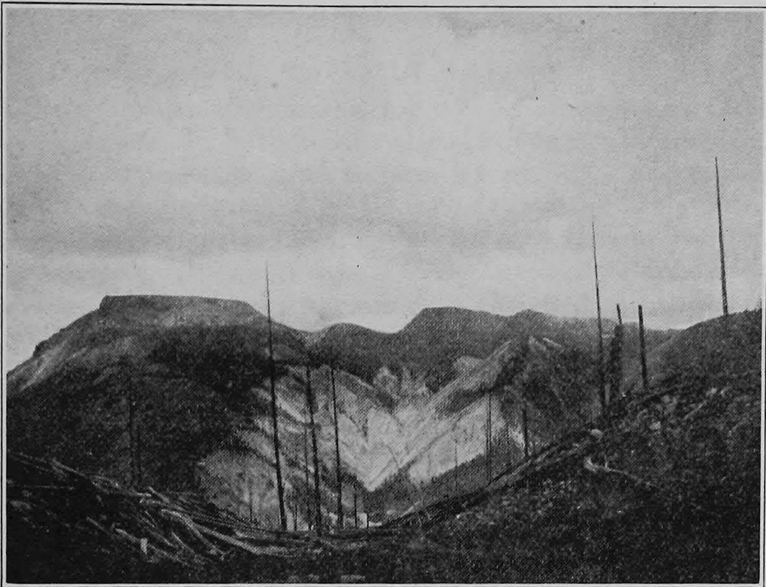


Fig. 1. Decomposed rock area of Alum Creek, as seen from the high ground on the opposite side of the Alamosa River. In the background is seen Lookout Mountain on the left and Cropsy Peak and Ridge on the right.

Fig. 2. Portion of the decomposed rock area (monzonite) forming a bluff eroded by the Alamosa River opposite Gilmore meadow.

under the influence of sulphuric acid arising from the oxidation of pyrite crystals that are very profusely scattered through this material.

BITTER STREAM WATERS

That sulphates and probably free sulphuric acid are present in great abundance in this altered material is evidenced by the fact that all the streams that drain the area covered by the altered zone have an extremely bitter and acrid taste. Samples of water taken towards the close of the summer when the streams were low from Alum creek, from a small branch of this creek, from Iron creek, and from Bitter creek, were analyzed by Merritt Hutton. The results are given below:

TABLE I

Analysis of total material in solution figured as Parts per million.

	Alum Creek	Branch of Alum Creek	Iron Creek	Bitter Creek
Volatile	240.75	1,189.0	48.5	44.6
SiO_2	70.5	328.0	29.5	29.5
Fe_2O_3	244.6	1,784.6	87.1	14.9
Al_2O_3	63.0	439.0	19.0	31.4
CaO	43.8	91.0	15.5	21.7
MgO	7.5	87.0	8.1	16.0
SO_3	633.5	3,813.0	145.1	129.3
Totals	1,303.65	7,731.6	352.8	287.4

TABLE II

Analysis of total material in solution figured as Grains per gallon

	Alum Creek	Branch of Alum Creek	Iron Creek	Bitter Creek
Volatile	14.04	69.36	2.83	2.60
SiO_2	4.10	19.13	1.72	1.72
Fe_2O_3	14.27	104.10	5.08	0.87
Al_2O_3	3.68	25.61	1.11	1.83
CaO	2.56	5.31	0.90	1.27
MgO	0.44	5.08	0.47	0.93
SO_3	36.96	222.43	8.46	7.54
Totals	76.05	451.02	20.57	16.76

While the amount of SO_3 is very marked in all four analyses, it is extraordinarily high in the case of Alum Creek and particularly of its small branch. These last two streams drain only territory covered by the decomposed rocks that are to a large extent bare of vegetation. The water obtained from the branch stream was so highly charged with iron that it was of a deep yellow color. Iron and Bitter creeks obtain most of their water from territory beyond the altered area.

ALUNITIZATION

The mineral alunite (composition $K_2O.3Al_2O_3.4SO_3.6H_2O$) has been identified in connection with a large number of sulphide ore deposits of the Cordilleran region. It was first recognized by Cross* as an alteration product of rhyolite in the central portion of the Rosita Hills in Custer county, Colorado, associated with quartz in a so-called quartz-alunite rock; also associated with diaspore. In connection with the discussion of gold-alunite deposits, Lindgren† states that "it is not uncommon to find considerable areas of bleached and altered lavas which contain more or less alunite, an earthy or compact, rarely coarsely crystalline mineral of inconspicuous appearance." That alunite may occur in areas of alunitization associated with rich gold deposits was made known through the investigations of Ransome‡ on the ore deposits of Goldfield, Nevada.

As stated above, alunite was observed in four of the samples of rock collected from the altered area. Three of the samples were taken from andesite or andesite breccia ground and one from latite. A specimen of andesite breccia (P 40) taken from the ridge on the west side of Lookout Mountain has an earthy appearance and an earthy smell. Its color is a grayish white. Small angular fragments of the breccia with somewhat whiter color are clearly discernible on a freshly broken surface. This rock, under the microscope, is seen to consist of alunite, quartz, and kaolin.

The alunite occurs fairly uniformly and thickly distributed through the rock in minute but sharply developed crystals that have the form of the rhombohedron combined with the basal pinacoid. As the pinacoid is the most conspicuous form, the habit is somewhat tabular. The most characteristic cross-sections are rec-

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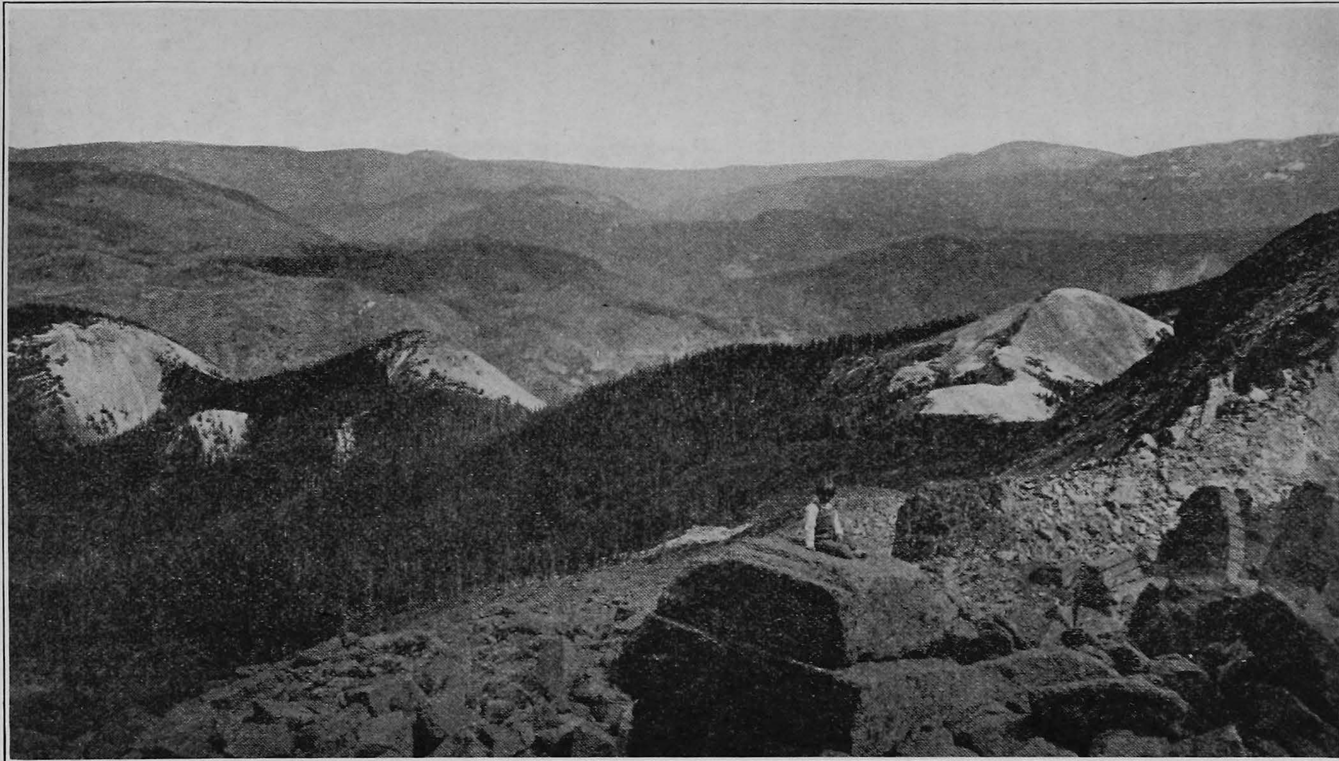
*Whitman Cross, On Alunite and Diaspore from the Rosita Hills, Colorado, Am. Jour. Sci., Vol. 41, 1891, p. 466. Also, Geology of Silver Cliff and Rosita Hills, Colorado, An. Rep. U. S. Geol. Survey, Part II, 1895-96, p. 314.

†Waldemar Lindgren, Mineral Deposits, 1913, p. 506.

‡F. L. Ransome, Prof. Paper, No. 66, U. S. Geol. Survey, 1919.



Portion of area of decomposed rocks as seen from Cropsy Peak, looking southeast. The three white-topped hills are "Big Red Mountain" to the left, "Little Red Mountain" in the middle, and a spur of Lookout Mountain on the right. See page 47.

tangles about twice as long as wide, and similarly elongated oblique-angled parallelograms. Other crystals of not quite so sharp forms show two parallel sides corresponding to the basal pinacoid and irregularly tapering ends. These crystals are surprisingly uniform in size. They measure .008 mm. to .012 mm. in length and about .004 mm. in width. They show a rather strong relief due to relatively high refractive power, similar in fact to sericite. The double refraction is only about one-half that of sericite as γ-α is seen to be about .02. The crystals have parallel extinction and negative elongation, corresponding to a positive hexagonal crystal.

The quartz associated with alunite occurs to some extent in nests of comparatively coarse, irregular grains, but mainly it is intimately mixed with the alunite in excessively fine and scarcely discernible particles. Kaolinite is also difficult to identify, as it occurs in almost impalpable powder.

This rock also contains a mineral that would appear to be rutile or possibly brookite. It occurs in minute prismatic grains that measure .01 mm. in length and .004 mm. in thickness, that have extremely high refractive powers and likewise very strong double refraction, in that the excessively minute prisms show interference colors of the second and third order. The extinction is parallel.

A chemical analysis of this rock was made by Messrs. George Roher and Esbon Y. Titus, with the following results:

Analysis of Alunite-bearing rock, No. P 40.

SiO_2	42.45	H_2O	8.86
Al_2O_3	28.64	TiO_2	1.08
Fe_2O_3	.90	ZrO_2	.06
FeO	.21	CO_2	.01
MgO	none	P_2O_5	.57
CaO	none	MnO	none
Na_2O	.85	Cl	.02
K_2O	3.56	SO_3	12.74
H_2O	.17	S	none
			100.12

Note:

Total loss on ignition	21.78
SO_3	12.74
Difference	9.04

which consists of

CO_2	.01
H_2O	.17
H_2O	8.86

Water by Brush-Penfield method gave 11.95%, 11.47%, and 12.19%, but contained SO_3.

In order to ascertain the percentage of alunite in this rock, the above analysis was recalculated. This can be done on the assumption that all the SO_3 is to be found in the alunite, or that all the K_2O occurs in the same mineral. The result in each case is practically the same, as shown in the tables below:

Percentage of Alunite based on

% of SO_3		% of K_2O	
SO_3	12.74	K_2O	3.56
K_2O	3.76	SO_3	12.08
Al_2O_3	12.14	Al_2O_3	11.52
H_2O	4.28	H_2O	4.06
Alunite	32.80%	Alunite	31.22%

On the basis that all the SO_3 is in the form of Alunite we have a percentage of K_2O that is .20% higher than the analysis allows. In this case this excess of .20% represents part of the Na_2O, which is likely to occur in this mineral.

Figuring out the percentage of alunite on the basis of the K_2O given in the analysis we are left with an excess of SO_3 amounting to .66%. On this basis we may assume that some SO_3 is combined in the form of an unidentified mineral. Assuming this to be the case, we have the following percentages:

Alunite	31.22
Kaolinite	43.33
Quartz, etc.	25.57
Total	100.12

Another rock containing much alunite was collected on the northwest slope of Lookout Mountain (specimen P 37). This is a very hard, compact rock that has the physical appearance of red jasper. Under the microscope alunite crystals similar to those described above occur except that they are not so sharply defined and that they are somewhat larger in size, namely, .02 to .04 millimeters in length. With the alunite is much silica in the form of opal and chalcedony.

Close to this specimen was collected a third that is nearly white in color and appears to be chert. This also contains alunite.

From the dump of the Iowa Tunnel on South Mountain a rock was collected that is an altered quartz latite. The original quartz crystals are still retained. All other original constituents are unrecognizable. The alunite crystals are rather irregular, with tapering ends, and are imbedded in a mass that appears to be nearly isotropic, and that is considered to consist essentially of opal and kaolinite.

Alunite has been used extensively in the manufacture of alum and of similar salts, and of late an effort is being made to use it as a source of potash, but it is not likely that any of the alunite-bearing rocks of this district are pure enough to be of any economic value.

QUATERNARY FORMATIONS

GLACIAL DEPOSITS

Just as there are today evidences that this portion of the San Juan Mountain range is unusually well watered, so we have also evidences that the same was true during Pleistocene times. It was hardly to be expected that mountain masses no greater or higher than are to be found in the Platoro-Summitville district should be centers of extensive glaciation. There is unmistakable evidence, however, that practically the entire area under consideration was heavily covered by a sheet of ice during the Glacial period. Most of the ice, it is true, came from the higher portions of the range lying to the south and west, more particularly from the vicinity of Summit and Conejos Peaks. But even these peaks are a thousand feet lower than the higher summits of the San Juan range to the west.

The evidences of this glaciation are seen in extensive ground moraines that cover many miles of territory; in sharply defined lateral moraines, a thousand or more feet above the valley bottoms; in the presence of glacial lakes; in the grooving and scratching of the rocks over which the glacier passed, and in the excessive steepening of the sides of the valleys.

There were two dominating glacial streams to which the others were tributary. These occupied the valley of the Conejos and Alamosa rivers. In addition to these main glaciers there were several local centers of glaciation, namely, Cornwall Mountain, the South Mountain-Cropsy Peak-Lookout Mountain range, and North Mountain lying to the north of Summitville outside the mapped area.

The Conejos Glacier

The Conejos glacier, which had its source in and around Conejos Peak, filled the entire valley between Klondyke Mountain, Mammoth Mountain and Cornwall Mountain. At the extreme southern margin of the mapped area to the southwest of Platoro, the course of the glacier was north, following the direction of the valley. It spread out to the west on the flat-topped Klondyke Mountain, covering the greater part of this flat top, and uniting somewhere towards the western part of the mountain with the Alamosa glacier, so that the two glaciers combined, covering the entire top of the mountain.

Between Platoro and Cornwall Mountain the flow of the glacial stream was in a southeasterly direction. This is shown by the configuration of the surface as indicated by the contour lines north and northeast of Platoro. The highest point reached on Cornwall Mountain is a little to the northeast of the prominent point marked on the map by the triangulation station T22 at an elevation of 11,700 feet. The southern contact of the main Cornwall Mountain basalt cap is practically the northern limit of the Conejos ice sheet. At this station the direction of motion was southeast. Between Klondyke Mountain and station T22 the glacial stream swung round in a fine great curve through an angle of about 135°. In the vicinity of the glacial lake to be seen a mile west of Platoro the glacial topography is characteristically and beautifully developed. (See Plate XX, Fig. 1.)

The Conejos and Alamosa glaciers combined over-rode the entire territory lying between these two streams. The exact line of junction was not determined, but it lies somewhere on the great flat divide to the east of Big Lily lake.

Whether this glacier over-rode the top of Mammoth Mountain was not determined, but this is not likely.

The Alamosa Glacier

The glacier that occupied the Alamosa valley filled this valley to the brim. On Cornwall Mountain it covered the area now occupied by Kerr lake and extended to an undetermined distance up the slope to the east of that lake. It filled the big gorge to the northwest of Cornwall Mountain, turned sharply to the east just above Jasper, and continued down the valley for something like fifteen

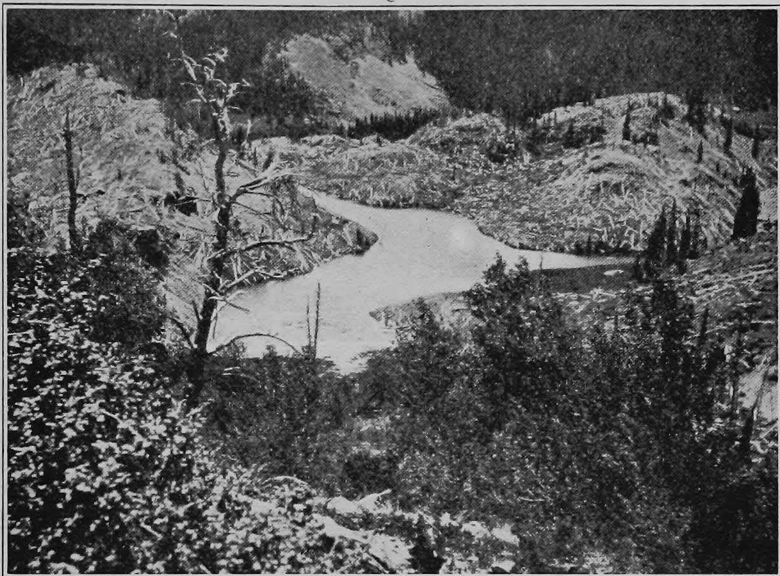


Fig. 1. Ground moraine with a glacial lake, one mile west of Platoro. See page 54.

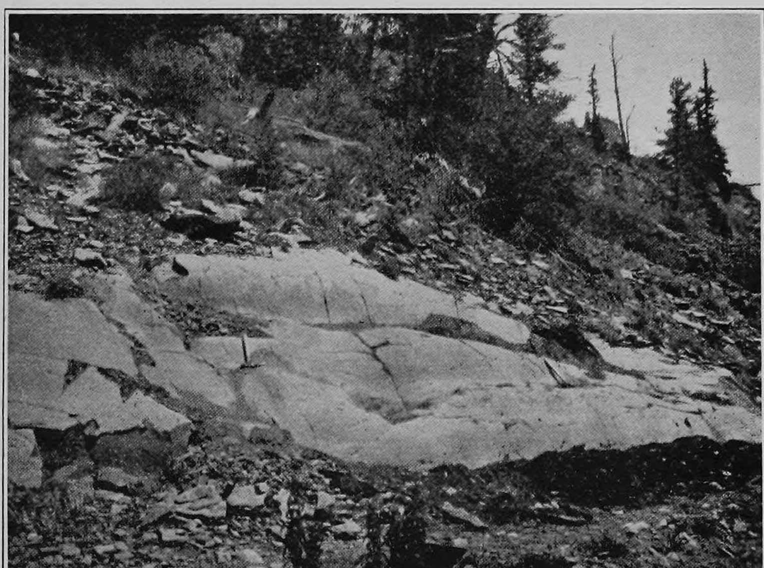


Fig. 2. Rock surface eroded and smoothed by action of the Alamosa glacier. Alamosa valley, below Jasper. See page 54.

miles, where it deposited a fine terminal moraine. This glacier is marked by evidences of extensive erosion. The steepening of the valley sides by ice action is very marked on the right side above and below Stunner. The principal tributary to this glacier came down Wightman's Fork from South and North Mountains and left sharply defined lateral moraines on the south side up to seven or eight hundred feet above the valley bottom.

Independent Glacial Centers

Although Cornwall Mountain was not over-ridden by either the Conejos or the Alamosa glaciers it was apparently a local center for the accumulation of snow and ice. A small glacier gathered on the northern slope and flowed down through Castleman Gulch. It formed a very pretty cirque that is now occupied by a little lake that goes under the name of Crater lake. This is at an elevation of 11,700 feet.

The north-south running range with South Mountain on the northern end and Lookout Mountain on the south, was another local center of glaciation. The motion of the ice on the northern end of this range was to the northeast and carried glacial boulders of the characteristic South Mountain latite and of the still more characteristic quartz replacement veins of this mountain well across the bottom of the Wightman's Fork and to a point some five or six hundred feet above the valley bottom on the north side of the valley.

From the central part of this range the ice moved eastward over-riding the summits of Elephant Mountain and of Big Red Mountain and Little Red Mountain. The evidence that this ice sheet moved over the summit of Elephant Mountain appears to be convincing. It consists in glacial striations on the very summit of the mountain running in an east-west direction, and in the discovery of South Mountain latite, and the black latite vitrophyre of the South Mountain range in the form of boulders on the summit of Elephant Mountain.

It is to be regretted that time did not suffice for a thorough study of the pleistocene deposits in the Platoro-Summitville district. No attempt to map the glacial moraines or to distinguish between the moraines has been made. In certain limited areas in the vicinity of Big Lily lake, the morainal deposits have been mapped for the reason that they so completely cover the underlying rock formations that a mapping of these formations was impossible.

LANDSLIDES

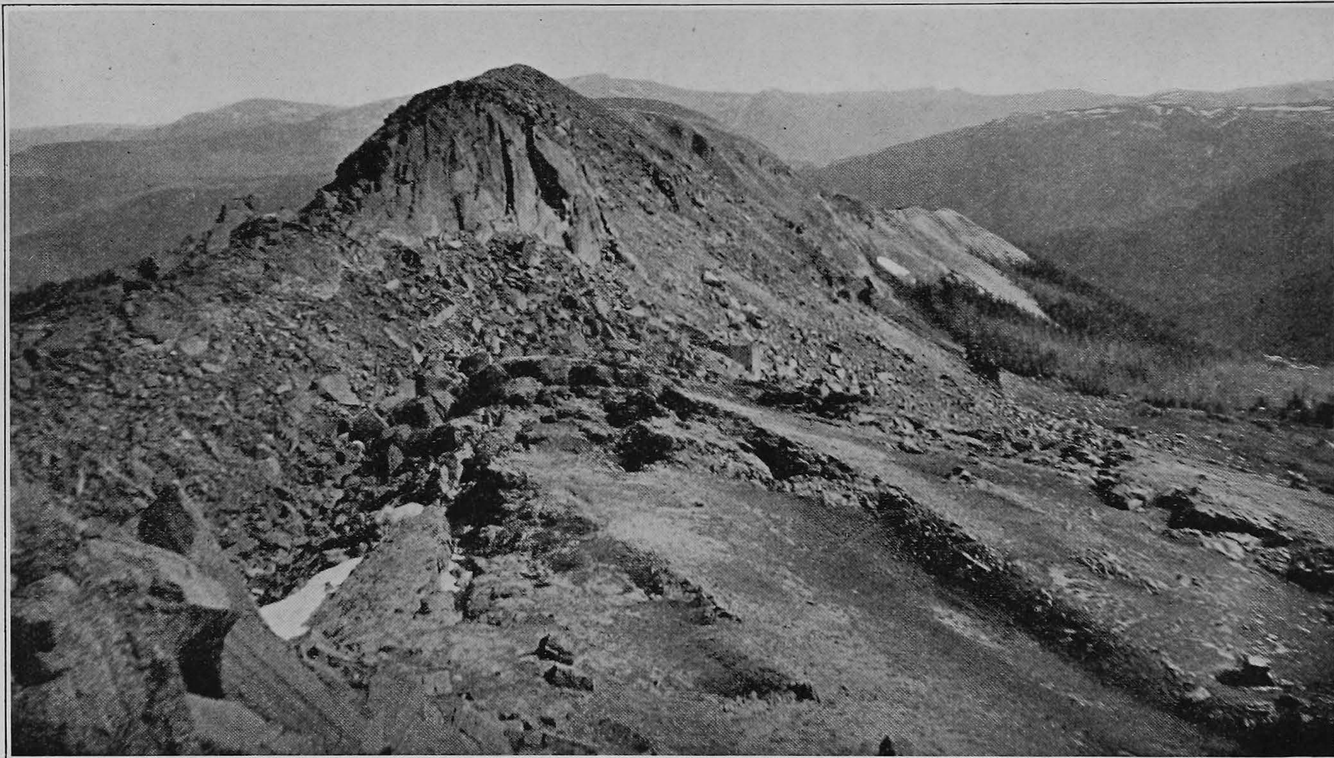
The occurrence of landslides in mountainous areas is a fairly common phenomenon and might naturally be expected wherever we have mountain slopes of sufficient steepness. Landslides on a tremendous scale have been described as occurring in the higher portions of the San Juan Mountains in Ouray and adjacent counties. More especially they have been described in great detail by Howe* in a lengthy paper entitled "Landslides in the San Juan Mountains, Colorado." In the portion of the San Juan Mountains covered by Howe's paper the landslides—and more especially that type of landslides characterized by a rapid plunge of broken rock down a mountain side with a stream-like movement, to which the name "rock streams" has been given—have been attributed to the over-steepening of the sides of the valley by the erosive action of active glaciers, and to the formation of glacial cirques. They are found mostly in the higher regions above timber line. Similarly in the Platoro-Summitville district we find landslides developed where the mountain slope is unusually steep, due in each case to glacial action.

One of these slides is to be found on the west side of Cropsy Peak and Cropsy Ridge for a distance of some 4,000 feet. Here the movement has probably been slow and has been due to the presence of soft decomposed rocks underlying the hard cap of latite. Over this area the ground has been broken up into irregular hummocks and hollows and has produced a topography somewhat suggestive of that commonly seen in regions of ground moraine. It has also caused the development of numerous cracks of considerable width and depth.

Before this movement started there was no saddle between Cropsy Peak and Cropsy Ridge, but the two formed a continuous ridge. The landslide movement in this case extended to the further side of the ridge and carried the crest of the ridge down with it. At the saddle in the ridge this has been very pronounced and has been responsible for the formation of the saddle. This saddle is now composed of jagged rocks that on the south side fall off perpendicularly into a deep depression caused by the movement of the rock formation away from the ridge. On Plate XXI and on Plate XXII may be seen a photographic view of this crater-like depression.

The summit of Cropsy Peak was similarly carried down in this landslide movement, and the rocks have been broken up into

*Ernest Howe, U. S. Geol. Suurvey, Prof. Paper, No. 67.



Landslide in the saddle between Cropsy Peak and Cropsy Ridge, as seen looking south towards Cropsy Ridge. See page 56. See also Plate XXII.

Landslide in the saddle between Cropsy Peak and Cropsy Ridge, as seen looking north toward Cropsy Peak. This is the same slide shown on Plate XXI. See page 56.

Huge blocks of quartz-biotite latite on the summit of Cropsy Peak, jumbled together as the result of a landslide. In the center is the so-called "Chipmunk rock" to the left of the peop e. See page 57.

great angular blocks that stand piled together in chaotic fashion. One of these blocks of more than usual size is left standing up on end and has a shape that from a distance reminds one of a chipmunk sitting up erect. This block is almost on the summit of the peak and can be see from a distance of several miles. On Plate XXIII is reproduced a photograph of this "chipmunk rock."

A second and more extensive landslide is to be seen at the foot of the steep cliffs that mark the right-hand side of the Alamosa valley at and below Stunner. Here the landslide movement has extended along the cliff for something like six or seven thousand feet. The movement seems to have started at or near the top of the steep declivity and to have extended half way down or even nearly to the bottom. In this case the movement cannot be explained by softening of the underlying formations or to any great decomposition of the rocks. The rocks involved are perfectly sound monzonite and monzonite porphyry. Undoubtedly the cliff had been eroded by the Alamosa glacier to a condition of very great steepness.

The Gilmore Landslide

A similar landslide that presents some features of remarkable interest is to be seen on the northwest side of Klondyke Mountain in the vicinity of the Gilmore mine. As this slide has an important bearing on the development of the gold telluride veins of the Gilmore and adjacent mines, it is worthy of a more detailed description than that given to the slide opposite Stunner.

Here, too, the rocks are solid monzonite with a very little monzonite porphyry. The movement extends for a length of nearly six thousand feet and for a greatest breadth of 1,200 feet. As in the case of Cropsy Peak, so here, the rocks have cracked back of the top of the cliff, which has been carried downwards. Near the upper part of the disturbed area the rocks are not badly broken up, but large cracks have developed and depressions have been formed by the dropping down of segments of the rock. (See Plate XIV, opposite page 58.) Lower down the slope the rocks on the surface have been left in a succession of ridges and trenches that bear a striking resemblance to lateral moraines. They differ from moraines in three respects: First, the ridges and trenches are not horizontal nor even approximately so, but run diagonally down the mountain side, keeping nearly parallel to each other; Second, the loose material of the ridges is not in the slightest degree rounded nor striated; Third, to a very considerable extent the ridges are composed of rocks unbroken or at most only slightly cracked and shattered. On Plate XXV will be seen photographs of two of these troughs. On account of the thick growth of trees it is difficult to obtain a photograph that shows more than a short length of trough. But these two photographs give a fair idea of the conditions found in this landslide area. In each case the left side represents the higher or mountain side of the trough. On this side we usually find broken rock fragments similar to those that form a rock talus slope. On the outer or down-hill side the inner surface of the ridge, facing the trough, is often smooth and composed of relatively unbroken rock masses.

An excellent idea of these troughs and ridges may be obtained by an inspection of Plate XXVII, facing this page. This is a reproduction of a photograph taken from a model of a portion of this landslide made by Messrs. R. W. Smith and Wm. G. Zulch, two student members of the party. This shows a succession of ripples running diagonally downward to the left. The ridges and troughs are confined to the upper half of the mountain slope, which has a total elevation above the valley of 1,500 feet. The lower half consists largely of talus material that probably represents in part loose blocks that have rolled to the bottom in connection with the landslide movement. There are ten or a dozen of these rock ripples that are conspicuous enough to show in the model. These have an average spacing of about one hundred feet. The ridges vary from five to twenty feet in height above the bottom of the troughs, and in a few cases greatly exceed twenty feet. Some of them continue unbroken for a distance of 2,500 feet. Above these conspicuous ridges lies an area of comparatively gentle slope on which occur other lesser troughs and ridges that do not show in Plate XXVII.

The model from which Plate XXVII was taken was prepared from a detailed contour map of this portion of the landslide. The contour interval of this map is twenty feet. It was surveyed by the same parties who made the model and is reproduced on Plate XXVIII.

On Plate XXIX, facing this page, will be found three sections of this area. The sections correspond to the three lines marked on Plate 17 and on Plate 18, marked respectively AA′, BB′, and CC′. These are drawn to scale and give a good idea of the sharpness of these ridges and troughs.

Not everywhere, of course, are these ridges regular in height and spacing. Locally there is great irregularity, due to unequal movement in different parts of the mass and to variations in the

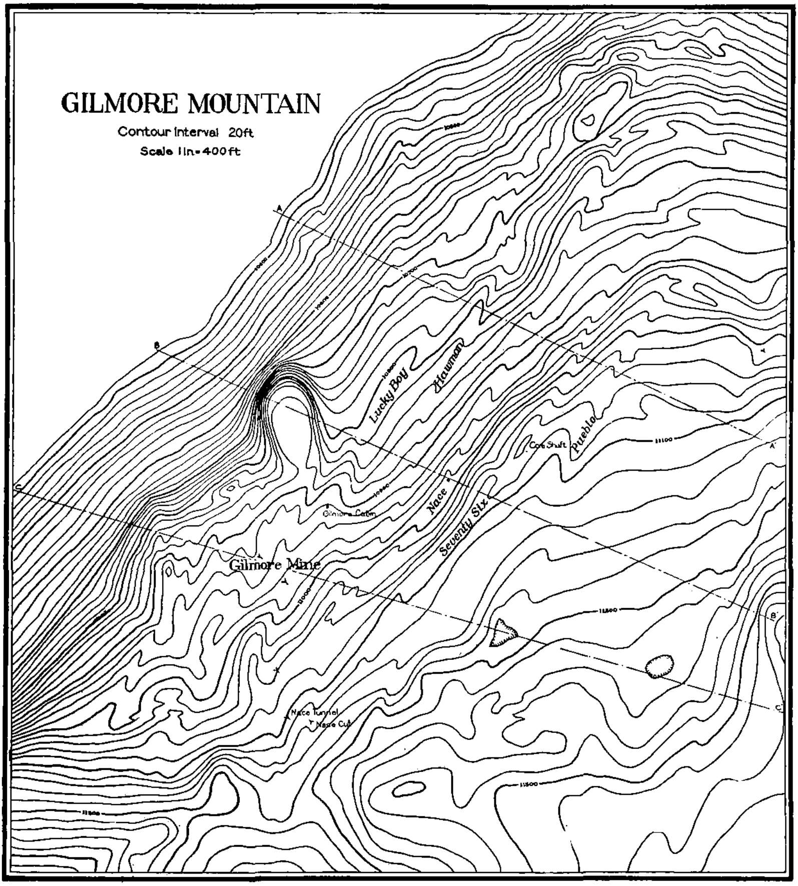
Block of sunken ground, to the left, in the upper portion of the Gilmore landslide on Klondyke Mountain. The low ground on the left was originally as high as the high ground on the right.

Fig. 1. Characteristic trough formed by the Gilmore landslide. See page 58.

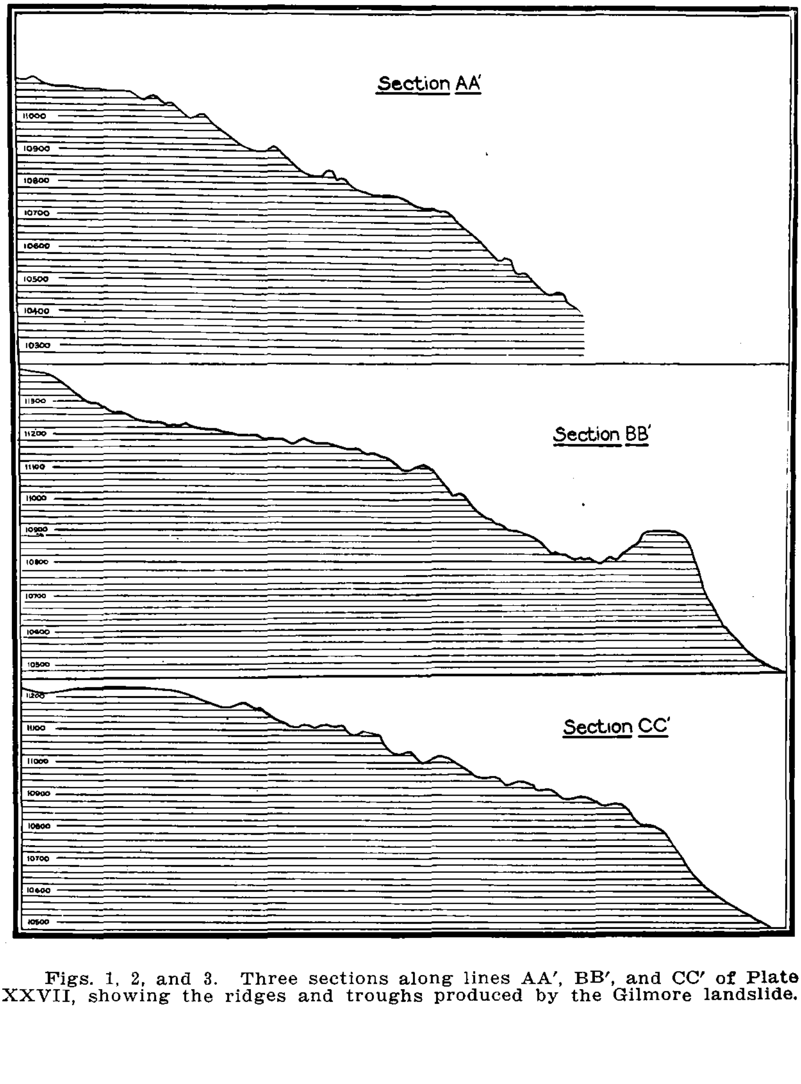
Fig. 2. Characteristic trough and ridge formed by the Gilmore landslide. The holes in the foreground are prospect holes, and disclose one of the quartz veins of the district. See page 58.

General view of the Gilmore landslide as seen from the north. The characteristic ridges are mostly hidden by the trees. See page 57.

Photograph of a relief model of a portion of the Gilmore landslide, showing the characteristic ridges and troughs.



Contour map of a portion of the Gilmore landslide.



Figs. 1, 2, and 3. Three sections along lines AA', BB', and CC' of Plate XXVII, showing the ridges and troughs produced by the Gilmore landslide.

surface before the movement started. The most striking instance is to be seen in the very conspicuous knob on the line BB′. This represents a solid mass of rock that was separated from the cliff above it and was not only moved bodily several hundreds of feet down the slope, but was swung around on a hinge, the hinge being located at the neck or saddle that connects this knob with the main mountain slope below the Gilmore cabin. The upper surface and likewise the outer surface of this knob are planed and groved by glacial action. Apparently the outer face has not been materially steepened by the movement of the knob. It represents the excessive steepening produced along this part of the valley by the erosive action of the Alamosa glacier.

It is difficult to estimate the total amount of movement that has taken place as it is almost impossible to establish the original topography. That the central portion has moved further than the two ends is shown by the fact that the ridges and troughs slope diagonally downward from the two ends towards the middle. That is, to the east of the central portion of the landslide area the troughs pitch diagonally downwards towards the west, while to the west of the center they pitch toward the east. In this central part the total movement must have been not less than four or five hundred feet. It may have been considerably more.

It is difficult to understand how this great movement could have taken place in rocks practically fresh and so massive as is the monzonite of the mountain slope. It must in some way have been due to the jointing of the rocks. An effort to establish a system of jointing in this area was not very successful, as the joints appear to be rather irregular. Still there does appear to be a system of joints that dip downwards with the slope of the mountain side. There are also several other systems of joints that run in other directions and doubtless occasioned the breaking up to some extent of the rock mass when once the movement had started.

But there are certain features that are difficult to explain by any accepted theory of landslide movement. As will appear later in Chapter VI the Gilmore mine is situated within this landslide area and is located on a quartz vein. Several of these quartz veins have been prospected for gold within the past few years. There are at least three or four of these veins, and all have a definite position with reference to the troughs and ridges. The direction of outcrop follows definitely that of the ridge or trough. The position of the vein is somewhere between the bottom of the trough and the top of the ridge, that is, on the inner slope of the ridge facing the mountain, never on the outer slope. In all cases they dip towards the mountain at angles between vertical and 60°. These veins may be traced for distances of several hundred feet to something like a thousand feet.

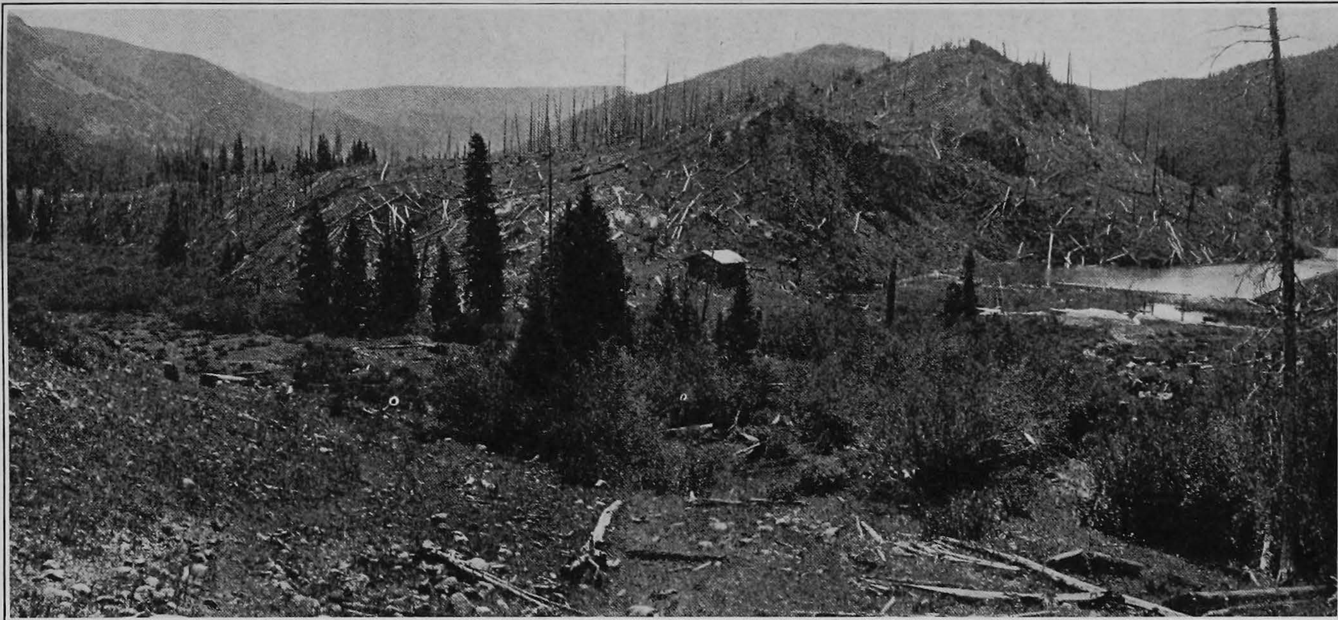
It is evident that there is some causal connection between the veins and the troughs and ridges. The theory that would seem to present the least difficulties is that there were a number of parallel-running quartz veins cropping out on the surface and striking approximately parallel with the contours of the mountain slope. When the slide started the superficial portion of the monzonite mass slipped by a shearing movement along steeply dipping joint planes, carrying with it the sheared-off quartz veins. This sliding superficial layer immediately broke up into numerous parallel blocks along lines of weakness that ran parallel to the quartz veins. As the blocks progressed down the slope they separated more or less from each other so that gaps of varying width had developed between them when they came to rest. For some unaccountable reason the blocks seem to have parted along lines that ran just back of the quartz veins, so that the veins determined not only the direction of the cracks, but also their location. No quartz veins have been noted outcropping on the outer slope of the ridges. It need not be assumed, however, that veins do not occur in this position. It may be that there are such veins, but they do not appear on the outer slope, because this presumably represents the original ground surface and is covered with soil, or because this outer slope above the cracks was particularly liable to break up into small talus blocks either during the movement of the landslide or subsequent thereto.

ALLUVIAL DEPOSITS

Alluvial deposits are of rather limited extent within this district. They consist of river gravels, sand and silt, alluvial fans, and high-ground meadows or swamps.

In the vicinity of Platoro is a river flood-plane deposit that extends along the whole course of the Conejos river within the boundaries of the mapped area. This varies from two or three hundred feet to two thousand feet in width, and is made up of the ordinary gravel, sand and silt of river bottoms.

At Jasper is an alluvial deposit of different character. At this point three streams enter the Alamosa from the north. Two of these drain an area of rock decomposition similar to that in the neighborhood of Lookout Mountain. These streams are subject to



View showing reversal of drainage caused by a delta deposit in a glacial lake one mile west of Platoro. The lake originally drained through the valley to the left. A stream hidden by the bushes in the right foreground deposited a delta which blocked the outlet and caused stream and lake to flow out through the valley in the right background.

floods and they bring down a tremendous amount of detritus from the deeply scoured, altered rocks above. The combined effect of these three streams is to develop a great alluvial fan upon which the town of Jasper lies. This fan extends along the river for a distance of seven or eight thousand feet and runs back from the river some four thousand feet.

A third form of alluvium is seen in the numerous flat swampy meadows that occur on flat ground, mostly at considerable elevations and usually surrounded by timbered ground. The deposits in these meadows is largely of organic origin. Some of the larger have been mapped. Among these is the Gilmore meadow situated at the foot of Lookout Mountain and affording a superb view of that picturesque peak. (See Plate XXXIX, facing page 98.)

Structural Geology

In a region confined entirely to igneous rocks it is hardly to be expected that there will be very great complexity of rock structures. Such structures as exist have been largely alluded to in connection with the description of the rock formations. Briefly summarized it may be stated that most of the igneous formations consist of surface lavas that have poured out in successive flows over an irregularly eroded surface. The different flows represent not only different rocks, but distinct periods of volcanic activity separated at times by prolonged periods of erosion.

Into this great series of volcanic rocks with their accompanying tuffs and breccias have been intruded irregular bosses of plutonic rocks and of their porphyritic equivalents. Dike rocks are not very extensively developed. There are dikes of andesite of composition similar to the Summitville andesite, and other dikes that are associated with the latite of South Mountain and that may be looked upon as feeders for these latite flows.

There is no very pronounced evidence of extensive folding, although some folding may be presumed to have taken place. On Cropsy Ridge the latite flows on the southern end assume an almost vertical dip as though they had been tilted up through an angle of 90°. But some of this steep dip may be due to the lava having been poured out over a country of rugged topography, and some of it may be due to the contortions that are often to be noticed in the flow planes of viscous lavas.

It is almost certain that faulting has taken place on a greater or less scale in different parts of the territory, but faulting is not always easy to recognize in rocks of this character unless it occurs on a large scale. There is, however, one great structural fault that has had a marked influence on the geology of the district, and that may be designated as the Cornwall fault. It may be seen running straight up the very steep slope of Cornwall Mountain about three quarters of a mile west of Jasper. On reaching the high point called the "Nose," this fault follows along the ridge that connects this point with the summit of Cornwall Mountain, then, crossing the ridge, it skirts along the northwestern slope of Cornwall in a general westerly direction, passes to the north of Kerr lake and then, after crossing Acme gulch, disappears in the intrusive monzonite below Stunner.

This fault has been traced on the surface for a distance of nearly four miles. It undoubtedly extends to some distance north of the Alamosa river above Jasper, under the alluvial fan, but at this point passes beyond the boundaries of the mapped area. On the west end it probably runs for some distance into the monzonite, where it could not be traced.

At the fault-line is disclosed a sharp contrast between the Summitville andesite on the north and west and the Treasure Mountain latite on the south and east. This is well exhibited on the ridge that runs north from Kerr lake, where the comparatively light colored and homogeneous Treasure Mountain latite comes in contact with the very dark colored and constantly changing andesite breccias of the Summitville formation.

By this fault the lower lying and older rocks of the Treasure Mountain formation on the southeast have been raised up to the level of the younger andesites on the northwest. How great is the amount of the vertical displacement there seems to be no way of ascertaining. As both the latite and the andesite extend from the bottom of the Alamosa valley at Jasper up to the level of the ridge that runs north from the summit of Cornwall Mountain, it might easily be assumed that the vertical displacement must at least equal the difference in elevation between these two points, which amounts to 2,200 feet. This does not, however, necessarily follow unless the original contact between these two formations was horizontal. There is no place shown on the map where the andesite can be seen lying on the latite. But a half mile southeast of Jasper along the road leading to Monte Vista the andesite may be seen lying directly on the Treasure Mountain latite. It is, therefore, younger than the latite.

At this place both formations lie east of the fault and are not affected by the fault movement. The plane of contact appears to have a northerly dip, but the amount of the dip could not be determined. In any case, however, it is probable that the andesite lies unconformably on the latite and may have been poured out on a surface of great irregularity. It will be seen, then, that the amount of the vertical displacement must be left an open question. But the extent of the fault and the great irregularity of the surface over which it has been traced call for a fault of very considerable displacement, easily two thousand feet and quite possibly more than this.

This fault shows no trace of a fault scarp, a fact that bears testimony to the great amount of erosion that has taken place since the beginning of the fault movement.

The map of the district shows a tongue of basalt west of Kerr lake extending north almost to the fault line. It is not known positively whether the basalt extends beyond the fault line or not. It would be of great interest could this fact be established, as it would throw light on the period during which the fault took place. Between the Treasure Mountain latite on which the basalt lies and the Hinsdale formation, to which the basalt presumably belongs, lies a great time interval during which very extensive faulting and erosion could have taken place. Mr. Esper S. Larsen, who has, in co-operation with Dr. Whitman Cross, made extensive investigation of the igneous series of the San Juan Mountains, informs the writer in a private communication that "a great thickness of rocks is normally between the two and there are at least four great unconformities (in the sense of long erosional intervals) in the intervening section." The intervening section includes the formations given the provisional names of Summitville, Alboroto, Huerto, Piedra, and Fisher quartz latite.

The position of the Summitville andesite in this series has not as yet been determined, except that it lies over the Treasure Mountain latite. If we may presume that it belongs to one of the lower of the formations named by Mr. Larsen, then it may safely be assumed that there has been abundant time between the laying down of the Summitville lavas and breccias and the outpouring of the basalt for the development of the Cornwall fault and for the removal of the fault scarp by erosion.

If the basalt is correctly mapped, as it presumably is, this faulting and erosion must have been completed before the basalt flows began. The grounds for possible doubt lie in the fact that the mapping of the basalt was done before the presence of this great fault was recognized and it was not recognized in the field how important it was to determine the exact position of the fault with reference to the basalt. At the point where the basalt terminates the flow is broken up into a mass of angular blocks from which a great talus stream extends many hundreds of feet down the mountain side, nearly to the bottom of Acme Creek gulch. There is no doubt that this extensive basalt talus extends far beyond the fault line, and it would seem almost necessary to assume that the flow itself did also extend beyond this line. At any rate, the basalt was originally mapped as shown. It is to be regretted that there was not opportunity subsequently to check up this observation.

CHAPTER IV

SUMMITVILLE DISTRICT

LOCATION

Summitville is situated in the extreme northwest corner of the mapped area of this report. Its location is at the north foot of South Mountain nearly at the head of Wightman's fork, a branch of the Alamosa river. The elevation of the town is approximately 11,300 feet. It was formerly known under the name of Summit district, and under this name the mining claims of the district have been recorded in the federal land office. A county road leads from Summitville in a northeasterly direction to Del Norte, distant some twenty-eight miles. Much of this road is in good condition, but in places, owing to neglect, it has become nearly impassible except during a few summer and fall months. Snow lies in heavy drifts on South Mountain until well into the summer.

HISTORY

Owing to the discovery of very rich gold ore in several of the mines in this district in the early days, Summitville for a brief space enjoyed one of those sudden, but evanescent, booms for which the Rocky Mountain west has become celebrated. Owing to the absence of authentic records it is impossible to verify most of the stories related concerning the development of this mining camp, but a file of the Rocky Mountain "News", published in 1877, contains an account of the discovery of the ore deposits of this district which Frank Hall* considered sufficiently reliable to incorporate in his history of the state, published in 1895. In the absence of more authentic records, this account is herewith presented:

"The first discovery of gold was made in Wightman's gulch about the last of June, 1870, by a party consisting of James L. Wightman, E. Baker, J. Cary French, Sylvester Reese and William B. Wightman. All the party excepting Reese and Wightman left

*History of Colorado, Vol. IV, p. 291.

by the middle of September, the two last named remaining engaged in sluicing until the 9th of November, when they also took their departure heavily packed, and made their way through snow waist deep, reaching the Rio Grande three days later. In the spring of 1871 a large number of people flocked into Summit, hundreds arriving while the snow was still very deep and work utterly impracticable. A general disgust followed, and by the last of August there were but three men in the district—P. J. Peterson, J. L. Wightman and J. P. Johnson, who remained until about the 20th of October, Wightman and Peterson being the last to leave. They took the gold produced by sluicing to Denver and had it refined at the mint, dividing $170 between the three after paying all expenses of the season's operation. Meanwhile several lodes had been found and claim locations made thereon. In 1872 a few locations were made, but in 1873 there came a new immigration, and it was in that year the richest mines were located. The Esmond (now the Aztec) was discovered in 1872 by Theodore Goupil, and by him sold to Dr. Adams. On the 13th of September, 1873, F. H. Brandt and P. J. Peterson located the Little Annie, Del Norte and Margaretta mines, the former being named for a daughter of Mr. Peterson, the latter for a sister-in-law of Mr. Brandt. During 1874 a large number of locations were made and the attention of mine owners turned to getting in machinery for reducing the ores. Dr. R. F. Adams, after locating the Summit mine, shipped a small lot of ore to be tested, and, having satisfied himself that it would pay, located a mill site, and ordered a mill, which was brought in, set up and commenced running the next spring."

"The owners of the Little Annie, Del Norte, Margaretta, Golden Queen and Golden Star, in the winter of 1874-75, contracted with capitalists to erect mills. Dr. Adams' five-stamp mill began work as soon as the advance of the season permitted. In the latter part of May the machinery for the Little Annie and Golden Queen mills reached Del Norte from Chicago, and was hauled over the summit of Pindata Peak and various spurs of the main range. The district was occupied for the first time during the winter of 1875-76, which was a remarkably mild one. That is, the miners built cabins and remained there all winter. In July, 1877, the population of the district was about 250."

Continuing the narrative to a later date, Hall states that:

"Subsequent to the discoveries heretofore mentioned, the Little Ida, Aztec, Odin, Golconda, Golden Vault, Parole and

General view of South Mountain as seen from the summit of Cropsy Peak. The nearest group of buildings is McDougalville. Beyond these in the valley is a part of Summitville. The white specks in the left middle foreground are sheep grazing.

others were located, and according to reports of that period produced about $1,000,000. * * * In 1883 there were nine stamp mills with a total of 155 stamps. The San Juan, Odin, Little Annie and Golconda had gravitation tramways for transporting the ore from mines to mills. The Iowa and Colorado Company had a wire tramway of the Halliday patent for like purposes.''

Placering, which was started in 1870, was continued up to about 1880. Considerable gold is said to have been produced in this way, but no information is available as to the actual amount. Nuggets were occasionally found, the largest of which measured about one inch.

It is known that very rich gold ore was taken out of some of the mines, as, for instance, from the Little Annie mine, and the profits to the owners must have been correspondingly great.

Since the period covered by the passage quoted above from Hall's History of Colorado, that is, since 1895, but very little ore has actually been produced, although considerable development work has from time to time been done, as will appear later.

All the mines of this district are located on South Mountain. With the exception of certain only slightly developed properties that have never shipped ore, located on the western and northwestern side of South Mountain, all the mines of the Summitville district are owned by A. E. Reynolds of Denver and by the Consol Gold Mining Company. This company was promoted by George Crawford of New York, and is now, or was in 1915, controlled by T. N. Barnsdale of Pittsburgh, Penn. A contract has been signed in accordance with which the interests of Mr. A. E. Reynolds and of the Consol Gold Mining Company are to be merged and the properties operated conjointly. The reopening of the Golconda tunnel and the working of the various properties on South Mountain are contemplated in the near future.

MINES AND MILLS

GENERAL DESCRIPTION OF MINES

All the mines of this district are located on a series of parallel running veins that have a general northwest and southeast strike. The extreme southeast end of these veins and, therefore, the most southeasterly of the mines, lie almost directly east of and not far from the summit of South Mountain. From this point northwesterly the outcrops of the veins and the line of mine workings follow the gradually descending ridge of South Mountain for a distance and then descend the northwestern slope of the mountain to the valley bottom.

Openings were originally made on the surface on the different claims and the earliest development work was done in open cuts or short tunnels or in a few cases by shafts. But nearly all of the development has been done through tunnels that have been driven at different levels along the very steep eastern slope of the mountain. These tunnels as they appear on the map shown on Plate XXXIII (in pocket) are as follows, beginning at the southeast or highest part of the ground:

1. Iowa tunnel.
2. Aztec tunnel.
3. Golconda tunnel.
4. Golconda No. 2 tunnel.
5. Highland Mary tunnel.
6. Bobtail tunnel.
7. Esmond tunnel.
8. Winchester tunnel.
9. Montroy tunnel.
10. French tunnel.
11. Ida tunnel.
12. Chandler tunnel.

These tunnels were started at various dates between 1870 and 1885, and were driven as working tunnels for the development of individual properties. As a general thing it is the local custom to speak of the product of a certain tunnel through which a mine is worked instead of referring to the mine concerned. In the following pages this custom will be adhered to except in individual cases.

By inspecting the above mentioned mine map it will be seen that the mine workings of South Mountain are grouped around three points. The first of these is at the southeastern end of the district and may be conveniently designated as the Aztec mine. The second, near the middle, will be designated under the name Bobtail mine. Lastly, at the northwestern end, is clustered a bunch of properties that is often referred to as the Little Annie mine or the Little Annie group.

When this district was investigated by the writer in the summer of 1913, and again for a very brief period in 1915, all these properties had been closed down for years, except for a very little work done by occasional leasers. In 1915 no work was being done.

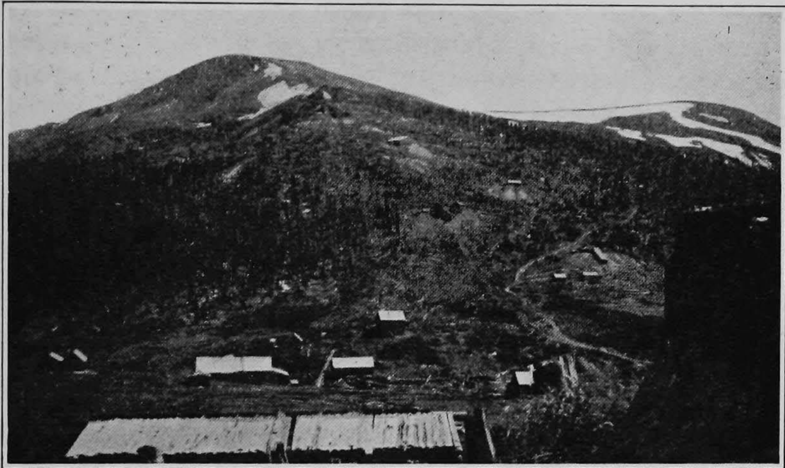


Fig. 1. View of South Mountain with part of Summitville, taken from the southeast.

Fig. 2. Mines on South Mountain. Little Ada mine above the center; Chandler mine to the rght.

In 1913 three or four men were working under the direction of Mr. Sam Carpenter of Creede. This work was being carried on in the properties of the Little Annie group.

Because of the long period of inactivity most of the tunnels had caved in or had become blocked with snow. Even where accessible the workings were unsafe so that any kind of a satisfactory investigation was out of the question. No attempt, therefore, will be made to give any detailed description of these properties, with the exception of the Little Annie group.

AZTEC MINE

What is here designated as the Aztec mine embraces the properties that have been worked through the Aztec tunnel, or, rather, through two or three tunnels that go under this name, and through the Iowa and Golconda No. 2.

The first discovery of gold occurring in a lode was made in 1872 by Theodore Goupil in the Aztec mine, which at first was known as the Esmond mine. This group, therefore, represents the earliest developed part of the district. It is reported that $300,000 in gold has been taken out of this mine.

There seems to be some difference of opinion as to the correct name for the tunnel, here called the Aztec tunnel, as it is said by some to be more properly called the Fairview tunnel. The name used by the writer is that found on the map on Plate XXXIII (in pocket) which is a copy of a map obtained from the office of Mr. A. E. Reynolds, the present owner of the property.

Some ten years after work was first begun on the Aztec lode the Iowa tunnel was driven at a level some two hundred feet lower than the Aztec tunnel. Ore values stoped out above this level are said to have amounted to some $200,000.

BOBTAIL MINE

Under this name is here included the Bobtail, Highland Mary, and Esmond tunnels. They occur near the center of the worked area and are separated from the two other groups of mines by a considerable stretch of apparently barren ground. Some pay ore was taken out through the Highland Mary tunnel and possibly through the Bobtail or the Esmond tunnel, but figures are not at hand as to the amount.

LITTLE ANNIE MINE

This mine, or group of mines, represents the heaviest producing area of the Summitville district, and has also produced some of the richest ore. It embraces the Winchester, Montroy, French, Ida, and Chandler tunnels. The mines, shaft houses, tunnel houses, and mill are located on the following claims:

Little Annie lode claim.
Del Norte lode claim.
Golden Queen lode claim.
Highland Mary lode claim.
Chas. Brastow lode claim.
Little Ida lode claim.
Margaretta lode claim.
Odin lode claim.
Peterson placer claim.
Brandt placer claim.
San Juan placer claim.

The conditions prevailing at the time field work was undertaken made an examination of these properties impracticable, although they were in much better condition, and somewhat more accessible, than was the case with the other properties in the district. Fortunately, however, the writer is able to avail himself of information obtained in 1900 when the mines were in much better shape and when active mining operations were being carried on. This information was obtained by two students of the Colorado School of Mines, Messrs. Chas. R. Ewing and Claude H. Smith, and was submitted by them in a graduating thesis entitled "Report on the Little Annie Group of Mines." As these two students were men of exceptional reliability, the writer is able to accept their work with some confidence and is glad of this opportunity to give the public the benefit of their investigations. What is given in the immediately following pages, including the assays and the description of the ore veins, is taken from this thesis. A more detailed description of the ore bodies and of the veins here referred to will be found in a later portion of this chapter.

It will be understood that the ore samples collected were done after all the earlier rich deposits had been worked out and the mines had stood nearly idle for some fifteen years. This is particularly true of the oxidized ores that in places yielded astonishingly rich gold specimens. The assays that follow, therefore, rep-

Colorado Geological Survey,
Bulletin No. 13

PLATE XXXIII

CONTOUR MAP

Showing

Mine Workings and the Principal Mining Claims of South Mountain

SCALE: 400 FEET TO THE INCH
CONTOUR: INTERVAL 20 FEET

resent the largely comparatively lean ores of the lower sulphide belt.

Ore Values of the Little Annie

"The development has been confined almost entirely to two main veins, viz., the Annie and Tewkesbury. The Winchester tunnel shows three other parallel veins, none of which, excepting the McDonald, about 120 feet west of the Annie, have been developed at all. The latter has a large cavity stoped out above the Winchester level.

"The method of sampling, as carried out throughout our examination of the property, was the picking of a groove, either around the entire perimeter of the cross-section of the drift or tunnel, when the latter was entirely surrounded by vein matter, or by cutting a groove across the face when the limits of the vein were exposed. In the sulphide zone large samples were broken down on a canvas blanket, and the sack sample, which in all cases was about two pounds, was taken from it. In the oxidized zone a much smaller sample was picked from the groove and caught in a box, from which the sack sample was taken.

"In the following tables of assays from the different veins, the numbers of the column headed 'No.' will be the sample numbers as recorded for convenience in assaying; the column headed 'Location' gives the nearest survey station, plus or minus its distance from the latter in feet, plus meaning in the direction to the next higher numbered station; the column headed 'Width' refers to the width and position of the vein at point of sampling; when width is unknown and vein lies on east of the drift, the symbol 'V E' will indicate the condition; when width is unknown and vein is on the west side, 'V W' will be used; when width is unknown and vein is on all sides of working, the symbol 'W V E' will be used; the other columns give the values in dollars of the gold, silver and copper per ton, gold at $20.00 per oz., silver at $.60 per oz., and copper at $.16 per lb."

McDONALD VEIN—

No.	Location	Width	Gold	Silver	Copper	Total
123	88—20	V E	$ 1.60	$ 0.15	....	$ 1.75
124	88+25	V E	1.90	.24	....	2.14
125	89	6 ft.	3.20	.42	....	3.62
126	90	30 ft.	1.20	.75	....	1.95
127	R—20	30 ft.	9.60	.45	....	10.05
128	R+30	V W	1.00	.20	....	1.20

TEWKESBURY VEIN—

No.	Location	Width	Gold	Silver	Copper	Total
11	10 to shaft	22 ft.	$ 2.00	$ 0.45	$ 6.40	$ 8.85
46	Shaft at Ida level	W V E	.60	.15	....	.75
52	35	V W	4.00	.39	....	4.39
53	35+25	V W	1.40	.18	....	1.58
54	35+50	V W	.40	1.38	......	1.78
106	70	20 ft.	2.40	1.02	....	3.42
107	72	20 ft.	.90	.15	....	1.05
108	M	20 ft.	2.40	.36	....	2.76
109	L—30	20 ft.	3.20	.45	....	3.65
110	L—10	20 ft.	6.40	.96	....	7.36
111	above 83	W V E	20.00	1.20	....	21.20
112	above 83 10	W V E	20.00	1.20	....	21.20
113	83+40	V E	22.00	1.26	....	23.26
114	83+40	V E	4.00	.33	......	4.33
115	83+60	V W	1.60	.36	....	1.96
116	83+80	V W	2.60	.33	....	2.93
117	83+90	V W	1.60	.21	....	1.81
118	Q	V W	2.60	.42	....	3.02

ANNIE VEIN—

No.	Location	Width	Gold	Silver	Copper	Total
1	7	W V E	$ 6.40	$ 0.98	$ 7.68	$15.06
2	7+10	W V E	1.00	.30	6.07	7.37
3	7+20	W V E	1.00	.15	trace	1.15
4	7+30	W V E	17.20	1.44	13.20	31.84
5	7+40	W V E	2.00	.33	1.94	4.27
6	7+50	W V E	2.00	1.20	18.55	21.75
7	7+60	W V E	1.60	.48	7.04	9.12
8	7+70	V E	2.40	1.02	8.95	12.37
9	8+10	V E	2.00	.90	11.20	14.10
10	8+20	V E	1.40	.24	trace	1.64
12	11	V E	1.60	.24	10.25	12.09
13	11+10	W V E	8.80	.72	3.84	13.36
14	11+20	W V E	2.60	.75	17.35	20.70
15	12	W V E	4.00	.30	2.88	7.18
16	12+10	W V E	5.20	2.85	12.15	20.20
17	12+20	W V E	1.60	.54	1.60	3.74
18	12+30	W V E	1.80	.54	2.88	5.22
19	15	W V E	.80	.15	9.60	10.55

ANNIE VEIN—(*Continued*)

No.	Location	Width	Gold	Silver	Copper	Total
20	14	porphyry	2.60	.18	trace	2.78
21	14+10	V E	2.80	.24	.96	4.00
22	14+20	V E	3.00	.21	1.60	4.81
23	14+30	V E	1.80	.12	trace	1.92
24	14+40	V E	16.00	1.35	.64	17.99
25	14+50	V E	1.40	.15	trace	1.55
26	C	V E	1.60	.27	trace	1.87
27	13	W V E	2.20	.43	23.70	25.33
28	17—10	W V E	1.60	.30	trace	1.90
29	16	W V E	1.60	.36	14.70	16.36
30	17—10	W V E	4.80	.66	3.20	8.66
31	17	W V E	6.00	.72	1.60	8.32
32	18	W V E	2.00	.54	3.20	5.74
33	18+10	W V E	2.00	.54	1.60	4.14
34	18+20	W V E	4.00	.42	3.20	7.62
36	19	W V E	6.00	1.14	trace	7.14
37	19+10	W V E	3.20	.45	6.40	10.05
38	20+20	W V E	6.20	.90	trace	7.10
39	20+30	W V E	2.00	.48	trace	2.48
40	20+40	W V E	14.00	3.06	trace	17.06
56	39	W V E	4.80	.30	....	5.10
57	39+45	W V E	.40	.30	....	.70
58	39+65	W V E	.20	.36	....	.56
59	39+85	W V E	1.20	.36	....	1.56
60	40+10	W V E	37.20	1.44	....	38.64
61	41+ 5	W V E	.40	.60	....	1.00
62	41+25	W V E	.40	.24	....	.64
63	41+45	W V E	.40	.66	....	1.06
64	41+55	W V E	39.20	2.16	....	41.36
65	41+65	W V E	2.00	.36	....	2.36
67	56+30	W V E	1.60	.36	....	1.96
68	56+51	W V E	2.00	.48	....	2.48
69	56+60	W V E	2.40	.36	....	2.76
70	60	W V E	1.60	.36	....	1.96
71	60+20	W V E	1.60	.36	....	1.96
72	61	W V E	1.60	.36	....	1.96
73	61+20	W V E	.80	.36	....	1.16
74	61+40	W V E	3.40	.45	....	3.85
75	61+60	W V E	.50	4.60	....	5.10

ANNIE VEIN—(*Continued*)

No.	Location	Width	Gold	Silver	Copper	Total
76	61+80	W V E	3.20	.42	....	3.62
77	63—10	W V E	3.20	.42	....	3.62
78	H—10	W V E	2.80	.36	....	3.16
79	H	W V E	3.40	.24	....	3.64
80	64—10	W V E	.50	.36	....	.86
81	64+10	W V E	2.80	.36	....	3.16
82	64+30	W V E	2.60	.36	....	2.96
83	67+15	W V E	3.00	.24	....	3.24
84	67+30	W V E	.50	.30	....	.84
85	67+45	W V E	2.40	.30	....	2.70
86	67+65	W V E	2.40	.30	....	2.70
87	67+77	W V E	2.40	.30	....	2.70
88	1—12	W V E	2.40	.30	....	2.70
89	I	W V E	.40	.60	....	1.00
90	20/61*	W V E	.80	.96	....	1.76
91	28/61	W V E	10.40	.90	....	11.30
92	38/61	W V E	4.00	.54	....	4.54
93	48/61	W V E	2.40	.54	....	2.94
94	58/61	W V E	8.00	1.80	....	9.80
95	68/61	W V E	1.60	.36	....	1.96
96	74+60	W V E	1.60	.36	....	1.96
103	69	W V E	.60	.15	....	.75
104	70-35	W V E	44.00	.30	....	44.30
105	70-15	W V E	10.40	2.40	....	12.80
120	15/80	pay-streak	155.00	6.90	....	161.90
121	15/80	W V E	13.00	.60	....	13.60
122	10/81	W V E	4.00	.36	....	4.36

CROSS VEIN AT STATION 25. (Probably the Oding)—

No.	Location	Width	Gold	Silver	Copper	Total
47	W-40	4 feet	$ 1.60	$ 0.37	....	$ 1.97
48	W-20	4 feet	.80	.18	....	.98
49	W	4 feet	.40	.18	....	.58

ODING VEIN—

No.	Location	Width	Gold	Silver	Copper	Total
41	31	W V E	$ 1.00	$ 0.24	....	$ 1.24
42	33—40	W V E	1.40	.36	....	1.76
43	33—30	W V E	1.40	.24	....	1.64
44	33	20 feet	1.40	.36	....	1.76
45	32	W V E	12.80	1.68	....	14.48

*20/61 indicates sample taken 20 feet directly above station 61.

CROSS VEINS AT STATIONS 55, 71 AND 77—

No.	Location	Width	Gold	Silver	Copper	Total
35	55—20rt	W V E	$ 3.20	$ 0.96	....	$ 4.16
66	55—20lft	W V E	1.60	.36	....	1.96
97	J	W V E	1.60	.36	....	1.96
98	J—10	W V E	.40	.36	....	.76
99	J—20	W V E	trace	trace	....	....
100	J—35	W V E	1.60	.36	....	1.96
101	J—45	W V E	1.60	.48	....	2.08
102	J—58	W V E	6.40	.48	....	6.88
109	X	W V E	12.00	.72	....	12.72

UNEXPLORED VEINS IN EAST DRIFT OF IDA—

50	34+21	5 feet	$ 1.20	$ 0.24	....	$ 1.44
55	36+30	16 feet	2.00	.30	....	2.30
51	37	6 feet	1.60	36	....	1.96

UNEXPLORED VEINS IN WINCHESTER TUNNEL—

129	92+10	6 feet	$ 4.40	$ 0.27	....	$ 4.67
130	92+30	6 feet	.80	.12	....	.92
131	93-30	unknown	1.00	.18	....	1.18
132	93-20	unknown	1.40	.38	....	1.76
133	93	unknown	.70	.70	....	.88
134	90+65	6 feet	1.00	.12	....	1.12

Description of Veins

MCDONALD VEIN—

"This vein is first exposed at the main bend in the Winchester tunnel, at station 90, the tunnel following it northward about 80 feet. Beginning at station 90 and extending southward about 50 feet, there is a large stoped-out cavity, which it was impossible, on account of lack of timbering, for us to explore. However, this shows an immense chute, which probably contained high-grade ore. The chute was 30 feet wide, and 50 feet long. At station 87 it appeared to have a dip of about 45° east.

VEINS IN THE WINCHESTER TUNNEL—

"Vein matter of mineralized gray quartz appears on the north side of the tunnel, 65 feet east of station 90; this does not appear on the south side of the tunnel. Sample 134 is from this material. There has been no development to prove this a separate vein.

"Just east of station 92 is a north and south vein, about 6 feet wide, which is located almost in the direct line of the Annie vein, and is from all appearances a part of the same. This vein has been exposed by drifting 10 feet to the north and 30 feet to the south. Samples 129 and 130 are from these drifts.

"For 30 feet along the tunnel west from stations 93 the characteristic vein matter of gray quartz appears; judging from the relative position and size of the vein, it is a part of the Tewkesbury vein. Samples 131, 132, and 133 are from this vein.

UNEXPLORED VEINS IN THE EAST DRIFT OF THE IDA TUNNEL—

"In addition to cutting the Tewkesbury and Annie, this drift cuts three other veins. Sample 50, near station 34, shows a quartz vein, but being totally undeveloped, its identity cannot be determined. It is very probable that this is only a spur from one of the main veins as it lies between the Annie and Tewkesbury.

"Sample 55, near station 36, shows another vein, which, being undeveloped, cannot be identified. It lies parallel to and is probably another spur of the main vein.

"In the end of the drift another quartz vein about 6 feet wide, apparently striking away from the main veins at a large angle, has been reveloped by a stope three sets high and 30 feet long. Sample 51 was taken across this vein. Such meager development makes the identity of this vein also indistinguishable.

CROSS VEIN AT STATIONS 55, 71 AND 77—

"Drifts on a cross vein in the French, Montroy and Winchester levels, which from the survey have the same general strike and lie nearly in the same vertical plane, indicate conclusively the extension of the same cross vein through the three levels. The workings on the vein were entirely in ore and were 15 to 20 feet wide in places, which shows this to be a vein worthy of further exploration in the lower levels.

ODING VEIN—

"This vein is exposed in the breast of the west drift of the Ida, at stations 31, 32, and 33. This vein has an easterly and westerly strike, and in the vicinity of the breast of this drift there is a large chute, the dimensions of which have not been entirely exposed, but the drift has cut through 50 feet of ore with some stoping. A drift southwest from station 25 discloses a 4-foot vein which strikes almost directly toward this chute in the Oding and it seems very probable that it is part of the Oding.

Tewkesbury and Annie Veins—

"At all points in which the Tewkesbury is open for examination, it is in such close proximity to the Annie vein, it seems very appropriate to discuss the two under the same general head. The two are nearly in contact near the Ida shaft at both the Chandler and Ida levels, and also near the Crawford raise in the Montroy, French, and Winchester levels. Tunneling and drifting on the Tewkesbury property has been carried on to the extent of 500 feet, together with the Ida shaft, which was sunk about 350 feet entirely in the vein. All other tunneling, drifting and sinking has been done in connection with the development of the Annie vein; but the close proximity of the two veins throughout, means that the development of the Annie can be used practically, by the addition of a system of cross-cuts, to prospect, and if it proves worthy, to develop the Tewkesbury.

"On the Annie vein proper there are 5,731 lineal feet of development. Our survey shows the following:

Tunnels and drifts 5′x7′, Chandler level	1,126 ft.
Tunnels and drifts 5′x7′ Ida level	1,227 ft.
Tunnels and drifts 5′x7′ French level	1,471 ft.
Tunnels and drifts 5′x7′ Montroy level	479 ft.
Tunnels and drifts 5′x7′ Winchester level	798 ft.
	5,431 ft.
Crawford raise, 4′x8′	187 ft.
Raise No. 1, 10′x10′	75 ft.
Raise No. 2, 10′x10′	68 ft.
	5,431 ft.
From company's maps, caved Montroy tunnel	300 ft.
In addition to workings on the Annie, the drifts	
To Oding, cross veins, etc.	1,394 ft.
Shaft in Tewkesbury	350 ft.
Drifts on Tewkesbury	500 ft.
Total workings accessible to survey	7,975 ft.

Other workings on the property which were inaccessible on account of caving or filling would greatly increase the above figures for the work that has been done."

OTHER MINES

On the west and northwest side of South Mountain are a number of claims owned by Henry C. Frick of Pittsburgh and by the T. M. Bowen estate, of which Judge E. T. Elliott of Del Norte is administrator. Mr. Frick owns the south two-thirds of the Anna Bell and Baker patented claims. The Bowen estate controls a number of claims that cover approximately 200 acres, of which 160 are patented as placer ground.

Work has been done on and off on these properties since 1880, but no ore has been shipped from them. A tunnel 600 feet long has been driven by Mr. Frick on his part of the Baker claim. The Bowen estate likewise has a tunnel of about 80 feet on their part of the Baker claim, a shaft on the placer, a tunnel 400 feet long on the Saunders claim, and a cut and tunnel on the Anna Bell claim of approximately 140 feet In the summer of 1915 Judge Elliott was drifting on the Anna Bell vein and was expecting to be in position to produce shipping ore.

GOLCONDA TUNNEL

What is now known as the Golconda tunnel is in part a cross-cut tunnel and in part a tunnel driven as a drift along the veins or approximately parallel to their course and connecting the workings of the different groups of claims.

This tunnel was started in 1897 by Manager Dan Kirby, and work was discontinued in 1906. It was started near the bottom of the valley at an elevation of 11,400 feet, a point over 500 feet below the Iowa tunnel—the lowest tunnel through which the ore bodies at the higher or southern end of the district had been worked—and 130 feet below the Chandler tunnel, which was the lowest tunnel at the northern end. This cross-cut was driven directly for the Tewkesbury winze located on the tunnel lode claim. Its length is 2,780 feet.

According to information secured from Mr. A. E. Reynolds, the following veins were cut by this cross-cut tunnel.

1st. At 1,600 feet from portal a large vein carrying copper values.

2nd. At 2,000 feet from portal a vein four or five feet wide carrying copper values, partly in the form of covellite.

Fig. 1. Dump at portal of the Golconda cross-cut tunnel, with South Mountain in the background.

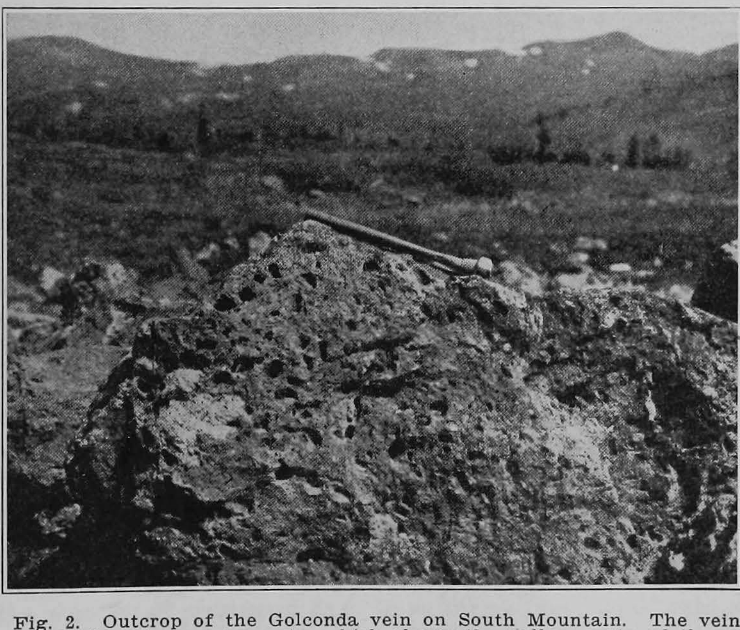


Fig. 2. Outcrop of the Golconda vein on South Mountain. The vein is composed of replacement quartz, which shows the hollow casts of the original sanidine phenocrysts.

3rd. At 2,700 feet from portal the so-called Tewkesbury vein, a vein carrying pyrite at the tunnel level and very rich gold ore in the upper oxidized zone.

4th. At 2,780 feet from portal the so-called Golconda vein, carrying copper.

No development work has been done on the two veins nearest to the portal of the tunnel.

From the point where this cross-cut tunnel cuts the Tewkesbury shaft the tunnel was continued as a drift along the veins running from the Aztec mine to the Little Annie group. The tunnel does in fact for some distance drift on one or another of these parallel running veins. But between the well-defined veins found in the Aztec and adjacent claims and the veins found in the Bobtail group there was struck a barren stretch of some 500 feet within which no definite vein could be followed. This stretch corresponds with an equal strip on the surface within which there are no surface workings.

During the years 1913 and 1915, when this investigation was undertaken, the Golconda tunnel was inaccessible so that information could not be obtained first hand as to the ore veins cut by the tunnel. At the date of writing this report, September, 1917, the tunnel is still closed, although, as stated elsewhere, plans are being made for re-opening the tunnel in the near future.

MILLS

It is difficult to secure reliable information as to the numerous mills that have from time to time been erected at Summitville. Most of them were of very short duration and appear to have been failures. In fact, none of the mills can be said to have been permanently successful. At least none of them proved capable of handling relatively low-grade ore found in the lower mine workings in a way to make mining a continued success. These mills were stamp mills erected with a view to handle the free-milling ore found in the upper oxidized portions of the veins. They were naturally not adapted to treat the more or less complex sulphides of the lower levels and no special effort seems to have been made to determine by careful and extensive investigation the type of mill required to handle such ores.

There have been altogether eleven mills erected in this district. They are given below with the dates of their erection and the number of stamps in each in so far as these facts were ascertained.

Mills	Dates	No. of Stamps
Adams	1874	5
Little Annie	1876	10
Queen	1876	10
San Juan Consolidated	1876	20
Iowa Consolidated	1876	20
Odin	......	....
Sperry	......	....
Cropsy	1881	....
Iowa	1882	40
Missionary	1882	....
Annie	1884	60

The Little Annie mill, erected in 1884, was built by the consolidation of the Little Annie, Queen, San Juan Consolidated, Odin, and Sperry mills. The older mills were dismantled and the materials used in the construction of the Little Annie, which was erected on the ground formerly occupied by the Odin.

None of the mills enumerated above are now standing except the Iowa and the Annie, and these two are now in a half-wrecked condition. The Annie mill was equipped with a fine 225-horsepower Corliss engine which became buried in ice some ten years ago when the mill was shut down. It has remained thus buried during the past ten years and is presumably still in good condition.

ORE VEINS

DISTRIBUTION

Owing to the inaccessibility of most of the mines on South Mountain at the time this investigation was undertaken, a satisfactory description of the ore veins of the district cannot at this time be undertaken. Except for what could be seen on the surface the writer is largely dependent on the description of a few men who have had practical experience in mining these veins, but who have not had the advantage of scientific training, on the scant information contained in the above-mentioned graduation thesis of Messers. Ewing and Smith, and on a paper published by Hills some thirty-four years ago.* Even those workings that were accessible to the writer had long since been almost completely worked

*R. C. Hills, Ore Deposits of Summit District, Rio Grande County, Colorado, Proc. Colo. Sci. Soc., Vol. I, 1883, p. 20.

out, so that only scant information as to the character of the ore veins could be secured by actual observation.

In the upper part of the workings, that is, in the workings that occur on the southern or higher part of South Mountain, there appear to be three fairly well-defined veins that have nearly parallel courses. They strike approximately N. 50° W, and dip southwesterly at angles from 85° to 90°. They are, therefore, practically vertical. These three veins named in order from east to west are known as 1, Tewkesbury vein; 2, Aztec or Golconda vein; 3, McDonald vein.

It has been definitely ascertained that the Aztec and the Golconda veins are parts of the same vein. Owing to a gap of some 500 feet occupied by apparently barren ground between the Aztec group and the Bobtail mine the identity of the veins that occur in the northern or lower lying part of the mountain has not been determined with equal certainty. In this part of the mountain the main vein goes under the name of the Little Annie vein. Owing to its position and to the strongly defined characteristics of this vein there is little doubt but that the Little Annie vein is the same as the Aztec-Golconda vein. And such it is generally considered to be. Ewing and Smith have described the vein immediately to the east of the Little Annie under the name of the Tewkesbury vein on the basis of the identity of these ore bodies with those of corresponding name in the higher lying properties.

GOLCONDA VEIN

The name Golconda will here be used to cover the vein of that name and likewise the Aztec and Little Annie veins.

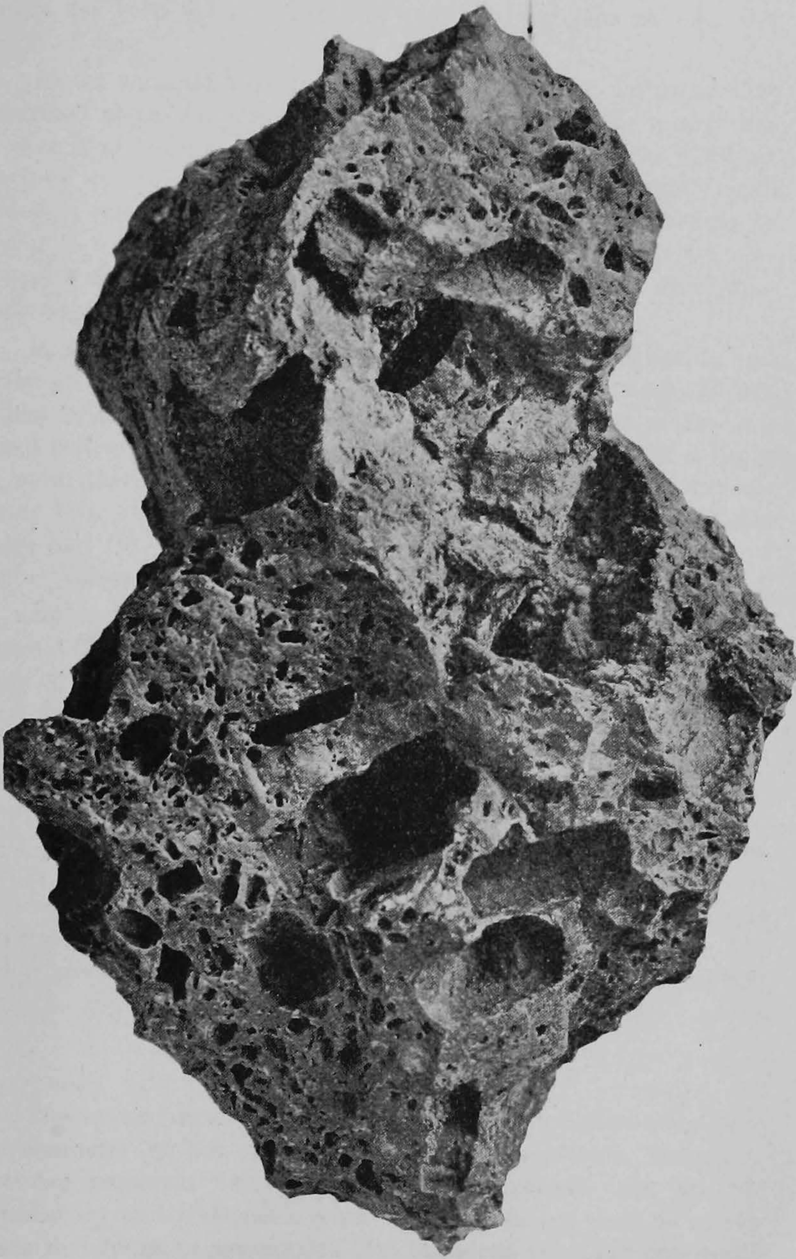
This is the most characteristic vein of the district in that it has produced most of the ore and has certain peculiarities that make it unique. The gangue consists almost entirely of quartz, but not of the ordinary vein-quartz type. It is a replacement of the country rock which is a quartz latite. The unaltered rock which is described in Chapter III is very coarsely porphyritic with large, pronounced phenocrysts of glassy sanidine that average about one inch in length and that may attain to two inches in greatest dimension, also smaller, but well-defined, phenocrysts of plagioclase, quartz, and biotite. In the replacement of this very striking porphyritic rock the phenocrysts of sanidine, plagioclase, and biotite have been dissolved out completely and have left absolutely sharp casts of their original forms. These casts occur in a matrix of quartz which has replaced the groundmass of the quartz latate and which has a finely granular texture entirely different from the texture of the groundmass in the unaltered rock. The only component of the original rock that has escaped destruction is the quartz in the shape of phenocrysts. These appear in the body of the quartz gangue without having undergone any apparent change. On Plate XXXV may be seen a photographic representation of a typical fragment of this gangue material. .

This quartz replacement vein fluctuates greatly in width, but may attain a thickness of some seventy-five feet. It strongly resists weathering and, where widest, forms a pronounced shoulder or butte that projects conspicuously beyond the line of the easterly facing cliff of South Mountain. It has no well defined walls, but shades gradually into the country rock. In the central portion of this vein there runs a massive quartz streak two or three feet wide that is composed of quartz similar to that of ordinary vein-quartz. Quite probably this central massive part of the vein is due to a more intense silicification along a narrow crack that furnished a free passage for siliceous waters.

Float from this vein showing the characteristic solution casts of the original phenocrysts is abundantly strewn over the surface from the summit of South Mountain to the bottom of the valley, and in the form of glacial drift it has been carried far beyond Wightman's Fork and may be found with other glacial material along the road to Del Norte for a distance of a mile or two from Summitville.

Barite is also to be noted as an occasional gangue mineral in this ore.

The Golconda vein, as is also the case with the other veins of the district, has an upper oxidized belt varying from fifty to three hundred feet in depth, and a lower or sulphide belt. In the oxidized belt the ore values consisted of free gold with a small amount of silver, and have practically been worked out. The gold usually occurred with limonite or with limonite mixed with clay, or in the quartz gangue stained brown with this same material. The gold might occur in the feldspar cavities, but the richer portions were usually found along the central band. This at least was true of the Little Ida and Little Annie claims according to Hills, who says of these claims that the gold is "usually in a disseminated form, like a thin continuous sheet of metal. Occasionally the grains unite and form flat nuggets, one or more ounces in weight. A large fragment of ore recently taken from the Little Annie contains



A fragment of the gangue of the Golconda vein on South Mountain, showing the hollow casts of feldspar and biotite phenocrysts.

several such nuggets. The occurrence of this exceedingly rich material is confined to the immediate vicinity of the central channel, which has been filled with earthy matter, fragments of rock and oxide of iron.''

In the sulphide zone the gangue is of the same nature as that described above for the oxidized zone except that the quartz has a dark gray color and is free from limonite stains. The feldspar cavities are thickly sprinkled with minute pyrite crystals with which is commonly associated enargite. The pyrite, according to Hills, is often auriferous, but very poor in silver. Pyrite and enargite also occurs in bunches. Sphalerite and galena occur sporadically.

A study of the assays made by Messrs. Ewing and Smith, and given on pages 72 to 74, shows a strong contrast between the ore values in the oxidized and unoxidized belts. The ores of the oxidized belt are free from copper and the values are almost entirely in gold, there being only a small amount of silver. In the sulphide belt, on the other hand, while the silver remains about the same and the gold shows smaller values, copper is apt to show higher values than do gold and silver combined.

In his paper on the Ore Deposits of the Summit District, Hills* states that in the Aztec mine gold and silver values are about equally divided in a rich ore streak measuring from a few inches to a foot or more in width. This occurrence is in the oxidized belt and the gangue consists of quartz with much barite and only a trace of iron oxide. At the time this observation of Hills was made, namely, in 1883, silver of course was worth much more than sixty cents an ounce, which is the price used in figuring the silver values in the analyses given in this report. Even so, the great contrast in silver values between those found in the Little Annie mine and in those of this Aztec ore streak is worthy of note. The richer silver values in the Aztec mine are apparently connected with the abundance of barite and the scarcity of limonite.

OTHER VEINS

The writer has not been able to secure much information as to the character of the other veins occurring on South Mountain. The two principal veins outside of the Golconda vein are the Tewkesbury and McDonald veins. There does not seem to be evidence justifying an assumption that these two veins are essentially

*Op. cit., p. 24.

different from the one just described. So far as the ore minerals are concerned, the distinctions already made appear to hold fairly well for the Tewkesbury and McDonald veins. As to the gangue it would appear that it consists to a much greater extent of more or less solid vein quartz without, however, definitely developed walls. There is good reason to believe that replacement of the quartz latite similar to that found in the Golconda vein has taken place in these two veins also.

As to the character of the ore-bearing minerals in the different veins the available data do not justify drawing any very definite conclusions. The writer has not been able to get information that he considers conclusive as to the individual veins insofar as mineralogical distinctions are concerned. In what follows, therefore, as to the copper minerals that are found within the sulphide belt, for the present it must be assumed that the conditions are common to most or to all of the veins.

Copper occurs in the form of enargite, covellite, tennantite, and chalcocite, rarely as chalcopyrite. The commonest form in which enargite occurs is as crystals in the feldspar cavities, but it also occurs in more solid masses or lumps not infrequently associated with barite, and always with pyrite. It was also observed by the writer intimately intergrown with massive tennantite on the Chandler level. This observation was made in 1902 during a brief visit to Summitville while active operations were going on. On the same level enargite was abundantly developed in association with pyrite and a little chalcopyrite. It occurred mostly in slender, flattish, brilliant-lustered crystals in the cavities of a porous quartz gangue.

Massive tennantite was also collected from the Chandler level in 1902. It had a peculiar pinkish gray color and was intergrown to some extent with enargite. This mineral appears to be abundantly developed in the lower levels of Summitville. It is known as gray copper or as tetrahedrite. The massive specimens collected proved, on being tested, to be arsenical gray copper.

Covellite occurs on both the Chandler and the Golconda levels. On the former level it was found in solid masses three to six inches thick. These masses were of irregular distribution and not persistent. Several tons of solid covellite were shipped in 1902. This same mineral was also observed by the writer on the occasion of this earlier visit in the breast of a drift that was being driven on the second vein cut by the Golconda cross-cut tunnel. At this place the mineral was sharply crystallized. It occurred in indi-

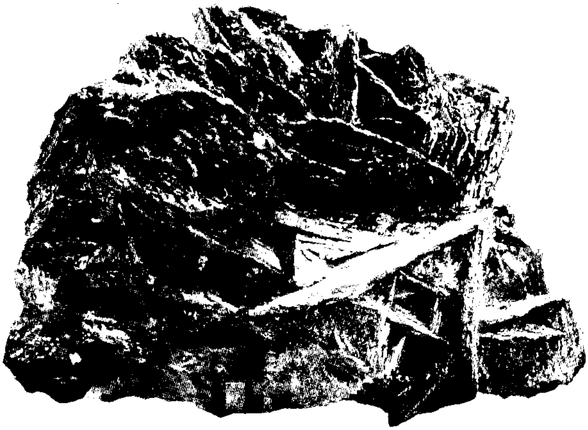


Fig. 1. A group of covellite crystals from the Golconda tunnel. Natural size. See page 85.

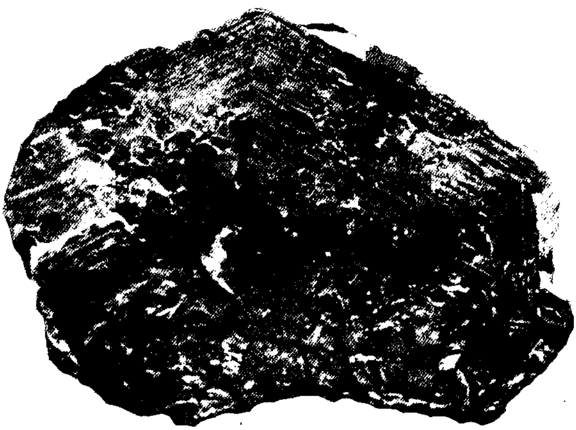


Fig. 2. A single covellite crystal, two and a quarter inches across, from the Golconda tunnel. See page 85.

vidual, very thin, flat leaves having a marked hexagonal habit, and in clusters of these leaves. The crystals were strongly striated parallel to the edges, and occurred in the cavities of a cellular quartz gangue and imbedded in hard, clay-like material of yellowish or of grayish color. Usually these crystals were small, but in some cases they reached to one and even to two inches in diameter. Plate XXXVI, Fig. 1 and Fig. 2, shows these large flat crystals of covellite.

Many of these covellite crystals were coated with a very thin film of a gray metallic-lustered mineral that had the physical appearance of chalcocite. This could not be positively demonstrated on account of the impossibility of separating the film from the underlying covellite.

How extensively chalcocite is developed in the ore of these mines the writer has no way of knowing. He was, however, informed by Mr. Sam Carpenter, who since 1885 has worked intermittently as leaser or as mine foreman in the mines of Summitville, that chalcocite is very commonly present. There is no reason to doubt that Mr. Carpenter is sufficiently familiar with the mineral to be able to distinguish it from the tennantite which it may perhaps resemble.

ORIGIN OF THE ORE VEINS

Information at hand is rather too scant to justify any very positive statement as to the origin of the ore veins of this camp. It is of interest to note, however, that the period of ore deposition in part at least followed the removal of the feldspar phenocrysts, as enargite, pyrite, and gold in crystallized form occur lining the cavities of the feldspar casts. As this removal of the feldspars and of biotite undoubtedly occurred in connection with the silicification of the groundmass of the quartz latite it may be presumed that the deposition of the gold and of the accompanying sulphides did not occur simultaneously with, but rather subsequently to, this silicification. It is probable that the mineralization accompanied the deposition of the quartz that forms the more solid streak near the center of the Golconda vein. In this way one could readily account for the greater richness of the vein along this central streak.

In close proximity to the Golconda vein the quartz latite has in places undergone extensive alteration of a nature very different from the silicifying process already referred to. This alteration is [illegible] process and has caused the rock to become extremely soft and clay-like. This is very pronounced in the Winchester tunnel where near the portal the large feldspar crystals have been altered into pseudomorphs of white, soft kaolin or of equally white and soft sericite. In this case so soft is the rock material that these pseudomorphs are readily separated from the surrounding matrix. Tests made on these altered feldspars indicate that sericite is the alteration product formed in most cases, but that kaolinite has been developed in some places.

Whether this hydration of the adjacent country rock was directly associated with the period of ore deposition or occurred at some subsequent period must be left an open question in the absence of fuller information.

As to the source of the mineralizing waters that were responsible for the deposition of the ores it would also be somewhat hazardous to venture on any very positive assertion. The mere presence of the minerals observed in these veins is not alone sufficient to prove the source of the solutions, as the origin of these minerals in ore veins is far from being settled at the present time. The writer may, perhaps, venture to state that, in his judgment, the occurrence of these minerals in the South Mountain veins appear to favor the theory that the ore deposits within the sulphide belt are primary in origin and are the result of deposition from rising waters. This very possibly may not be true of all the sulphides or of the sulphides in all parts of this zone. As chalcocite has until recently been supposed to be always of secondary origin and is admittedly so in many or most cases, this mineral may well have been formed by reaction between the oxidized salts of descending waters and the primary sulphides below. The same is likely to be the case with the covellite.

The sudden and marked decrease in gold values in passing from the oxidized to the sulphide belt can hardly be accounted for except on the theory of secondary enrichment by meteoric waters near the surface. Mr. R. C. Hills* has very lately described two occurrences of gold from the Summitville district that he believes indicates the secondary origin of this metal. The first case is that of some extremely rich gold specimens that came from the Little Annie mine in the early eighties. These specimens consist of gold and limonite intimately intergrown in such a way as to indicate the simultaneous deposition of the two. The gold is so rich that it can readily be beaten into nuggets.

*Proc. Colo. Sci. Soc., Vol. XI, 1917, p. 205.

The occurrence of gold with limonite seems to be very characteristic of the bonanza deposits of the Little Annie and other mines worked in the early days. That waters containing ferric sulphate are capable of dissolving gold has long been recognized. Also that such waters will precipitate the gold when in contact with reducing agents. An interesting instance of the solution of gold, presumably in the presence of water containing ferric sulphate was observed by the writer in one of the old workings of the Iowa tunnel where the tunnel crosses the Golconda vein. At this point stalactites and stalagmites of limonite had formed, the stalactites, small and slender, being about three-eighths of an inch in diameter. The stalagmites were more or less hemispherical in shape and were extremely soft. They measured one and a half inches in diameter. The limonite of these stalagmites was evidently deposited in the tissues of a fungus growth, as the material became fetid on exposure.

Assays of this material made by Mr. Carper, one of the students of the party, gave the following results:

	Gold	Silver
Stalactites	$2.40	$0.30
Stalagmites	7.20	1.25

Here we have, then, a demonstrated case of gold precipitated along with the limonite. It is worthy of note that the gold and silver in the stalagmites are three times as great as in the stalactites. An easy explanation is to be found in the fact that the gold may be presumed to have been deposited in the stalagmites by the reducing influence of organic compounds produced by the decay of the fungus.

The second case cited by Hills that indicates the secondary origin of the gold in the oxidized belt is that of gold associated with barite in the Aztec mine. In this instance we find that "a careful examination with the aid of a lens reveals the fact that the gold was deposited after the barite and in conjunction with limonite. In fact, the gold follows the limonite absolutely, not only in the spaces between the barite plates, but in the multitude of irregular capillary cross fractions, in places the limonite and gold being in nearly equal proportions."

In the paper by Mr. Hills on the Ore Deposits of Summit District, which was quoted above, he has described a most complex folding of the rocks of South Mountain as well as of the ore veins cutting those rocks. He conceives that there occurred first, the silicification of the igneous rocks along certain contacts; second, the intense folding of these locally silicified rocks; third, the concentration of the rich gold ores at the lower levels by downward moving waters and a consequent improvement of the superficial rocks. According to this theory the depth of the veins would depend on the depth of the closely folded silicified contacts.

The writer has been unable to verify these conclusions of Mr. Hills. A study of the rocks as they occur on the surface do not seem to justify the conclusion that they have been pressed into a series of folds. Furthermore, the very nature of the igneous formations, they being surface flows, would hardly allow of their being so intensely folded as Mr. Hills appears to believe. The writer, therefore, is of the opinion that the veins are not limited in depth by reason of folding of the rocks, but that they should persist to considerable depths.

As is shown in Chapter III, the rocks that form South Mountain are quartz latite overlying augite andesite. So far as known the andesite lies entirely beneath the mine workings, so that the rocks exposed in connection with the development work of the district are all quartz latite of somewhat varying texture and composition.

CHAPTER V

PLATORO DISTRICT

LOCATION AND HISTORY

The town of Platoro is delightfully located at an elevation of 9,900 feet, in the midst of a flat, open expanse of the Conejos River valley that measures some half to three-quarters of a mile wide and three miles long. There was formerly a good road following all the way down the Conejos valley to the railroad at Antonito, a distance of some sixty miles. This road was not passible in the summer of 1913. Two other roads are available for teams. The shorter leads to the Worrel ranch in the Alamosa valley and from there to Monte Vista and to Alamosa in the San Luis valley. The distance to Monte Vista is forty-eight miles, and to Alamosa a few miles further. Between Platoro and the Worrel ranch, a distance of fifteen miles, the road climbs over a high mountain ridge and is not kept in repair. The longer of these two roads goes to the west over a low divide to Stunner in the Alamosa valley, distant only four miles. Over a considerable portion of these four miles the road was found to be in bad shape, but from Stunner all the way to the towns of the San Luis valley an excellent road leads.

This camp is said to have been opened in the early eighties, some ten years after ore was first discovered at Summitville, and grew rapidly until in 1890 it contained some 300 population. In this time one or two very promising mines were developed and a large number of claims staked out, and worked to a greater or less extent. Extremely rich silver ore seems to have been shipped from several of the properties, but the rich ore soon gave out, and the low-grade ores could not be worked with profit owing to the remoteness of the camp.

Platoro received a great, though temporary, stimulus in the spring and early summer of 1913, because of the discovery of very rich ore at the Gilmore mine on Klondyke Mountain to the west of the town. As the ore was in the form of telluride of gold, and similar, therefore, to the gold ore of Cripple Creek, it was not surprising that in popular imagination, especially in the imagination of those who happened to have interest in mining claims in the vicinity of Platoro, this mining camp was in a way to become a second Cripple Creek. The easy prophecy made by some enthusiasts soon after this gold strike became known, that the summer of 1913 would see 5,000 or 10,000 prospectors making their way to the Platoro district, was hardly realized. Still the buildings of the town were inadequate to meet the requirements of those that did come, and a large number of tents were put up, and Platoro had for a time almost the appearance of a tent city. As the summer passed and it became known that the rich gold ore at the Gilmore mine had apparently given out and no further discoveries of equal richness had been made, the population gradually dwindled away to a fraction of those present in June.

Owing to the peculiar circumstances surrounding the gold discovery on Klondyke Mountain, this matter will be treated in a separate chapter.

MINES AND CLAIMS.

From the mining claim map shown on Plate III (in pocket) it will be seen that the mining claims of the district surrounding Platoro form a group south and west of Platoro and run from Platoro to Lake Fork, some two miles to the south. Another bunch of claims are clustered around Axell, two or three miles from Platoro down the Conejos river. In undertaking a survey of the Platoro-Summitville district it had not been expected that the work would include the region around Lake Fork and Axell, as the time available was not sufficient for this purpose. It was, however, found possible to extend the topographic and geologic work to this portion, although this could not be done as thoroughly as might be desired. But there was no time to make investigation of the mining claims and these will have to be dismissed with rather scant consideration. The claims in the immediate vicinity of Platoro will be described under groups based on common ownership, only the more important groups being taken up.

It may be stated at the outset that the rather extensive prospecting that the Gilmore gold discovery incited for a brief time did not result in the opening of already worked properties to any appreciable extent, so that almost all the properties by long idleness had become choked with snow and ice or had been made inaccessible by caving in of the tunnels.

Fig. 1. View of Platoro, looking eastward down the Conejos River valley from the road to Stunner.

Fig. 2. View of the Parole mill at Platoro.

As the time of the writer was given up almost entirely to the investigation of the general geological problems of the greater district and to the supervision of the parties in the field, it was deemed advisable to assign the study of the mining properties of Platoro region to Mr. C. Erb Wuensch, one of the student members of the party. It will be understood, therefore, that what follows here in regard to the mines and mining claims of Platoro is in large part taken from his report.

The geology of this particular region could not be worked out as thoroughly as might be desired and may be accepted as only approximately correct. The ore veins lie mainly in the Treasure Mountain latite and in part apparently in the overlying andesite.

MAMMOTH GROUP

General Description

The Mammoth group consists of fifteen patented claims having a total area of 126 acres, and lying upon the northern slope of Mammoth Mountain. Most of the country covered by these claims is densely forested with spruce and other fir trees suitable for mining timbers. The principal workings are on the Mammoth and Revenue claims that join each other end to end. These workings consist of a main tunnel 1,600 feet long, the breast of which is 332 feet beneath the surface; a 1,200 feet long level or drift at a depth below the main tunnel of 100 feet; and a further second level or drift 400 feet long and 200 feet beneath the main tunnel. In addition to these there are three small adits above the level of the tunnel. The two levels below the main tunnel were filled with water and could not be inspected. Comparatively little stoping has been done, and this, so far as known to the writer, only on the levels above water. Plate XXXVIII shows the underground workings of the mine for the ground above water. It is copied from a map prepared by Mr. C. S. Barnes in connection with a sampling of the mine, to which further reference is made below.

Some very rich ore has been taken out of this mine, the total amounting to some $300,000. The ore had to be shipped by burros or wagon to Monte Vista, and from thence by rail to Pueblo or Denver. Because of the great expense involved in shipping so great a distance it did not pay to ship ore assaying under fifty dollars a ton.

Character of Vein and Ore

The ore of the Mammoth mine comes from the Mammoth vein, which is a continuation of the Valley King vein. This is a quartz fissure vein striking somewhat east of south and dipping westerly some 68°. This is a very strong vein that shows up conspicuously on the surface and has been traced for over a mile, beginning at the Conejos river, where it has a width of some fifty feet, to and beyond the crest of Mammoth Mountain, in the direction of Lake Fork.

With the quartz there is associated as gangue material marcasite and arsenopyrite. It is a complex sulpho-telluride ore in which the tellurium is presumably present in the form of the silver telluride petzite $(AuAg)_2Te$. The other ore minerals present are argentite, Ag_2S, pyrargyrite, Ag_3SbS_3, and proustite, Ag_3AsS_3.

Ore Values

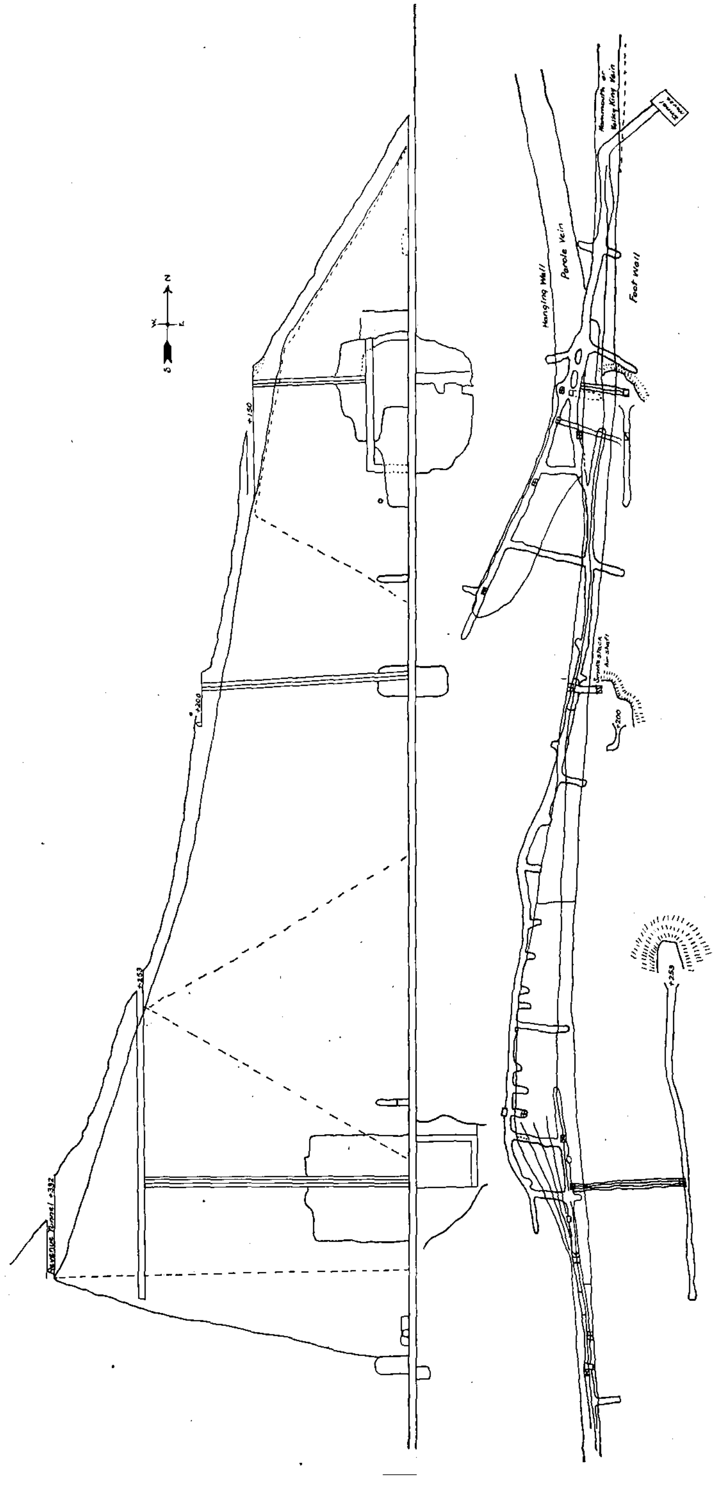
Some very rich ore must have been mined from this vein in the early days. Even now pockets of rich ore can be found in the mine that have not been entirely stripped. The following records of shipments taken from the books of the company give a good idea of the richness and character of some of the ore shipped from the Mammoth mine:

Ore Shipments from Mammoth Mine

Date	Weight	Oz. of Ag per ton	Oz. of Au per ton	Net value of shipments after deducting freight
Sept. 5, 1889	20,612	277.50	20.90	$ 6,448.74
Sept. 13, 1889	23,136	306.00	22.36	7,851.93
Oct. 18, 1889	23,651	239.70	15.85	5,344.53
Feb. 6, 1890	22,661	250.70	9.73	4,469.18
Apr. 12, 1890	22,523	402.10	30.42	10,435.68

The following assays were made from samples taken to illustrate different grades of ore as at present found in the mine.

	Oz. of Au per ton	Oz. of Ag per ton	Total value Au at $20 Ag at 50c
Massive arsenopyrite taken from foot wall	.4	1.4	$ 8.72
Characteristic low-grade ore	.4	1.6	8.80
Characteristic medium-grade ore	.88	8.5	21.85
High-grade ore	1.30	125.50	88.75



Map and section of the workings of the Mammoth mine at Platoro. See page 91.

From the above assays it may be seen that the ore from this mine, in spite of the silver minerals that appear to make up the values, really contains greater values in gold than in silver. This appears to be more pronounced in the lower than in the higher-grade ores.

In order to ascertain the average value of the ore body after the removal of the high-grade ore, very careful sampling of the ore in the levels free from water was made by Mr. C. S. Barnes, deputy mineral surveyor for the district. The samples were taken every twenty feet, in each case entirely across the drift or stope. The width of the vein thus sampled varied from three to 42 feet, the average being eight feet. After eliminating all high-grade assays, 27 samples gave an average value of $7.75 per ton. It was reported that the ore values in the two levels under water are higher than those above water. But there was no way to substantiate this.

CONGRESS GROUP

The Congress group lies to the south of and adjoining the Mammoth property, and is on the south slope of Mammoth Mountain. It consists of seven claims with an area of 61.35 acres. These claims cover the Mammoth vein to the Lake fork of the Conejos river. Little development work has been done and no ore shipped, though it is claimed that phenomenal assays have been obtained from the vein.

A tunnel has been driven for a distance of 450 feet on the vein from the lower end of the Congress claim, but no quantity of high-grade ore has as yet been struck.

PAROLE GROUP

This group of claims lies north of the Mammoth property. It consists of two claims that embrace an area of 20.662 acres, and that cover 1,500 feet of the Mammoth vein. Midway on the Parole No. 1 claim a shaft 125 feet deep has been sunk and a short cross-cut run to the east at the 100-foot level. This shaft is in bad condition.

The vein at this point is very wide and shows large bodies of low-grade ore. Small streaks of high-grade ore run through the quartz at intervals. Only small quantities of ore have been shipped.

VALLEY QUEEN GROUP

The Valley Queen group is also located on the big Mammoth vein and lies to the north of the Parole group. On the surface a shoot of ruby silver carrying good values was uncovered and a shaft was started and sunk vertically to a depth of 125 feet, although the ore shoot dipped to the north. From this shaft a cross-cut was run fifty feet to the east. A shaft house with hoisting plant has been erected. The shaft was being operated in 1913, and a 12 to 18-inch streak of ore was struck in a 34-foot quartz vein, the ore running $75 to $100 per ton. The entire vein appears to be mineralized to some extent.

MERRIMAC GROUP

The vein on which the claims of the Merrimac group are located lies somewhat west of and approximately parallel to the Mammoth vein. Six claims with an area of 62 acres and an adjoining mill site of five acres belong to this group. The claims cover 6,000 feet of the vein. The vein is from eight to ten feet wide and carries large amounts of low-grade ore in which several good-sized shoots of high-grade ore have been uncovered.

The Merrimac was the first shipper from this camp. Prospectors found an ore shoot at the surface, and, obtaining a lease, took out 3,300 pounds of ore from a hole 14 feet deep. This ore netted them $320 after paying a royalty and shipping and smelting charges. The ore was packed to the railroad on burros.

A shaft 175 feet deep with two drifts, respectively 90 and 146 feet long, was sunk on the vein and considerable high-grade ore extracted. Two other shafts and several surface cuts are found on the vein.

FOREST KING GROUP

On the western slope of Mammoth Mountain and about one mile west of the Mammoth vein is located a group of 19 claims, known as the Forest King group.

The exact width of the vein is not known as no cross-cuts have been driven. So far as exposed the vein shows a width of 20 feet. The ore is very similar to that of the Mammoth vein. A tunnel has been driven on the vein for a distance of 1,200 feet. The ore taken out in driving this tunnel was thrown on the dump, which is said to have an average value of $31.20, of which $15 is in gold.

After the completion of the tunnel several thousand dollars' worth of the ore was stoped out and shipped. Some beautiful specimens of free gold have been taken from this vein.

CLAIMS IN THE VICINITY OF AXELL

A large number of claims have been located in this area, distant some two or three miles from Platoro in an easterly direction. As already stated, on account of lack of time, no effort was made by the writer to investigate these claims, but as a company has recently been organized for the purpose of developing some of these claims as well as for treating the ores of other properties in the Platoro district, brief mention will be made of these properties at this time. The information available, however, is that contained in a prospectus issued by the company.

The company in question is the Colorado Hydro-Electric Company, with William S. Allen, President; Charles O. Axell, Vice-President, and Otto L. Lundgren, Secretary and Treasurer. This company owns three claims—the Queen Bee and April Queen, adjoining claims, and the Lake View claim. On the first two claims the development work consists of a tunnel 175 feet long with some cross-cuts and a trench. The ore dump contains 500 tons of milling ore.

On the Lake View claim is a tunnel of 200 feet and a shaft on the southern end. The ore dump of this tunnel contains 440 tons of milling ore. The prospectus of the company quotes from the report made by United States Mineral Surveyor Charles S. Barnes to the effect that the ore dump of these three claims averages about $7.00 per ton.

This company, which was organized this year (1917) contemplates operating a reduction plant for the handling of the ores of the Platoro district, and likewise the erection of a hydro-electric power plant on the banks of the Conejos river.

OUTLOOK FOR THE PLATORO DISTRICT

It may safely be stated that this district is able to produce a large quantity of relatively low-grade ore from veins already to a greater or less extent developed. A reasonably conservative estimate of the value of these ores is on the average of from six to eight dollars a ton. This, of course, under favorable conditions of location and character of ore would hardly be considered a very low-grade proposition. The district, of course, is greatly handicapped by its remoteness; but, even so, this would not seriously interfere with the profitable working of the mining properties provided an economically profitable method of treatment of these complex ores can be found.

Several efforts have been made in the past to find a profitable method of treatment, but for some reason or other these efforts have not been put into practical operation.

For instance, in 1892 experiments were carried on by the Hendryx Cyanide Machine Company to treat the ore of the Mammoth mine by cyanidation. The results of these experiments do not appear to have been very satisfactory, partly because of the large loss of values involved.

Within the past year or two experiments by parties unknown to the writer are said to have been made on the Mammoth ore with a view to treating by the flotation process.

It would seem as if there ought to be no insuperable difficulty in finding a practical method of treating these ores, although it may require a considerable outlay of capital. It can only be a question of time when the problem will be solved.

CHAPTER VI

GILMORE DISTRICT

LOCATION AND DISCOVERY OF ORE

The temporary excitement that caused many hundreds of prospectors and others looking for lucrative investments to throng into and over the Platoro-Summitville district was due to the discovery in October, 1912, of gold telluride ore on the west slope of Klondyke Mountain on a claim owned by Mr. Gilmore. Assays of this ore yielded several hundred dollars to the ton, and not unnaturally caused the happy discoverer to see visions of millions. The discovery was made too late in the season to cause an inrush of prospectors that fall, but the newspapers of the state gave wide publicity to the event during the winter and speculated on the possible development of a second Cripple Creek. It is not to be wondered at, therefore, that the opening of summer saw many a prospector from Cripple Creek and Creede and other mining camps making their way to the new gold strike. Long before the arrival of these new recruits, however, it was known to those on the ground that the ore vein had been quickly lost and that fruitless efforts had been made to locate it.

The Gilmore claim is located about three and a half miles almost directly west of Platoro on the very steep northwestern slope of Klondyke Mountain, overlooking the Alamosa valley. It is but two miles from the town of Stunner, located in this same valley, but the mountain slope on this side is so steep and so heavily wooded as to be inaccessible except to pedestrians. On the other hand an easy trail led from the Conejos valley to within a short distance of the Gilmore claim, so that Platoro rather than Stunner became the center of operation for Klondyke Mountain.

At the foot of the mountain and half way between the Gilmore claim and Stunner is a beautifully located meadow that appears on the map as the Gilmore meadow. This meadow was once located as the "Little George" placer, and a townsite is said to have been laid out at this place. Early in 1913 the erection of a tent and two wooden shacks functioneering as a "hotel," a "store" and a photographer's studio was deemed sufficient to justify the mapping of this new center of population under the title of the "town" of Gilmore. So at any rate it appeared on the hastily improvised maps in the daily press.

Opposite the Gilmore meadow rises the wonderfully impressive and beautiful summit of Lookout Mountain, of which a photographic reproduction is to be seen on Plate XXXIX.

EFFORTS TO DEVELOP ORE VEIN

For the figures and maps introduced in connection with this description of the Gilmore district the writer is indebted to Messrs. R. W. Smith and Wm. G. Zulch, two student members of the party to whom was assigned the special study of this part of the territory investigated.

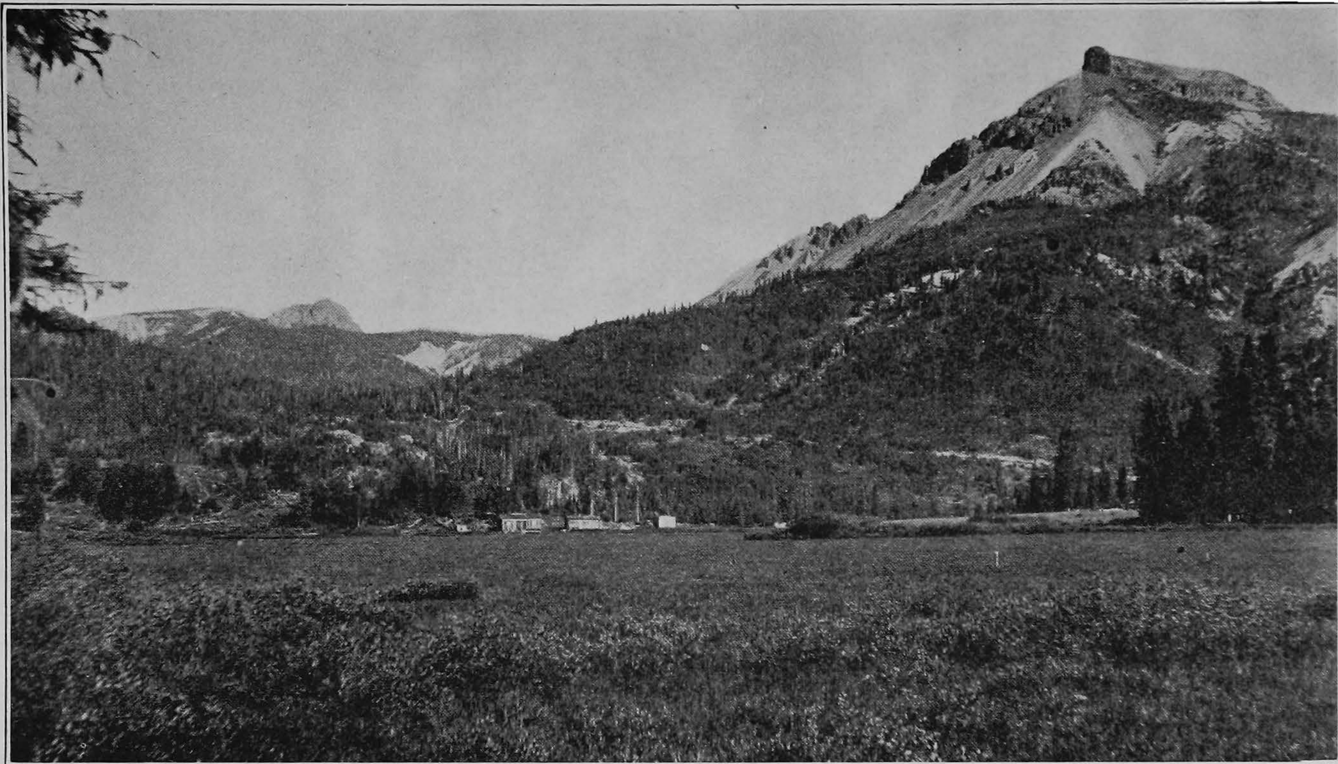
The telluride of gold that carries the values of the Gilmore ore is of uncertain character, as specimens pure enough for satisfactory determination could not be obtained. It is much darker in color than is the case with the Cripple Creek tellurides. The crystals are usually invisible although they occur disseminated through the quartz gangue and give a characteristic dark color to the ore.

When the rich ore was first encountered it was worked by means of an open cut and the values were found to continue for ten or more feet. But the ground became broken below this point and the ore ceased entirely. A tunnel was then driven fifteen feet beneath the discovery point with the expectation of cutting the vein, and two small winzes were sunk thirty feet apart from this fifteen-foot level, but no ore was encountered.

Again a tunnel was started at a level 70 feet beneath the outcrop of the vein and driven to a point beyond where the vein should have been found. In this cross-cut tunnel a barren quartz vein was struck and followed for a short distance. Likewise other small veins were struck, and finally, at about the point where the ore vein was looked for, a large amount of vein material was cut, but proved to be barren.

GEOLOGY OF KLONDYKE MOUNTAIN

The reason for the sudden discontinuance of the ore was not difficult to find. Unfortunately the vein in which this ore was found is situated on a mountain side in the midst of an extensive landslide of such a nature that the superficial portion of the rock formation was sheared off and carried downwards without completely breaking up into fragments. In this movement the Gil-



View of the Gilmore meadow; the background showing Lookout Mountain on the right and Sheep's Head and Prospect Mountain on the left.

more vein and other veins in the immediate vicinity were sheared off. Apparently this shearing movement at this particular point occurred close to the surface. That vein material was encountered in the lower cross-cut tunnel about at the place where the vein was expected may readily be accounted for, as in the case of a fault, on the supposition that a different vein happened to occur at that point, of similar appearance to the ore vein, but barren. Investigation disclosed the fact that a number of such veins occur with parallel courses within the limits of the landslide area, so that the movement of the sheared rock mass might readily bring one vein into line with another one.

The rock formation on the Alamosa slope of Klondyke Mountain consists entirely of monzonite with a very small area of monzonite porphyry. Andesite appears on the summit of the ridge above the Gilmore claim and from there extends eastward over the whole flat-topped summit of the mountain, but it is not involved in the landslide area. This rock is perfectly fresh over the entire area of disturbance and nowhere shows decomposition.

Under the head of "Landslides," in Chapter III, it is pointed out that there are several parallel running quartz veins that correspond in course with the ridges and troughs formed by the movement of the rock material of the slide. These quartz veins have in the past been prospected for gold and several claims located on them. The occurrence of gold telluride is not confined entirely to the vein on which the Gilmore strike was made, but this mineral has also been found to some extent in one or two other quartz veins lying immediately up the slope from the Gilmore property. One of these unpatented claims that has been worked to a slight extent for gold telluride ore is known as the Peterson claim.

CHAPTER VII

STUNNER AND JASPER DISTRICTS

MINES IN VICINITY OF STUNNER

LOCATIONS

Following the discovery of rich ore deposits at Summitville, vigorous prospecting in the regions adjacent to this district resulted within the next ten or fifteen years in opening up other properties in various places in the Alamosa valley and local centers of industry were established at Jasper and Stunner.

All of these properties, most of which have never really produced any shipping ore, had long remained idle until the excitement aroused by the Gilmore discovery gave a temporary stimulus to the efforts to reopen some of the more promising mines.

The town of Stunner in the summer of 1913 had a half dozen or more houses in good condition and supported a store and U. S. Post Office. Numerous prospects, some of them with shafts and short tunnels, had been worked within a radius of two or three miles of this town, but only one of them, the Eurydice, had achieved the distinction of producing shipping ore. In addition to these old properties two other ventures of recent development have been started somewhat further removed from Stunner, but near enough to be included properly within this district. These are known as the Pass-me-by mine on the southern slope of Lookout Mountain, and the Asiatic mine at the east foot of Prospect Mountain.

EURYDICE MINE

The Eurydice mine is located a mile below the town of Stunner on the east side of the Alamosa river. It was not working in 1913 and was, in fact, quite inaccessible, so that no investigation of the mine could be made. This mine has not been worked since 1893, but the size of the dump, which contains some good looking ore, indicates extensive operations before closing down.

The mine was found in charge of Mr. B. Sanford, through whose courtesy access was given to a report on the mine made when the mine was still in operation by Mr. P. H. Van Diest, a mining engineer. What is presented here is taken from this report of Mr. Van Diest and is given practically as found in the graduation thesis of Mr. Merritt Hutton, student member of the party, to whom this district was assigned.

The Eurydice mine is in a quartz fissure vein containing streaks of iron and copper pyrite, which carry sulphides and tellurides of gold and silver. The out-crop of the vein can readily be traced for several hundred yards up the gulch and is from two to four feet wide. It is stained brown by the oxidation of the iron sulphide. The Louisa shaft has been sunk on this vein. At a depth of thirty feet in this shaft the brown stain disappears. The vein, which is four feet wide at this point, shows 18 inches of quartz.

The Eurydice shaft is sunk on this same vein about 600 feet north of the Louisa shaft. Eight tons of ore taken from this shaft near the surface were sorted and netted $155 a ton after deducting the freight and smelting charges. In the sinking of this shaft a distance of 192 feet, about 18 tons of $150 ore was sorted out.

From the bottom of the shaft a drift was driven along the vein in a southerly direction for a distance of 192 feet. Nine tons of $125 ore was sorted from the rock taken from this drift. A drift was also driven in the opposite direction, likewise several cross-cuts to a parallel vein. Later additional development work was done, and by 1891 the shaft had reached a depth of 300 feet.

Fig. 2, on page 103, shows a sketch of the mine working as prepared by Mr. Van Diest.

The average value of the ore on the dump is $25 a ton. The assays that follow are taken from this same report and have been selected with a view to indicate the values under varying conditions.

Assays by Henry E. Wood made for the Eurydice Company:

Date	Description of Sample	Oz. Gold	Oz. Silver
Mar. 18, 1891	specimen	2.10	21.00
May 25, 1891	specimen	9.00	1,760.00
May 25, 1891	specimen	10.00	2,049.00
May 26, 1891	specimen	4.00	573.50
Oct. 2, 1891	specimen	21.50	529.50
Feb. 13, 1892	specimen	5.00	500.00
Feb. 19, 1892	specimen	26.75	25.30
Feb. 19, 1892	specimen	27.04	1,138.60
Feb. 20, 1892	specimen	2.80	398.20

Assays by Eurydice Company:

Description of Sample	Oz. Gold	Oz. Silver
Talc from hanging wall	.06	3.26
Talc from hanging wall	.16	10.05
Talc from hanging wall	.30	27.00
General sample of talc	.30	26.00
Gouge between porphyry and vein	.33	39.66
Quartz with iron	.13	8.66
Quartz streak	.23	28.10
Quartz streak	.10	2.23
Black mineral in talc streak	.80	71.63
Brown quartz	.13	15.73
Dark green gouge	.10	3.50
Mud from ore room	trace	9.30
Talcose streak	.16	3.50
Talcose streak	.06	2.60
White quartz	trace	2.73
White talc	trace	2.13
Green gouge	.06	3.46
First class ore	7.30	553.30
Wash from sorting table	6.60	545.70
Ore room waste	1.00	9.30
Talc from north drift	1.20	14.45
Ore from long drift	1.33	32.00
Gravel from washing tables	1.00	10.00
Sample from load	3.70	60.00
Doubtful stope	.66	32.00
Specimen for reference sorting	.20	6.20
Talc from north drift	.53	17.20
White rock	trace	5.30
Talc near quartz streak	.26	45.40
East wall of stope	1.13	6.73
South breast of stope	trace	4.60
Light brown ore	.40	9.53
Black wall rock	.33	21.33
Quartz from stope	1.70	1.33
Zinc and quartz from stope	1.60	1.66
Sample from stope	1.33	1.00
Porphyry from stope	.....	2.00
Gouge from foot wall	.16	1.90
Sample from N. drift, lowest level	.26	4.73

Description of Sample	Oz. Gold	Oz. Silver
Sample from raise, lowest level	.33	12.60
Sample from south stope	.13	1.88
From stope, lower south drift	.60	39.00
From stope, lower north drift	.40	8.90
Roof, lower north drift	.16	1.80
Talc, lower north drift	.66	23.00
Foot wall, lower drift	4.40	288.93
Hanging wall, lower drift	1.00	220.60
Breast of lower south drift	.26	6.40
Breast of lower south drift	.66	2.60
Sample, lower south drift	.20	16.40
General sample, unsorted ore	.33	24.00
General sample, south drift	.33	21.30
General sample, north drift	.16	5.50

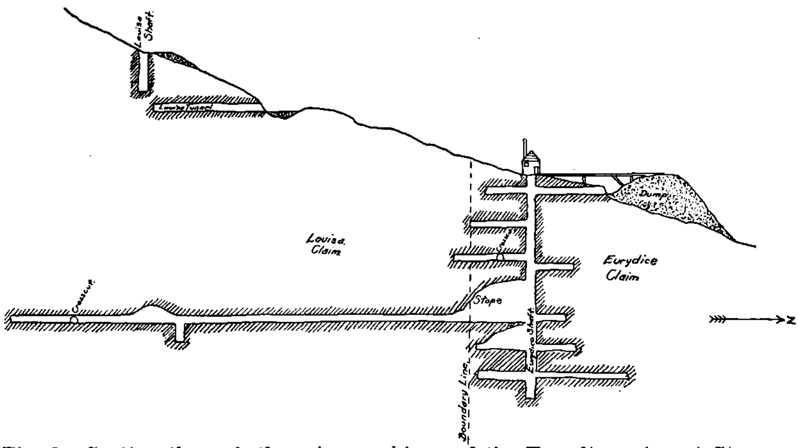


Fig. 2. Section through the mine workings of the Eurydice mine at Stunner.

PASS-ME-BY MINE

This mine is located about two and a half miles from Stunner on the state highway, at the west foot of Lookout Mountain. The mine buildings are located not far from the road at the mouth of a long tunnel which has been driven with a view to cutting the veins located high up on the western slope of the mountain.

The company owns several claims, of which the Arla claim is considered the most promising. Gold was discovered in the Arla vein in 1897. The present tunnel was started at a level 600 feet below the apex of the vein. In 1913 work was in active progress in the tunnel, which had attained a total length of 3,600 feet. From the portal the tunnel runs north 85° west for a distance of 2,500 feet, and then north 50° west for 1,100 feet, without having struck the Arla vein. The total cost of driving the tunnel was stated to be over $62,000.

In the expectation that further work on this property might open up the ore vein, the writer visited the property in 1915 in the hope of making an investigation of the underground workings. The tunnel, however, was closed, and on account of foul air could not be entered. Apparently no work had been done since 1913. The surface plant is new and includes a large bunk house, a tunnel house, and power plant. In the latter is a return tubular boiler of 100 horsepower and a Leyner compressor.

The water issuing from the tunnel is very highly charged with ferrous sulphate and contains considerable arsenic.

ASIATIC MINE

The Asiatic mine is located at the southern foot of Prospect Mountain about a mile southwest of the Pass-me-by mine. It is reached by an excellent road that branches off from the state road a half mile south of the last-named mine. Prospect Mountain does not appear on the map, but a spur of the mountain, known as Sheep's Head, is shown on the western edge of the map, just north of the mine.

A cross-cut tunnel starting from the base of the mountain has been run to intersect the vein, the apex of which is located 650 feet above the tunnel level. The mine was under the management of Mr. Orean Carpenter in 1913, but had been closed for several years.

Admission to the tunnel was barred at the time this survey was undertaken, as there was no one in charge. The tunnel has a length of 1,300 feet and runs north 15° west. The vein had not yet been reached. The buildings at the tunnel portal are in good condition. The power house contains a return tubular boiler of 120 horse power and two Leyner compressors.

WATROUS CLAIMS

About three miles below Stunner on the south side of the Alamosa river and near the mouth of Acme creek are a group of claims known as the Watrous claims. These embrace the Emma tunnel and shaft, the Molly tunnel, and the Apex tunnel. The only claim from which ore has been shipped is the Emma, and in this case not enough has been shipped to pay for the production.

The Emma tunnel was the original or discovery point on these claims and was commenced in 1881. The tunnel has been driven a distance of 375 feet with one cross-cut of 50 feet at about 60 feet from the breast. A shaft 350 feet deep, and connecting with the tunnel, was started in 1895. Gray copper with some tellurides make up the principal ore. No work was being done in 1913, and an examination of the property could not be made, as both tunnel and shaft were caved in.

The Molly tunnel is at an elevation of 9,500 feet. It has been driven about 200 feet, but at the time of examination was caved at a point 100 feet from the portal. The tunnel was expected to cut veins located higher up on the slope, but no ore was taken out.

The latest tunnel to be run on these claims is the Apex tunnel. It has about 150 feet of workings and was driven to cut a large quartz vein which may be seen crossing Acme gulch. Some pretty stibnite crystals have been taken out of this tunnel.

MINES AT JASPER

HISTORY AND DEVELOPMENT

The information here presented in connection with the mines of Jasper is very largely the result of investigations made by Mr. J. H. Woolf, Jr., one of the student members of the party.

Jasper is located in the Alamosa valley, just below where the river makes a great sweep around the northern base of Cornwall Mountain. Next to Summitville it is the oldest of the towns to be located in the district under consideration. It was founded in 1874-1875, at which time the first ore prospects were opened up.

The Perry mine was the first to be located and was discovered by Andrew Johnson, with whom Alva Adams was in partnership. Later associated with these men were G. G. Calkins and Pascal Craig. These men, together with Frank Moody, who later became interested in Jasper and laid out the townsite, still own most of the territory around Jasper. They control the Perry and Gaudaloupe mines under the name of the Cornwall Mining Company. The Miser mine; the only other mine of consequence at Jasper is owned by Frank Moody, Dr. Ross, G. W. Ballentine and John Gabriel, all of Denver.

About two and a half miles above Jasper in the Alamosa valley is a group of old buildings and workings called the Sanger mine. Interesting tales are told as to the manipulation of this property, tales that are perhaps not possible to verify, but that are commonly accepted as true. The story goes that the founders of this enterprise claimed to have a mountain of what they termed "bird's-eye porphyry" that had an average value of ten dollars a ton. After securing all the money possible by means of these alluring but false representations, the too confiding investors were swindled out of their money and the "mine" ceased operations. There is no doubt about a mountain of rock, but it assays only a small fraction of what was claimed.

However much truth there may be in this story, it remains true that the unsavory reputation gained thereby for Jasper has operated to discourage investment in such genuine mining enterprises as Jasper may have to offer.

A general view of the town may be seen in Plate XL, facing page 106.

PERRY MINE

The Perry mine is located directly across the river from the town of Jasper at an elevation above the river of 800 feet. It is owned by the Cornwall Mining Co., and was opened about 1874. It has not been worked for a number of years.

Some very rich ore appears to have been taken out of this mine, as assays are reported commonly running as high as 1,200 ounces in silver and 2.20 ounces in gold per ton. Some very rich specimens from this mine are still shown and even now it is not uncommon to find silver nuggets on the mine dump.

For the purpose of getting the ore down to the river level an inclined wooden railway, supported on rocks and wooden trestles was constructed on a slope of 32°. Its remains are still visible. It is reported that the car jumped the track on the second trip and was never used again.

The mine was originally worked through a shaft located at an elevation 150 feet above the tunnel level. A tunnel 225 feet long was driven connecting with the shaft. Wooden cars were used and run on wooden rails. These wooden rails and one of the cars were observed in the tunnel, both in good preservation. The vein is reported to be 12 feet wide, but the tunnel was caved near the

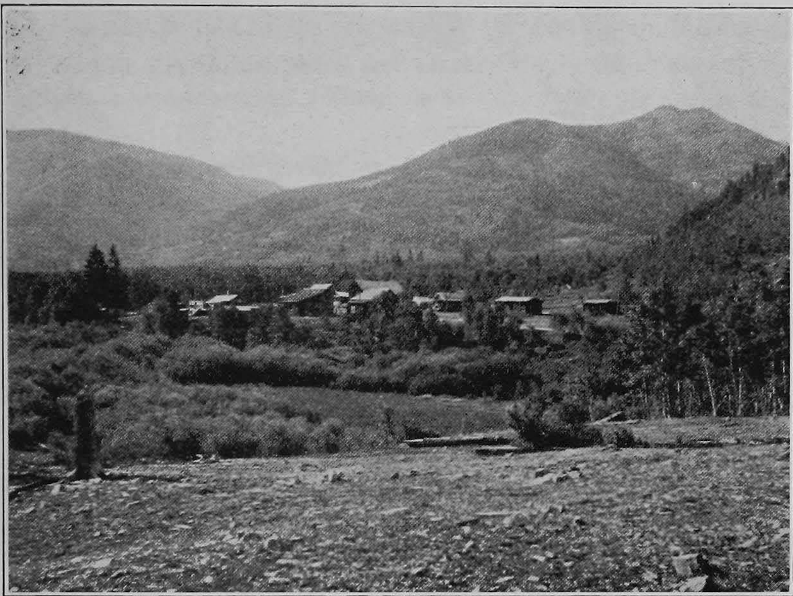


Fig. 1. View of Jasper, from the east.

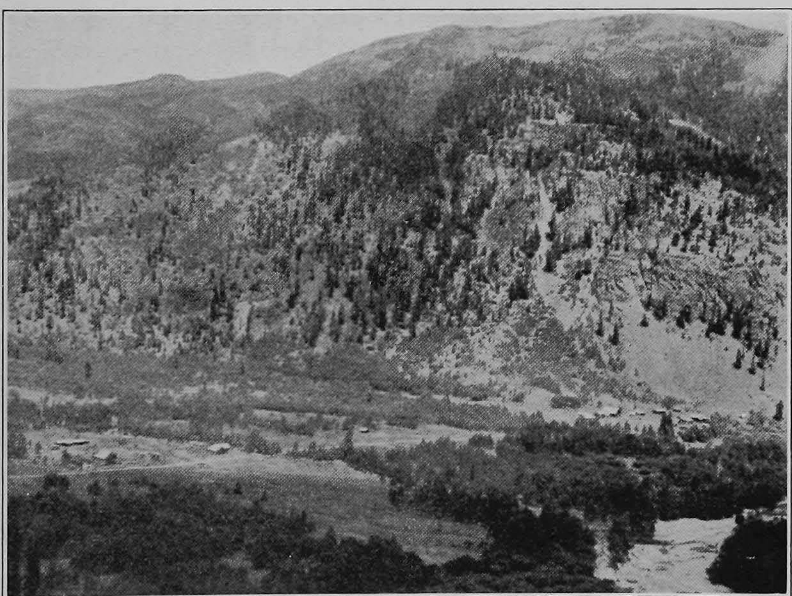


Fig. 2. View of Jasper, from the south side of the valley.

vein, as was also the shaft, so that an inspection of the vein was impossible. The gangue of the vein is quartz, which appears to have been separated from the walls by well defined clay gouge, so far as may be told by the character of the material on the dump.

Within the tunnel three well-marked fault slips marked by clay gouge were observed. These showed the following strikes and dips:

1. 150 feet from portal, strike N. 35° W., dip 50° S.W.
2. 180 feet from portal, strike N. 60° W., dip 50° S.W.
3. 220 feet from portal, strike N. 35° W., dip 50° S. W.

MISER MINE

The best-known mine at Jasper is the Miser mine, located almost at the river level, one-half mile above Jasper on the south side of the river. This mine was opened over 30 years ago and at that time most of the development was done. It is owned by Frank Moody, Dr. Ross, G. W. Ballentine, and John Gabriel.

The mine was originally opened on the Tip Top vein, and most of the claims are located in the vicinity of this vein, but the company also controls about 300 feet of the Perry vein which strikes across the lower part of the property. A cross-cut tunnel was driven about twenty feet above the river level and extended directly into the mountain. This tunnel is 700 feet long and cuts the Perry vein at 350 feet from the portal. About 50 feet of drifting has been done on this vein. From this point the tunnel was extended with a view to cut the Tip Top vein or other possible veins, but apparently without success. This work was done in the eighties and the mine lay idle until quite recently. Some extremely rich specimens are said to have been taken out of this mine. Report has it that specimens assaying $52,000 per ton in gold have been found. Mrs. G. M. Hook of Jasper states that she has seen specimens belonging to her uncle, Frank Moody, with gold stringers all through the rock.

On the first day of November, 1912, Mr. G. M. Hook, John E. Field, Charles W. Foster, and H. L. Morrison took a bond and lease on the Miser property and also on the Guadaloupe mine. During the following spring they worked the Miser, but about the first of July changed over to the Guadaloupe. In the Miser they sank a small shaft on the vein and found a few rich specimens, but were obliged to cease work on account of the water. They also did some stoping, but did not find ore that paid the expense of mining.

The mine at present is in good condition.

The vein is a quartz vein with clay gouge on each side and measures several feet in width. Its strike is S. 40° E, dip rather uncertain. Apparently there has been considerable faulting along the vein. Above the tunnel is an intermediate level where the view shows a dip of N.E. 70°.

At the entrance to the tunnel are several small buildings, including a blacksmith shop, a dry and change room, and a small engine room, containing a gasoline engine.

GUADALOUPE MINE

About 400 feet east of the Miser mine on the same side of the river, and just above the river level, is located the Guadaloupe mine, which was the only mine being worked in 1913. It is owned by Alva Adams and others.

The mine is supposed to be working on the Perry vein. The claim was patented in 1882, and the apex and discovery tunnel are still open to examination. The vein is of quartz, apparently replacing the country rock which is a monzonite porphyry. At the apex this vein strikes S. 70° E., and dips S.W. 70°. The vein is about six feet wide. It contains some vugs in which may be seen sphalerite, galena and pyrite.

The tunnel, which was being worked by the four leasers named above, is located 400 feet lower than the apex vein. The work done up to late in August, 1913, was mostly clean-up work. There was a day and a night shift working, with three men on each shift. The tunnel had originally been driven to cut the Perry vein, but for some reason, after driving 295 feet, work was discontinued. In the clean-up work the tunnel has been lowered and the original wooden rails replaced with rails of steel. At 226 feet from the portal a small vein was encountered and one shift was being employed in drifting on this vein. This vein shows a strike of N. 65° E., and a dip of N. E. 72°. It has a width of two to three feet and has been exposed for 15 feet. It shows a quartz gangue mixed with the above-mentioned sulphides. The country rock is close-grained monzonite porphyry.

SUPPLEMENT

List of Mining Claims in Alphabetical Order

Name	Section	Township	Range
A and E	35	36	4
Adams	32	37	5
Agnes	7	36	4
Alabama	11	36	3
Alaska No. 1	35	36	4
Alaska No. 2	35	36	4
Albion	32	37	5
Alpha	32	37	5
Alta	21	36	4
Amazon	25	36	4
Annex	21	36	4
Annie	27	36	4
April Queen	24	36	4
Arla	6	36	4
Armes	26	36	4
Asiatic M. S.	11	36	3
Asiatic Placer No. 1	11	36	3
Asiatic Placer No. 2	11	36	3
Asiatic Placer No. 3	11	36	3
Asiatic Placer No. 4	11	36	3
Atlantic	25	36	4
August Flower	24	36	4
Aurania	22	36	4
Baltimore	11	36	3
Bayard	30	37	4
Belle of Conejos	27	36	4
Belle Ward	26	36	4
Best End	26	36	4
Bismarck	12	36	3
Black Prince	1	36	3
Bonanza King	28	36	4
Boss	30	37	4
Boyd	17	36	4
British Queen	21	36	4
Brooklyn	11	36	3
Bryan	18	36	4
Buckeye	19	37	5
Burlington	27	36	4

Name	Section	Township	Range
Burris	22	36	4
Cabinet	26	36	4
Catamount	12	36	3
Champion	24	37	4
Chelan	22	36	4
Chicago	23	36	4
Chicago	27	36	4
Chicago	30	37	4
Chile	30	37	4
Chilkal	25	36	4
Clara	31	37	5
Clarence White	12	36	3
Cleora	6	36	4
Cliff	9	36	4
Climax	32	37	5
Colorado	32	37	5
Columbia	30	37	4
Compromise	32	37	5
Congress	26	36	4
Congress	27	36	4
Cornucopia	9	36	4
Cranky	26	36	4
Daniel Webster	12	36	3
Daylight	6	36	4
Decoy	26	36	4
Delaware	11	36	3
Dillon	26	36	4
Edna	7	36	4
8th Wonder	30	37	4
Elkton	25	36	4
Ella	32	37	5
Ella "K"	25	37	4
Emma	3	36	4
E. P.	19	37	5
Escambia	19	37	5
Etruria	23	36	4
Eureka	23	36	4
Eureka	30	37	4
Eurydice	9	36	4
Evalyn No. 1	30	36	5
Evalyn No. 2	30	36	5
Evangeline	22	36	4
Evening Star	32	37	5
Evergreen	26	36	4
Fetterman	12	36	3
Flag	26	36	4
Forest King	21	36	4
Forest Lily	28	36	4

Name	Section	Township	Range
Fork	26	36	4
Fortune Teller	21	36	4
Free Coinage	25	36	4
Glacier	25	36	4
Golconda	27	36	4
Golconda	30	37	4
Gold Bug	24	36	4
Golden Egg	22	36	4
Golden Star	30	37	4
Golden Star	31	37	4
Golden Vault	30	37	4
Gracie No. 1	12	36	3
Gracie No. 2	12	36	3
Gray Eagle	30	37	4
Grover Cleveland	22	36	4
Gt. Independence	30	37	4
Guadaloupe	31	37	5
Guild	4	36	4
Hallam	22	36	4
Hardscrabble	25	37	3
Hardware	30	37	5
Hairy	24	36	4
Helen	17	36	4
Highland Mary	30	37	4
Homestake	12	36	3
Horace Greeley	12	36	3
Horace M.	30	37	5
Horace M. No. 2	30	37	5
Hyman	27	36	4
Ida	27	36	4
I Don't Care	25	37	4
Illinois	11	36	3
Illinois	22	36	4
Independence	24	36	4
Indiana	25	36	4
Iron Clad	11	36	3
Jessie	12	36	3
Jessie	27	36	4
Jessie "S"	30	37	5
Jimmy Walker	21	36	4
Jubilee	25	37	3
June Bug	25	36	4
Justice	32	37	5
Katy	27	36	4
Kearsarge	11	36	3
Keystone	31	37	5
King	31	37	5
Kirby	11	36	3
Knoblock	31	37	5

Name	Section	Township	Range
Lake	35	36	4
Lake View	21	36	4
Last Chance	26	36	4
Learney Dune No. 1	36	36	4
Learney Dune No. 2	25	36	4
L. E. S.	21	36	4
Little Jessie	30	37	4
Little Joe	35	36	4
Logan	30	37	4
Louisa	9	36	4
Louisiana	11	36	3
Lulu	24	37	4
Lyla	27	36	4
M. A. E.	31	37	5
Maggie May	27	36	4
Maine	11	36	3
Mammoth	22	36	4
Mary "L"	19	37	5
Mask of Venus	25	36	4
May Queen	24	36	4
Merrimac	11	36	3
Merrimac	22	36	4
Middle	22	36	4
Midway	12	36	3
Miser	30	37	5
Missing Link	11	36	3
Missionary	30	37	4
Molke	30	37	4
Monitor	11	36	3
Monte Cristo	27	36	4
Monterey	11	36	3
Montgomery	11	36	3
Morning Star	22	36	4
Mt. Pleasant	27	36	4
Napoleon	12	36	3
Nellie	27	36	4
Nellie Nelson	19	36	4
Nellie Pearl	12	36	3
New Deal	21	36	4
Nick	31	37	4
Ninety Six	21	36	4
North Side	12	36	3
North Star	22	36	4
No. 10	9	36	4
Osceola	19	37	5
Ohio	11	36	3
Olympia	11	36	3
Omaha	22	36	4
Omaha	25	37	4

Name	Section	Township	Range
Omega	30	37	4
Omega No. 2	31	37	4
Ophir	18	36	4
Ophir	27	36	4
Oregon	11	36	3
Orekiss	35	36	4
Orok	24	36	4
Orpheus	9	36	4
Oyama	30	36	5
Pacific	25	36	4
Palmer	21	36	4
Parole	30	37	4
Parole No. 1	22	36	4
Parole No. 2	22	36	4
Pascoe	20	37	5
Pass-Me-By	7	36	4
Pavonia	22	36	4
Perry	32	37	5
Petrel	11	36	3
Plat	24	36	4
Pokehagan	31	37	5
Prospect	26	36	4
Queen Bee	25	36	4
Quincy	27	36	4
Quinland	26	36	4
Rambo	25	36	4
Revenue	27	36	4
Robinson	13	36	4
Rock Hill	20	37	5
Roe	17	36	4
Rose	30	37	5
Rosy "S"	30	37	5
Sam Cooper No. 1	35	36	4
Sam Cooper No. 2	26	36	4
Saunders	25	37	3
Scorcher	26	36	4
Scranton	36	37	3
Seminole	19	37	5
Senate	27	36	4
Servia	22	36	4
Sheridan	30	37	4
Sickles	32	37	5
Silver Bell	1	36	3
Silver Ben	25	36	4
Silver King	35	36	4
Sixteen-One	18	36	4
Smuggler	8	36	4
Snow Drift	28	36	4
Snowstorm	27	36	4

Name	Section	Township	Range
South End	26	36	4
Standard	30	37	5
Star	28	36	4
Starlight	7	36	4
St. Louis	27	36	4
Sunbeam	8	36	4
Sunbeam	30	36	5
Sunnyside	1	36	3
Surprise	9	36	4
Tallaho	25	36	4
Texas	11	36	3
Tidal Wave	31	37	5
Tinware	32	37	5
Tip Top	31	37	5
Tonana	25	36	4
Topsy	27	36	4
Trap	26	36	4
Treasury	22	36	4
Triangle	25	36	4
Troy	21	36	4
Umbria	22	36	4
Upper Ten	6	36	4
Utah	29	36	4
Valley King	22	36	4
Valley Queen	22	36	4
Venus	23	36	4
Vivian	6	36	4
Walker	25	36	4
Walter "S"	30	37	5
Washington	12	36	3
Wesley	24	37	4
West Side	27	36	4
Wildcat	22	36	4
Winnetka	21	36	4
Wisconsin	28	36	4
Wonder No. 2	12	36	3
Youel	12	36	3
Yukon	25	36	4
Zenobia	30	36	5

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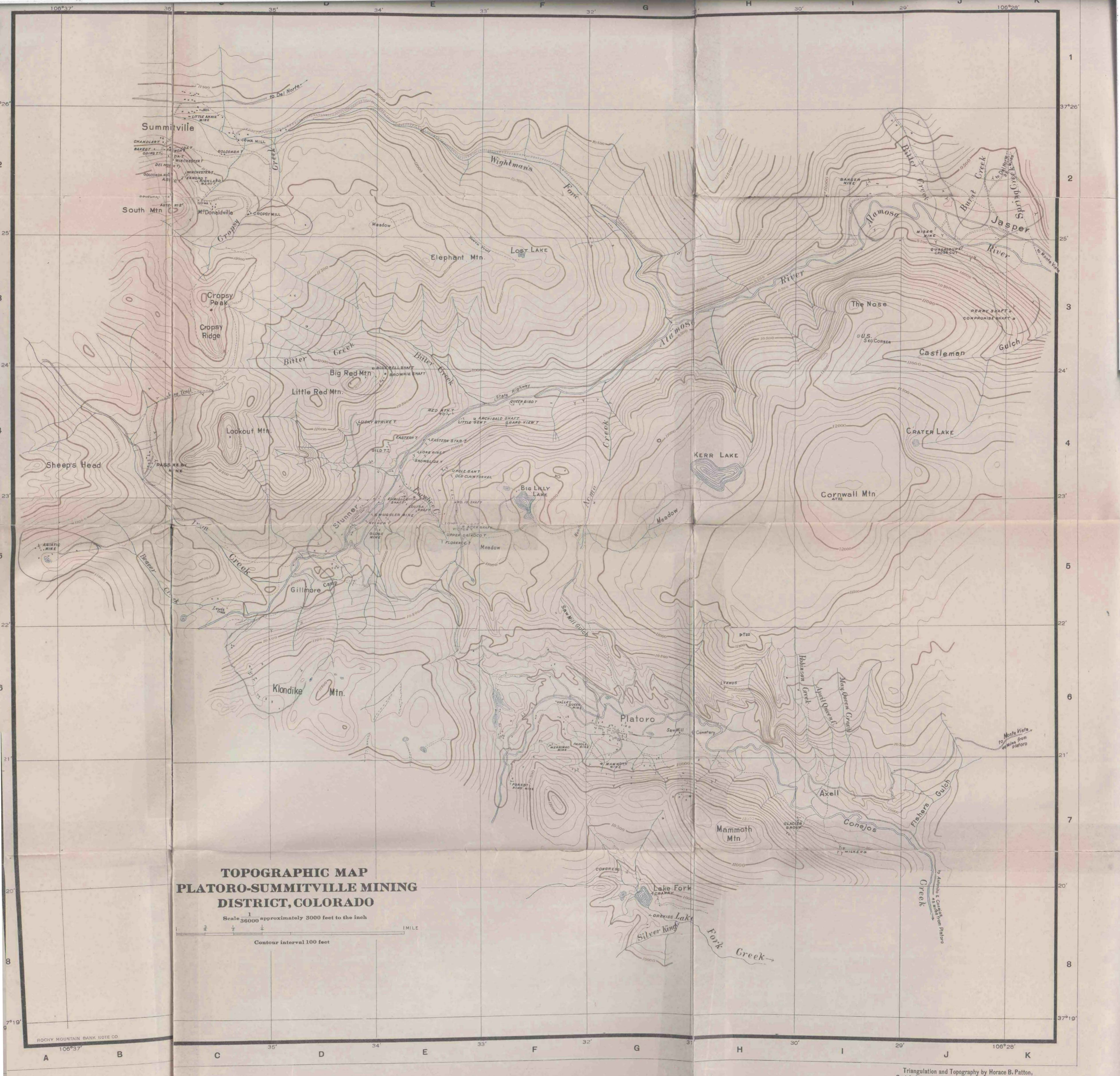

TOPOGRAPHIC MAP PLATORO-SUMMITVILLE MINING DISTRICT, COLORADO

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

Contour interval 100 feet

Triangulation and Topography by Horace B. Patton, Carl A. Allen, I. I. Taytor, Chas. E. Smith and Students of the Colorado School of Mines. Surveyed in 1913.