

WASHINGTON GEOLOGICAL SURVEY

HENRY LANDES, State Geologist

BULLETIN No. 1

GEOLOGY AND ORE DEPOSITS

OF

REPUBLIC MINING DISTRICT

By JOSEPH B. UMPLEBY



OLYMPIA, WASH.:
E. L. BOARDMAN, PUBLIC PRINTER.
1910.

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CONTENTS

	<i>Page</i>
ILLUSTRATIONS	5
LETTER OF TRANSMITTAL	6
INTRODUCTION	7
Location	7
Field work and acknowledgments.....	7
Previous work	8
General remarks	8
CHAPTER I—PHYSIOGRAPHY	9
Topography	9
General character	9
Drainage	9
Principal features	9
Changes in drainage	10
Glacial features	10
Eocene peneplain	11
Correlation	12
Climate	14
CHAPTER II—GENERAL GEOLOGY	15
General statement	15
Description of rock formations.....	16
Paleozoic series	16
Distribution	16
Characteristics	16
Age	17
Granodiorites	17
Distribution	17
Characteristics	18
Age	18
Tertiary formations	19
Relation to older formations.....	19
Dacite flow conglomerate.....	20
Distribution	20
Characteristics	21
Age	22
Andesite flows and lake beds.....	23
Earlier andesite flow breccia.....	23
Distribution	23
Characteristics	23
Age	24
Lake beds	24
Distribution	24
Characteristics	24
Age	24

CHAPTER II—GENERAL GEOLOGY (*Continued*):

Description of rock formations—

Tertiary formations—

Andesite flows and lake beds (<i>Continued</i>):	<i>Page</i>
Trachyte flow	25
Later andesite flows.....	25
Distribution	25
Characteristics	26
Latite porphyry	27
Distribution	27
Characteristics	27
Basalt flow	28
Relations	28
Characteristics	28
Quaternary history	28
Glaciation	29
The drift	29
Stream erosion	30

CHAPTER III—ECONOMIC GEOLOGY 32

History of mining development.....	32
Production	34
Metallurgy	34
The veins	37
Distribution	37
General characteristics	37
Minerals of the ore.....	39
Geologic relations of the veins.....	41
Genesis of the ore.....	41
Effect of solutions on wall rock.....	42
Placer mining	43

CHAPTER IV—DETAILED DESCRIPTION OF PRINCIPAL MINES..... 44

New Republic mine.....	44
Location	44
History and production.....	44
Development	45
Wall rock	45
The vein	46
The ore	48
Ben Hur mine.....	50
Morning Glory mine.....	52
South Republic mine.....	52
Quilp mine	53
Surprise mine	54
Black Tail mine.....	56
Lone Pine mine.....	59
San Poil mine.....	62
Mountain Lion mine.....	63
Tom Thumb mine.....	64
Elcaliph	65

ILLUSTRATIONS

<i>Plate.</i>	<i>Facing Page</i>
I. Town of Republic.....	8
II. Black Tail and Lone Pine mines.....	8
III. Geologic map of Republic mining district.....	16
IV. Dacite flow conglomerate; A, Usual texture; B, Coarse phase	24
V. Interstratification of shale with dacite breccia.....	24
VI. Quartz breccia from Lone Pine mine.....	32
VII. Andesite flow breccia.....	32
VIII. A, Elongation of vesicles in trachyte; B, Tufaceous lake beds	40
IX. Claim map of Republic district.....	40
X. A, Details of crustification in ore; B, Typical appearance of Republic veins	48
XI. Vertical distribution of gold and silver in Republic mine...	48
XII. Mine map of New Republic mine.....	48
XIII. Mine map of Lone Pine mine.....	59

<i>Fig.</i>	<i>Page</i>
1. Diagram showing relation of Tertiary to older formations....	11
2. Distribution of ore in one part of Surprise vein.....	55
3. Pattern of veins on Lone Pine and Black Tail claims.....	57
4. Diagram showing occurrence of ore in lenses in Lone Pine No. 2 vein	60
5. Vertical distribution of gold and silver in Lone Pine mine.....	63

LETTER OF TRANSMITTAL

Governor M. E. Hay, Chairman, and Members of the Board of Geological Survey:

GENTLEMEN—I have the honor to submit herewith a report entitled "Geology and Ore Deposits of Republic Mining District," by Joseph B. Umpleby, with the recommendation that it be printed as Bulletin No. 1 of the Survey Reports.

HENRY LANDES,
State Geologist.

UNIVERSITY STATION, SEATTLE, July, 1910.

GEOLOGY AND ORE DEPOSITS OF REPUBLIC MINING DISTRICT

By JOSEPH B. UMPLEBY

INTRODUCTION

LOCATION

The Republic mining district, which is also known as the Eureka mining district, is located in eastern Washington, in Ferry county, about 20 miles south of the Canadian boundary. Definite boundaries for the district are not on record, but in general terms, it includes about six townships and has its approximate center a little west of the south end of Curlew lake. The accompanying map of a part of the district (Plate III) represents an area eight miles north and south, by seven east and west. Republic, the county seat of Ferry county, is the only mining camp represented on the map, and is the most important one in the county. It has a population of about 1,500 inhabitants and is accessible by two railroads, the Republic & Kettle Valley, and the Spokane Falls & Northern, a branch line of the Great Northern system.

FIELD-WORK AND ACKNOWLEDGMENTS

Field work was begun June 23, 1909, and was continued until July 29, 1909. By this time the geological mapping was completed and most of the problems had taken satisfactory shape; but in view of certain developments in progress and a few outstanding problems, work was resumed September 4, 1909, and was continued until September 21, 1909, although most of this time was spent in a preparation of the preliminary report.

Mr. Olaf Stromme, who assisted in the field, did a large part of the mapping and aided in some of the economic studies. During the preparation of the report many valuable suggestions were received from the professors of the Department of Geology in the University of Chicago, and for these the writer

wishes to express his appreciation; particularly is he indebted to Dr. W. H. Emmons for suggestions in connection with the sections on ore deposits. The mining companies, and the residents of Republic and vicinity offered every encouragement to the work. The writer is especially indebted to Mr. Sam Richardson, county surveyor of Ferry county, whose courtesies greatly facilitated the progress of the studies.

PREVIOUS WORK

In 1904 the United States Geological Survey published a topographic sheet of the Republic area, on a scale of one-half inch to the mile and with a 100-foot contour interval.

Save for a few articles in technical journals¹, and statistical statements, there is but little literature on the camp. F. L. Ransome visited Republic in connection with his work on the International Boundary Survey in 1901, but the results of his observations have not yet been published. A statistical statement and passing note is made by W. Lindgren in *Trans. Am. Inst. Min. Eng.*, Vol. XXXIII, p. 838. In the annual report of the Washington Geological Survey for 1901, pp. 52-60, a brief description of the district and of the principal mines is given.

Reference to work in adjoining districts will be made in the text.

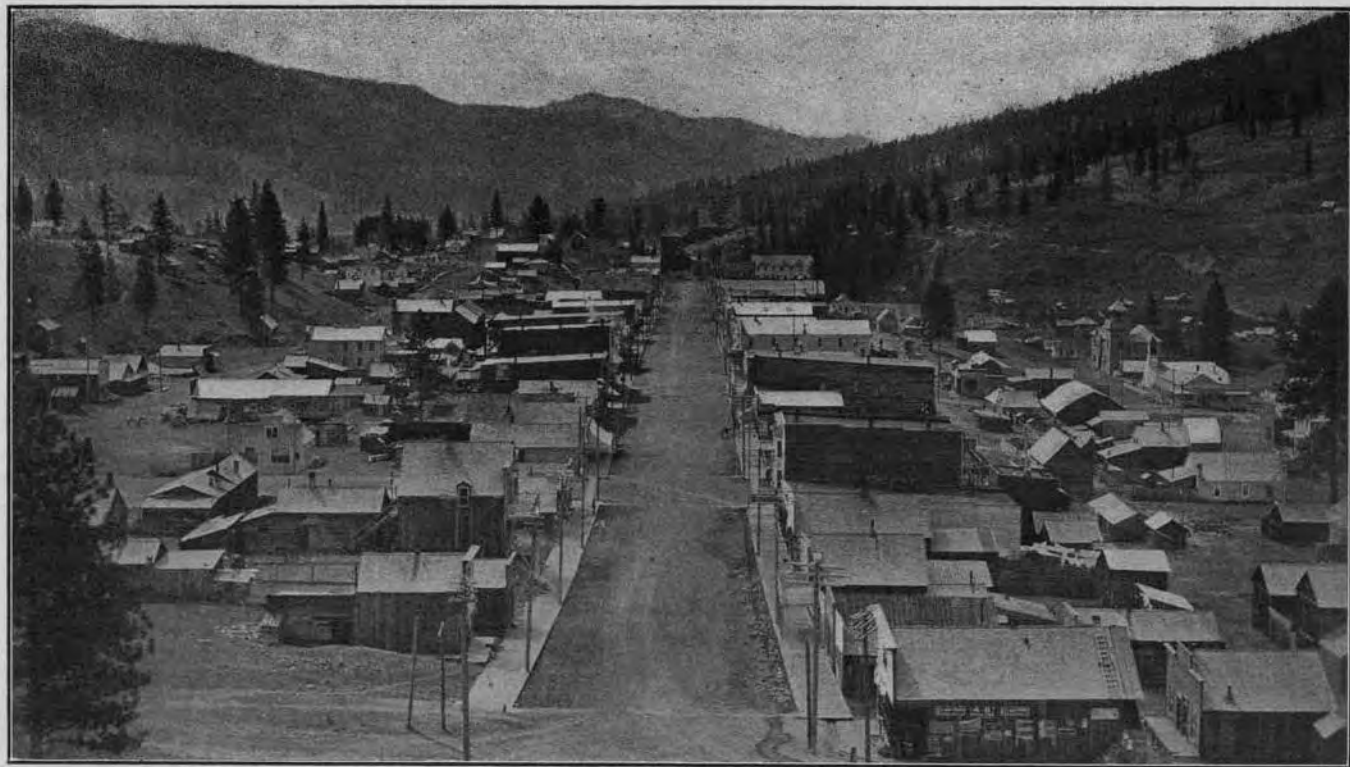
GENERAL REMARKS

The Republic area is covered with a fairly uniform growth of medium sized evergreen trees. Although it is a district of but moderate rainfall (about 18 inches), most of the streams live throughout the year and supply an abundance of water for mining and other purposes.

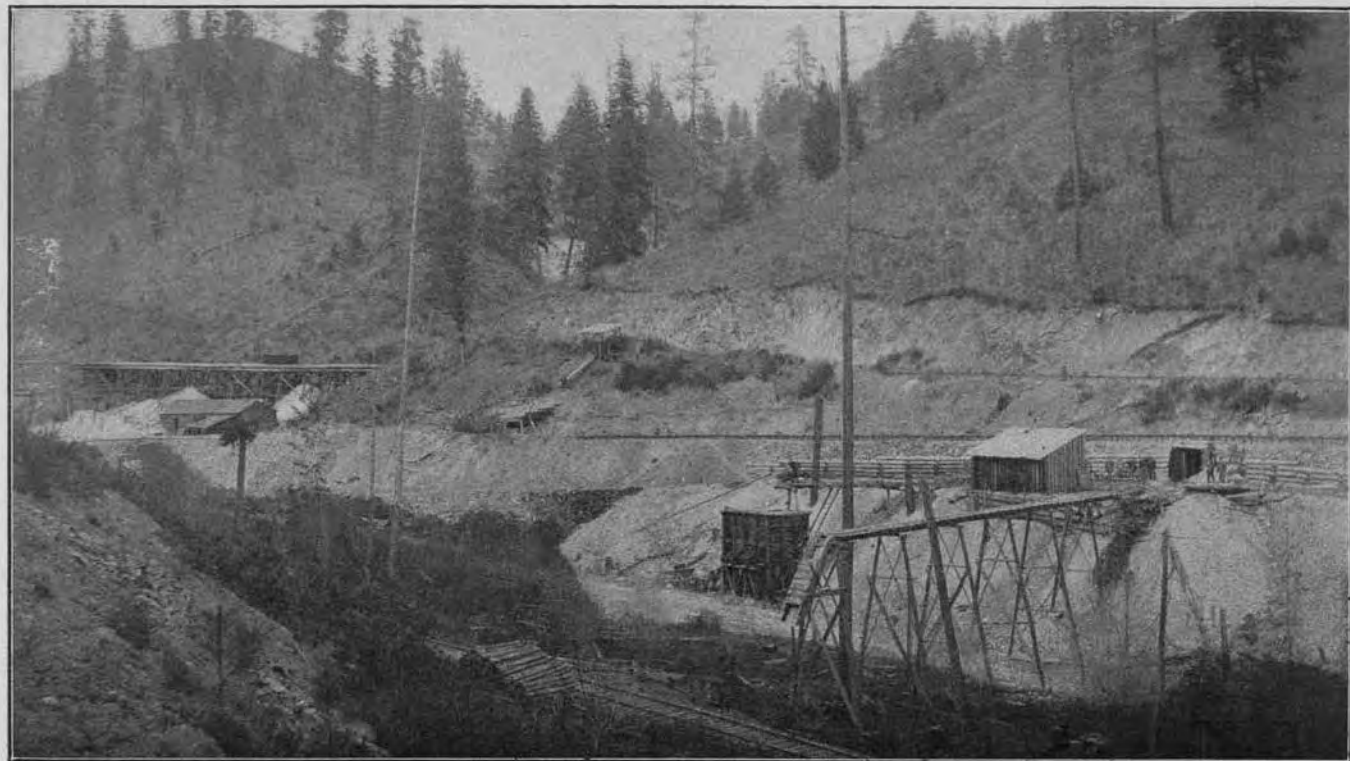
The entire region is more or less thickly covered by glacial drift which, together with the vegetation, offers serious difficulties to geologic studies. The general concealment of contacts and crucial points is discouraging almost to the point of making detailed studies impossible.

¹The Republic Mining Camp, Washington, M. H. Joseph, *Eng. & Min. Jour.*, Vol. LXVIII, pp. 635-636.

The Mountain Lion Mine, M. H. Joseph, *Eng. & Min. Jour.*, Vol. LXIX, p. 285.



Town of Republic, Looking South. Old Mill in the Distance.



Black Tail (on right) and Lone Pine Mines in Eureka Gulch.

CHAPTER I

PHYSIOGRAPHY

TOPOGRAPHY

General Character.—The Republic district is one of bold topographic features. The mountains are of fairly uniform elevation and all have rounded tops. No broad flats exist either along the streams or on the divides, and the surface consists of almost uniformly steep slopes produced by the erosion of many branching streams, which flow in valleys from 2,000 to 3,000 feet deep. An occasional valley flat is wide enough for agricultural purposes. The larger north-south valleys in many instances present a succession of narrow terraces, at some places five or six in number.

Drainage.—The area includes the divide between Curlew creek, which flows north into the Kettle river, and thence east by a circuitous route into the Columbia river, and San Poil river, which flows south directly into the Columbia. Granite and O'Brien creeks are principal tributaries of the San Poil, while Curlew creek is fed by many small streams. Although none of the streams are large, yet they furnish abundant water for mining and domestic purposes. There are no valuable water-power sites.

Principal Features.—Within the area mapped, Granite mountain, lying six miles northeast of the town of Republic, is the highest point (5,326 feet). Copper mountain to the southwest and Gibraltar mountain to the southeast, are 4,446 feet and 3,783 feet in altitude, respectively. The San Poil-Curlew valley, in which two streams flowing in opposite directions are subsequent to an older and larger stream which probably flowed to the south, is deep and flat bottomed, with its bed about 2,300 feet above sea level.

Changes in Drainage.—The San Poil-Curlew valley is steep sided with a depth of from five or six hundred to fifteen hundred feet. Within the valley the place representing the divide between north and south flowing drainage is fully as wide and well developed as any other part. This incongruity in development is further emphasized by comparing Granite creek and San Poil river valleys above the point where their streams unite. Granite creek and San Poil river are of almost equal size at their point of junction, yet the latter is flowing in a valley vastly larger than the former. These facts are interpreted to mean that the San Poil-Curlew valley was developed by an earlier and larger stream. Comparing its valley¹ with that of Kettle river, which runs south from Canada, then east and north again into Canada, it is seen to be very similar in degree of development. It is concluded, therefore, that Kettle river at one time flowed south directly into the Columbia and afterwards took its present circuitous course to the east. This change of drainage is probably one of the results of glaciation, although the area studied did not afford conclusive evidence of its cause.

Glacial Features.—A recessional moraine, in places over 200 feet high, extends east and west of the town of Republic. West of the town it is well developed and there reaches its present maximum thickness, while to the east subsequent erosion has removed much of it. The topography of this moraine in its western development is very rough, abounding in steep-sided kettles, in many instances 50 to 100 feet deep. Along the San Poil-Curlew valley terraces cut in valley train material and lateral moraines² are very conspicuous, while the stream is now working in a valley train. Rolling topography typical of ground moraine is widely distributed throughout the area.

¹See topographic map of Republic quadrangle published by the U. S. Geol. Survey.

²Developed by a tongue of ice which extended down the valley from the edge of the continental glacier at the time of its recession.

EOCENE PENEPLAIN

Looking out over the broad expanse of mountain tops from any point of vantage, the irregularities caused by many deep and ramifying valleys are not conspicuous and in every direction there is striking accordance in general elevation of the mountain tops. This accordance in elevation, together with the fact that the individual mountains in some instances are limestone (Buckhorn mountain) and in others granodiorite (Granite mountain), which offer very unequal resistance to erosion, strongly suggests an old erosion surface, which now



Fig. 1. Diagram showing occurrence of Tertiary formations in an old erosion valley. The surfaces at the extremes of the diagram represent an Eocene peneplain.

has an elevation of from 5,000 to 6,000 feet above sea level in the vicinity of Republic.

G. M. Dawson¹ recognizes what is probably a portion of the same surface in the Interior Plateau of Canada and describes it, in part, as follows:

"These remnants of an old Eocene land surface are most marked in the southern half of the Interior Plateau of today, where they have elevations of from 4,000 to 6,000 feet above the actual sea level and stand 3,000 to 5,000 feet above adjacent valleys and low tracts of later origin."

Mr. Dawson regards this peneplain as Eocene both on the strength of its relation to known Miocene beds, and on the broad fact that great Eocene lakes are known to have existed to the south in Washington, Oregon and Idaho, while no evidence of Eocene sedimentation occurs in this general area, seeming to imply that the area of the Interior Plateau was land during Eocene times, and if land, evidences of a great period of erosion should be found.

¹Trans. Royal Society of Canada, 1890, p. 11.

The only bearing of the present studies on the second point of Dawson's is that the extent of area where Eocene beds are absent has been increased. On the first point, however, strong support is offered. The early Miocene deposits of the Republic area lie in a great valley which was cut in the Eocene peneplain by a late Eocene or early Miocene river (Fig. 1). From this relation it is obvious that the peneplain surface is pre-Miocene, and from the fact that the early Miocene beds, which lie unconformable above earlier Tertiary lavas, occur in a deep, steep-sided valley, it seems altogether probable that the peneplain is Eocene.

CORRELATION OF EOCENE PENEPLAIN

No attempt will be made at definite correlation, but it is thought wise to record certain general features which have been suggested by the present studies. The relation of the Eocene peneplain to the Miocene deposits at Republic is quite definite (see p. 17) and analogous to that which Dawson recognized in British Columbia as shown in part by the following statement¹:

"There is in British Columbia some reason to suspect that a considerable amount of erosion of the surface of the Eocene peneplain occurred before the deposition of the Miocene."

And on the same page Mr. Dawson writes:

"By an interruption of drainage * * * the great Miocene lakes of that portion of British Columbia between the Coast and Gold Ranges were first formed."

In general features the similarity between the Interior Plateau of British Columbia and the Republic highlands is suggestive of a close relation between the two areas. In opposition, however, to this general correlation is the fact that to the south, in central Washington and as far north as the Lake Chelan district, the oldest erosion surface recognized is the so-called Methow Stage of Willis, which includes beds of known Miocene age. Regarding the Methow Stage, Mr. Willis writes as follows:²

¹Trans. Royal Society of Canada, p. 13, 1890. G. M. Dawson.

²U. S. Geol. Surv., PP. 19; G. O. Smith and Bailey Willis, p. 71.

"It has been identified by Russell, Smith and the writer as a feature cut upon nearly all rocks of the region, the schistose metamorphics, the Tertiary arkose sandstone, the bedded basalt flows and the pumiceous clastics of the Ellensburg formation." On page 17 of the same paper G. O. Smith states that the Ellensburg sandstone "is known definitely to be of Miocene age."

It thus appears that the Interior Plateau of Canada, although broken by mountains along the 49th parallel, may extend down into Washington and include the Highland country of Ferry and parts of adjoining counties. If this is true, this area and the central Cascade mountains of Washington are different physiographic units, and have different Tertiary histories.

Smith and Calkins¹ recognize this fact, for in speaking of the differentiation of the Cascade mountains they say:

"An example of this is found in the occurrence of an Eocene peneplain in the Interior Plateau region, while in the Cascades peneplanation of Eocene age has not been recognized, and indeed in central Washington the Miocene lavas are known to rest upon a surface possessing considerable relief."

In connection with the last phrase in the above quotation a fact was noted, the interpretation of which is not here attempted. Columbia river south of Keller is essentially the boundary between the Eocene Interior Plateau to the north and the great Miocene Basalt Plateau to the south. The Interior Plateau stands at least 1,000 feet higher than the basalt plateau, and the lavas of the latter are at least 1,000 feet thick. Removing the basalt, therefore, we have two areas joining along a definite line and the one at least 2,000 feet higher² than the other, with the lower surface "possessing considerable relief."

Conclusions.—In so far as conclusions are justified it appears that the Republic area and probably a greater part of the Colville Indian reservation is a part of that physiographic unit which is known as the Interior Plateau, and which is

¹U. S. Geol. Surv., Bull. 235, G. O. Smith and F. C. Calkins, p. 90.

²The observations were made from a stage near Keller and are thought to be greatly minimized.

bounded on the west by the Coast Range and on the east by the Gold Range and which extends north to the McKenzie river and, if relations here suggested be correct, it extends south to the Columbia river. South and west of this great unit is an erosion surface recognized as post-Miocene in age.

CLIMATE

The climate of Republic and vicinity is semi-arid, although it receives more moisture than many parts of eastern Washington. The temperature is not extreme either in summer or in winter. A forest growth of evergreen trees which covers the greater part of the area conserves the precipitation and distributes the runoff throughout the entire year. The following table compiled from the United States weather reports¹ gives the more important details of climatic conditions at Republic.

TABLE SHOWING WEATHER CONDITIONS AT REPUBLIC

<i>Temperature</i>	<i>Degrees fahr.</i>	<i>Precipitation (rain and melted snow)</i>
Maximum (July '05).....	102	
Minimum (Jan. '09).....	-32	Annual avge. 17.96
Mean annual	43.9	Avge. No. rainy days.... 96
Killing frost—		Avge. No. clear days...186
Last in spring avge. June 15.		Avge. No. partly cloudy.. 74
First in autumn avge. Sept. 3.		Avge. No. cloudy.....105
		Prevailing windN. W.

¹Data furnished by G. N. Salisbury, Weather Bureau Official, Seattle. The observations cover the period from 1900 to 1909.

CHAPTER II

GENERAL GEOLOGY

GENERAL STATEMENT

The geologic history of the Republic district has as its great features sedimentation in the Paleozoic, erosion with minor vulcanism in the Mesozoic, igneous activity and erosion in the Tertiary, and continental glaciation in the Quaternary.

The oldest rocks exposed in the district are the metamorphic equivalents of a great series of shales, sandstones, limestones and lava flows which are of Paleozoic age, and are provisionally assigned to the Carboniferous. After the deposition of this series, the area passed through a long period of crustal disturbance which, although not developing sharp folds, metamorphosed the beds and raised the area far above sea level. Either during this period of crustal disturbance or shortly thereafter great batholithic masses of granodiorite were intruded into the Paleozoic series.

From the time of the granodiorite intrusions, which are probably of early or middle Mesozoic age, to middle Tertiary times, there was a great period of erosion which may be divided into two parts; a first, during which the entire area was reduced probably to base level (Eocene surface); and a second which was introduced by decided elevation and during which broad valleys at least 2,500 feet deep were developed.

The next rocks in order of formation are of Oligocene age, and occupy one of these broad, deep valleys. They are dacite flows, including great quantities of stream gravels. Overlying these, unconformably, are andesite breccias, lake beds, and andesite flows, all of which occur within the old erosion valley. Next in order of age are intrusive latite porphyries with which the ore deposits are thought to be genetically related.

From the time of the latitic intrusions to the Pleistocene, erosion was the dominant process, although during this time there was a short period of basaltic eruption. In the Pleistocene period, the Cordilleran ice sheet covered the entire area.

DESCRIPTION OF ROCK FORMATIONS

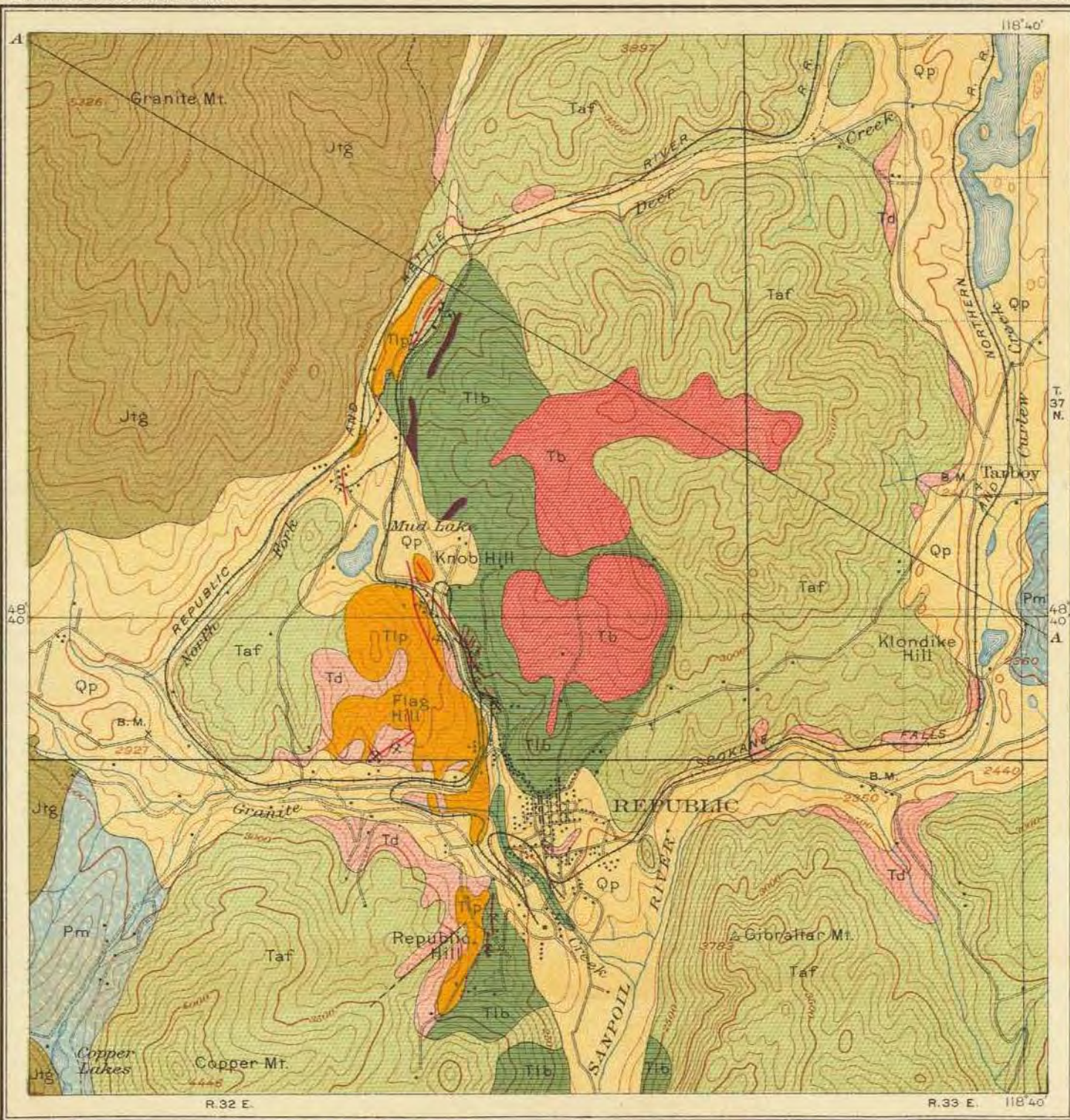
PALEOZOIC SERIES

Distribution.—The oldest known formation exposed in the area is a series of metamorphic rocks including slates, schists, quartzites, marbles and greenstones. It is most extensively developed (see Plate III) southwest of Republic, where about two square miles are known. East of the San Poil-Curlew valley, and largely beyond the limits of the map, are extensive areas where the metamorphic series is the predominating formation. Both areas are so poor in exposures that it is impossible to determine detailed relations.

Characteristics.—The Paleozoic rocks are very uniformly but not intensely metamorphosed. True schists are not common, and in many instances the limestone has not been changed to marble. Nevertheless, the series has been so disturbed that a given set of characteristics seldom persists for more than a short distance in any direction. Neither bottom nor top of the series was found.

Black carbonaceous argillite is the predominant rock type, although bluish-gray non-fossiliferous limestones have a wide development. Massive gray quartzites were noted in one exposure southwest of Republic. Porphyries of intermediate and basic composition are found both as dikes and sills, apparently intruded into the series before its metamorphism. The age relations of the various phases of the series are not obvious from studies in the Republic area, but to the north, at Phenix, B. C., LeRoy¹ reports a section including all the above types of rocks

¹Canadian Geol. Surv. Bull. 1072, p. 65.



which he divides into three parts with an unconformity between the upper two. His section places the argillites in the upper part, separated from the limestones and tuffs (no tuffs of this age were noted at Republic) by a pronounced unconformity, while the lower member is quartzite with intruded dikes and sills of basic porphyrites.¹ The Paleozoic beds are folded and metamorphosed, and are in marked contrast with the overlying Tertiary series in which folding is less marked and the beds are not metamorphosed.

Age.—It is not possible, on the strength of facts now known, to assign this formation to a definite place in the Paleozoic series. Near Republic the formation carries certain fossils, not well preserved, but which seem to be crinoid stems. In an exposure of limestone near the top of Buckhorn mountain in the northwest part of Republic quadrangle, several fossil crinoid stems were found which are not out of harmony with a provisional assignment to the Carboniferous. These remains, together with the lithologic characteristics of the series, suggests a correlation with the Cache creek series of Dawson,² which is of Carboniferous age. On lithologic grounds, however, it is thought that rocks of more than one age are present.³

GRANODIORITES

Distribution.—Great batholithic masses of granodiorite which cut through the Paleozoic formations are shown along the west side of the map, and are exposed a short distance beyond the limits of the map to the east. They are not exposed in the central part of the area nor for several miles north and south along the same general direction, although they may be present beneath the Tertiary lavas which are continuous as a narrow

¹This series will be more fully discussed in a bulletin of the Washington Geological Survey now in course of preparation by the author and entitled "A Reconnaissance in Mining Districts of Northern Okanogan County, Washington."

²Ann. Rep. Geol. Surv. Canada, new series, vol. 7, 1894, pp. 37 B-49 B.

³Lithologically and structurally, there are many points in common between this series and the Calaveras formation of California, which reference to the California literature will suggest.

north-south belt for a distance of over 60 miles. Granite mountain, situated northwest from Republic, is a great batholith of this type, which was so denuded before Tertiary vulcanism that rocks of that age now rest on its flanks at a point more than 2,300 feet lower than its summit.

Characteristics.—The surface of the mass as exposed on Granite mountain is characterized by great ledges and low cliffs, usually rounded by glaciation and covered by a fairly dense forest growth. The rock is dark gray in color and made up of orthoclase and plagioclase feldspars, with lesser amounts of hornblende and biotite, and occasionally microcline crystals. Magnetite, pyrite, apatite, titanite, and rutile are the principal accessory minerals. The rock is inequi-granular in texture, in places having scattered feldspar crystals up to one inch in length surrounded by inequi-granular material of much smaller size. At a few places the granodiorite has been made schistose by movements which took place after its solidification.

Age.—The rock of Granite mountain is clearly younger than the Paleozoic series which it intrudes, and its lack of extensive schistosity indicates that it is more recent than the dynamic movements which metamorphosed that series. It is, on the other hand, much older than the Tertiary formations which lap up on its sides, and which contain fragments of its material. Since the top of Granite mountain is probably a remnant of an old peneplain surface, the relation of the Tertiary to its exposed sides indicates that sufficient time had elapsed after its intrusion and before Tertiary volcanic activity, for erosion to remove the cover of the batholith and reduce the entire area to near sea level; for dynamic stresses to raise the area, and for erosion to develop the broad valleys in which the Tertiary formations are now found. The schistosity observed along certain zones on the mountain can be readily explained by movements known to have taken place in early Tertiary times.

From the evidence in hand it is only possible to place this period of igneous activity somewhere in the Mesozoic, and possibly about the middle of that era.

TERTIARY FORMATIONS

The Tertiary history includes several periods of igneous activity. The rock formations are divisible into two series which are unconformable. The lower is a series of dacite flow conglomerates inclosing thin beds of stratified shale. The upper is a succession of andesite flows which are separated into upper and lower groups by extensive lake beds.

Relation to Older Formations.—The Tertiary beds occupy a deep, broad valley cut in the older rocks after the elevation of the Eocene peneplain. The evidence for this relation is the geographic distribution of the Tertiary series, and the vertical distribution of contacts of Tertiary with older rocks.

The Tertiary andesite flows extend in a narrow belt over 40 miles south from Republic, and continue at least 17 miles north. The east-west distribution is limited to a comparatively narrow belt—about five miles wide at Republic.

At Phoenix, LeRoy records a similar north-south distribution of Tertiary beds which are in general alignment with those at Republic and may be in the same river valley. In speaking of these LeRoy says:¹ "They are unconformable to the Paleozoic and form a long irregular band extending from the War Eagle to the Gilt Edge claim, crossing the east side of the town of Phoenix."

Although this areal distribution of Tertiary beds is suggestive of deposition in an old valley, it is not as rigorous as the vertical distribution. The older metamorphics and granodiorites outcrop at conspicuous elevations along the east and west side of the Republic area. In the central north-south zone only Tertiary formations are found and they rest against the steep slopes of the older formations for a vertical distance of several hundred feet. (See Fig. 1). A more definite idea of the vertical distance to which they once lapped up on the older rocks is obtained by projecting the elevation of the lava series in the central part of the area across the post-Miocene erosion valley

¹Summary Rept. Geol. Surv. Canada, 1908, p. 65, A. E. LeRoy.

of North Fork, to the face of Granite mountain. Such projection indicates that the Tertiary series once rested against the face of the mountain to a height of more than 2,000 feet above its lowest exposed part. On the lower slopes of Granite mountain itself remnants of Tertiary material appear at several places, among others west of the Mountain Lion mine.

There is a possibility, of course, that faulting may account for the relation of the Tertiary beds to Granite mountain, but the same relation is found along both east and west limits of the Tertiary formations, and nowhere is there direct evidence of faulting. In this connection it is worthy of note that the basal formation of the Tertiary contains a large percentage of well-assorted and water-worn pebbles. Some of them are of granodiorite.

From these lines of evidence collectively, it is fairly certain that the Tertiary series was accumulated in a great valley developed by erosion.

DACITE FLOW CONGLOMERATE¹

Distribution.—Dacite flow conglomerate is exposed at various places near the bottom of San Poil-Curlew valley, along Granite creek as far west as North Fork, along North Fork and at various places along the ore zone. Except along the ore zone the formation is found only near the bottoms of the deeper valleys. Wherever it was possible to determine their dip, the beds were found to be tilted at angles varying from 15° to 80° . In an exposure near the Mountain Lion mine the beds dip 45° southwest; near the Kettle Valley station they dip 23° east; near San Poil lake the dip is nearly 60° west; and an occurrence in O'Brien Creek canyon of what may possibly be a lower member of the same formation, dips 80° west. These four out

¹*Flow conglomerate* is here proposed as a term to be used parallel with *flow breccia*—the two to hold the same relation to each other as obtains between conglomerate and breccia when applied to clastic beds. The parallel use of these terms makes it possible to distinguish between a flow which has picked up distinctly water worn material, and the more common type where the included fragments are angular. Rhyolite, latite, dacite, andesite, basalt, etc., according to the nature of the including rock, should precede the term.

of the numerous exposures of this formation, are the only ones of value in determining their attitude, but in so far as they are to be relied upon the beds represent an anticline about two miles across in the west part of the area and a syncline in the east part.

The formation is folded, but very much less intensely than the Paleozoic, while the next following series shows little or no folding, indicating an unconformity at both top and bottom of the formation.

Characteristics.—The series is made up of lava flows which have picked up a great quantity of stream gravels and so distributed them through their mass that not one exposure in ten is free from rounded pebbles, which in most instances, constitute from 5% to 30% of the rock. The pebbles have been derived from the underlying metamorphic rocks and the granodiorite batholith. Layers of hard shale with a very subordinate amount of sandstone are occasionally¹ found in definite, often laminated, layers in the igneous rock. These vary from a fraction of an inch to five or six feet in thickness and are always sharply separated from the igneous material above and below. Occasionally wood fragments, of no value for age determinations, occur in the shale layers. A partial section of the formation is given below.

Section of Dacite Near Kettle Valley Depot

Beds concealed.

- | | |
|---|-------|
| 7. Dacite, pebbles scattered through like phenocrysts. More abundant near base..... | 80' |
| 6. Shale, as in No. 4..... | 3' |
| 5. Dacite, in bottom about 30% pebbles grading upwards to 1% pebbles at top. Pebbles oriented flat to shale..... | 5' 6" |
| 4. Shale, in places very sandy. No pebbles..... | 2' 6" |
| 3. Dacite, with pebbles over $\frac{1}{8}$ " making up 25% of mass. Irregular in thickness. Pebbles oriented flat to shale..... | 8" |
| 2. Shale, arenaceous, firm but finely laminated. No pebbles. Contains wood fragments..... | 10" |
| 1. Dacite, (lowest member exposed) resembles a coarse sandstone with 70% of tuff intermixed. Includes many slate and a few quartzite pebbles all rounded and varying up to 1" in diam. 80% are the size of rice grains..... | 12' |

Beds concealed.

¹Four exposures before mentioned.

Microscopically the inclosing rock is porphyritic in texture with the relative amount of phenocrysts to groundmass, about three to one. The principal constituent minerals, approximately in the order of their abundance, are plagioclase, quartz, orthoclase, magnetite, pyrite and apatite, with various secondary minerals. The groundmass is microcrystalline to glassy. Some of the phenocrysts are fractured and sometimes the quartz is rounded, but these features are no more conspicuous than in many other effusive rocks.

A study of the above characteristics leads to difficulties in giving the occurrence a rational explanation. The formation underlies an area of at least 30 square miles, and throughout that extent few, if any, exposures are free from the small rounded pebbles. The way in which the beds are tilted seems to imply a considerable thickness, which adds a remarkable vertical to the wide horizontal distribution of the pebbles. The presence of finely laminated shale and sandstone layers, sometimes highly carbonaceous, and usually thickly bedded, clearly indicates a succession of dacite flows separated in time by periods of quiescence of sufficient duration to allow sedimentation in small lakelets formed on the upper surfaces of some of them. The most feasible explanation of the origin of this formation seems to be that in each case the dacite lava poured out over a surface strewn with stream pebbles, the pebbles of each of the upper flows having been washed onto the underlying surface during the period of quiescence which separated the eruptions.

Age.—The degree of folding which the dacite flow conglomerate possesses and which is vastly more than that of the Eocene peneplain, might be thought to signify a pre-Eocene age. On the other hand, its known exposures, except along the ore zone where elevated by later intrusions, are all near the bottom of an Oligocene stream valley, and therefore must be younger than the Eocene. The formation is also unconformable below the next younger beds which are of early Miocene age. Because of this unconformity with the Eocene below and the early Miocene above the formation is assigned to the Oligocene.

ANDESITE FLOWS AND LAKE BEDS

Separated from the dacite flow conglomerate by a structural unconformity are andesite flows which in the following pages are divided into earlier and later because in their midst are lake deposits over 750 feet thick. Beyond the limits of the lake beds no line of demarkation was determined between the earlier and the later flows. These three divisions will be treated separately.

EARLIER ANDESITE FLOW BRECCIA

Distribution.—Overlying the dacite flow conglomerate unconformably, is a succession of andesite flow breccias which occurs along the entire extent of the ore zone and is the wall rock in many of the more important mines. In the fourth tunnel of the New Republic mine one phase of the series is well shown and has a thickness of 1,000 feet with neither top nor bottom exposed. The flows here dip about 25° east, which is higher than in the other exposures, although in the same general direction.

Characteristics.—The formation varies greatly from place to place. In the Republic mine the material is both agglomerate and flow breccia. At some places the groundmass is stratified, half indurated sand with igneous boulders of varying sizes up to 7 or 8 feet in diameter, imbedded in it in haphazard manner. In other places the matrix is firm andesite. The included boulders are chiefly andesite with a subordinate number which are sedimentary, metamorphic, or granodiorite. In still other places layers of sand and clay, only partially indurated, are found. Of these three varieties the flow breccia is predominant. Other exposures occur in the Quilp, Surprise, Black Tail, Lone Pine, Mountain Lion and Tom Thumb mines, as well as in various surface croppings. In all instances, except the New Republic mine above mentioned, the material is typical andesite flow breccia throughout.

Not all of this formation has the same genesis. The beds of agglomerate, sandstone, and shale which are included in the flow breccia in the Republic mine points to deposition of these beds by running water, and it is probable that this section is

along the stream channel or possibly across an alluvial fan which was at different times a site of stream aggradation and lava flows. The andesite flow breccia which predominates in the formation, is explained by lava pouring out over a rubble strewn surface and incorporating boulders in its mass.

Age.—The formation overlies the dacite flow conglomerate unconformably and has, so far as could be determined, the same altitude as the superimposed lake beds, while in composition it is similar to the flows overlying the lake beds. From these facts it appears that this formation is the beginning of andesitic activity which continued for a long time, and resulted in many flows which, as will appear later, were separated by considerable periods of time. The flows belong to the same general period as the lake-beds, which are assigned, on the strength of fossil evidence, to the early Miocene.

LAKE BEDS.

Distribution.—Lake beds appear at the surface along a zone very similar in extent to that occupied by the andesite flow breccia, but just east of its outcrops. The beds are structurally conformable with the underlying flows and dip easterly at an angle of about 23° . The total thickness of the deposits is not known but in an exposure south of Republic, with neither top nor bottom exposed, a thickness of 750 feet was measured.

Characteristics.—The beds are usually of buff to grayish-brown color and are made up of finely laminated sandstones, shales and tuffs, all of which are predominantly fine grained. Tuffaceous material probably constitutes over one-half of the mass, since it occurs not only in distinct layers, but also as appreciable parts of the sandstones and shales. The finely laminated arrangement of the shales and sandstones points to quiet water as the site of deposition.

Age.—The beds are fossil bearing, yielding both plant and fish-remains. The plants were not determined, but Dr. C. R. Eastman examined the fish-remains and reports on them as follows:

"The smaller and imperfectly preserved fishes are difficult to determine, but the three larger ones are well characterized, and belong



A—Usual texture of dacite flow conglomerate. The dark areas are water-worn pebbles largely from the underlying metamorphics.
Actual size.



B—Coarse phase of dacite flow conglomerate. Actual size.



Dacite flow conglomerate, including layers of stratified shale and fine-grained sandstone. Exposure near San Poil Lake.

without any doubt to the Carp family (*Cyprinidae*). * * * I feel certain, even from a brief inspection of the material, that the beds yielding these fish-remains are not of Green River Eocene, but belong much higher up in the column, perhaps approximating those at Florissant, Colorado."

In answer to the question whether or not the fossil evidence would be compatible with an assignment of the beds to the early Miocene, instead of the Oligocene which corresponds to the Florissant beds, Dr. Eastman states:

"I should say that the evidence afforded by your material is entirely compatible with the view that the beds yielding it are of early Miocene age."

An assignment of the lake-beds to the early Miocene is in perfect harmony with the geologic relations as interpreted in the field, since it gives the entire Oligocene for the development of the broad, deep valley in the elevated Eocene peneplain, and probably for the pouring out and deformation of the dacite conglomerate, before the formation of the Miocene beds.

TRACHYTE FLOW

Inclosed in the lake-beds are two trachyte flows, the principal one of which varies from less than 10 to 75 feet in thickness. It is exposed for about a mile along the bluff south of the Tom Thumb mine, and may be readily recognized by its marked development of vesicles (Plate VIII, A).

The rock is microcrystalline in texture and composed principally of orthoclase, calcite and quartz. The calcite and quartz are secondary, largely after biotite and hornblende. No unaltered biotite or hornblende were present in the slides studied.

LATER ANDESITE FLOWS

A series of andesite flows overlies the lake beds with apparent conformity. The exact number of flows was not determined, but in an exposure south of the area mapped, seven of them can be seen in the side of San Poil valley. At this point the individual flows vary from ten to one hundred feet or more in thickness.

Distribution.—The andesite appears in the eastern and central part of the area mapped, and has been traced for 17 miles

north from Republic and for about 40 miles south. Its east-west extent is not known to be over five or six miles at any place, but if it was poured out in a river valley as has been suggested, spurs to the east and west, representing the valleys of tributary streams will be likely to be found. The andesites have, in places, as on Gibraltar and Copper mountains, a total thickness of 1,000 to 2,000 feet.

Characteristics.—The andesites overlying the lake beds do not contain nearly so much foreign material as those underlying them. In the upper series, however, flows of different age are recognized in many instances, by the occurrence of a zone of breccia lying above andesite which is free from foreign material. In no instance, however, does breccia make up any considerable part of the upper members. A platy structure with plates varying from one-eighth of an inch to several inches in thickness, is very conspicuous in the later andesites.

The rock has a great range in color, presenting variations in lavender, green, pink and gray shades, although the typical color of the fresh specimens is a dark gray. The pattern of the rock is fairly constant and is formed by medium sized feldspar, hornblende, and biotite crystals set more or less closely in a dense groundmass. In the fresh rock, the most conspicuous crystals are hornblende, but in weathered specimens the feldspars assume a dull white color and stand out conspicuously among the other phenocrysts.

Microscopically, the rock is porphyritic with a glassy to microcryptocrystalline groundmass. The chief minerals are plagioclase feldspars of the oligoclase-andesine variety, hornblende, pale green augite, and biotite. The accessory minerals are quartz, magnetite, pyrite, apatite, and very rarely rutile and titanite. Chlorite, calcite, and some sericite are the more important secondary minerals. Excellent resorption rims in many instances surround nuclei of biotite and hornblende. Flow structure, fractured feldspar and hornblende, and bent biotite crystals appear in several slides.

LATITE PORPHYRY

Distribution.—Latite porphyry outcrops at various places along the ore zone. Its largest exposure is along the east side of Flag Hill, where it is the surface rock over an area of almost one square mile. Smaller outcrops appear both north and south of this principal one. The rock is clearly intrusive into all the rock formations heretofore described, as shown by its influence on the dip of surrounding formations, its massive character, its metamorphosing effects on overlying beds, and its contact with all the earlier rocks.

Characteristics.—The latite porphyry is very variable in composition, but from field relations it is, nevertheless, thought to be a single rock unit. It is usually highly altered to calcite with a minor development of chlorite and sericite so that accurate determinations are sometimes impossible. The rock varies from a dark gray to a chalky white with all gradations between. Typical specimens are steel gray and on megascopic examination, are found to be composed of both lath-shaped and stalky feldspars, hornblende, biotite and pyrite crystals set in an aphanitic groundmass with fine quartz grains as the only recognizable mineral.

Under the microscope the phenocrysts of the typical specimens are seen to be oligoclase, orthoclase, quartz, hornblende and biotite with apatite, pyrite, magnetite and some ilmenite as accessories. The groundmass is a fine-grained aggregate, principally composed of feldspar, with some quartz. Calcite, chlorite, a little sericite and rarely leucoxene, are secondary. Most of the pyrite and some of the quartz appears to be secondary. The biotite is bleached and in places has been removed.

While the above is the typical rock, marked variations from it are found. A specimen taken near the flag on Flag Hill shows no orthoclase and little hornblende, although the other minerals, both primary and secondary, are similar to the above. Another specimen from the lower tunnel dump on Knob Hill has no plagioclase but is otherwise similar to the rock first described. Between the two last named localities specimens of the

typical rock occur. The typical rock is also found between the Mountain Lion and the Tom Thumb properties.

From these general facts it appears that the intrusion along the ore zone is a latite porphyry with variations to dacite porphyry on the one hand and to rhyolite porphyry on the other. The ore deposits are thought to be genetically related to this intrusive.

BASALT FLOW

Relations.—A single basalt flow with a few accompanying dikes, is exposed here and there over an irregular area of about four square miles, and has a maximum thickness of about 100 feet, although it is in general not more than 25 feet thick. The greater part of the flow lies at an elevation of about 4,000 feet, but an outlier near the Great Northern depot is only 2,500 feet above sea level. This difference in elevation of 1,500 feet is not to be accounted for by post-basalt movements, but rather by a great period of erosion between the extravasation of the andesites on which it lies, and the time when it was poured out.

Characteristics.—The exposures of this formation nearly always present excellent columnar structure. In the flow the columns are vertical or slightly inclined, while in the dikes they are horizontal. The rock is fine-grained, and steel gray to black with a distinct greenish tinge. It weathers to a brownish red color and then has a finely, though scattered, pitted appearance due to the leaching of some of the ferro-magnesian minerals.

Microscopically the rock is very finely crystalline and composed of olivine, plagioclase feldspar, usually labradorite, augite and diopside with other minerals too small to identify. The rock varies markedly from place to place, olivine and augite showing the greatest range of variation.

QUATERNARY HISTORY

The Quaternary history includes ice-sheet glaciation, and erosion by running water. No igneous activity and no dynamic movements were found to be of this age.

GLACIATION

Boulders which are of material foreign to the bed rock where they occur, and many of which bear the peculiar striations typical of glacial action, are found at all elevations in the area, while distinct grooves on bedrock were observed in two exposures. One of these is near the summit of Copper mountain, where an area a few feet square has been exposed by an uprooted tree. It is significant, in dispelling the possibility of Alpine glaciation, that the grooves here found are almost parallel to the crestline of the mountain. The other exposure of grooves is at an elevation of 4,200 feet and near the blind road which leads into the central part of the area mapped. In both instances the direction of grooves indicates that the ice advanced from a direction 5° - 7° west of north. This direction of ice movement, together with the distribution of the drift at all altitudes in the area, clearly indicates that the district was entirely covered by glacial ice, and therefore that it is a part of that great area extending north to Alaska, and west to the coast, which was covered to a great depth by the Cordilleran ice sheet in Pleistocene times. Some idea of the minimum thickness of the ice in the vicinity of Republic is gained by a consideration of the local distribution of elevations. The top of Granite mountain is a little over 2,200 feet higher than the bottom of the valley of North Fork at a point due east from it. Since the ice advanced from the north this relation of highland and lowland indicates that the ice-sheet had a thickness of at least 2,200 feet at this point.

THE DRIFT

The drift takes the form of a *ground moraine*—or that generally distributed over the area covered by the ice; a *terminal moraine*—or material deposited at the edge of the ice; *lateral moraines*—or material deposited along the sides of ice tongues which extended down the principal valleys from the edge of the ice-sheet during its recession; and *valley trains*—or material deposited in valleys by streams flowing from the ice.

The ground moraine covers perhaps 70% of the area. It

varies in thickness from a few inches to perhaps a hundred feet, as on the south slope of Granite mountain and also on the south side of Deer Creek valley.

A terminal moraine extends east and west through the city of Republic, although its morainic characteristics are not so pronounced near the city as about two miles west. In the latter locality the debris is piled some 200 feet high, and there are numerous kettles and knobs with a relief of over 100 feet. East of Republic and in the city the striking terminal morainic characteristics have been partly removed, and partly modified by recent stream erosion.

Lateral moraines are conspicuous along the San Poil-Curlew valley. They are not more than ten to twenty feet high, but in many instances continue for a mile or more, with broadly regular outlines, disposed in the manner of terraces. Not all the terraces along this valley, however, are to be considered as lateral moraines, for in several places the terrace is of solid rock, while many and probably most of the terraces are due to the down-cutting of the stream in valley train material. In general, only the terraces which are rougher, more hummocky in detail, are to be considered as lateral moraines.

A valley train extends throughout the entire part of San Poil-Curlew valley which is included on the map. The thickness of the train is not known, but from the general shape of the valley it is probable that it has been filled from 100 to 200 feet with glacial debris. Those of the terraces which have been developed by the down-cutting of the stream in valley train material indicate that the filling is not now as deep by about 50 feet as it once was.

STREAM EROSION

The erosion features which have been formed in post-glacial times are strikingly inconspicuous in comparison with those which are of pre-glacial age. The drift covers a surface of bold relief, yet erosion has not been sufficient to remove it in most places, however well exposed; and indeed, several of the larger streams of the area are not flowing on bed-rock for any

appreciable part of their course. Granite creek, near the Republic mill, flows in a very narrow valley which is about 100 feet deep and is of post-glacial origin. This is by far the most striking instance of post-glacial erosion in the area.¹ Its occurrence, however, at the place where a comparatively large stream crosses a terminal moraine, affords conditions favorable to erosion and meliorates the significance of the amount of erosion which has taken place.

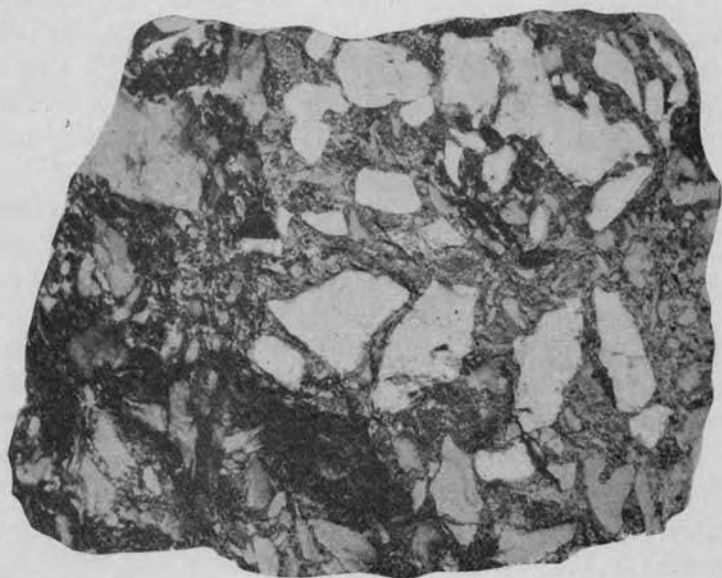
¹O'Brien Creek Gorge is probably largely of pre-glacial age.

CHAPTER III

ECONOMIC GEOLOGY

HISTORY OF MINING DEVELOPMENT

The Colville Indian reservation was thrown open to mineral entry February 21, 1896, and on the following day Philip Creaser and Thomas Ryan, two prospectors, left Rossland, B. C., for the reservation. They were grubstaked by L. H. Long, C. P. Robbins and James Clark. The two prospectors went to Bossburg on the Spokane Falls & Northern Railroad, where they outfitted and then proceeded on horseback to Nelson, a hamlet in the reservation a few miles southwest of Grand Forks, B. C. There they met George Welty, who with his brother John, had camped on San Poil creek all winter watching the ground now included in Republic camp and awaiting the opening of the reservation. Welty persuaded Creaser and Ryan to return with him and they all arrived at the Welty camp on San Poil creek February 28. The next day Creaser and Ryan located the Iron Mask, Copper Belle and Lone Pine. Closely following this the Quilp, Blacktail, San Poil, Mountain Lion and other claims were located, and on March 5 the Republic and Jim Blaine were staked out. It is worthy of note that among the locations made in the first two weeks of prospecting are included all the leading mines of the district. This accuracy of discovery is readily accounted for by the strong outcrops of the veins along the productive zone. The locators took liberal samples from the outcrops and sent them to James Clark and his associates, who made careful assays. The highest assay ran one dollar and a half gold, while none of the others showed more than a trace. Nevertheless the great strength, continuity and size of the ledges, together with the presence of a trace in each sample, were potent arguments for further investigation, and as a result Messrs. Creaser and Ryan returned to the district to



Quartz breccia from cross vein, Lone Pine mine. Later solutions introduced much pyrite not shown in cut. Actual size.



A—Andesite flow breccia. Actual size.



B—Andesite flow breccia. A common phase. Actual size.

do more development work, make other locations and secure more samples. A little development work was done on all the claims, and the next lot of samples gave returns of \$4.00 in gold from the Iron Mask and \$35.00 from the Lone Pine, but only a trace from the Republic, which has since become the leading producer of the camp. With further development, both the showings and values improved. Reports were so favorable that James Clark visited the camp personally and was impressed by the strength, size and continuity of the veins. He immediately interested his brother Patrick Clark and from that time on there was no lack of funds for development work. A limited amount of development on the Republic claim revealed ores running upwards of a hundred dollars in gold and a subordinate amount in silver. Also in the summer of 1896 some ore giving assays of \$320.00 a ton was struck on the Lone Pine lead. Immediately following these discoveries several mining companies were organized for active and systematic development work. In May, 1898, a mill was erected for the treatment of the lower grade ore, while the highest grades were hauled by teams 80 miles to Marcus, on the Spokane Falls & Northern Railroad. Later two other mills were erected, one at the Mountain Lion mine and a large custom mill at the Republic mine, and for a time all the ore was treated locally.

Active mining continued up to the spring of 1901, when the large custom mill and also the Republic mine were closed down. From that time until the coming of the railroads in 1902 and 1903 little work was done. But with ready transportation to British Columbia and coast smelters, operations revived, and for some time shipments approximating 1,000 tons a week were made. This did not continue long, however, for owing to its highly siliceous character, the ore was found refractory by the smelters and the market became uncertain. Operations continued in a half-hearted way until early in 1909 when contracts for a period of years were made with the smelters, and operators resumed work.

About this time the new Republic Company, which had acquired the old Republic mine, discovered high-grade ore. New

bodies of ore were discovered elsewhere in the camp and several leases taken. During 1909 shipments were regular and there was a gradual return to prosperity. A reduction in freight rates to the Puget Sound smelters of from \$1.25 to \$1.50 a ton increased greatly the amount of marketable ore in the camp.

PRODUCTION

The total bullion production of the camp cannot be stated with accuracy, but from the best information available it is about \$2,000,000 and of this amount approximately 90% in value has been gold, and the remainder silver. The great losses of early mining methods makes the actual production of the veins very much higher, but the amount lost cannot be approximated. The New Republic mine leads in total production with about \$1,400,000, while the Quilp, Mountain Lion, and Lone Pine hold about equal rank and represent most of the remainder.

METALLURGY

With great deposits of ore which runs about \$7.00 per ton, and *comparatively limited* amounts which run over \$12.00, the treatment of the ores becomes the most essential factor in the future prosperity of the camp. Many processes have been tried, but without great success. In view of the importance of the metallurgical treatment of the ore it is thought wise to record the known facts in this connection.

Early amalgamation tests showed that even on ore assaying upwards of \$100.00 it was seldom possible to get an extraction of much more than 40%. Various experiments made with cyanide led to the adoption of the Pelatin-Clerici process and the erection of a ten-ton test plant. This was later increased to 35-tons capacity and although the extraction was better than by previous methods, especially when the ore was crushed to 120 mesh, still the saving on \$30.00 ore fell as low as 70%. The loss and cost of treatment made the process prohibitive on ores running less than \$25.00 and hence was abandoned.

In the fall and spring of 1899 and 1900 the Mountain Lion

Gold Mining Company built a 100-ton mill,¹ using plate amalgamation followed by the McArthur-Forrest cyaniding process. The extraction (a bullion recovery of 64% gold and 35% silver) fell much below the anticipations of the company, and in view of railroad transportation to smelters, which was expected in the near future, the mill was closed.

Messrs. T. M. Chatard and Cabell Whitehead² made a series of experiments on Republic mine ore which from their description probably came from the upper workings, and for that reason is only in small part applicable to the deep ores of the camp. They found only a minute trace of sulphurets, no free gold, no arsenic, antimony, tellurium or selenium and indeed "there appeared to be no chemical reason why gold should not be easily extracted by cyanide. Moreover, when a sample of the ore was treated with hydrofluoric acid, the gold in the residue was clean and bright, and under the microscope showed indications of crystallization." Ore of various sizes was subjected to cyanide solution and the fact of increased extraction with fine grinding was established. It was found that treating the ore with acid freed the gold while alumina, oxides of iron and lime were contained in the solution after the ore had been treated. Thinking that lime carbonate was the masking agent, calcining was substituted for the acid bath and savings of 94.60% gold secured. It was found, however, that some of the gold contained no lime carbonate and yet roasting was equally beneficial. This fact, after a series of corroborative tests, led the authors to the conclusion "that the material which envelops the gold and prevents its dissolving in the cyanide consists mainly of the hydrated oxides of alumina and iron."

The above experiments and conclusions are very suggestive, but it is thought that they can only be applied to the upper workings where secondary agencies have been operative in destroying the primary minerals. The authors describe the ore as

¹An article by Fritz Cirkel, Eng. and Min. Journal, Vol. 85, p. 246.

²Trans. A. I. M. E., Vol. 30, p. 419 *et seq.*

"grayish-white lumps of chalcedonic material, intermixed and coated with a soft friable substance having the appearance of amorphous silica." It is noted that nothing is said of the bands of metallic to submetallic luster which are the conspicuous features of high-grade ore found in the workings of even moderate depth (say 100 feet), and from this fact it is to be inferred that the samples sent to Chatard and Whitehead were from comparatively near the surface. On roasting the high grade ore of the lower levels strong sulphur, antimony and selenium fumes are given off, indicating that in the primary ore sulphides are present. Future metallurgical tests should carefully take into account the two types of ore.

In March, 1899, the Republic Consolidated Gold Mining Company succeeded the old Republic Company and shortly thereafter erected a 200-ton mill, the essential features being fine grinding and roasting followed by cyanide. The mill received its first ore in October, 1900, and continued to run, most of the time at part capacity, until July, 1901, when it was shut down on account of an insufficient ore supply. The lack of supply was due principally to three causes; first, the Republic mine reached a place where it was unable to supply its proportionate amount of 100 tons per day; second, the charges for treatment of custom ores varied from \$5.50 to \$8.25 per ton, which, added to mining and haulage expenses, was prohibitive on most ores of the camp; third, the ores of the camp usually, if not universally, increase in silver with depth, and since the method of treatment allowed for the payment of only 50% of the assay returns on silver, this also acted as a condemning argument against the process. The mill went into the hands of the receiver some months later, and has since been dismantled.

The Mountain Lion Company during the winter of 1903 and 1904 installed the Hendryx process, but the results did not come up to expectations and the mill was closed.

The mines which have been operated with even moderate degrees of success in recent years have depended on the smelters for treatment. British Columbia and coast smelters have offered

a market which, although somewhat spasmodic, has, withal, been very satisfactory in view of the highly siliceous character of the ore. Within the last two years the market has become much more stable, so that the smelters are willing to make term contracts for definite amounts of ore, which is largely used for convertor linings.

The present outgoing tonnage of the camp is approximately 125 tons per day, most of which is being shipped to the Tacoma smelter, the minimum freight and treatment rate being \$5.50 per ton.

THE VEINS

Distribution.—The productive belt at Republic is included in an area about one mile east and west by five and a half miles north and south. The veins may be divided according to direction into two systems. Those of the principal system vary in strike from 7° east to 30° west of north, and, with the exception of the Mountain Lion, dip east. It is made up of from one to four approximately parallel veins which vary from less than 100 feet to over 4,000 feet in length, while as a whole it has a known extent of some four miles. The veins of the second system strike from 30° to 60° east of north, and with few exceptions dip southeast. These veins have never been found to be continuous for more than the length of a claim and are in most instances much shorter. Although in many places apparently cut off by the north-south veins they are thought to be essentially contemporaneous with them in origin. The Tom Thumb veins have been provisionally assigned to this system.

In addition to these two general classes a few narrow veins having a strike intermediate between the above two are found on the west slope of Copper mountain. They have not proven to be of economic importance, and although mentioned again under the next topic, they are not given special attention in this paper.

General Characteristics.—The veins are strong fissure fillings having an average width of about $3\frac{1}{2}$ feet. The unaltered vein material is a firm white quartz with wavy ribbons of a bluish-

gray cast distributed in parallel bands. Broadly, these are parallel to the walls of the veins, but in detail they are very irregular, and are frequently concentrically crustified. The ore is generally altered for 30 to 100 feet from the surface, and here has a dull chalcedonic appearance with banding rather ill defined, and a mixture of earthy material and colloidal silica distributed in minute cracks in the quartz. The outcrop of the veins, where free from moisture, is of firm white quartz except where iron stains give a reddish-brown appearance. It is in some places slightly porous, in others decomposed to a mealy, chalky mass, but in most places it is hard and vitreous and stands in slight relief above its surroundings.

The veins are made up of quartz, chalcedony, opal, calcite and adularia, carrying inconspicuous amounts of pyrite and chalcopyrite, with silver, and possibly gold, in association with antimony, sulphur and selenium. The only gangue mineral which varies conspicuously in amount from place to place is calcite, which varies from nothing up to 25% in the productive veins, with probably 5% as an average, while in one non-productive vein on Flag Hill calcite makes up perhaps 75% of a three-foot vein. Values are in gold and silver and vary from a trace to several thousand dollars a ton; the workable values occurring in shoots which, as a rule, pitch to the south at a high angle, while the high grade is found in kidney and lens-shaped aggregates within these shoots. Within a given shoot the ratio of gold to silver usually decreases with depth.

The vertical distribution of values in the Republic mine is shown in Plate XI, which may be considered as fairly representative of the entire camp.

The veins are not generally fractured, and since the country has been recently glaciated, the leached zone is less extensive than in many mining districts; indeed in several instances returns of over \$100.00 a ton have been secured just beneath the lichens.

The veins on the west side of Copper mountain are narrow and only persist for short distances. They contain pyrite, chalcopyrite, arsenopyrite, galena, and zinc blende in a quartz-

calcite gangue. Several hundred feet of development work has been done on some of the veins, but as yet no deposit of economic importance has been discovered.

MINERALS OF THE ORE

Perhaps the most striking feature which a cursory examination of the Republic ores reveals is the extremely barren appearance of the quartz. Assays show that the values occur in the bluish-black metallic to submetallic ribbons, but a careful microscopic study of these shows only a disseminated aggregate of small opaque specks which as a rule are undeterminable. Scattered grains of pyrite and chalcopyrite are the principal exceptions, although one small crystal of fluorite and two others which resemble titanite were noted in the slides. A partial analysis was made by Mr. S. G. Dewsnap, of Seattle, of a pulp made by mixing specimens of high grade which were taken from the intermediate levels of the New Republic mine. The results of the analysis follow:

Partial Analysis of Selected Republic Highgrade Ore by S. G. Dewsnap.

Silica	47.62
Alumina	9.73
Iron	4.94
Copper	9.74
Sulphur	8.23
Selenium	5.26
Magnesia	trace
Arsenic	trace
Fluorine	not determined
Water of composition.....	not determined
Gold	2.81
Silver	7.34
Ca Ti and earths.....	.14
Tellurium.....	.4 to 2.12 in dif. samples of same pulp

This combination of elements together with certain blowpipe tests, suggests that the silver is partly in the form of silver selenide and partly as gray copper. Some of the gold is free but most of it is probably combined with the selenium and tellurium. From the relative amounts of selenium and tellurium in the

analysis it appears that the selenide is much the more important form. The minerals certainly identified are listed below.

Adularia.—This vein-forming potassium mineral was found in various slides of ore, especially in those of the New Republic mine, where the mineral occurs as linings in the little vugs of microscopic size and associated with quartz crystals on drusy surfaces. It is also found as a replacement of feldspar in several of the slides of wall rock.

Calcite.—Carbonate of lime occurs as a subordinate part of the gangue of most of the veins. It is very conspicuous as a replacement in the wall rock.

Chalcopyrite.—The copper iron sulphide occurs in microscopic sizes very sparsely scattered through the richer ore. It is usually massive, although in some places there are suggestions of crystal outline.

Gold.—From the metallurgical studies it appears that about 40% of the gold is free, while the remainder is in a combined state; probably as a gold-silver selenide. Some placer gold is reported to have been worked on Granite creek.

Gypsum.—Calcium sulphate occurs in a few places as secondary deposits in both the vein and the country rock.

Iron Oxide.—The red oxide of iron is found as a precipitate from the mine waters, especially in those places where the deposits are in flow breccias. It occurs also as a stain on the quartz of the outcrops.

Malachite.—Copper carbonates are very rare, but malachite stains are found in certain places, as for example, near the winze in the New Republic mine.

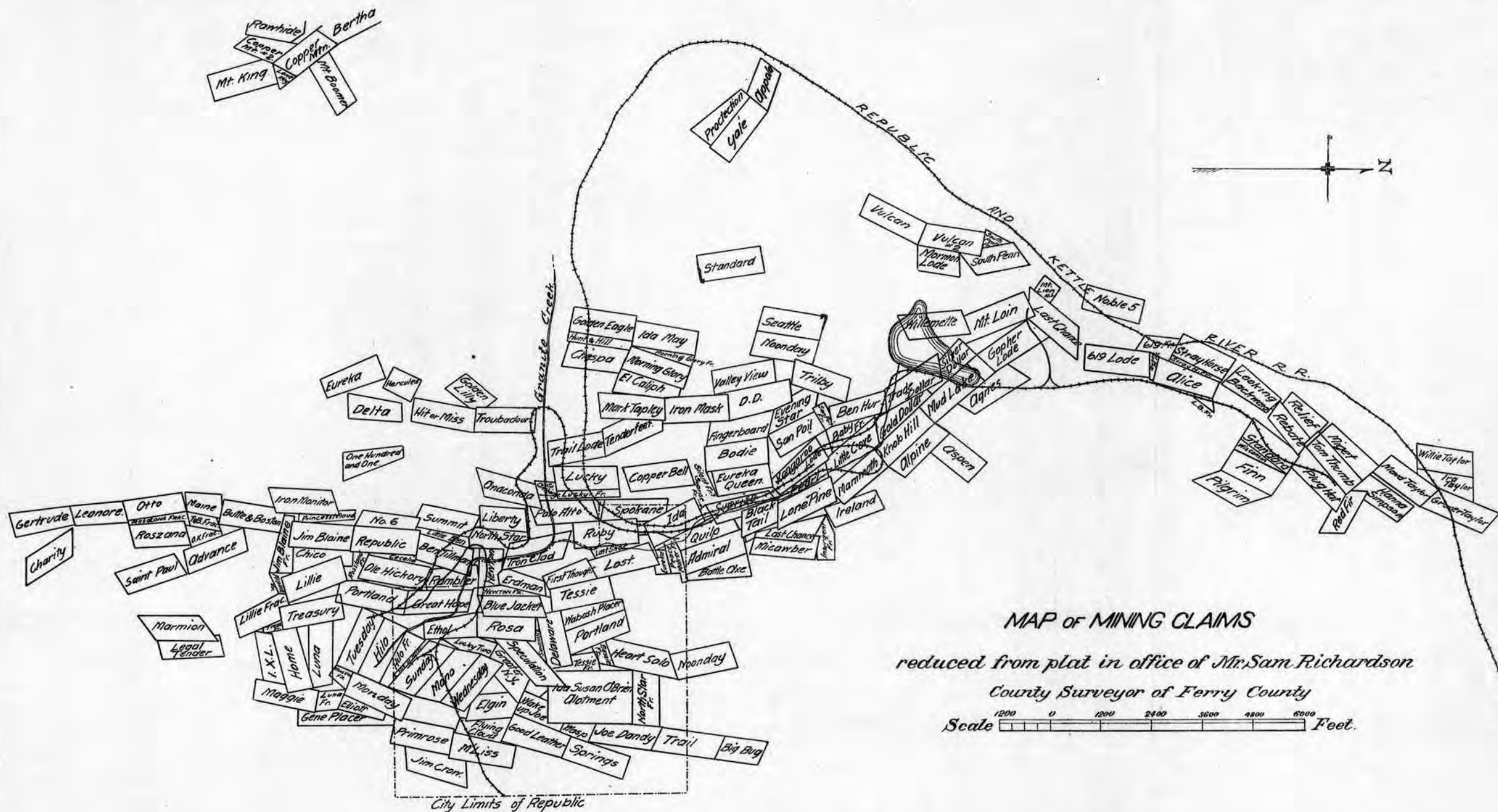
Pyrite.—Pyrite occurs in the veins and in the country rock, but is never conspicuous in the former, while in the latter it is found in almost every specimen. In the country rock it is usually in cubes and less frequently as irregular masses. In the veins it occurs massive, or as crystals which are predominantly cubes, but occasionally octahedrons and pyritohedrons.



A—Elongations of vesicles in trachyte. Actual size.



E—Showing the degree of stratification in the tufaceous lake beds.
The white layers are tuff. Actual size.



Quartz (including chalcedony and opal).—The productive veins run from 75% to 97% silica. The quartz is usually milk white to clear, and in general is concentrically crustified.

Silver.—A small amount of native silver is reported from the lower levels of the Quilp mine.

GEOLOGIC RELATIONS OF VEINS

The Republic lodes are all inclosed in formations of Tertiary age. They cut latite porphyry, dacite flow conglomerates and andesite flow breccias. Following is a tabulation of the more important veins (given by mines) with their inclosing rock and approximate total production.

Table Showing Geologic Distribution of Productive Veins at Republic.

Name of Mine.	Approximate production.	Latite Porphyry.	Andesite flow breccia.	Dacite flow conglomerate.
South Republic.....	\$10,000(?)	X		
New Republic.....	1,400,000		X	
Quilp.....	275,000		X	
Surprise.....	100,000		X	
Black Tail.....	15,000(?)		X	
Lone Pine.....	140,000		X	
San Poil.....	10,000(?)	X		
Ben Hur.....	65,000	X		
Mountain Lion.....	200,000(?)		X	
Tom Thumb.....	15,000(?)		X	
Morning Glory.....	40,000			X
Elcaliph.....	15,000(?)			X

GENESIS OF THE ORE

The open fissures in which the vein matter was deposited were probably all formed at approximately the same time. Their arrangement and distribution relative to the latite porphyry intrusion, suggests that the fissures resulted from stresses set up by activity in that body. Their contemporaneous origin is also suggested by the fact that the east-west lodes abutt against the north-south lodes, but in no observed case continue on the opposite side. In two places—Lone Pine mine and south of Tom Thumb—quartz breccia of vein material is cemented by primary ore (Plate VI). This is, however, thought to be only a minor episode in the vein forming period.

The depth at which the veins were formed cannot be absolutely determined, although geologic relations suggest a fairly definite maximum. The veins cut a series of formations which have accumulated in a post-Eocene peneplain valley. The upper surface of these deposits along the mineralized zone has at present an altitude of 3,200 feet above sea level, which is 1,800 to 2,300 feet lower than the old peneplain surface. From these relations, and since there is no evidence that the beds now found in the old valley ever lapped out onto the peneplain surface, it follows that the veins were formed at a depth of less than 2,500 feet.

The veins are thought to be genetically related to the latite porphyry both by reason of their similar distribution, and the apparent relation between the strains which made the fissures for the veins and the intrusion which bowed up the rocks along the zone where the veins occur. It will be noted that some of the veins occur in the rock from which they are thought to have been derived. This relation, however, is in perfect harmony with the principles of ore deposits as now known, the idea being that the solutions remained in the magma after its outer part had solidified and were expelled at a later time, probably by the forces of crystallization in the deeper, cooling part.

The solutions were hot ascending waters rich in silica, lime and potash, and carried subordinate amounts of sulphur, iron, copper, gold and silver, selenium, and a little tellurium and fluorine.

EFFECTS OF SOLUTIONS ON WALL ROCK

Broadly, the effects of the solutions on the wall rock are silicification near the vein, and calcification farther away. In the New Republic mine silicification near the vein is very conspicuous on the fourth level, where loose agglomeritic material up to within about 200 feet of the lode, grades into a compact siliceous mass from there on to the vein. Calcite appears in most slides taken within a mile of the lodes and in some which were taken much farther away. Microscopic examination shows that calcite has been developed after feldspar and hornblende, and chlorite after hornblende and biotite. The biotite crystals

have been bleached and secondary pyrite is very extensively developed.

PLACER MINING

In the spring of 1900 extensive placers were reported on Granite creek above the outcrops of the known ledges, and claims were "staked for fifteen miles up the creek." The pay streak was a fifteen-inch gravel seam on a clay bedrock. A total production of \$8,000 is claimed, although this amount is open to question. The claims were worked for one summer, but since they were patented no work has been done.

SIMILAR DEPOSITS

There are no deposits known in the United States which are altogether like those at Republic. Their striking feature is the great amount of selenium in the ore, along with appreciable amounts of tellurium. The deposits at Tonopah carry selenium but have no tellurium. At Goldfield both selenium and tellurium occur, but not in very conspicuous amounts. Aside from these two camps and Republic there are no known selenium ores in the country. Selenium has been found at a few places in Mexico, and the Waihi mine in New Zealand is one of the best known foreign deposits.

In the great amount of calcification which has taken place in the wall rock near the veins the deposits resemble the California gold veins, but in the general nature of the veins themselves, and in the type of the inclosing rocks the Republic lodes are most like those of the Great Basin province, and it is with Tonopah and Goldfield that they can be most nearly correlated. Like the Great Basin deposits, the Republic veins have yielded few placers.

CHAPTER IV

DETAILED DESCRIPTION OF PRINCIPAL MINES

The various ore bodies are very similar in most respects, but for some of them the wall rock is andesite flow breccia, for others latite porphyry, and for still others it is dacite flow conglomerate. The New Republic, Ben Hur, and Morning Glory mines are described as types of the first, second and third respectively. Following the description of these, the more important mines are taken up in the order of geographic location, beginning at the south.

NEW REPUBLIC MINE

Location.—New Republic mine is situated on the west side of Granite creek a short distance south of the town of Republic, and at an elevation of about 2,500 feet above sea level. The area embraced by the property is nearly co-extensive with Republic hill, which is an elongated mound trending north-south. The hill is carved out of the east slope of Copper mountain and stands as a topographic feature by reason of the vein, which being more resistant than the country rock, forms the crest line of the hill.

History and Production.—The history of New Republic mine is essentially the history of the camp. The claim was located early in March, 1896, and in June, 1897, active development was commenced. In May, 1898, a 30-ton mill of the Pelatin-Clerici type was erected, which enabled the treatment of considerable quantities of ore that was not sufficiently high grade to justify a haul of eighty miles to Marcus—the nearest railroad station. In March, 1899, this plant was dismantled to make room for a 200-ton mill which was designed for cyaniding the roasted ore. This mill was in operation for less than a year. Both of the mills were expensive to operate and did not

make a satisfactory saving. Thus far smelting seems to be the most satisfactory treatment for the ore, and for several months past the entire output has been shipped to the Tacoma smelter, which makes a freight and treatment rate of \$5.50 to \$6.50 per ton, depending upon the ore.

The total production of the property is said to be about \$1,400,000—over one million of which was produced between the years 1897 and 1902. During 1909 the mine produced from \$10,000 to \$15,000 per month.

Development.—The property has nearly two miles of tunnels, drifts, winzes, raises and cross-cuts. The policy of development has been a progressive effort to acquire greater depth without sinking a working shaft. No. 1 tunnel enters the hill from the west, and cuts the ore at a point 125 feet below the surface. The ore on this level having been blocked out and its continuance in depth determined, No. 2 tunnel was driven westward on a level 78 feet lower. No. 3 tunnel was then driven westward on a level 180 feet lower than No. 2; and shortly thereafter, No. 4 was driven in the same direction from a point 180 feet lower than No. 3. The latter tunnel, which is 2,240 feet long, is large and well timbered, and gives a total depth on the vein of 565 feet. From this level a winze, sunk on the ore, connects with the fifth or lowest level. The amount of mining from the various levels is shown on the stope sheet, Plate XII.

The method of mining is simple overhead stoping—power drills being used. At the mine the ore is passed over grizzlies and the fines loaded into cars direct, while the oversize is hand-picked before shipment.

Wall Rock.—The wall rock of the vein is well exposed in all four tunnels. In the main, it is an andesite flow breccia which alternates with layers of waterlaid material. The wall rock is a part of the great Tertiary series, largely lava flows, which rests directly upon rocks of vastly older age. In the parts of the mine which were accessible at the time of the investigation no igneous rock younger than the flow breccia was noted, but from surface relations there is some reason to think that latite

porphyry lies at no great depth below the present workings. This inference is based on the occurrence of intrusive latite porphyry on the adjoining claim to the southwest and also near the G. N. R. R. bridge immediately north of the New Republic property.

The strike of the sedimentary layers which are associated with the flow breccia in the mine is north-south with a dip of 20° to 30° east.

The Vein.—New Republic vein strikes 1° to 7° east of north and dips 54° to 65° east. On the north end of the claim the vein splits into stringers, but to the south it is well defined to a point beyond the limits of the property. The outcrop of the vein stands as the crest of the ridge on which it occurs, and at some places is four or five feet higher than its surroundings, although more frequently the cross profile of the hill is a fairly regular curve with the vein at the highest place. The outcrop is white quartz save where the extensive iron stains give a reddish brown appearance. In most places it is slightly porous, although in some it is decomposed to a mealy, chalky mass. Surface clay fills crevices in the vein material, and where mixed with the partially decomposed quartz, gives the exposure a muddy appearance. Several minor veins join the principal lead. Some of them have approximately the same strike but differ in dip, while others have the same dip but differ in strike, and still others vary by both strike and dip. With one possible exception (on the No. 4 level where the vein was badly split up) the branches extend into the foot wall, and where due to a difference in dip, always diverge toward the top, as the limb of a tree.

On No. 4 level, 100 feet north of the winze, a spur of the vein runs into the footwall with a strike of S. 15° W., and approximately the same dip as that of the main vein. A short distance below the intermediate between 3 and 4 a spur with lower dip than the main, runs into the footwall. On the second floor above the third level, the main stope has a north-south strike and dip of 62° E., while the back stope, which is in a

branch of the main vein running into the footwall, strikes S. 30° W. and dips 50° E. The spur veins are always narrower than the main lode and never acquire a distance of more than 10 or 15 feet from it. As shown by a survey of the old stopes, the width of the main vein varies from 2 to 8 feet. The wider parts are great conchoidal places in the walls and seldom have a corresponding curve opposite. In several places groovings and partly preserved slicken-sides were noted.

The vein matter below the oxidized zone is a firm vitreous quartz with wavy ribbons of a bluish-gray cast closely distributed in parallel bands. Although in bold features these are parallel to the walls of the vein, in detail they are irregular, and frequently concentrically crustified. These concentric crustifications may vary from a fraction of an inch to several feet across; may be circular, elliptical, or angular, but nearly everywhere the parallel, crimped arrangement is the striking feature. In many places angular pieces of country rock are found included in the ore, and the contact of the vein material with them, as with the walls, is always sharp. In parts of the vein where values occur and the ore is fresh, there are found intermixed with the wavy ribbons of bluish-gray cast, other ribbons of a bluish-black color and of sub-metallic to metallic luster. Such ribbons carry the values and their presence will generally serve to distinguish between barren and pay rock. This does not apply to the altered ore near the surface, for here leaching has in most instances destroyed the distinctive appearance of the ribbons.

The vein presents very few minerals. Quartz constitutes over 90% of the whole. Calcite is present, and adularia, as crystals which are usually of microscopic size, is found in considerable amounts. In the upper workings kaolin, probably carried in from the walls and also due to the alteration of adularia, is conspicuous. Chalcopyrite and pyrite are rarely seen in the mine, although in microscopic sections both appear in small quantities. Near the winze on the fourth level are small amounts of malachite and iron oxide, precipitated on the walls from the mine waters. In places gypsum is found, and

occasionally little needle-like crystals of some calcium magnesium salt. The light colored bandings of the vein are due to coarser grained quartz being arranged parallel to that of finer grain, while the dark bands of metallic luster are due to the presence of some dark metallic mineral which, under the microscope, proves to be an aggregation of small crystal grains which are never of sufficient size, nor sufficiently isolated from other minerals, to afford satisfactory determination, either microscopically or chemically. From various tests made, these are thought to be a silver antimony sulphide, possibly carrying a little copper, although the copper reaction may be due to the inability to separate completely the silver antimony sulphide from the chalcopyrite known to be present in crystals of microscopic size. The presence of selenium is known and it is thought that some of the silver and all of the gold which is not free, may be associated with it. The composition of the ore is shown by the following analyses:¹

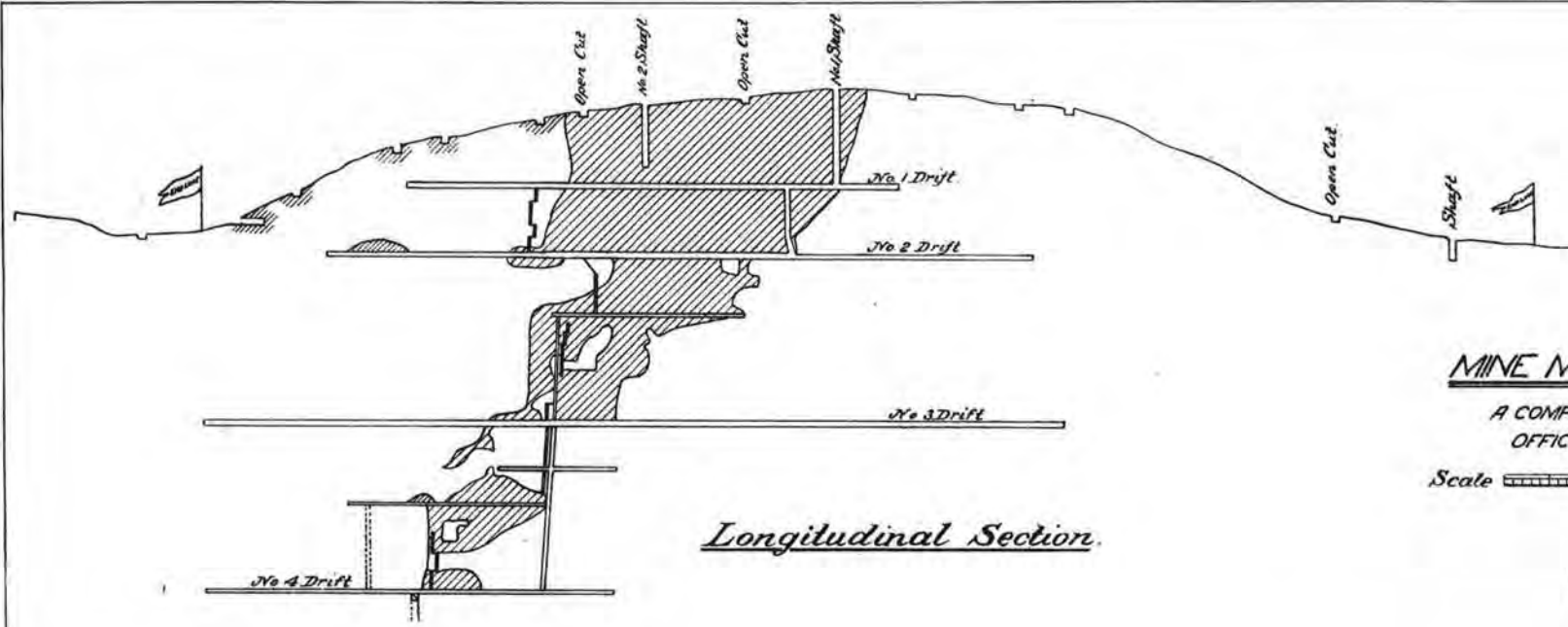
Analyses of Ore From New Republic Mine.

CONSTITUENTS.	A.	B.	C.	D.
Silica.....	85.61	90.55	94.41	47.62
Alumina.....	6.37	4.73	2.95	9.73
Iron Oxide.....	3.16	2.57	1.29	(Fe) 4.94
Copper.....			.016	9.74
Zinc.....	Trace		.025	Not determined
Manganese.....		.20	Trace	" "
Lime.....		.90	.06	" "
Lime Carbonate.....	4.37			" "
Sulphur.....	.04		.06	8.23
Water.....		1.20	1.14	
Selenium.....				5.26
Totals.....	99.55	100.15	99.951	

The Ore.—The values in the ore are gold and silver. Nearly everywhere on the vein some values can be found, but the part of sufficiently high grade to constitute an ore lies in shoots

¹A, B and C are analyses cited by Chatard and Whitehead in Trans. A. I. M. E., Vol. XXX, p. 423.

Analysis D is of selected highgrade and was made by S. G. Dewsnap, Seattle.

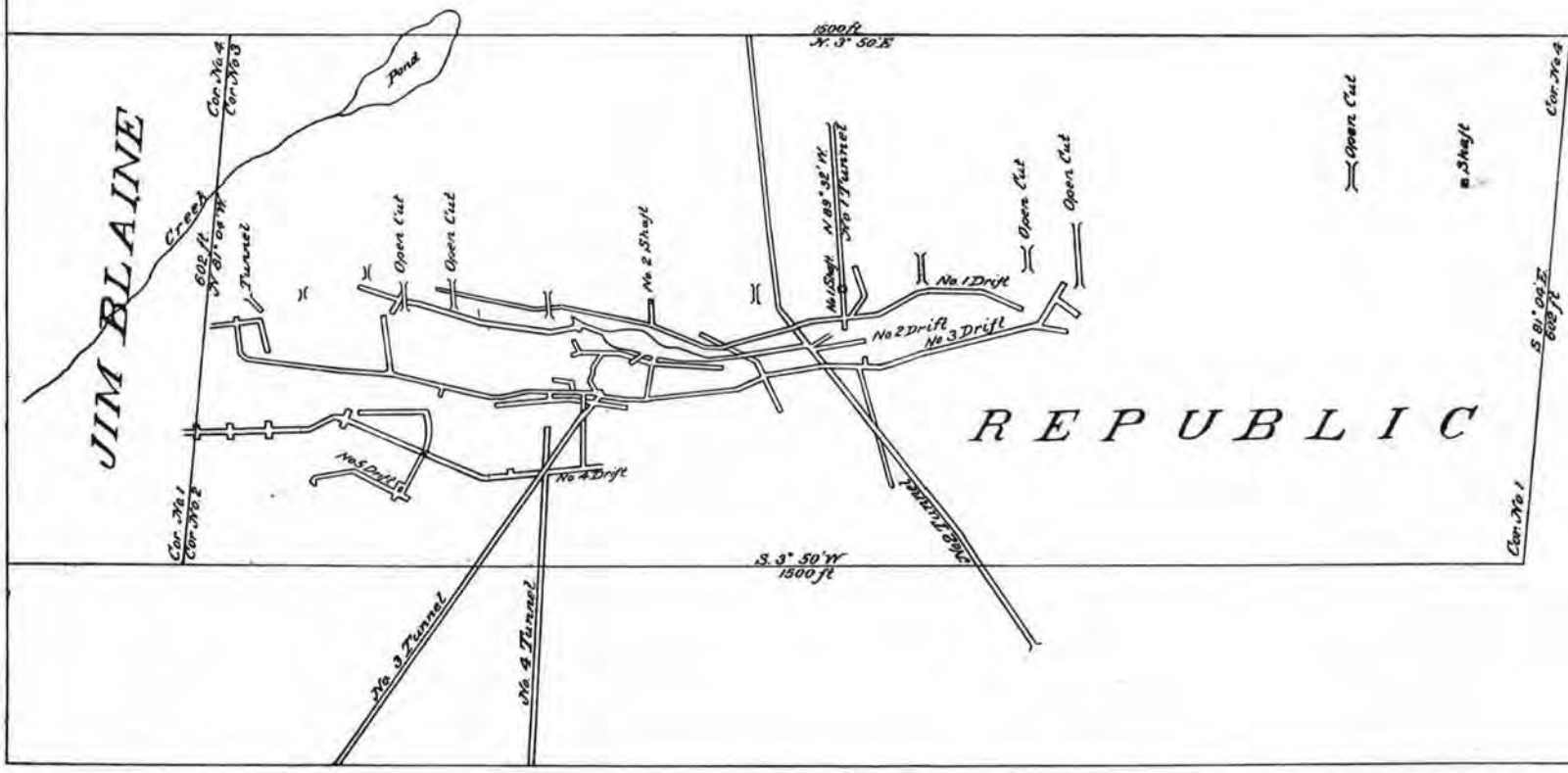
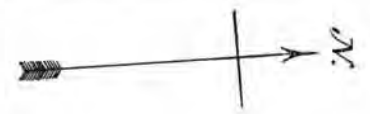


Longitudinal Section.

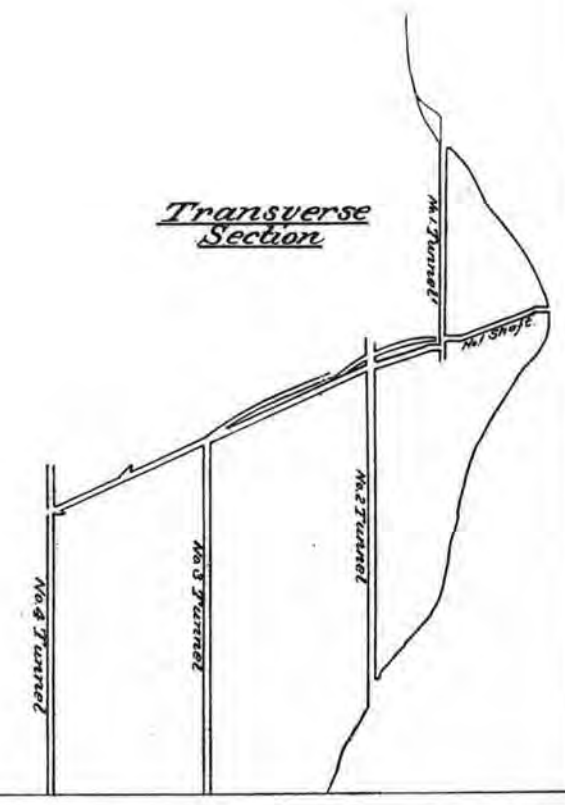
MINE MAP OF NEW REPUBLIC MINE.

A COMPILATION FROM MAPS IN THE COMPANY'S OFFICE WITH A FEW MINOR DIFFERENCES

Scale 0 100 200 300 400 feet

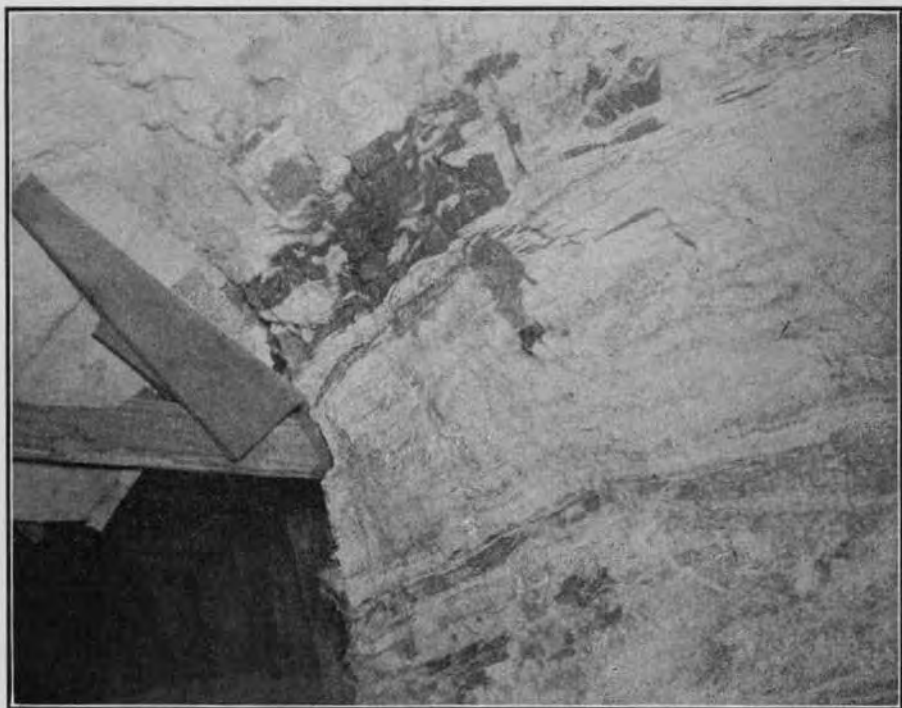


Transverse Section

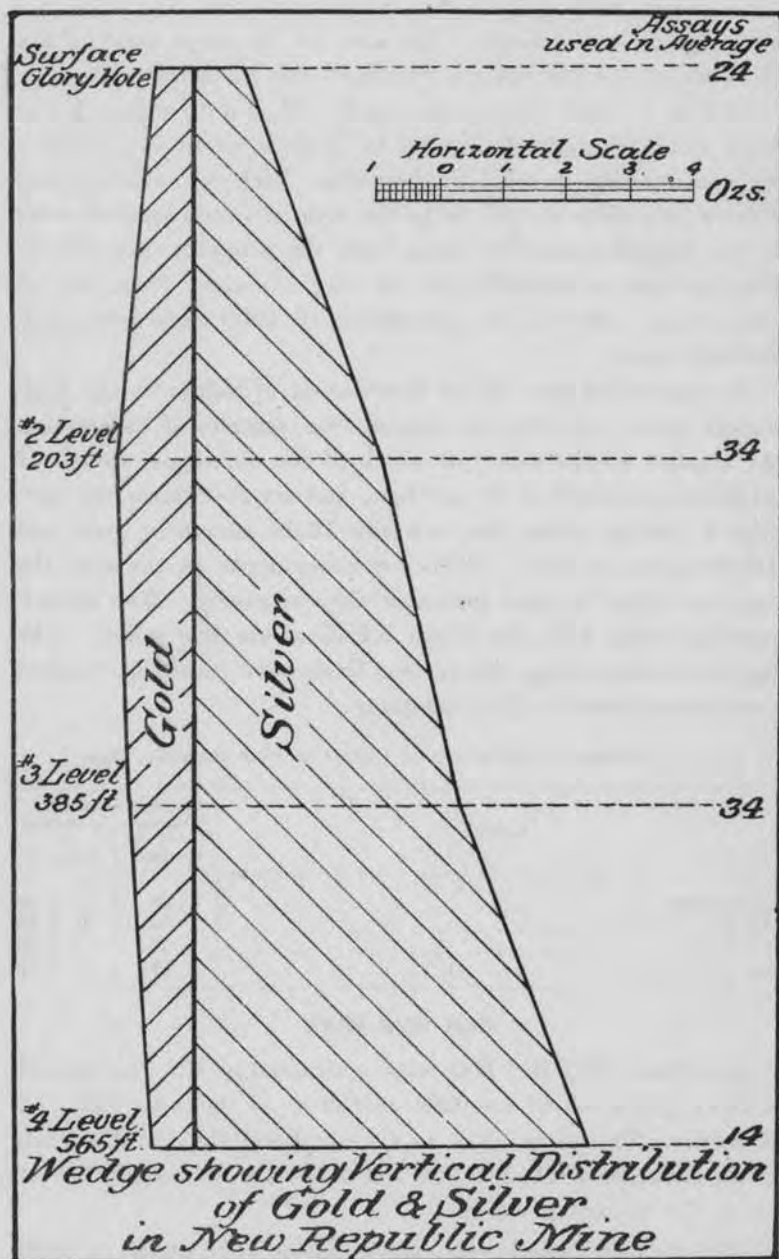




A—Fragment of vein showing crustification. A coarse phase. From New Republic mine. Actual size.



B—Typical appearance of Republic veins. Photo from fourth level, New Republic mine.



which pitch to the south. The area on the stope sheet, Plate XII, which has been mined, represents one of these shoots.

Within a shoot the ore is usually all mined, although the high grade is generally limited to kidneys, or to one or more ribbons running parallel to the walls. Rich ore occurs in the subordinate veins as well as in the main channels; indeed some of the highest grade ore taken from the property, ore said to run upwards of \$40,000 to the ton, has come from one of these veins. Most of the production of 1909 came from such footwall spurs.

A noteworthy fact of the distribution of values, is the high assays which may often be secured from samples of the gossan. At a point on the vein just south of the old stope, assays of \$135 were secured at the surface, and six feet below the surface a section across the vein ran 15.08 ounces in gold and 10.08 ounces in silver. With increasing depth on the vein, the ratio of silver to gold increases very markedly. The accompanying table and also Plate XI illustrate this point. The figures in the average for various levels were picked at random from assay records of the company.

Table Showing Distribution of Values in New Republic Mine.

Level.	Number of assays used in average.	Ratio in ounces of Au to Ag.
Glory Hole.....	25	1 : 1.09
No. 2.....	34	1 : 2.45
No. 3.....	34	1 : 4.19
No. 4.....	14	1 : 6.19

BEN HUR MINE

Location.—The Ben Hur mine is situated on the west side of Eureka gulch, about one mile northwest of the town limits of Republic. The property is on the northeast slope of Flag hill at an elevation of about 3,000 feet above sea level and 200 feet above the adjoining valley.

History and Production.—Development work began in 1898 and continued until 1901. Between 1901 and 1909 work was

carried on intermittently. The Ben Hur Leasing Company is now operating under a lease which went into effect May 27, 1909, and between that date and September 10, 1909, put the mine in shape for operation and shipped seven cars of ore. The total production of the property is said to be about \$65,000.

Development.—A tunnel near the north end of the claim cuts the vein on what is known as the 150-foot level, and by a drift of about 750 feet south on the vein connects with the shaft which extends from the surface down to a 300-foot level. Below the 150-foot level the workings were flooded at the time of the investigation. The ore recently mined came from small stopes on the 150-foot level.

Wall Rock.—The country rock is a massive latite porphyry which varies from light gray to bluish-gray in color. The rock is composed of crystals of orthoclase and plagioclase feldspar, quartz, hornblende and biotite, closely set in a crystalline groundmass. As found in the mine it is highly altered, calcite replacing the feldspars and groundmass, with chlorite in conspicuous amounts. Some sericite is formed. The biotite is bleached. Secondary pyrite is present and the presence of quartz pseudomorphic after hornblende indicates that at least some of that mineral is secondary.

The Vein.—The Ben Hur vein strikes N. 30° W. in the south part of the claim, but near the north end line turns to a position east of north. It dips 65° easterly. The vein is known to extend the full length of the claim, and as a rule varies from two feet to five feet in width.

The vein is the same in general appearance as that of the New Republic mine. In general the bands are more regular and fewer fragments of wall rock are included.

No complete analysis of the ore is available, but the terms of a contract with the British Columbia Copper Company at Greenwood, B. C., under which a penalty is required when the ore runs under 70% or over 80% silica, indicates a less siliceous gangue than in the New Republic vein. From the amount of calcite noted in the ore it is probable that the deficiency in

silica as compared to the New Republic ore, is made up by an excess in lime. Out of 30 cars shipped only two were subject to penalty, and both of these ran a little over the silica limit. Commercial values are limited to shoots which, although not very well developed in the upper workings, seem to pitch uniformly to the south.

THE MORNING GLORY MINE

Location and Development.—The Morning Glory property is situated about three-fifths of a mile west, and a little south, from the Quilp mine. At the time of the investigation the workings were badly caved, so that only a very limited examination was possible. Some 1,700 feet of development work, giving a depth of over 250 feet below the surface, is reported.

Wall Rock.—The wall rock is dacite flow conglomerate and consists of a dacite matrix including numerous small waterworn pebbles of slate, quartzite, and igneous rock. It is highly altered, having a white chalky appearance due to the extensive development of calcite, with lesser amounts of sericite and occasionally adularia.¹

The Veins.—The main vein strikes 55° east of north, and dips 60° northwest, while almost at right angles to this and dipping 85° southwest is a subordinate vein. The vein, where seen, was from 2 to 18 inches wide, and made up of a firm white quartz, banded and often drusy along the median plane. Vugs are not uncommon and these are frequently partly lined with pyrite crystals, which are always in the form of octahedrons and pyritohedrons. It is stated that the ore which has been shipped from the property carried values up to \$400 per ton in gold and silver, principally gold. The total production is about \$40,000.

SOUTH REPUBLIC MINE

Location.—The South Republic property is situated on the west side of Granite creek south of Republic, and near the base

¹This peculiar formation is described more fully in the chapter on general geology.

of the east slope of Copper mountain. It joins the New Republic claim on the southwest.

History and Development.—The property was formerly known as the Princess Maude and under that name most of the development work was done. The present company was active during the summer of 1909 in installing new machinery, cleaning out the tunnel level, and unwatering the lower workings. The total development consists of a 100-foot shaft from the surface, a tunnel 488 feet long on the second level, a winze 225 feet deep from that level, and various drifts leading from it said to aggregate over 700 feet.

The Vein.—The South Republic vein strikes 5° to 10° east of north and dips about 57° east. It is inclosed in latite porphyry. The vein matter is the characteristic vitreous milky white quartz showing lines of crustification parallel to the walls. Some calcite is present as the filling of vugg-like cavities. The vein, which is inclosed between well defined walls, is regular in strike and dip, and about $3\frac{1}{2}$ feet wide. At the time of the investigation the workings below the third level were under water.

THE QUILP MINE

Location.—The Quilp property is situated north of Republic, partly within the city limits, and on the east side of Eureka gulch. It is bounded on the north by the Surprise, while a break of over a mile intervenes between its southern boundary and the north line of the New Republic property.

History and Development.—This property was one of the first claims located after the reservation was thrown open to mineral entry, and was then known as the San Poil, but later relocated as the Quilp. The development consists of an adit on the 100-foot level, and a vertical shaft 400 feet deep starting from this level. Drifts extend from the shaft both north and south, on the 50-foot, 100-foot, 200-foot and 400-foot levels.¹ Exploration work and some stoping have pro-

¹Adit level is used as datum.

ceeded from each of the levels, while from the 400 a winze connects with the 500, the lowest level in the mine.

Wall Rock.—The wall rock is andesite flow breccia, consisting of andesite matrix with included fragments of igneous material which are largely andesite. The lower workings were flooded at the time of the investigation, but from reports, it seems that loose gravel was encountered in the bottom of the mine. Since the wall rock of the upper workings is a flow breccia, the presence of gravels in the bottom of the mine suggests the rubble strewn surface upon which the flows were extravasated. It is not obvious that any economic significance can be attached to their presence.

The Vein.—The vein is of the type characteristic of the camp, and varies in width from 4 to 14 or more feet. The outcrop is of a reddish-brown color and stands as a bold face on the east side of Eureka gulch. The Quilp vein has been explored 600 feet on the dip, and continues north as the Surprise vein, while to the south it has not been identified.

The Ore.—The ore occurs in a shoot which pitches 50° to 60° south. Values are in gold and silver in the average ratio by ounces of 1 of gold to 9.1 of silver. Above the 100-foot level gold was to silver as 1 to 12.19, while at greater depth the ratio was as 1 to 6.08. It will be noted that this is the reverse of the rule for the camp, for in all other mines where data were available, the ratio by ounces of gold to silver decreases with depth. (See Plate XI and Fig. 5). The incongruity may possibly be explained by a local secondary concentration of silver in the upper levels. It is also noteworthy that assays running as high as \$300 have been secured from the very grass roots.

The total ore shipped aggregates 24,000 tons with a value of about \$275,000. The company estimates 80,000 tons of ore in sight.

THE SURPRISE MINE

Location.—The Surprise mine is situated on the east side of Eureka gulch, and lies between the Blacktail property on the north and the Quilp on the south.

History and Production.—The claim was among the first to be located in the camp and during the early days of activity was extensively prospected but never mined. Early in the spring of 1909 D. H. Wells and associates secured a six months lease providing for a 25% royalty, on 100 feet of the vein. An upraise was immediately started from the 100-foot or tunnel level and after raising through some 20 feet of low grade quartz the ore body was found. The total production of the mine is about 2,400 tons, with an average value of approximately \$21.65 per ton, all of which came from the upper 85 feet of a section of the vein 100 feet long.¹ The property is one of the Lone Pine-Surprise group of claims, which recently passed into the hands of the Republic Mines Corporation.

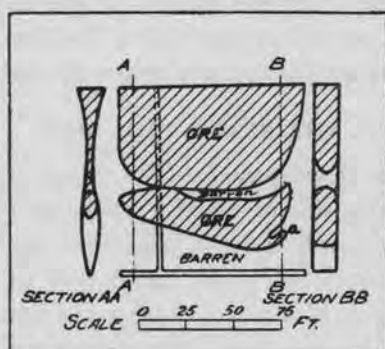


Fig. 2. Surprise stope and cross section of vein showing distribution of ore.

The Vein.—The Surprise vein, which is included in andesite flow breccia, strikes north 30° west and dips 70° east. Along the strike it can be readily traced onto the adjoining properties both north and south. The fresh vein matter is firm quartz of bluish color, showing the characteristic ribbon-like banding of darker material, with here and there cubes of iron pyrite. The upper 30 to 60 feet of the vein is oxidized to a red-dish color.

¹It is reported that a shoot of ore some 400 feet long and giving assays which range up to \$700 per ton has been recently discovered just north of the one above described.

The walls are approximately parallel and faced by countless small angular irregularities. The contact of wall rock and ore is clean cut, however, so that in mining the ore is readily stripped.

The Ore.—The ore occurs in shoots which, as far as the limited development indicates, pitch toward the south. The stope sheet (Fig. 2) of the 100 feet worked by the leasers shows the distribution of the ore in the only part of the vein which is well known. In places along the vein the ore grades out into lean quartz, but in others it is sharply cut off by fragmental wall material which completely fills the fissure. The writer visited the point "a," Fig. 2, just before the noon blast and found a face of good ore. After the blast a clean face of brecciated country rock was found. There was no evidence of faulting and it seemed probable that the fissure at this point had been filled by wall fragments before the metal-bearing solutions entered.

THE BLACK TAIL MINE

Location and Development.—The Black Tail property is located on the east side of Eureka gulch, between the Surprise property on the south and the Lone Pine on the north. The development consists of about 2,000 feet of horizontal and vertical workings. Not much stoping has been done, but several carloads of ore have been shipped from above the first level.

The Veins.—Three distinct veins (see Fig. 3) are found on the Black Tail property, all of which are included in andesite flow breccia. The main tunnel, which enters the hill about 30 feet above the level of Eureka creek, cuts the No. 1, or Surprise vein, 80 feet from the portal. The vein is somewhat indefinite at this place, but is apparently about 4 feet wide, and strikes N. 40° W., dipping 75° east. It has been mined to a limited extent farther north on the Black Tail property, where a shoot of medium grade ore about 65 feet long and pitching 20° to the south, was found. About 300 feet east of the No. 1 is No. 2, or Black Tail vein. North of the center of the claim it has essentially the same strike as No. 1 vein, but differs from that

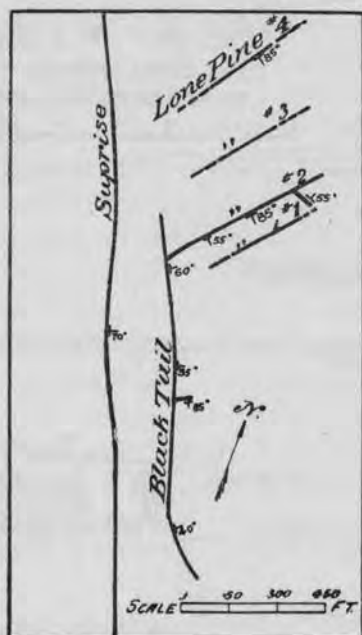
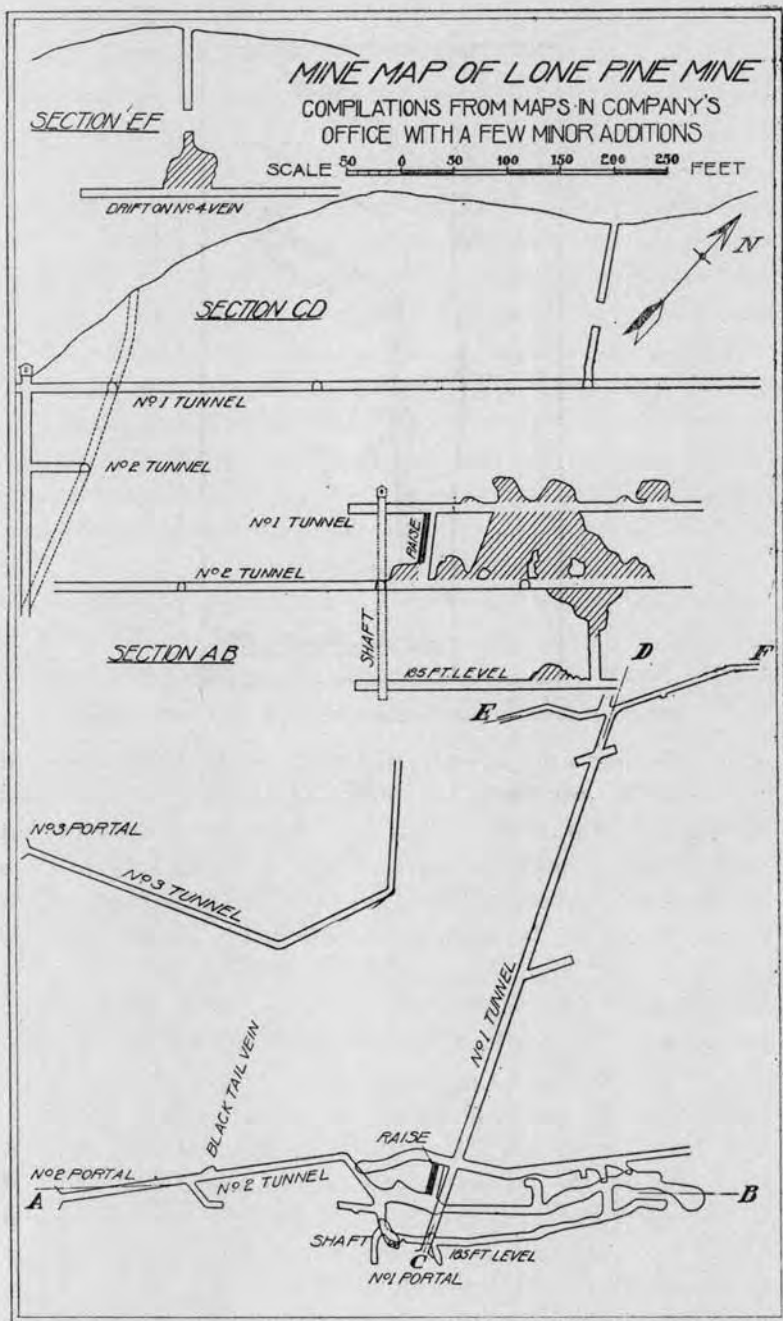


Fig. 3. Pattern of veins on Lone Pine and Black Tail claims.

vein in having a dip of only 46° east. South of the center of the claim the vein turns to a direction 45° west of south and flattens to a dip of 40° . It is near this bend in the vein that most of the ore has been found. South of the bend the vein can be traced for a short distance, but not beyond the limits of the claim. No. 2 vein is irregular in width and in values, especially on the second level. The walls are slickened and frequently show distinct groovings, which, when measured, are found to incline about 15° south. While the movements making the slickensides are thought to be pre-mineral, yet post-mineral movements are evidenced by a slight brecciation in parts of the vein. Vein No. 3, which has not produced any ore, outcrops near the north end of the property, and east of the No. 2 vein. It strikes north 48° east and dips 85° southeast, thus placing it almost at right angles to the other veins. Eastward its outcrop is concealed by drift, while to the west it does not appear to cross No. 2 vein. The three veins are believed to be essentially contemporaneous in origin.



LONE PINE MINE

Location.—The Lone Pine mine is situated on the east side of Eureka gulch about three-quarters of a mile north of Republic. It is bounded on the south by the Black Tail, on the north by the Little Cove, on the west by the Pearl, which is a part of the same property and included in this discussion, and on the east by the Insurgent fraction, which has been largely worked through the Lone Pine tunnels.

History and Production.—The Lone Pine was located in March, 1896, being one of the first claims staked in the camp. It is the principal claim of the Lone Pine-Surprise group, and for several years was owned by the Pearl Consolidated Mining Company. Recently, however, the Lone Pine-Surprise group of claims was purchased by the Republic Mines Corporation, who are now actively operating the properties.

The total production of the property is about 8,600 tons, carrying in round figures \$119,000 in gold and \$18,000 in silver. Except for a small amount of ore which was handled by the old Republic Power and Cyaniding Mill, the output has been shipped to British Columbia and Washington smelters.

Development.—The property has been explored by over three thousand feet of tunnels, shafts and drifts. The No. 1, or principal development tunnel, approximately follows the lode line of the claim for 700 feet, roughly paralleling one system of veins and cutting four veins of another system. Drifts have been run both ways on three of the veins crossed. The first vein appears under shallow cover near the portal, but has not been explored. No. 2 tunnel enters the hill from a point near the junction of a tributary with Eureka creek and gives 72 feet additional depth. The lowest level is 95 feet below No. 2, or 185 feet below the surface, and is reached by a double compartment shaft located near the portal of No. 1 tunnel. No. 3, or Pearl tunnel, enters the hill from a point on the Pearl claim near the level of Eureka creek and cuts the most northerly of the four veins found in No. 1. These relations will be readily seen by reference to Fig. 3.

The Veins.—There are seven veins on this property (Lone Pine and Pearl claims) and all are enclosed in andesite flow breccia of the usual type. The Black Tail and Surprise veins, which continue here, strike 20° to 30° west of north and dip east. The Lone Pine Nos. 1, 2, 3, and 4 strike from 33° to 42°

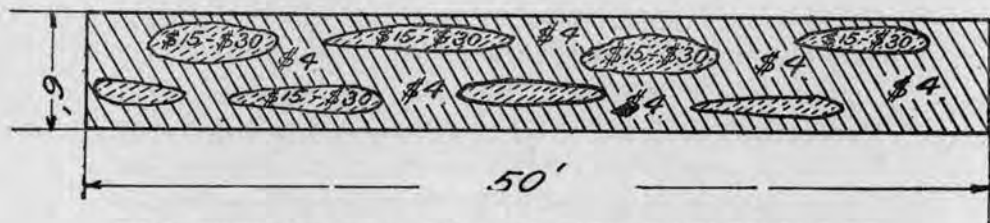


Fig. 4. Diagram showing occurrence of ore in lenses in Lone Pine No. 2 vein.

east of north and dip south. Not one of the latter veins have been found west of the Black Tail vein. The Lone Pine No. 2 in turn cuts off a vein which strikes 60° west of north and dips east (see Fig. 3). Thus there is a northwest-southeast vein cut off by a northeast-southwest vein and this in turn cut off by a northwest-southeast vein. In no case has a continuation of a vein been found beyond the vein which crosses its course. The several veins will be separately considered.

The Surprise vein, as found on this property, strikes north 20° west and dips 70° east. The outcrops are along the base of the valley side, and, although uncovered by several prospect pits and short tunnels, no shipments have been made, although the same lead has been mined on the Little Cove property to the north, and on the Black Tail to the south. The vein varies between four and eleven feet in width, and is composed of a firm bluish quartz showing the characteristic ribbon-like banding of darker material. As seen on this property it is usually oxidized to a reddish-brown color.

The Black Tail vein is exposed south of the draw which crosses the south end of the property, and also at a point 130 feet from the portal in the No. 2 tunnel, but does not appear in the No. 3 tunnel. The Black Tail and Surprise vein is about five feet wide on the north side of the tunnel, but on the south

side it is a gouge seam 8 to 16 inches wide with about 2 feet of badly disturbed ground on either side. Grooves on the hanging wall incline 15° to the south. The southward extension of the vein is readily traced into the Black Tail property, but north of the exposure in No. 2 adit it has not been identified.

No. 1 Lone Pine vein, which is five feet wide, strikes N. 40° E. and dips southeast. It does not appear in No. 2 tunnel, and is thought to be cut off by the Black Tail lead.

No. 2 vein lies about 100 feet north of No. 1 and is essentially parallel to it. It dips 85° southeast. No. 2 adit, running N. 20° E., crosses the Black Tail vein 130 feet from the portal, which is about 15 feet beyond the normal position of No. 2 Lone Pine vein. The tunnel extends ahead from this point about 100 feet, then makes a right angle turn to the southeast, and crosses the No. 2 vein in a short distance. Stated otherwise, the No. 2 vein does not appear west of the Black Tail lode, but east of that vein it is found.

No. 2 has been traced from its junction with the Black Tail to a point well beyond the east limits of the claim, and explored along its dip to a depth of about 300 feet. On the Lone Pine property the vein varies from 4 to 14 feet in width, but beyond a point about 100 feet east of the boundary of the claim, it is poorly defined. In the old stopes horses up to 15 or 20 feet in length are found in many places. The unaltered vein material is firm vitreous quartz of bluish cast, carrying from 6% to 9% of calcite, usually in the form of small vug fillings, but sometimes as crustifications interbanded with quartz. The banding is similar to that occurring elsewhere in the camp, the bolder features being due to alternating layers of different shades of quartz, while the minor bands have a sub-metallic luster and are more crimped and closely spaced. The bands of sub-metallic luster carry the values. In the upper workings the ore is largely altered to a light buff chalk-like material, which is slightly friable on exposure.

The values are in gold and silver in the proportion of about \$6.75 in gold to \$1.00 in silver. The distribution in ounces is 1 of gold to 5.75 of silver above the No. 2 level, and 1 of gold

to 8.59 of silver below that level. These relations are shown diagrammatically in Fig. 5. The ore occurs in lenses which in the upper workings ran \$15 to \$30 per ton, while the intermediate vein material carries about \$4 values. (See Fig. 4.)

No. 3 vein has been explored for a short distance, but has never been worked. It is a quartz vein similar in strike and dip to Nos. 1 and 2, but is not considered commercial ore under existing conditions.

Vein No. 4 is approximately parallel to No. 2 and lies about 400 feet south of it. It is intersected by No. 1 and No. 3 tunnels. From the No. 1 tunnel a little over 700 tons of ore with an average value of about \$15 per ton has been shipped. The ratio in ounces was 1 of gold to 3.82 of silver.

The north-south vein which is cut off by No. 2 vein is about four feet wide and dips 50° east. The vein matter is a typical quartz breccia, firmly cemented by dark siliceous material with frequent films and irregular patches of pyrite scattered through (Plate VI). Values in the vein run from \$4 to \$5, but at the contact with the No. 2 vein ore running as high as \$157 was found. The brecciated appearance of this vein, in contrast to the firm nature of the No. 2 vein which it abuts, suggests an earlier and later period of mineralization. As discussed in the section on genesis, this contrast in the physical character of the veins is, however, thought to be only indicative of stages in a somewhat broken period of mineralization.

SAN POIL PROPERTY

Location and Development.—The San Poil claim is situated on the west side of Eureka gulch almost opposite the Lone Pine, and south of the Ben Hur. The property has been developed by some 2,500 feet of tunnels and drifts which explore the vein for about 1,000 feet along the strike and for 300 feet on the dip. Little stoping has been done.

The Vein.—The vein, which is enclosed in latite porphyry, extends throughout the entire length of the claim, and has the banded vitreous appearance characteristic of the entire camp.



Fig. 5. Diagram showing variation in vertical distribution of gold and silver in Lone Pine mine. The solid lines apply to values, above No. 2 level, and the dotted lines to values below No. 2 level. Wedges show relation of gold to silver in each. Diagram based on average values in ounces per ton.

It is the southward extension of the Ben Hur vein, but has not proved as productive as on that property.

MOUNTAIN LION MINE

Location.—The Mountain Lion mine is situated about three miles north-northwest of the city limits of Republic, and on the east side of the north fork of Granite creek. Although north of the end of Eureka gulch, the veins are in essential alignment with the leads there found.

History and Development.—The Mountain Lion, which is the principal claim of the Mountain Lion group, was located March 20, 1896. Two years after the location the owners incorporated under the name Mountain Lion Gold Mining Company, and began extensive development work early the following year. A tunnel starts from a point near the level of North fork and cuts the vein 1,260 feet from the portal, giving a depth on the vein of 310 feet. A double compartment vertical shaft, which passes near the inner end of the tunnel, reaches a depth of about

700 feet from the surface. Drifts and crosscuts leave the shaft at several levels.

The total production of the mine is not known, but it is generally reported to be about \$200,000. The ore largely came from stopes above the tunnel level.

Wall Rock.—The wall rock is andesite flow breccia. As elsewhere, it has an andesite matrix with included fragments largely andesite. It is always highly altered to a whitish color, due to the decomposition of the feldspars and the development of calcite and sericite and, near the vein, to the introduction of silica.

Veins.—There are three almost parallel veins on the property, but only one of them carries sufficient values to be considered commercial under existing conditions. The productive vein has been traced for more than 800 feet along the strike and to about the same distance on the dip. It strikes nearly north and south and dips 60°-70° west, being the only westward dipping vein in the camp. The vein material is similar to that found in all the other productive veins of the area.

TOM THUMB MINE

Location and Development.—The Tom Thumb is the most northerly mine in the district, and is situated near the headwaters of the North fork of Granite creek, three and one-half miles north of the city limits of Republic. The croppings are on a bench a quarter of a mile back from North fork and at an elevation 200 feet higher.

The development consists of three shafts, and drifts and crosscuts from them, aggregating in all some 1,600 feet of exploitation work. The working shaft has two compartments and is so situated that it intersects the vein 365 feet below the collar. For several years the mine was idle, but early in the fall of 1909 it was leased by the New Republic Mining Company, and is now shipping about 25 tons per day. The values are said to run from \$12 to \$14 per ton.

Wall Rock.—The wall rock, as seen from the surface,¹ is andesite flow breccia, although a latite porphyry lies a short distance to the west. Immediately overlying the andesite breccia is a series of tufaceous lake beds, which outcrop along the Great Northern railroad tracks between No. 2 and No. 3 shafts. The series strikes parallel to the veins and dips in the same direction, but at a much lower angle. Intruded into both the flows and the tuffs is igneous material which, since it was found at one place on the Tom Thumb claim to include vein quartz, is younger than the veins.

The Veins.—The veins are a complex system striking 30° to 45° east of north and dipping 35° to 40° southeast. The main vein is about nine feet wide and outcrops along the lode line of the Plug Hat claim, which lies just east of the Tom Thumb claim and is a part of the same group. The vein is traceable only for about one-third of the length of this claim, but to the west a similar vein extends about three-fourths the length of the Tom Thumb claim. These may be the same vein offset with overlap, but the evidence is not sufficient to warrant a definite statement. A number of small veins which seldom continue for over 50 feet along the strike lie parallel to the main vein, which is itself very variable in width.

The outcrops of the veins are usually milky-white quartz devoid of metallic minerals, but in places a heavy iron stain suggests their former presence.

THE ELCALIPH MINE

The Elcaliph property lies just east of the Morning Glory, and the vein is similar in all characteristics noted to the Morning Glory vein. It was possible to visit the surface workings only.

¹At the time of the investigation the mine had not been unwatered, so that the following observations are all made from the surface.

INDEX

	Page		Page
Acknowledgments	7	Morning Glory Mine	52
Adularia	40	Location and Development	52
Andesite Flows and Lake Beds	23	Veins, The	52
Andesite Flow Breccia, Earlier	23	Wall Rock	52
Age	24	Mountain Lion Mine	63
Characteristics	23	History and Development	63
Distribution	23	Location	63
Andesite Flows, Later	25	Veins	64
Characteristics	26	Wall Rock	64
Distribution	25	New Republic Mine	44
Basalt Flow	28	Analyses of Ore	48
Characteristics	28	Development	45
Relations	28	History and Production	44
Ben Hur Mine	50	Location	44
Development	51	Ore, The	48
History and Production	50	Vein, The	46
Location	50	Wall Rock	45
Wall Rock	51	Ore, Minerals of the	39
Vein, The	51	Analyses of high grade	39
Black Tail Mine	56	Genesis of the	41
Location and Development	56	Paleozoic Series	16
Veins, The	56	Age	17
Calcite	40	Characteristics	16
Chalcocopyrite	40	Distribution	16
Changes in Drainage	10	Peneplain, Eocene	11
Climate	14	Placer Mining	43
Correlation of Eocene Peneplain	12	Previous Work	8
Dacite Flow Conglomerate	20	Production	34
Age	22	Pyrite	40
Characteristics	21	Quartz	41
Distribution	20	Quaternary History	28
Drainage, Present	9	Quibb Mine	53
Drainage, Former	10	History and Development	53
Drift, The	29	Location	53
Elcaliph Mine	65	Ore, The	54
Eocene Peneplain	11	Vein, The	54
Correlation	12	Wall Rock	54
Erosion, Stream	30	Rainfall	8, 14
Eureka Mining District	7	Remarks, General	8
Field-work	7	Republic Mine (see New Republic Mine)	7
Genesis of the Ore	41	Republic Mining District	7
Geology, General	15	San Poil Property	62
Glaciation	29	Location and Development	62
Glacial Features	10	Vein, The	62
Gold	40	Silver	41
Granodiorite	17	South Republic Mine	52
Age	18	History and Development	53
Characteristics	18	Location	52
Distribution	17	Vein, The	53
Gypsum	40	Stream Erosion	30
Iron Oxide	40	Stromme, Olaf, work of	7
Lake Beds	24	Surprise Mine	54
Age	24	History and Production	55
Characteristics	24	Location	54
Distribution	24	Ore, The	56
Latite Porphyry	27	Vein, The	55
Characteristics	27	Tertiary Formations	19
Distribution	27	Relation to Older Formations	19
Lone Pine Mine	59	Tom Thumb Mine	64
Development	59	Location and Development	64
History and Production	59	Veins, The	65
Location	59	Wall Rock	65
Veins, The	60	Topography	9
Malachite	40	Trachyte Flow	25
Metallurgy	34	Veins, The	37
Minerals of the Ore	39	Characteristics	37
Mining Development, History of	32	Distribution	37
Moraines	29	Geologic Relations of	41
		Weather Conditions at Republic	14

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