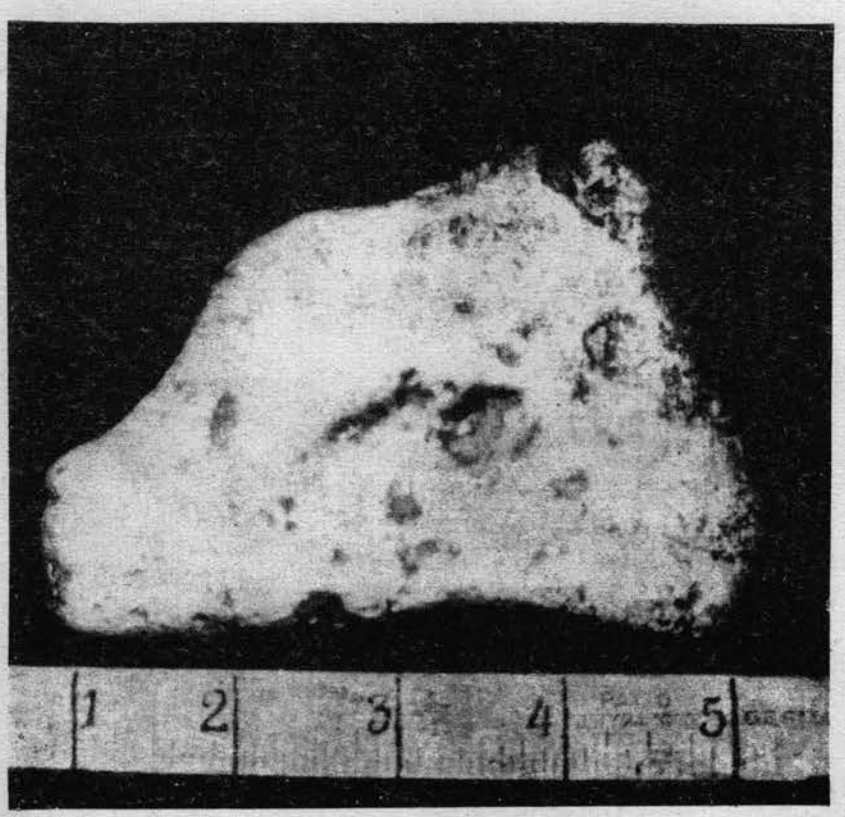
VOLUME I NUMBER 8

DECEMBER, 1914

THE MINERAL RESOURCES OF OREGON

Published Monthly By

The Oregon Bureau of Mines and Geology



An Eastern Oregon Gold Nugget

Ore Deposits of Northeastern Oregon

By ARTHUR M. SWARTLEY

229 Pages 98 Illustrations

Entered as second class matter at Corvallis, Ore. on Feb. 10, 1914, according to the Act of Aug. 24, 1912.

OREGON
BUREAU OF MINES AND GEOLOGY
COMMISSION

OFFICE OF THE COMMISSION
526 YEON BUILDING, PORTLAND, OREGON

OFFICE OF THE DIRECTOR
CORVALLIS, OREGON

Volume I Number 8

December Issue

of the

MINERAL RESOURCES OF OREGON

Published by

The Oregon Bureau of Mines and Geology

CONTAINING

Ore Deposits of Northeastern Oregon

By ARTHUR M. SWARTLEY

229 Pages 98 Illustrations

1914

ACKNOWLEDGMENTS

This report is the result of about one month's field work in the fall of 1913, which was continued in 1914, from May 6 to October 20. During the field season of 1914 until September 10, G. E. Goodspeed, Jr., assistant geologist for the bureau, aided in the work. From that date until the present he has devoted much of his time to assisting in laboratory and office, in which his service has been invaluable. In the reading and criticism of the manuscript, Ira A. Williams, the ceramist for the bureau, has been exceedingly helpful. Much helpful advice was given freely at all times by the director of the bureau, H. M. Parks.

It is impossible to name all those who rendered service and furnished information while in the field. To do so would be to give a complete list of every man interested in mining in the region. It has never before been my good fortune in the western United States, a country noted for its hospitality, to receive such kindly treatment without exception.

The masterly report of Waldemar Lindgren upon "The Gold Belt of the Blue Mountains of Oregon," has been used freely, and many statements, although not specifically acknowledged in the text, were secured from his work.

A. M. SWARTLEY.

Dec. 20, 1914.

CONTENTS

	Page
Acknowledgements	4
Contents	5
Illustrations	9
Introduction	11
Nature of the report	11
History	16
Production	17
Topographic features	19
Climatic conditions	19
Temperature	20
Precipitation	20
Literature	21
The Wallowa range deposits	22
Cornucopia mining district	22
Geography	24
Rock exposures	24
Interesting geology	25
Mines and prospects	35
Union-Companion mine	36
History	36
Geology	36
The vein	39
Future of the mine	40
Cyanide plant of the Cornucopia Mines Company	44
Methods of crushing and grinding	44
Continuous cyanide treatment	45
Clarifying and precipitation	48
Last Chance mine	49
Geology	49
The vein	49
Mine development	52
Aerial tramway	53
Mill practice and flowsheet	53
Veins west of Union-Companion and Last Chance	53
Queen of the West mine	54
Mayflower mine	55
Jim Fisk vein	55
White Elephant vein	57
Wild Irishman vein	57
Jackley claims	57
George W. Smith's claims	57
Simmons prospect	59
Steen and Lindgreen claims	61
Red Mountain property	62
East of Cornucopia	63
Southwest of town	63
Cornucopia placers	65
The Wallowa district	67
East fork of Wallowa river	68
Aneroid to Cornucopia	72
West fork of Wallowa river	74
Fraser's property	77
Andy Heaverne's claim	79

The Wallowa District—Continued. Page
Manuel Lopez claim ... 79
Gem group ... 79
Hurricane creek ... 79
La Gore prospects ... 81
Gyllenberg's claims ... 82
Gyllenbergs to Minam lake ... 86
Donnelly group ... 89
Lostine creek ... 93
Economic geology of the Wallowa district ... 95
Contact-metamorphism ... 96
Homestead or Snake river copper district ... 99
Homestead geology ... 103
Copper properties ... 107
Iron Dike ... 107
MacDougal group ... 109
Brooklyn group ... 113
Koger group ... 114
McCarthy claims ... 114
Cole claims ... 115
Ballard claims ... 115
Hill claims ... 115
Native copper deposits ... 115
Limestone contact ... 115
Other claims ... 116
Southern slopes of Wallowa range ... 116
Eagle creek district ... 116
Quartz mines and placers ... 117
Conundrum group ... 117
Woodard group ... 117
McGee property ... 117
Paddy creek ... 118
Placer mines of Eagle creek ... 118
Sanger district ... 118
Greenstone copper belt ... 119
Gilkeson's claims ... 120
Poorman group ... 121
Other claims ... 124
Deposits in the Sparta granite district ... 125
Haybolt property ... 125
Gem mine ... 127
Virtue district ... 129
Geology ... 129
Ore deposits ... 129
Virtue mine ... 130
Flagstaff mine ... 130
White Swan mine ... 131
Norwood mine ... 131
Bald Mountain-Elkhorn region ... 132
Granite district ... 134
Placer mines ... 134
Quartz mines ... 134
Cougar mine ... 135
Independence mine ... 135
Magnolia mine ... 136
Buffalo-Monitor mine ... 137
Blue Ribbon prospect ... 137
La Belleview mine ... 138

Bald Mountain-Elkhorn Region—Continued Page
Veins in granodiorite ... 138
Monumental mine ... 139
Cable Cove district ... 139
Imperial mine ... 140
California mine ... 140
Last Chance mine ... 142
Camp Carson district ... 142
Eastern veins in argillite ... 143
Ibex mine ... 144
Bald Mountain mine ... 145
Mammoth mine ... 145
North Pole-Columbia lode ... 146
Other properties in the district ... 159
Mountain View mine ... 159
Buckeye mine ... 160
Rock creek mining district ... 160
F. F. Johnson claims ... 160
D. M. Kelly claims ... 160
Highland mine ... 160
Maxwell mine ... 161
Baisley-Elkhorn mine ... 161
Southeastern Elkhorn ridge veins and placers ... 162
Carpenter Hill mine ... 162
Young America prospect ... 162
Yellowstone mining company ... 162
Kent mine ... 162
Nelson placers ... 163
Powder River Gold Dredging company ... 163
Greenhorn mountain region ... 166
Geology ... 166
Susanville district ... 168
Placer mines ... 169
Quartz mines and prospects ... 170
Badger mine ... 171
Stockton, Ophir, Mayflower prospects ... 171
North Gem and South Gem groups ... 171
Compton Mining company ... 171
Chattanooga group ... 171
Porphyry hill prospects ... 172
Susanville summary ... 172
New Eldorado district ... 173
Butler antimony claims ... 173
Krause, Reed, Wray and Chisholm groups ... 173
Reed copper group ... 174
Heppner mining company ... 174
Lemons claims ... 175
South side silver-gold district ... 175
Ornament mine ... 175
Tempest groups ... 175
Chloride, Carbonate and Ruby groups ... 175
North side silver-gold district ... 176
Ben Harrison mine ... 176
Morris group ... 180
Bimetallic claims ... 181
Intermountain claims ... 183
Altered dike deposits ... 183
Morning mine ... 183
Richardson claims ... 184

Greenhorn Mountain region—Continued Page
Vicinity of Greenhorn city ... 185
The Psyche ... 185
Roberts group ... 185
Snow creek mine ... 185
The Banzette ... 185
The Diadem ... 186
West side claims ... 186
Spero, Virginia, Don Juan, Phoenix properties ... 187
Golden Eagle ... 187
Royal White ... 187
Golden Gate mine ... 187
Veins in argillite ... 188
Bonanza mine ... 188
Red Boy mine ... 189
Quartzburg district ... 194
General features ... 194
Gold-quartz veins ... 196
Present Need, Keystone, Equity and Cougar properties ... 196
Dixie Meadows mine ... 196
Copper veins ... 197
Standard mine ... 197
Copperopolis claims ... 198
Gauthier claims ... 198
Placer mines ... 198
Canyon mountain region ... 200
Canyon district ... 200
General features ... 200
Geology ... 200
Gold-quartz veins ... 204
Placer mines ... 205
Lookout-Pedro mountain region ... 210
Connor creek district ... 213
Placer mining ... 213
Quartz properties ... 213
Mullin prospect ... 213
Runner claims ... 215
Liddy group ... 216
Connor creek mine ... 216
Gallagher group on the north side of Lookout mountain ... 217
Burnt river deposits ... 217
Gold Hill mine ... 218
Mormon Basin district ... 218
Rainbow mine ... 220
Humboldt mine ... 224
Other Prospects ... 227
Production ... 227
Other placer and quartz properties ... 228
Gold Ridge mine ... 228
Gold Coin placer ... 229

ILLUSTRATIONS.

			Page
Fig.	1.	Relief map of northeastern Oregon ..... opposite	11
	2.	Last Chance mine, Cornucopia district	13
	3.	Granodiorite. Hand specimen and thin section	14
	4.	Twin lakes, Cornucopia district	18
	5.	Cornucopia and the "Granites" in winter	23
	6.	Fine-grained schist. Hand specimen and thin section	26
	7.	Amygdaloidal basalt. Hand specimen, natural size	28
	8.	Granodiorite porphyry. Hand specimen and thin section	30
	9.	Aplite. Hand specimen and thin section	32
	10.	Basalt. Hand specimen and thin section	34
	11.	Union-Companion mill and mine, Mayflower mill	37
	12.	Part of Union-Companion vein on 500-foot level	38
	13.	Ideal cross section Union-Companion vein, showing dikes	41
	14.	Working plan Union Companion mine ..... opposite	42
	15.	Tongue of basalt injected into quartz vein	43
	16.	Union Companion mill	46
	17.	Last Chance mill. Aerial tramway and mine	50
	18.	Queen of the West mine	54
	19.	Granite or Cornucopia mountain from the south	56
	20.	Where Smith vein cuts apex of Granite mountain ridge	58
	21.	Main street of Cornucopia. Edge Simmons mountain	59
	22.	West fork Pine creek. Trail to Norway Basin	61
	23.	Red mountain from Smith claim on Granite mountain	62
	24.	Pine covered hills southwest of Cornucopia	64
	25.	Underwood or Boulder creek placers	66
	26.	Wallowa lake ..... opposite	67
	27.	Joseph, Oregon ..... opposite	67
	28.	Aneroid lake	68
	29.	Granodiorite. Hand specimen and thin section	69
	30.	Contact-metamorphic zone near Aneroid lake	70
	31.	Pass between Wallowa and Imnaha rivers	71
	32.	Near the "Tenderfoot mine"	72
	33.	Up the Imnaha from Blue river trail	73
	34.	The Granites from pass to the Imnaha	74
	35.	Folded sediments at head of Imnaha river	75
	36.	White marble between darker sediments	75
	37.	Head of the Imnaha	76
	38.	Dull-colored schist and light granodiorite	76
	39.	Granodiorite. Glacial smoothing	77
	40.	Sketch of mineralized contact at Frasers	78
	41.	La Gore contact and cabin	80
	42.	The elevated B. C. basin	81
	43.	Double basaltic dike in limestone	82
	44.	Looking east from Gyllenbergs	83
	45.	Looking up Hurricane creek. Eagle Cap	83
	46.	Looking down into "Hell"	84
	47.	White edge of the Matterhorn	85
	48.	Glacial smoothing of the granodiorite	85
	49.	Eagle Cap	86
	50.	Mirror lake. Slopes of Eagle Cap	86

		Page
51.	Looking down Lostine creek	87
52.	Eagle Cap and pass to Minam lake	87
53.	Brown mountain from pass to Minam lake	88
54.	Distant view of Donnelly group	89
55.	Trail to Donnelly prospect	90
56.	Looking south from Donnellys	91
57.	Other side of Brown mountain	92
58.	The backward trail	92
59.	Looking up at the Peacock prospect	94
60.	Lamprophyre. Hand specimen and thin section	96
61.	Snake river at Copperfield. Turbine casings	99
62.	Snake river canyon	101
63.	Snake river canyon below MacDougals	104
64.	Folded limestone in Snake river canyon	105
65.	Less rugged part of Snake river canyon	106
66.	The Iron Dike croppings	108
67.	Amygdaloidal greenstone. Hand specimen and thin section	111
68.	Carnahan's camp	113
69.	Copper butte	120
70.	Poorman group of copper claims	123
71.	Shaft house and well at Gem mine	126
72.	The Gem mine	127
73.	Elkhorn ridge from Sumpter smelter	133
74.	Part of Cable Cove, showing location of properties	141
75.	Portal of lower tunnel, Ibex mine	144
76.	Development of North Pole-Columbia lode	opposite 146
77.	Outcrop North Pole-Columbia lode on Golconda ground	148
78.	Exposure of lode on North Pole ground	149
79.	North Pole hill from Eureka claim	154
80.	Columbia mine and mill	156
81.	Powder river dredge	164
82.	The Armstrong nugget	169
83.	Ben Harrison mill	177
84.	Underground development Ben Harrison mine	opposite 178
85.	Location of Bimetallic group	181
86.	Plan of Red Boy mine	192
87.	Old placer gravels of Dixie creek	199
88.	Strawberry butte and Strawberry range	201
89.	Canyon creek and John Day valley	203
90.	Canyon mountain and Canyon city	206
91.	Placer of Pacific Lime and Gypsum Co	211
92.	Location of Mullin prospect	214
93.	Sketch showing Mullin veins	215
94.	Rainbow mine and mill	221
95.	Underground in the Rainbow mine	223
96.	Humboldt mine and mill	225
97.	Faulted quartz vein in the Humboldt lode	226

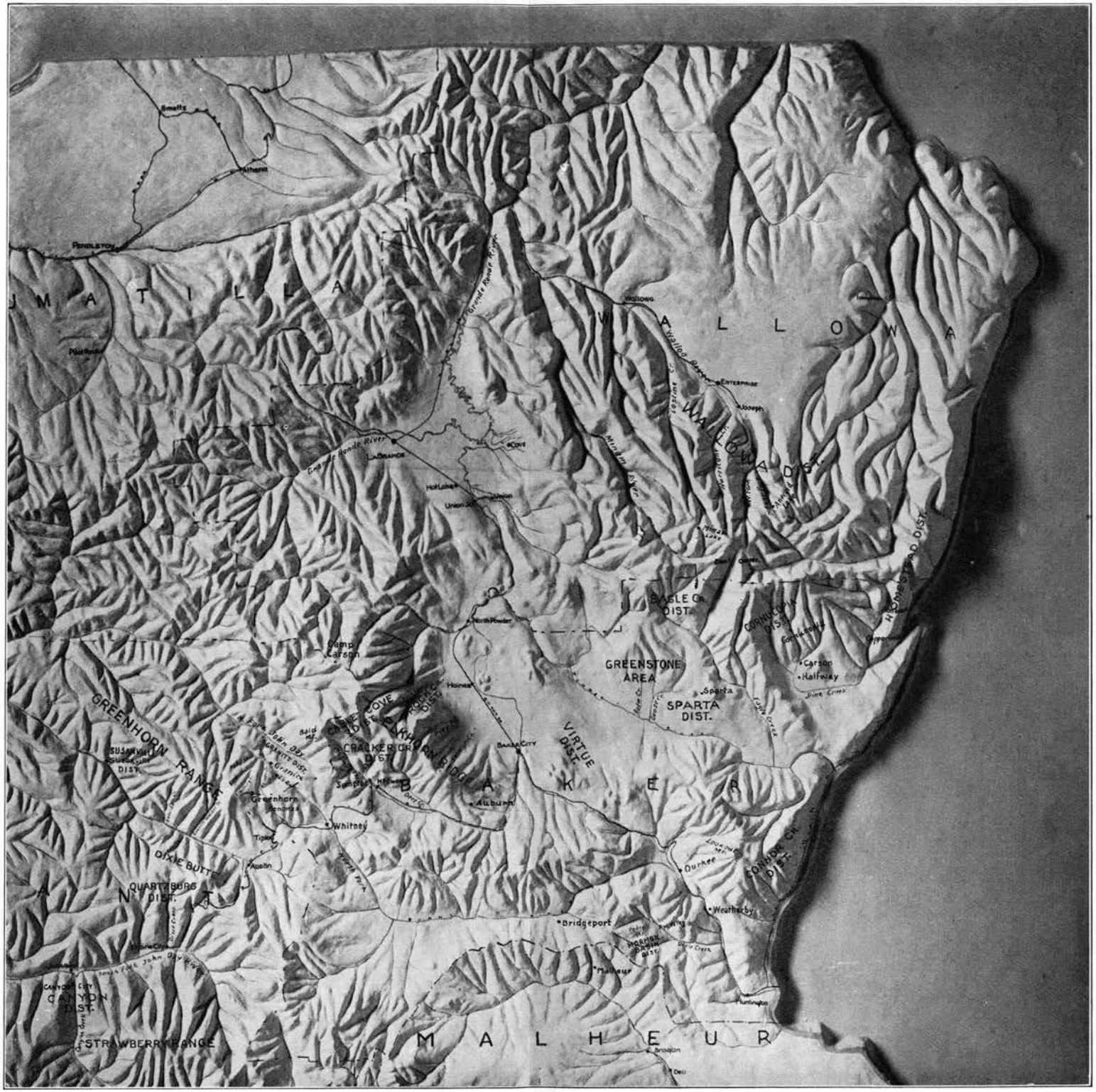


FIG. 1. RELIEF MAP OF NORTHEASTERN OREGON

VOLUME I NUMBER 8

DECEMBER, 1914

THE MINERAL RESOURCES OF OREGON

A Periodical Devoted to the Development of all her Minerals

PUBLISHED MONTHLY AT CORVALLIS BY
THE OREGON BUREAU OF MINES AND GEOLOGY
H. M. PARKS, Director

ORE DEPOSITS OF NORTHEASTERN OREGON

By ARTHUR M. SWARTLEY.

INTRODUCTION

NATURE OF THE REPORT

The ore deposits of northeastern Oregon, like those of most of the principal mining regions of the western United States, and much of the mining world as well, are the product of a granitic intrusion into the older rocks. Without such intrusions arts and industries would lack in metals, and civilization as we understand it, would not exist. It should go without argument that a fair understanding of the dominant factor in ore deposition should be had by all those who mine in that region. A knowledge of the source of the metals, the nature of the channel, and the agencies which precipitated them in those channels is of great practical importance to mine operator and prospector alike. Without such knowledge and the ability to make broad comparisons of one region with other regions, each is at the mercy of his necessarily limited actual experiences, or the frequently arbitrary conclusions of others.

Realizing that mining consists of two parts, the exploration and development of the ore body, in which geologic principles are dominant, and the extraction and bringing of the ore to the surface in which mechanical principles are dominant, we feel that a proper

understanding of both of these parts is essential to successful operations. The need of the first is never absent in the most highly-developed mine, and the usefulness of the second begins with the first mine opening. It was, however, deemed advisable, although this report is written by the mining engineer for the bureau, to dwell chiefly upon those geologic facts whose proper understanding is of use in exploration and development because there has been only one comprehensive report upon northeastern Oregon, that of Lindgren in 1900, and that report is now out of print.

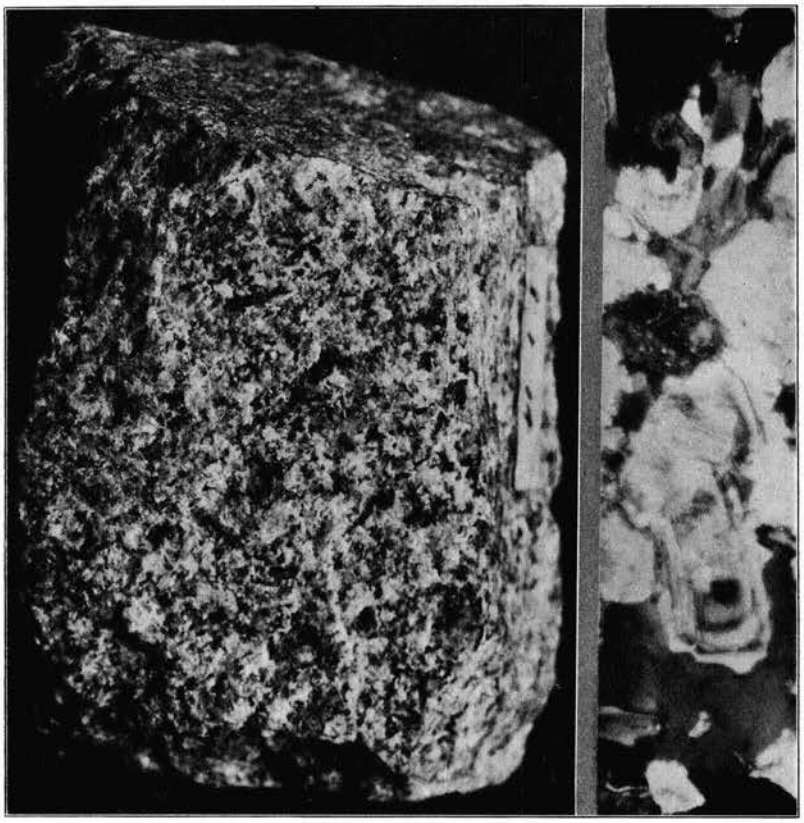
That part of eastern Oregon which is best known as a metal mining region includes all of Baker county, much of Grant, the southern parts of Union and Wallowa and the northern part of Malheur. Although there are several mountain ranges within the area, they are generally grouped together and called the Blue Mountains of Oregon. This is the region of which this report treats.

The dominant geologic feature of this mining region is the granitic mass which is here called, for want of a better name, the "Blue Mountain Batholith." The word batholith is the geologist's name for a giant intrusion of a granitic rock reaching to unknown depths. This body of granitic rock which is, except locally, a granodiorite, represents an invasion from below by an enormous volume of molten rock. The cover, or roof, of older rocks under which the granodiorite cooled and solidified, has to a considerable degree been stripped off by the erosive action of atmosphere, running water, snow and ice, until now we have in a dozen or more places granodiorite exposed to view. These separate exposures vary from a few to as much as 250 square miles. It is believed that below the surface where the granodiorite is not now exposed, it nevertheless exists concealed at varying depths by the cover of older and newer rocks. The present exposures represent the higher altitudes of the invasion, or lower points where the forces of erosion have been especially active.

Long after the intrusion took place there was a large number of lava flows which, if they did not cover the entire region, surrounded it. All but the higher parts at least were submerged, as it were, in a wide exposure of lava. We thus have three main geologic subdivisions, the older, the intrusive, and the recent rocks. Those rocks which came since the time of the intrusion are too new and have been too little disturbed to have ore deposits in them. They are a hindrance to mining. They not only cover nearly half of the Blue Mountain region, but also vast adjoining areas under which doubtless many unknown ore deposits exist.

Fig. 2. Last Chance mine, Cornucopia district.

As a result of the granodiorite intrusion a series of ore deposits were formed in its margin and in the overlying and surrounding older rocks. Where the intrusion is too far below the surface ore deposition is scanty or absent, and where erosion has cut deep into the intrusive mass, the ore deposits are seen but sparingly. Other things being equal, they are found in greatest abundance where there are projections of the older rocks into the granodiorite, and also where there are local invasions of granodiorite into the older rocks. In other words, they are found in greatest profusion in the vicinity of the re-entrant angles of both the older and newer rocks.



Natural size Magnified thin section

Fig. 3. Granodiorite. A medium-grained plutonic rock, which was formed by slow cooling of a molten magma at depth. As seen in the thin section the mineral composition is chiefly plagioclase feldspar, quartz, and biotite.

No attempt is made in this introduction to go into detail as to the nature of the rocks except to state that the older rocks consist of considerable areas of argillites, limestones, old volcanic flows and breccias, and that the intrusive rock is a granodiorite with the exception that near its borders the incorporation of the older rocks into the intruded mass has changed it to tonalite, diorite or other phases. Where erosion has scored its way even a short distance into the intrusive mass normal granodiorite is always found.

For detailed statements the reader is referred especially to the main sub-divisions of this report, and especially to that treating of the Cornucopia district. Little attention has been paid to county lines, mining districts or the mining territory tributary to towns or valleys, in making these sub-divisions. All the mining territory on or bordering upon each separate dominant exposure of the intrusive are grouped together, since the ore deposits are all created there as the result of one cause.

The report begins with the Wallowa region, which comprises the ore deposits found on the slopes of the Wallowa mountains, the most rugged range of eastern Oregon. This region includes the contact-metamorphic copper deposits of the several branches of the Wallowa river adjacent to Wallowa valley. It includes the Cornucopia gold mining district, with its steady and increasing annual production. It includes the disseminated chalcocite and chalcopyrite deposits near the Snake river, and upon the mountains' lower southern slopes in the vicinity of Goose and Balm creeks.

Sparta, Virtue and Quartzburg, separately treated, are smaller exposures of the great Blue Mountain batholith, and each includes but one district.

Canyon mountain has but one mining district described, although there is much other territory that may be mining ground, and of which little is now known.

The Bald Mountain-Elkhorn region includes the districts of Granite, Camp Carson, Cable Cove, Cracker Creek and the various old camps of southeastern Elkhorn ridge, which are a part of Baker district.

The Greenhorn Mountain region includes Susanville, New Eldorado, South Side and North Side Silver districts, Greenhorn, Bonanza and Red Boy districts.

The Lookout-Pedro Mountain region includes Connor Creek, Gold Hill, Rye valley, Mormon Basin and Malheur city areas.

It should be borne in mind that in the descriptions of the mining districts the space devoted to any district is not necessarily the measure of its importance. Travel over wide areas and the service of uncertain transportation have caused a disproportionate amount of time to be spent in the investigation of the various camps. The geology and other features of some districts are comparatively simple and can be described more briefly than others of less commercial importance which, because of their complexity, may demand a more extended description.

It should also be remembered that the general and mining geology was secured at first hand, while much of the information dealing with development, assay values and production has been supplied by the owners or residents of the locality in question. It was not possible to visit all the mines and prospects in the region, and it should be emphasized that failure to mention any particular deposit is no indication whatever that it lacks merit.

This report deals with an immense area, which was examined in a short time. The examination must be considered, therefore, as being more in the nature of a scouting expedition, the report of which is only to be used until more useful information is made available as the result of detailed field work.

HISTORY

The first gold discovery in eastern Oregon was at Griffin gulch, a few miles southeast of Baker, in the fall of 1861. In 1862 the large placer mines of Auburn, nearby, were discovered, and the following year Auburn camp had a population of 5,000. By 1864 nearly all of the mining districts of eastern Oregon were known. Supplies were brought in from The Dalles, 300 miles away. Because of the difficulty of access and cost of transportation of supplies, gravels which did not yield $8 per day for each man were not considered.

In 1863 the Auburn canal was completed. The next year the Rye valley ditch was constructed, and 9 years later Sparta ditch was completed, as was the Eldorado ditch with its total length of over 100 miles to supply water to the Malheur diggings. But by this time the principal placer deposits were largely exhausted and a gradual decline in production began which has continued nearly to the present day. The introduction of standard gold dredges has caused an increase in placer production in the last two years which is apt to be further increased by the same cause.

The Virtue quartz mine was discovered soon after the discovery of placer gold. Quartz mines were worked at Susanville and at Mormon Basin as early as 1865 and 1868. One of the first mills was built at Susanville in 1869. Connor creek and Cable Cove were worked, but the shipment of ore on horseback for several hundred miles caused the development to be slow. Real activity in quartz mining followed the construction of a transcontinental railroad in 1885, and the development of the many camps was thereafter placed on a more permanent and productive basis.

Speculation was rife from 1899 to 1903, and much money was unwisely spent. Eastern Oregon is just now recovering from the injurious effects of this "boom," and since the greater number of producing properties are in good hands, we have a steady production from most of them, which is being increased by the addition of other producers to the list.

PRODUCTION

The production of this region previous to 1880 is very imperfectly known. Since that time the total annual production has been compiled by the federal government. Taking into account the best information obtainable, the total production for this area from 1861 to the end of 1914 is estimated at $95,000,000. This estimate is based on that of Waldemar Lindgren up to 1899, to which has been added the production since that time as found in governmental reports.

Production previous to 1904 was for some years above the million-dollar mark, but beginning with that year there was a decreasing annual production to 1911, the low-water mark, when $460,248 was produced. Since 1911 there has been a marked increase in production, so that in 1913, the last year for which figures are available, the production from the three counties, Baker, Grant and Malheur, for all metals, was $1,625,761. Since the phenomenal production of the earlier placer days this amount has been exceeded but once when, in the year 1891, the gold and silver production was $1,849,131.

Every one of the producing counties in this region enlarged their output in 1913, both placer and quartz mines increasing their production. The only falling off in metal output was in the amount of copper and lead.

The following is taken from a chapter in "Mineral Resources" of the United States for 1913, written by Charles G. Yale:

Fig. 4. Twin Lakes at the head of Pine creek, Cornucopia district.

"Northeastern Oregon comprises the counties of Baker, Crook, Grant, Harney, Malheur, Umatilla, Union, Wallowa and Wheeler. In 1913 the counties of Harney, Umatilla, Union and Wallowa returned no production. The combined gold output of the five producing counties of this region—Baker, Grant, Malheur and Wheeler—in 1913, was $1,525,182, of which Baker county contributed $1,373,480, or 90 per cent. This is an increase for 1913 of these counties, as compared with 1912, of $972,706. The placer gold yield in 1913 was $378,912, an increase of $316,199, or 491.04 per cent. The lode mines produced in gold $1,146,270 in 1913, as compared with $489,763 in 1912, an increase of $656,507 for 1913 or 134 per cent."

This production comes from 55 placer mines and 20 quartz mines. Of the placer mines 3 are yielding more than $10,000 each, and 5 quartz mines produced more than $100,000 each.

TOPOGRAPHIC FEATURES

An understanding of the topographic features of northeastern Oregon can best be secured by a careful inspection of the relief map reproduced herewith.

CLIMATIC CONDITIONS

The climatic features of the eastern half of Oregon, comprising nearly 50,000 square miles of territory, are well stated by Edward A. Beals, district forecaster of the United States Weather Bureau, Portland, Oregon:

"In its essential features the climate is much the same in all parts of the section, and its chief characteristics are a scanty rainfall, large ranges in temperature, low absolute humidity, rapid evaporation and an abundance of sunshine. The variations which take place are due to topography, and marked differences in rainfall and temperature often prevail in places relatively near each other. The air from a hygienic standpoint is stimulating and healthful, and although summer temperatures of 100° are common, sunstrokes are practically unknown on account of the dryness of the air, which permits evaporation to take place freely, thereby lowering the surface temperature of perspiring humanity by several degrees.

"The strong insolation in the plateau sections promotes active convectional currents and these in turn increase the velocity of the wind, which in the daytime is apt to be disagreeably strong; these conditions are reversed at night, when the air is usually calm and cool. Except in winter the rainfall is nearly always associated with thunderstorms and occasionally heavy downpours happen that are popularly known as cloudbursts. Mountain and valley winds are common, but tornadoes with funnel-shaped clouds and destructive winds seldom, if ever, occur.

"Cold waves are infrequent, but when they are experienced the cold spell may last a week or slightly longer. They are usually caused by northeast winds drawing cold air from the north and east into the valleys, where it remains until the warm winds from a southerly quadrant become sufficiently strong to mix with and impart their warmth to this cool lower air in the valleys. In many places during the cold season the Foehn or 'chinook' winds not infrequently descend along the mountain slopes and cause short spells of abnormally high temperatures. These winds rapidly melt the snow and the air feels mild and spring-like when they blow.

"The observations made at twenty-six stations are used in this discussion, and the average length of the rainfall record is about fifteen years. Short records are used only where there are no others to represent the locality.

TEMPERATURE

"The mean temperatures range between 43° and 56°, being highest in the bottom lands along the Columbia river and lowest in the high lands and mountains. The highest temperature that has ever been recorded is 119° at Pendleton, Umatilla county, on August 10, 1898, and the lowest is 34° below zero, at La Grande, Union county, on January 14, 1888. The average absolute annual range in temperature is 124°, and it is greatest in the south and least in the north. The warmest month as a rule is July, and the coldest is January. The average annual range in mean temperature is 39°; it is least, 31°, at Prineville, in Crook county, and greatest in the northern portion of Malheur county, where at both Beulah and Vale it amounts to 44°.

"The growing season varies greatly, being over 200 days in some favored localities, while in others freezing temperatures may occur every month in the year. Owing to the dryness of the air, frost does not always form with temperatures as low as the freezing point, or even four or five degrees below that mark, and hardy varieties of vegetation are seldom seriously injured by low summer temperatures.

PRECIPITATION

"The annual rainfall ranges between 8 and 25 inches at the observing stations, but greater amounts occur in the higher portions of the mountains, where it is estimated that on the windward slopes as much as 50 or 60 inches falls every year. The minimum of 8 inches, however, is probably within 2 or 3 inches of the lowest amount in any locality.

"A large portion of the precipitation falls as snow, the annual amount of which varies from 122 inches at Sparta, in Baker county, to only 2 inches at Umatilla, in the county of the same name. The number of days with 0.01 inch or more of precipitation ranges from

108 at Baker City, to 44 in portions of Crook and Gilliam counties. The precipitation is heaviest during the winter months, but there is a secondary maximum during May and June which is plainly noticeable on the diagram showing the monthly distribution at representative stations. This secondary maximum during May and June is an important feature, as it is the time of the year when vegetation is making its early growth and requires more moisture than is the case later in the season. Only 6 per cent of the annual amount falls during July and August, and these months constitute the driest season of the year. The greatest monthly amount covered by the observations is 8.02 inches, recorded at Weston, Umatilla county, and nearly every year there are some stations where no rain falls for a month, and sometimes for two months at a stretch.

"The prevailing winds are westerly, with a shifting of a few points to the south in the winter and to the north in the summer. Fog is of rare occurrence, and the relative humidity is seldom high."

LITERATURE

Previous to 1900 R. W. Raymond's statistical reports upon mines and mining were about the only available sources of information concerning Oregon. In 1900 Waldemar Lindgren's report upon "The Gold Belt of the Blue Mountains of Oregon" was issued by the United States Geological Survey.

In 1909 the United States Geological Survey published "Faulting and Vein Structure in the Cracker Creek Gold District," by J. T. Pardee, and a year later his "Placer Gravels of Sumpter and Granite Districts." Besides these reports and the annual "Mineral Resources," published by the United States Geological Survey, there has been but little upon this region until the Oregon Bureau of Mines and Geology in 1914 began the publication of their monthly magazine, "The Mineral Resources of Oregon," in which there is published from time to time information concerning these districts.

One of these will contain a preliminary report upon the geology and mineral resources of the Sumpter quadrangle, by J. T. Pardee and D. F. Hewett, prepared in co-operation with the United States Geological Survey, and another will contain a paper by U. S. Grant of similar nature, upon a part of the Baker quadrangle.

THE WALLOWA RANGE DEPOSITS

The mining districts in this region are the Cornucopia, Wallowa, Homestead, and those on the southern slopes of the range, which include Eagle creek, Sanger and the Greenstone area in the vicinity of Balm and Goose creeks.

CORNUCOPIA MINING DISTRICT

The Cornucopia mining district in northeastern Oregon has been a steady and profitable producer of gold and silver since the completion of a well-devised cyanide plant at the Union-Companion mine the first of March, 1913.

The success of this company induced the Baker Mines company to build a somewhat similar plant to treat ore from the Last Chance vein, which began the operation of its 20 stamps and cyanide plant the latter part of October, 1914.

Gold was discovered about 1880. And soon afterwards production began in the intermittent way usual with new, isolated mountain mining camps.

According to Bernard MacDonald's report upon the property, the Union-Companion, Red Jacket and Last Chance claims produced $1,008,000 previous to 1903.

Estimating the years 1906, 1908 and 1914, and taking the official figures of Charles G. Yale, of the United States Geological Survey for the other years since 1903, the entire production to January 1, 1915, for the district is in excess of $2,500,000.

The production for 1914 is estimated at $380,000 for three deep mines and one placer, which amount will be increased in 1915.

The deposits are normal white quartz veins in granodiorite, schist and greenstone.

The principal values are in gold which, except near the surface, is but little amenable to amalgamation.

Amalgamation and concentration recovered but 65 per cent of the gross value, which is largely locked up in iron and other sulphides occurring in irregular bunches within the white quartz body of the vein.

Fine grinding, 80 per cent through 200 mesh screen, and cyaniding recover 90 per cent.

The ores so far mined have a gross value well above $10 per ton.

This region appeals to all because of its pine-clad lower slopes, rugged mountain tops, many fish-stocked streams, invigorating air and

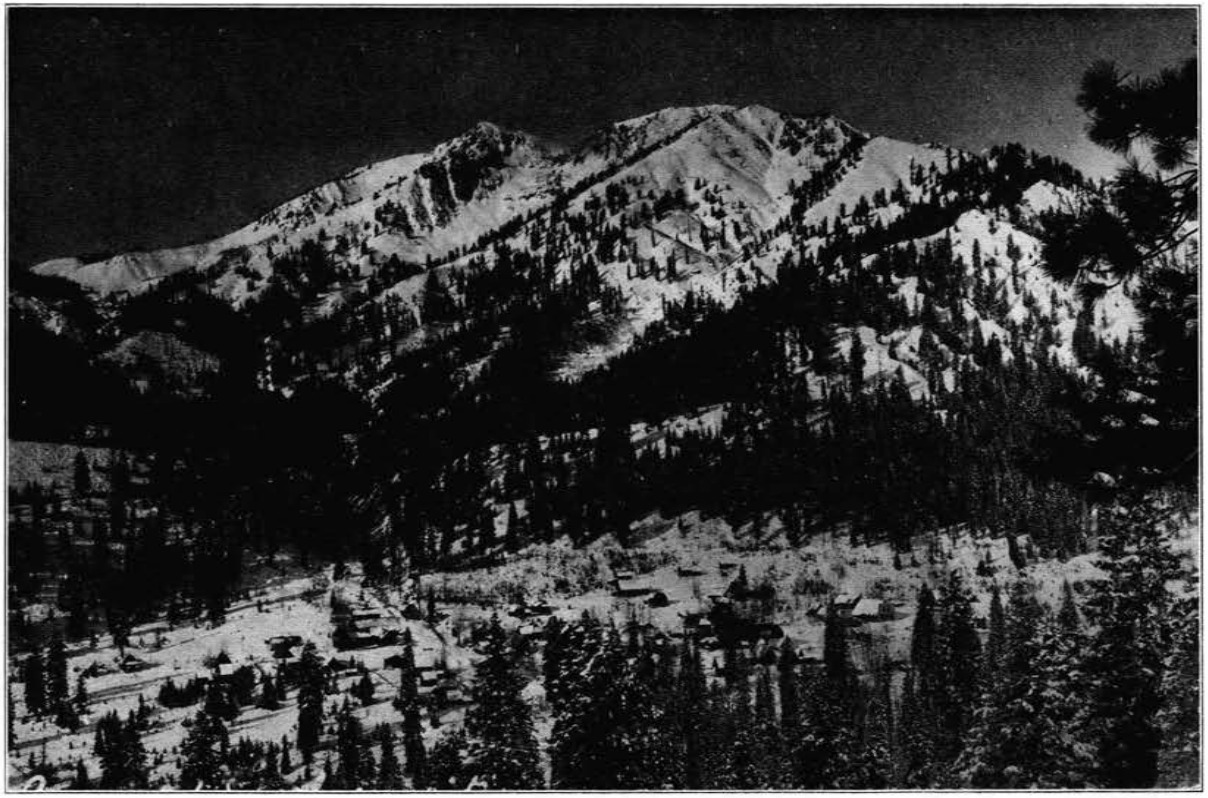


Fig. 5. Cornucopia and the "Granites" in winter.

the additional interest due to its possessing many mineral-bearing veins. There are deep snows in winter and from many mountain slopes magnificent avalanches hurl themselves with resistless energy into the stream beds below.

The district appeals to the geologist because the processes of nature and their results are nearly all laid bare for his inspection.

Mining engineers will do well to become informed upon this district, and to follow this with an unhurried summer visit to it to examine its many undeveloped, though well-defined mineral-bearing veins.

GEOGRAPHY

The small incorporated town of Cornucopia situated on the upper reaches of Pine creek, in the Wallowa* range, is in the center of the district. It is 25 miles from the railroad town of Robinette, on the Snake river branch of the O.-W. R. & N., 33 miles north and down the river from the main line at Huntington. A good wagon road from Robinette to the camp leaves the Snake river at about 1,900 feet elevation at the mouth of Powder river which it also shortly leaves to mount on even grades to the divide between this stream and Pine creek at 3,060 feet.

From here one drops by easy grades 400 feet into the delightful Pine valley and the thriving town of Halfway. A 2 per cent grade carries us up beyond Carson, where begins a steady 1,200-foot rise along Pine creek to our destination, 6 miles beyond. This part of the journey is through a fairly dense forest and within sight and sound of a good-sized mountain stream. This passage from the hot sage-brush hills along the Snake, through a fertile agricultural valley dotted still with pines, into a region of deep canyons and precipitous slopes, is both impressive and refreshing. Except in winter, regular auto, as well as the daily wagon mail stages, take the traveler in by way of Robinette or directly in from Baker some 65 miles by road to the southwest.

ROCK EXPOSURES

From the time one leaves the watershed between Powder river and Pine creek, until well on his way from Carson to the camp, he passes over ordinary Columbia river basalt. One then begins to see

*Named by National Geographic Board. Often called Eagle Creek Range, Powder River Range, Granite Mountains, or Cornucopia Mountains.

greenstones and similar rocks, while in the stream beds bowlders evidence the fact that Pine creek has its sources in granitic areas.

Many days of arduous climbing up steep slopes and oftentimes precipitous cliffs, are necessary to acquaint one in a general way with the rocks in the Wallowa range of mountains. He finds that the town of Cornucopia is situated at the eastern limit of a granitic outcrop approximately 250 square miles in extent. Its outline is quite irregular. Its greatest dimension is southeast to northwest, a distance of about 30 miles.

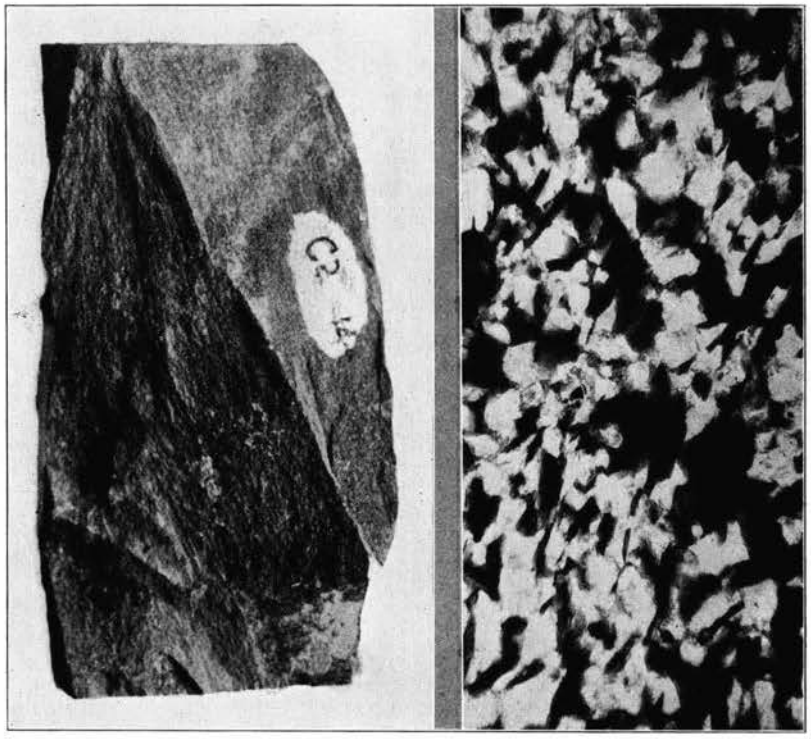
Eagle Cap mountain, elevation 9,860 feet, is the highest peak in all eastern Oregon, but the granodiorite which forms the watershed for the Imnaha river flowing northeast into the Snake river, the various branches of the Wallowa flowing northwest into the Grande Ronde, and Pine and Eagle creeks and Powder river which flow southwest into the Snake, has, in the main, elevations exceeding 8,000 feet. Surrounding this granitic area are found limestones, greenstones and schists. To the south and east these surrounding rocks are generally much lower in height. To the north and west many of their higher points rival the "granite" in the steepness of their slopes and in the loftiness of their elevations. Surrounding all is the Columbia river basalt, which covers so much of the area of Washington, Idaho and Oregon.

This is a country worthy of visitation by the most seasoned traveler in search of beauty and magnificence in nature. It is a region which would especially appeal to the geologist seeking to observe the way in which nature has built her mountains. Here much, if not all, of the records carved in stone are laid open and bare for him. However, to those of us who are more especially interested in interpreting that portion of the records which will assist in successfully exploiting the mineral resources, the following statement as to the forces which placed the granodiorite, the limestone, the schist, the dikes and the veins in the positions in which they are now found, is given.

INTERESTING GEOLOGY

The oldest rocks in the region are the greenstones and sediments. The youngest is the Columbia river basalt. After, and perhaps long after, the greenstones and sediments were placed in position, came the intrusion of the granitic mass. After, and perhaps long after, the solidification of the granitic mass, came the tremendous flow of basalt.

This oldest formation which we have heretofore called greenstones and sediments, is made up of a thick series of ancient lava flows interbedded with schists and limestone. Possibly at some points there may have been intrusions between the bedding planes. Of the sediments, limestones are found to the eastward along the Snake river, on the north side of the "granite" toward Joseph, and on its southwest side near the head-waters of Eagle creek. Most of these limestones have been so much metamorphosed that they are now marbles.



Natural size Magnified thin section

Fig. 6. Fine-grained schist. A dark-colored, fine-grained rock with a slightly schistose or laminated texture. It consists chiefly of quartz with biotite and chlorite. In the microphotograph notice angular shaped fragments of quartz and the parallel attitude of the biotite and chlorite which are black in the photograph. This rock is of clastic origin, that is, it was deposited in an ancient sea from materials derived from the then existing land surface. On being subjected to pressure the secondary biotite developed and this mineral has since been partly altered to chlorite.

The other sediments of the series have been changed to schists, and because of their high content of chlorite and biotite, it is probable that the rock was once a basic sandstone, somewhat similar to the sand-

stones that now make up a large portion of the Coast range in Oregon.

The limestones and schists which make up the sediments are probably much less in quantity than the series of lava flows with which they are interbedded. These lava flows, or extrusives, vary in texture from dense to amygdaloidal. The latter texture resulted from the spongy condition due to gases in lava that left rounded openings which, after cooling and solidification, were filled with quartz or calcite through the medium of circulating waters. Their presence is in itself pretty certain evidence that the rock flowed out on what was then the surface of the earth.

All of these ancient lavas have, since their solidification, suffered from regional metamorphism. After their alteration as a result of these regional disturbances and pressure, they became meta-basalts, meta-andesites and silicified trachytes. In fact, an outcrop of the latter is so dense and so light in color that it was mistaken for a quartz vein. Besides these extrusive flows, there were probably some small intrusions in the form of dikes, sills or sheets.

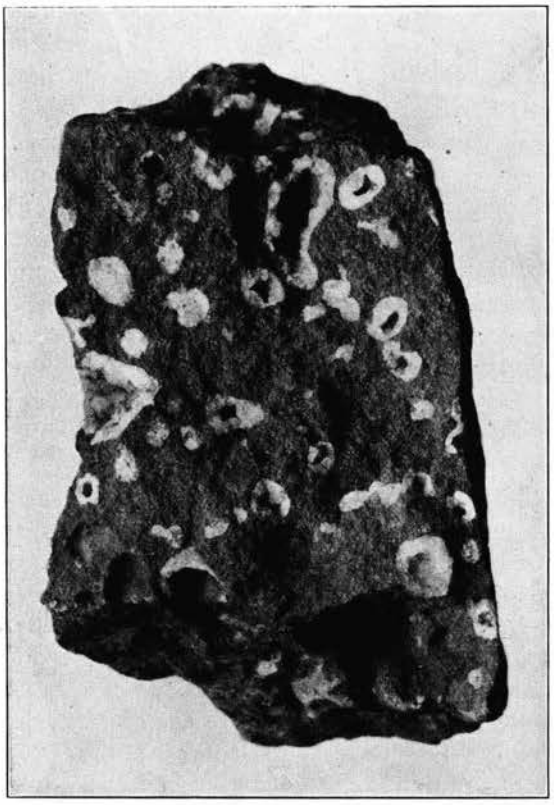
No true volcanic sediments were found in the vicinity of the Cornucopia camp, although some of the most badly altered greenstones may have had that origin. On Eagle creek, however, fine-grained breccias composed chiefly of angular fragments of altered basic volcanics were found.

Some of the rocks of this series are so very dense in texture that it is almost impossible to gain an idea as to whether they were originally a sediment or a flow. The fact that they show slight indications of bedding will probably place them in the sedimentary class. The supposition is that they are mud sediments, the finer products of erosion from basic rocks deposited some little distance out from the shore of an ancient lake or sea.

The presence of the sediments interbedded with lavas, as above described, indicates that these flows took place near sea level, and that the shore line rose and fell so that at one time the streams carried sand and silt from the basic sandstone land areas and deposited them on the floor of the shallow ancient lake or sea. This shallow floor, due to movements of the earth's crust, rose out of the water and upon it the ancient lava may soon have flowed.

This portion of the earth may have oscillated several times to complete the series of sediments and lavas found here. That they were formed in some such way is further strengthened by the fact that in Wallowa county we find what was once limestone now a marble

interbedded with sediments which are now schists. This means that this region during the entire period may never have had land exposed above the surface of the water. Nevertheless, during the time the sediments which are now schists were being formed, it was much nearer to the surface of the water than it was during the time when the limestones, which are now marble, were deposited. The floor of the sea rose and fell.



Natural size

Fig. 7. Amygdaloidal basalt. This specimen, taken from one of the recent lava flows, shows some of the gas-formed cavities filled with secondary minerals thus forming amygdules, while some are only partially filled. The elevation of this particular flow is now 9,500 feet.

Now, remember that we have in this series sediments altered to schists, flows of basalt, andesite and trachyte severely altered mostly into greenstones, and limestone largely changed to marble. How and when were these conditions brought about? These Triassic series have

suffered severely from dynamic and regional metamorphism. By this we mean that after the series had been formed as above described, they were subjected to tremendous compressive stresses, that resulted in a large amount of folding and faulting. These forces were so tremendous and so widespread that large areas of the sediments were rendered schistose. The limestones, due to this compression, together with other activities attendant upon the movement and following it, were changed into marble, and the basalts, andesites and trachytes were, as has been stated before, so altered that they became meta-basalts, meta-andesites and silicified trachytes.

The region was subjected to these tremendous forces, not for a day nor for a year, but for very long periods of time, and the weakening of the earth's crust under the strain of this compression resulted in a gradual elevation or folding of the series in which the yearly elevation of the fold may have been quite small. Accompanying this folding, or following closely upon it, came the extensive intrusion of the granitic mass previously mentioned. This intrusion then in a liquid or at least viscous condition, welled up underneath the large upward folding of the crust of the earth. This welling up of the molten rock rose as the fold rose, but probably at no point and at no time found a vent to the surface to flow away in the form of an acid lava or rhyolite. Probably there was a rock-bound roof over the molten intrusion all the time.

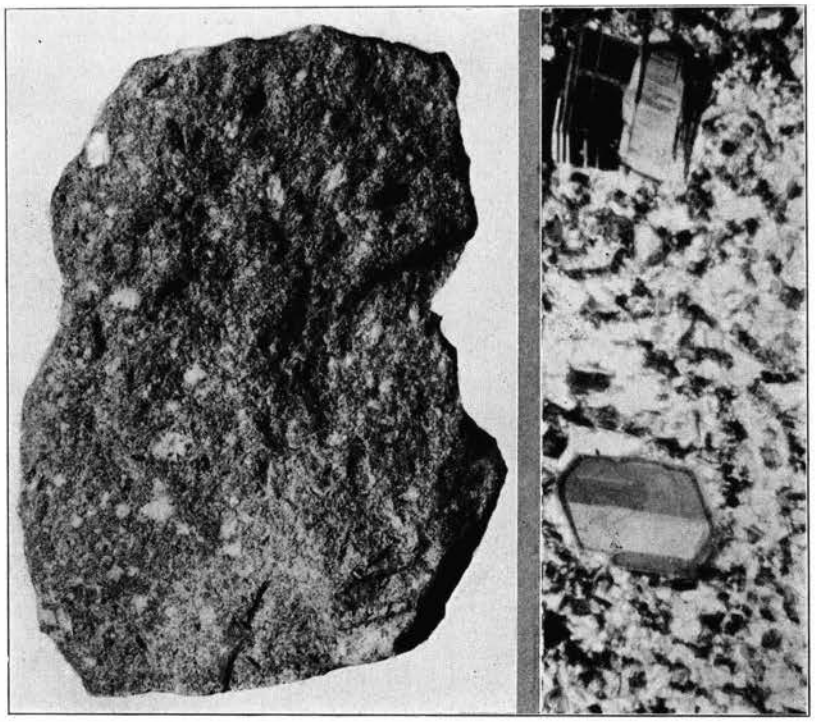
This high temperature intrusion in a liquid or at least viscous condition, reaching to unknown depths within the earth and of great horizontal area, must of necessity permit the dislodging of large blocks of rocks into which it is being intruded. This sloughing off of the enclosing walls of the molten intrusion whose blocks sink into its interior to be melted and largely dissolved had vastly more destructive effect upon the walls surrounding the intrusion than the melting or other contact effects due to high temperature. This sloughing off of the enclosing walls into the molten intrusion has been given the name "magmatic stoping."

The prolonged action of such an intrusive means a great increase in the size of the chamber which it stopes in the older rocks. At different points where it is excavating and dissolving wall rocks of different chemical composition there will be more or less local variations in chemical composition. This is because convection currents cannot freely take place in a viscous fluid.

After a time the mountain building forces ceased for a while their

activities, the pressure upon the viscous intrusive from below decreased, and the main mass of the intrusive became somewhat chilled due to the continued incorporation of blocks of cooler wall rock. The borders of the intrusive were in addition chilled by mere contact, so that they became so viscous that eventually pieces of the wall rock sank but little into the mass.

In the earlier stages of this intrusion the period of time was so long, the temperature so high and the mass so fluid, that the blocks which fell off and sank into the interior were completely dissolved. As time went on a continued decrease in temperature especially near the exterior, made action insufficient to dissolve completely the pieces of wall rock. They sank partly into the mass, and the action was suffi-



Natural size **Magnified thin section**

Fig. 8. Granodiorite porphyry. One of the common dike rocks cutting the granodiorite. Has a similar appearance but is finer grained with a few larger crystals of feldspar (which are white in the photograph) and hornbende (which are black in the photograph). The larger crystals are called phenocrysts and the spotted appearance, a porphyritic texture. The thin section clearly shows the crystal outlines of the phenocrysts and the slightly darker band around the lighter colored one indicates a different composition from the central portion.

cient in the earlier part of this second stage to re-crystallize them to a large degree. Its power to do this lessened as time went on so that one finds particles of the wall rock within the granodiorite near the contact practically without alteration.

These inclusions of the wall rock found on the exposed contacts of the "granite" in the Cornucopia region or any other, especially the angular fragments, are proof in themselves that the included fragments are parts of the older rock. The enclosing rock must of necessity be younger than the enclosed fragment.

The chilling of the intruded rock progressed toward its center, the deep seated portion in all probability remaining in a molten condition for a long period of time. After this solidifying or freezing of the exterior, it is quite reasonable to expect that cracks would form in the newly solidified rock, due probably to strains set up by cooling.

Do not forget that there still remained a roof of the older rock covering the intrusion. The contraction of the latter, with perhaps a decrease of regional pressure and a continued enlargement of the cavity on some of its deeper levels, may have caused a subsidence of the roof due to these causes. In this way extensive fissures were created not only in the upper and outer part of the cooled intrusive but in its roof of older rock as well. It is to be expected also that regional disturbances did not abruptly disappear. These may have been an additional cause of fracturing.

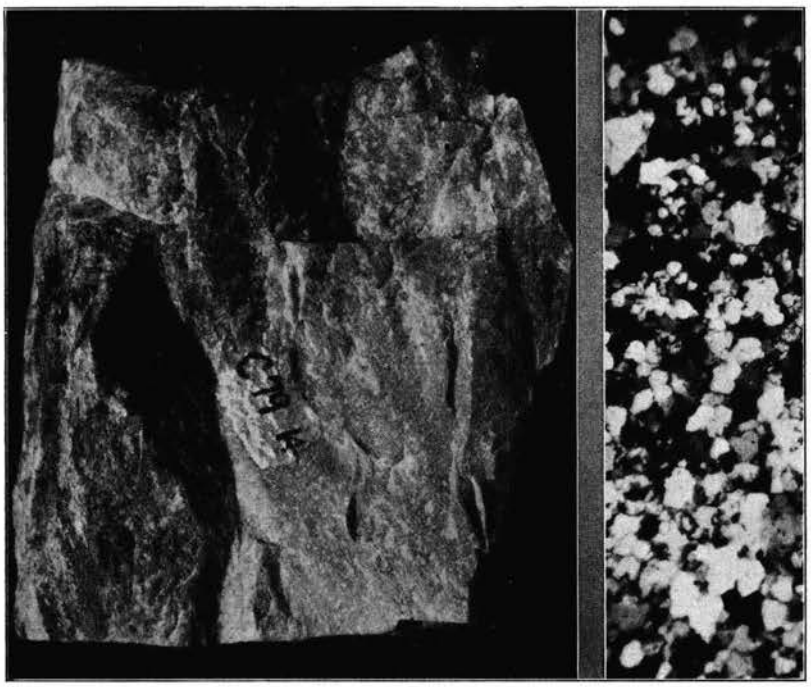
Now if at this stage the interior portion is still in a liquid condition and under some pressure from below, it will force its way up into these freshly formed cracks or fissures and, after solidifying, become dikes. The lower part of this intrusive magna although molten, has already started to crystallize, the crystals, large because they formed at depth under slow cooling conditions, will be carried up into the fissures. Here on account of quick cooling conditions these larger crystals will be caught in a fine-grained groundmass. In this manner a porphyry dike is formed. The composition of the porphyry will indicate whether there is much difference in the composition of the still molten interior from that of the now solidified exterior. The granodiorite porphyry taken from the dikes of the Union-Companion property is not only of more basic composition than the enclosing granodiorite wall rocks, but the zonal growth of the large crystals shows a gradual change; the central or older portions are more acid than the outer or younger portion.

A recurrence of fracturing may follow from time to time, which

fractures may be filled with material widely variant from the previous fissure filling. A subsequent fissuring contains aplite dikes. Aplite, consisting as it does chiefly of quartz and feldspar, represents rapid cooling during the later stages of the solidification of the main intrusion. Since it is composed of the light colored minerals quartz and feldspar, it is a light colored rock, and since it cooled quickly, it is fine-grained. That the aplite is younger than the poryhyry in the Cornucopia region is proven by the fact that aplite dikes cross the porphyry dikes uninterruptedly. Some of these aplite dikes appear to grade into quartz.

The aplite dikes were the last molten filling of fissures to occur and probably those dikes which are found to grade into quartz were the latest aplite dikes, since the last mineral to crystallize in an acidic magma is quartz.

From now on no further filling of fissures by molten rock occurred until the next great regional disturbance. The freezing or solidifying



Natural size Magnified thin section

Fig. 9. Aplite. A light-colored, fine-grained dike rock consisting practically entirely of quartz and feldspar.

of the outer portions of the intrusion had gone deep, and a much more quiet condition of the earth's crust prevailed. It must be borne in mind, however, that this intrusion was well covered by the older rocks; that its mass is to be thought of in cubic miles; that its temperature although lowered to such a point that the mass had become solid, was still very hot.

It must further be remembered that the same causes which produced the fracturing before this time will create fractures again. These fractures may cut through both the intrusion and the older rock as well. They will not be filled by molten rock, either of porphyry or of aplite, but will be filled in the main by the precipitation of quartz and other vein minerals from ascending circulating waters. Now these circulating waters, because of the temperature of the region, will be hot because of the uncooled condition of the intrusion and the wall rocks as well, and since they are well below the surface of the earth, they will be under considerable pressure. With high temperature and pressure chemical activity is much more intense. This of course refers to the ability to take material into solution. Whether the ascending waters are a product of the intrusion or come from the older rocks, they will in the deep interior dissolve a great deal of quartz and lesser amounts of other rock and metallic minerals.

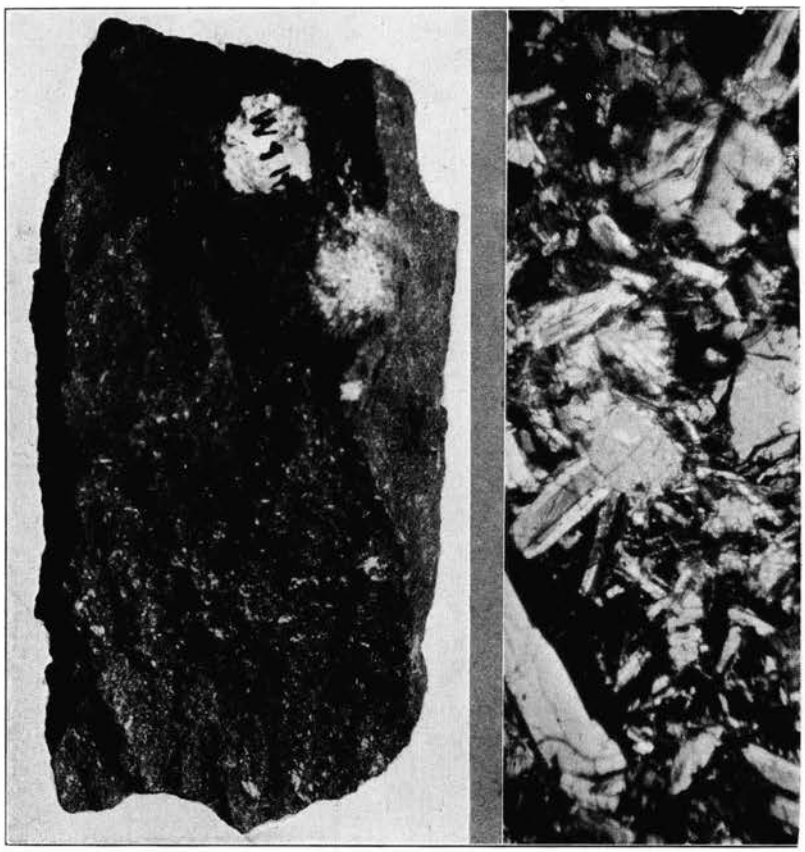
From whatever points or regions the solution of these substances may come, whether from the uncongealed remnants of the intrusion or from the adjoining older rock, either or both, it will be from a few thousand feet below the surface. As the hot water containing the dissolved quartz and metallic minerals ascends, pressure and temperature decrease. With decrease in pressure and temperature, following the chemical law above stated, the ability to hold in solution is lessened and precipitation begins. If, in the deep-seated region where the taking into solution is going on, there are little or no metallic minerals, the ascending hot water will of course not contain them. It will deposit in the fissures in the upper few thousand feet quartz upon the fissure walls, and a barren quartz vein, when the fissure has been completely filled, will have been created.

It is plain to be seen then that the proportion of minerals deposited in the veins is largely dependent upon the proportions present in the deeper zones.

It is also seen that, although the interior may have contained plenty of metallic minerals which have been taken into solution and have ascended through the fissures made for them so that the

fissures have been completely filled with quartz and other minerals, still the finding of ore at or near the earth's surface will depend upon how much that surface has been lowered since the completion of the vein.

Also, when a primary ore is found at or near the surface whether ore will continue to a considerable depth will also depend upon the amount of erosion. In other words the vertical distance between the points where deposition begins and ceases is considerable. The latter point is usually well below the surface at the time of deposition. The distance between these two points under conditions similar to those found at Cornucopia is rarely as little as one thousand feet, and is



Natural size **Magnified thin section**

Fig. 10. Basalt. The most common recent lava rock. Dark in color, fine-grained porphyritic in texture. Consists chiefly of basic plagioclase (labradorite) pyroxene and olivine. The microscopic thin section at the right shows the lath-shaped labradorite phenocrysts, and the olivine of high relief is slightly altered to serpentine.

usually much increased in length by the presence of certain wall rocks, such as found there. To what point has erosion progressed at Cornucopia? The erosion has progressed to the point where the roof of older rocks has been removed together with considerable of the intruded granodiorite itself over an area of something like 250 square miles.

Throughout the long period of time when the large quantity of ascending water was filling the fissures, the region affected was slowly cooling. Perhaps during much of this period the erosion of the then existing surface was progressing more or less rapidly. What the topographic forms were at the end of this period would be impossible to determine.

In our story we have arrived at the period of greatest quiet which was followed by another regional disturbance due to unbalanced forces within the earth, the effect of which was to make complex fractures out of which flowed enormous quantities of basaltic lava. How great a quantity may be imagined when one considers the great depths and the enormous areas of it now covering large parts of Idaho, eastern Oregon, and eastern Washington. According to Waldemar Lindgren the region under consideration was the principal source of Columbia river basalt.

This lava, welling up through the complex fractures in the granitic and older rocks of the region filled the then existing gulches and other depressions of the surface. Such overflowing may have continued to so great an elevation that when cooled the Cornucopias were a plain or else an island in a sea of basalt.

Following the final flow of lava, for there were many flows, erosion began again and has progressed to such a point that now, over most of this region, the lava has disappeared and only the basalt in the dikes is left. These dikes cutting the granitic and older rocks in all directions, crossing the quartz veins, breaking along their sides or else diagonally through them, are the most striking visible feature of the Wallowa range.

Above, in bare outline, is the geological history from the forming of the Triassic sediments before the coming of the granitic intrusion down to the present time. It is a necessary prerequisite to an understanding of the ore deposits of this region.

THE MINES AND PROSPECTS

The producing veins are all situated on "Granite" mountain two or three miles to the north and east of the town of Cornucopia, and at elevations of 1,000 to 3,000 feet above it.

There are many prospects on both slopes of this mountain as well as the ones on Red mountain, Simmons mountain, in Norway basin and those to the east and south of town. There are also the placers on Pine creek. There are several parallel veins on Granite mountain which strike a few degrees east of north and usually dip 45° westward.

UNION-COMPANION MINE

This mine is now the property of the Cornucopia Mines Company.

History.—The gold bearing veins of the Cornucopia district were discovered about 1880. The nearest railroad at that time was the main line at Baker. This distance to railroad transportation, together with the isolation of a snowy mountain camp, caused production to be intermittent for some little time. The strikingly favorable appearance of the veins attracted investors, and early in 1895, although but slightly developed, the Union-Companion claims were sold for $60,000. The purchasers proceeded vigorously with development and installed a 20-stamp mill and chlorination plant to treat the ore. The latter proved to be unsuitable and was abandoned.

The method followed from this time on was by* "the customary method of crushing with light stamps, amalgamating, and concentrating, with a canvas plant for the tailings. The mill was built in 1896 and succeeded in extracting only about 65 per cent of the values. Owing to the fact that the mine is situated 25 miles from a railroad, the hauling, together with smelting charges on the concentrates, combined with the low extraction, made it very difficult to keep the property on a paying basis. It was therefore decided that, if possible, the ore should be treated by cyanidation, thus eliminating outside charges on concentrates and at the same time making a better recovery of the metals contained in the ore. Tests showed that a satisfactory extraction could be obtained by grinding fine, and treating the product by agitation and filtration. Accordingly, in June, 1912, construction on the cyanide plant was started. The crusher, ore bins and stamps of the old mill were left intact, and only such changes were made to the mill buildings as were necessary to accommodate the new machinery." Since the completion of this plant, March 1, 1913, the production has been steady and profitable.

Geology.—The outcrop of the Union-Companion vein is at an altitude of 6,100 feet, or 1,400 feet above the town of Cornucopia, one and one-half miles away down Fall creek. The outcrop of this vein is traceable, according to Bernard McDonald, for 6,800 feet throughout the

*Paul W. Gaebelein in the Engineering and Mining Journal of February 28, 1914.

Fig. 11. Union-Companion mill and mine. Mayflower mill in foreground. Outcrop of Union-Companion vein at the upper left in the view.

lengths of the Union, Companion, Red Jacket, and Robert Emmett claims. Its strike is about N. 20° E. and dip 45° W. into the mountain; its maximum width is 20 feet.

The chief country rock is granodiorite, but the vein is near the extremely irregular borders of the intrusion, so that in the plane of the vein the wall rocks alternate continually between the intrusion and the intruded. This older rock in some places on the walls is greenish schist, originally probably a basic sandstone; in other parts of the mine the walls were found to be a part of an old intrusion or flow now altered to greenstone.

One characteristic specimen shows what appears to be a rather irregular contact with the granodiorite, so vague that one might almost say that the assimilation, or melting of it by the intrusion had been arrested when its work had been but partially completed. On the surface granodiorite is in evidence on the Union and Companion claims, while on the Red Jacket and Robert Emmett the older rocks chiefly prevail.

Numerous dikes of granodiorite porphyry are found varying from a few inches to a few feet in width and cutting both the older and the

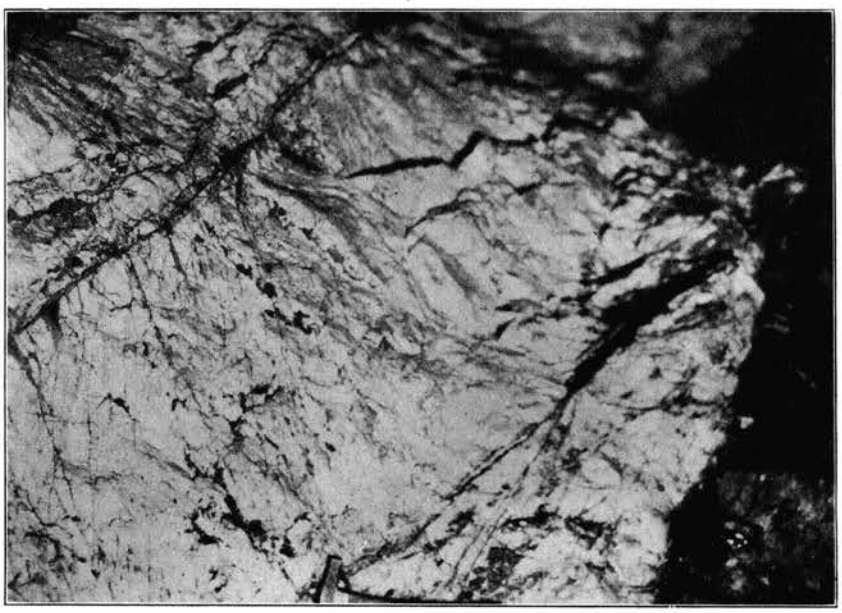


Fig. 12. Part of Union-Companion vein on 500-foot level, showing banded character. Dark spots are sulphides.

newer rocks. Aplite dikes are less conspicuous here than at points farther up on the mountain.

Another rock type is the Tertiary Columbia river basalt in the form of dikes. These dikes are shown on the surface with outcrops in all directions. These reddish-brown weathered outcrops contrast strongly in color with the whitish granodiorite in which they are placed.

The Vein.—The width ordinarily is 2 to 5 feet but it swells in places to a maximum of 20 feet.

"On the whole the vein is remarkably persistent. Hanging and footwalls are sharply marked, inclosing a massive vein of white normal quartz. A ribbon structure by shearing is usually developed in the lower parts of the vein, or at least for a few inches from the footwall."*

"The Union-Companion-Red Jacket vein has been developed, at one place in the Union claim, to a maximum depth of 800 feet, while in its northerly extension through the Union, Companion and Red Jacket claims, it has been developed to variable depths averaging 300 feet. This development has revealed the existence of four ore shoots having an average width of three feet and an aggregate length of 1,200 feet along the vein."†

"The ore is a hard quartz, containing 3 to 5 per cent pyrite carrying the gold. Silver is present partly as a sulphide, and the proportions of gold to silver by weight are approximately 1-5. There are also present in the ore appreciable quantities of chalcopyrite, arsenopyrite and blende. The ores are variable in value, ranging from $10 to $20 for mill-run grade."‡

The principal shoot on the Union claim is now down to the 500 level, 100 feet lower than in 1903. The drifting on this level revealed a shoot of ore whose length, width, and grade compare favorably with those above. Of course a vein in which the gold is locked up in sulphides not usually disseminated, but rather in bunches within the massive quartz, must of necessity vary from place to place. Nevertheless when considered in a larger way the precious metal content is quite regular in the stopes from the different levels. Sinking on the vein has been started from the 500-foot level since the camp was visited.

This vein probably represents the final activity of the granodiorite. It would appear from the excess of sulphides on the borders of "greenstone" fragments in the vein that these ferro-magnesian silicate rocks assisted, at least locally, the other agencies in the precipitation or deposition of the metals in the vein. How much of practical value this

*Waldemar Lindgren. The Gold Belt of the Blue Mountains of Oregon. 22d Annual Report U. S. G. S. Part II, p. 74.

†Bernard MacDonald's report upon the property, April 10, 1903.

‡Paul W. Gaebelein in the Engineering and Mining Journal of Feb. 28, 1914.

might prove to be in determining the advisability of developing veins where they cut granodiorite only, would require considerable field examination, geologic mine mapping and assay maps to determine even if it is determinable.

The Union-Companion operators need be but little concerned on this point because they have on each level a sufficient amount of granodiorite and greenstone to secure whatever favorable influences either one of these wallrocks might provide. The lowest developed level, the 500, has perhaps a greater proportion of greenstone wallrocks than the others, although "granite" is abundant; so that the ore developed for the next lift or two at least should be unaffected by this suggested influence.

Future of the Mine.—It seems reasonable that since the ore has continued for 1,000 feet in depth without appreciable diminution in value, it may be expected to continue to a much greater depth. It might even be expected, if the greenstone wallrocks had an appreciable effect in the precipitation of sulphides and, therefore, in the location of at least the richer parts of the ore shoots, that new development below the present lowest level might reveal even better ore there, because of the great amount of greenstone found at depth.

The unbroken continuation of one and the same shoot is not necessarily to be expected. Barren levels occasionally interrupt rich and extensive shoots in any district.

A matter of considerable importance in developing ore bodies in this camp is the large number of basalt dikes found in close proximity to the veins. These dikes are found with strikes in all directions. Whatever the forces were which created these deep-seated fractures now filled with the once molten rock, they must have been very great to overcome the rock's tremendous resistance to rupture. Nature, like armies on the offensive, seeks out the lines of least resistance, so that fracturing will always follow, as much as may be, old breaks or lines of weakness. When the rocks or crust of the earth is being broken at or nearly at right angles (greater than 45°) to a then existing line of weakness, such as a quartz vein, it will break directly across it. This is seen to have occurred in the Union-Companion vein and is shown on the map as the "Cross dike." But should the break approach at less than 45° to the old line of weakness it will turn and break into it, will follow as far as it can the easiest way, to finally break through the other wall and continue on its general course.

The latter condition is well shown in the "Parallel" dike on the working plan and in the ideal cross section.

The "Cross dike" passes through the quartz vein and, therefore, was made since the completion of the vein. It can, then, have had no effect upon the vein, except a mechanical one, that is, to cut it in two where it crosses.

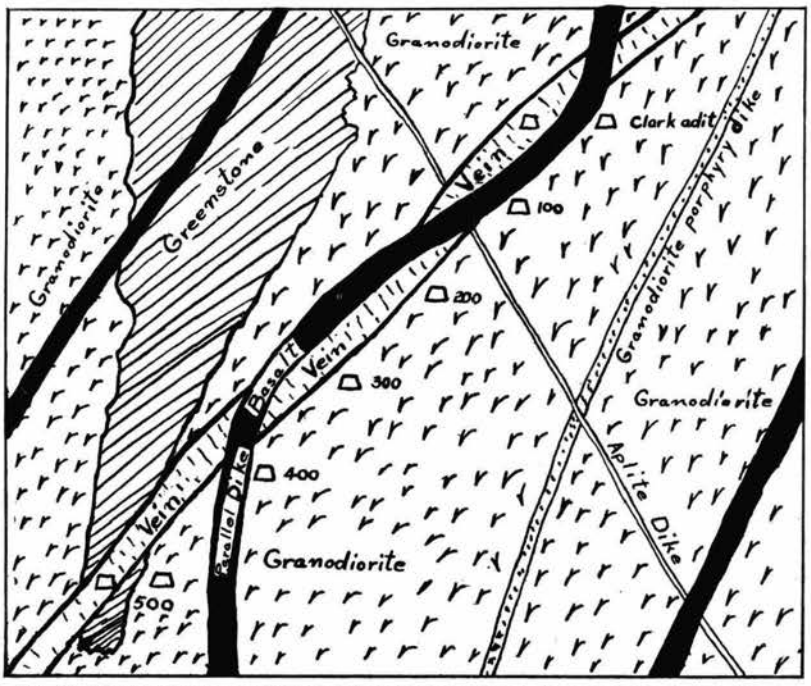


Fig. 13. Ideal cross-section of Union-Companion vein showing country rock and dikes.

In the case of the "Cross dike," no question would arise in the minds of prospectors or operators as to which came first, the vein or the dike. The vein was plainly completed before this crosscutting dike came to cut the vein in two.

Although the "Parallel" dike undoubtedly came since the entire filling of the quartz vein was completed, and at the same time as the "Cross dike," it is less easy to believe that it did succeed the quartz vein. This confusion arises quite naturally:

1. Because this dike is found in the plane of the vein over a large area of its walls.

2. Because the vein is found on both sides of the dike, although

ore is but rarely found locally on both sides except at the outer limits of some of the stopes.

3. Because in the Last Chance vein ore is found on both sides of an aplite dike undoubtedly older than the vein.

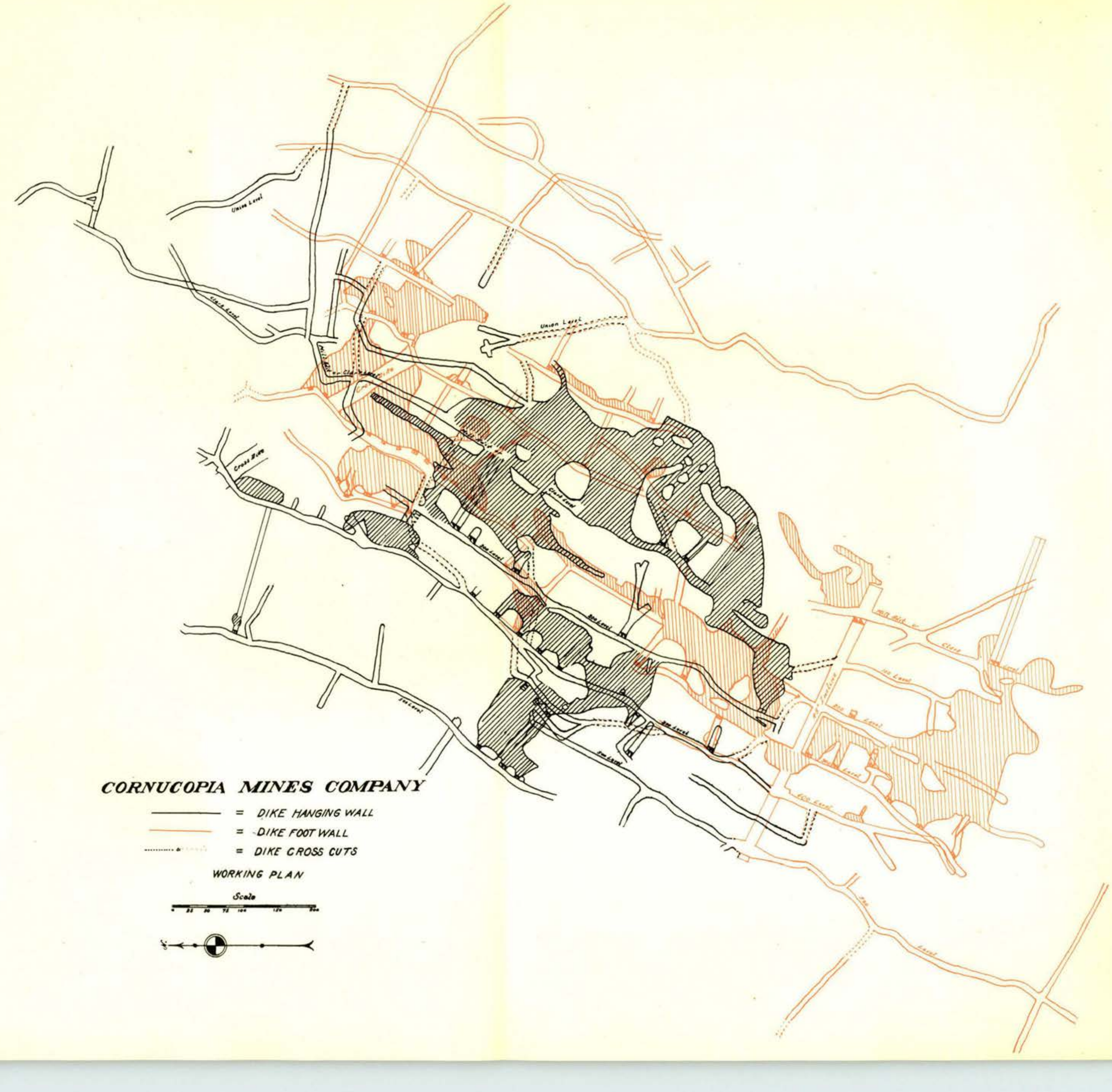
The plane of the vein has a dip into the hill of approximately 45°. The forces which fractured the earth at this point to let in the basalt were applied in such a way that it broke at a steeper angle than the vein fissure previously formed. Approaching the plane of the vein at a rather acute angle, it then had every reason to take advantage of the plane of weakness of the quartz vein to break into and remain in it over a large area.

The dike fracture broke into the vein through the latter's hanging-wall above the Clark level and remained in the vein to a point between the third and fourth levels where it broke through the foot-wall to continue its natural and steeper dip, so that on the 500-foot level it is some 80 feet away from the vein.

It should cause no surprise that in the fissuring anew in the plane of the quartz vein the break should follow in places the hanging-wall, in others the foot-wall of the vein, breaking diagonally across from one wall to another, and occasionally splitting the quartz vein for considerable areas. The intrusion of the basalt into this fracture left large lenses of ore on both sides of the basalt dike in such forms that the most natural conclusion to be arrived at is that the vein was formed since the dike was formed, that the dike had considerable to do with the vein and its values, and that exploration should follow closely the walls of the dike. Because of this conclusion previous managements followed the dike rather than the vein on its downward course, and for a long time crosscutting in the hanging-wall of the dike was not prosecuted. In various parts of the mine evidence is seen of much wasted money spent in the search for ore because of this erroneous theory.

Because of the habit in this camp of following dikes in the search for ore, rather than making the search independently of dikes and on the general course of the vein, it seemed advisable to make the foregoing lengthy statement and to prove its correctness by field study in the following manner:

Intrusions of molten rock naturally solidify quickly next to their cool walls. This chilling comes so quickly that close to the walls it is almost like glass, very dense and fine-grained. Here it remains fluid for so little time that crystals have little time to form. As one


CORNUCOPIA MINES COMPANY
= DIKE HANGING WALL
= DIKE FOOT WALL
= DIKE CROSS CUTS
WORKING PLAN
Scale
Union Level
Clark Level
Cross Bore

goes farther towards the middle the cooling is more and more delayed and larger and larger crystals have time to form, so that in a thick dike while its borders are almost glassy its interior contains crystals of considerable size.

1. Search was made along the walls of the dike in contact with the vein to find a branching of either one into the other. When this was found, as illustrated in the sketch, the "glassy" borders of the tongue

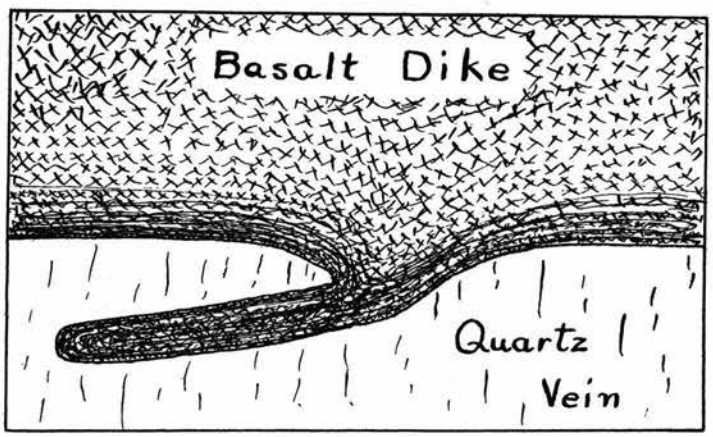


Fig. 15. Tongue of basalt injected into quartz vein.

of basalt into the quartz, together with the "glassy" condition of the main wall of basalt nearby proved that the basalt was intruded into the quartz; that the tongue of the basalt was not a "horse" in the vein and therefore older. This in itself is sufficient proof that the vein is the older.

2. Contacts of the dike with the vein were investigated at various points and it was found that these contacts are invariably chilled contacts and do not show the alteration due to the action of hot circulating waters, evident in all the other wall-rocks of the vein. This new or fresh condition of the basalt adjoining the vein is sufficient proof in itself that the vein was formed first.

3. On the Clark level of the Union-Companion mine, it was noted that the "Cross dike," plainly and admittedly of later age than the vein merged into the "Parallel" dike at their junction in such a way as to prove that they were intruded into these fractures and solidified at the same time. Besides the evidence of the eye at this junction of the two dikes, the microscope revealed in thin sections taken

from each dike that they had identically the same mineral composition. This is in itself a sufficient proof that the "Parallel" dike came since the vein was formed.

It is quite evident that both prospector and mine superintendent can make practical use of the conclusion that the basalt or "iron" dikes came since the veins were formed. They should look upon the "iron" dike as a mechanical interruption of the continuance of the vein which must be broken through or passed over to find the vein beyond. If a dike follows a vein for some distance, when it does leave the vein rather than worry for fear the values will cease in its absence they should give thanks.

Cyanide Plant of the Cornucopia Mines Company.—The following excellent description of the crushing and cyaniding methods practiced at the Union-Companion mill is from the pen of their mill superintendent, Paul W. Gaebelein, in an article in the Engineering and Mining Journal of Feb. 28, 1913.

"*Methods of Crushing and Grinding.*—The ore is received directly from the mine cars on three grizzlies set to 1½ in. The undersize falls directly into the ore bin, which has a capacity of 150 tons, and the oversize passes to a 9x15-in., Blake crusher, reducing the ore to 1½-in. size and delivering to the ore bin. The rock is then fed by challenge feeders to 20 950-lb. stamps which make 98 drops per minute through 7-in. Approximately 6 tons of a 0.125% solution of sodium cyanide per ton of ore are fed to the mortars, and the ore is crushed through through No. 930 ton-cap screens, which correspond to about 8 mesh. Lime is added at the feeders in sufficient quantity to give the solution a protective alkalinity of 0.7 to 0.8 lb. CaO per ton. The stamp duty is 5.15 tons per stamp. Chrome-steel shoes and cast dies are used, which combination is giving excellent results. The shoes last from 80 to 90 days, while the dies usually last from 40 to 50 days.

"At the beginning of operations amalgamation was given a thorough trial extending over a period of several weeks. With finer screens, the results obtained did not justify its continuation, due to the fact that there is but a small amount of free gold in the ore, and that the coarse crushing in cyanide solution made conditions unfavorable to good work. It was therefore discontinued.

"The battery product is equally divided between two 4-ft. Callow cones, which remove the coarse sand and feed it direct to the tube mills. Fine grinding is accomplished in two 5x22-ft. tube mills mounted on tires. The advantage of this type of mill over the trunnion type is its lower power consumption. Each mill is driven by a 50-hp., back-geared, General Electric induction motor, which is connected to the tube-mill drive by a spring coupling. The mills make 26 r.p.m.

and are lined with 4-in. silex blocks. This lining lasts seven months. Local quartzite is used for pebbles.

"Each tube-mill works in closed circuit with a simplex Dorr classifier, the overflow from the Callow cones being joined with the tube-mill discharge and fed to the classifiers. The sand discharge, joined with the underflow of the Callow cones, runs by gravity to the tube-mills, which are equipped with scoops 6 feet in diameter. The only product leaving the crushing and grinding department is the slime overflow of the classifiers.

"Each tube-mill is fed with 50 tons per day of material, which has the following screen analysis:

	per cent		per cent
-10 mesh	95.9	- 60 mesh	36.5
-20 mesh	74.2	-100 mesh	26.7
-30 mesh	60.8	-150 mesh	22.9
-40 mesh	50.4	-200 mesh	20.9

"This material is first fed to the classifier, which removes the product finer than 200 mesh, returning the remainder to the tube-mill for regrinding. The finished product has the following average analysis:

-100 mesh, 98% -150 mesh, 94% -200 mesh, 86%

"As mentioned above, the ore is hard quartz and difficult to grind, and even when ground so that 86% passes 200 mesh, it is still fine sand, and contains practically no colloidal matter or true slime.

"Continuous Cyanide Treatment.—The entire product from the crushing and grinding department flows by gravity to a 30x10-ft. Dorr thickener, where it is thickened from a ratio of 6:1 to 2:1 for agitation. The solution overflowing this thickener is used for dilution, as will be described later. The thickened underflow is transferred by a 3-in. air-lift to the agitation tanks.

"The three agitators are of the standard Pachuca type, 12 feet in diameter and 36 feet deep. They are operated in series, the pulp receiving about 36 hr. agitation in passing through the three tanks. The solution is brought up to the standard strength of 3 lbs. per ton as it enters the agitation series. Continuous agitation has proven to be efficient and economical in operation, and the Pachuca tank gives satisfaction. Notwithstanding the sandy nature of the pulp and its quick-settling properties, the agitators keep the pulp of a uniform grade throughout the series, and after a year's continuous operation have disclosed no objectionable features. Compressed air at 30 pounds pressure is used, and when necessary, as after a shut-down, high-pressure air from the mine compressors can be furnished for starting.

"Tests and experiments on the mill solutions have shown that approximately 35% of the total dissolution of the gold and silver takes place in the mill, while the remaining 65% is dissolved in the

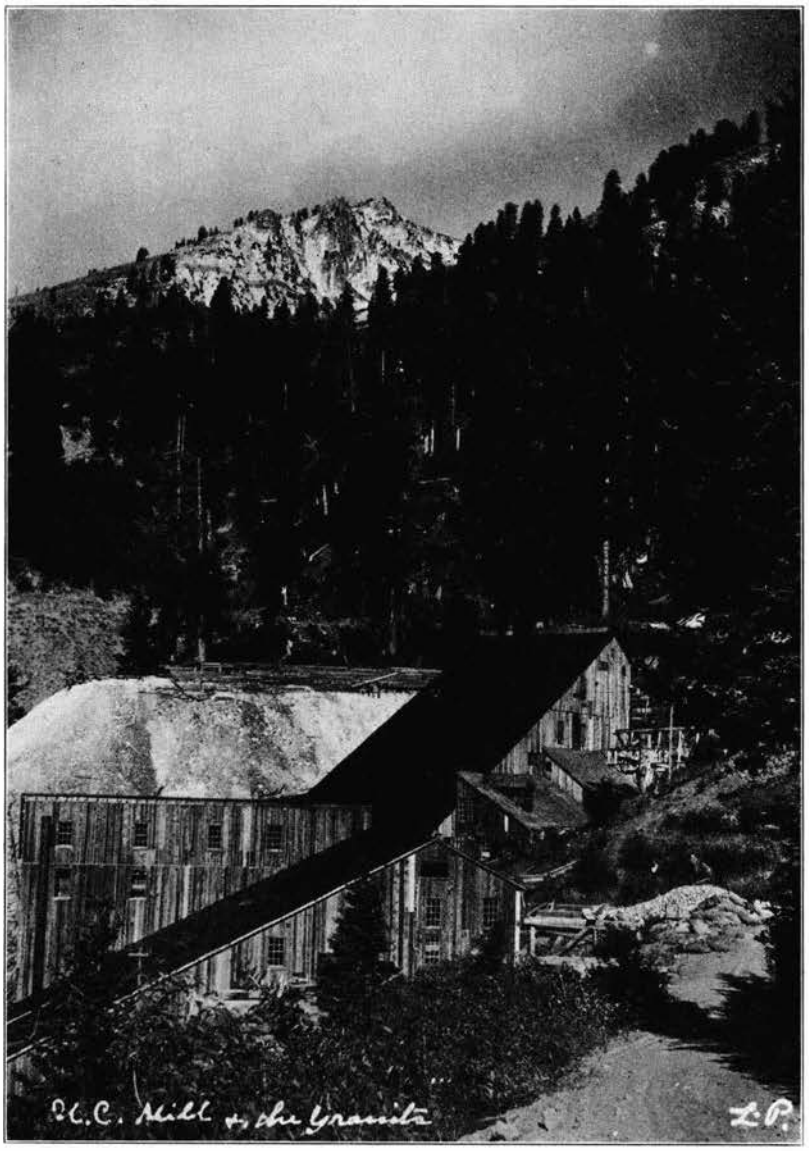


Fig. 16. The Union-Companion mill.

agitators. The solution carrying the pulp from the last agitator of the series is consequently relatively high in value. The solution overflowing the 30-ft. thickener is also the lowest grade of the mill solu-

tions. Owing to the fact that the filter plant consists of continuous, revolving drum filters, which are not adapted to the filtration of pulp which is carried in a high-grade solution, it is necessary to reduce, by dilution, the value of the solution which leaves the last agitator with the pulp.

"This dilution is accomplished in two 20x10-ft. Dorr thickeners, and the diluting solution is the solution overflowing the 30-ft. thickener. The two 20-ft. thickeners are run in series, and the solution overflowing the 30-ft. thickener, runs into a collecting box from which it is pumped by a 2-in. centrifugal pump and equally divided between the two thickeners. The pulp leaving the last agitator overflows into a 3-in. air-lift which transfers it to the first of the two thickeners. On entering, it is mixed with the diluting solution, which brings the dilution up to approximately 4:1. It is thickened in this tank to 1½:1, and the thickened underflow is transferred by a 3-in. air-lift to the second thickener. The solution overflowing the first thickener is collected in a box, and flows by gravity to the precipitation plant. The pulp entering the second thickener is mixed with diluting solution and thickened to 1 to 1 for filtration, while the solution overflowing is returned to the battery for use in crushing. This dilution reduces the value of the solution, leaving the second thickener to one-third of its original value, which is low enough for filtration. The pulp from the second thickener is carried by a 3-in. air-lift to the filter plant.

"The filter plant is composed of two continuous, revolving drum filters. The drums are 14 feet in diameter and 9 feet face. In common with most vacuum filters, their capacity varies with the character of the pulp filtered, and on this sandy material the capacity is great. The entire product of 20 stamps can be handled easily on one machine, and as much as 115 tons have been filtered in 24 hours. The cake is ½ inch thick, and is washed by a series of sprays, which are intended to keep the cake moist on its way to the scraper. The level of the pulp in the tank is kept as low as possible, and the cake receives a thorough air-drying before emerging from the tank. By the combined air-drying and spray-washing, the dissolved loss is kept to a reasonable figure.

"A 12x14-in. Buffalo wet vacuum pump furnishes the vacuum for the filters, and discharges the filtered solution into a small collecting tank. The tailings from the filter are removed by the scraper and deposited on a belt conveyor which stacks it on the dump. The great advantage of these filters is in their low maintenance and repair cost, and in the fact that they do not require the services of a special filterman.

"Clarifying and Precipitation.—The solution to be precipitated comes from two sources; the solution overflowing the first of the 20-ft. thickeners, and the filtered solution. These solutions flow into a small collecting tank, from which they are pumped by a 3-in. centrifugal pump through a 36-in., 18-frame Merrill clarifying filter. The effluent from the press flows by gravity to four pregnant-solution sumps, each 14 feet in diameter and 6 feet in height. The Merrill system of zinc-dust precipitation is used. The zinc-dust is fed by a screw feeder into an emulsifier, and the resulting emulsion of zinc-dust is fed to the suction line of a 4½x6-in. Buffalo triplex pump. There are in use two 36-in., 18-frame Merrill zinc-dust presses. The triplex pump works against a head of approximately 85 feet when filling the presses. The barren or precipitated solution leaving the presses flows by gravity to the main storage tank, 26 feet in diameter and 6 feet in depth, which is situated in a separate building, and which supplies the small battery feed tanks.

"Precipitation results have been satisfactory in spite of the fact that there is considerable copper dissolved from the ore, the precipitate often running 35% copper. The clean-up is made from 3 to 4 times a month. The precipitate is dried in a muffle furnace and melted direct in a No. 125 Donaldson tilting furnace using fuel oil. The resulting bullion varies considerably in grade, depending on the amount of copper in the precipitate, but it usually averages 750 fine in gold and silver.

"The extraction obtained is 90% of the gold and from 70% to 80% of the silver, making a total of 87.5% to 89% of the value contained in the ore. Each ton of ore treated consumes 1.40 lbs. cyanide, 3 lbs. of lime, 0.90 lb. of zinc-dust. These vary considerably with the different grades of ore, and the figures given above are an average of the consumption over a period of several months' operation, during which period the value of the ore varied from $10 to $16 per ton.

"In designing the plant, it was endeavored to make as many of the operations as possible, continuous. The object has been attained in that, since the beginning of operations, the plant has been run by two men on a shift, exclusive of the crusherman. Crushing is done on two shifts only. The batteryman has charge of the stamps and the tube-mills. He attends to all the work incident to the operation of this portion of the plant, and is assisted only in the larger battery repairs. The solution man operates the remainder of the plant. There is no steady attendant in the precipitation room. Melting is done by the assayer, with his assistant. On the day shift there is a repair man with one helper, who keeps up all the necessary repairs.

"The plant requires 230 hp. when operating at full capacity. Power is furnished by the company's hydro-electric plant, situated about two miles from the mine. Current is transmitted at 6,600 volts and transformed to 2,200 volts at the mines for use in the motors.

The cost of treatment averages $2 per ton, and is subdivided as follows:

	per ton
Labor	$0.65
Supplies	1.03
Power	0.12
Marketing product	0.20
Total	$2.00

"Owing to the distance from the railroad, a 25-mile haul, most of which is a rather heavy grade, the freight charges on all supplies are high. The property has been under the management of Robert M. Betts, since the present owners acquired possession, and the mill was designed by Walter L. Reid, of Telluride, Colorado."

THE LAST CHANCE MINE

The Last Chance mine is the property of the Baker Mines Company.

Geology.—The Last Chance is the next vein of importance to the westward and higher up the mountain from the Union-Companion vein. The outcrop at the principal workings is at about 7,000 feet, or 1,000 feet above the principal outcrop of the Union-Companion vein. Horizontally the Last Chance vein is about 3,100 feet from the Union-Companion vein.

The wallrock in part, is granodiorite, similar to that found at the Union-Companion mine. In other places it is a dense dark green rock that was probably once an argillaceous sediment laid down between the old surface flows.

The striking point of difference between this vein and the others of the district is its location on both sides of an aplite dike that is older than the vein. This aplite dike, locally known as the "Forest dike," is probably the same as found alongside the vein in the Mayflower mine on the other side of the mountain.

Sufficient manganese oxide is present in the surface waters to precipitate on the joints and seams of the dike, black tree-like forms so characteristic of this element. These tree-like forms, which the mineralogist calls dendritic manganese, has caused the prospector to give this dike the apt name of "Forest dike." This dike has a greater amount of dark minerals than ordinarily found in aplite. Basalt dikes also break across both the vein and the aplite dike.

The Vein.—The strike of the vein is N.20°E. and the dip 45° W.

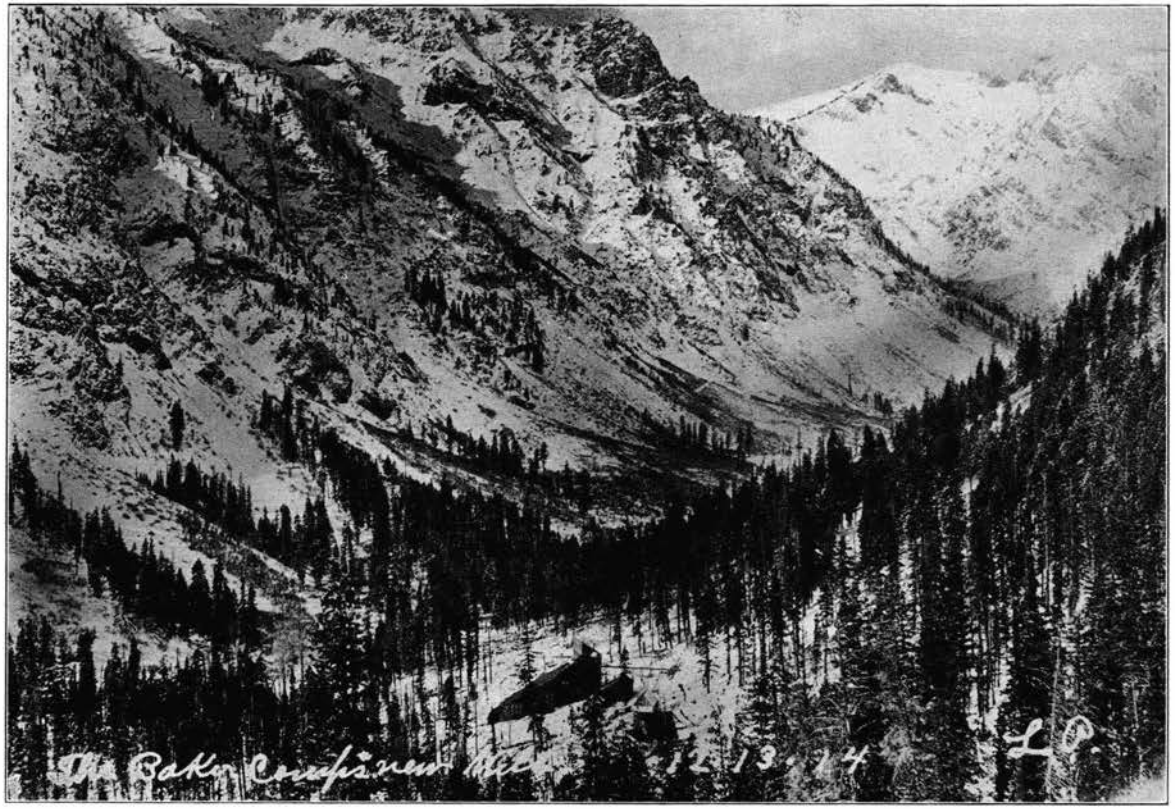


Fig. 17. Last Chance mill. Connected by aerial tramway with the mine, the position of which is indistinctly seen near the upper left corner of the photograph.

Massive white quartz, through which pyrite with a little chalcopyrite and zincblende are irregularly scattered, makes up the vein. Whether the walls of the vein are of schist, granodiorite or aplite, they are bleached and sericitized, such as is ordinarily found next to any vein made by ascending hot waters.

The stoping width of the Last Chance vein probably averages at least five feet of higher average grade of ore than found so far in the other properties. Because of a small cave-in in the lower working tunnel, the underground investigation of the Last Chance was not completed.

It seems probable that the re-fissuring in the general plane in which the aplite dike had been placed, broke the aplite dike in the same way that the Union vein was broken to receive the basalt dike. On the Union-Companion ground the vein was broken to receive a dike. On the Last Chance ground the dike was broken to receive a vein.

Further similarity probably exists in that the re-fissuring alternated from wall to wall of the dike like the re-fissuring of the Union-Companion quartz vein. Doubtless at some points it may have loosened the dike along both walls and shattered it in many places. Similarity as to fracturing is pronounced. Here the analogy ceases.

The molten basalt intrusion into the Union-Companion vein cooled rather quickly, but even if it should not have done so, it nevertheless would have had but little effect on the simple quartz of the vein, always slow to alter. Alteration of the walls of the basalt dike are practically negligible. But in the Last Chance vein they are altered whether it be schist, greenstone, granodiorite, or aplite dike. All the rocks except the crosscutting basalt dike are considerably altered next to the vein. The aplite dike especially so because it was a thin sheet between two walls subjected to compression and movement. This together with its being very fine-grained caused more shattering, therefore more area within it to be subjected to the action of hot ascending waters.

The aplite dike and the Last Chance vein are seen on the surface to be probably several claims in length. The stope lengths are about 300 feet in a development of the vein of not much more than 600 feet with much of the latter distance unfruitful because of a failure to determine the form of a thick irregular basalt dike that cuts the vein. Doubtless when the interrupted vein is found on the other side a good shoot of ore will be discovered. The considerable horizontal length, the

good width of the vein, the length of the stopes, the persistence of fair values with frequent bodies of high values, the nature of mineralization of the vein, and the pronounced alteration of the walls all indicate the likelihood of a continuation of shoots of ore to considerable depths.

Mine Development.—We do not possess maps of the mine showing its present development. The following description shows less than the present amount of work done, although it gives a fairly good idea of the development accomplished. This is a description of the work completed up to 1903.

"The Last Chance vein is developed by an adit tunnel, driven south on the vein for a length of 690 feet. This tunnel undercuts the vein at a maximum depth below the surface, on its dip of 500 feet. At a point in the tunnel 105 feet from its mouth, a shaft is sunk on the vein to a depth of 265 feet. From this shaft, two levels are run on the vein, at a depth of 100 feet, level drives are run north and south on the vein 270 feet and 180 feet respectively, and at a depth of 200 feet level drives are run on the vein 375 feet and 270 feet respectively. From the north level drives a cross-cut 296 feet is run to the surface, for the purpose of drainage and ventilation."*

Since that time this property, until 1914 a part of the Cornucopia Mines, was operated only in a small way by the company or by leasers. These operations were spasmodic and did not extend the development to any great degree. The last work, which was done by leasers milling their ores at the Union-Companion mill, was successful in finding ore of sufficient grade to stand the heavy expense of wagon transportation to the mill. Unfortunately for them their lease expired November 1, 1913, which came too soon after the finding of the rich ore to get more than a small part of it to the mill to reap the profit for themselves.

The finding of larger and better grades of ore than were already known to exist encouraged certain western and New York persons, largely of the same group already in the Cornucopia Mines Company, to form a strong leasing company to take over the Last Chance vein. This new company, with John M. Baker as general manager, is called the Baker Mines Company. It perfected its organization last winter and arranged for the financing of the development work in the mine, the erection of a surface plant at the mine, an aerial tramway, a water power plant, and a 20-stamp mill with a sand and slime cyanide plant. This work was started early in the spring and late in October they commenced to mill their ore.

*Bernard MacDonald's report upon the property, April 10, 1903.

They have also acquired claims adjoining them in the Bonanza basin upon which it is said the development is decidedly encouraging.

Aerial Tramway.—The ore is conveyed to the mill by means of a Bleichert aerial tramway 5,500 feet long. The difference in elevation between the loading and discharge terminals is 1,675 feet. There are only two intermediate supports for the cable. The upper span has two locked-coil track cables 616 feet long, one is 1⅛ inches in diameter and the other ⅞ inch. The middle span has two similar cables each 1,410 feet long; while the third span has two cables 3,210 feet long of 1⅜ inches and 1⅛ inches in diameter respectively. This span has a clearance of over 500 feet above the bottom of the gulch. The traction rope used is made of special cast steel. This tramway when operated at a speed of 500 feet per minute has a capacity of 15 tons of ore per hour.

"*Mill Practice and Flowsheet.*—The ore is dumped from tram buckets onto grizzlies, the undersize falling into a bin and the oversize passing to a No. 3 Austin gyratory crusher. Twenty stamps are employed in crushing to 'so-called' 25-mesh. About 25 per cent of the values are recovered on the plates, which are eight feet in length and have a slope of 2 inches to the foot. After passing through a mercury trap the pulp is treated by a Dorr classifier. The sands are leached in 30-foot vats, the slimes passing to a 30-foot Dorr thickener, and from thence to two 20x16 Dorr agitators. The slime is again thickened in a 20-foot Dorr thickener, diluted and again thickened in a 30-foot Dorr thickener. The reason for the use of two thickeners is because of the necessity of obtaining a large amount of dilution owing to the high value of the slimes. From the last thickener the pulp goes to a 20x16 Dorr agitator used as a stock tank for a Portland filter. The precipitation is with zinc-dust and Merril zinc presses."*

VEINS WEST OF THE UNION-COMPANION AND LAST CHANCE

On the north side of the curving apex of "Granite" mountain, with its glaciated amphitheater of Bonanza basin, is found a series of parallel veins of which the most easterly is the important Last Chance vein just discussed. Some of the veins west of the Last Chance are in Bonanza basin, also in the granite cliffs at the Queen of the West and up beyond to the very "top of the world" where the Red Cross vein is seen.

On the southern slopes of this mountain there is another series of veins. Some of these undoubtedly are continuations of those to the north, others have not been traced through. Even though the

*Will C. Higgins, in Salt Lake Mining Review.

outcrop of the veins were in every case plain to be seen the tracing of each one would be slow and difficult, because of the ruggedness of the mountains.

Fig. 18. Queen of the West mine. Buildings against sky-line at left side of view.

Queen of the West Mine.—Located to the westward on the opposite side of Bonanza basin from the Last Chance in the almost inaccessible cliffs of the mountain is the Queen of the West vein. Picturesque indeed is the position of its mine buildings; its boarding house is on a narrow cliff where material thrown from its windows falls downward for hundreds of feet. A steady nerve and a sure foot are needed on the trail from the mill to the mine and to explore the cliffs above. With snow on the ground it is impossible, and unless they brave the snowslides of the Bonanza basin trail, miners must remain at the mine for some four or five months in winter.

Nearly all of the country rock is granodiorite, similar to that at the Union-Companion mine. There are a few fragments of schist in the vicinity of the vein which are remnants of the old roof.

The vein has the usual strike of N. 20° E. and a dip near the surface of about 45°, but at depth this decreases to about 30°. The average width of the vein near the surface is between three and four

feet, but generally speaking it decreases in width with the decrease in dip.

The gangue minerals are quartz and calcite containing pyrite, chalcopyrite, galena, and sphalerite in bunches. It is said that the zinc, lead, and copper minerals carry most of the gold values. In many places the vein shows included fragments of altered granodiorite, and the granodiorite on each side of the vein for about two feet is badly altered and impregnated with pyrite which is said to contain some values in gold and silver. This vein can be traced for a long distance, reported to be as much as 3,000 feet.

The development has been considerable, but much money has been unwisely spent both underground and in the erection of a mill unsuited to the ore.

Future development plans are to crosscut from the lower tunnel a few hundred feet farther from the Queen of the West vein, to cut the Red Cross vein whose principal outcrop is some 1,500 feet above the lower tunnel. The Red Cross vein is similar to the other veins, but little is known with reference to ore shoots therein.

The mine workings are connected with the mill by an aerial tramway erected under the most difficult conditions. There is also a telephone line, and an air line to the mine from the compressor located at the mill.

The Mayflower Mine.—This mine is probably located on an extension of the Last Chance vein but on the other side of the mountain. The vein has the same strike and about the same dip. Its mineralization is similar to the other veins in the region, though the amount of sulphide is somewhat less.

The vein here is smaller than at the Last Chance, being at the widest place not over three or four feet and in many places pinching out entirely. There is evidence in the walls that they have been subjected to a great deal of pressure, but there are no signs here of any great movement. This mine is developed with two adit levels and one intermediate. A raise in the vein 530 feet to the surface connects the several workings.

The property operated its stamp mill and cyanide plant with steam power. They exhausted their developed ores during the summer months of 1914 and closed down.

The Jim Fisk Vein.—The Jim Fisk vein is located but a few hundred feet west of the Mayflower. Where observed there was a very large mass of quartz 20 to 30 feet wide. To both the north and the

Fig. 19. View of Granite or Cornucopia mountain from high table land to the south. The Jim Fisk, White Elephant, Wild Irishman and Jackley groups are on the slopes of the mountain to the right. The George W. Smith claims are on the steep slope at the extreme left.

south this soon narrows down to ordinary widths. The length of the vein was not determined. No shoot of ore has been encountered. The country rock is granodiorite.

The White Elephant Vein.—The White Elephant, west of the Jim Fiske, is a well-defined quartz vein four to five feet wide in granodiorite, having a strike N. 20° E. and dip 45° W. It is said that this vein contains fair values in gold.

The Wild Irishman Vein.—The Wild Irishman vein, now called the Valley View, is located about one-half mile west of the White Elephant. It cuts across the southern end of Granite mountain at an elevation of about 9,000 feet. The vein has a maximum width of six to eight feet and can be seen from the apex of the mountain to continue clear across Bonanza basin and up the other side. It is probably a continuation of the Red Cross vein. Some of the quartz in the vein shows well-formed crystals. The strike is N. 20° E. and the dip 50° to 60° W.

The Jackley Claims.—The "Jackley" vein is about one-fourth mile west of the Wild Irishman vein, at a little lower elevation. It is a vein of fair width and considerable work is being done upon it by the owner. Fair values are encountered in the drift at times although the main objective has not yet been reached. The surface beyond shows some displacement of the vein by basalt dikes which may prove troublesome. Fragments of greenstone in dimensions from a few inches to a few feet are found here in the granodiorite. The granodiorite is more basic, probably due to its melting and assimilation of greenstone. Some of the unmelted fragments actually show recrystallization decreasing toward their interiors. This place is probably near the roof of the intrusion, only a downward projection of the greenstone roof remaining, the rest having been eroded away.

George W. Smith's Claims.—These claims are situated about one mile north of the Jackley claims near the northern end of Granite mountain and at the head of Little Eagle creek. The elevation of the shallow workings is from 9,000 to 9,500 feet. The latter elevation is that of the mountain ridge.

The country rock is granodiorite with the exception of the basalt dikes. In contrast to the opposite side of the mountain this side has a long and rather even slope and is deeply weathered. Float is rarely seen and vein croppings are buried under the sand and rock fragments. Veins are traced here only by the slight discoloration of the surface due to iron stains.

Fig. 20. Where the George W. Smith vein cuts the apex of the main Granite mountain ridge. Elevation about 9,500 feet.

On the lower slopes development by open cuts and short tunnels has not exposed large veins in place, but on the apex of the ridge a pit has exposed a somewhat brecciated quartz vein with altered walls striking N. 80° E. and dipping 60° N.

It will be noted that this vein has a different course than the other veins on the mountain. It has fairly parallel walls and in the pit shows a width of nine and one-half feet with reported fair values in gold. This shallow pit is sunk along the side of a thick basalt dike that cuts the vein. Many dikes are seen on this part of the mountain and doubtless will frequently interrupt development.

By a glance at the picture it will be noted that this side of the mountain has no prominent ridges upon which mine buildings could be erected and protected from snowslides. Prospecting cannot be prosecuted here for more than three and one-half months of the year. Snows on the flat come early and stay late and attain a maximum depth of at least 15 feet. Development if done in this short season can practically all be done on the vein but when the time comes to prepare for production and the erection of upper terminals of an aerial tramway, a working tunnel will have to be driven from some protected point to the vein to avoid the possible destruction of the mine structures by avalanches.

SIMMONS PROSPECT

Simmons mountain, the eastern end of which is seen in the distance, is a long ridge between the east and west forks of Pine creek. It is on the northern or right hand side of the West fork, while "Granite" or "Cornucopia" mountain as it is locally known, is on the south or left hand side. This mountain, although of lesser elevation than the "granites" to the south, has extremely precipitous slopes, particularly the southwest portion of which lies to the left and just out of the picture. Readings taken with a clinometer near the principal outcrop of the Simmons' vein to the stream 2,000 feet below gave a slope in excess of 40°.

Fig. 21. Main street of Cornucopia and eastern end of Simmons mountain.

This mountain is made up chiefly of a series of flows in which dense volcanics are interbedded with amygdaloids. Because of their alteration and their present color these rocks can well be called greenstones, although meta-basalt might be considered a more scientific name. The apparent strike of this series of flows is north and south and the dip is 40° to the east, judging by the parallel elongation of the amygdules or calcite-filled cavities seen in the lower tunnel.

The principal vein of the Simmons group has a strike 25° to 30° northwest. It has a flat dip to the east rarely exceeding 30° and more often much less. The principal vein has been traced on the west and

north sides of the mountain for more than 2,000 feet. It is, however, where exposed, for the most part too small to make ore unless of high grade. A great deal of work has been done on the croppings so that its width at almost all points can be easily seen and measured. The exposed part of the vein of workable size, unless some of the narrow portions should have very rich ore of which we have no information, is about 350 feet long, the maximum width a little more than four feet, the minimum eighteen inches; the average width would not exceed three feet for this distance, perhaps a little less. The vein consists chiefly of quartz with small amounts of feldspar. Probably less than one per cent of the sulphide minerals, chalcopyrite and galena, are present in thin streaks near the center of the vein.

The development consists of the surface work before mentioned, short inclines sunk on the vein and two short crosscuts to the vein, besides the principal crosscut. Outside of the principal crosscut and the surface work, the development gives little information as to the nature of the main shoot below the surface. The inclines for some strange reason were sunk at the ends of shoots rather than in them where the best of the lens was exposed. The main crosscut also started towards and did cut the vein at a point outside of the principal shoot. In drifting to reach the shoot, although evidently mistaking a branch shattering of the foot wall for the vein, it was luckily encountered near the edge of the shoot. Drifting, at the time the property was visited in July, had progressed less than 100 feet upon the quartz lens. This development is nearly all the underground development of value. The width of the lens over this distance underground seems to be about the same as that directly above it on the surface.

This group is one of the oldest in the district and has been examined by several engineers with a view to purchase. Although not in possession of any of their reports or assay results, I am confident that the principal shoot contains considerable ore of milling grade.

Both high price and large initial payments are practically impossible to secure when selling well-developed properties. In selling prospects it is much harder to secure a high price, a large initial cash payment and heavy additional payments following so rapidly that little additional ore can be proven before further payments must be made.

There are several other quartz lenses both on the Simmons' property and on the southern end of the hill.

STEEN AND LINDGREEN CLAIMS

Norway basin seen in the middle background of the picture is some three miles from Cornucopia on the headwaters of the West

Fig. 22. West fork of Pine creek. Trail to Norway basin.

fork of Pine creek. The right foreground shows the West fork across which are the lower slopes of Simmons mountain. Directly above and out of the view is the Simmons' vein. In the upper corner of the picture and to the left of Norway basin is seen Red mountain, and away beyond is the pass to the Imnaha.

In winter during the period of heavy snows, this wagon road and trail is dangerous because of snow slides. Another trail goes up on the more gentle slopes to the north of Simmons mountain and drops down some 300 to 400 feet into Norway basin.

The country rock is greenstone varying from dense to amygdaloidal and from fine-grained to porphyritic. It is made up of a series of flows similar in every way to those of Simmons mountain.

The situation of the outcrop of the vein is on the floor of the basin, but it is somewhat concealed because of loose rock and freshly made soil. The vein has a north and south strike and dips 65° to the east. It is developed by an adit upon the vein 750 feet long which reaches a maximum depth of 200 feet. The vein is of the shear zone type and varies in width from a streak of gouge up to 16 feet. Three

ore shoots have been found; the first runs 100 feet in from the portal; the second begins 80 feet beyond the first and continues to the face; while they expect to be well into the third before the season closes. This third shoot is the main objective of the owners, because of the good values found at the surface.

RED MOUNTAIN PROPERTY

The eastern end of Red mountain can be seen on the way to Norway basin and to the Queen of the West mill. The rest of it is well observed from the apex of the ridge on the George W. Smith claims where, looking north from the snowbank one can see Twin lakes far below the contact of the lighter colored granodiorite with the darker

Fig. 23. View of Red mountain from George W. Smith's claims on Granite mountain.

schist of Red mountain above. Nearly all of this eminence (9,500 feet) is bare of vegetation. The rock, of reddish brown color, is almost as solid at the surface as below. Loosened by the action of ice and snow loose rock is not permitted long to remain upon its forbidding walls.

Although not examined much except at the contact with the "granite," Red mountain appears to have been once a sediment, but due to the regional disturbances occurring before that which permitted the granitic intrusion, it is now a schist. The granodiorite is clearly seen to have intruded into the schists, because along its border are found

innumerable inclusions of angular fragments of schist within it. Both porphyry and aplite dikes cut the granite and the schist.

The Red mountain vein is situated close to the contact with granodiorite and roughly parallel to it. Its location can be seen near the right hand border of the picture. The outcrop of the principal shoot has an elevation of about 7,200 feet, but the vein can be seen for a considerable distance to much higher elevations. It is not a contact vein, although locally so considered. The contact of the "granite" with the schist does not appear to be mineralized, although there are effects which appear in the character of the granodiorite. The roughly parallel attitude of the large biotite mica crystals gives an appearance of gneissic texture. Many of the large quartz grains are cracked and wavy, evidencing contact stresses.

The vein has a strike of north 80° east, a dip of 50° north and a maximum width of five feet, but pinches to small dimensions within a few hundred feet. It is seen to cut granite, schist and the granite-porphyry and aplite dikes as well, showing that the vein is later than all of these. It is of the simple quartz type, showing banding in places together with white sericite mica. Iron pyrite, also the green stains of copper are seen in the vein material found near the collar of the shaft. This incline sunk on the vein for about 100 feet is now partially caved. A crosscut (several hundred feet long) at an elevation of 6,600 feet, is being driven to cut the vein, but has not yet reached it. It is still in the granodiorite, although it would appear from the nature of the rock near the face of this crosscut that the tunnel is approaching the contact and perhaps the vein.

EAST OF CORNUCOPIA

Opposite Pine creek from the town of Cornucopia the rock is largely greenstone. Prospecting on this side of town is only half-heartedly continued. No veins of large promise were observed.

SOUTHWEST OF TOWN

The pine-covered hills to the south, between the "Granites" and Pine creek, and below Cornucopia, are made up of a series of flows which were probably trachytes. They are now badly altered, in some places showing extreme silicification and in others impregnations of pyrite. The remains of the flow structure and an occasional rock crystal makes clear their original character. Little development of value was observed in these hills.

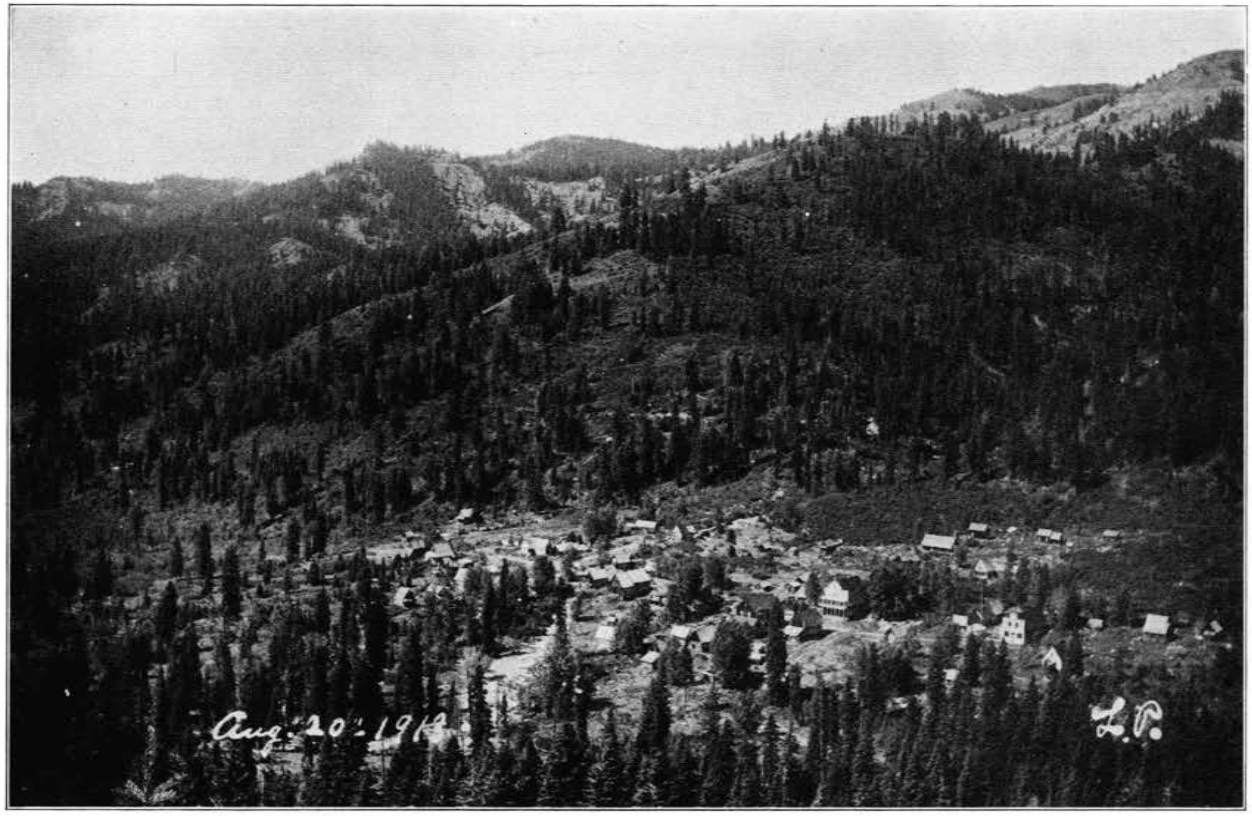


Fig. 24. The pine-covered hills southwest of Cornucopia.

The veins which have been exposed in the past by shallow workings have since been caved, but veins up to four feet in width are said to exist here. Pieces found on the old dumps consist chiefly of massive quartz, with a few well-formed quartz crystals. These quartz veins in the greenstone, a considerable distance away from the "granite," contain chiefly copper sulphide minerals, chalcocite and chalcopyrite, while the veins in or close to the granodiorite contain chiefly iron sulphide minerals.

It is possible that the hot silica solutions, ascending for long periods of time through greenstones of considerable depth, may have had a leaching effect upon this rock, which usually contains copper, and carrying it upward has precipitated it to form quartz-copper veins. The quantity of copper contained, however, is insufficient to make ore in a vein of fair width unless considerable gold is also present.

The prospectors here, because values in the Cornucopia mine are roughly proportional to the amount of sulphides present, rely too much on the presence of sulphides and too little upon assays. To retain possession of a prospect and do the annual assessment work year after year and maintain hope upon the slender thread of one or two assays from samples poorly taken is not good business.

THE CORNUCOPIA PLACERS

Placer deposits in the Cornucopia region are of rather limited extent, although further investigations may reveal new workable ground. The only placers now being worked are situated about two miles below the town of Cornucopia, on Pine creek, near the mouth of Boulder creek. They are known as the "Underwood" placers, and are now operated under the name of the Boulder Creek Mining Company, Charles Campbell, superintendent. It is a bench bowlder gravel deposit with the bed-rock several feet above the present stream, and the "pay" in an old channel of Pine creek. The gold, which is usually quite coarse, is nearly all found close to bed-rock, or within a few feet of it. The bed-rock is covered by a deep overburden, composed largely of heavy bowlders, some up to 6 or 7 tons. Previous to the sale to the present owners this property was worked by drifting, and the returns are said to have been about $25 a day per man after the "pay" channel was struck.

The new owners have equipped the property with flumes, pipe, giants and derricks operated by water power, and have proceeded to hydraulic the ground. It would seem to a casual observer that the place where they began to hydraulic the ground was ill-advised.

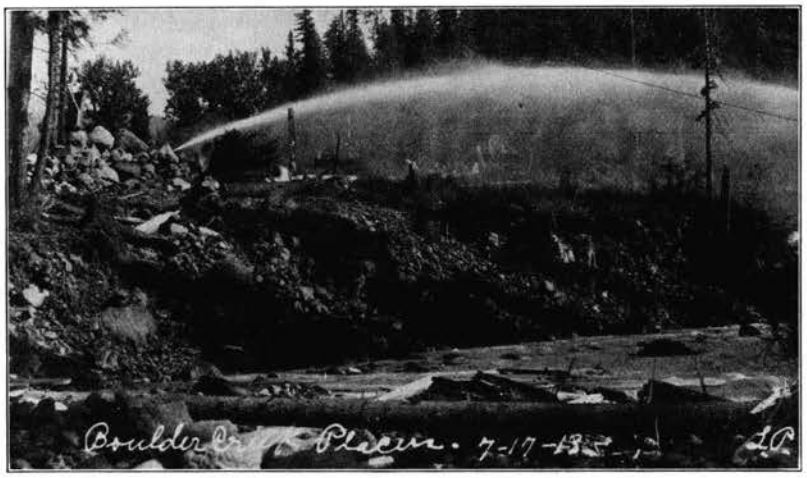


Fig. 25. The Underwood or Boulder Creek placers.

Apparently it should have been begun farther down the stream so that bowlders and wash could have been placed on worked ground rather than to have begun apparently in the middle of the deposit. It would seem that there would be a greater profit to continue with the working of the mine by means of drifting, because of the coarse deep overburden of low value.

It is not to be expected that extensive placer deposits will be found in a glaciated region above the lowest terminal moraines. Glaciers are moving streams of solid ice, which in their slow but forceful progress cut deep into the solid rock, taking both rock and ice to the valleys below. Here the warm air melts the ice as rapidly as it arrives and piles up the ever-increasing amount of bowlders stripped from the mountains above. With a change to warmer climate the ice melts faster than it advances, so its lower limit recedes up the glaciated valleys to at last disappear, as it has done in the "Eagle Creek" range. At certain points it halts, like a modern army in retreat, to build new ramparts of moraines.

Extensive placers are the result of rock decay and erosion. In nature's method of concentration in stream beds, cubic miles are often concentrated into cubic yards. No such work has been accomplished above the terminal moraines in this region. Extensive stream deposits will not then be found above the lower moraines. Above that point, if the hills had plenty of it, the moraines may contain deposits of gold, but these are apt to be only the coarser particles.

Fig. 26. Wallowa lake. Lateral moraines at each side; view taken from a high point on the terminal moraine. Peak in the center separates the canyons of the east fork and the west fork of the Wallowa river.

Fig. 27. The city of Joseph, Oregon. Position of Wallowa lake at extreme left. Canyon of Hurricane creek at right.

It would be then of practical use to the placer miner to know how far glaciers have gone down Pine creek. An undoubted terminal moraine is found on the East fork in the narrows, but a short distance above its junction with the West fork, a mile above town. Lindgren speaks of a terminal moraine but a short distance above Carson. Time did not permit the working out of this problem.

THE WALLOWA DISTRICT

The mineral deposits of chief interest in the Wallowa district, although but a few miles from Cornucopia, are best approached from the north because high passes lie between. The branch line from La Grande runs down the Grand Ronde river a little east of north, most of the way through a productive agricultural valley. When it reaches the junction of the Wallowa river with the Grand Ronde it turns southeast and up the former through narrow defiles to enter soon, delightful Wallowa valley. The road and the river are at the foot of steep mountains on the right, while to the left stretching out in the distance is the valley and the slowly ascending hills.

Near the head of the valley at Joseph our railway journey ends. Located on wash from the terminal moraine at the lower end of Wallowa lake, only a mile away, the town is almost within the shadow of lofty mountains having no intervening foothills.

On horseback from Joseph one travels up the East fork of Wallowa river, up the West fork and up Hurricane creek, each a separate journey, because no trails have been dug as yet along the barren ridges which separate these mountain streams. Above Joseph and the lake, out of the first pass to the left, flows the East fork of Wallowa river, and close to the right the West fork issues. Across the town one sees the way up Hurricane creek, while beyond the farthest mountains to the right the Lostine flows.

Wallowa lake is about 5 miles long, a mile wide, and in places is said to be 400 feet deep. It is the product of an immense flow of ice, which, coming down the forks of the Wallowa from the south, spread out as it emerged to be destroyed as it advanced, by the valley's warmer air. Its burden of stone brought down for tens of thousands of years built up the high ridges on the sides of the present lake and dammed it up at its foot. A warmer climate afterwards prevailing, the glacier melted away and Wallowa lake is there to take its place. Only incipient glaciers are found on the northern slopes

of the higher peaks far back in the mountains to indicate how great a change has occurred. This is the greatest of all these glacial lakes, but throughout all the region smaller ones are there to fill the places where the streams of ice with tools of stone carved out great basins in the solid rock.

The region which we are to enter is on the northern side of the same intrusion seen at Cornucopia. Here its roof of sediments is all but gone, and on its irregular sides schists and limestones expose their complex borders. Here and there on the broad expanse of the intrusion large isolated blocks of the ancient roof still remain. Water and ice has removed all but these and, laboring on, has scored deep valleys in the younger rock.

Where limestone is in roof or wall at the contact, copper and gold appear. In basic dikes copper and gold are also found, and where these products of the great intrusion cut the contacts, increased copper sulphides next to the dike are found.

Along these contacts and in the basic dikes called lamphrophyres, are the chief economic deposits. There has been but little development in the Wallowa region, and with the exception of test shipments it has no production.

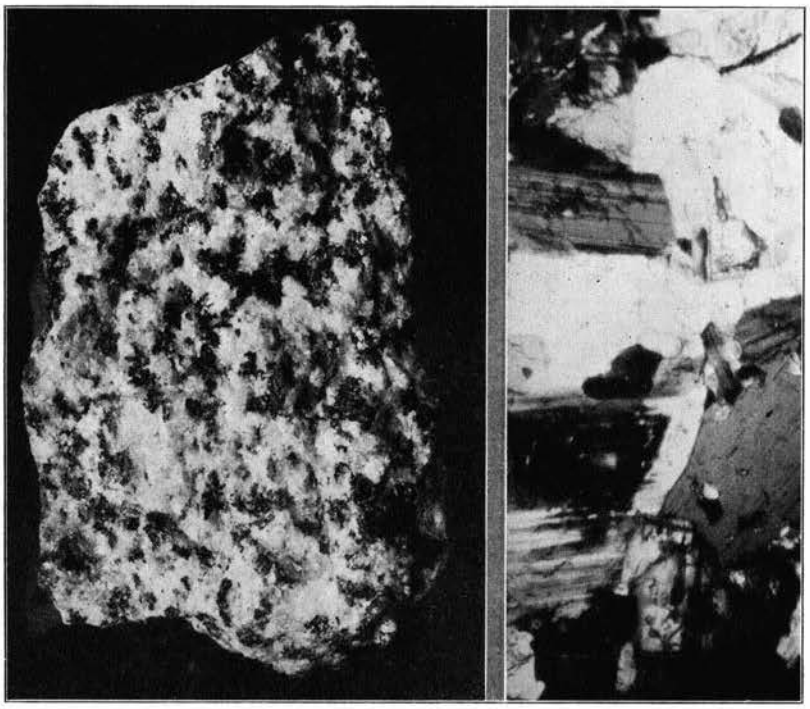
THE EAST FORK OF WALLOWA RIVER

Small short streams which flow into Aneroid lake, 13 miles south

Fig. 28. Aneroid lake, looking southwest.

of Joseph, are the sources of the East fork. The journey from Joseph along the east shore of Wallowa lake and for a mile through the park is level and easy, but as soon as one gets beyond the confluence of the West with the East fork, to go up the latter, the road ceases and a steep and rocky trail begins the 3,000-foot ascent to Aneroid lake, seven miles away. For the first two or three miles the canyon's walls are of greenstone and schist, but the rest of the way is between high ridges of granodiorite. At the end of our journey we reach limestone and schist. At the lower contact we pass by the old "Royal Purple mine," at the upper contact we arrive at the Walla Walla group of claims.

Near the end of the journey the U-shaped valley widens and mountain meadows appear. Aneroid lake, about a quarter of a mile in diameter is but half its original size. Eventually it too will be



Natural size **Magnified thin section**

Fig. 29. Granodiorite, tonalitic phase. Similar in hand specimen to the normal granodiorite. In thin section is seen to consist chiefly of plagioclase (andesine) feldspar, hornblende, biotite and quartz.

filled with wash and another mountain meadow will have been created. This alpine lake, with its wooded and grassy shores surrounded by ragged peaks on which snow fields ever lie, is a delightful mid-summer camp.

The destruction of the Aneroid cirque on its retreat to the southward was halted on the contact of the intrusion with limestone. This contact has a general northeast and southwest direction, and dips to the southeast at the high angle of 80°.

The limestone is white or bluish in color and so crystalline in texture that it might well be called a marble. The granodiorite, due to the absorption of lime along this border of the intrusion, could be given the more exact name of tonalite, but since it belongs to the

Fig. 30. Location of contact-metamorphic zone near Aneroid lake.

granodiorite clan it is best to call it by that well-known name.

Basaltic dikes are frequently seen in this vicinity, although much

less so than in the Cornucopia region. Pegmatite dikes are found as well as lamprophyres of unusual composition.

Development work has been done in two places on the contact between the limestone and the granodiorite. One is in the abrupt walls just above the lake, and the other is along the contact some few hundred feet to the northwest.

At the latter place a tunnel, about 100 feet long, is driven near the contact in the altered granodiorite, but attains less than 50 feet in depth. The mineralized zone is about 20 feet wide, although the granodiorite is altered to a greater width. Typical contact-metamorphic minerals, such as garnet and epidote are found, and the recrystallized limestone contains some quartz. Sometimes the garnet and epidote crystals are very small, but frequently are as much as three-fourths of an inch in diameter. The altered granodiorite is impregnated with chalcopyrite in spots, and small indistinct veins of molybdenite also occur.

A better place to observe this contact is on the abrupt walls above the lake, where it is exposed for several hundred feet with widths up to 50 feet.

The mineralization is similar to the one just described, but considerable chalcocite is present. This high-grade copper mineral is disseminated along the contact zone for some 200 feet and for con-

Fig. 31. Pass between the Wallowa and Imnaha rivers.

siderable widths. It is found both in the altered granodiorite and in the recrystallized limestone, although more of it is seen in the latter. The intergrowth of garnet, epidote, and quartz is usually fine-grained. Besides chalcocite, small amounts of molybdenite and chalcopyrite are present.

This contact with its metamorphic zone has been developed but phyre dike, along the sides of which chalcocite is much increased within the contact zone. The dike itself contains considerable disseminated pyrite. It looks as if the intrusion of this dike or the action following it had aided in the dissemination of chalcocite.

This contact with its metamorphic zone has been developed but little, and much of this could have been done to greater advantage. The crosscut started some distance below the contact in the loose rock and has not yet reached it. The outcrop is so situated that it would not be very hard to develop it with open cuts. In the present state of development it is impossible to make any predictions as to what future development might bring forth.

ANEROID TO CORNUCOPIA

Aneroid lake is on the main trail from Joseph to Cornucopia, a total distance of some 35 miles. If one were to make the journey on Independence day he would take the short ascent to the divide over ground partially covered with snow. This pass, elevation 8,500

Fig. 32. Near the "Tenderfoot mine."

feet, is the watershed between the east forks of the Wallowa and the Imnaha rivers. Dropping down 1,000 feet in the next mile or so, he passes to the left of the old abandoned "Tenderfoot mine," the wildest of "wild cats." The trail this far and on down the East fork to its mouth passes over argillaceous and calcareous sediments contorted and altered.

The trail then turns up the main Wallowa river to the westward until the mouth of the Blue river, flowing into the Imnaha from the south, is reached. Ancient volcanic flows make up the main body of the high mountain ridges on either side; breccia, amygdaloids, and the coarsest of coarse feldspar crystals in porphyry abound.

Crossing the Imnaha, just above the mouth of the Blue river, one begins a rapid ascent up the latter stream, much of it over deep banks of snow. When nearly to the top he may turn to look to the north and west toward the sources of the Imnaha, where miles

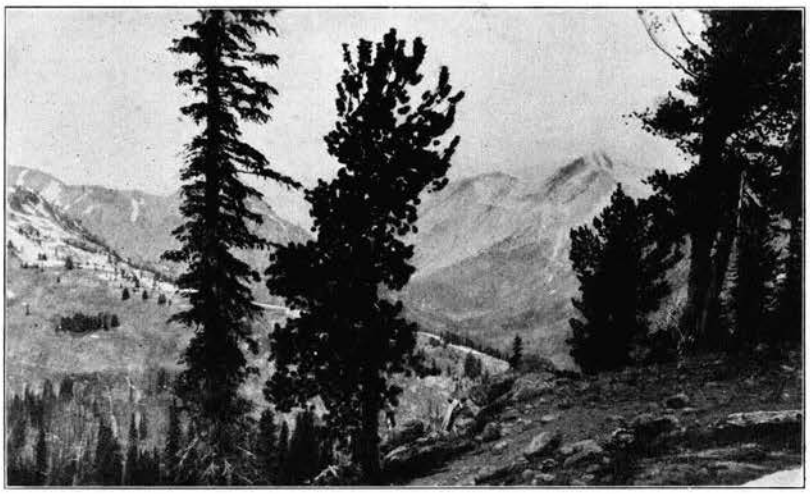


Fig. 33. Looking up the Imnaha from the Blue river trail.

away, beyond the darker color of the greenstones, are seen the blue and the white of the limestones and the granodiorites. From this snow-covered divide the westward view discloses the sharp ridges of the Granite range.

We enter now the Pine Creek region. We look down from the trail on our right into Norway basin, we pass over Simmon's mountain, drop down into the East fork of Pine creek and soon enter

Fig. 34. A view of the Granites looking west from the Pine creek pass to the Imnaha.

Cornucopia. The whole is a pleasant journey for the traveler and geologist alike, but disappointing in that prospects are not more in evidence.

THE WEST FORK OF WALLOWA RIVER

Returning from Aneroid lake down the trail again to the park at the south end of Wallowa lake we turn again toward the south to climb the West fork trail. This stream parallels the East fork three miles away, a steep and high mountain ridge separating the two. As might be expected from its location the geology is much the same. Greenstones for the first mile or two, on our right "granite" without interruption, but to our left large blocks of massive marble and other eastward tilting sediments occur. At the very head of this fork, nearly 4 miles to the southwest of Aneroid lake and 17 miles from Joseph, we arrive at the same irregular border of sediments seen at the head of the East fork. The elevation of this watershed, to the south of which rises the Imnaha, is more than 8,000 feet. The contorting of these sediments is seen looking to the eastward across the basin from the ridge.

Northeastward limestone is found interbedded with fine-grained schists, originally fine-grained sediments.

The north-south outcrop of the eastward dipping white limestone

Fig. 35. Folded sediments at the head of the Imnaha river.

contrasts strongly with the darker schists. Looking southward across the Imnaha over sediments in the foreground, we see old volcanic flows in the middle ground and far in the distance, nearly

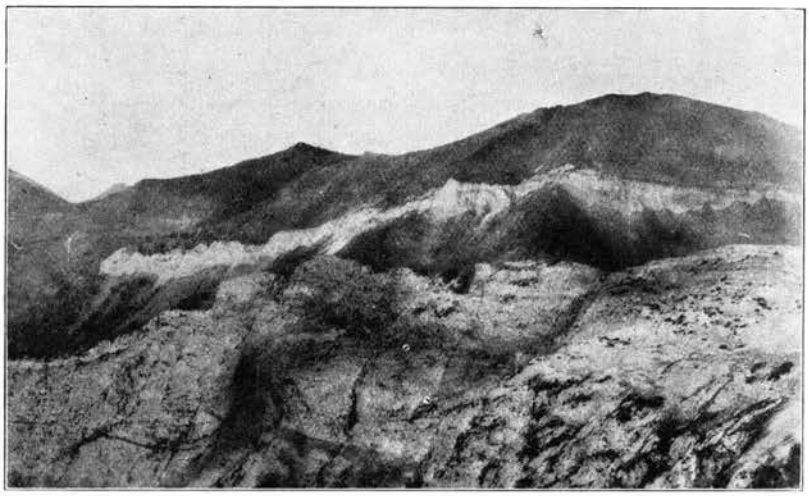


Fig. 36. White marble between darker sediments.

Fig. 37. Head of the Imnaha. Granite mountain in the distance.

10 miles away, Granite mountain, 5 miles northwest from Cornucopia.

Southwest the highly-tilted schists are seen in contrast with the lighter colored nearby granodiorite.

To the westward the principal rock exposure is granodiorite (p. 77). This illustration gives a good idea of the glacial smoothing that

Fig. 38. Dull-colored schist and light granodiorite.

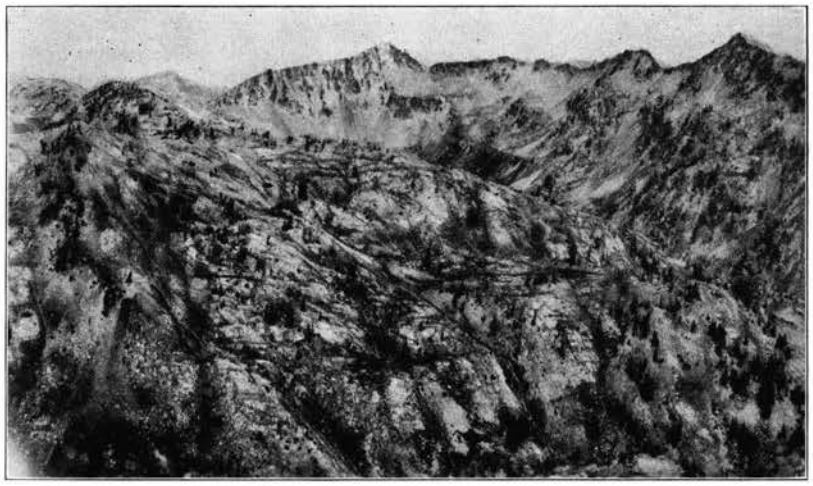


Fig. 39. Granodiorite. Glacial smoothing in the foreground.

has taken place on the rounded ridge nearby, with its small cirque lake, while in the distance the sharp non-glaciated peaks are seen with Eagle Cap in the rear.

A new variety of lamprophyre dike 40-50 feet wide, differing widely from the one found near Aneroid lake, cuts the serrate ridge a few hundred feet north of the Fraser property.

Fraser's Property.—At the Fraser property we have a block of limestone or marble several hundred feet long, occupying the top of the same ridge from which the preceding pictures were taken. This limestone outcrop is entirely surrounded by granodiorite and the contact between the two is an irregular ellipse, with its major axis that of the ridge's crest and its greatest vertical distance below the ridge at either side about 200 feet. The contact-metamorphic zone goes all the way round the limestone block, but the northern side of the ridge has the greater amount of mineralization.

The mineralized zone is from 20 to 50 feet wide. The principal gangue minerals are garnet, epidote, calcite and quartz. Much of the garnet and epidote is fine-grained, but when these typical contact-metamorphic minerals had the opportunity, as in vugs and small fissures, they formed into crystals of considerable size. Some of the garnets were found to have a curious zonal structure indicating a change of composition in the outer part of the crystals. Since their exterior is of different composition from their interior which was formed first, the depositing solution must have changed in composi-

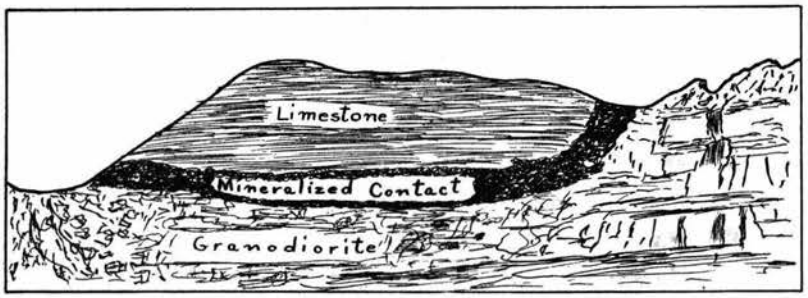


Fig. 40. Sketch showing mineralized contact at Frasers.

tion during the slow building up of these crystal forms.

The ore minerals are chalcopyrite, pyrite and molybdenite. Chalcopyrite is found in a zone from six to eight feet wide near the actual plane of the contact in what appears to be altered granodiorite. Chalcopyrite is also found in bunches filling in the spaces between the fairly well formed zonal type of garnet crystals.

Molybdenite, with some chalcopyrite, occurs in the altered granodiorite alongside the chalcopyrite, and appears to be the result of fissuring within the contact-metamorphic zone after the zone had been at least partially formed. It appears likely that the feldspar, biotite or black mica, and the hornblende of the granodiorite had been nearly all replaced by silica; molybdenite afterward completing the replacement of these minerals. This highly siliceous molybdenite vein is from one to two feet wide.

There are also irregular lens-like quartz veins. Small amounts of chalcopyrite and epidote are found, besides the tabular and for the most part badly-formed crystals of molybdenite.

W. Sutton and associates, of Butte, began last summer the development of this interesting contact deposit, where considerable surface work had previously been done by Mr. Fraser. A crosscut tunnel 300 to 400 feet long is being driven to get well below the surface, not only to determine the extent and value of the deposit below, but to avoid trouble with snow at the present surface workings.

Systematic channel sampling had not been done at the time of the visit to the property, so that no statement can be made as to actual percentages of copper or amounts of gold at various parts of the surface workings, but it is said that there is 20 to 25 cents in gold to each per cent of copper, and that samples contain copper up to moderately high percentages.

Andy Heaverne's Claim.—About one and one-half miles below the Fraser property, and to the east of the stream, is located Andy Heaverne's claims in a limestone-granodiorite contact. The limestone here has approximately an east-west strike, with a high angle of dip to the north. The contact appears to be somewhat irregular and of less width than at Frasers, but considerable epidote and chalcopyrite are visible in the small amount of surface work accomplished. The lesser amount of contact-metamorphism may be due to a steeper angle of dip than found at Frasers.

Manuel Lopez Claim.—Some three miles farther north Manuel Lopez has located on a north-south contact of similar nature. Here, too, the contact has a high angle of dip and shows a small amount of mineralization.

The Gem Group.—Turning up a side gulch to the west and within three miles of Wallowa lake we reach the Gem group of claims about one-half mile away from the main stream. The elevation is approximately 6,000 feet at the principal contact of the granodiorite with limestone and calcareous schists.

Pegmatite and aplite dikes are present. The aplite dikes for the most part are small ones in the granodiorite, while a pegmatite dike, consisting chiefly of quartz and feldspar, is about 10 feet wide.

The characteristic contact-metamorphic minerals, such as garnet, epidote, quartz, calcite, pyrite, chalcopyrite, molybdenite and magnetite are found. The molybdenite is associated with pyrite, with quartz, epidote and calcite as a gangue. The magnetite is associated with quartz, and pyrite with a small amount of epidote.

A short crosscut tunnel has been driven diagonally toward the contact in granodiorite, but has not reached it, but has cut through an irregular bunch of fine-grained pyrite, chalcopyrite, quartz, garnet and epidote. A crystalline limestone float containing considerable fluorite was found, which doubtless came from the limestone farther up the mountain. Fluorine is one of the so-called mineralizers, and its presence is indicative of activity subsequent to the intrusion of the granodiorite. Further field investigation might indicate that the mineralizers have penetrated considerably the overlying sediments. A storm prevented completing the field work here.

HURRICANE CREEK

Traveling westward from Joseph through an exceedingly fertile valley for a distance of three miles, we reach Hurricane creek, some

8 miles south of its junction with the Wallowa river near Enterprise. This north-flowing stream is about 4 miles west of the West fork, which it parallels; the broad, high mountain range of greenstone and marble, granite and schist, lies between them. Some 3 or 4 miles up from the entrance to the canyon, and some 6 or 7 miles from Joseph we reach the mouth of Fall creek, which flows into Hurricane in a series of cascades from the high mountains to the west.

Fig. 41. LaGore contact and cabin.

As in the previous trips, the first half of this distance we are hemmed in by typical greenstones, succeeded by schists and limestones.

La Gore Prospects.—A zig-zag branch trail, some two miles long, takes us up to the La Gore prospects, some 2,500 feet above. This elevated hanging valley has steep walls of badly contorted and faulted schists and marbleized limestones along the irregular granitic border of the intrusion.

The contact between the intrusion and the limestone is shown in the foreground adjoining the lighter colored exposure.

The deposit is 4 to 8 feet wide, has a general north-south strike and dips 60° toward the west. Considerable faulting is apparent, but the outcrops of rock in place are so nearly continuous that little difficulty should be experienced in locating these fault blocks. The principal contact-metamorphic minerals are garnet, epidote, quartz, calcite, chalcopyrite, pyrrhotite, and in the most northern claim, molybdenite.

Several cuts and two short tunnels constitute the development. This best appearing surface cut has chalcopyrite and pyrrhotite abundantly disseminated in what is probably an altered granodiorite. Here the vein is about 4 feet wide and is said to contain about $9 in gold, $2 in silver and $10 in copper.

Looking eastward across Hurricane creek from the La Gore cabin, one sees the outlines of the B. C. basin, where lead deposits in limestone, similar to those at Gyllenberg's claims, are said to occur.

Fig. 42. The elevated B. C. basin.

Gyllenberg's Claims.—Some 1,500 to 2,500 feet above and west of the Hurricane trail, and a mile or so beyond the mouth of Fall creek, is a considerable area of banded blue-gray crystalline limestone. Above this limestone is a large exposure of schist which apparently is conformable with the limestone. This high amphitheatric basin built of marble, and walled in by ancient volcanics from pit to gallery, is swept almost clean of loosened stone.

Both limestone and superimposed schists have been cut by numerous dikes. Some of these are light in color, showing in the groundmass but few crystals of quartz and feldspar. These quartz porphyry dikes since they have neither mica nor hornblende approach aplite in character. In contrast to these acidic dikes are the more interesting lamprophyres. This rock occurs in slightly lens-like dikes parallel to the schistosity of the limestone.

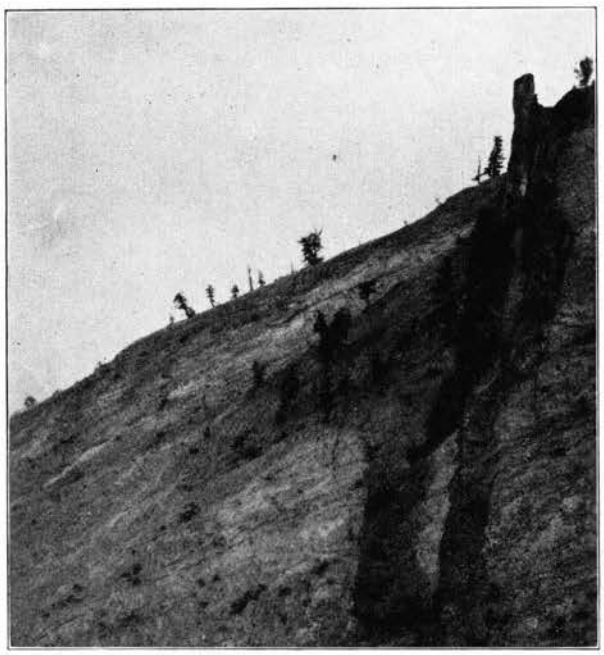


Fig. 43. A double basaltic dike in limestone near Gyllenberg claims.

In texture they are very fine-grained, almost dense. These dikes contain about 5 per cent of pyrite, and in thin sections are found to be a lamprophyre, variety kersantite.

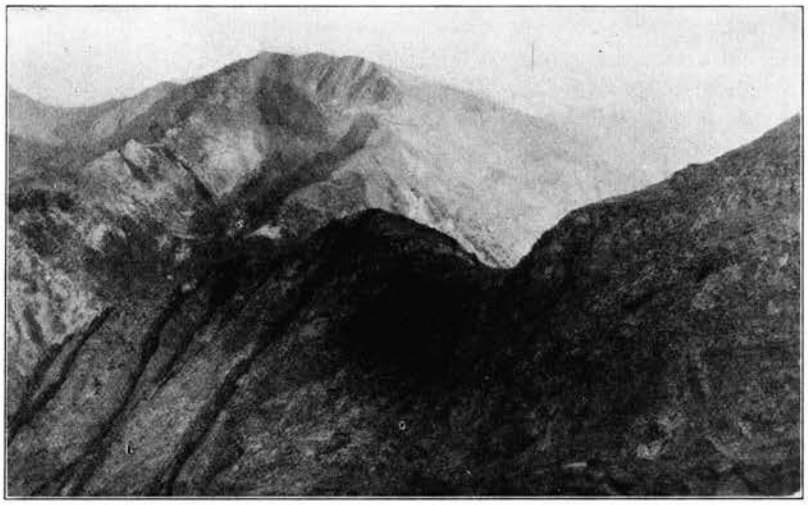


Fig. 44. Looking east from Gyllenbergs.

Basalt dikes in this region are the youngest dikes of all. A double dike of basalt is well shown. The ore, which is chiefly galena and sphalerite, with a little pyrite, occurs in small lenticular-shaped bodies, less than a foot wide and only a few feet long. The long axes of these lenses are parallel to the schistosity or banding

Fig. 45. Looking up Hurricane creek. Eagle cap in the distance.

noted above. On each side the limestone is recrystallized and nearly white in color. A little cerusite, lead carbonate, colored green by copper stains, was seen.

These small, tight lenses, although of high grade, in a limestone that has not been sheared or shattered to any extent, do not extend much hope of finding commercial ore bodies. A large area of this

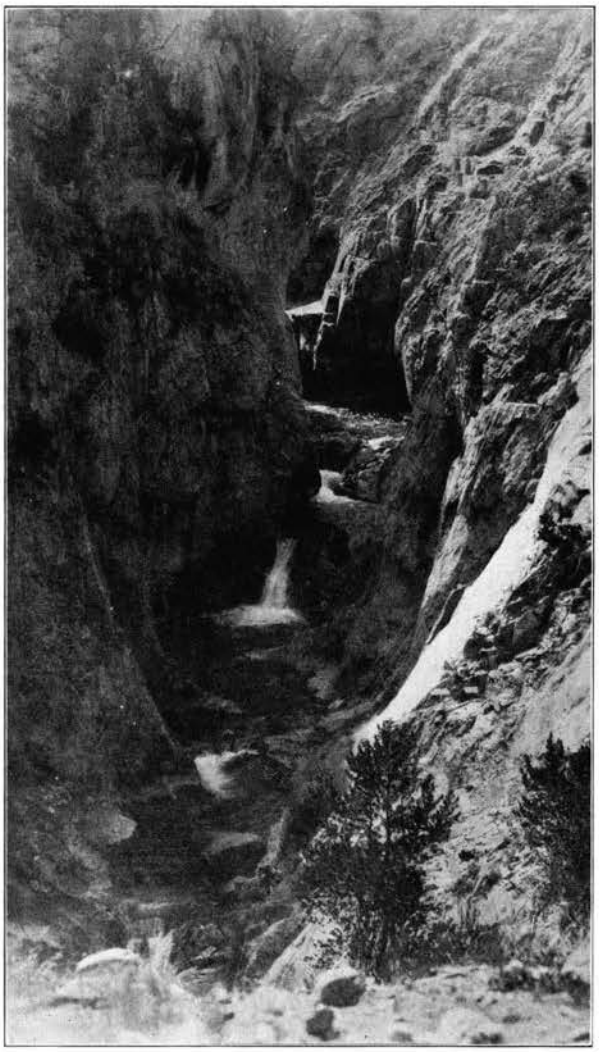


Fig. 46. Looking down into "Hell."

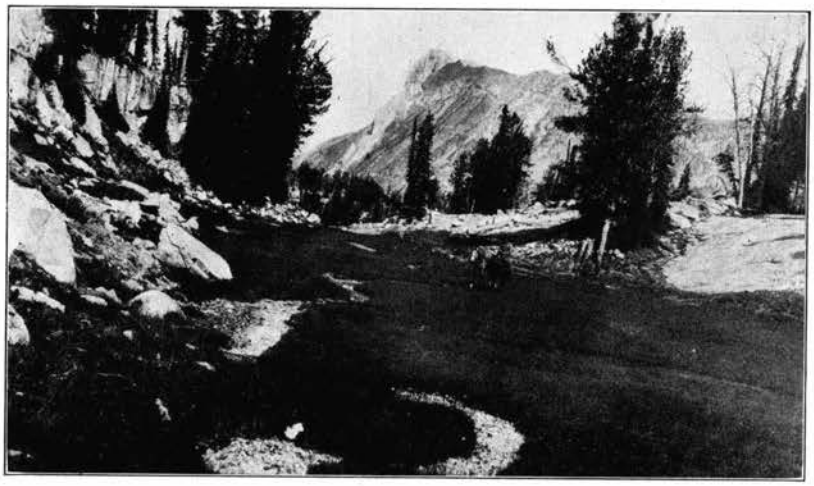


Fig. 47. The white edge of the Matterhorn.

limestone is exposed unobscured by any loose material, and this large area is roughly at right angles both to the banding of the limestone and to the small lenses of ore so far exposed. It would seem as if in this large cross section absolutely free to be observed over the entire surface, there should be exposed more than two or three small lenses of ore before one is warranted in spending money to search for it

Fig. 48. Glacial smoothing of the granodiorite.

Fig. 49. Eagle Cap. According to Forest Service maps, elevation is 9,860 feet.

beneath the surface. It seems likely that emanations from the granitic intrusion finding their way into the limestone created these deposits.

GYLLENBERGS TO MINAM LAKE

Looking eastward from Gyllenbergs in the foreground is seen

Fig. 50. Mirror lake. Slopes of Eagle Cap at the right.

Fig. 51. Looking down Lostine creek.

the limestone, dark because it is in the shadow, and to the left of the foreground it is seen to be cut by several basaltic dikes. In the background, high above Hurricane creek on the east side, is another hanging valley and glistening in the light of the descending sun is seen the massive marble of the Matterhorn (p. 83).

Part way back on the descending trail one gets a view up Hurri-

Fig. 52. Eagle Cap and the pass to Minam lake.

cane creek of Eagle Cap, 10 miles away. Continuing our journey from the point where we left it to climb to Gyllenbergs we start on the long trail up Hurricane creek. Within the first mile we look deep down where Hurricane creek has carved its deep channel in solid marble. (P. 84)

For several miles the trail passes through dense forest, mountain meadows and bowlder strewn paths. On both right and left large blocks of limestone and schist, surrounded by the granodiorite, are observed until we are well past the Matterhorn beyond which granodiorite prevails. We are entering upon the broadest exposure of the Wallowa range granitic intrusion. Some distance past the Matterhorn we mount more rapidly to enter a region in which the granodiorite is heavily scored by glacial action.

Looking backward we see in the distance the white edge of the Matterhorn and nearby the stunted vegetation and the glacial smoothing of the granodiorite. Continuing on we pass through parks paved with white granodiorite, and at various points we catch glimpses of distant Eagle Cap, which on closer view is seen to carry on its protected sides vast banks of eternal snow. We cross here the upper end of the East fork of Lostine creek and look eastward and down into Mirror lake with Lake basin in the distance. (Figs. 47, 48, 49, 50)

Part way up the last steep climb we look northward and down the East fork of the Lostine getting a distant view of the main stream.

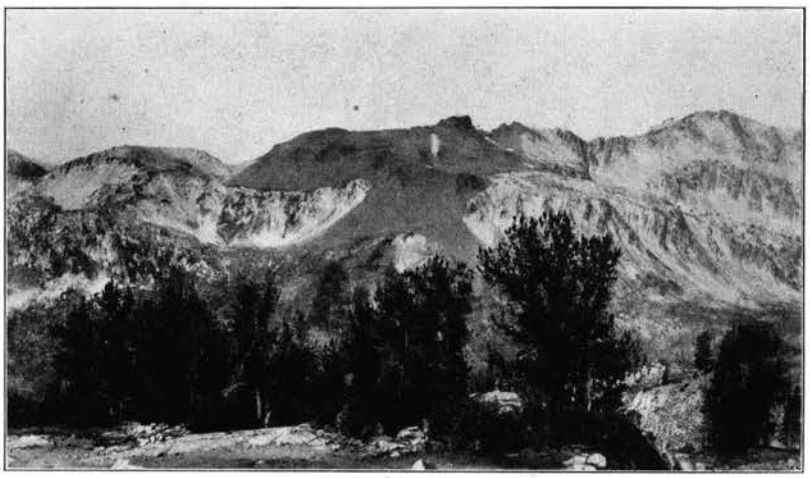


Fig. 53. Brown mountain from the pass to Minam lake.

Next we reach the pass to the Minam and get a closer west side view of Eagle Cap, the highest Oregon peak east of Mt. Hood. (Figs. 51, 52)

On the other side of the pass in the narrow valley below us is Minam lake, from the north end of which the West fork of the Lostine flows northward, while from its southern end the Minam river starting southward swings rapidly around the mountains there to flow northwest into the Wallowa at Minam, more than 50 miles away. From this pass, and across the lake a little north of west is seen Brown mountain, whose irregular basaltic top attests the filling of old drainage systems by recent volcanic flows. Erosion since has left but this mountain top to hint of what once has been. (Fig. 53)

To the south of west we note the granite ridge around which the Minam makes its sharp curve toward the north. In the middle distance, some 600 feet higher than Minam lake, is seen a cirque lake which is 23 miles from Joseph, and on the shore of which is Donelly's camp. Cutting across the high saddle beyond is the Donelly vein.

Donnelly Group.—A closer view of this saddle brings out strongly the amount of bowlders fallen from the cliffs since glacial days on which a zigzag trail is built to the prospect, 950 feet above the lake.

Here, in the central part of the exposure of the great intrusion, the granodiorite more nearly resembles that found at Cornucopia. We are too far away from limestone borders to have the "tonalitic phase."

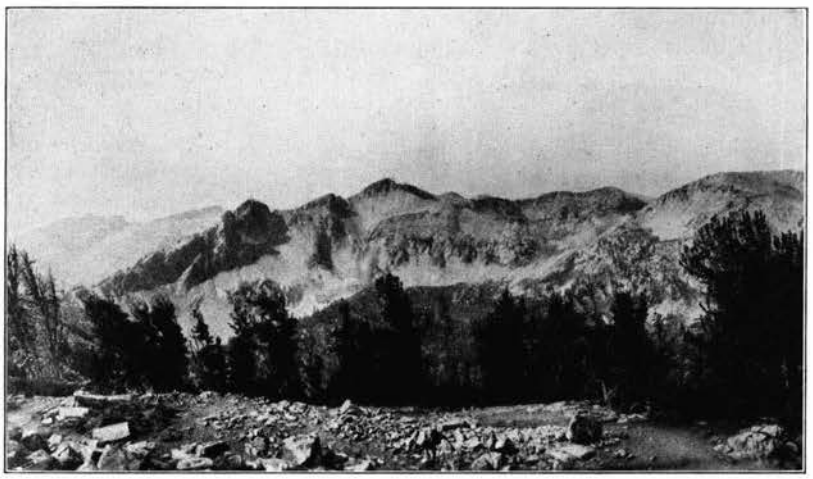


Fig. 54. Distant view of Donnelly group.

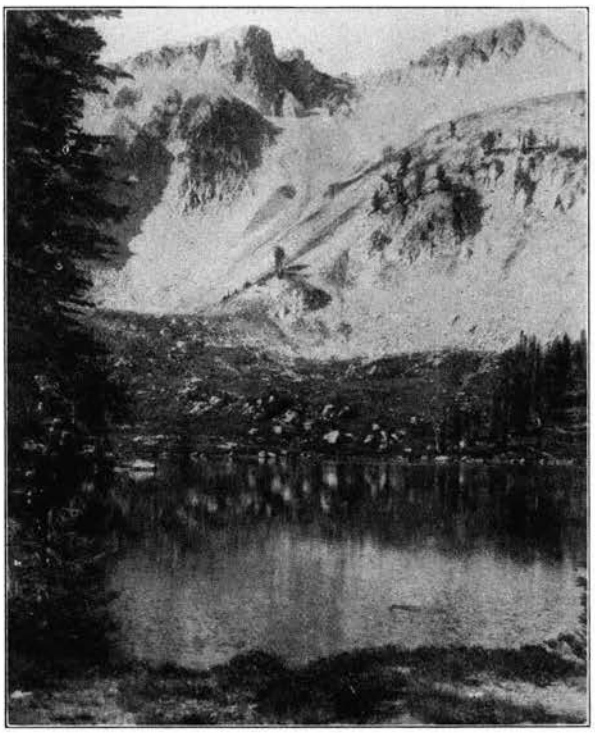


Fig. 55. The zigzag trail to Donnelly prospect.

The granodiorite is cut by porphyry dikes, one of which 20 to 30 feet wide crosses the top of this ridge with a strike N. 25° E. dip 80° to 85° E. This dike is shattered eight to ten feet wide and in this width irregular quartz veins have been deposited. This porphyry dike is undoubtedly connected with the granodiorite intrusion, but the peculiar mineral composition of the groundmass places it midway between a true porphyry and an aplite. The dike was formed later than the granodiorite porphyry dikes found elsewhere and before the true aplite dikes, since it partakes of the nature of each. In the shattered portion the porphyry shows the effects of pressure and the subsequent alteration especially of the feldspars and biotite, has produced small amounts of calcite and secondary quartz from the feldspars, and chlorite from the biotite.

Basalt dikes cutting in almost every direction are found in this vicinity. A small one cuts from side to side of the quartz vein, while

a much larger one roughly at right angles to the vein is seen in the shadow of the cliff. The principal quartz vein in the shattered zone is from four to six inches wide, is somewhat lenticular and has small branching stringers extending into the shattered zone.

The ore minerals are galena, tetrahedrite, sphalerite, and a very small amount of chalcopyrite. It is said that high values in gold and silver are also present. The sulphides occur in some stringers an inch or so wide in the quartz. From the field relations, the mineral characteristics of the vein and the alteration of the porphyry, it is evident that hot aqueous ascending solutions filled the fractures and profoundly affected the adjoining porphyry.

This vein was found late in the fall a year ago and it has not been developed to prove or disprove its worth. Its actual width is small and if enlargement at depth is not found the ore will have to be rich to pay the high cost of mining and transportation to the railroad and smelter. The smaller parallel quartz veins in the shear zone give some promise that they will unite with the larger one at a little greater depth. The owners have started a drift with the hope that this will prove to be the case.

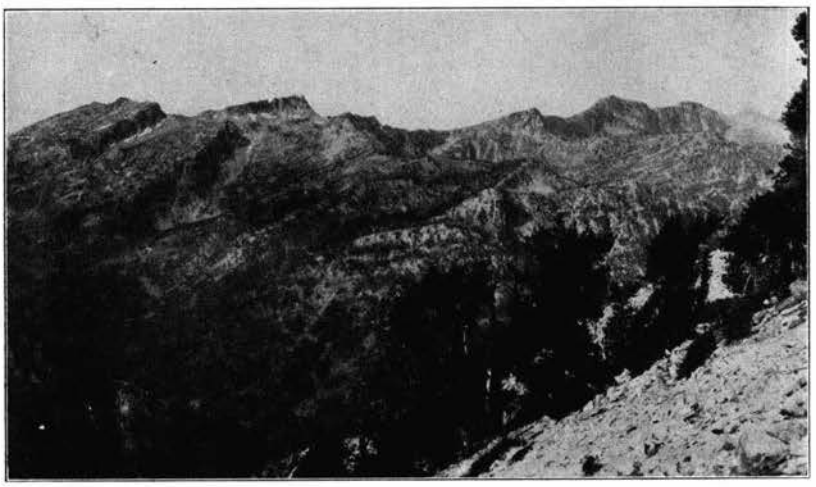


Fig. 56. Looking south from Donnellys.

From the apex of the Donelly vein we look southward across the Minam at the granite ridges beyond which Eagle river flows toward the south.

Fig. 57. The other side of Brown mountain.

To the northwestward looking across the lower part of the curving ridge on which we stand, we get a view of Brown mountain on its other side and see still more plainly the outlines of the ancient channel.

Looking backward across the cirque lake we see a part of Minam lake, the backward trail and the pass over which we came. Between

Fig. 58. The backward trail.

the first and second ridge is the East fork of the Lostine and the high ridge in the background is the watershed that separates Hurricane creek from the West fork of Wallowa river.

LOSTINE CREEK

Traveling down the mountain side again and circling Minam lake we start down the West fork of the Lostine to the "Contact mine" ten miles away. This glaciated stream with its mountain meadows and hanging valleys passes through a deep U-shaped valley all the way in granodiorite. Halfway to the mouth of West fork, Copper creek comes in from the west. Some three miles up the latter prospects are situated, but time did not permit a visit to them.

About three miles north from the mouth of Copper creek we pass the junction of the East and West forks, and some four miles farther on we arrive at the Iron Dike ranger station. Miles before we reach this point we catch glimpses high up on the eastern canyon wall of the long contact of the granodiorite with the limestone. This long and thick body of white limestone which makes up the top of the ridge is doubtless the western part of the same block seen at Gyllenbergs on the other side of the mountain. The "Peacock" or "Contact" property is situated on this contact a mile away and more than a half mile above the creek.

In taking a picture from the bed of Lostine creek with the camera considerably tilted the impression of the steepness of the trail and mountain side is lost.

The Peacock camp, elevation 7,000 feet, is about 2,000 feet above the ranger station. About 200 feet still higher up, considerable work has been done on the contact which here for some distance is between calcareous or limy schist and the granodiorite. Mineralization appears to be less prominent than on the contacts elsewhere with purer limestone.

This contact with its contact-metamorphic minerals is not the chief point of interest at this property. Development sometime ago ceased on the contact and was transferred to a nearly vertical pyroxenite dike 5 to 40 feet wide, which diagonally cuts across the limestone in an E.-W. direction. A few hundred feet of the lower end of this dike was observed, and as far as one could see the dike continued to the very mountain top. A distant and indistinct view of this dark colored curving dike in the white limestone is seen in the upper part of the picture.

Fig. 59. Looking up at the Peacock prospect.

The dike rock is dark green in color with a texture nearly dense. In thin sections it is seen to consist of about 75 per cent augite pyroxene, about 15 per cent labradorite, 5 per cent biotite, and 5 per cent quartz. The quartz is probably a secondary mineral. Most of the labradorite feldspar crystals are badly altered.

The dike has been somewhat fractured and in the small fissures the pyrite and pyrrhotite have been deposited together with some chalcopyrite. Some of the contact-metamorphic minerals, garnet and

epidote, are in evidence near the borders of the dike for the most part, but sometimes are seen in the adjacent limestone. The pyrite and pyrrhotite appear in greater percentages in the outer portions of the dike. This dike, a basic differentiate of the great intrusion injected in a molten condition into the fissure in the limestone, probably had sufficient heat with the assistance of mineralizers to form the small amount of garnet and epidote present.

Practically no mineralization is seen in the limestone adjoining the dike. In an examination of several open cuts scattered for a considerable distance along this dike the copper minerals appear to be too thinly scattered through the dike to call it ore. Without the presence of precious metals in fair amounts this primary deposit would not pay to work.

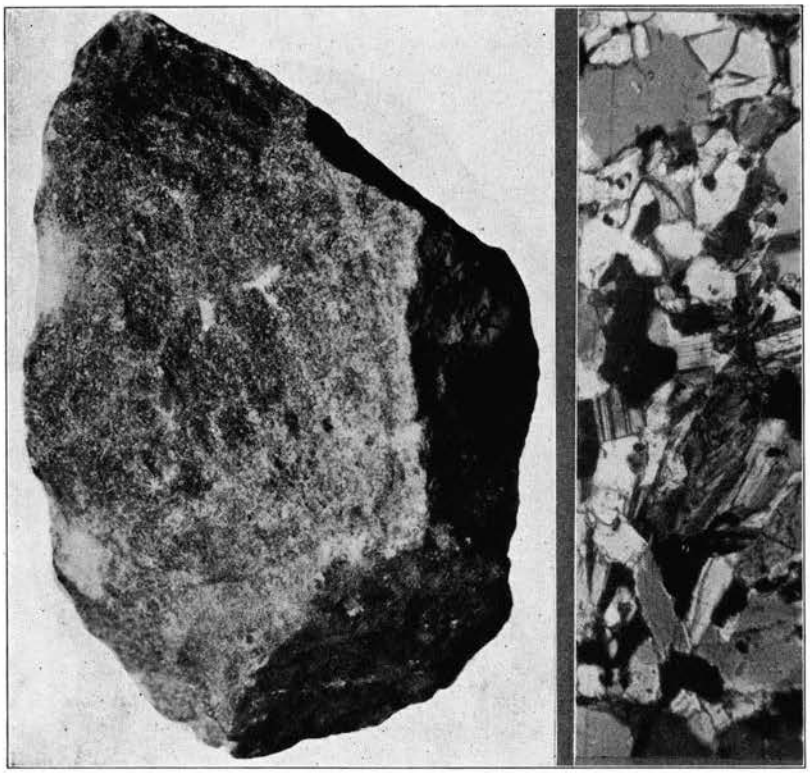
Returning to the stream again we start north for Lostine, 17 miles away. Most of the way granodiorite predominates on our left, while on the right besides granite much limestone and other sediments appear.

ECONOMIC GEOLOGY OF THE WALLOWA DISTRICT

The geology of this, the northern part of the Wallowa range, is similar to the Cornucopia or eastern portion. It is a part of the same granitic intrusion. The greater differences are in the sediments which made up the roof of the batholith of which much was absorbed by this intrusion, and the metamorphism at the contact with these sediments. The minor differences are a few occurrences of pegmatite and numerous occurrences of lamprophyres.

The roof of the batholith in the Cornucopia region was composed probably of altered basic volcanics, or greenstones and their volcanic breccias together with schists which were once basic sandstones. In the Wallowa country, however, we had for a roof a limestone, probably of considerable thickness, together with considerable calcareous and other schists and some greenstones. The area which the limestone originally covered has not been determined, but it is probable that a large part of the northwestern border of the intrusion was covered by it many hundreds of feet thick. The composition of the granodiorite shows the effect of the absorption of calcareous sediments. In every case the feldspars are more basic and in many places hornblende becomes a prominent accessory mineral.

Lamprophyres of various compositions, such as, quartz-kersantite, kersantite and pyroxenite were found to be more or less closely con-



Natural size Magnified thin section

Fig. 60. Lamprophyre. A dark-colored dike rock consisting chiefly of biotite, hornblende, plagioclase feldspar and a small amount of quartz. The presence of quartz makes it a quartz-kersantite.

nected with ore deposits. The origin of these dikes is still a matter of hypothesis. It also appears that gases or vapors called mineralizers accompanied or immediately followed the intrusion of some of these dikes.

Contact-Metamorphism.—The ore deposits are chiefly those on the contact between granodiorite and limestone. By contact-metamorphism is here meant the change that takes place at the contact of a granitic intrusion with a calcareous or limy sediment. It is characterized by a replacement of some or all of the minerals of each rock by other minerals.

The limestone is replaced more or less completely by such lime-silicate minerals as garnet and epidote, and by other minerals, such

as, quartz, calcite, pyrite, chalcopyrite, magnetite, and molybdenite. The intrusion, in this case a granodiorite, is not altered to such distances from the contact as is the limestone. The replacement of the granodiorite when complete, results in it becoming almost completely siliceous. In some of these deposits considerable garnet and some epidote are found in the granodiorite.

Without stating the evidences found in this region or that derived from like deposits elsewhere, the conclusion is reached that the silicate minerals and the sulphides were derived in large part from emanations from the intrusion during the long period of its cooling. To a lesser degree the limestone contributed some of its lime and impurities; the immediate granodiorite furnished a little from its feldspar, hornblende, and biotite. The limestone and the intrusive emanations formed a chemical system in which reactions of great intensity proceeded. Sometimes the limestone and the intrusive show by the development of epidote and garnet in the latter that a vigorous interaction has taken place.

These deposits were formed beneath the surface, but in the absence of knowledge of the depth of the overlying sediments its depth cannot be stated. In other states similar deposits have been formed at a minimum of less than a thousand feet. Other things being equal, contact-metamorphism will continue downward to the lowest limits of the contact.

Mineralogists and physical chemists have agreed that these minerals are a product of high temperature only. The deposits are not continuous along contacts, but are massed in certain places dependent probably on the facilities for the escape of the gases. The size of these deposits seems to be influenced by several factors:

1. Whether the contact is flat lying or is at a high angle. Where it is at a high angle the deposit is not of great extent. This may seem to be contradictory to the field evidence at Fraser's property, but even there the main plane of contact is essentially flat lying. For the greatest possible amount of mineralization the plane of contact should have a low angle of dip with limestone for a hanging wall, so that the ascending emanations may penetrate more extensively the overlying sediments.

3. The effect of fissuring seems to be particularly important during the latter part of the formation of the contact zone. It is then that we have conditions similar to that of fissure veins. Fissuring in the plane of the contact, especially at the Fraser property, seems to

have occurred after the formation of this zone was well under way. In this fracturing the high-temperature aqueous solution of quartz and molybdenite and other minerals creates more or less vein-like deposits. This fracturing has tended to prolong the period of mineralization by re-opening the channel.

3. In many cases mineralization seems to be closely connected with both acidic and basic dikes, technically called "complementary dikes." At the Gem group we find aplite associated with ore minerals and at the Lostine contact and at the Walla Walla group at Aneroid lake we find lamprophyres closely connected with the ore-bearing minerals. The effect of these dikes on the size alone of contact deposits is probably similar to that of fissures. They furnish means for the distribution of mineralizers; they also probably contained mineralizers and maintained them at elevated temperatures.

4. The character of the overlying material is by far the most important factor in determining the size of the deposit. Limestones or a rock that contains lime are the only ones mineralized to any considerable extent. The degree of alteration probably depends more on the physical character of the rock than on its composition. The fact that the limestone is loose textured and granular makes it more easily affected than a dense hard rock. In any case alteration is somewhat capricious.

The point of most interest and worth is the probable value of these deposits. Can we reasonably hope that some of these contact-metamorphic copper deposits may become mines? The development is practically negligible so that we are forced to view these croppings, open cuts, and extremely shallow underground workings in the light of similar deposits in other parts of the world.

Those who are interested in comparing the conditions obtaining here with those deposits already developed elsewhere are referred to the considerable literature upon the subject. This can be found in technical periodicals and official publications.

In the southwest contact-metamorphism is the dominant factor in mineralization in such well known camps as Clifton and Bisbee in Arizona, Bingham in Utah, and some districts in New Mexico and Nevada. Contact-metamorphic deposits are also found in Montana, Idaho, and Alaska, but in the southwest this type of deposits is mined more extensively than elsewhere.

By comparing the conditions of these developed deposits with those found in the Wallowa region the interested person can form an idea as to the probabilities of developing considerable ore bodies.

HOMESTEAD OR SNAKE RIVER COPPER DISTRICT

A few miles south of Huntington at the mouth of Burnt river the Snake river enters a canyon through which it flows north until it enters the Columbia, some 250 miles away. For a few miles north of Huntington the canyon is quite narrow and about 2,000 feet deep. North of this point it broadens and the mountains recede; the slopes are gentle, although the depth is maintained.

Along the river several large bars support prosperous fruit and hay ranches. North of Burnt river the next stream flowing in from the Oregon side is Powder river, 33 miles north from Huntington at Robinette. About 20 miles farther Pine creek enters the Snake. No important tributaries join the river for a long distance north of Pine creek. From Huntington to Robinette the river flows chiefly through Triassic limestones, shales, and greenstones. Just below Robinette the canyon is entirely in flows of Columbia river basalt. A short distance below the mouth of Pine creek the older rocks emerge again from below this cover of igneous flows. On the west side lava continues for many miles northward, forming the upper wall of the canyon slope, well marked by its brown color and lines of volcanic flow.

Four miles down the river from Pine creek and Copperfield is

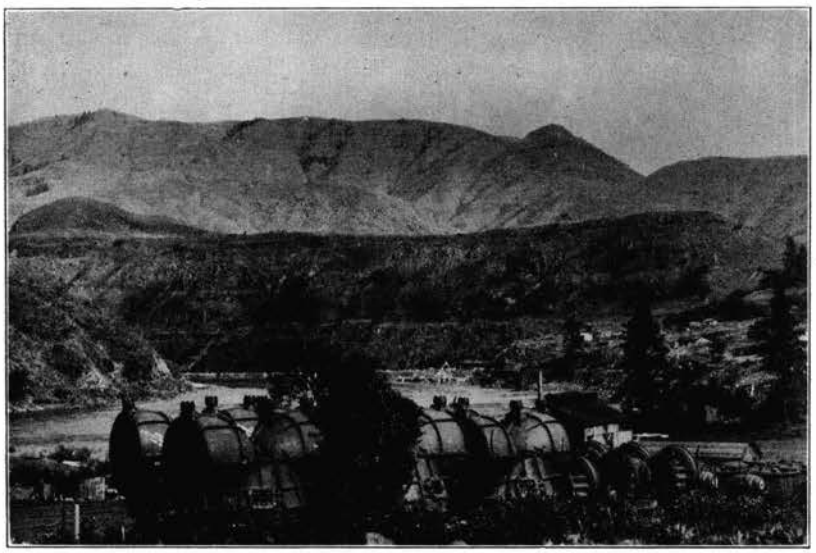


Fig. 61. Oxbow on Snake river at Copperfield. Turbine casings for new power plant of Idaho-Oregon Light & Power Company.

Homestead, the terminus of the Snake river branch of the O.-W. R. & N. Co.'s line, 58 miles north of Huntington. A wagon road extends seven miles farther down the stream. A trail continues along the river four or five miles farther, and from there on the canyon is impassable.

"For 125 miles northward, as far as Asotin, a few miles above Lewiston, Snake river flows through one of the most remarkable canyons in the United States, comparable to the Canyon of the Colorado in grandeur, and in places surpassing it in depth. Professor I. C. Russell has described its lower part as far as Mount Wilson, 40 miles south of Lewiston. Near Asotin 3,000 feet of basalt beds are exposed along the walls of the canyon. At Buffalo Rock a peak of the underlying mountains, buried by the basalt, rises to a height of 2,000 feet, but is still covered by 1,000 feet of basalt flows. At Mount Wilson, near the southeast corner of Washington, the underlying schists again appear, and are exposed to a height of 2,500 feet along the canyon side; the level basalt flows bury the old mountain to a depth of 1,500 feet above its summits. Thus 4,000 feet of lava are exposed from the bottom of the canyon to the brink at Mount Wilson. Back of this point basalt flows again rise to a thickness of 1,000 feet, giving a total depth of 5,000 feet of Columbia lava. The deepest part of the canyon is the part near the Seven Devils.

"The narrow backbone between the Snake river, on one side, and the Salmon river and the Little Salmon on the other, rises to elevations of 3,000 to 8,000 feet, and is generally referred to as the Seven Devils country. More especially is this name given to a group of extremely sharp peaks rising to elevations of 9,000 feet on the eastern side of Snake river, 25 miles northwest of Meadows. . . .

"From the vicinity of the copper mines south of the Seven Devils the view of the canyon and the Columbia lava is magnificent. Pls. XIV and XV are views looking west across the river, but they only feebly illustrate the grandeur of the canyon.* Above 7,500 feet the peaks of the Seven Devils and of the Eagle Creek range, across the river in Oregon, are bare, flecked with snowdrifts and scored by rock slides. Between 7,500 and 4,000 feet lies a forest zone, the upper part a slender growth of black pine, the lower part excellent yellow pine. Below 4,000 feet the vegetation is scant and the canyon sides are nearly bare. Snow rarely falls in the bottom of the canyon, which has an elevation of about 1,600 feet. A few small bars along the river in the upper part of the canyon support thriving vineyards and orchards, but for many miles north of the Seven Devils rocky bluffs line the river, and the canyon is impassable. At the place photographed the canyon is scarcely 7 miles wide. The view is taken at an elevation of 6,500 feet. From the summits of the Seven Devils a slope of 7,000 feet descends to the river in about 6 miles. West-

*Only Plate XV reproduced (fig. 62).

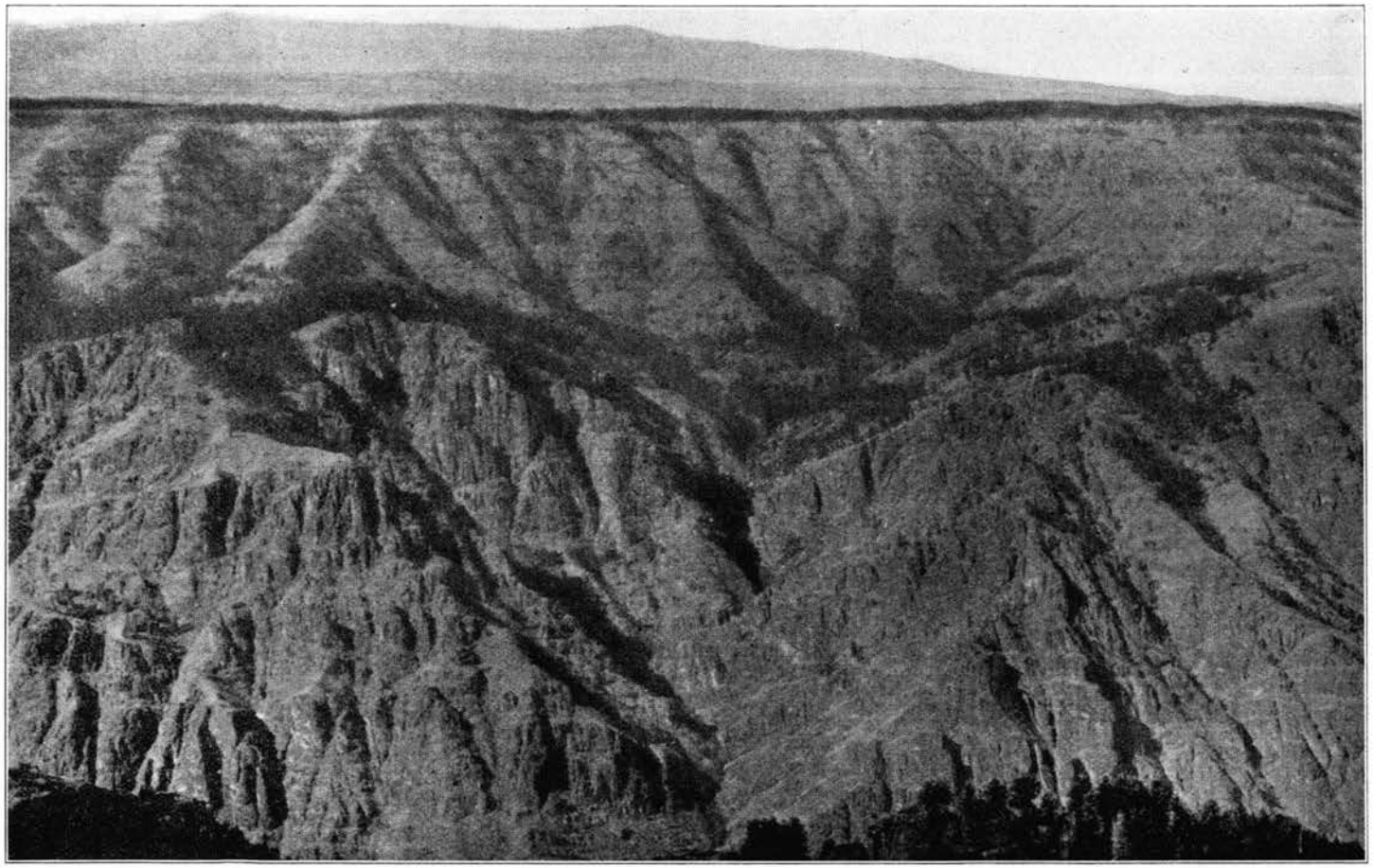


Fig. 62. Snake river canyon showing older rocks underneath thick flows of recent basalt.

ward, across the canyon, extends the great lava plateau, at elevations of from 6,000 to 7,000 feet. Columbia lava, in somber-brown flows, looking like a horizontal series of sedimentary beds, is exposed to a thickness of 2,500 feet along the western side of the trench. These rest upon an irregular surface of old rocks, chiefly porphyries, but also diorites and some sedimentary rocks. The canyon is cut into these older rocks to a depth of 2,500 feet, giving a total depth on the western side of 5,000 feet. Below the lava the canyon walls are exceedingly steep. The erosion gives to the short ridges a distinctive type of buttresses, well shown in the photograph. The whole color of the scene is dark in the extreme. The successive precipices of the buttresses are dark gray, almost black. The river, wherever visible, seems like a slender green thread between black walls. The dull brown of the basalt capping and the dark green of the forests of the plateau unite to make a study in somber colors.

"A little to the south of the place shown in Pl. XIV the basalt flows attain a thickness of 4,000 feet, but do not, in this part of the canyon, descend to its bottom. It is clear that the basaltic plateau to the south of the Seven Devils once continued across the canyon. The course of the Snake has been laid out across the high lava plateau. Once established, it has rapidly deepened its canyon. There is no doubt that the whole canyon has been cut since the close of the Miocene period. Thirty miles west of the Seven Devils, in Oregon, the Eagle Creek range (also known as the Powder River mountains), rises above the basaltic plateau, and is well shown on Pls. XIV and XV. This is a circular mountain group with a diameter of 24 miles. Its bare peaks, white or dark brown in color, consist of older rocks and rise several thousand feet above, the plateau surrounding them on all sides. They are but the summits of a far more imposing mountain group now buried under the basalt flows. In the same manner, the Seven Devils may be considered an outlier of the main old mountain mass of Idaho, against which successive fiery flows piled up, until now only the summits protrude above the lava plateau. North of the copper mines, on the western side of the river, the contact of the old rocks, with the basalt, rises to nearly 7,000 feet, and the whole canyon is cut in these old eruptives and allied rocks. But immediately north of this point the contact again sinks, and heavy basalt flows form the brink of the canyon continuously down to Lewiston.

"Thus the gigantic trench of the canyon has shown the structure of the Columbia lava and laid bare the formation upon which it rests. Below the broad plateau lies a buried topography—mountain ranges, deep valleys and canyons, all blotted out by the swiftly succeeding flows, only the very highest peaks still showing their heads. The bottoms of the old valleys clearly lie far below the deep cut of Snake river, how far is not known. More detailed investigation will reveal more of the character of this old submerged topography. It may be confidently advanced as a working hypothesis that this whole dis-

trict, including the Lower Snake River valley, far from having been elevated since the Tertiary era, like the vicinity of the Yellowstone National park and the region of the Grand Canyon of the Colorado, represents an area of depression, standing now at lower levels than during the Miocene period."

The region bounded on the west and south by Wallowa and Pine valleys and on the east for over a hundred miles by the Snake river is in large part a terra incognita to geologists. Nearly a million and a quarter acres is its extent, but aside from some 15 or 20 miles opposite the Seven Devils in which preliminary work only has been done, the geology of this region can only be inferred.

The western limit of Wallowa valley, a precipitous mountain range, is supposed to be the line of an immense fault, and the vast region to the north and east is regarded as an enormous block which, slipping down the great escarpment, made the Wallowa valley and the ascending eroded land to the eastward. With the exception of about 10 square miles near Homestead none of this territory was visited and only the conflicting evidence of a few travelers is available concerning all the rest. Some say that it is covered with Columbia river basalt, except along a part of Snake river, as previously described. Others say that many of the streams have cut their way through these recent flows into the older rocks. Probably the latter is more nearly true.

HOMESTEAD GEOLOGY

As has been stated before, the older rocks emerge from below the basalt between Copperfield and Homestead where in the basin west of Homestead, the contact is a thousand feet or more above the Snake; at Ballards it is about two thousand feet; at Spring creek, seven miles from Homestead, a little less; and at Squaw creek, twelve miles away, considerably more.

Basalt and the river and inaccessibility make this mining district's limits. This ragged edge of the older rocks elsewhere covered by the red blankets of recent flows, is for the most part made up of greenstones. This greenstone series, the oldest rocks of the district, consist of amygdaloidal, porphyritic and dense flows with interbedded breccia, tuffs, sandstones, and conglomerates. The igneous flows make up by far the larger part of the series. Smaller streaks of sandstone and conglomerate are imbedded in the flows.

W. Lindgren. The Gold and Silver Veins of Silver City, De Lamar and other Mining District in Idaho. Twentieth Annual Report, U. S. G. S., pp. 91-93.

The general direction of the strike is N.-S., but the dip varies in both angle and direction. Microscopic examination of many thin sections reveals the fact that the original character of these rocks is much obscured by their pronounced alteration. This much is evident, that before their alteration the flows ranged from ordinary basalt to rhyolite, from basic to acidic flows, in which are roughly bedded masses of volcanic tuffs, breccias, and occasionaly thin beds of sandstone and conglomerate. These older rocks are old lavas erupted during the Triassic period. They are the same kind of rocks, of the same age and are the product of the same disturbances and rupturing of the earth's crust that caused the outpouring of the streams of molten lavas which are now the greenstones exposed at Cornucopia, at Joseph, on the southern slopes of the Wallowa range, and doubtless concealed under vastly greater areas by the great outpourings of recent basalt, the Columbia river lavas. The imbedded sandstones and conglomerates show that at intervals this region was submerged to receive for a short time a deposition of coarse and finer sediments, but the lifting out of the water or the coming of the next flow was too soon to permit anything but thin beds of these sediments to be laid down.

Following the last flow much of this as well as a vast region to

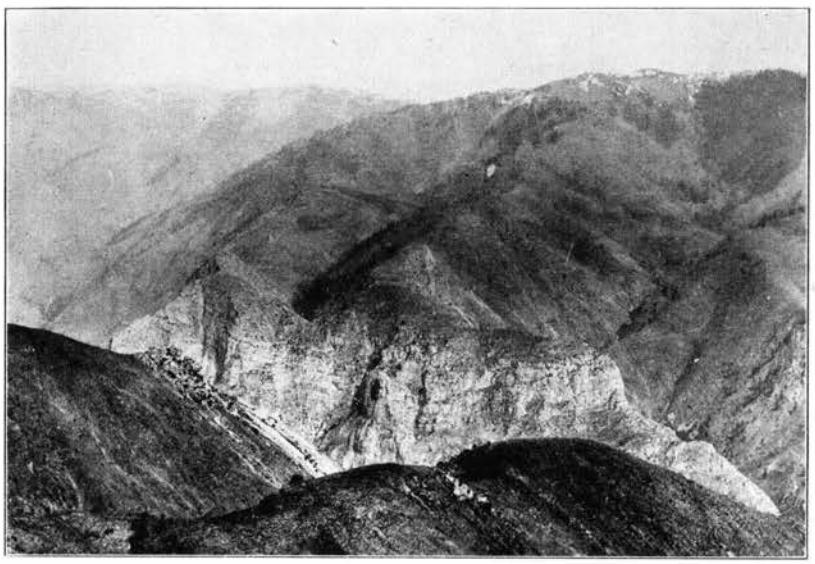


Fig. 63. Snake river canyon showing limestone beds on the Idaho side just below MacDougals.

the north and west was submerged for a considerable length of time, and during this time of submergence limestones in the deeper portions and muddy sediments in the shallower parts were laid down in considerable thicknesses.

About eight miles north of Homestead and continuing for about three miles, limestone lies conformably on the flows and is folded with them. This limestone has a thickness of 300 to 500 feet. It is probable that it at one time covered much of the greenstones in this vicinity. In many places the flows are badly contorted, so much so that the rock has become banded. This folding which followed the deposition of the limestone and included both it and the series of flows beneath it, was doubtless the result of the same forces which preceded

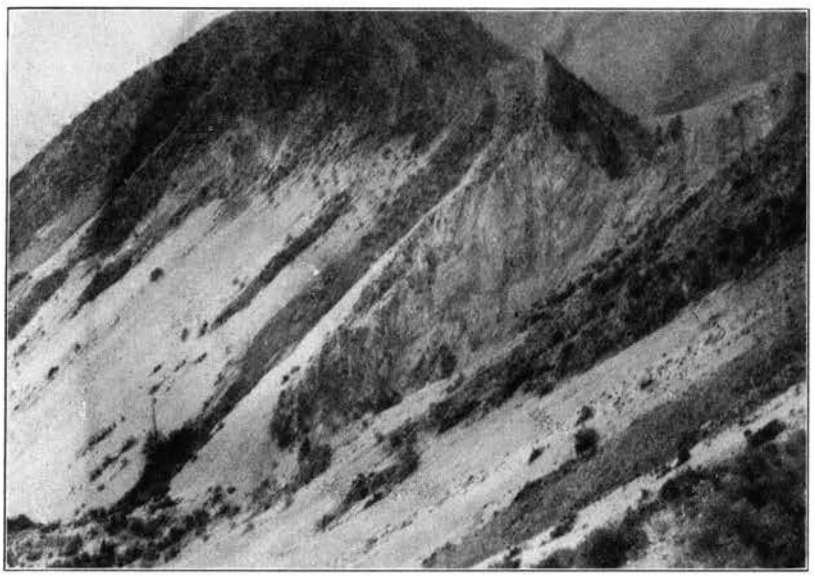


Fig. 64. Sharply folded limestone in Snake river canyon.

and accompanied the great intrusion of granodiorite that makes up the main body of the Wallowa range. The effects of these movements are not as pronounced here as in much of the regions farther west. It is farther away from the greatest folding and is also farther from the great intrusion which nevertheless came in under this region as well. If the northwest and southeast folding had extended in full effect to this region erosion would have removed lava, limestone, and greenstone

here as well and have left exposed the granodiorite. This did not occur, but nevertheless underneath this region there exists the concealed granodiorite intrusion. Numerous dikes of granodiorite-porphyry extending upward from the mass below cut the greenstones of Snake river.

Another effect of these movements was the development of a large number of shear zones where often the country rock has been made schistose. The strike of this schistosity is about N.-S. and it dips usually at a high angle.

The shearing, fissuring, faulting, and brecciation of the greenstone gave ample opportunity for lateral and ascending waters to do their work of alteration and mineralization, the activity of which was much intensified by the after-effects of the deep-seated granodiorite intrusion. In some places the former and in others the latter type of solution appears to have been the chief factor in ore deposition.

Fig. 65. A view of the less rugged part of the Snake river canyon.

The deposition of native copper and the mineralization between greenstone and limestone is probably due to lateral secretion. The quartz veins at Carnahans in all probability are due largely to ascend-

ing solutions, while deposition in shear zones, as for instance, at MacDougal's property and at the Iron Dike, may be due to a combination of lateral secretion and impregnation from sources below.

After the vein formation there was a period of erosion, after which came the enormous outpourings of basalt. When these had ceased another period of erosion began which continuing to the present time has permitted the Snake river to cut its deep channel down even into the older rocks.

COPPER PROPERTIES

The discovery of and activity in this district has taken place within the last 20 years. Copper indications at the surface are evident to some degree almost everywhere in the exposed greenstones. Much of this territory is held by location, besides many claims are patented.

There is no production from the Oregon side, and the camp is more quiet than at any time since its discovery. The majority of the owners, however, in spite of discouragement, retain their faith in the district. Out of the large number of groups a few of those easiest of access, or those toward which our attention had been directed are discussed below.

Iron Dike.—This is a copper deposit discovered in 1897, situated about 2,000 feet from the railroad at Homestead. The lower tunnel is about 300 feet above the town. The main croppings are about 375 feet above the lower tunnel and 70 feet below the croppings is the upper tunnel. Down 50 feet farther is an intermediate crosscut, and midway between the latter and the lower tunnel is a fourth crosscut.

The lower tunnel is in some 1,300 feet, cutting the ore body about 800 feet in and, passing through it, continues on without discoveries. A zigzag raise connects this tunnel with the three tunnels above. Unfortunately this raise was started a hundred feet beyond the ore in the lower tunnel, and much other development could have been placed to better advantage. The opportunity here to block out the ore and to determine its limits were excellent.

The series of trachytic or perhaps rhyolitic flows here have been so badly altered and silicified that they are now a chloritic indefinite greenstone. Intercallated with the flows is a body of dark-brown altered andesite which may have been an intruded sill.

The greenstone in the hand specimen is in color light green and quite dense. Under the microscope thin sections vary from very fine-grained to considerably coarser, but contain very poorly formed silici-

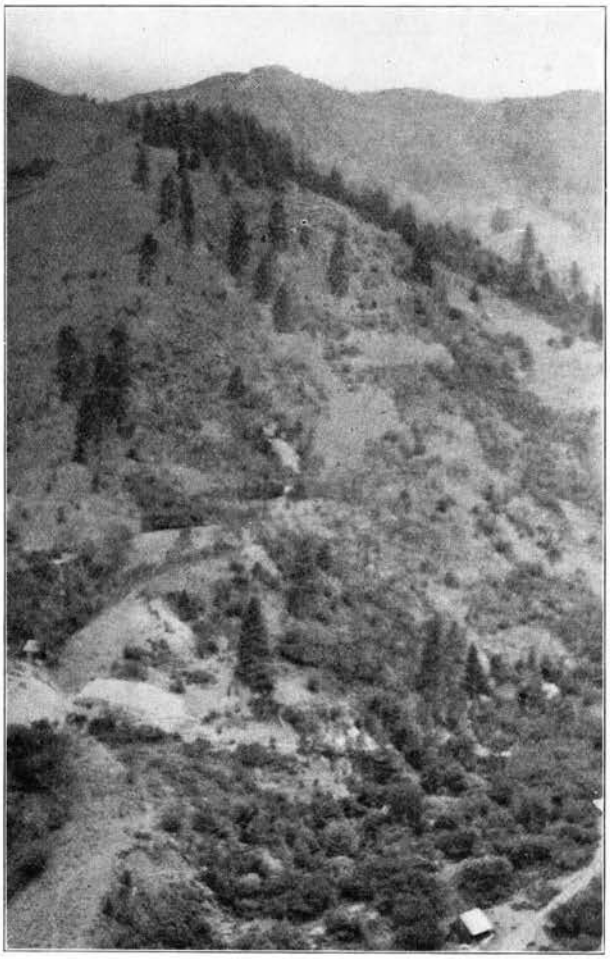


Fig. 66. The Iron Dike croppings.

fied feldspars in a groundmass of abundant sericite with some chlorite and a few crystals of secondary quartz. Minute faulted quartz veinlets are revealed throughout this altered greenstone. No thin sections were made of the meta-andesite to determine exactly its present character.

Although the character of some of these flows due to a variation in their composition and structure might be much more favorable to concentration than other flows, nevertheless the factor of most importance here is the opportunity for ore concentration through fault planes and shear zones.

A considerable amount of shearing and faulting has taken place in this immediate vicinity. Several pronounced slips were noted all having a strike of N. 20° E. and dipping at rather high angles eastward. For a considerable width a shear zone, many feet wide, has the same general direction. The best ore in the lower tunnel is massive chalcopyrite and pyrite with but little quartz as a gangue in a lens-shaped body dipping 60° E. with a maximum width of about six feet which is said to extend from the lower to the upper tunnel.

On the west side of the lens in a short crosscut from the lower level the ore seems to be cut off rather sharply by a fault. On either side of this high grade ore, which is said to average 15 to 20 per cent copper, is a much larger body of disseminated pyrite and chalcopyrite in the chloritic greenstone, in which are abundant quartz seams, veinlets, and nodules that contain pyrite. There is often a silicification of the rock itself. Statements are made that it contains about $2.00 in gold, and 6 to 30 ounces in silver, regardless of the per cent of copper present. This deposit, both high and low grade, is in a zone of crushing in which copper bearing solutions have deposited their contents largely by replacement.

This series of rocks has suffered severely and has become badly altered. This of course creates the best conditions for the concentration of metallic minerals whenever opportunity offers whether it be in great or small fractures, shear zones, or in amygdules. In this particular property a study of thin sections has shown the formation of minute veins which were afterwards broken. The field evidence clearly shows the faulting and shearing that have taken place. All of these conditions are favorable to the deposition of copper minerals that have been dissolved from the greenstone series which practically always contain some copper.

However, as noted before, the presence of such an amount of highly silicified rock and the fact that the gold and silver values are considerable and independent of the copper content seems to indicate an impregnation of this shear zone from sources connected with the granodiorite. The gold and silver and possibly some of the copper impregnated the shear zone which at a later time, having been re-sheared, has permitted a re-concentration of copper from the shear zone along principal planes assisted by a deposition of copper brought in from the greenstone walls from which it had been dissolved by circulating waters of moderate depth and temperature.

The MacDougal Group.—These twenty claims owned by W. B.

MacDougal are for the most part patented claims. They are located about five miles north of Homestead, from one-half to a mile from the river and up to 3,000 feet above it. The region consists of a greenstone series which is made up of altered dense porphyritic and amygdaloidal flows with interbedded breccias and tuffs and possibly some intercallated sheets and sills. Considerable shattering has taken place, in fact the principal mineralization is in brecciation zones. The observed porphyritic and amygdaloidal flows are andesite, while the breccia is made up of the angular fragments of various types of lavas held in a dense groundmass of ferruginous material in which there has been quite a development of secondary calcite.

The different types under the microscope show that these greenstones have been extensively shattered with the subsequent development of calcite, epidote, and quartz in gash veins. Some of these veins contain small amounts of pyrite and chalcopyrite. Occurring in this way it indicates that these materials are the result of lateral secretion processes.

The principal mineralization is in brecciated steep dipping N.-S. shear zones. Three of these zones were observed and there is said to be four others beyond. Although no surface crosscuts have been made to determine the width, they are said to be from 30 to 200 or more feet wide.

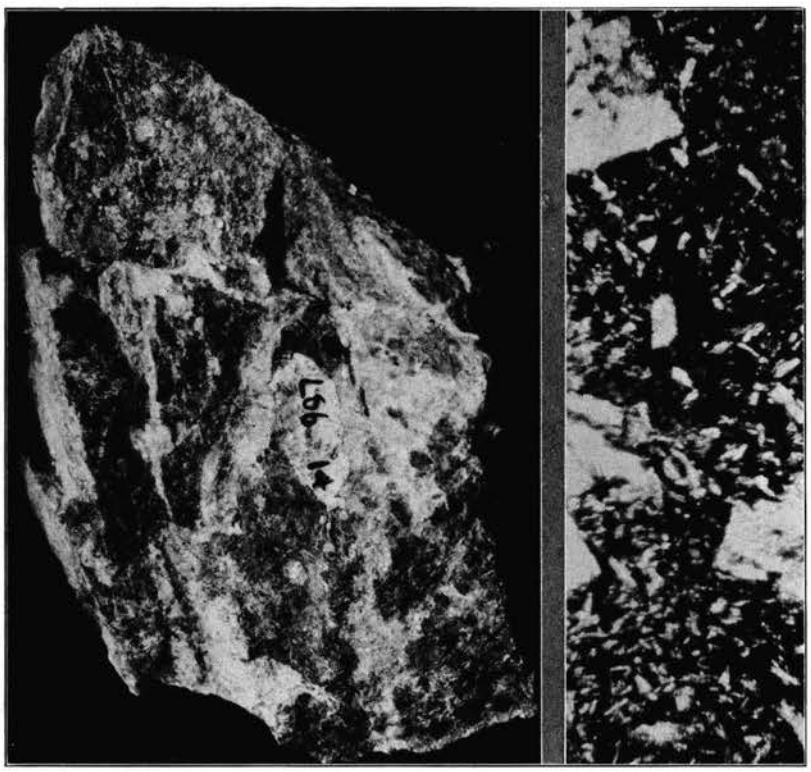
In these shear zones occur various sized stringers of quartz, calcite, and chalcocite. In some places stringers of chalcocite more than an inch wide are found. These stringers of chalcocite are intimately mixed with a lesser amount of quartz. In some places the country rock on each side of the stringers is impregnated with chalcocite for several inches. At the immediate surface the chalcocite is partially altered to malachite with some azurite, but even there the alteration is quite incomplete and three or four feet below, the green and blue colorings of the copper carbonates are nearly absent.

A very important undetermined question is the primary or secondary nature of the chalcocite. If it is primary the same type and degree of mineralization might well be expected to continue far downward in the sheared zones. If it is secondary the chalcocite at shallow depths would cease and much smaller percentages of copper in chalcopyrite mingled with pyrite would be found as the primary ore below the shallow secondary chalcocite.

Some of the chalcocite, as before stated, is intimately mixed with quartz and is apparently a primary mineral. On the other hand on the

surface of one of the upper zones a bowlder was broken open which contained crystals of chalcopyrite which are being replaced by chalcocite. This bowlder has been shattered somewhat and contains chalcopyrite as scattered grains and also associated with quartz and epidote. Some of these grains have been altered to malachite.

In from the portal of the lowest crosscut tunnel 500 feet, but said to be 300 feet away from the first shear zone, is found a rock with a few amygdules filled with calcite and a small amount of chlorite along



Natural size **Magnified thin section**

Fig. 67. Amygdaloidal greenstone. An old lava flow that has been altered to a large extent. Specimen from 500-foot cross-cut at MacDougals. In the hand specimen note the small calcite vein cutting an amygdule. In thin section note the indistinct outlines due to alteration of the primary minerals.

their borders. This rock is cut by numerous calcite gash veins, some of these containing chlorite and a small amount of chalcopyrite. The calcite in the amygdules is pink, while that in the gash veins is white.

The fracturing came later than the filling of the amygdules since these veins cut the latter without faulting. In this rock the small amount of chalcopyrite is primary. The chalcopyrite in the bowlder mentioned above is primary, but the sooty chalcocite there replacing it is secondary.

When the lower tunnel reaches the shear zones several hundred feet below their outcrops, will it find primary chalcopyrite or primary chalcocite? The evidence would lead one to hope that chalcocite will be found.

The shear zones were probably created at about the same time as the vein forming period elsewhere in eastern Oregon. This was probably after the lateral secretion processes had largely completed their widespread alteration and deposition as evidenced in the lower 500-foot tunnel. The quartz and chalcocite in these shear zones are apt to be the product of ascending thermal solutions. If this be the case the chalcocite in conformity with its appearance and its intimate association with quartz is probably primary and, therefore, will be the copper mineral to be found at depth within the shear zones.

These claims cover steep to gently rolling hills in which at various points there are many open cuts and pits, numerous short tunnels and three long ones, approximately 200, 300, and 500 feet respectively. The open cuts have in nearly every case disclosed copper in stringers which have been followed. No open cuts cross the shear zones at points most favorable to expose possible wide disseminations. These could have been made quite cheaply and would have exhibited the width of the shearing, whether the fractures are closely spaced or too widely separated, and whether there might be at some points ore sufficiently rich to ship. After the open crosscuts have been made conclusions could be drawn as to whether the chalcocite is sufficiently disseminated to make low grade ore throughout, or whether there is higher grade but more limited bodies of ore.

If favorable results were secured by the crosscuts, keystone or diamond drilling could be first done at the most favorable points which, if promising, could be followed by systematic arrangement of the drill holes so as to determine the limits of the ore bodies. Should wide zones of low grade primary chalcocite be disclosed, its proximity to the railroad, to water and water power, the favorable climate, and absence of overburden or leached zone requiring stripping, would permit as low grade of ore to be profitably mined as at any of the porphyry coppers now successfully operated.

The Brooklyn Group.—These claims, owned by A. P. Carnahan, are situated about 12 miles north of Homestead and about one-half mile from the river both vertically and horizontally. The location of the camp is a picturesque one, situated as it is in an open space on the edge of a heavy forest with precipitous rocky walls both above and below.

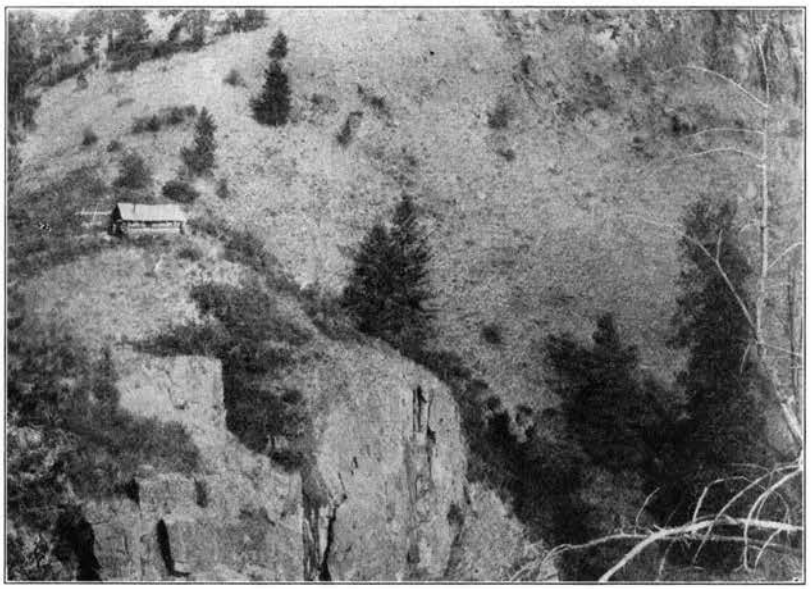


Fig. 68. Carnahan's camp.

These rocks are quite similar to those at MacDougals. They consist of amygdaloids, breccias, and dense flows cut by granodiorite-porphyry dikes. The amygdules are filled chiefly with calcite, although some contain calcite and epidote, and some quartz and epidote. Volcanic breccia resembling Lake Superior rocks have cementing material of calcite with small amounts of chlorite associated with it. At another point dense greenstones identical with those at the Iron Dike contain minute grains of iron pyrite.

A fault type of breccia is made up of fragments of dense greenstone with chalcopyrite and calcite as cementing material. It is a fine-grained porphyry in which there is a very finely interwoven groundmass of altered feldspars with sericite, chlorite, kaolin, quartz, and epidote as alteration minerals. Judging from these alteration

products the original was probably an andesite. The chalcopyrite is probably due to impregnation and occurs in the fracture planes and also as scattered grains.

Considerably altered granodiorite-porphyry dikes contain resorbed feldspar crystals which probably indicates that the parent granodiorite is a considerable distance underneath this greenstone series. Just how far it may be, it is of course impossible to say. The presence of this porphyry implies a considerable influence of the granodiorite upon the deposition of ore.

The series of flows have a N.-S. strike and a dip 30° west. There are several N.-S. nearly vertical shear zones. On each side of an E.-W. granodiorite-porphyry dike are quartz veins. There are several other E.-W. veins. These E.-W. veins are fissures while the N.-S. ones are shear zones of moderate widths but the mineralization of both types is quite similar. The gangue minerals are chiefly quartz with some calcite and chlorite. Barite is in one of the E.-W. veins. The ore minerals are gold and silver bearing chalcopyrite and chalcocite. The latter was found with specularite.

It seems probable that a large part of the mineralization is due to ascending currents of water from the underlying granodiorite batholith. The leaching of copper from the shattered greenstone played but a minor part.

Over 400 feet of development work has been done on these claims in crosscuts toward the shear zone and on the E.-W. quartz veins. None of the several crosscuts have arrived at the shear zone vein and no open cuts have been made upon it to demonstrate its value, although it is undoubtedly worth all such work.

Because of a misunderstanding as to the nature of the deposit, crosscuts were started instead of tracing the outcrop into a deep gulch where a drift upon the zone could have been easily started. This drift would have been in material in which at least double the progress could have been made, besides every bit of work would have given information.

The Koger Group.—The Snake River Mining and Milling Company has many claims located in the basin northwest of the Iron Dike, about one-half mile from Homestead. The same types of dense greenstones are found here which have scattered through them small amounts of pyrite. In contrast with the Iron Dike, this property has but a very slight amount of faulting and no shearing.

McCarthy Claims.—The McCarthy property, situated about one-

half mile northwest from Homestead, has chalcopyrite in a small shear zone, but development work has been interfered with by a basalt dike which has obscured the deposit and interrupted its development.

The Cole Claims.—These claims are located in a branch gulch less than a half mile west of the river from Ballard's landing. The country rock is an altered volcanic breccia containing some chalcopyrite. The deposition of this mineral was probably influenced by a shear zone. The chalcopyrite is in fair sized grains and in minute reticulate veins. Much secondary quartz and chlorite are present. A vein about one foot wide is being followed with the expectation, after some further work, of reaching one of much greater width which is said to outcrop upon the hill. This larger outcrop was not visited.

The Ballard Claims.—These claims are on the other side of the small creek from the Cole claims and upon the same vein. They were reported to be in every way similar and were therefore not visited.

Adjoining the MacDougal group to the south is another Ballard group. These claims are on the extension of the shear zones of the MacDougal group. The description given of the latter applies as well to them.

Hill Claims.—South of the MacDougal group are a number of claims on which there is a variety of rocks belonging to the greenstone series. One of them, although locally called "monzonite," undoubtedly belongs to the greenstone series. Its exact original character was not determined. Although considerable development has been done in this rock the more favorable parts of this group are those places where the conditions are similar to the MacDougal and Ballard claims.

Native Copper Deposits.—Just north of MacDougal's a dense greenstone contains native copper in small quartz veinlets. In thin section the rock is seen to be made up of alteration minerals. These deposits were not visited. Judging from the specimens, its location, and the description given of it the resemblance to Lake Superior deposits is rather striking.

Limestone Contact.—Between MacDougal's and Carnahan's close to the river a bed of andesitic breccia is in contact with limestone. A large portion of the steep-dipping limestone has been eroded so that the underlying breccia which is impregnated with pyrite and chalcopyrite is exposed for inspection.

This very low grade copper deposit probably does not extend more than a few feet from the contact. It is not a contact-metamorphic de-

posit because the limestone was deposited upon greenstone, while in contact-metamorphic deposits the igneous rock is intruded into limestone. One would naturally expect that there would be more or less of a channel for percolating waters between two rocks of a different nature, and that these waters would have some mineralizing effect. In this particular case, for instance, the waters percolating through the limestone coming in contact with a rock such as greenstone is apt to develop some iron and copper minerals. It is only exceptionally that a contact of this type makes ore.

Other Claims.—Many claims near the mouth of the Imnaha and for some miles up this stream have been patented for some years. These claims are reported to have large quantities of low grade chalcopyrite ore, but no information could be secured as to the type of deposit or the country rock. At other places deposits of copper are reported both below and above the mouth of the Imnaha, especially along the Snake river. Some 20 miles north of Homestead near the Snake river a gold prospect equipped with some sort of small stamp mill is reported to be in operation a part of the time.

In the northern part of T. 5 S. R. 46 E. is located the "Williams mine," a prospect which is reported to be a quartz vein containing a small percentage of copper in chalcopyrite form containing some gold. The nature of the country rock is not reported.

SOUTHERN SLOPES OF WALLOWA RANGE

Much of the area south of the Wallowa range and north of lower Powder river is covered by recent lava flows. Those areas not so covered are, with the exception of the small area of granite upon which the town of Sparta is located, made up of old sediments and old lavas and volcanics. The steep slopes and high ridges which form the upper drainage area of Eagle creek are made up of various sediments and old volcanic flows and breccias in considerable complexity. The lower foothills from near Sparta west to North Powder, where they are not covered by Columbia basalt, are seen to be made up almost entirely of greenstones.

EAGLE CREEK DISTRICT

Eagle creek is an important stream with several branches that head far back into the Wallowa range. Upon these several branches which reach even to the western limits of the Cornucopia mining district are many quartz veins and placer deposits. There has been little

activity in the development of quartz veins in recent years, but the placers, although not as active as formerly, are worked in a small way.

Much limestone is found in the upper drainage area of Eagle creek. This limestone and the other sediments which are largely calcareous appear to have once covered much of this region but now only remnants remain which have escaped erosion. These limestones, sandstones and argillites have frequently been made schistose and crystallized by the mountain building forces which created the Wallowa range.

It appears probable that in this locality as elsewhere in the Wallowa region these sediments were laid down upon a wide belt of old lavas and breccias. Volcanic breccia is also frequently interbedded with them. These breccias and old flows have been generally altered and nearest to the Wallowa granodiorite intrusion have been compressed and altered into dark green amphibolitic schist.

Quartz Mines and Placers.—The two branches of Eagle creek which have received most attention in quartz and placer mining are East Eagle and Paddy creeks.

About two miles south of the George W. Smith claims and located in the argillite is the *Conundrum group* of claims which are owned by James Chandler of Carson. The country rock is argillite and greenstone. The vein strikes E.-W. and dips about 50° S. There is but a few inches of quartz in the vein, but it is reported to have good values in gold.

Some five or six miles up from the mouth of East Eagle creek is the *Woodard group* which has considerable development in a large quartz vein in what is reported to be argillite. The vein contains copper and gold.

Two miles above the mouth of this same creek is the *McGee property,* commonly known as the Sheep Rock mine. The rocks in this locality are sandstones and volcanic breccias somewhat tilted. Upon the Sheep Rock claim there is a dike of altered igneous rock 30 to 40 feet wide which strikes N. 40° W. and dips 50° SW. There is auriferous quartz on both sides of this dike. The veins are from 10 to 18 inches wide and contain from $1 to $3 in gold besides carrying some pyrite and chalcopyrite. The principal veins on this property have a strike from N. 30° to 60° E. and a dip of from 27° to 37° NW. These veins have gouge and show slickensides on both walls.

According to an engineer's report upon this property from which

the above statements are taken, some of these veins have widths of 20 to 40 inches and values, secured by panning, of from $1.40 to $16.80. Considerable development work has been done on these claims.

On *Paddy creek* considerable work has been done, most of which has been upon lens-like veins in sedimentary rocks. Although there is a mill upon one of the properties the production from occasional runs is very small.

The *placer mines of Eagle creek* have been worked ever since the late '60s, and each summer some placer mining is done. All along Eagle creek there are benches of heavy gravel up to 100 feet above the stream. These benches have been worked to some degree from below the mouth of Paddy creek to a few miles up stream beyond the mouth of East Eagle creek. Placer mines are also found both on upper and lower Paddy creek. It is reported that late in 1914 the deposits, both bench and stream, near the mouth of Paddy creek and above on Eagle creek have been sold to persons who promise extensive operations.

SANGER DISTRICT

The Sanger mines are located in the northern part of T. 7. S. R. 43 E., on the western side of Eagle creek in a quartz and placer mining area which has a record of considerable production. There has been little activity outside of small placer mining operations since 1900, and the camp is said to have only one permanent resident. The mine workings are reported to be inaccessible. This locality was not visited.

The ore deposits are several miles distant from the granitic outcrops of both the Wallowa range and the Sparta district, and may have been due to the intrusive influence of either or both. Because they are located in argillite and far to the north of Sparta they have for convenience been grouped with those others which were the undoubted product of the Wallowa intrusion.

The following description of the deposits and the production from the placer mines of Sanger is taken from the work of Waldemar Lindgren* frequently quoted in this report:

"The vicinity constituted the old placer camp of Hog'em, and from the gulches leading up to the mine the sum of $500,000 is reported to have been extracted. The principal vein, called the Summit lode, was discovered in 1870, and actively worked during the fol-

*Waldemar Lindgren. The Gold Belt of the Blue Mountains of Oregon. Twenty-second Annual Report U. S. G. S. Part II., pp. 738-739.

lowing years. In 1874 the production was $60,000, from ore containing $16 per ton. Just how much was produced up to 1887 cannot be ascertained, but it is not probable that the amount was very great. In 1887 a 10-stamp mill was built, and in 1889 the production began to increase rapidly. During the four years 1889-1892 the Mint reports give a total of $813,000 for this mine. Work was discontinued in 1897 and the mine was idle until December, 1900, when preparations were made to reopen it. It is commonly given as $1,500,000, and this figure is very likely approximately correct.

"The developments consist of several tunnels and an incline shaft 400 feet deep. Unfortunately there was no opportunity to examine the deposit, so that the information available is scanty.

"The country rock is a black clay slate, containing pyrite near the veins. The latter are well-defined quartz veins, with clay selvage, and dipping at gentle angles. To judge from available specimens, the ore is a normal coarsely crystalline vein quartz, with a little gray calcite. It contains about 3 per cent sulphurets, consisting of pyrite, chalcopyrite, brown zinc blende, and a little galena, together with free gold. On the whole, it has considerable similarity to the ores of many California gold-quartz veins. The principal vein is said to contain three pay shoots. The upper stopes were worked for a horizontal distance of 600 feet, 50 to 100 feet below the surface. The average width of the vein was here 15 inches, and the ore yielded $20 to $25 per ton. Below the zone of surface oxidation the vein was from 2 to 4 feet wide and the ore yielded $12 per ton. If these figures are reliable it may mean that the oxidized vein has been leached and compressed to smaller volume; while the absolute amount of gold remained the same the tenor appeared to be increased by this process.

"Several other mines and prospects have been discovered in this district. Among them are the Basin claims, a few miles northwest of Sanger, which have been small producers. Three miles southeast of Sanger is the Snowstorm, cropping in greenstone, striking northeasterly and dipping 30° N. W., developed by a 160-foot incline. Some rusty quartz was extracted and milled in the arrastre at Lily White.

"The Lily White is situated 4 miles southeast of Sanger, on the divide between Eagle and Goose creeks, has the same strike and dip, and crops in argillite country rock. The production is small.

"Four miles south-southeast of Lily White, on the same divide, is the Dolly Varden. This is a big outcrop of rusty quartz and silicified shale, developed by irregular surface cuts and pits. No regular vein could be recognized. The Mint reports credit this locality with a production of $115,000, probably contained in rich pockets."

THE GREENSTONE COPPER BELT

There are three large exposures of greenstone in the drainage area of lower Powder valley, only one of which is of much importance

as a mining territory. The one west of North Powder has been mentioned in the discussion of the Bald Mountain-Elkhorn Region; the other is nearly surrounded by the most northerly bend of Powder river and is commonly known as Farley hills. No description of either of these greenstone areas will be attempted. The third area extends from Medical Springs south and east some 20 miles.

This latter greenstone belt makes up much of the middle drainage area of the various creeks which flow southward from the Wallowa range into Powder river, of which Goose and Balm creeks are the most important streams when considering the prospects of this region. As examples of the two types of copper deposits found in this area two prospects which are apparently the leading ones, will be described. They are the Gilkeson group with its chalcocite deposits and the Poorman group which contains chalcopyrite. These two properties are only three miles apart.

Gilkeson's Claims.—These claims are located on upper Clover creek in Sec. 24, T. 7 S., R. 42 E. The region in which these claims are located is made up of low hills, some of which are capped with basalt and many of which are partially forested. The older rocks are the typical greenstones. Surface alteration has made it difficult to determine their exact character, but many of them are undoubtedly amygdaloidal with calcite filling. One of these flows near Copper

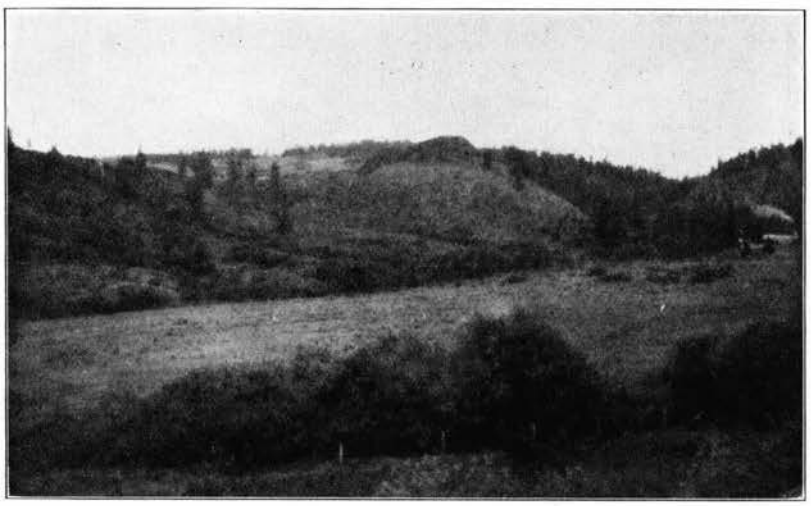


Fig. 69. Copper butte.

Butte, which apparently makes up the horizon of economic interest, has been very badly shattered. In fact the whole flow seems to have been sheared in a very irregular manner. Although it probably can not be called a shear zone, still this shattering serves the same purpose since it permitted easy access for the circulating waters to do their work of deposition.

In many of the joint cracks cuprite and chalcocite have been deposited. Some of the chalcocite stringers are as much as one inch in thickness. Chalcocite is also found disseminated in many places in the shattered greenstone. The exact thickness of this flow which contains chalcocite and cuprite could not be determined. It appears to be flat lying and from 60 to 70 feet thick. The upper part is highly amygdaloidal, while the lower part, as shown in a shallow shaft, is dense in character. The development work has not been of such a nature as to give even an approximate idea of the amount of metal available. A few short tunnels and shallow shafts have been made on the richer stringers. Surface crosscuts and crosscutting raises would best determine how much of the flow contains copper.

This property known under the various names of Gilkeson, Copper Butte, and Copper Queen had at one time a small furnace constructed upon it. The slag rich in copper from this small furnace can still be found nearby. It is reported that about 100 tons of 12 per cent copper was shipped in early days and some copper ore of lower grade is seen upon the dumps. If this is a flat deposit, as before intimated, the development, which was done before the idea of disseminated copper in shattered zones became as well understood, was evidently done in an attempt to determine whether the ore went down or not. Shafts and other development soon reached the dense part of the flow, which proved disappointing, and development has languished even until now.

The Poorman Group.—The Poorman claims are situated in Secs. 32 and 33, T. 7 S., R. 43 E., between Balm and Goose creeks, on a small stream known as Slide creek, which flows through the property into Balm creek.

The topography represents a partially eroded basaltic plateau and is characterized by small streams whose branches head into comparatively short gulches. In this immediate vicinity the basalt caps only the higher ridges and is not of very great thickness.

The country rock is for the most part a dense altered greenstone, somewhat brecciated and cut by quartz-calcite gash veins. In some

parts it is very siliceous, which may be due to the more acidic composition of the original rock or as is more probable to secondary silicification as a vital or contributing factor. On account of the obscuring effect of alteration not much can be said about the original character of these rocks. It is probable, however, that they were trachytes and andesites. For instance one specimen taken from the outcrop shows a light-colored dense rock cut by gash veins of pyrite. In thin section it is seen that the groundmass is a confused indeterminable mass of alteration minerals consisting chiefly of chlorite and sericite. Apparently the rock before alteration had a texture approaching closely that of a glass. It can also be seen in the thin section that pyrite is associated with quartz in the veinlets.

The mineralization is in a shear zone having a strike of about N. 65° W., a dip of from 40° to 60° to the south and is from 150 to 300 feet in width. On the surface the red stain of iron oxide is very noticeable, and occasionally there are stringers of hematite from one to two inches in thickness. Pyrite was found on and near the surface associated with quartz in gash veins. At a depth of one to two hundred feet chalcopyrite is the chief ore mineral. Many large sized blocks that have been taken from the development drift and crosscuts have had enough chalcopyrite in gash veins to contain 7 per cent copper. These richer portions may in fact be considered as a type of quartz vein. This is well illustrated by a specimen from a silicified zone. Chalcopyrite is in the form of gash veins. The rock is intensely silicified and appears to have suffered a brecciation since the silicification, as is shown by the fact that the cavities are partially filled with minute quartz crystals intermingled with chalcopyrite. In thin section it is seen that the main mass consists of interlocking quartz grains impregnated with chalcopyrite, and also cut by gash veins of chalcopyrite. In these veins some chlorite is associated with the chalcopyrite.

Not enough development work in crosscutting has been done to find out the extent of the deposit. The similarity between this region and the silicified flows of the Iron Dike mine in the Snake river region is quite striking, and it may be that future development work upon these fractured zones may reveal some similar high-grade portions.

It seems probable that this brecciated zone in the old greenstones made an excellent opportunity for the replacing action of hot ascending silica solutions which carried their metallic content, although a

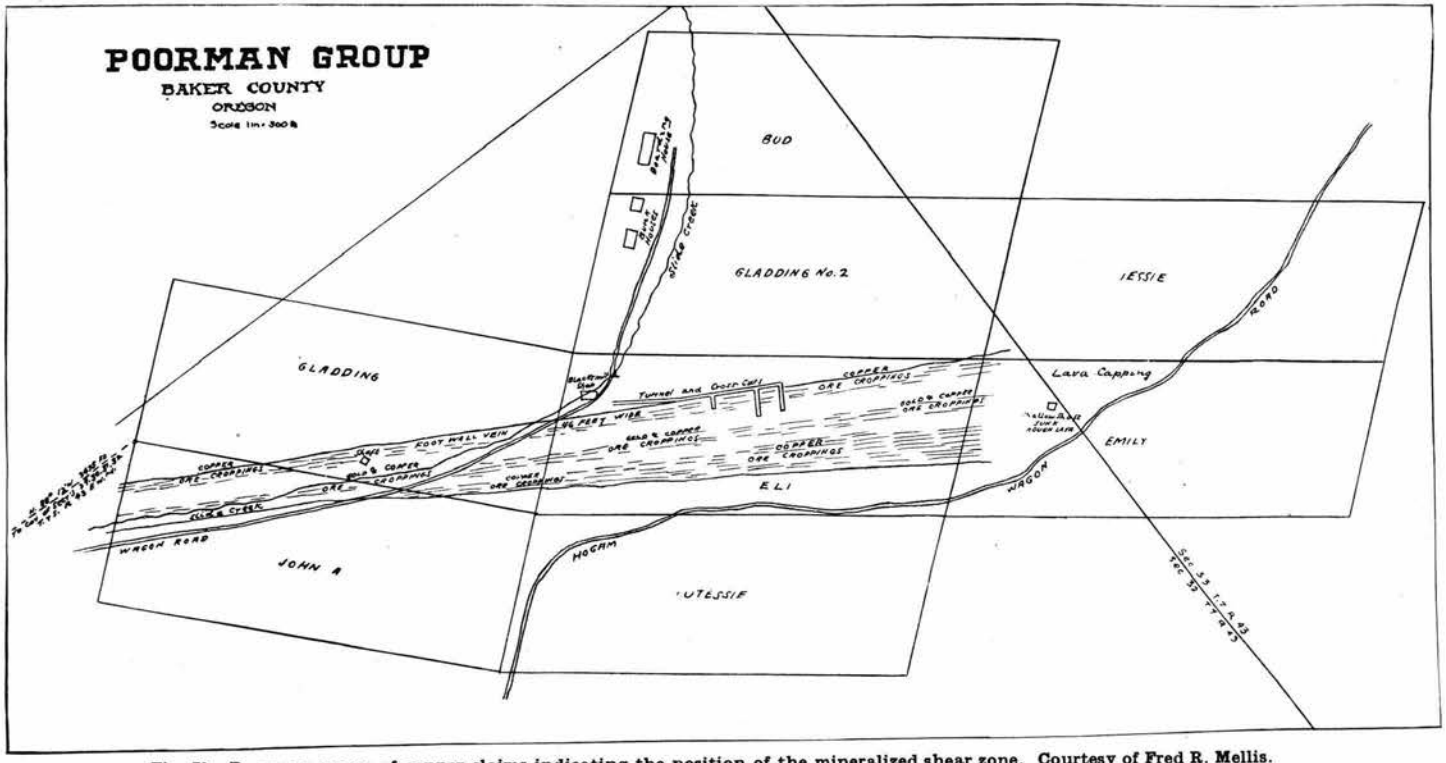


Fig. 70. Poorman group of copper claims indicating the position of the mineralized shear zone. Courtesy of Fred R. Mellis.

certain portion may have been leached from the greenstones. The excess of silica and the presence of gold would indicate other sources besides that of andesitic or basaltic lava.

After the silicification and impregnation of pyrite and chalcopyrite the zone was fractured again and probably a further concentration of the copper took place by circulating or perhaps even descending waters.

The specimens clearly show a brecciation after the silicification, and it is not unreasonable to suppose that where this fracturing is most pronounced there might be found deposits of richer ore.

One noteworthy fact in this connection is the scarcity of copper on the surface. It may have been that meteoric waters have leached the copper from the upper part of the mineralized zone redepositing it again at depth and leaving on the surface iron oxide and a certain amount of unoxidized pyrite.

Other claims which belong to this greenstone area are those located upon upper Goose creek, the next tributary of Powder river east of Balm creek. H. C. Thomas and H. W. Forster have claims about three miles south of Sanger, near this stream. The country rock is a dense greenstone, in places slightly brecciated and cut by small irregular quartz veins which contain small amounts of galena, zinc blende and chalcopyrite.

C. C. Cox, of Baker, has two groups of claims in this region. One group is located about three miles south of Sanger on Goose creek, and the other three miles still farther south on Sawmill gulch, a tributary of Goose creek. The country rock in both places is a dense greenstone. At the upper claims there are small lenticular veins which contain chalcopyrite. At the lower claims the country rock is cut by small gash veins of quartz and pyrite. They also contain some epidote and chalcopyrite.

There has been in previous years a great deal of activity in this greenstone area in prospecting for copper, but in the last few years the work has been almost entirely confined to the required assessment work and much ground has been abandoned.

DEPOSITS IN THE SPARTA GRANITE DISTRICT

The Sparta mining district is located in T. 8 S., R. 44 E. This township is between lower Eagle creek and Powder river, and with the exception of its northern border is a granitic area surrounded by recent basalts. Doubtless it was once entirely covered by the Columbia river basalt since Sparta Butte, close to the town of Sparta, is an uneroded remnant of basalt. The Sparta region, no larger than 30 square miles, is a granitic stock which was intruded into the older greenstones and sediments. These older greenstones and sediments which covered this granitic stock at the time were eroded from its top. Afterwards when the great flows of Columbia river basalt spread over wide expanses in eastern Oregon they covered the Sparta region also, and erosion, with the exception of the northern border, has not fully uncovered all of the intrusion which had been uncovered previous to the first flow of this late basalt.

This intrusion is a light-colored rock of very coarse-grained texture, and consists chiefly of feldspar and quartz. The rock, in thin section, is seen to be composed chiefly of albite feldspar, which sometimes shows zonal growth with the central portion of the feldspar crystals more basic than the outer parts. This rock is a soda granite and the much larger quartz grains and the more basic portions of the feldspars suggest that it is a more acidic phase of the intrusion which elsewhere in eastern Oregon is almost altogether the more basic granodiorite. Besides the granite there are outcrops of porphyry in the vicinity.

In the granitic area adjacent to Sparta we have normal fissure veins formed by the deposition of quartz coming from the cooling mass below. The same type of vein is found cutting the greenstones, but the more distant they are from the intrusive the less extensive is their mineralization.

There is very little activity in mining in this district at the present time. Some work is being done upon the Haybolt property and at the Gem mine. A small amount of placer mining is also carried on. The surface of the granite is badly weathered and the shafts and various tunnels and open cuts have nearly all caved in so that there is little to be observed.

On the *Haybolt property* development work is being done upon stringers of quartz which are reported to be frequently of high grade.

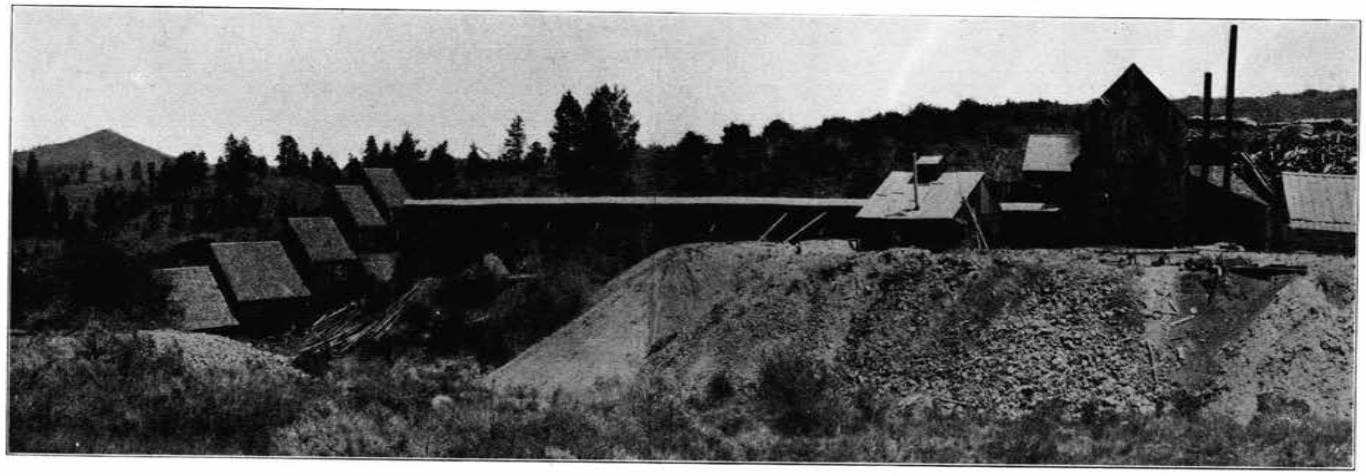


Fig. 71. Shaft house and mill at Gem mine.

The *Gem mine,* located upon a vein which strikes N.-NE. and dips 30° E., has been developed to the depth of 500 feet. The development is well illustrated in the figure. The mine workings were filled with water in June, 1914, but it is said that the vein shows sharply-defined foot and hanging walls up to four feet apart. The vein filling consists of crushed and altered granite with streaks and lenses of quartz up to two feet wide. The ore is ordinarily coarse-grained quartz,

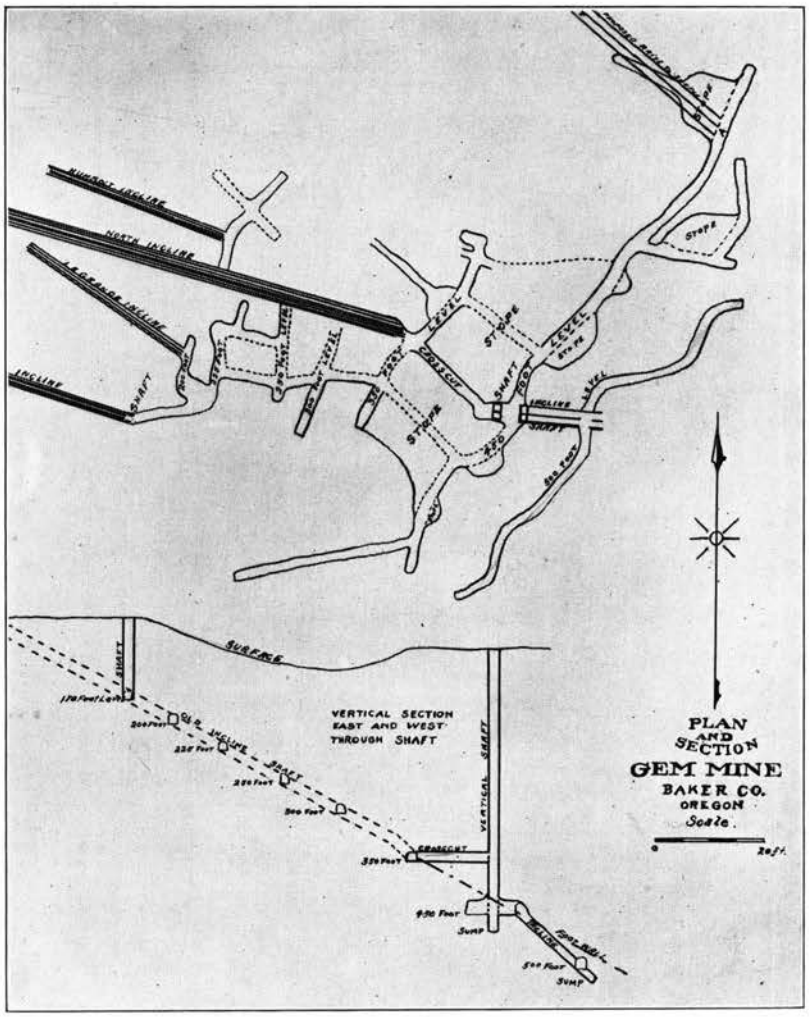


Fig. 72. The Gem mine.

containing free gold with some pyrite and black zinc blende. Neither the record of production of the Gem mine nor of any of the other properties in the district is available.

The granite which forms the country rock at Sparta is deeply decomposed and the gulches are filled with gravel. These gulches draining in all directions from the highest elevation contain placer gold. There was but little water for placer mining in the early days until the Sparta ditch was completed in 1873 to furnish water to the various gulches. This ditch is 22 miles long, with a reported capacity then of 3,000 miner's inches or 75 cubic feet per second. A good deal of activity in placer mining followed its completion for a few years, but the water is now used almost altogether for irrigation.

THE VIRTUE DISTRICT

This old mining district, about seven miles east of Baker, is situated in the great bend of Powder river in a region of low arid hills, 3,400 to 5,000 feet high.

GEOLOGY

The geology is similar in the main essentials to that of the other mining sections of eastern Oregon, in that the ore deposits are the result of an intrusion into older flows and sediments. Obscured as it is by the covering of hillside wash, basalt, and lake beds laid down since the time of the intrusion and only partially removed, makes field investigation difficult.

The intrusion exposed over but a limited area in the northern part of the district is a greenish-gray diorite, grading into gabbro. This diorite is probably a local development of a granodiorite intrusion. By this we mean that the intrusion in stoping its way into the older greenstones and argillites has incorporated so much of these older rocks that its acidic nature has been so modified on this upper part as to become sufficiently basic to be called a diorite. Erosion has exposed nothing but the diorite, but there are many things which evidence that underneath this modified exterior it will shade into granodiorite at depth.

The argillites and greenstones into which the intrusion came have been much mashed and altered by regional metamorphism, doubtless both before and during the time of the intrusion. Of the older rocks greenstones predominate in the northern part of the district, while argillites are the chief older rocks in the southern part. They doubtless continue underneath their basalt covering many miles to the south and west. Thin basalt flows are found on the tops of the elevations and on much of the hillsides. In Virtue Flat lake bed materials to considerable depths exist.

ORE DEPOSITS

At different times during this period the intrusion was fractured and its roof of sediments and flows as well. Into these fractures was injected the dikes which grade from basic to acidic, the latter from granodiorite-porphyry to aplite. After the dikes had been formed, later fractures were filled with gold-bearing quartz

deposited in them by hot ascending waters coming from the intrusion itself. Since the intrusion apparently is a stock or roughly circular, it is to be expected that there would be no parallel vein system. The quartz veins strike in many directions and individual veins are not traceable for long distances. Most of the deposits are normal, simple, quartz veins containing very small amounts of sulphides and the free gold is coarse and contains but little silver. Very rich pockets were frequently found. The total production of the district is about two and one-half millions.

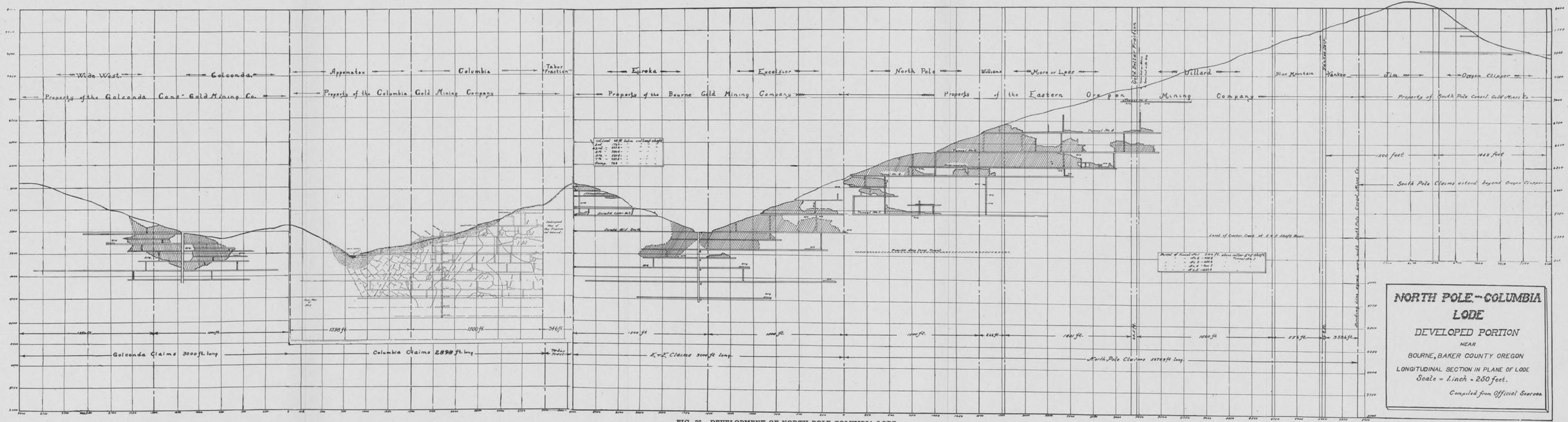
The Virtue mine, the most productive in the district, was discovered in 1862, and is by wagon road about eight miles from Baker. A great deal of work was done in the eight years following its discovery and with the exception of seven years beginning in 1884 the mine was in operation most of the time until 1889. Since that time there has been no production from the mine, although some $1,500 was extracted from the dump. Its total production is $2,200,000.

There are two levels above and eight below the lowest tunnel level. From the 800-foot vertical shaft each 100 feet has crosscuts to the vein where the development varies upon each from 1,000 to 1,400 feet.

There are eight nearly parallel veins, but only two have produced and only the most productive one farthest to the northeast will be described. The veins strike N. E. and their dip southwest varies from 45° to 80°. The principal vein's width is from 6 inches to 12 feet, but the average is about 14 inches. The length of the shoot is about 1,200 feet from the seventh level up to the tunnel level. There was not much ore stoped below the seventh. The average yield per ton in the upper workings was from $20 to $40, while from the later operations in the lower levels it was about $15.

The rock is a fine-grained dull greenish-gray greenstone, which was originally a volcanic tuff or breccia. Most of it is very much altered.

The Flagstaff mine, 4 miles north of the Virtue mine, and about 6 miles from Baker, is on the small knoll in the same low range of hills. Work was begun here about 1894. It has a 760-foot incline from which drifts on the different levels total approximately a mile. The vein roughly parallels the Virtue, but dips in the opposite direction about 65°. A 20-stamp mill and cyanide plant has been erected, but the production has not been large. Except for the time in the spring of 1910 it has not been worked since 1900.



NORTH POLE — COLUMBIA LODE

DEVELOPED PORTION

NEAR

BOURNE, BAKER COUNTY OREGON

LONGITUDINAL SECTION IN PLANE OF LODE

Scale = 1 inch = 250 feet.

Compiled from Official Sources.

FIG. 76. DEVELOPMENT OF NORTH POLE-COLUMBIA LODE

The country rock here is the diorite previously described. The vein is said to have an 18-inch pay streak in a very persistent 5 to 8-foot vein. The ore is white massive quartz with little calcite and few sulphides. The average value of the ore is said to be $16 in gold, about 800 fine.

The White Swan mine, about three miles southeast of the Virtue, has been practically idle since 1903. The mine was worked successfully in the 80's and was idle from 1897 to about 1900, when it came into the possession of Letson Balliet, who operated this and other properties with a brass band and other similar features until 1903, when the Federal government stopped his operations. Previous to his time the production was estimated to have been not less than $200,000.

The country rock here in contrast to the diorite at the Flagstaff and the greenstone at the Virtue is a black soft argillite with a few well-defined diorite dikes which are off-shoots from the intrusion below. There are many small veins in the vicinity of the White Swan and in some of these chimneys of coarse gold have been found, although none of large amounts.

The Norwood mine, near the Virtue, is in similar greenstone, which is more altered. There are several veins, most of them too small to be considered seriously. Quartz and calcite are the vein minerals which in many of the veins has been shattered and slickensides are present as a result of these movements since the vein was formed. The largst vein is an E-W. steep dipping vein, consisting of quartz, gouge and altered rock. The average width of this vein for 450 feet is about 2 feet. In 1913 a small mill was installed, but no idea of the value of the ore could be obtained and apparently no systematic sampling has been done recently.

BALD MOUNTAIN-ELKHORN REGION

This region comprises several mining districts whose deposits are the result of a giant intrusion of granodiorite, the present exposure of which is practically of the same extent as that of the Wallowa range, or about 250 square miles. In contrast with the Wallowa intrusion, a northwest-southeast range of granitic rocks, the granitic exposure in this region has a very irregular outline. Its maximum dimension east and west from below the Baisley-Elkhorn mine to its limit on the lower western slopes of Bald mountain is some 20 miles; its southernmost outcrop is near the wagon road from Sumpter to Granite, and it is observed at least 6 miles north of Camp Carson on the Grand Ronde river.

Bald mountain, although 767 feet lower than Rock Creek butte (9,097 feet) and nearly 600 feet lower than several other points on Elkhorn ridge, because of its isolation from this main ridge is an object of more frequent observation and is hence better known than any of the higher points.

Consideration is given above only to the exposures of the granodiorite intrusion. The area coming under the influence of the intrusion is much greater. Its length from the old town of Auburn southwest of Baker, northwest to beyond Camp Carson is at least 30 miles, and its width from near North Powder to the town of Granite is at least 20 miles.

Elkhorn ridge then, with its series of high elevations, is the backbone of this region, with Bald mountain at one side as a partially isolated eminence. Granodiorite probably welled up underneath all of the Elkhorn ridge as well as under much additional area on each side. Erosion has since uncovered only a part.

On the south the older rocks into which the intrusion stoped and pushed its way are nearly all argillites. To the west they are mainly recent flows, but erosion has proceeded far enough to have removed irregular patches of the older rocks next to the granodiorite.

East of the intrusion no older rocks were seen. The granodiorite is succeeded at the eastern base of the Elkhorn range by Baker valley with its glacial drift and wash of more recent time. However, the argillites to the south of the exposures of the intrusion continue to Baker valley and on southeast to Auburn, thus making up the southeastern part of Elkhorn ridge for several miles in that direction before they pass under the recent basalts of Powder river.

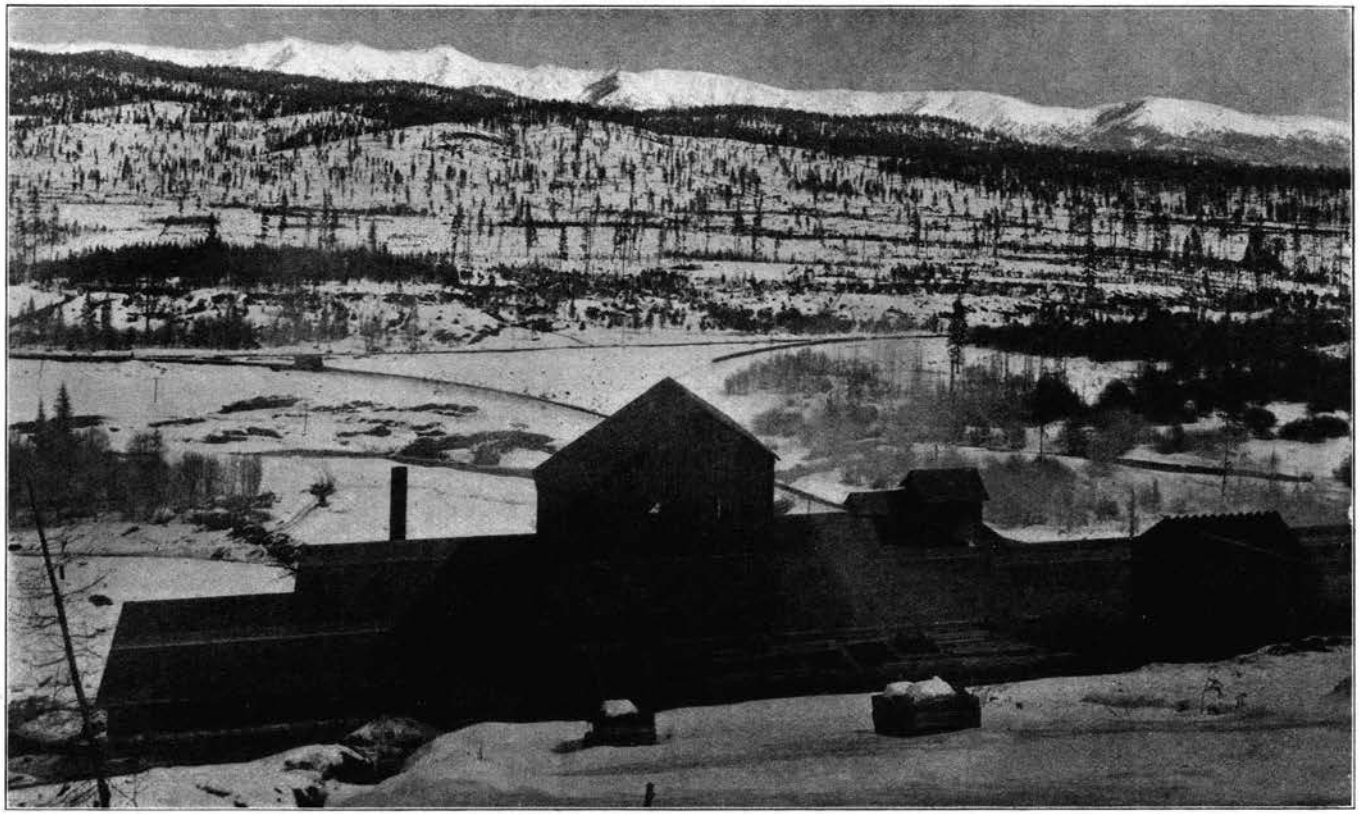


Fig. 73. Elkhorn ridge from the Sumpter smelter, across Sumpter valley.

The limits of the granodiorite north of Camp Carson were not reached, but greenstones prevail generally west of North Powder and doubtless continue around for some distance on the northern border it is by the covering of hillside wash, basalt, and lake beds laid down to be met lower down on the Grand Ronde river by the northwestern border of recent lavas.

Ore deposits are found in granodiorite, in argillite and, west of North Powder are some in greenstone.

The mining districts are Granite and Cracker Creek, almost entirely in argillite. Cable Cove, Camp Carson and parts of the other districts are in granodiorite.

THE GRANITE DISTRICT

The Granite district comprises the placer mines of Granite and Bull Run creeks to the north and east of Granite, and those on the north fork of the John Day river.

PLACER MINES

The several branches of Granite creek have been extensively placer mined, and if the depth to bedrock is sufficient there are considerable areas from Lawton to upper Bull Run creek which possibly might be successfully dredged.

During the summer of 1914, a specially designed light-weight dipper dredge was constructed on what is known as the Wetherell placers, in the upper part of Bull Run creek, but it so far has failed to handle much yardage. The machine is not properly designed for the work and is entirely too light for such heavy duty as gold dredging demands.

The north fork of John Day has several placer deposits of which the Trail creek, Klopp and Crane creek placers are examples. One of these deposits located on Crane creek had a dredge installed on it by Albert Burch and associates, but this dredge has been idle for some years. These placer deposits were not visited.

QUARTZ MINES

The quartz mines situated along the western border of the granodiorite intrusion are practically all in the irregular patches of argillites exposed between the intrusion and the recent lava flows.

The quartz mines, beginning with the one farthest to the south, are the Cougar, Independence, Magnolia, Buffalo, Blue Ribbon and

La Belleview in argillite, and the Monumental, on the northwestern slope of Bald mountain, in granodiorite.

Cougar Mine.—About 3 miles north of Granite, a half mile west of the creek is the Cougar mine, at an elevation of 5,200 to 5,400 feet. It was discovered in the 90's. The development extends over a vertical distance of 300 feet and consists of short crosscuts to the vein and over 2,000 feet of drifting on three levels.

The country rock is a black siliceous semi-slaty argillite. The strike of the lode is northeast and its dip is 60° to 70° S. E. The underground workings, combined with the surface pits, trace the lode for about 2,000 feet. The outcrop on a gently rolling timbered ridge is inconspicuous. The lode is from 2 to 10 feet wide, although in the lower and recent development it appears in one place to be much wider. The walls over a considerable area in the stopes are fairly well defined, although the filling is largely brecciated argillite.

There is very much less quartz than in most of the brecciated zones in argillite in eastern Oregon. Aside from the quartz and shattered argillite, there is a gouge of light color that is said to contain the highest values which gradually lessen away from it. This would indicate that the ore was deposited by a combination of replacement and quartz filling of the smaller fractures. There are 3 or 4 shoots in the 1,200 feet of development on the strike of the vein, whose combined stoping length is more than half that distance. According to reports there is a large tonnage of ore averaging nearly $7 a ton and a much smaller quantity in one block which contains nearly twice that value per ton.

A few thousand tons at various times have been stoped and treated in a crude mill upon the property, but there is practically no free gold even at the surface. Cyaniding this ore, which is by no means easy to treat although the sulphides are nearly all pyrite, has been attempted by incompetents or else the management so interfered with competent metallurgists that they gave up in disgust before a process could be successfully established.

Of the gross value in the tonnage of ore treated all but a tithe went down the creek. In the last few years work has been confined to development 100 feet below the mill level for 500 feet along the vein.

Independence Mine.—The Independence mine is located about one mile northwest from the Cougar on the opposite side of the same ridge.

The country rock is argillite. The underground development of

the vein along its strike is about equal to that of the Cougar, although the development on the dip is only about 200 feet. It has approximately the same strike and a little flatter dip to the southeast. It is developed by an incline and two tunnels.

There are two shoots of ore, the larger one having a stope length somewhat in excess of 300 feet and the smaller a little over 100 feet. The average width of these is slightly less than three feet.

A block of ore from the larger shoot of some 3,000 or 4,000 tons has been milled in the Independence mill, situated about one-half mile farther down on Granite creek. Cyaniding has been attempted, but with indifferent success.

The ore is composed of gouge and brecciated argillite with a small amount of quartz. In the oxidized portion of the vein, which is considerable, the whole is much stained with iron precipitate deposited from circulating waters. Dolomite and quartz were observed in some places and chalcedonic quartz was also seen. Pyrite and arsenopyrite are found both in quartz and in argillite, while the silver minerals are largely confined to the dolomite. The oxidized portion of the ore is said to contain about $8.50 in gold, while below it is said to contain more than twice that value. The silver, about 2½ ounces in the oxidized portion, is said to be nearly 4 times that quantity below. Silver is quite easily dissolved and carried downward in the oxidizing part of the vein, but the large increase in gold content below can hardly be ascribed, except perhaps in part, to this cause, although there is present in the vein some manganese.

Late in 1914 the Gleason Development company acquired the property and began to make such adjustments and changes in the mill as were considered necessary to make cyaniding a success.

The Magnolia.—The Magnolia, also in argillite, has the same strike and dip as the Independence, and is located on the eastern side of Granite creek, about five miles away from the town of Granite.

There has been but little development since 1900, which has been done in extending the drift on the vein in the lower tunnel. The vein exhibits some small faults. Several shoots of short stope length are shown in the mine workings. The vein material is altered and silicified argillite with pyrite and arsenopyrite in the argillite fragments. The width of the ore does not often exceed 5 feet, and is ordinarily no more than 3 to 4 feet. Near the surface the vein shows a great quantity of chalcedonic quartz.

There is a mill upon this property containing plates and concen-

trators, but in the quantity of ore milled only a small percentage of the assay value was saved. The ore is not high grade; the average value is under $10.

Drifting in the fall of 1914 is said to have proven the existence of another shoot of ore of good width and fair value.

The Buffalo-Monitor.—The Buffalo-Monitor, situated on the southern slope of the divide between Granite creek and the north fork of the John Day river and about 5 miles from Granite, has two types of veins, the one narrow and frequently frozen to the walls and of high grade, and the other a broad shear zone about 50 feet wide, of crushed argillite of low value. The narrow high-grade veins are between walls of a dense highly siliceous argillite and close to the granodiorite intrusion which was observed in the development of the No. 3 vein, the farthest one in. These small veins are made up of gouge and fragments of argillite cemented together with quartz and hardened by silicification.

The ore minerals are pyrite, galena, tetrahedrite, chalcopyrite, and some stibnite, although occasional bunches high in galena contain gold and silver up to several hundred dollars a ton. Most of the ore shipped contained about $100 in silver and gold in the ratio of 16 to 1 by weight. The widest of all the various lenses was 30 inches, they were rarely more than half that and frequently only a few inches wide. Their stope and pitch length were usually only a few feet.

The Monitor vein approximately 50 feet wide, made up of crushed argillite with occasional seams of quartz, has been developed by one crosscut and some drifting and other incomplete crosscuts. The channel samples in the one crosscut taken in 5-foot section averages for the full width between $1 and $2.

The property has not produced for 5 years. The total production is said to amount to about $75,000, entirely from the 3 small veins.

The Blue Ribbon.—About a mile east of the Buffalo-Monitor, and on the Crane creek side of the ridge, is the Blue Ribbon prospect. It is developed by two crosscuts and drifts on the vein. This property is also in argillite. In the upper crosscut drifting on the vein has opened up two bodies of ore from 2 to 10 feet wide, and in values usually between $10 and $20, with occasional high values. The full stope length has not been developed on this level. Several hundred feet of work has been done in a branching crosscut in a lower tunnel in the search for the vein below, but so far these attempts have been unsuccessful. There was more than a foot of snow upon the ground, so that nothing could be observed of surface conditions.

La Belleview Mine.—La Belleview mine, about 2 miles northeast of the Blue Ribbon, is in argillite, but its location is such that during the time of the intrusion of the granodiorite into the argillite this particular locality was more intensely affected than elsewhere. Its situation is such that it is more than half surrounded by granodiorite and the nature of the reported mineralization indicates that granodiorite is but a comparatively short distance below the surface and the vein is probably in granodiorite in all but its upper part.

The vein has the same strike and dip as those just mentioned, although in the upper levels the dip is steeply to the northwest. The wall rock is highly metamorphosed. The ore minerals are pyrite, arsenopyrite, zinc blende, and galena, with small amounts of chalcopyrite and pyrrhotite. Specimens of the ore show that fragments of argillite in the vein have been considerably replaced by quartz and sulphides. Tetrahedrite and silver sulphide minerals are reported present.

The workings are inaccessible, but development work is said to aggregate about a mile and a half in drifts on the veins some 1,800 feet horizontally in a vertical distance of about 600 feet.

A production of $200,000 from 8,000 tons is reported, part of which is from crude ore and the rest from concentrates.

There are other veins of the same general character upon this property and at other locations in the agillite farther northwest.

VEINS IN GRANODIORITE

The Cougar, Independence, Magnolia, Buffalo-Monitor, Blue Ribbon and La Belleview, and various others not described, are in argillite on the general western border of the intrusion. Another series of veins in argillite are found upon the southern and eastern border, while upon the surface of the granodiorite itself, where it has been stripped of its cover of older rocks, is a large number of veins having the same general strike to the northeast as all the veins in the argillite.

Most of these veins are in Cable Cove mining district on the divide which separates the north fork of the John Day from that of Silver creek, one of the sources of Burnt river.

In Cable Cove district proper, there are an almost innumerable number of veins and doubtless upon much of the exposed surface of the granodiorite elsewhere, especially away from the central mass and nearer its border, are also many veins. West of Cable Cove, on the

northwestern slopes of Bald mountain, is the Monumental mine, and in the northern part of Cracker creek district are other veins in granodiorite. Far to the north, near the head waters of the Grand Ronde river, on the northern part of this great intrusion, is Camp Carson, where quartz veins in granodiorite and large placer deposits are found.

The Monumental mine, located on the northwestern slope of Bald mountain, is one of the oldest producing quartz locations in eastern Oregon, it having shipped some 14 tons of ore to San Francisco in 1874. Very little work has been done upon the property in the last 20 years.

The country rock is granodiorite and the principal vein strikes N.-NE. It consists of shattered granodiorite in various stages of alteration. Light-colored gouge and lenses of quartz containing pyrite, arsenopyrite, zinc blende, tetrahedrite and galena, together with some silver minerals in the richer ore, constitute the vein. The shattering and alteration of the granodiorite may be as much as 4 or 5 feet wide, but the lenses of ore have a maximum width of only 18 inches and stope lengths of less than 100 feet.

The production to date is reported to be approximately $100,000. Lindgren states that the gold values increase in depth.

CABLE COVE DISTRICT

Cable Cove is about 10 miles from the railroad at Sumpter, and is reached by a good wagon road up Cracker and Silver creeks. The elevation of the camp near the creek is about 7,000 feet, while the higher points are about 700 feet above. Although but of moderate elevation a great deal of snow falls in the various basins near here, of which Cable Cove is a type. The slopes of the divides are dotted with dumps and prospect holes upon the closely spaced parallel veins which cut across the district in a NE.-SW. direction.

Work was extremely active in this camp about 1900, a period of great activity in mining everywhere in eastern Oregon. Ore was discovered in the district in 1872, but not until 1885, when the transcontinental railroad was completed, did the district become active. One mill was erected previous to 1900, and others have been built since, but only a small mill was in operation in 1914.

The geology of all of these veins is simple since the country rock is entirely the intrusive granodiorite and aside from aplite only a few dikes are seen. Glaciation caused these basins to have their present

form. The veins are normal fissure veins, the result of an extensive system of parallel shearing planes. The vein matter consists largely of granodiorite crushed and chloritized, and close to the ore lenses in the more important veins, which are usually on the hanging wall side, the granodiorite is largely altered to sericite and kaolin. These high-grade lenses are rarely more than a foot in width and consist of a small quantity of quartz and calcite gangue and the remainder is heavy sulphides. In a few places concentrating ore of lower grade is found up to a few feet in width alongside the higher grade lenses. The ore minerals are arsenopyrite, galena, chalcopyrite, pyrite and zinc blende, with gold and silver.

The Imperial mine, the first one reached upon entering Cable Cove, was developed largely during the period of greatest activity at the beginning of the last decade. Three veins are upon the property, the Winchester, the Imperial and the Eagle, of which the Imperial has received the most attention.

The Winchester is apparently a branch of the Imperial vein, while the Eagle, although the widest and longest vein having been traced, it is said for 2 or 3 miles, because of its lower grade of ore has received but little attention since it was proven that their mill could not successfully concentrate these ores. The Eagle vein was not examined, but it is said to be as much as 15 feet between the walls. The vein material, largely altered granodiorite, contains streaks of arsenopyrite up to a half foot wide in some places, and in other places as much as 3 feet of $12 ore.

The Imperial vein usually from 3 to 4 feet wide, although there are places much wider, probably has the greatest alteration of the granodiorite between its walls of any vein in the district. The narrow lenses up to 24 inches wide, with stope and pitch length of usually less than 50 feet, are found usually near the hanging wall. The vein filling is made up of the fragments of granodiorite considerably altered, while considerable widths have been completely altered to a soft white gouge. This is usually close to or surrounding the lenses of ore. This alteration extends often into the wall rock of the vein and is doubtless due to the ascending hot waters which deposited the ore and altered the brecciated vein and the wall rock. The total production probably does not exceed $75,000.

The California mine, adjoining the Imperial on the west, is one of the oldest mines in eastern Oregon. It was located in 1873 and at various times up to the building of the mill in 1897 shipments of

Fig. 74. Part of Cable Cove showing location of properties described.

high grade ore were made assaying from $50 to $500 per ton. In 1897 several carloads were shipped. The 10-stamp concentrating mill was a failure. It is said that a test run upon $25 ore produced concentrates of less value than the crude ore. There has been quite a little development upon the property in several tunnels over a vertical distance of 800 feet, but the mine is not accessible.

The ore, like that at the Imperial mine, consists of heavy sulphides in quartz and calcite in narrow streaks in a 3-foot vein.

The Last Chance mine is located upon a probable northeastern extension of one of the veins of the Imperial mine. There are several veins on the Last Chance ground, but the one to which attention is at present directed is on the Last Chance claim. The vein is developed for 400 to 500 feet by a drift upon it.

The mineralization in this narrow vein is similar to those previously described. The maximum width of the ore is probably not more than 18 inches, and the greatest stope length of the shoots does not exceed 50 feet. The ore so far opened up, taking into consideration its width and nature, is not sufficiently high grade to pay operating expenses.

CAMP CARSON DISTRICT*

"The mountainous and heavily-timbered country north of Cable Cove does not contain extensive mineral deposits. Camp Carson, 20 miles in an air line north of Sumpter, is the principal mining district known in this region. Lying at the western foot of the high granite peaks of the Elkhorn range, near the head of the Grande Ronde river, it is accessible only by wagon road via Granite and Woodley, or by going up the Grande Ronde valley from the town of Hilgard. This district was not visited; the following notes were obtained from Mr. Imhaus, of Baker City:

"The formation is reported as granite. Near Hunters, 3½ miles below Camp Carson, on the Grande Ronde, are prospects on gold quartz veins containing much sulphurets. Among them are mentioned the Royal, 6 miles south of Woodley. The vein is said to be 7 feet wide and to contain chalcopyrite and galena rich in gold. From the Pay Boy, 1½ miles southwest of Woodley, two carloads of ore are said to have been shipped. From the Muir, zinc blende and galena, with good silver value, are reported.

"Old placers have been worked in the Grande Ronde below Camp Carson, and also on Limber Jim creek, 6 miles northward. Camp Carson itself is located at the head of Tanner's gulch, 1,200 feet

*Waldemar Lindgren. The Gold Belt of the Blue Mountains of Oregon. Twenty-second Annual Report U. S. G. S. Part II., pp. 676-677.

above Grande Ronde river. These high placers contain a large body of well-washed, cemented, coarse gravels, presenting a bank 2,500 feet long and generally 15 to 20 feet high. This body of gravels is not exactly situated on the divide, as there are granite hills rising behind them; but it is apparent that they must have been deposited by a river system at a very different level from that of today, and it is probable that they should be placed in the same category as those of the Griffith claims below Bald mountain.

"While the gravels contain gold, their cemented nature interferes with the normal hydraulic process. A French company bought the deposits some years ago and installed hydraulic works, but the enterprise did not succeed well and the property was recently sold at auction."

This district on the far northern slopes of the exposure of granodiorite was not visited and little additional development of interest is reported from it in quartz mining. This may be due largely to its isolation and the nature of the ore. Some work has been done upon the placer deposits since the above statement was made by Lindgren in 1900, although none of it has been done upon a sufficient scale to succeed. Reports upon placer conditions by disinterested parties indicate that there is probably a large yardage of gravel of fair to high grade.

EASTERN VEINS IN ARGILLITE

It will be observed that first is described the series of NE.-SW. veins in argillite extending from the Cougar to La Belleview, and located along the western exposed limits of the granodiorite. Next farther east is the lone Monumental vein roughly paralleling the previous ones. Still farther east are the many parallel veins in the granodiorite of Cable Cove, and still farther east, where argillite is reached again, other veins roughly paralleling the previous series are found extending from the Ibex to the Baisley-Elkhorn, a distance of some 12 miles. In between these latter groups in a series of fractures are found Bald mountain, the Mammoth, the great North Pole-Columbia lode, the Highland, the Maxwell and many other properties.

The Highland, Maxwell and the Baisley-Elkhorn are in the Rock creek mining district, which is reached from Haines in Baker valley. The Ibex and Bald mountain at the southwest extreme are reached from Sumpter by a 10-mile wagon road up McCully fork. The Mammoth is reached by a branch of the Cable Cove road on Silver creek. The mines of Cracker creek district are reached by a wagon road up from Sumpter to Bourne and Columbia.

Ibex Mine.—The vein at the Ibex mine strikes northeast with a steep dip to the southeast, and is located upon the divide between McCully's fork and Granite creek. The elevation of the croppings is about 6,300 feet, and the lowest and longest tunnel driven in from the western side of the divide is about 500 feet lower. The slopes are well wooded, as are practically all of the argillite areas, and from the croppings a fine view is obtained of Greenhorn mountains and the region to the west.

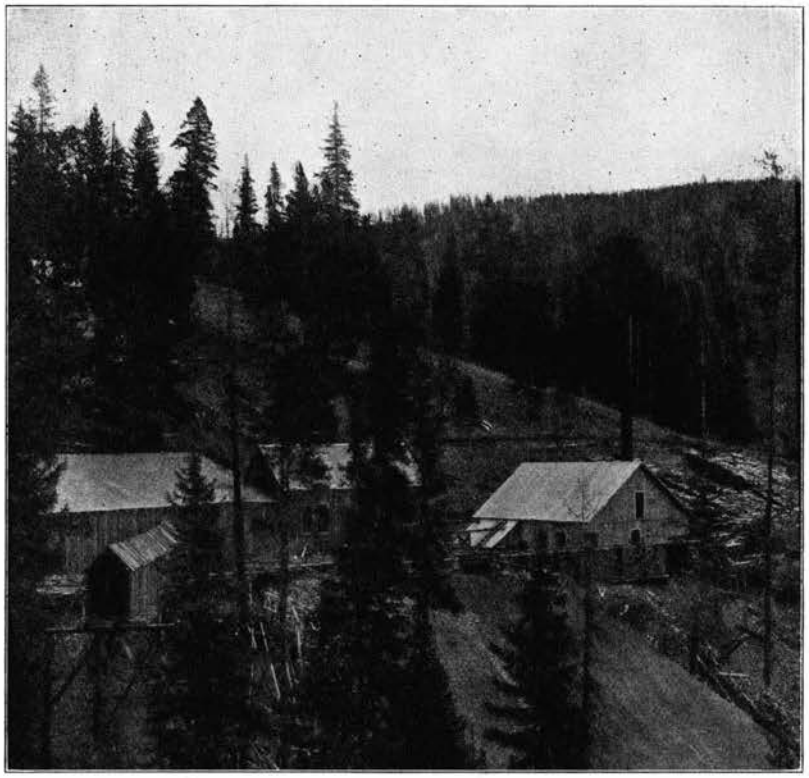


Fig. 75. Portal of lower tunnel, Ibex mine.

The vein entirely in argillite is developed by 4 levels, all but one of which has been driven from the surface. Most of the development, which totals about 1½ miles, has been done in the last 15 years. Development work upon the vein extends over a distance of about 3,000 feet.

This vein, as far as developed, averages about 5 feet, with a maximum width of 25 feet. The vein material for this width was originally a crushed and sheared argillite, the result of crumpling and movement of the earth's crust. Into this line of crushing upward flowing solutions deposited quartz between the fragments of argillite and has replaced in variable degrees of completeness much of these fragments with quartz. After the zone had been largely cemented togther and much of the argillite fragments silicified another movement in the vein fractured the quartz and silicified argillite which was cemented together again by additional silica brought up from below.

Small amounts of sulphides are found in the quartz and in the argillite fragments. These sulphides consist of pyrite and arsenopyrite. White iron or marcasite and mercurial gray copper, with small amounts of other secondary minerals, are found. The average value of the large amount of ore is said to be so low that high extraction and strict economy would be required for profitable operations. There is a wide variation in the quantity of silver present in various parts of the mine, a variation which bears little relation to the amount of gold contained.

The Bald Mountain mine is on the extension of the Ibex vein, and is said to be similar to it in every way with the exception that there is a greater proportion of quartz to argillite between its walls. Since the mill was built in 1901 very little has been done upon the property.

The Mammoth mine, although upon the McCully fork side of the divide, between that stream and Silver creek, is reached by a branch wagon road from Silver creek. This property, purchased from the Bald Mountain Mining company by the Mammoth Mining company a few years ago, was closed down late in 1914 after having been operated by the purchasers largely through a system of leasing since the time of purchase.

The country rock is granodiorite and argillite, but the vein is not a contact vein since the plane of the vein locally cuts both. There are two shoots of ore upon the property, one upon the Mammoth and the other upon the Belle of Baker claim. Little has been done upon the former for 12 years, the work having been confined largely to the latter since the discovery of rich ore there in 1900. It is here developed by a shaft and four levels. There are two shoots of ore about 50 feet apart, one with a stope length of 150 feet and the other

100 feet. These shoots go down to the 300-foot level, but wedge out above the 400-foot level.

The good ore follows along the foot of a black gouge streak near, but not on the hanging wall of the vein. The hanging and much of the foot wall is granodiorite. The vein is from 4 to 30 feet wide. It has been stoped from 2 to 20 feet wide. Assay values range from $2.50 to $10,000 per ton. The large stope averaged $5 to $6 a ton.

The vein material consists of sheared argillite and short silicified lenses in which much of the argillite has been replaced, alternating with irregularly located streaks of gouge.

The ore minerals, pyrite and arsenopyrite in small percentages make up the concentrates, while rich ore in the vein is usually wire gold associated with roscoelite.

The work in the last two or three years has been confined to the upper levels, especially in following a narrow streak in which pockets of high-grade ore were occasionally found.

THE NORTH POLE-COLUMBIA LODE

The North Pole-Columbia lode, roughly paralleling the Ibex, Bald mountain and Mammoth veins, and approximately a mile and a half southeast of them, is the most extensive gold lode in northeastern Oregon. It can be traced from near McCully's fork northeast to Rock creek, a distance of about 6 miles, by its frequent and oftentimes prominent outcrops of brecciated argillite cemented together with quartz. Considerable development has been done upon many claims between McCully's fork and Silver creek, among which are the Bunker Hill, Annalula, Amazon, Mayflower and Mountain Belle, located upon the two branches of the vein which splits upon the Golconda property.

These claims just mentioned southwest of the Golconda, although having considerable development upon the lode, which is frequently very wide and highly silicified, have produced practically no ore. They have been either abandoned, patented and lying idle, or else development is confined to the annual assessment work.

The properties which have a record of considerable production beginning with the one farthest southwest, are the Golconda, the Columbia, the Taber Fraction, the Eureka and Excelsior, and the North Pole. The South Pole, upon the same lode and adjoining the North Pole on the northeast, has but a small record of production.

The country rock is the usual black siliceous argillite, sometimes

schistose, but more often massive. In addition to the argillite there is near the vein on the Golconda on its footwall side a body of greenstone, while on the hanging wall side of the Excelsior and North Pole claims is another body of the same rock which appears to have been an intrusive sheet or sill.

The exposed granodiorite intrusion to the west and north, although at considerably higher elevations, is at no point as much as 2 miles away. The presence of frequent granitic dikes, especially in the vicinity of the northeastern part of the lode, points convincingly to its presence below the surface at much less distances.

These dikes are usually granodiorite porphyries, although near the divide between Silver creek and McCully's fork, kersantite lamprophyre was observed. Away from the lodes these dikes are sufficiently fresh to determine their character, but those within the lode have been altered to such an extreme that their original character can only be inferred.

By reference to the section showing the developed portion of the lode attention is called to the fact that the northeast or South Pole claims which extend over to the Rock creek slope includes the highest part of the lode, and is in close proximity to the granodiorite intrusion, which is about one-half mile north of the South Pole tunnels. This high ridge has dikes in great profusion. They become less frequent as one goes down the hill towards the E. and E. shaft, although they are not absent even as far as Golconda ground.

The crosscut on the Yankee Jim claim shows a considerably altered granodiorite-porphyry dike 50 feet wide, with quartz and sheared argillite upon both sides of it.

In tunnels 5 and 3 of the North Pole mine, in the face of the Excelsior adit north on North Pole ground, in the Columbia, and in the Bonanza, is found a greenish-white rock which is probably a porphyry that has suffered extreme alteration and has been impregnated with pyrite. In thin sections of this dike material the feldspars are so badly altered as to be indeterminable. It is simply an aggregate of sericite, kaolin, secondary quartz, feldspar and chlorite. Field evidences, together with the examination of hand specimens and thin sections, indicate that this intrusion, found at various points in the vein over a distance of more than 3 miles, in which the various specimens are strikingly similar, was originally a granodiorite-porphyry. Its extreme alteration indicates that it came into the plane of the vein, although probably not in a continuous sheet, at a time previous to the formation of the vein.

Fig. 77. Outcrop of North Pole-Columbia lode on Golconda ground.

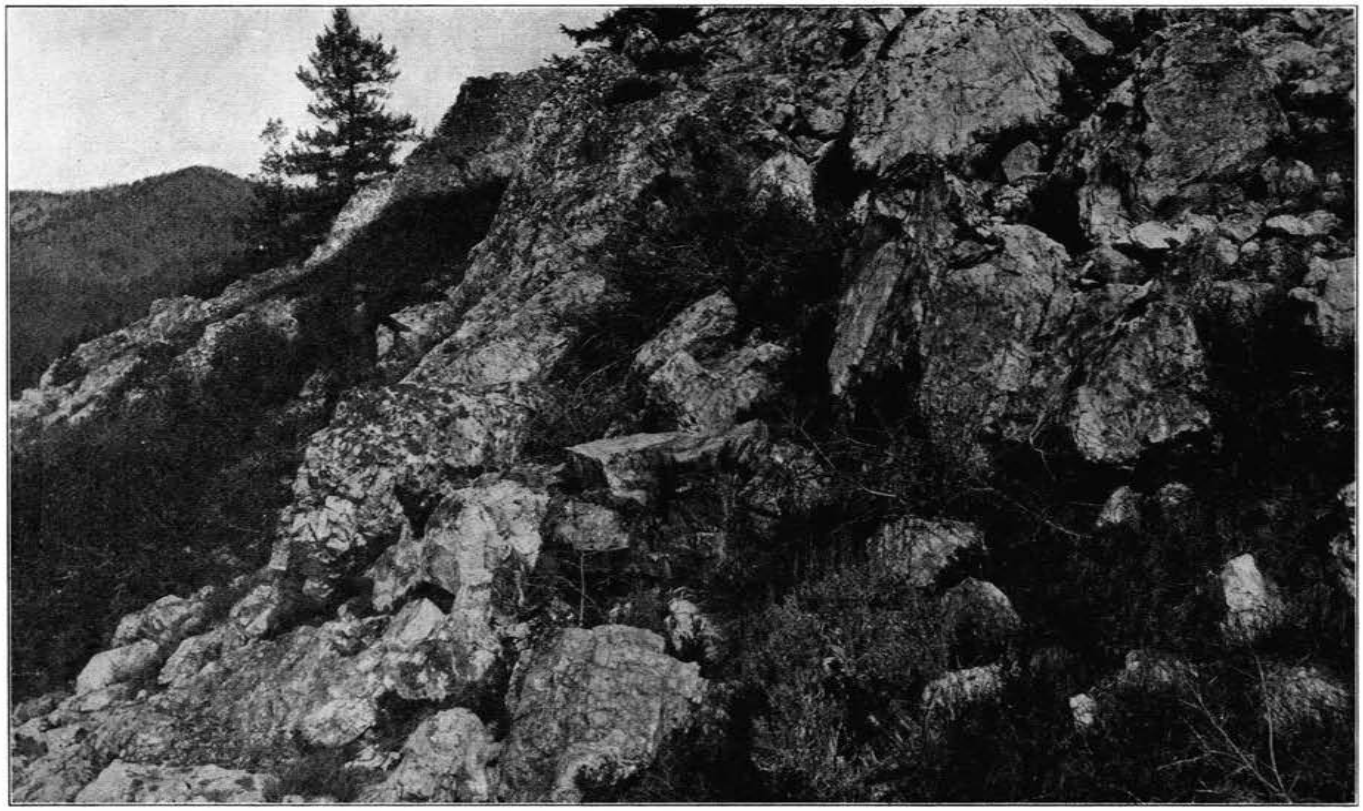


Fig. 78. Exposure of lode on North Pole ground.

The lode at Silver creek strikes approximately N. 60° E., but changes its strike to the northward until upon the North Pole hill it is N. 30° E. Its dip in Columbia ground is about 60° S. E.; in the Eureka-Excelsior 70°-75°; and in the North Pole 75°-80°.

The lode is easily traced by its croppings of silicified argillite wherever rock in place comes to the surface. The most prominent outcrops are those upon the Golconda, which projects at least 20 feet above the adjoining country rock and upon North Pole ground, where an exposure of quartz is some 300 feet wide.

The width of the lode in the Golconda as determined in the workings is about 175 feet in the upper levels, and about 100 in the lower. In the Columbia it is shown upon the surface to be about 75 feet wide, and averages about 28 feet on the 900-foot level. In the E. and E. the vein is as much as 30 feet wide. In the North Pole, although it has the wide exposure of white quartz above referred to, underground the lode shows from 7 to 40 feet wide except one crosscut in No. 2 tunnel, which, according to the maps, is in quartz far more than 150 feet, indicating that the large exposure upon the surface above the portal of No. 4 tunnel may extend downward indefinitely in a sort of quartz chimney. The mine maps indicate that development in No. 1 tunnel below and between No. 2 and the surface, has been almost entirely confined to drifting, with but few crosscuts, so that this probability is not demonstrated. The footwall vein on the dike in the Yankee Jim crosscut is about 16 feet wide. A cave prevented the observation of the hanging wall vein in this same crosscut, but it is said to be several feet wide. Although the lower tunnel is 1,200 feet long on the South Pole, practically no crosscutting has been done to determine the width of the lode, but it evidently will average more than 10 feet.

The walls of the lode on the North Pole ground are fairly well-defined fault planes, especially the footwall. The Columbia is similar to the North Pole, the walls being fairly well-defined. The Golconda is between two usually well-defined walls.

J. T. Pardee, in his description of the faulting and vein structure of the Cracker creek district, states:

"That this wide zone is a normal fault, which has a vertical displacement of at least 400 feet and a horizontal displacement of approximately 1,800 feet."

This considerable movement brecciated and pulverized the material between the walls, which in part at least was the location of an intrusive dike of granodiorite-porphyry. Along this dike faulting

occurred in a series of movements because it was a plane of weakness ever since the first fracturing that permitted the introduction of the dike. This movement brecciating this argillite zone was probably at about the same time of other vein fracturing in eastern Oregon, or some time in the later stages of the cooling of the Bald mountain intrusion.

This wide brecciated zone made an excellent channel through which the waters driven off from the cooling interior could ascend. These ascending waters, rich in silica, flowing more freely in some places in the zone than in others, deposited variable amounts of quartz from place to place, so that in the lode we have everything from slightly altered argillite to massive quartz. While much of this quartz is the filling between the argillite fragments, still a great deal of it replaced the argillite. This replacement was made so completely in places that only fine specks of carbon remain to indicate that where the quartz now is was once an argillite that contained elemental carbon.

The ascending hot solutions, besides the quartz, carried in solution and deposited with the quartz many different metallic sulphides. Those of much significance were arsenopyrite, pyrite, and to a lesser degree chalcopyrite. These sulphides in which is practically all of the silver and gold, except in the shallow oxidized parts of the vein, are not disseminated throughout the lode's entire width, but occur in shoots upon one wall or the other, and occasionally at intermediate positions. Most of the massive quartz does not contain to exceed $1 per ton in gold, while much of the less altered argillite is of low grade. The best values are more frequently contained in highly-replaced argillite, and often bear a close relation to a gouge streak.

The gold occurs chiefly in fine arsenopyrite. There is also iron pyrite which is usually of lower grade. The ore is usually in a series of overlapping lenses, which make up the several shoots found in the developed part of the lode. These lenses vary from a mere seam to 25 feet in width. The average width of all the ore stoped in the North Pole mine is a little more than 3½ feet. While figures are not available as to the width of the ore stoped in the E. and E. mine, it probably approximates this figure. The Columbia ore reserves at the present time average 47 inches wide. The Golconda averages are not available, but the maximum width stoped is 25 feet, and doubtless the average for the mine would approximate the figures for the other properties.

With the exception of the Columbia's excellent systematic assay maps there are none available for this lode. Probably such maps have never been made by the other companies.

It will be observed in the figure that the shoots in the Columbia property have no regular pitch in one direction in the plane of the vein, although they are fairly regular and persist to the lowest limits of development. In the other properties we have only the limits of stoping shown and these stopes, especially on the North Pole ground, are of such great horizontal length compared with their depth that a pitch cannot be asserted.

The form of the stopes in the sketches and drawings available to the general public has caused many to assume that the shoots so far stoped have been the result of a downward enrichment, but when a few facts are considered it is apparent that little downward sulphide enrichment occurs. The arsenopyrite, which carries the greater part of the gold, is a primary mineral, and is unknown as a secondary constituent of ores enriched by descending sulphate solutions. Very few occurrences of secondary pyrite have been reported from sulphide deposits in western United States, and chalcopyrite in the greater number of its occurrences is clearly primary. The gangue minerals are quartz and calcite.

As already stated, the gold is found in the arsenopyrite, the pyrite containing but low values of that metal. The arsenopyrite and quartz in many places show comb structure, thus indicating successive depositions of these primary minerals from ascending thermal solutions. Frequently whole masses of the first-deposited quartz and arsenopyrite have been shattered and recemented by a second deposition of quartz, which contains pyrite. Another phase in the mineralization that often occurs is a further brecciation and the filling of the minute fractures with calcite. Pyrite and arsenopyrite, which are characteristic of the lower vein zone, occur with the calcite. All of these successive mineralizations are the product of ascending hot waters. It would be rather difficult to account for the mineralization of the vein by the process of downward enrichment due to the occurrence of oxides of manganese found in some parts of the lode, which has been used by some as evidence favoring the downward enrichment theory. The presence of calcite occurring as the last phase of mineralization was overlooked, and it is, of course, a well-known fact that this mineral will nullify the dissolving action of manganese upon gold.

The fact that in many of the mines the ore has been stoped practically to grass roots would indicate that no lessening of value due to the leaching of the upper portion of the vein has taken place.

A very superficial enrichment of this type of vein may be caused by erosion and the leaching of calcite, which causes a removal of a valueless element, thus leaving a smaller mass of richer ore; and also by a mechanical concentration of the fine gold along channels caused by fracturing and the removal of calcite by solution.

A casual examination of the underground workings, together with an inspection of the plans of the five mines located upon the developed portion of this lode, brings out the fact that with the exception of the Columbia, but little systematic crosscutting has been done on the various levels of the several properties.

While the ore shoots are more often located upon or in close proximity to the footwall they are not all so located. In the Golconda the lode is very wide and some crosscutting has been done which disclosed shoots upon both walls and an intermediate one cutting diagonally across from the foot to the hanging wall with a dip of 30°. In the Columbia a shoot is found not only on the footwall of the vein, but also on the hanging wall, and in one instance in an intermediate streak. Below the shaft the only shoots found are upon the footwall of the lode. In the E. and E. the shoots are found upon the footwall. In the North Pole they lie occasionally upon the footwall, but more frequently away from it, and occasionally upon the hanging wall. In the South Pole the development is practically confined to the hanging wall.

It will be also noted that there are 2,500 feet on the North Pole hill between tunnel No. 5, on the North Pole, and No. 3, on the South Pole, which has had no drifting in the lode. It will also be seen that No. 1 tunnel on North Pole ground, which has no crosscuts, does not extend underneath the full length of the shoot above. Between the E. and E. shaft and the apex of the ridge, and above its 7th level, there is a million square feet of lode without development, above which there has been over a greater part of the distance ore extracted or evidences of it discovered as the result of widely-separated prospect holes.

There is a very incomplete development between the walls by means of crosscuts where drifting has been done along the strike. Considerable lengths have not even a single drift, while beneath the known shoots of ore development has not been done in much of the ground to determine whether barren levels occur between bodies of ore, such as is found to occur in the Columbia on the 300-foot level north, where the wall is a carbonaceous argillite.

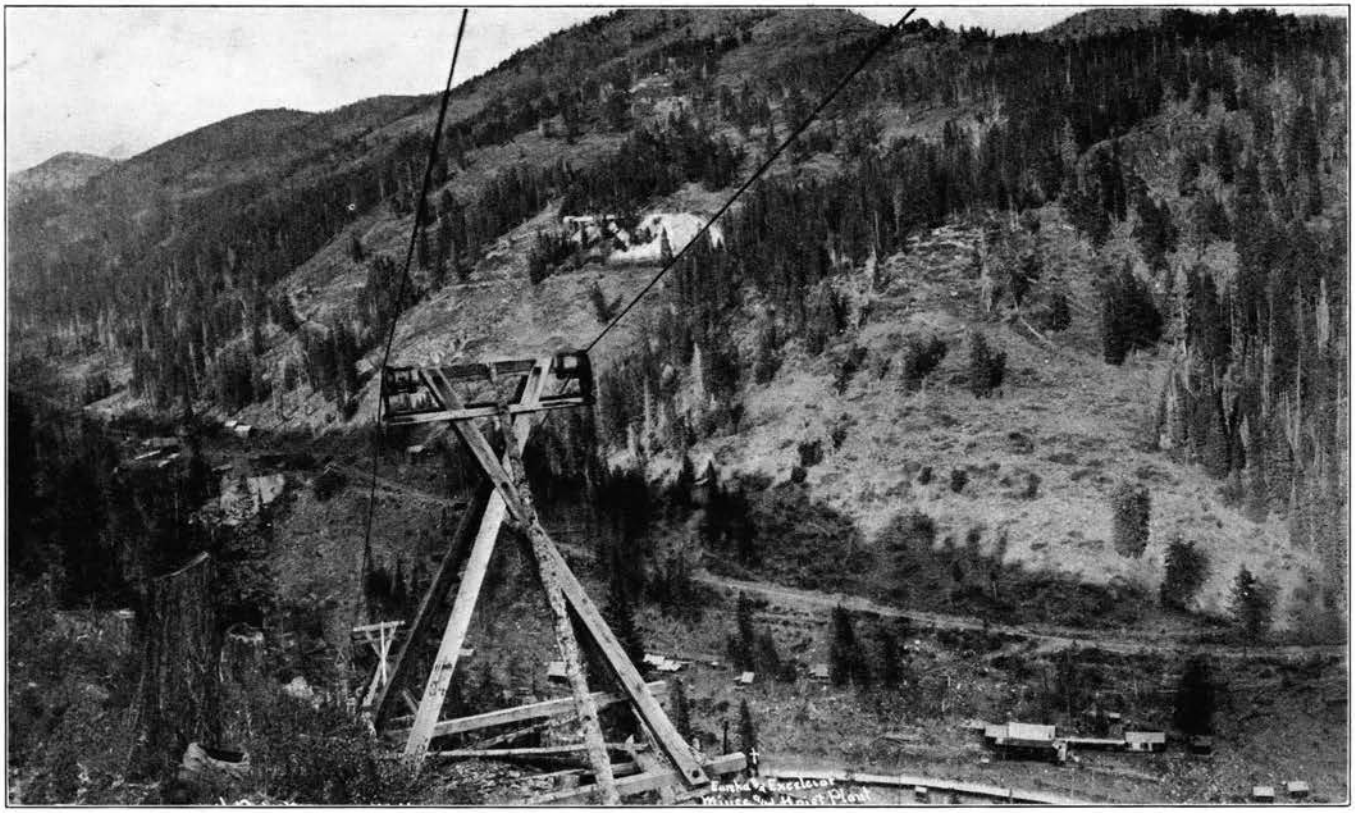


Fig. 79. A view of North Pole hill from the Eureka claim. North Pole mine and tram. E. and E. shaft house in the gulch below at the right.

The percentage of recovery at the North Pole mill from 1895 to 1908, in treating approximately 158,000 tons of ore, averaged $12.22, or approximately 75 per cent. At the E. and E. mill between 1891 and 1905 the recovery was no more than 63 per cent. The percentage of recovery at the Bonanza mine is not available throughout a considerable period of its activity, but to illustrate, the percentage of recovery was 68 per cent from 16,515 tons treated from February 1, 1903, to February 1, 1904. The Columbia secures the highest extraction of any, although the exact figure is not available for publication, but owing to the nature of the milling plant it is necessarily low.

The Bonanza, Columbia and E. and E. mines are equipped with 20-stamp mills; the North Pole has a 30-stamp mill. The average daily tonnage capacity for the 20-stamp mills probably was below 50 tons, with a probable present maximum of 2,000 tons a month at the Columbia, while the tonnage capacity for the 30-stamp mill did not exceed 65 tons daily throughout any one year.

These small capacities and the consequent high milling costs in conjunction with the large losses in the tailings demand a high average grade of ore. The total mining costs cannot very well be kept below $6 per ton, and without efficient management it will exceed that figure. With a 75 per cent extraction an ore averaging $8 is the lowest that can be mined.

The total production from the entire lode, estimated to January 1, 1915, is somewhat in excess of $8,000,000. The smallest production from any one of the properties amounts to more than $400,000. The recovery of $8,000,000 was secured from the several properties, whose combined efficiency from beginning to end does not exceed 67 per cent. The losses, therefore, in the tailings from these mills, was $4,000,000. The lowest acceptable percentage of recovery in present practice is 90 per cent, which signifies that $2,800,000 could have been saved in modern mills. If the present milling practice were continued until the production from this lode were doubled, the losses in excess of a permissible minimum recovery would be more than $1,000,000.

These statements might, at first thought, appear to be a reflection upon the persons who have operated these properties, but it must be borne in mind that their plants, though possible of improvement from time to time, were nevertheless installed before recent development in cyaniding complex ores or concentration by means of flotation had become available.

Fig. 80. Columbia mine and mill.

The improvements in these processes have been accomplished within the last two or three years, while the Golconda, Taber Fraction and E. and E. mines ceased operations 9 years ago, and the North Pole mine 6 years ago, which leaves the Columbia as the only steady producer since the North Pole closed down in 1908.

The Columbia mine is owned by four persons, with one of their number, Frank S. Baillie, as manager of the property. Under the efficient management of Mr. Baillie, who has been in charge of the property for 18 years, this company has never delayed a pay day a single day; it was for some time during this period the only steady producing quartz mine in Oregon. The owners naturally feel that a property which has eclipsed all others in the state in steadiness of operation and production, in conservative and successful management, should hesitate to make radical changes in methods which have been and are now successful. They realize that to effect a 90 per cent or more extraction at this mine would require extensive alterations in and additions to the present mill, which would involve the expenditure of considerable sums and would absorb their dividends for some time. The above reasons doubtless have had much to do with the failure of the stockholders to authorize the manager to make such extensive improvements.

A proper consolidation of these properties is an economic necessity for most of them and would be highly beneficial to all. Attempts to consolidate the leading properties have been made by some of the owners as well as by outside interests, but for one cause or another have been unsuccessful. The usual difficulties have arisen when consolidation of properties is attempted where parties at interest attempt to set prices and make terms each upon his own.

An agreement could be made by the parties at interest to have all their properties examined and valued by a committee of three thoroughly competent engineers who would report upon ore blocked out upon three or more sides, upon probable and possible ore, upon a new milling plant, and those parts of the surface plant including water rights and equipment which would be of value to the consolidation. The new organization would then be in a position to purchase from the individual owners paying each company for their ore reserves on a basis of the net profits which would be secured in their individual plants.

The ore blocked out on three or more sides, although too low grade to mine in separate mills, would nevertheless pay in a consolidated

new mill, and should therefore secure to the individual company possessing it some consideration other than stock.

A fair valuation of the separate properties in addition to the reserves and useful equipment as determined by the committee of engineers, could be paid for in stock of the consolidation.

Aside from the amount of stock issued in payment for the individual properties a sufficient amount should be placed in the treasury to be sold to meet the obligations to pay for the ore reserves under the terms above given and to supply an adequate sum to develop additional ore reserves and to construct a proper reduction plant when sufficient development work has been done to determine the size of plant which should be installed.

The ore actually blocked out in the Golconda and North Pole mines is small. The actual number of tons and value per ton fairly well blocked out in the E. and E. mine is not available, but a statement from the office of the company states that there is $500,000 worth of ore blocked out. This estimate probably refers to ore which could be treated at a profit in their present plant. There may be a much greater tonnage of ore averaging $5 or $6 which could probably be treated at a profit in the mill of the consolidated company. It is officially stated that there is 100,000 tons of $10 ore blocked out on 3 or more sides in the Columbia mine, and that the conditions with reference to ore on the 900-foot level are identical with those on the 600, 700 and 800-foot levels. No official statement is made as to the tonnage of ore blocked out which would be available in a new mill, but a reference to the sectional elevation of the mine, together with statements from persons not connected with the company, leads one to believe that this tonnage is large.

The North Pole mine, officially known as the Eastern Oregon Gold Mining company, is owned by Baring Brothers, of London, and is at present under bond and lease to John C. Lewis, of Portland, Oregon. The Bourne Gold Mining company, commonly known as the E. and E. Mining company, is owned by ex-Senator Jonathan Bourne, Jr., and associates, of Portland, Oregon. The Columbia mine, officially known as the Columbia Gold Mining company, is owned by Edward W. Bakus and two other men of Minneapolis, Minn., and the fourth owner is Frank S. Baillie of Sumpter, Oregon, the managing engineer. The Golconda mine is owned by Mr. C. S. Jackson, the well-known owner of the Portland Daily Journal, Portland, Oregon.

The owners of these properties are practically all men of affairs actively engaged in banking, publishing, politics and industry. Their multiplicity of interests causes all but one property to be kept idle. Their chief interest lies not in mining, and their experiences in it were for most of them secured during a period when close valuations upon mining properties were much less common than now, and the experienced engineer, metallurgist and mining geologist, now so prominent in the operation of successful mining companies throughout the world, had then but a small part in operations. A failure to fully realize that experienced technical men can solve their problems of mining and milling keeps some of them from operating their properties themselves, and the experience of some of them during the time when the element of adventure existed to a greater degree than now causes some to over-value their property when considering its sale.

With the exception of a limited amount of development in the last two or three years at the North Pole mine the properties other than the Columbia have kept only a watchman. Mine openings are not permanent ones. They have a considerable annual depreciation, and most of them, if left idle for a decade or two, will become nearly a total loss. The only factors which increase the value of known bodies of ore are a reduction in the cost of and an increase in the percentage of extraction. But the idle property, with its rapid depreciation in the value of mine openings and the loss of returns upon capital invested during the period of idleness, will in future vastly exceed any gain from improvement in processes. It is to be hoped that a proper consolidation will be early effected before some of these good properties become an almost total loss.

OTHER PROPERTIES IN THE DISTRICT

Paralleling the North Pole-Columbia lode in the Cracker Creek district are several other veins of a similar type, although of much less magnitude. Some of them are quite extensively developed and ore sometimes of high grade has been found in them. The Climax, Cyclone and Summit groups are nearby on the footwall side of the lode. The Cracker-Oregon and Sampson groups are the best known nearby properties on the hanging wall side. During the period of greatest activity in promotion, the greater portion of this district was under location.

About 2½ miles north of Bourne is the *Mountain View* mine, which produced between $60,000 and $75,000 for a 4-year period

ending in 1907, when their mill was burned. This fissure vein is located upon the highly metamorphosed border of the intrusion, and cuts both granodiorite and altered argillite. This mine has had little done upon it for some time, and because it was reported inaccessible was not visited.

Northeast of Bourne, on the divide between Rock creek and the head of east Cracker creek, about two miles northeast of Bourne, is the *Buckeye mine,* the property of the Sipe Gold Mining company. Most of the development of this property has been accomplished in the last 10 years. There is about two-thirds of a mile of drifts and raises upon the property, most of which is on the Cracker creek side of the divide. The strike of the main vein is N. 60° E. and the dip is approximately 70° SE. Besides the main vein there are narrow branch fissures containing limited quartz lenses in which are frequently found excellent specimens of coarse free gold. The upper 2 tunnels on the Cracker creek side of the vein averages about 4 feet wide, and is said to have a good grade of ore for a considerable part of the developed distance.

The tunnel next below, or No. 3, about 300 feet below the one next above, followed a branch fissure for at least 1,000 feet before crosscutting back to the main ledge, which was finally encountered late in 1914. Because of this failure to maintain their direction upon the probable strike of the main vein, this level, which has the most work done upon it, has developed very little of the main vein.

ROCK CREEK MINING DISTRICT

Upon or close to the E.-W. contact of the granodiorite with the argillites there are many veins between the Mountain View, above mentioned, and the Baisley-Elkhorn, 6 miles farther east. The west branch of Rock creek was not visited, but it is reported that *F. F. Johnson* has claims located on an E.-W. vein in argillite, 300 feet from and parallel to the granodiorite outcrop. It is said that a shoot of good grade ore 8 to 10 feet wide, but of short stope length, has been encountered. It is also reported that *D. M. Kelly,* of Baker, has a silver claim in argillite, just east of the Johnson claim, upon which there is 1,400 feet of development in 4 adit drifts, in which there are considerable bunches of $20 to $60 silver ore.

The most important properties in the Rock creek district are the Highland, Maxwell and Baisley-Elkhorn.

The *Highland mine* is located a mile southeast from Rock creek,

in the lower end of what is frequently called Maxwell basin. This property, which has been developed since 1900, was closed down in April, 1914, after having produced a little less than one-third of a million dollars.

The country rock varies from carbonaceous to siliceous argillite, and is close to the border of the intrusion. The strike of the vein is N. 75° E., and the dip is nearly vertical. The lode, although locally as much as 25 feet wide, has usually no more than 2½ feet of ore. Four shoots have been encountered in the development of the vein. The principal one is 1,000 feet long, and has been the source of most of the ore recently extracted. The ore is a concentrating one, and the values are in pyrite, blende, galena and lesser amounts of arsenopyrite, chalcopyrite and tetrahedrite. The average value of the ore mined is about $8, and the recovery is 75 per cent or less.

The present concentrating mill, which has a daily capacity of 50 tons, is neither properly equipped nor of sufficient size to operate profitably upon this ore. It is reported that only a small part of the available tonnage of ore has been extracted from the principal shoot, which has only been developed to about 350 feet in depth.

The Maxwell mine is a short distance east of the Highland and at a higher elevation; its principal vein strikes N. 60° E. More than a mile of development has been done in 18 separate tunnels. The principal vein is in argillite and the ore is similar to that in the Highland. Two shoots, one 250 feet long, with a maximum width of 4½ feet, and another 80 feet long, with a maximum width of 6 feet, are found in No. 14 tunnel. Tunnel No. 10 is about 300 feet long and has been driven on a vein which is partly in granodiorite and partly along its contact with argillite. This vein strikes N. 30° E. and the ore mineral is pyrite in dense quartz. The productive period for this mine was from 1900 to 1905.

The Baisley-Elkhorn mine, the property of Wm. Pollman, of Baker, Oregon, has produced approximately $1,000,000. It was closed in 1907 and is now inaccessible.

The country rock is granodiorite. The vein strikes northeast and is nearly vertical. The vein filling is composed of altered fragments of granodiorite, quartz and some calcite. The ore minerals named in the order of importance are pyrite, sphalerite, galena, chalcopyrite and occasionally ruby silver. About 25 per cent of the gold is free. The two pay shoots were from 2 to 10 feet wide, one 150 feet long and the other 850 feet long.

SOUTHEASTERN ELKHORN RIDGE VEINS AND PLACERS

The three mines just described are located upon a north branching ridge from the main Elkhorn ridge or range of mountains, which forms the western limit of Baker valley. This ridge continues with decreasing elevations from the vicinity of these mines to the southernmost bend of Powder river which, beginning near Sumpter, flows around Elkhorn ridge to turn northward through Baker valley, on the other side of that ridge.

This high ridge, which has a maximum elevation of 9,097 feet, is made up of slates, argillites, and some limestones, together with interbedded greenstones, some of which are old flows. That the main granodiorite intrusion extends underneath this ridge is made evident by the numerous dikes of granodiorite-porphyry.

In the many branches of Pine creek which flow into Baker valley are a number of prospects, most of which have been idle for some years.

The Carpenter Hill mine, located on Salmon creek, above the old Nelson placers, has driven 1,200 feet in greenstone and intercepts many quartz veins, the largest of which is 6 inches wide. There is a 5-stamp mill on this property, but operations ceased several years ago.

The *Young America* prospect, situated about one-fourth mile up the creek from the Carpenter Hill mine, is also in greenstone, and the development is upon a massive quartz vein which has a maximum width of five feet.

The Yellowstone Mining company, of McCord gulch, is in slate and black limestone cut by many kinds of dikes. The two principal veins upon this property are the Old Soldier and Tom Paine. The former is 3 feet in width and is developed by 2 tunnels, one of which is about 60 feet and the other some 600 feet long. The Tom Paine vein varies in width from a few inches to several feet.

Along Washington gulch there are many prospects, but for the most part the veins are small and the mineralization and shattering are but slight.

The Kent mine, in the upper part of Washington gulch, has the most development work of any in this area. It is located in Sec. 20, T. 9, S. R. 39 E., and has a small, poorly-designed mill located about one and one-fourth miles away from the mine.

The country rock is made up of argillite, greenstone and chert. The vein has a N.-NE. strike and a nearly vertical dip, with but a few inches of quartz to several feet of broken rock.

The development consists of a tunnel, several hundred feet long, a short winze and some raises. A. J. Thronsen, of North Powder, Oregon, has recently taken over the property, and a test run made in September of this year is reported to have returned $1,140 from 140 tons of ore.

In former times considerable placer work has been done in this region. In almost every gulch are diggings, some of which are being worked on a small scale at present.

The Nelson placers, situated at the mouth of Salmon creek, has a reported total production in excess of $400,000.

At Auburn there are several quartz veins situated N.-NE. of the settlement, most of which appear to be small seams many of which contain occasional rich pockets. The Auburn placers now practically exhausted have been productive, and for many years Auburn was the most important place in eastern Oregon.

The Auburn ditch, which was completed in 1863, took water from the head of Pine creek and carried it over 30 miles to Auburn for use in hydraulic mining there. This ditch now belongs to the Baker water department, and forms the source of supply for that city.

Deer creek, which receives much of the drainage of Elkhorn ridge on the Sumpter valley side, has recently been prospected with a view to dredging, the results of which have not been made public.

THE POWDER RIVER GOLD DREDGING COMPANY

The most important placer mining operation in the state is that of the Powder River Dredging company, located near Sumpter, Oregon. The total holdings of this company is about 1,500 acres, of which about 700 acres is to be dredged. This 700 acres of commercial gravel extends from a point a short distance north of Sumpter to McEwen, a total distance of about 5 miles.

The commercial gravel is in a meandering channel from 300 to 2,000 feet wide, and averaging about 1,000 feet, and occupies only a part of the valley floor. The average depth of the gravel is 18 to 20 feet. The bedrock is a soft, decomposed rock, which dredgermen call "clay webfoot." Nearly all of the gold is on bed-rock, and the condition of the gravel and bed-rock is such as to be called quite hard digging. This fact will be better understood when it is known that the manganese steel bucket lips last only 5 months, while in California practice they last about 18 months.

The dredge is of the standard type and was constructed by the

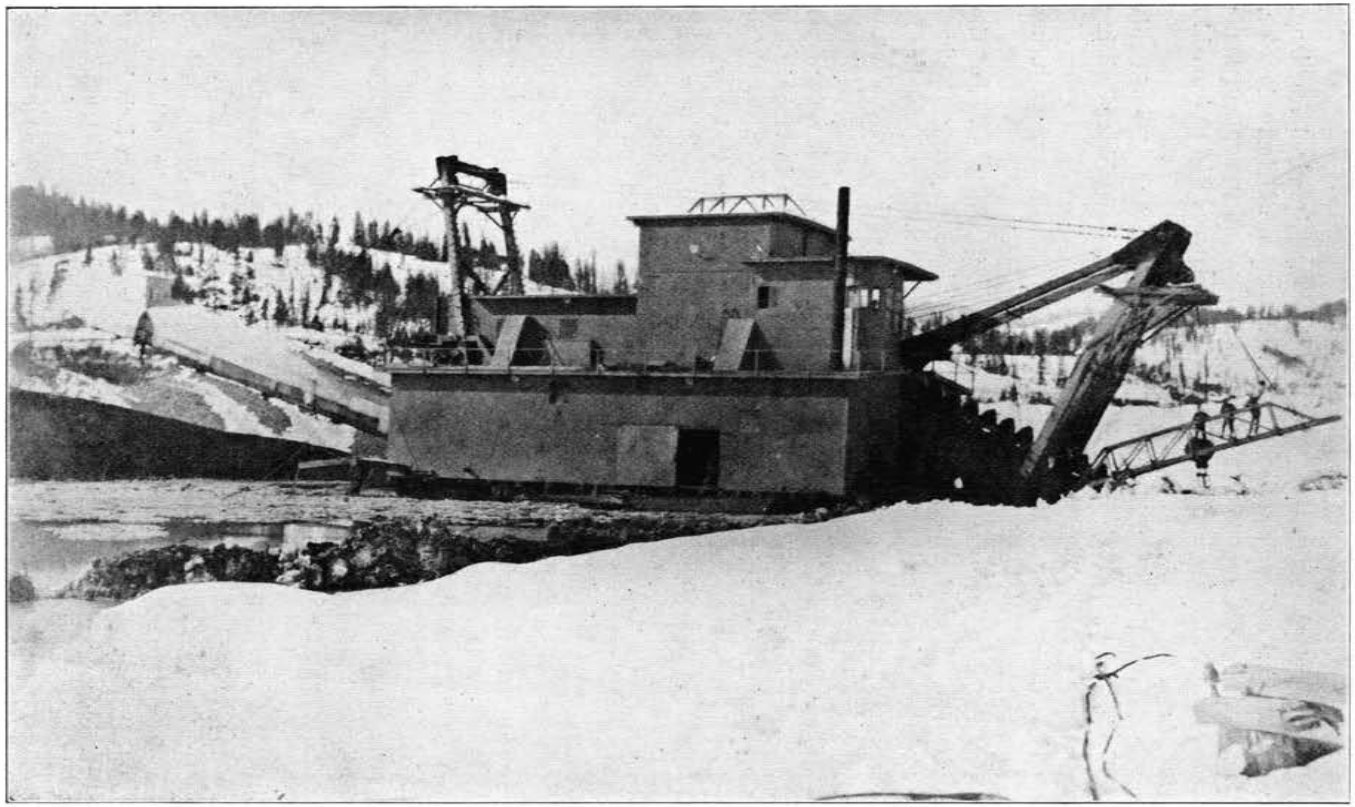


Fig. 81. Powder river dredge.

Yuba Construction Company, of Marysville, California. Its 65 buckets have a capacity of 9 cubic feet each, and the dredge will dig to a maximum depth of 30 feet. It has an actual capacity of about 5,000 cubic yards daily. The dredge has a wood hull which, according to California experience, has an average life of 10 to 12 years. The dredge has no amalgamating plates. It is equipped with Hungarian riffles which have a slope of 1¼ inches to each foot of length.

The power is furnished by the Eastern Oregon Light & Power company. The horsepower required is naturally variable. The consumption averages about 450-hp. in 7 motors.

The clean-up is made weekly, and the high extraction, estimated at 95 per cent, is made upon easily washed gravels, which contain but little clay. The gold is medium coarse. The particles average larger than those in the California dredging field. The largest nugget secured is ⅝x⅜ inch, while perforations in the revolving screen are ¾ inch. It is evident that no nuggets of gold are lost in the oversize. The average fineness of the gold is 785. The total cost per yard is approximately 3½ cents, which is higher than California practice, due largely to the more difficult digging.

Between 100 to 105 acres was dredged from February 1, 1913, to October 8, 1914, a period of about 20 months, or about 60 acres annually.

This company secured in November, 1914, some additional ground for which negotiations had been in progress for some time. Since this purchase has been effected they have begun the digging of a pit to install another dredge to work the ground up-stream from the point where the present dredge began to dredge the channel down stream toward McEwen.

THE GREENHORN MOUNTAIN REGION

North of the Middle fork of the John Day river is one of the three most important exposures of granitic rocks—the Greenhorn Mountain region. Although not a rugged spur of the Blue mountains, this range is rather high and somewhat irregular. Vinegar hill, the highest point of the range, is about 8,200 feet. Under the influence of this intrusion into the older rocks we have upon and around its borders several mining districts. This mountain range extends from near Whitney to a few miles west of Susanville, a total distance of at least 30 miles.

Most of this territory is heavily timbered with only portions of the higher ridges bare. It is well watered by many fair-sized, swiftly-flowing creeks on both sides of the range.

On the northern slope the Eastern Oregon Light & Power company stores water in a reservoir and in Olive lake, to use it at Freemont station to generate electricity not only for the mines of this region, but for various other parts of eastern Oregon.

During the winter there is a heavy fall of snow in the higher parts of the range, and in the spring and fall the roads in certain parts make transportation difficult because of deep mud.

GEOLOGY

On its southern slopes the older rocks are largely greenstones, succeeded on the western limits by argillites. These greenstones are old volcanic flows similar to those found elsewhere in eastern Oregon. The argillites are similar to those east of Baker. The farthest western limit of the exposure of granodiorite was not determined, but it extends at least a few miles beyond Susanville.

The region north of this range, and as far east as Olive lake, was not visited. The testimony of prospectors and our observations made near Olive lake and at the head waters of Desolation creek, leads one to believe that over much of this country both granitic and the older rocks prevail, although previously mapped as though covered by recent basalts.

Northward paralleling Clear creek, and extending some distance west of the Red Boy mine, is a branch range of the intrusion. The eastern part of the region along the northern border is largely made up of older sediments, while the southern part is largely composed of ancient flows.

The region coming under the influence of the intrusion and not covered by recent flows of basalt has a total area of some 200 square miles. Since nearly all but its highest ridges are covered with timber nothing but detailed field work could give even approximately the limits of the exposure of the older rocks.

The intrusion into the older sediments, lava flows, and older small intrusions, is in the main a granodiorite similar to that of the Wallowa and Bald mountain ranges. There is more than the usual variation from its ordinary character near the limits or border of the intrusion.

Near the town of Greenhorn most of the intrusion is medium-grained, slightly porphyritic diorite. Near the Ben Harrison mine it has the "tonalitic" phase. It can be properly inferred that elsewhere on its border there will be more or less local variations in the intrusion due to its incorporation of different kinds of older rocks.

Along the Middle fork of the John Day river from Austin to Galena, and beyond there is an increasing amount of recent basalt as one goes toward the latter. Emerging from underneath this basalt, but a short distance up from the stream, there are old volcanic flows that are now greenstones which range from meta-andesites to meta-basalts. Still higher up and ordinarily within 1,000 feet of the highest points of the ridges, is found the irregular line of contact of these older flows with the intruded granodiorite.

Near Galena the old rocks reach down to the river and cross it and continue down the Middle fork to beyond the mouth of Big creek, 6 miles below the town where the recent lavas appear again. The principal rock of the Susanville district is a fissile, steep dipping, dark-gray clay slate. Between the slate near Susanville and the granite of the ridge there is much greenstone in which there are considerable bodies of serpentinized rocks. The exterior of some of the blocks are serpentine while the interior, by comparison, is but little altered.

As previously stated, the whole concave northern border, from Big creek to a point 2 or 3 miles northwest of the Red Boy mine, is believed to have considerable granitic and older rocks at various places before they are entirely submerged beneath the recent basalts lower down on Granite and Desolation creeks.

The exposure of older rocks to the east which have been affected by the intrusion have a large number of mines and prospects in them. They extend from the Red Boy camp through Alamo and continue eastward to the Bonanza mine. Near the Red Boy mine the older rock

is a not very fissile, flat dipping, siliceous to calcareous, dark-colored argillite. The black argillites continue nearly to the mouth of Beaver creek, where they are succeeded by an east and west ridge of siliceous cherty rocks.

In the Alamo district the Alamo, Quebec and many other old claims are in the argillite, but as one proceeds southward the argillite belt swings to the southeast into the region of the old Bonanza mine. Between these argillites and the border of the intrusion to the west of Greenhorn City the rocks are largely of the old greenstone series, in which are considerable lenses of serpentine that were probably originally small intruded sills of a still more basic rock.

East of this belt of old sedimentary, volcanic and plutonic rocks, is a continuation of the argillites and greenstones with lake beds and recent lavas on the southeastern extension. These older rocks are apparently too far from the influence of either the Greenhorn or the Bald mountain intrusion to have become well mineralized.

Upon the large exposure of granodiorite are seen the usual granodiorite-porphyry and aplitic dikes. Naturally the older surrounding rocks underneath which is the concealed intrusion exhibit many of these off-shoots from the mass. Basalt dikes were not observed, but it is said that they are seen cutting the granodiorite to the north of Susanville. After the aplite dikes, which were the last molten product of the intrusion, came another fracturing of both the intrusion and the older surrounding and covering rocks in which ascending solutions from the interior of the magma filled the veins and altered and replaced the wall rocks. These hot solutions deposited quartz and in many of them both precious and base metals in various mineral forms. Their considerable variety will be noted in the description of some of the mines and prospects.

The ores of this mountain range are gold and silver, with copper and lead ores of minor importance. Some of the gold ores are free milling, but usually they are not. Cutting across the middle portion of the range is a belt in which there is much silver in antimonial sulphides. The mine which has produced the most is the Red Boy. The mine which has the most ore blocked out is the Ben Harrison.

SUSANVILLE DISTRICT

The Susanville district is about 22 miles down the Middle fork of the John Day river from Austin, a station on the Sumpter Valley

Railroad. A good wagon road could be built rather easily in place of the present one, which in 3 or 4 places deliberately leaves water grade to swing around over rocky ridges to return after some circling to the stream again. Not only is the distance longer, but the ascent and descent of rocky ridges makes it a disagreeable and expensive haulage road.

Production at the present time is small and comes from the placers.

Placer Mines.—The placer mines of Susanville were discovered in 1864 and have been worked practically every season since then.

Elk creek has produced the most, but other creeks lower down, along the north side of the John Day, have also yielded considerably. The total placer production is approximately $600,000.

The Middle fork, below Elk creek, is reported to have produced $50,000 in fine flour gold, but the creeks usually contain coarse gold, 865 fine.

The largest gold nugget found on Elk creek during the more

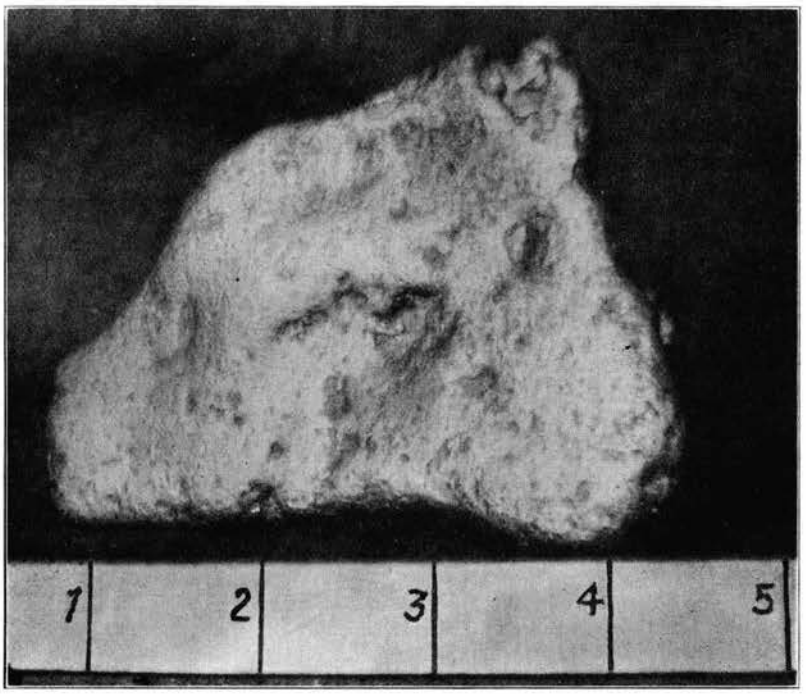


Fig. 82. The Armstrong nugget.

active operations was worth $480. Deep creek had one worth $625. Buck gulch, below Deep creek, years ago had one worth $800, but on June 19, 1913, George Armstrong found another on Buck gulch weighing 80.4 ounces, which at $17.60 per ounce would be worth $1,415. Most of the gold in the Elk creek placers seems to have come from the west side of the creek, although the most productive quartz mine is on the other side.

Considerable drifting has been done near the Middle fork of John Day underneath the basalt capping, in hopes of cutting old stream channels in the search for placer gold, but such operations have not been successful because they have as yet been unable to cut through the rim-rock to enter these old channels anywhere near the bed-rock.

The Middle fork from a point somewhat above Elk creek down stream for a distance of 4 or 5 miles, was partially prospected in 1898 with a view to dredging, but nothing came of it. In this same ground in 1913 the entire valley for this distance was under option, and test pits were sunk at various points. The results of these shafts are said to average 14 or 15 feet in depth and to contain sufficient value to warrant a systematic drilling of the ground with a view to the installation of a dredge.

Quartz Mines and Prospects.—The quartz prospects and mines of the Susanville district are confined to a belt extending northeast from the old town of Susanville, now called Galena. This belt is less than 2 miles wide and less than 4 miles long. It has a great many prospects and mines. They are in slate, serpentine and porphyry, and a few are in greenstone. Most of the veins strike in an E.-W. direction, but most of those in the serpentine are N.-S. ledges.

On the south side of Elk creek is the most important property of the district. The *Badger mine* is owned by the same interest that controls the Bunker Hill and Sullivan mine, in the Couer d'Alenes. This vein was discovered in the late 60's, and in the early 70's free gold was extracted in an arrastre from the decomposed croppings, which yielded about $25 per ton. Later on a 10-stamp mill, with concentrators, was built, but there was not a high percentage of extraction. The mine was closed down in 1906 because of litigation with the Stockton Mining company. This litigation continued until 1914, when it was reported to have been settled. It was another one of those troublesome apex suits.

The country rock is slate, some of it so siliceous that it might be called quartzite. The vein strikes a little north of east and dips

60° to 70° south. The shaft is down 900 feet below the collar of the shaft and 400 feet below a 1,600-foot crosscut driven from Elk creek. It is said that the principal ore shoot is 190 feet long and from 1 to 20 feet wide, with 10 feet of a massive irregular mixture of pyrite, arsenopyrite, zinc blende, galena, chalcopyrite, and tetrahedrite containing high values in silver and gold. It is also stated that both sorting and milling were practiced. Sorted ore was kept above $150 per ton. It is also said that the ore has been only partially stoped between the fifth and seventh levels, and has not been touched between the seventh and ninth.

The prospects on the same side of the creek as the Badger mine are the *Stockton, Ophir* and *Mayflower.* These properties which have had considerable prospecting done upon them, apparently have not found a sufficient amount of ore to encourage them to proceed with more extensive development.

On the northern side of Elk creek, a little farther up than the Badger, is the Homestake Mining company, which has a N.-S. vein in serpentine in which a shoot 4 feet wide and 300 feet long contains $8 free gold near the surface. Zinc-iron sulphides are found but a short distance below the surface.

Farther north, the *North Gem* and *South Gem* groups are upon the same N.-S. vein. This vein dips E. 60°. On the North Gem an incline is down 350 feet from which 4 levels have been driven connected by raises. The shoot is said to be 2 to 6 feet wide and 300 feet long. The ore averages about $10, with concentrates $40 to $50; 75 to 100 tons have been milled and a few tons shipped. Only $3 or $4 is in free gold. The ore is a massive coarse intergrowth of copper, iron and zinc sulphides in a quartz gangue. The country rock is argillite. The property closed down in 1909. On the South Gem is a 100-foot shaft with about the same width of vein as at the North Gem.

The *Compton Mining Company's* vein is in slate and serpentine. An incline 140 feet deep has been sunk on a 4-foot vein of ore which averages about $15. The shoot is said to be at least 125 feet long. Rich ore is found on the walls from 6 inches to a foot wide. The ore contains some galena and a trace of copper in massive arsenical iron and zinc sulphides. Only the assessment work is done each year.

At the *Chattanooga,* which was closed in 1909, they have the same ore as at the Compton. The perpendicular shaft is down 200 feet and the ore is said to average about $9 in a ledge 1 to 8 feet wide in a shoot at least 75 feet long.

North of these claims previously mentioned are claims in "granite." They were not visited, but are locally said to be of some promise.

North of Elk creek, between the claims just described and as far west as Quartz gulch, which enters Elk creek from the north, is what is known as *"Porphyry hill."* This hill is made up of slate cut by several light-colored, much-altered dikes. The dikes have a general E.-W. strike and dip N. into the hill at high angles. Three dikes were noted from 30 to 40 feet wide.

In thin section these dikes are seen to consist of larger grains of quartz, imbedded in a much finer-grained ground mass consisting of quartz, feldspar and sericite. These larger grains are curious in that they do not have a true crystal outline, but appear to be made up of broken fragments. The ground mass is undoubtedly of igneous origin, although some of the quartz and the sericite is secondary.

These dikes are probably quartz porphyries, which after consolidation were shattered at depth. The formation of secondary quartz in the ground mass has obliterated the evidence of shattering, but the large quartz crystals show it in a striking manner. The intergrowth of quartz and feldspar indicate that this porphyry has aplitic tendencies.

Although there has been but little development, ore has been shipped or milled at various times. Shipments of a few tons each have been made that reported gross values from $80 to $100 per ton. Ore was treated in an arrastre with returns of $3,162 from 150 tons. This ore came from the slate adjoining the porphyry. At another time from porphyry $1,600 from 80 tons was received; at another time in a Huntington mill, 44 tons returned $7 per ton; later 8¾ tons produced $237; some 80 odd tons milled from a dump returned $125; and from another claim 31 tons were arrastred, producing $5 per tion; and on still another claim a 9-foot channel sample assayed $4.10.

All the above statements concerning these porphyry deposits were furnished by J. C. Haskell, one of the owners. Channel samples taken by the writer in a tunnel cross-cutting a massive and hard part of one of the dikes averaged $1.80 a ton for 15 feet. It is stated that in the principal workings at the bottom of a winze a rich streak of ore is made up of sulphides similar to those in other parts of the district.

Susanville Summary.—The conclusions reached from a casual visit to this district leads one to believe that a large dredging area might be developed on the Middle fork. Also that several veins

contain some shipping ore, but most of these bodies of ore have their sulphides, which are mainly arsenical, in so massive and low grade form that but little can be shipped crude, while the sulphide content is so great that concentration is not effective. Perhaps all of these ores could be successfully roasted and cyanided. The porphyry dikes and perhaps some of the adjoining slate might average sufficiently high to be mined in a plant with a large daily tonnage capacity.

THE NEW ELDORADO DISTRICT

Between Elk and Granite Boulder creeks the mountain streams flowing south into the Middle fork are Coyote, Big Boulder, Horse and Beaver creeks, of which Big Boulder, with its several branches, is the largest. Between the Middle fork of John Day river and the ridge above and largely in the drainage of Big Boulder creek is the New Eldorado camp. The prospects here are in both granodiorite and greenstone. The only producing property, and that only in a small way, is the Heppner Mining company.

The prospect farthest west is in Sec. 2, T. 10 S., R. 33 E., about 4 miles east from the present location of Susanville, on the steep west slopes of the north branch of Big Boulder creek. These claims were located last summer by *W. H. Butler.*

The country rock is granodiorite. A nearly vertical vein strikes N. 70° W., and is about 12 feet wide where it is opened up in 2 or 3 surface cuts. The vein consists chiefly of quartz, with small included crystals of stibnite, the sulphide of antimony. In places stibnite is abundant in stringers about an inch wide. The vein is of the replacement type, and is reported to have, in the few assays made, about 30 ounces of silver.

At various places on the lower half of the Big Boulder drainage area are copper claims in greenstone, some of which is amygdaloidal. The principal locations are those of *J. L. Krause, E. B. Reed, Chas. Wray* and *Collin Chisholm.* These groups are located on shear zones which are mineralized in places. Pyrite is the chief ore mineral. Pyrrhotite and some chalcopyrite are also present. These zones strike about N. 60° E. and appear to be somewhat similar to those on the southern slope of the Wallowa range, of which the Poorman is a type, although the shearing and percentage of copper is much less. How much gold and silver is present in these copper claims was not learned.

The lowest claim on Big Boulder is a quartz vein about 3 feet

wide, containing small amounts of galena. It is said to assay about $10 in gold and silver.

Above these copper claims in Sec. 7, T. 10 S., R. 34 E., is another group owned by *E. B. Reed.* The country rock is granodiorite cut by numerous rather coarse-grained dikes of granodiorite-porphyry. These dikes are so much closer grained than the granodiorite that they remain hard after the granodiorite alongside has become quite soft in the altered zones. This altered zone is the peculiar thing about this property. It strikes N. 35° E., has a vertical dip and a width of something over 200 feet, and has been traced for several hundred feet. It is a soft mass of extremely altered granodiorite, in which the ferromagnesian minerals have been nearly decomposed and the feldspars have been kaolinized.

There are a large number of veins in this zone varying in width from 5 feet down to a few inches. These veins are roughly parallel to the strike of the zone. The larger veins usually consist of bluish quartz; the coloring effect is probably due to minute crystals of stibnite. One vein had a streak of stibnite about 1 inch wide, associated with small amounts of pyrite, and zinc blende. A specimen containing silver sulphide, either stephanite or pyrargyrite, was found at one point. Besides the large veins, there are a number of small veins which cut the rock in every direction. These contain some sulphides of antimony and iron.

This property is said to contain low values throughout the altered zone, but the development work consists almost entirely in drifts along the larger veins, so that there is little chance to sample in cross-cuts in the zone.

East of Reed's property, just described, on another branch of Big Boulder creek, are the claims of the *Heppner Mining Company.* D. B. Stalter, manager. The country rock is a medium-grained granodiorite, cut by granodiorite-porphyry dikes. Considerable surface weathering of the granodiorite has taken place. The remarkable thing here is the fact that one crosses in a distance of a little over 1,000 feet a dozen or more veins or lodes consisting largely of quartz, and varying in width from about a foot to 20 feet or more. These veins strike N. 40° E. and dip 50° to 75° E. They are fairly strong fissures, some having been traced for several hundred feet along the strike. These veins are made up of solid quartz, replaced rock, gouge, and in one of the veins considerable pyrite was noted. Gold is free, at least near the surface. Most of the work has been done on the

upper and smaller veins, where the ore in places is said to be rich enough to pay to treat in their 2-stamp mill, to which the ore is hauled from the tunnel portals. It is said that on the lowest vein a sample across more than 20 feet assayed $16.20.

Between Stalters and Granite Boulder creek are *Ira Lemon's* claims in granodiorite and greenstone, both considerably altered. A 4-foot lenticular vein strikes N. 20° to 30° E. The ore minerals are pyrite, arsenopyrite and chalcopyrite. The gold content was not learned.

SOUTH SIDE SILVER-GOLD DISTRICT

In the upper drainage basin of Granite Boulder creek there are several silver-gold prospects. With the exception of that near the Ornament the country rock is granodiorite.

The *Ornament* is about 7 miles above the mouth of Granite Boulder creek, in Sec. 11, T. 10 S., R. 34 E., on the east side of the creek. There is no road up this creek from the Thomas ranch on the Middle fork, but these claims are reached by a wagon road from Greenhorn, a distance of about 7 miles.

The vein is located near a contact, where granodiorite forms the footwall and argillite and limestone the hanging wall. It is a fault contact for only a part of the vein. Quartz is the gangue and the ore minerals are arsenopyrite, pyrite, zinc blende, chalcopyrite, galena and tetrahedrite. It contains moderate values in silver and gold. The maximum width is about 3 feet. The property is developed by 3 long drifts upon the vein. Small shipments have been made from the property, but the values per ton are too low to ship the crude ore.

About one-half mile above the Ornament on the other side of the creek at an elevation of 6,500 feet is the *Tempest* group. The development here consists of several short tunnels from which quite a little ore has been shipped. There is said to be five veins cropping in granodiorite which strike N. 35° E. and dip nearly vertical, but only one was examined. This one is up to four feet in width and consists of altered sericitic kaolinized rock in which there are small stringers of quartz with arsenopyrite, pyrite, and zinc blende, a little gold, but with the chief values in silver. Very little work has been done on this property in the last few years.

Going north on the main branch of the creek one reaches Boulder gap one mile above the Tempest. In making this one mile one passes the *Chloride* and the *Carbonate* and reaches the *Ruby* group near the

pass (7,200 feet). These veins are in granodiorite striking northeast and each vein is developed to some degree by drifts and crosscuts. Minor shipments have been made from some of these properties.

The ore consists of quartz, arsenopyrite, pyrite, zinc blende, and a little galena in small veins in country rock which has been bleached by the development of sericite and calcite stained green with chromium mica. Great widths of the veins are claimed for some of these properties due to the parallel fracturing or shearing of the granodiorite for considerable widths, but these large dimensions are of little economic importance since the mineralization outside of the principal fracture is nearly always insufficient to warrant mining.

The vein proper does not usually exceed two feet and is ordinarily narrower. The values are in silver and gold. Reported assays from various points range from $5 to $250, more than half of which is in gold which below the zone of oxidation may be reversed.

NORTH SIDE SILVER-GOLD DISTRICT

On the opposite side of the Greenhorn range from Granite Boulder creek and near or within two miles of the main ridge are several silver-gold properties of which the most important mine is the Ben Harrison, and the most important prospects are the Morris, Bimetallic, and Intermountain groups. In the Ben Harrison the gold and silver values are about equal, while in the others silver is of chief importance.

THE BEN HARRISON MINE

The Ben Harrison mine is located near the headwaters of Clear creek close to the northwest corner of Sec. 36, T. 9 S., R. 34 E. It is 23 miles by wagon road from Whitney and 28 miles by wagon road from Sumpter. These are stations on the Sumpter Valley, a narrow gauge railroad.

The general topographic and forest conditions are well illustrated in the view of the mill. The elevation of the working tunnel is about 6,500 feet. The country rock is a medium-grained slightly porphyritic "tonalitic" granodiorite. The granodiorite is cut by what are probably granodiorite porphyry dikes. About a mile northeast of the mine on the same branch ridge of the intrusion which extends out toward the Red Boy mine is an exposure of badly altered rock. The roughly parallel attitude of the hornblende crystals and the glassy nature of its feldspars suggest that this rock may have been a flow

Fig. 83. Ben Harrison mill.

of dacite, the effusive equivalent of granodiorite. In any case it is genetically connected with the granodiorite intrusion and may have been caused either by a volcanic eruption or else to a foundering of the roof of the Greenhorn intrusion which had stoped its way so close to the then existing surface that a portion of the roof of ancient rocks broke loose and was submerged, permitting the molten rock to flow out.

Aplite dikes abound in the granodiorite and vary in size from an inch or less up to a foot or more in width and some of them, probably the last ones formed, have such a decreased amount of feldspar that they approach quartz veins in composition, but are not mineralized.

About one-half mile south of the Ben Harrison mine and crossing the saddle of this north and south branch of the main ridge is a body of older rocks which at the apex of the ridge is nearly one-half mile wide. This older rock is greenstone and greenstone schist. Its contact with the granodiorite on the north and south sides was not fully observed, but underground in the Ben Harrison mine inclusions of greenstone were noted in the granodiorite, proving that these greenstones are the older rocks.

This greenstone is a very fine-grained, badly kaolinized and sericitized rock containing considerable secondary quartz and chlorite.

It was probably originally a basalt. The schists are fine-grained, consisting chiefly of biotite and apparently secondary quartz with a few garnets. This rock is probably also of igneous origin. This greenstone schist is surrounded on all sides by granodiorite, indicating that it was a downward projecting portion of the roof of older rocks, the main body of which has since been eroded. A great many good-sized veins are found exposed in this greenstone which have been prospected from time to time, the oldest of which is the "Potosi."

The Ben Harrison vein strikes N. 3° E. and dips 67° E. and is lenticular in shape both along its strike and dip. Its minimum width of gouge and altered rock is about 18 inches and its maximum 21½ feet.

The length so far stoped above the 200-foot level is about 400 feet; above the 350 and 500-foot levels the stopes are about 300 feet long. On the 600-foot level the vein has been drifted upon for 350 feet, which at the south face is 12 feet wide and the north face 6 feet wide and averaging 68 inches for the 350 opened up. This is the same average width for the length of the drift as is the 500 stope on that level. The average stoping width for the entire mine so far opened up is 77 inches, and the lowest level, the 600, has good faces of ore both north and south and will likely exceed all other levels in tonnage-feet. Its average value is between 19 and 20 per cent higher than the average value of the ore in the rest of the mine, which averages a little above $10 a ton for the 87,000 tons blocked out on at least three sides above the 500-foot level.

The vein, a brecciated replacement, between the gouge on both walls is made up of fragments of granodiorite up to a foot or so in diameter surrounded by vein quartz up to six inches wide. The fragments themselves are much silicified and cut by minute reticulate veins. The ferro-magnesian silicate minerals are entirely decomposed and the feldspars largely kaolinized. Calcite, probably derived from the country rock, is present. The same alteration occurs in the wall rocks to a lesser degree, but this alteration of the wall rock is greatest next to the widest part of the vein.

The outcrop of the vein is inconspicuous and is at a narrow portion of the lens, where it is only about two feet wide. At the surface it shows a typical sheared character and mineralization. Quartz, limonite, and kermesite, the red oxide of antimony were observed there.

The ore minerals are pyrite, stibnite, a little chalcopyrite and sphalerite. The silver sulphides are pyrargyrite and stephanite with gold of about equal value to the silver in the ore. The gold values in

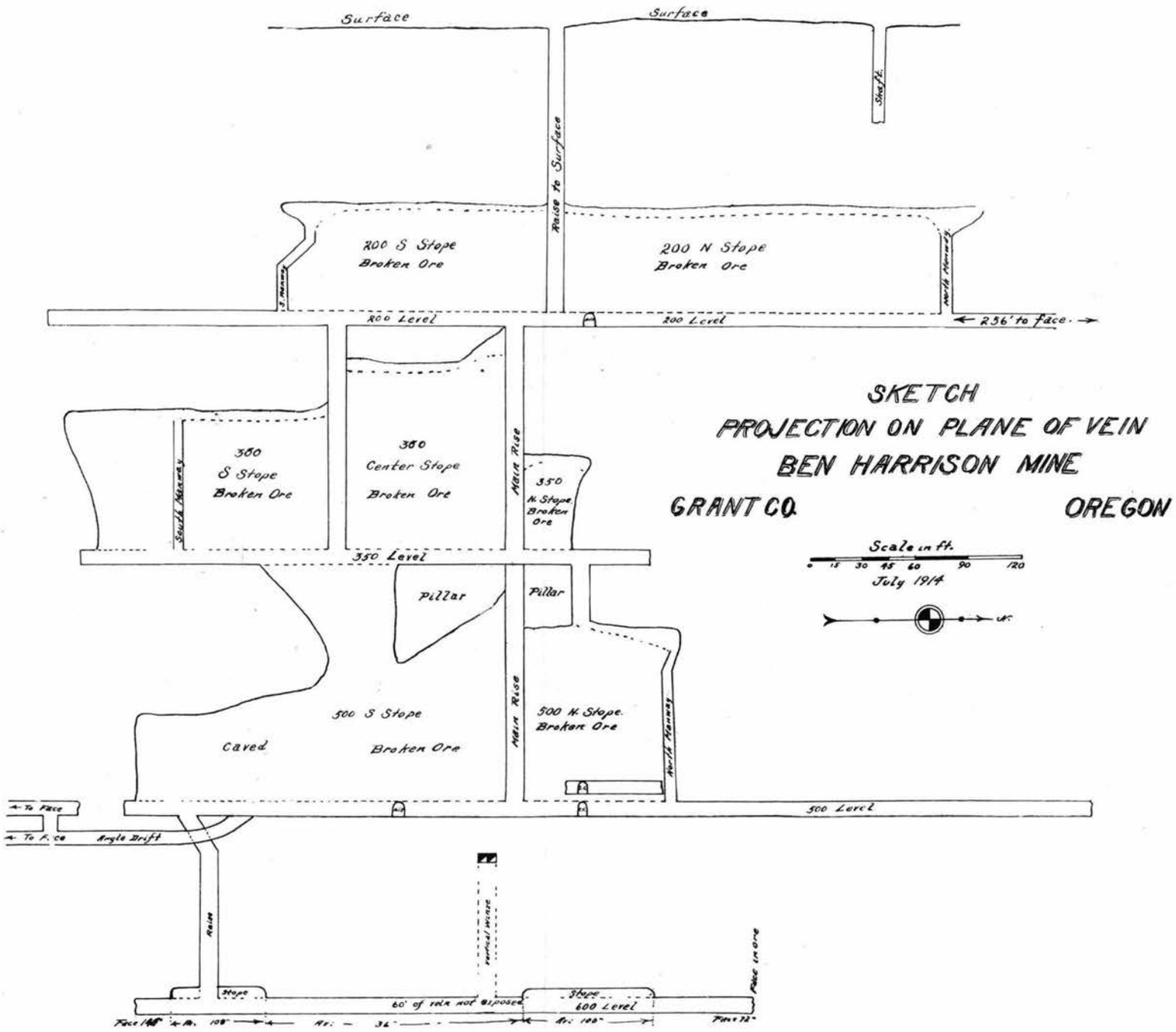


Fig. 84. Underground development Ben Harrison mine.

the various parts of the shoot so far opened up, remain reasonably constant, but the silver values are quite variable. The good silver ore is in horizontal layers, a streak of lean and a streak of fat as it were. The silver values vary also greatly between the foot wall and hanging wall. There are many thin lenses of considerable wall area more often on the foot wall, though frequently on the hanging wall and occasionally between walls or else in branch veins into the hanging wall. Sometimes these sulphide sheets are almost pure stibnite with only a moderate silver content, while in other places they consist of quartz and disseminated stephanite, the black brittle sulphide of silver and antimony, in which there is present a small amount of pyrargyrite.

There is also a wide variation in the silver content along the strike of the ore shoot. For instance, upon the lowest level which is only partially developed the average gold content north of the shaft compared with that south differs only 14 per cent, while the silver content has fourteen times as much in one as in the other.

This vein was formed by hot waters coming directly from the interior of the intrusion. This hot water, using the fissure as a channel, percolated through the brecciated rock in it which at the beginning was unaltered. The moderately high-temperature ascending water together with the material in solution, brought directly from deep-seated sources or extracted from the deeper parts of the channel, possessed a vigorous altering effect upon the fragments of granodiorite and the wall rock. They kaolinized the feldspars and the ferro-magnesian silicates were broken down so that now we have the softened badly altered fragments and wall rocks. At the same time that the hot ascending waters were metamorphosing the wall rock and brecciated granodiorite in the vein, it was also depositing the quartz in between the fragments and silicifying their interior, and was also bringing iron, antimony, silver, some copper and zinc, and gold in solution. Lessened temperature and pressure together with changes in the nature of the solution itself when it reached the upper few thousand feet of the vein caused a deposition in the vein of the gold and various other metals in their present form as sulphides.

This locality is undoubtedly a glaciated basin. The oxidation in the vein is very shallow and every appearance of the hard silver ore in quartz leads one to conclude that this ore is a primary and not a secondary ore of silver, and, therefore, the development of this silver-gold ore is not in a zone of secondary enrichment which will, a short distance below the lowest level, become lean in silver values. We con-

clude rather that any changes in the silver content below the 600-foot level will be due to some other factor in ore deposition than to the leaching of silver from the upper part of the vein to deposit it below, forming what is called downward sulphide enrichment.

The mine is equipped with a gyratory crusher, 20 stamps, a tube mill, Richard-Jenney classifiers and Isbell vanners. The concentrates were hauled to Whitney at a cost of $8 per ton when the roads were good, but in the fall and spring the roads are almost impassable for heavy traffic, so that the five or six tons of concentrates produced daily accumulated too rapidly during those periods.

Although the pulp was carefully classified and the product of the first two spigots returned to the tube mill for regrinding, nevertheless the vanners had difficulty in maintaining a 75 per cent extraction. The difficulties in getting the concentrates to the railroad, the high cost of transportation and smelting together with the loss in the tailings of $2.50 to $3 per ton caused the owner, Mr. A. L. White, president of the Lima Locomotive Works of Lima, Ohio, to await the results of a series of tests made at the mine by Manager Walter C. Fellows, and by the Merrill Metallurgical Company at San Francisco, in order to work out an efficient process of extracting the values on the ground.

The experiments have gone far enough so that the probability of success can be confidently asserted. The process will probably involve the present mill and concentration plant, to which will be added cyanidation of the tailing and concentrates after the latter have been roasted. Utilization will be made of some of the recent successful methods followed in cyaniding the complex silver ores of Canada which have gone into use in the last two or three years.

This has been dwelt upon at some length in order to give a considerable note of encouragement to many, although the successful extraction upon the ground is not yet a reality which possesses the advantage of a proved method. Those who have ores less complex than this one, too low to ship crude and frequently too massive to concentrate, may be able to successfully treat them in some such way.

Morris Group.—The Morris claims are about 1½ miles southeast of the Ben Harrison mine, in Section 1, T. 10 of the same range. These claims are on and beyond the lesser one of the elevations seen from the Ben Harrison mill. These claims have been located at least 20 years and have had considerable sorted silver ore shipped from them from time to time.

The country rock is granodiorite, although argillite and limestone

are found in the immediate vicinity. In fact the veins are almost on the contact of the intrusive with the sediments. There are four nearly parallel N.-S. veins with vertical dip which are branch veins of a larger one of moderate width which strikes S. 35° W. The N.-S. veins are narrow, rarely as much as a foot in width, but the wall rock shows considerable alteration.

The minerals found in these small veins are silver sulphides, some tetrahedrite, stibnite, pyrite, and arsenopyrite, and at some points silver chloride.

The large vein, three or four feet wide, seems to consist of quartz, massive pyrite, and arsenopyrite. It is said to have moderate values in gold and silver. It has one drift upon it for a couple of hundred feet.

The ore which has been sorted and shipped at various times since the discovery has all come from the narrow veins. To indicate the proportions of gold and silver the mint of 1891 credits the Morris with a production of $15,000 in silver and $3,400 in gold. During 1913-14 the few shipments made from the property averaged about $50 per ton.

Bimetallic Claims.—The Bimetallic group, formerly called the Intrinsic, is located in Secs 6 and 7, T. 10 S., R. 35 E., near the headwaters of Salmon creek, about 2½ miles from the Ben Harrison mine in a straight line and about the same distance from the town of Greenhorn with which it is connected by wagon road. The elevation of the

Fig. 85. Location of Bimetallic group.

principal workings is about 7,000 feet. It is on the southern slopes of a branch ridge of the main Greenhorn range.

The principal country rock is diorite, a peripheral differentiate of the granodiorite intrusion. Much serpentine and greenstone was observed on the opposite side of Salmon creek. The immediate geology is complex. Large dikes which are neither a true granodiorite-porphyry nor an aplite, but a sort of intermediate which might be called a granodiorite-porphyry aplite strikes north and south on the east side of the property. They were probably welled up in fissures at a period of time midway between the time when the two types of dikes were being formed. After this dike had become solidified, the dike and the adjoining diorite along its western side was shattered in a series of parallel breaks partaking of the nature of a shear zone. This must have been at a period considerably after the time when true aplites were formed elsewhere in the intrusion because it has been filled with almost pure quartz. The bands or ribbons of quartz are so completely cemented to the intervening dike rock that cross sections with the splendid luster of the quartz in contrast with the creamy but dull color of the dike rock makes a decidedly pleasing appearance.

On the northeastern part of the claims, just beyond the saddle, is a light-colored rock composed almost entirely of calcite impregnated with chalcopyrite and tetrahedrite and containing some secondary feldspar and quartz. This has low values in gold and silver.

The general direction of the veins is E.-W., but these veins are the result of a more or less complex fracturing. The principal workings are in a basin about half way up to the saddle from the creek. There has been a great deal of weathering and decomposition of the rock generally which may have been due to a centralizing of the fracturing in the basin.

On the side hill west of the development is a large cropping at least 25 feet wide which appears to be the result of a partial replacement of country rock with quartz in which there are many veinlets and quartz crystals. Manganese is evident throughout, although in small percentages, and samples taken from this exposure assay about $1 in gold. It could not be determined with the limited amount of development on the surface nearby whether or not this is a harder portion of the same lode seen in the principal workings to the east, which because of its more resistant nature, has not weathered as fast as the country rock or the softer part of the vein.

The underground workings were so poorly ventilated that candles

would not give sufficient light to observe very much, but it appears that there is a wide zone of softened badly decomposed rock in which there are lenses of good ore either along the walls or at places between them. How much value, if any, is contained throughout the mass is unknown, but from its appearance it is probably too low grade to mine outside of these lenses. Whether these lenses, which in places are of stoping width, have much vertical or horizontal extent was not ascertained.

On the dump there is quite a tonnage of ore in which there is varying amounts of tetrahedrite with some pyrite and chalcopyrite. It is said that this ore has been sorted over twice and the first shipment contained between two and three hundred dollars a ton, and that the second sorting brought between one and two hundred dollars, while a third sorting, which has been begun, assays about $75. The main ore dump will naturally average much less than the latter amount.

This deposit is also the product of ascending magmatic waters, but the extremely soft nature of the entire lode would lead one inevitably to question the primary nature of the sulphides present, although tetrahedrite is normally a primary mineral.

The gold values are usually between one and two dollars per ton, and the amount of gold present seems to bear but little relation to the amount of silver present.

Intermountain Claims.—Northeast of the Bimetallic and practically on its extension is the Intermountain group with the same strike of vein. It is in diorite and greenstone. The ore consists of quartz with tetrahedrite rich in silver, and the pay streak is reported to be as much as three feet wide. This property has shipped ore from time to time. The work is usually performed by leasers. Owing to a combination of circumstances this property was not visited.

ALTERED DIKE DEPOSITS

The Morning Mine.—The Morning mine in Sec. 13, T. 10, R. 34 E., is on the south side of the main Greenhorn ridge a little over two miles south of the Morris and about five miles by wagon road from the town of Greenhorn. This property and its extensions are in a class by themselves in this region in that they are in a mineralized dike.

The country rock is greenstone probably of igneous origin, although it is so much altered that its original character is scarcely determinable. Considerable masses of serpentine are in the immediate vicinity. The ore deposit is in an altered N.-S. steep dipping dike. In thin section

it is seen to be a confused mass of altered andesine feldspars, many of which are intergrown with quartz forming a micrographic structure.

The alteration minerals present are sericite, secondary feldspar, and secondary quartz. This rock could be called a feldspar porphyry with aplitic tendencies. Its composition shows that it is closely related to the granodiorite. The dike rock is cut by minute quartz gash veins, many of which show small well-formed crystals. The pyrite, associated with the quartz, has been altered to limonite, as have also the minute grains of pyrite with which the dike rock was impregnated.

Lenticular veins of massive pyrite, approximately parallel to the walls of the dike which in some places are several inches wide, are found on the lowest or working level of the mine and apparently near the upper limits of the sulphide zone. The dike at this point is 30 to 40 feet wide, and is reported by different persons to assay from $2 to $5 throughout. Near the surface a stope, several sets wide, called the "ball room" stope, was mined several years ago and undoubtedly was of good grade. Most of the enriched parts have been stoped down to the lowest or mill level.

The present leasers are mining from various parts of the mine and treating the ore in a small Chilean mill and a home-made arrastre, the latter for regrinding purposes. Amalgamation recovers a few dollars per ton and concentration on revolving canvass tables is being attempted. The massive sulphides are known to be worth from $20 to $30 per ton and clean concentrates approximate this value, but crude methods of milling and simple cyanidation will doubtless be unsuccessful in securing a reasonably high extraction.

A complete engineer's examination of this property together with some well directed additional exploration, might demonstrate the presence of a considerable body of ore which although of low grade would nevertheless be profitable to work. It is probable that the impregnation which formed the quartz gash veins and the sulphide veins took place at a period closely following that of the intrusion. The type of alteration suggests conditions of high pressure and temperature.

Richardson Claims.—The southern extension of the above dike was not seen, but northward what appears to be a continuation of the same dike or at least a similar one is on the Richardson group of claims with greenstone as the country rock. The light-colored altered por-

phry dike is similar to that at the Morning mine. The dike here is five or six feet wide, but has associated with it a two-foot quartz vein. The values are said to be about the same as the average at the Morning mine.

VICINITY OF GREENHORN CITY

Mining in the region on the eastern side of the Greenhorn intrusion and in the older rocks into which it came can be placed roughly in two groups. This area is exposed to view because of the erosion of recent basalt which probably once covered it entirely. The region around the Red Boy and that around the Bonanza mine are in argillite, while those in the vicinity of Greenhorn are practically all in the greenstone series. The latter group extends from near the Morning mine through the town of Greenhorn and old Robinsonville to Quartz creek, two miles north of Greenhorn. There is an exceedingly large number of veins which are usually small, but are frequently productive of rich ore.

The Psyche, 1½ miles east of the Morning mine, is in serpentine with some altered dolomite. A fine-grained light-colored sericitized porphyry was also noticed. Considerable development has been done upon this property and a stamp mill was erected, but was removed in 1914 to Cable Cove. Only the old badly weathered surface workings were visited. At these points the true nature of the mineralization is not very apparent.

The Roberts Group, about two miles southwest of Greenhorn, is in greenstone. The vein strikes about N. 70° W. and dips nearly vertical. The actual width of the vein was not determined, but the silicified replacement of the brecciated vein is of moderate width. Some of the material shows high values in the pan. Development work consists of open cuts, a crosscut and a drift which has not gone far enough to get underneath the croppings exposed in the open cuts.

Farther east in Sec. 16, T. 10 S., R. 35 E., at the head of Snow creek is the *Snow Creek Mine.* This property has a 10-stamp mill and three vanners and is developed by a shaft. It was not visited.

The Banzette is a little over a mile southwest of Greenhorn, and is a soft decomposed serpentinoid rock containing vein quartz, a little galena and some chalcopyrite, and some high grade ore. This property is practically abandoned.

On the northwestern extension is the *Diadem,* and but a short distance from the Banzette. The country rock is greenstone. The vein

strikes E.-W. and has a vertical dip and is of the shattered replacement type. The ore minerals are pyrite and cinnabar. Only a part of the old surface workings was visited. The property appears to have been abandoned.

In the vicinity of Greenhorn city most of the geology is difficult to make out, since the rocks are so badly altered and weathered and because so much folding and faulting has taken place. They are made up of a complex of greenstones, argillites, serpentines, and near the West Side vein and in a few other places there are beds of dolomite.

The greenstones, at least in part, appear to have been intrusions rather than extrusions because a granular texture is often observed. The serpentine, formed from previously existing rocks and consisting chiefly of magnesian silicates, has been exposed to processes at work in the zone of hydration.

The serpentine, originally more basic than the greenstones with which it is now associated, may have been intruded sheets, sills, or stocks, or possibly a basic differentiate of the greenstone intrusive. In many cases the larger blocks are incompletely serpentinized. Some show small reticulate veins of serpentine in the badly altered basic greenstone. The whole series has gone through all of the various periods of metamorphism, ending with the intrusion of the Greenhorn granodiorite to the westward.

The argillites noted in the lower tunnel at the West Side claim are metamorphosed mudstones which have suffered severely from shattering and weathering, although some of the more dense unaltered slaty type were noted.

The dolomite, found in some places 200 feet in width, is a bluish colored dense soft rock, composed chiefly of dolomite with some sericite and enough talcy material to give it a greasy feel. It is impossible to determine its origin.

As in other camps the veins were formed after the intrusion. After the veins were formed a long period of erosion and weathering followed before a series of recent lava flows came which are only partially removed at the present time.

Adjoining Greenhorn City are the *West Side claims,* on which there are steep dipping N.-S. veins. A "dolomite" bed is cut by the veins.

These veins are in the form of narrow broken lenses and consist chiefly of quartz, with some dolomite and calcite. The ore minerals are galena, pyrite, gold and silver. Some time after the veins had

been formed shearing took place involving a width of possibly 20 feet or more. The shearing and movement was approximately parallel to and inclusive of these lenticular veins. Since the shearing was quite pronounced with a considerable movement, perhaps involving oscillations, it has obscured and mixed the blocks of ore with the wall rocks in the shattered zone so that it is somewhat difficult to follow the ore.

Since the shearing of the veins about the only mineralization which has taken place is a deposition of chalcedonic quartz. A few carloads of ore were shipped from this mine in 1914 from which the returns were between $50 and $75 a ton. The West Side is developed by shafts about 40 feet deep, and a tunnel upon the general strike of the vein 300 to 400 feet long.

There is a large number of groups to the south and east of Greenhorn City. The ridge is dotted with small stamp mills and prospecting work has been done upon a great number of veins, many of which fail to persist. On most of these little work has been done for some few years. The *Spero* is in serpentine; the *Virginia,* one mile northeast of town, is in coarse partly crushed gabbro; *Don Juan,* about one mile southeast of Greenhorn, is in altered greenstone and serpentine, with ore of altered granodiorite, dolomite, and a little quartz and galena, and the *Phoenix,* nearby, is of similar nature. These are a few of the claims with considerable development, nearly all of which have produced more or less high-grade ore, but either the shoots are short lenticular bodies or else those who have been doing the work have failed to follow the ore. There is but little activity on this type of vein.

The Golden Eagle is in serpentine the principal vein of which has a maximum width of 3 feet on which some faulting has taken place. On this vein the gangue is principally quartz, while on the two other mineral-bearing veins the gangue is a creamy-colored dolomite. Chalcopyrite, galena and gold are the principal ore minerals.

At the *Royal White,* the chief development is 95 feet below the outcrop. The country rock is a gray, thin-bedded, thoroughly-fractured siliceous argillite. In two places the vein, which is in widths up to 3 feet, has been stoped, one about 150 feet long and the other 30 feet. Considerable faulting and movement has occurred. In one place the vein has formed an arch. The ore is said to be of good grade.

The Golden Gate mine, two miles east of Greenhorn, has 3 veins

upon the property. The Golden Gate and Belcher veins have nearly all of the developmnt. The Golden Gate vein is some 40 feet in width, most of which is quartz. But little work has been done upon this vein in the last 10 years. Judging from the general appearance of the quartz, and from the fact that little has been done upon it in the last five years, the values are probably low.

The country rock next to the Belcher vein is greenstone and greenstone breccia. The greenstone is a fine-grained greenish-colored rock. Its appearance indicates that originally it was an andesite. The breccia is grayish-green in color and the angular fragments an inch or more in diameter consist of dense, almost purplish-colored, rock. These fragments are probably trachytic in composition. The matrix is a rather indeterminable mass which seems to consist of a more or less granular aggregate, now nearly obscured by the alteration products, chlorite and calcite. It has been badly altered by surface weathering and the oxidation is quite deep.

This vein strikes N.-NE. and dips steeply eastward. The quartz is lenticular, with a maximum width of 3 or 4 feet, diminishing in places to a streak of gouge. There are 2 tunnels upon the vein, the upper some 800 feet long and the lower, together with crosscuts and raises, amounts to some 2,400 feet. The shoots said to contain the best ore are found not very far from the mouth of the lower tunnel. The two shoots are about 225 feet and 60 feet long, with a maximum width of 20 inches. Some distance farther in is a third shoot, with much less quartz and about 200 feet long, with a maximum width of about 3½ feet. A 10-stamp mill is under construction to treat the ores from the Belcher vein.

VEINS IN ARGILLITE

Bonanza Mine.—About 4 miles east of Greenhorn is the old Bonanza mine, discovered in 1877, and actively operated from 1892 until December, 1904, since which time leasers at different times have sought for ore in some of the old workings. The total production was approximately $1,750,000. From the various levels the property is developed to a depth of 1,250 feet below the outcrop.

The country rock is argillite, although a little limestone and serpentine are near. The vein strikes about N. 55° W. and is said to be nearly vertical. According to Lindgren the pay streak averaged only 5 to 6 feet, but swelled in places to 40 feet by the appearance of a vast number of quartz stringers.

The Red Boy Mine.—The total production of this mine is between $800,000 and $1,000,000; it is one of the best known mines of eastern Oregon. Its activity at the present time is confined to prospecting in certain parts of the mine and to re-cyaniding some of the low-grade concentrates.

The country rock is a slaty siliceous to calcareous black argillite, originally a mud deposit in quiet waters on the floor of an inland sea. Since the time of its deposition this mud, which aggregated hundreds of feet in thickness, became cemented into a rock that was afterwards subjected to pressure, making it somewhat laminated. Since the elevation is 4,600 feet at the mine they have been uplifted since deposition about a mile. The bending, squeezing, slipping or faulting has tilted them to the westward 15° to 20° from the horizontal.

The granodiorite intrusion which now makes up the main ridge of the Greenhorn range, has a northward spur on which is the Ben Harrison mine, about a mile from the main range. This same spur extends northward on the west side of the Red Boy mine. From this spur, as in practically all the other districts, dikes ranging from granodiorite porphyry to "quartz aplite" have filled fissures in the adjoining argillite.

The dikes in the underground workings of the Red Boy mine are very badly altered, but a microscopic examination of some of the fresher pieces shows that they are felsites of aplitic tendencies. These dikes, which near the veins are quite narrow, were injected into the fissures in a molten condition from below at some time well along in the dike-forming period. The upward flow had no crystals formed in it previous to the somewhat sudden ascension of the molten material, which because it was injected in narrow, sheet-like form between cold walls, congealed so quickly that only small or incipient crystals of quartz and feldspar had time to form.

A further shifting and movement occurred and the planes in which the dikes were located were fractured again because they were planes of weakness. This fracturing and movement involved both dike and adjoining argillite, but the latter was fractured to a much greater degree. This fracturing from one to several feet wide permitted the ascension of solutions from the concealed intrusion from which were deposited the quartz, the sulphides, and the silver and gold. These ascending solutions must have brought the gold and silver from the igneous intrusion, although it may have secured some quartz by leaching from the walls on its upward journey. The shattered

dikes and the adjoining argillite which make up the irregular walls of the veins both contain disseminated pyrite. These are undoubtedly deposits from ascending hot waters, which were especially active in their alteration of the aplitic dikes.

The quartz in the veins fills in and surrounds the sheeted and brecciated argillite. In some places white quartz and dark argillite are in roughly parallel bands when the vein is observed in cross section; at other places the appearance is more that of fragments of argillite of all shapes held in a white quartz matrix.

The characteristics of the vein itself are well stated by Lindgren.*

"In their general character the veins are similar to those of Cracker creek, though they are not so wide. They consist of a crushed fault zone in argillite, from 3 to 15 feet wide, in which the broken rock is cemented by a great number of quartz seams.

"The footwall of the Monarch is usually smooth and sharply defined, while the hanging is less well marked, a definite wall being often entirely absent. The width between walls varies from 5 to 7 feet. The vein matter is a black, crushed slate, and sometimes, also, masses or bunches of soft porphyry, both containing finely divided pyrite. The vein matter is traversed by a number of small quartz seams, rarely over 4 inches wide. Most of the seams are on the footwall side and produce a banded appearance of the vein. The best pay is contained in the 2 feet on the footwall, though the whole width is mined. In a few places on the Monach vein bunches of 5 to 6 feet of solid quartz were found. The seams usually show clearly defined comb structure, the crystals projecting from both sides of the seams, meeting in a median line. There is no evidence of surface oxidation of the Monarch on this level.

"The Red Boy vein averages from 3 to 6 feet in width and is in general structure similar to the Monarch, though the quartz is apt to form somewhat heavier bodies. It also contains more clay than the Monarch vein.

"The value of the ore appears to be entirely contained in the quartz seams and consists chiefly in free gold alloyed with much silver, the bullion being from 515 to 525 fine. The quartz contains a small amount of sulphides, pyrite with very little chalcopyrite, and arsenopyrite. . . . . Metallic silver and copper have also been found on the Monarch vein, inclosed in white massive quartz, and thus probably primary. The 5 per cent sulphurets contained in the ore are low grade, from $5 to $20 per ton, and probably are largely contained in the slate milled with the quartz."

It is believed that a careful reading of the above will bring out the following facts:

*Lindgren. Gold Belt of Blue Mountains of Oregon. Twenty-second Annual Report U. S. G. S. Part II., pp. 681-683.

1. That the best channel was along the foot wall which lessened toward the hanging wall.

2. That the best pay is contained in 2 feet on the foot wall, although the vein is from 5 to 7 feet wide. The values lessen, generally speaking, from foot toward hanging.

3. That the quartz seams are banded with free crystal faces in the middle of the bands, indicating that they were formed from ascending hot solutions. Quartz formed in the cold is chalcedonic.

4. That the value of the ore appears to be largely contained in the quartz seams, chiefly in free gold and silver.

5. That the sulphides found disseminated in the dike and in the argillite, although taken from near the surface, are undoubtedly primary and are of low grade because of their method of deposition outside of the channel.

All of the facts indicate that the ore in the Red Boy mine is primary, notwithstanding the fact that the vein so far developed below the 200-foot level is too low-grade to mine. The ore shoots of good grade above that level are not the result of downward sulphide enrichment, although a superficial examination of the mine maps might cause one inclined to over-emphasize the effects of secondary enrichment to draw such an inference because the stoped length of 800 feet is so much greater than its 300 feet of pitch length.

Primary ore deposition is a physico-chemical process which involves many variable factors. Lessening temperature and pressure, different wall rocks from horizon to horizon, mingling of different solutions by the joining of ascending flows of water and the great variableness in the velocity of the ascending waters passing through open fissures, filtering through brecciated fragments or stagnating next to impervious layers of gouge, all combine to influence ore deposition or to prevent it in any given place, to give it with a lavish hand or sparingly or not at all.

A careful examination of the mine map shows that the N.-S. Red Boy vein dips steeply west and the Monarch vein, with a medium dip also west, joins the Red Boy vein at a horizontal angle of about 30°. The difference in dip of the two veins would cause their junction to pitch to the N.-NE. The maps show this to be the case.

The value of the ore was said to have been maintained, at least as far as the 200 level, but the development from the 200 to the Chapman level and from that level to a lower one, failed to develop ore. It is said that upon the lower level the Red Boy vein was not recognized. This would eliminate from consideration all development except approximately 300 feet on the Chapman level which, judging from its position, is on the Monarch vein.

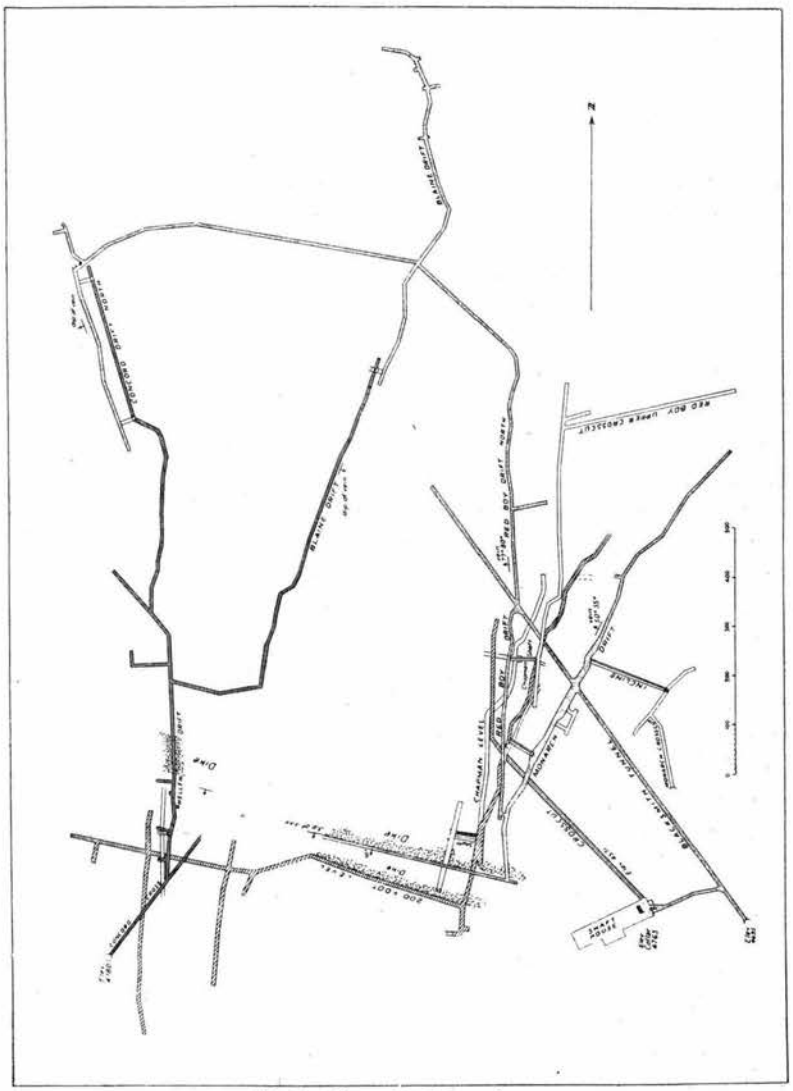


Fig. 86. Plan of Red Boy mine.

The excessive amount of water made mining so difficult and expensive which, combined with the low values encountered along this distance, caused further drifting north on the Monarch vein to be abandoned. It will be noted further that crosscutting on those lower levels is practically absent. The development below the stopes

is so limited and insufficient that one cannot state that the vertical limits of the stopes is the vertical limit of the ore.

Ore might not be found by new development upon the Chapman level. It might be absent upon the Chapman level and be present upon lower ones, or there might be little or no ore outside of that already stoped, due to the effects of one or more of the causes enumerated above, which affect the deposition of ore from ascending solutions in a great variety of ways. All possible shapes of primary ore shoots are apt to be found.

In any of the above statements it should be remembered that there probably was some mechanical concentration of gold at or near the surface due to the removal of the valueless part of the vein.

A fault zone appears in the Red Boy mine cutting across the Red Boy and Monarch veins in the position marked on the map and labeled "dike." This fault zone is in a great many respects quite similar to the Red Boy and Monarch veins, but differs from them in its greater width between the hanging and foot walls. On the 200-foot level this zone must be more than 100 feet wide. This shearing was along an old line of weakness which contained one of the intrusive dikes. This dike, only a few feet wide, was involved in the shearing and faulting and blocks of this igneous rock are found in the crushed mass showing little or no shattering, doubtless due to its greater ability to resist crushing than the adjoining slate. Whether this particular fracturing occurred at the same time as that which permitted the formation of the Red Boy and Monarch veins was not determined, but some evidences point to its having been later.

A large amount of clay along the south wall of this broad zone of crushing is indicative of the amount of movement that occurred, which may or may not have been a compensating one.

Red Boy hill has many dikes and veins and upon many of the latter considerable development work has been done in the past, the results of which are not available at this time, but considerable ore has been extracted from some of them. Perhaps a detailed and thorough examination of the surface and underground workings made by a thorough-going engineer might disclose evidences of additional ore bodies.

THE QUARTZBURG DISTRICT

The Quartzburg district is the next mining region south of the Greenhorn Mountain region. Waldemar Lindgren* gives the following general features of its geology:

"*General Features.* Between the Middle and South forks of John Day river rises a complex of older rocks, culminating in the round-topped Dixie Butte, which attains an elevation of 7,700 feet. It is probably on all sides surrounded by Miocene lava flows. From the bare summit of Dixie Butte, one of the landmarks of the country near which the old California trail runs, heavily timbered ridges extend in all directions. The thick forests on the north side of Dixie Butte are said to be favorite haunts of elk and bear.

"The geological structure of this area is complicated, but in general the rocks consist of diorite, diabase, and other greenstones, together with serpentine, inclosing smaller areas of clay slates, the exact age of which is not known; they are, however, older than the accompanying intrusive rocks. The stage road to Prairie crosses the most easterly part of the area; imperfect exposures show diabase, porphyry, serpentine and siliceous clay slates. But immediately at the summit, toward Prairie, basalts and andesites begin and continue down to John Day valley. A beautiful view of the latter is obtained from this place. Between the scattered yellow pines of the park-like forest the bare volcanic slopes of the valley with its broad pastures and irrigated fields present an attractive picture, and across it toward the south rise the jagged, snow-flecked lava peaks of the Strawberry Range. On the easterly road, leading down to the valley from the summits by way of the sawmill and Spanish gulch, first clay slates and then 2 miles of serpentine are crossed before the lava again begins.

"Going up from Prairie to Quartzburg district, the road follows Dixie creek, with its extensive and not yet exhausted placer deposits. Two miles upstream the valley widens and the covering basalt and andesite give place to an old sedimentary rock, a massive argillite. Two miles farther up, at the road junction, a narrow canyon begins, at the entrance to which is a little serpentine. The canyon, however, is cut in a normal, hard, medium-grained diorite, consisting of green hornblende and feldspar. One and a half miles still farther up, the valley opens, the diorite grows darker, and at the forks of the creek it is replaced by a diabase-porphyry. This is a very tough, dark-gray rock with dark-green crystals of augite in a groundmass of medium grain. Between Comer post-office and Present Need mine there is a great complication of igneous rocks, most of them dark-green diabase of varying grain, and also some diorite-porphyries or lamprophyric

*Lindgren. Op. Cit., pp. 708-12.

dike rocks. Similar rocks, mostly uralite-diabases, are seen on the east forks of the creek, where the copper prospects are located.

"Just above the Present Need mine coarse diabase appears, in places containing small seams of dark-gray dense rock which consists of quartz and tourmaline; but these veinlets carry no ores. In the crosscut of the Present Need a 200-foot-wide belt of peculiar grayish-green, fine-grained, sometimes flinty rock appears, which seems to be diabase-tuff and allied rocks greatly altered by contact metamorphism. These are described more in detail on page 588.

"The auriferous character of this area is shown by the fact that in practicaly all of the streams heading toward Dixie Butte placers have been worked. Important placers are found in Dixie Creek, but auriferous gravels have also been worked on Camp, Ruby, and Happy Camp creeks, draining toward the north, and Rich and Spanish creeks, toward the east.

"The principal quartz veins have thus far been found on the west fork of Dixie creek, though it is by no means improbable that discoveries will be made in other parts of the area. The veins are narrow and rich and contain heavy sulphurets in quartz gangue. The oxidized surface ore contains much free gold, but at slight depth the ores become much more base. The strike is generally north-northeast or northeast, while the dip, with few exceptions, is steep to the east.

"On the east fork of Dixie creek copper deposits of a very different type occur."

Further field investigation brings out the fact that a series made up of meta-andesites, some of which are amygdaloidal and some porphyritic, with altered tuffs and serpentines, and argillites make up the older rocks. Most of the flows are so chloritized as to warrant their being called greenstones. Gash veins and the amygdule filling evidence the alteration of the rock.

An intrusion into the greenstone, which is apparently a fine-grained granodiorite, is exposed to some extent west of the camp. Its presence underneath the mining camp is made known by the numerous porphyritic dikes, which all have granodiorite tendencies. Many of these dikes are said to contain low values in gold. After the intrusion there was another period of shearing and fissuring which furnished channels for hot ascending solutions that filled the fissures and shear zones with quartz containing gold, silver, copper and other sulphides.

In the shear zones on the eastern part of the camp there was much replacement of the shattered country rock. From this time on the geologic history is similar to the rest of eastern Oregon in that flows of Columbia river lava were succeeded by the erosion which created the present topography.

GOLD-QUARTZ VEINS

The Dixie creek placer mines were discovered in 1862, and soon after that date the quartz veins on the West fork were found and have been worked intermittently, at least since 1880. Lindgren states that the production to 1900 is not believed to have exceeded $100,000 and the production since that time has been considerably less.

The properties on this fork are the *Present Need, Keystone* and the *Equity,* formerly the Colorado, and the *Cougar.* All but the last one named are practically worked out as low as the creek bed. The veins in all are narrow. The maximum stoping width probably does not exceed 18 inches, while the most of it is less than half that amount. The lenses are very limited in dimensions, the maximum less than 100, usually confined to a few feet of stope and pitch length. The veins strike about N. 20° E. and dip 70° E. These fissure veins cannot be traced for long distances.

The ores consist of solid quartz with heavy sulphides in an irregular intergrowth. These sulphides are pyrite, hard and yellow, and soft yellow-gray marcasite, and a little chalcopyrite, blende and galena.

Leasers now from time to time work on the present levels or sink from the lowest ones in the search for shipping ore, or else make a low extraction in the crude mills erected there years ago.

Dixie Meadows Mine.—Three miles north of the properties just mentioned upon the headwaters of Ruby creek, which flows northward into the Middle fork of the John Day river, is the Dixie Meadows mine. This mine has been quite extensively developed and has a small mill upon the ground. The vein is a large one, much of it decomposed country rock containing considerable gold-bearing pyrite and arsenopyrite.

The ore body, although a large one, is quite spotted and its soft condition makes difficult the extraction of the higher grade bunches. These higher grade bunches are much less in evidence in the lower levels. There is difficulty in concentrating this ore, at least with the present equipment, so as to have much margin above transportation and treatment charges. If the entire body of ore could be treated cheaply upon the ground perhaps this property could be successfully worked. Leasers during the winter of 1913-14 extracted and milled some of the higher grade ore, but ceased operations about the middle of the year.

COPPER VEINS

On the East fork less than a mile above the junction, is the *Standard* copper mine, located on the east side of the creek, and for some few hundred feet above it. The country rock is made up of a series of old volcanic flows. In many places these have an amygdaloidal texture in which calcite is the chief filling material. Dark, finely granular dense flows are also present, made up of much andesine feldspar, and considerable uralitic hornblende, with some sericite and chlorite which probably makes it an altered uralite andesite.

On top of the ridge, above the mine workings, is a fine-grained, light-colored altered dike about 50 feet wide, which has a ground mass of badly formed intergrowth of quartz and feldspar. Its mineral composition indicates the parent granodiorite below. Its texture indicates it to be a granodiorite porphyry grading into aplite.

There are several developed veins on the property. These veins strike approximately N. 70° E. The most important are the Juniper and Standard veins. The Juniper vein is steep dipping and has a maximum width of about 2½ feet, and is of the replacement type with quartz and calcite as gangue minerals in with the altered country rock in the vein. The ore minerals are chalcopyrite, pyrrhotite, pyrite and some smaltite. These sulphides occur in small lenses with chalcopyrite as the chief sulphide. It is said to carry $3 in gold per ton. It has been developed by 120 feet of tunnel and has been traced by means of prospect pits for about 1,000 feet.

The Standard vein has a dip a little over 50° S. and in widths up to 10 feet. The mineralization of this vein is similar to that in the Juniper. It is said that lenses of sulphide 100x50x5 feet have been stoped. It is developed by three tunnels about 100 feet apart, 700, 1,200 and 1,300 feet long, respectively, all of which are connected by raises.

The Willie Boy vein, farther to the eastward, contains a small rich stringer of the usual minerals, but besides the massive cobalt di-arsenide, smaltite, there are small crystals of safflorite scattered through chlorite. Safflorite is identical in composition with smaltite, but crystallizes in the orthorhombic instead of the isometric system.

It is probable that these veins were formed by hot ascending solutions which were the last action of the intrusive mass at depth. The veins are of the replacement type, and the influence of the wall rock was probably an important factor. The mineralization is unique in that cobalt minerals are present. Although the region is somewhat weathered, it is doubtful if there is much secondary enrichment.

These small veins have been practically worked out to the level of the creek. Large croppings of a lode into which these small veins lead appear to be many feet wide, but no development was observed upon them. These wide N.-S. croppings of quartz and partially replaced country rock contain bunches of chalcopyrite within a foot or two of the surface.

A great deal of money has been expended upon this property which closed down in 1907, after operating the mill for 6 months. Development work was started again in the spring of 1914 by new owners.

The Copperopolis claims are located on the west side of the canyon, about a mile above the Standard. The development consists of several cuts and tunnels. An 800-foot tunnel from the creek level taps the lode 300 feet below the croppings. The development of this level shows a large irregular chimney-like body of massive quartz containing tourmaline and chalcopyrite. The total copper-bearing width at the surface is about 40 feet. It can be traced for about 1,000 feet. The ore is largely a replacement of the country rock by quartz, tourmaline and chalcopyrite, but in the rock are richer seams of comb quartz and chalcopyrite. The presence of tourmaline indicates magmatic mineralizers and a high formation temperature. Some 250 tons of ore was milled in a small concentrating mill upon the property, which closed down in 1906.

F. X. Gauthier, about three miles north of the Standard mine, is developing an altered volcanic tuff along the side of an intrusion of magnetiferous feldspathic porphyry.

The ore minerals occur in small veins in what is locally called a dike, but is probably an altered and shattered contact of the porphyry with the fragmental volcanic rock.

PLACER MINES

No change in Lindgren's report of 1900, which is quoted below, is to be noted. Locally the gross production from the Dixie placers is reported from $600,000 to $6,000,000. Probably the lesser amount approximates the truth. The depth of the gravel and the condition of the bed-rock was not learned, but if these were proven suitable it might pay to install a dredge.

"*Placer Mines.*—The Dixie creek placer mines were discovered about 1862, and were reported rich, though no data as to production are at hand. Raymond's report for 1870 contains the statement that at that time there were 100 white men and 200 Chinamen employed,

Fig. 87. Old placer gravels of Dixie creek.

and that the fine, scaly gold was 860 fine. In 1873 the creek is reported as turned over to Chinese labor. In 1882 two small hydraulic plants were in operation, producing $30,000 (Mint report). At the present time very little placer mining is done.

"The placers consist of the gravels accumulated in the present creek to a depth of 10 to 15 feet. The workings extend upstream from Prairie for 5 miles, or to the entrance of the diorite canyon, where the grade becomes very steep. The width of the gravel-covered river bottom is from 300 to 800 feet, the whole of which has been worked.

"Six miles east of Prairie are the old Spanish Diggings, which have yielded a moderate amount of gold. The upper end of John Day valley contains no placers. On the east side of Dixie Butte are the old placers of Happy Camp, still worked on a small scale by Chinese. Northwest of the same mountains are the Ruby Creek placers, still worked by whites and Chinese. Small placers are also reported from the head of Camp creek."*

*W. Lindgren. The Gold Belt of the Blue Mountains of Oregon. U. S. G. S. Report 1900, p. 712.

CANYON MOUNTAIN REGION

CANYON DISTRICT

The extended quotation which follows is taken from Waldemar Lindgren's excellent report upon "The Gold Belt of the Blue Mountains of Oregon," pp. 712-720, and is the result of his visit to this district in 1900.

"*General Features.*—The celebrated placer mines of Canyon are situated in the upper drainage basin of the South Fork of John Day river. The valley here widens to a broad depression, about 18 miles from east to west, and from 4 to 8 miles from north to south. In contrast to the narrow and heavily timbered valleys of the North and Middle forks, this is a bare expanse of gravelly pasture land with strips of alluvial soils along the river from a quarter mile to 1 mile wide. The elevation at John Day is 3,000 feet; at Prairie, 3,500. The climate is fairly mild and dry, the water supply ample; in consequence the valley was settled soon after the discovery of the placers, and has for thirty-five years supported a prosperous community of cattlemen and farmers. North of the river the hills rise gradually and culminate in a timbered ridge forming the divide between the Middle and South forks of John Day river. The eastern end of the valley is surrounded by dark forested mountains rising to about 6,500 to 7,000 feet. At the very head of the valley there is, however, an unexpectedly low pass (elevation about 4,500 feet), through which a wagon road leads over to the Malheur river basin. South of the valley the picturesque Strawberry range rises abruptly, with serrated peaks, culminating in Strawberry Butte, with an elevation of about 8,600 feet. Toward Canyon the sharp ridges are a little lower, but still attain 8,000 feet. The range presents a steep but not very regular slope, with numerous salients and deeply incised canyons. Hot springs are found on Reynolds creek in the uppermost part of the valley.

"*Geology.*—The older pre-Miocene diabases, slates, and serpentines from the north side of the valley have been described under the heading "Quartzburg district." The eastern end of Strawberry range, including the butte of the same name, is built up of Tertiary lavas. But at the foot of this mountain the underlying rocks appear, and their contact gradually rises westward, until in a short distance they form the summit of the mountains, culminating in a group of peaks and ridges which a few miles south of Canyon attain 8,000 feet above the sea. South of Prairie, below Strawberry butte, serpentine appears in great development. It reaches 900 feet above the foothills, and also continues westward across Indian creek. At Gillespie's sawmill it contains small bunches of chromite. The range was not ascended any farther than to the claim known as the Oregon Wonder, at an elevation of 6,300 feet; but the color and configuration of the high ridges

Fig. 88. Strawberry butte and the Strawberry range.

back of Canyon indicate that they are composed of a granitic rock. Prospectors state that diorites and porphyries are the prevailing rock, and in the gulches, coming down from the peaks, are abundant cobbles of a very coarse diorite with hornblende crystals up to 2 inches in length.

"Above Canyon serpentine crops below the gravels almost within the limits of the settlement. Immediately above and on the west side fissile clay slate begins, with east-west strike and steep southerly dip. This continues for a few hundred feet, with a smaller mass of serpentine intercallated with slates. The relations between the two rocks are not clear, though the serpentine, an altered igneous rock, is probably intrusive in the slates. Above this follows another belt of serpentine about 1,000 feet wide and adjoined on the south, without well-exposed contact, by diabase and diabase-porphyry. At this point the canyon becomes deep and narrow; on the east rises the pronounced salient, Canyon peak, which is also made up of diabasic rocks.

"In general there is a marked similarity in geological structure between the Greenhorn mountains, Dixie butte, and the Strawberry range. All of them are built up of diorites, diabases, and serpentines, inclosing smaller masses of sedimentary rocks, usually clay slate.

"Extensive areas of basaltic and andesitic rocks surround John Day valley. Most of them, it is believed, are of early Neocene age. The road from Austin to Prairie, after crossing the divide, descends over long ridges of pyroxene-andesite, both massive and brecciated. Lower down the gradually flattening ridges are made up of massive basalts, and these continue for 3 miles, down to the level of the valley. The same fine-grained, often vesicular basalts form the low hills bounding the alluvium on the north for several miles east of Prairie. Augite-andesite directly overlies the argillite on Dixie Creek a couple of miles above the junction with the main river, and it is, indeed, probable that the andesites are the older of the two rocks. All the way down to the town of John Day basalt bluffs follow the north side of the river, gradually increasing in height; near John Day they are about 500 feet high. In places white tuffs alternate with the basalt. The surface ascends gradually from the bluff to a moderately high divide, the slope probably indicating the surface of the lava flows. At a few places near John Day the black, glassy olivine-basalt appears on the north side of the river, but the exposures are usually small and covered by gravels.

"Along Canyon creek above John Day the basalt is overlain by a considerable thickness of light-colored rhyolitic tuff, extensively used as a building stone at Canyon. Above this tuff again rest more recent gravels.

"The uppermost part of the valley was not visited, but it is believed to be entirely covered by basalt and andesite, these extensive areas forming a continuation of the area surrounding Austin and extending over the headwaters of Burnt river. Without much doubt

this area of lavas continues and forms the summit of the Strawberry Range to a point a short distance west of Strawberry butte. The form and color of the jagged ridges indicate clearly enough their volcanic origin. Strawberry butte is formed by a great number of superimposed dark lava flows, and was no doubt once the locus of a most intensive eruptive activity. The rock forming its slope is a basalt cut by a rhyolite dike of immense size.

The broad extent of the valley from Prairie across to the foot of Strawberry butte is a gently sloping surface covered with coarse basaltic gravel. Broad gulches cut in this slope reveal thick strata of these coarse gravels interstratified with some sandy material. At some point near the river coaly material has been found, no doubt embedded in these strata. West of Prairie the basalt north of the river is for some distance covered by these gravels.

"Along the road down to John Day, volcanic bluffs, as stated, follow the north side of the river. The south side of the alluvium is bordered by lower bluffs, from 100 to 300 feet high, less abrupt and with smoother outlines. They consist of coarse gravel with occasional softer strata, and in several places are seen to rest on basalt. All these gravels form a part of the old, late Neocene flood plain which shortly after the close of the eruptions covered the John Day valley to a height several hundred feet above the present river level.

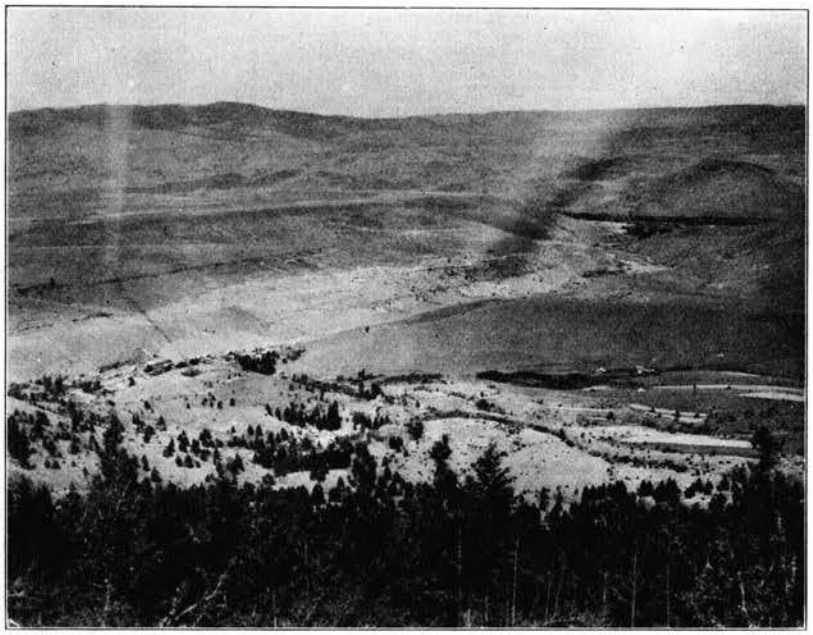


Fig. 89. Canyon creek and John Day valley from Canyon mountain.

The position of this flood plain indicates that the river then took a course from 2 to 3 miles south of its present channel. The exposures at Canyon (see below under "Placer mines"), indicate that the bottom of these old river deposits lies considerably below the present bed of the river.

"The most recent deposits are the alluvial sands and gravels along the present river course. These are over 1 mile wide at the junction of John Day river and Strawberry creek. Two miles below Prairie are narrows, where a little canyon has been cut through a bed of basalt. Below this the alluvial deposits are from 1,000 to 2,000 feet wide.

"*Gold-Quartz Veins.*—Canyon Peak, the bold salient from the main range which rises back of Canyon, consists of coarse gabbro or gabbro-diabase containing irregular masses of a dark-green, finer-grained diabase or diabase-porphyry. This hill is celebrated for its rich pocket veins, and most of the placer gold in the vicinity is probably derived from its veinlets. The production from these veins is very difficult to estimate. At any rate it has not been very considerable, and few of the prospects rise to the rank of a mine. On the summit of Canyon peak, 1½ miles above the Great Northern, is the Idaho vein. There is said to be a strong vein of quartz, in the vicinity of which many small pockets have been found. Some distance below is the Mountain View. Here also is a well-defined strong vein, 3 feet wide, crossed by a network of stringers carrying products of coarse gold.

"The Great Northern mine is located 2 miles southeast of Canyon, on a steep slope 1,540 feet above the town, at an elevation of 4,700 feet. A very fine view of John Day valley is obtained from this point. This deposit was discovered in 1898 by Ike Guker. Placers have been worked in the gulch a couple of hundred feet below it. In 1898, $30,000 was extracted from one of the seams in a surface cut, and prospecting operations have since that time been carried on by a company having its headquarters in Salt Lake City. The developments aggregate 2,000 feet of drifts and crosscuts.

"The country rock consists of gabbro and irregular bodies of diabase porphyry. The latter, being often soft and traversed by calcite seams, is locally called lime, though it is without doubt an igneous rock.

"A surface pit, about 50 feet by 50 and perhaps 20 feet deep, shows decomposed rock cut by seams usually dipping 30° to 40° east or west. The bonanza mentioned above was extracted from one of these seams. From a tunnel level 50 feet below extensive drifting has been done in an attempt to follow these seams. A vein of quartz 1 to 2 feet thick has been uncovered, striking north to south, and dipping 25° W. This is practically barren and is accompanied by an impregnation of pyrite and seams of calcite. Some of the seams in the tunnel above the vein carried wire gold, with a tendency to crystallization, inclosed in calcite.

"About 300 feet east of this point another strong quartz vein, 2 feet thick, has been found. This strikes east-west, and dips 35° S. It carries massive white vein quartz, in places stained green by chromium.

"At Prairie Diggings, 3 miles east of Canyon, placers containing rough quartz gold have long been worked. In the same vicinity is reported a large vein of base character and, to judge from specimens, inclosed in slate. In Raymond's report for 1870 it is stated that the body of quartz mixed with country rock is 400 feet wide, strikes northeast to southwest, and dips 60° SE. In 1872 a mill had been erected and $10,000 extracted, but soon after this the enterprise was abandoned, the quartz being, it is stated, of too low grade.

"Aside from the occurrences described, the Strawberry range apparently contains few mineral deposits. Near the head of Canyon creek, 7 or 8 miles southeast of Canyon, claims have been located. The Chambers group is said to show a strong quartz vein 5 to 30 feet wide, containing a litle chalcopyrite and limonite. The strike is said to be N. 60° E. In the Will Cleaver group, in the same vicinity, similar ore is found, claimed to average $8 in gold and 4 per cent in copper.

"Almost due south of Prairie, high up on the side of Strawberry butte, a great number of claims have been located, the principal one known as the Oregon Wonder. A trail leads up to this place from Gillespie's sawmill (elevation 4,200 feet) near the mouth of Indian Creek canyon. The trail for the first few hundred feet leads over serpentine. Above this rock lie heavy flows of basalt, which at the claims (elevation 6,300 feet) is cut by a big rhyolite dike at least 300 feet wide, the outcrops of which form a bold and precipitous cliff. This dike continues for a long distance eastward and a continuous chain of claims is located on it. The rock is a yellowish-gray to brownish lithoidal rhyolite, showing very pronounced flow structure. It consists of sanidine crystals embedded in a microfelsitic groundmass. Little spots and seams of limonite abound in it, and it also carries traces of silver, and occasionally traces of gold.

"Placer Mines.—The placers of Canyon are justly celebrated as the most important and productive deposits of the kind in Oregon. They were discovered in 1862, and in less than a year many thousand miners were at work on the gravel bars of the creek and in the gulches of the surrounding hills. During the first few years the production was very great, but exact figures will probably never be known. Estimates are made varying from $3,000,000 to $5,000,000 a year. In 1865 the product was estimated at $22,000 a week (Raymond's report, 1870), or about $1,000,000 a year. In 1870 it had already fallen to $300,000 a year. In the following year the production was still further reduced, but remained for a long time about $100,000. The Mint reports for 1883 and 1884 estimate $87,000 and $80,000; for 1890, $72,000, and for 1891, $100,000. While the figures are incomplete and untrustworthy, it is scarcely probable that the total production

much exceeds $15,000,000. In 1882 there were 16 hydraulic plants (many of them small) in operation, and two-thirds of the products were derived from Chinese companies.

"At the present time both white and Chinese miners are operating, mostly on a small scale. Mines near Marysville and the Humboldt hydraulic mine were worked. The amount annually extracted from the placers during the last few years probably varies between $30,000 and $50,000.

"The water supply is abundant, being secured from Canyon creek and gulches east of it. . . .

"The section exposed along Canyon creek above John Day shows well the position of the older gravels. Resting on basalt and rhyolite tuff are heavy, coarse gravels, which are well exposed on the west side of the creek at Canyon, where they are 150 feet deep and overlain by finer gravel, in part sandy or clayey. At the Humboldt hydraulic mine 80 feet of the latter is exposed. On the south side of the creek, on the road leading up to Marysville and the Great Northern mine, much of these overlying sandy and clayey sediments are exposed, and they reach up to the foot of the mountains at an elevation of 3,900 feet, 750 feet above the town. In the gulches descending from the gold-seamed Canyon peak, which have cut into these soft deposits, rich placers are found. Some of these gravels are worked now near Marysville.

"In the creek bed near Canyon a shaft is reported to have been sunk in 1873 to a depth of 300 feet without reaching bed-rock.

Fig. 90. Canyon mountain and Canyon City.

"It is clear that there is a great complication of deposits at Canyon, gravels of very different periods being present, and considerable time would be required to establish the exact relations. On the whole, it seems that shortly after the eruption of the basaltic and rhyolitic lavas flowing down from the north the stream was crowded over close to the mountains and heavy gravels accumulated in it. This must have taken place in the Pliocene epoch. The bottom of this channel has never been exposed. It is probable that the Pliocene gravels cover earlier accumulations of auriferous gravels, but that these can ever, if found, be profitably worked is extremely unlikely. The coarse gravels are very poor in gold—in fact, practically barren.

"As the deposit deepened the width of the river bed increased, and several hundred feet of finer sediments were deposited on top of the coarse gravels. At the same time the detritus from the high mountains on the south began to push the river northward again, and during this gradual process the high bluffs on the north side of the river were formed.

"The finer gravels are workable only at certain places. The most important locality is the Humboldt mine, 150 feet above Canyon, and on the western side of Canyon creek. Hydraulic operations have been carried on here for many years. A strip of ground half a mile long and several hundred feet wide has been washed, leaving a bank 80 feet in height. The bed-rock is formed by coarse, cemented gravel; the pay is said to be concentrated in the first 4 feet overlying the bed-rock. The exposed bed-rock is nearly level, but is said to slope gently westward. This gravel mine has been worked for over 30 years, the output being reported as from $10,000 to $20,000 per season. These gravels, no doubt, represent the beds of Canyon creek at a time when the main stream had already been pushed northward to nearly its present position. The rich gravels of Marysville, situated on the hill 1½ miles east of Canyon, and the gravels of the present gulches above Marysville are comparatively recent deposits; they are derived from the rich pocket veins of Canyon peak and some of the deposits have been worked almost up to the veins. Most of the gold has, however, been caught on the clays and gravels of the older river sediments, below the outcrops of the older rocks.

"With the final establishment of the present drainage, Canyon creek has been deepened to its present level. Its bed is from 200 to 600 feet wide, covered with gravels to a depth of 15 to 18 feet. These have, of course, been worked over, some parts more than once, but a certain amount of gold is still found concentrated on the bed-rock. The workings extend for 5 miles up from John Day river. In 1900 prospecting shafts were sunk in these gravels with a view to dredging operations, and the results are said to have been satisfactory. The placer gold from Canyon is often 900 fine, and sometimes, as at the mouth of Canyon gulch, 990, or $19.82 per ounce. The gold from the quartz veins averages 830 fine.

"Above John Day there is apparently not much gold in the main river, but below this place for several miles the bars have been, and are still, worked by derricks and wheelbarrows. The depth to bed-rock is usually only about 18 feet. Extensive prospecting for dredging ground was recently undertaken 4 miles below John Day by the Pomeroy company, of Portland. The results have been so satisfactory that a dredger will soon be erected here. The gravels are reported to average over 30 cents per cubic yard, most of the gold, of course, being found on the bed-rock. Bed-rock of serpentine and slate shows at intervals, according to Mr. J. H. Pomeroy, in the river below John Day, and the gold is often so coarse that it must be of local origin instead of having been washed down from Canyon creek.

"At Spanish gulch, about 70 miles west of Canyon, on Crooked river, auriferous gravels were deposited on serpentine, and have been worked for many years. A production of $1,400 is given for 1882 in the Mint reports. In 1898, $16,000 was taken out in a couple of months, the gold being very coarse. This locality, which was not visited, is, as far as known, the most westerly point of the gold belt of eastern Oregon.

"Another district not visited is that of Fox, Hamilton and Long creeks, about 20 miles due west of Susanville. Small but persistent amounts of from $1,000 to $7,000 of placer gold are yearly reported from this vicinity."

The annual production from placer mines since 1900 has decreased. In 1912 the production from six placers in this district was $6,380.

The Canyon Mountain Mining Company built a 10-stamp mill on the property described above as the "Mountain View," but have operated the mill but a short time since its completion about a year ago.

Work was continued since 1900 on the "Great Northern" in search of more high-grade ore, but it has been closed down for a few years.

"The Chambers Group and the Will Cleaver Group" have been abandoned for some time because of their inaccessibility and the base nature of the ore.

The "Oregon Wonder" has been closed for some years.

Regarding Spanish Gulch, 60 miles west of Canyon City, Arthur J. Collier* states that:

"This camp, like that of Canyon creek, is nearly worked out, but there are at least two good prospects of hard rock mines. One of

*The Geology and Mineral Resources of the John Day Region, by Arthur J. Collier. The Mineral Resources of Oregon. March, 1914.

these is being guarded by some parties who are in litigation over it. The other, to which the title is good, is wholly undeveloped."

The "Pomeroy dredge" was constructed and operated, but for some reason did not continue. It may have been due to the small size of the buckets. The general construction of the smaller type of dredges built at that time were usually insufficient in strength and capacity to permit their successful operation in gravels of moderate values on firm bed-rock.

Rich pockets are found from time to time upon the Dan O'Shea claim, now owned by Salt Lake City parties, and under lease to Dwyre and Brown.

The above notes bring Mr. Waldemar Lindgren's account of the district up to date. The rich placer mines and pockets of high-grade ore, together with a determination of the resident miners to have nothing to do with any ore which is not free milling, has had a decidedly retarding influence upon development in this district.

THE LOOKOUT-PEDRO MOUNTAIN REGION

This area is also closely associated with a granodiorite intrusion that outcrops, although not continuously, for about 25 miles in a southwest-northeast direction and forms Pedro and Lookout mountains and many other smaller outcrops.

Adjacent to Pedro mountain but located in the older rocks are the mines of Mormon Basin, one of which, the Rainbow mine, is the greatest gold producer in the state. Those near Lookout mountain and Burnt river and those along the Snake river, a few miles north of Huntington, in all probability owe their mineralization also to their proximity to the intrusion underneath.

Lookout mountain is situated about 7 miles northeast of Burnt river and 8 miles west of the Snake river. The O.-W. R. and N. Co.'s main line follows Burnt river canyon from Baker to Huntington much of its way. On the Snake river a branch of the same line runs from Huntington to Homestead. The Mormon Basin district is the farthest removed from a railroad since it is 22 miles from Durkee and 25 miles from Huntington. The wagon roads are excellent, and even in winter the snowfall is not sufficient to cause much inconvenience. Gold Hill and Weatherly deposits adjoin or are within a few miles of the railroad. The Snake river prospects are also very favorably located with reference to river and railroad.

The higher altitudes of Pedro and Lookout mountains are sparsely timbered, while the remainder of the country is covered with sage brush.

Briefly stated the geology of this region consists of an older series of rocks composed chiefly of slates, argillites, schists and limestones, interbedded with volcanic flows now altered to greenstone and probably also some intercallated intrusions. These older rocks have been subjected to mountain building forces and as a result have been so much altered that in some places they have been changed to slates and schists. Generally speaking they are tilted at high angles.

The limestone belonging to this older series of rocks is already of some economic importance and in the future will probably become still more valuable. At Nelson Siding, 4 miles southeast of Durkee, is a large exposure of limestone. A cliff within a few feet of the railroad rises abruptly to a height of a few hundred feet and extends to the eastward for about a half mile or nearly to the Gold Hill

mine. There are kilns at Nelson Siding and considerable lime has been burned there.

Along the Snake river between Connor and Soda creeks and about one mile west of the river is a limestone ridge that is about 4 miles long and one-half mile or more wide, which attains an elevation above the river of nearly 2,000 feet. Most of this is blue in color and of dense texture. Some of it is schistose in character. The lime in this locality has not been used for any economic purpose.

Other large masses of limestone are found 4 miles above Huntington on Burnt river and here kilns have been in operation. Besides the above mentioned deposits there are many other occurrences which may in the future be of economic importance.

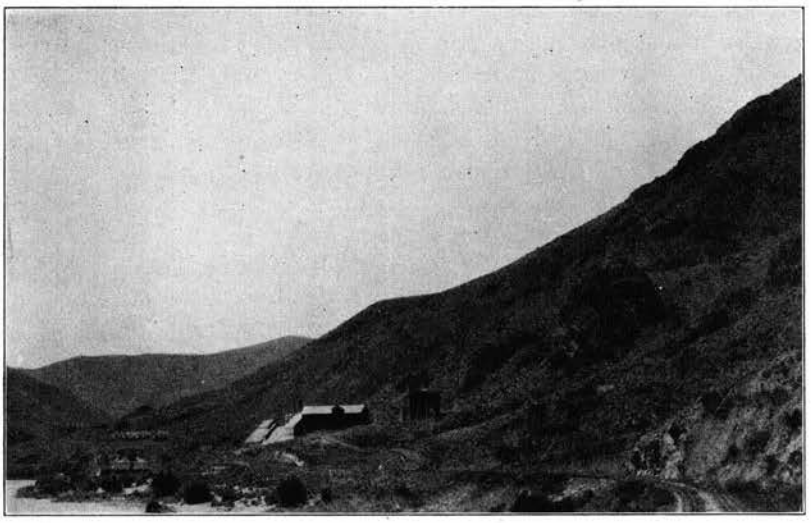


Fig. 91. Plant of Pacific Lime & Gypsum Company.

Gypsum deposits are situated 4 miles north of Huntington by rail on the ridge overlooking the Snake river. This deposit belongs to the older series and occurs as a highly-tilted bed, 30 to 40 feet thick, and interbedded with impure limestone and altered volcanic tuff. The crude material is ground and calcined at a plant located on the railroad near the river.

To give in detail a story of the conditions which this region underwent, previous to and accompanying the intrusion of granodiorite, would be but to repeat in all except unimportant details, those already

given of other regions. The intrusion here failed to rise to such elevations as in most of the regions elsewhere, consquently erosion has failed to remove completely the roof over such a wide expanse, but we have the many local outcrops of it. It is, nevertheless, at greater or less distances underneath a large part of the region.

The sediments and flows which made up the crust of the earth in this region were crumpled and folded at the same time as those in adjoining regions. Accompanying or following closely upon this activity came the molten rock underneath it. This molten intrusion may have had sufficient pressure behind it to displace the older rocks from their position. But this displacement, if it really occurred, was of minor importance to the stoping effect which the intrusion had upon its roof of older rocks. The contact effects, although not worked out, are probably not extensive, but peripheral variations in the composition of the intrusion undoubtedly are caused by the incorporation of the enclosing rocks into it.

The intrusion is, for the most part, a rock of medium granular texture. It is made up of feldspar, chiefly andesine, quartz, hornblende, biotite and small amounts of magnetite. It will be seen that this mineral composition is that of the tonalitic phase of granodiorite. Where the intrusion extended farthest upward into the older rocks, erosion has since denuded it. Pedro and Lookout mountains are the most important of such exposures.

Dikes, chiefly of the granodiorite porphyry type, are found both in the intrusion and in the enveloping older rocks. The granodiorite porphyry dikes came first and more acid phases grading into aplite followed after. Finally came the fissuring, partly due to cooling and partly to mountain building movements, which were the channels of ascending thermal solutions that deposited in them great quantities of quartz and metallic sulphides and the precious metals. For the most part these quartz veins are normal fissures. Some of them, like those near Lookout mountain, occur in lenticular form in the highly tilted argillite and schist. Other veins, as in the case of the Rainbow mine, have been formed alongside of porphyry dikes that have been altered and impregnated with quartz and small amounts of gold.

After the intrusion there was a long period of erosion, which was followed by recent lava flows and the deposition of lake beds. In this area many of the recent lavas are rhyolitic, although many basaltic flows also occur. At Rye valley and Mormon basin lake beds are especially well developed. They may have a thickness of several hundred

feet but subsequent faulting makes it hazardous without detailed work to estimate the amount. Sometimes the gravel beds in this formation carry gold. Elevation and erosion have taken place since the lava flows and lake beds were formed. Gold bearing gravels which in some places have been large producers, were laid down in recent times.

The mines and prospects of this region are those in the vicinity of Connor creek, near Lookout mountain and Lower Burnt river, Mormon basin, Rye valley and those near Malheur City.

CONNOR CREEK DISTRICT

The Connor creek district is one of the oldest in Oregon. The well-known Connor Creek mine was discovered in 1871.

PLACER MINING

Upon the several small streams which flow into the Snake river there have been placer mines since early days. Those on Connor creek have been the most productive. It naturally has derived considerable coarse gold from the Connor creek vein. The whole creek below the mine has been worked over twice and parts of it are worked at the present time. The total production of the placer gold for this locality is about $125,000.

QUARTZ PROPERTIES

The Mullin Prospect.—This property, upon which gold was discovered in the spring of 1914, is on the north side of the district near Soda creek, close to the south edge of Sec. 27, T. 11 S., R. 45 E., about 19 miles north from Huntington. The prospect is reached from the railroad by a trail one and one-half miles long.

The hills are covered with bunch grass and sage brush, and are quite rugged and steep. The elevation of the river at this place is about 1900 feet, and that of the claim 3500 feet above sea level.

The climate along the Snake river canyon is mild in winter and hot in summer.

The geology of this immediate vicinity is comparatively simple. The country rocks are limestone and schist. No true bedding of the limestone was noted but the schistosity strikes N. 70° E. and dips from 80° N. to vertical. The limestone is blue in color and has a finely crystalline texture. In some places it is brecciated and recemented with calcite. Where the pressure of the mountain building forces was strong enough the limestone has been changed into a lime-

stone schist. The schist found in this locality is bluish and quite dense. In thin section it is seen to be very fine-grained and to consist chiefly of elongated quartz grains with fine parallel bands of sericite. Most of the quartz veins are fissures although some secondary silicification has taken place in this altered sedimentary rock.

The small but well defined fissure vein upon this property strikes northwest and dips 60° southwest, and cuts limestone and limestone schist. It is about 2 feet wide and has been traced for about 300 feet. The vein for the most part is milky quartz with a few well-formed quartz crystals. Sometimes native gold occurs near these crystals.

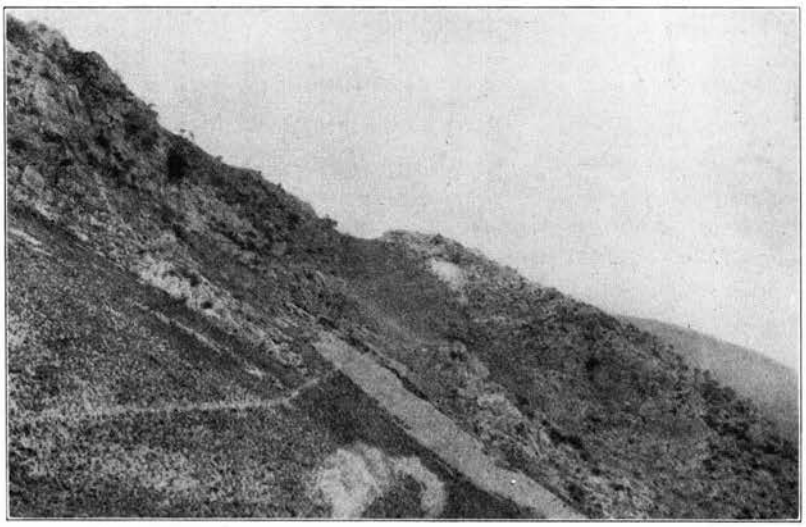


Fig. 92. Location of Mullin prospect

Some tetrahedrite is present in the vein and near the surface its oxidation products, malachite and azurite are seen. There are also parts of the vein which appear to have been fragments of limestone which are now almost completely replaced with silica, and in these bluish siliceous portions are the richer parts of the vein.

Besides the vein just described there is another 2 foot vein which strikes N. 55° E. and dips 80° northwest to vertical. It consists of massive quartz and calcite. It does not carry any values and is supposed to be cut by the gold bearing vein above described.

Near the top of the ridge the gold bearing vein is cut by a north-south vertical basalt dike about 30 feet wide. A slight displacement

of the vein next to the dike has occurred. It seems quite clear that this vein was formed by ascending thermal solutions. Granodiorite outcrops on Lookout mountain only a few miles to the west and the presence of the granodiorite underneath the immediate vicinity of this prospect is proven by the porphyry dikes nearby.

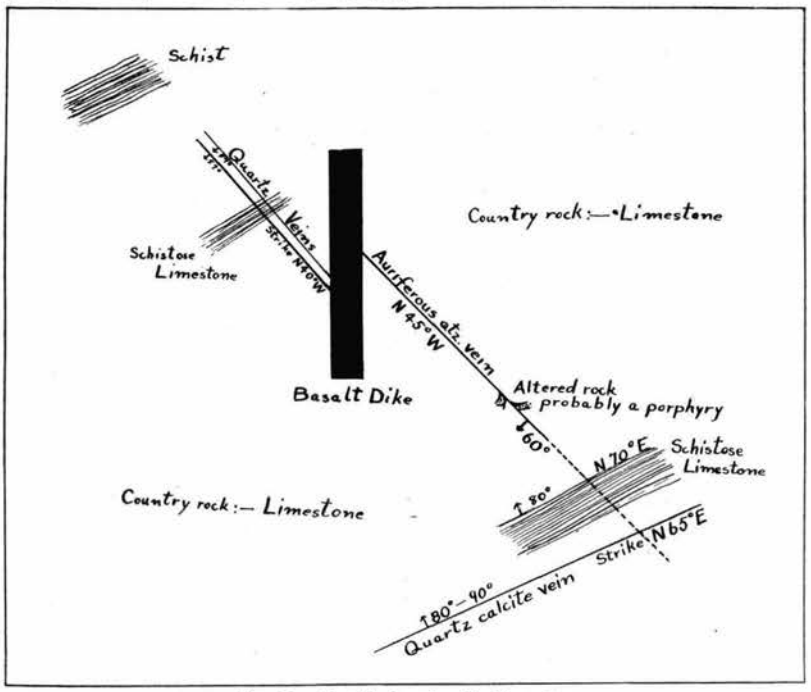


Fig. 93. Sketch showing Mullin veins.

Development work consists of several open cuts in which the values, although quite variable, are said to contain gold up to $60 a ton. A drift upon the gold bearing vein should be started at a point but a short distance below the place where the two veins cross. This drift would permit a systematic sampling of the vein and continued development would depend upon the assay values and their regularity.

The Runner Claims.—This group is situated about a mile southwest of the Mullin property. The country rock is a schist similar to the one above described. It is here cut in many places by quartz veins a few inches wide from which probably branch minute reticulate veins impregnate the body of the schist. Samples taken of the country rock all show the presence of gold. It is probable that this metal is

contained in the minute stringers while the unaltered schist is barren.

The genesis of this deposit is similar to that of the Mullin claim in that the quartz and the gold were deposited in the shattered schist from ascending solutions coming from the underlying cooling magma. In this case apparently the values have been disseminated widely throughout the schist. The limits of the gold-bearing schist have not been determined in two crosscuts which are being driven upon the property.

It is reported that channel smaples taken regularly in these crosscuts over a width of 90 feet averaged $3.26 a ton with no samples below $1.00. If an average value anything like the above can be maintained for a sufficiently large tonnage of the schist to warrant large scale operations it would become one of the great gold mines of the world. The reported value is nearly twice that of the gold deposited in schist now being developed on a large scale near Juneau, Alaska. The conditions of climate, topography, and transportation are decidedly favorable all the year round for outside mining operations. This group is being developed by John Wilson of Baker and R. M. Betts of Cornucopia.

The Liddy Group.—Between one and two miles south of the Runner group are the claims owned by J. J. Liddy. The vein, in places several feet wide, has been subjected to a great deal of movement which has produced much sugary quartz. On account of the movement and faulting there is much difficulty in following the vein. Tetrahedrite occurs in the vein in small amounts. The gold values were not ascertained.

The Connor Creek Mine.—The Connor Creek mine is situated on Connor creek about two and one-half miles northwest of the Snake river. It is one of the oldest mines in Oregon, the veing having been discovered in 1871. The total production is approximately $1,250,000. The property is not now in operation.

The immediate country rock is a black slate which has a general north-northeast strike and dips about 60° west-northwest. The vein strikes about N. 40° W. and dips 70° to 75° southwest. The average width is 3 to 4 feet. The value of the milling ore was from $3 to $10 a ton, but several rich pockets were found in which coarse gold was associated with argentite. So much native mercury was contained in the ore at times that amalgamators had difficulty in maintaining a proper hardness of the plates.

The vein has been developed by 6 tunnels, the shortest of which

is about 500 feet in length and the longest 3,700 feet. At the present time most of these are caved. The stopes on all levels continue in a northwest direction until a fault is reached. This fault strikes N. 30° E. and dips 45° to 60° southeast. The vein has been picked up on the other side of this fault, but has not been developed.

Not much of the mine is at present accessible since its period of greatest activity was some 20 years ago. Nothing can, therefore, be added to the information given in the more extended report by Waldemar Lindgren, frequently quoted in this report.

THE GALLAGHER GROUP ON THE NORTH SIDE OF LOOKOUT MOUNTAIN

There are few prospects located upon the north side of this mountain, the only ones worthy of mention are the two groups owned by Gallagher Brothers, located on upper Manning creek in Sec. 2, T. 11 S., R. 45 E. The nearest town is Durkee, which is reached by a good wagon road 12 miles long. The region is moderately hilly. Timber can be obtained from the slopes of the mountain.

The country rock consists of schists, argillites and greenstones all tilted at high angles. Much faulting and shattering has taken place. The gold is contained in quartz lenses of various sizes. The maximum width observed at the old Gallagher property was about 20 inches. Minute impregnations of quartz in argillite also contain gold. Many porphyry dikes were observed in the locality so that it is probable that the granitic intrusion is at no great depth below the surface. This property has been idle for 9 years. It is said to have produced $30,000 within a short time from a small tonnage of ore.

The new Gallagher group has a crosscut upon it in which is seen a badly altered porphyry dike and many stringers of quartz in the adjoining argillite. A width of some 15 or 20 feet which includes the altered dike and stringers is reported to contain fair values in gold.

BURNT RIVER DEPOSITS

Gold is found along Burnt river from Gold Hill to Huntington and much of this distance was placer mined in early days. A two and a half cubic foot dredge was built and operated for a time some years ago by the Pomeroy Dredging Company of Portland. It has been idle for several years. A standard dredge of larger capacity operated with electric power might possibly have been a success.

The quartz prospects on the north side of the river are the Gold Hill mine and various prospects on Chicken and Sisley creeks. Owing

to a combination of circumstances none but the Gold Hill property was visited.

Gold Hill Mine.—The mine is situated about 5 miles southeast of Durkee on the east slope of Gold Hill. The immediate vicinity represents a small stock of granodiorite intruded into limestone and schist.

The veins upon this property are found both in granodiorite and schist. They are fissure veins, although when cutting schist considerable replacement has occurred. The several veins strike from east-west to 20° southeast and vary from 2 to 10 feet in width. Several veins have been cut by a long crosscut, but the examination of much of the development was prevented by bad air. High values are reported in some of the veins, the higher values usually in the smaller veins.

There is a 10-stamp mill upon the property in which some ore has been treated. Some work was done here in 1914 by Mr. Al Geiser of Baker in opening up the Spring Gulch, one of the smaller veins, which is nearest to the portal of the tunnel.

MORMON BASIN DISTRICT

The Mormon Basin mining district is situated a few miles south-southwest of Pedro mountain. It covers an area of about 15 square miles and is partly in Baker and partly in Malheur county. It is a true basin in shape with many small gulches draining towards the central part where they unite with Mormon Basin creek, which makes its exit through a small canyon in the southern rim. The elevation of the floor of the basin is about 4,700 feet and it is probable that the maximum relief is about 1,000 feet.

The steep sloping hills are covered with sage brush and the higher elevations with sparse timber. There is a small precipitation. In winter the snowfall is not heavy enough to be of any great inconvenience. The railroad points are Durkee, 22 miles away, and Huntington, 25 miles distant.

The geologic history of this immediate vicinity is similar to many other regions of eastern Oregon, but with certain phases somewhat accentuated.

The oldest rocks, which are also the predominant ones, are a series consisting chiefly of what were originally mudstones, sandstones, and siliceous and calcareous sediments. Interbedded with these may have been some lava flows or perhaps the basic igneous rock was intrusive into sediments in the form of sheets and sills.

This series was then subjected to severe mountain building forces

which folded and faulted the rocks and altered the shales, sandstones, siliceous and calcareous rocks into slates, quartzites, cherts and marbleized limestones. By these same forces the basic igneous rocks were altered until they now consist of secondary hornblende, serpentine, and other green-colored minerals, so that they are now called greenstones.

Just at the close of this period of mountain building which contorted, fractured, and changed the series into rocks very much as they are at present, there came a granitic intrusion. The largest batholithic mass now exposed by erosion is that of Pedro mountain to the northeast. A stock of considerable size occurs west-southwest of the basin and can be seen along the road to the town of Malheur. Generally speaking the rock is a granodiorite of medium granular texture and consists of andesine feldspar with quartz, hornblende, and biotite and small amounts of magnetite. There are of course local variations in its composition due to magmatic differentiation. Increase of quartz bringing it nearer a granite, the decrease of quartz making it a quartz-diorite while the absence of quartz makes it a diorite.

Accompanying the intrusion in its closing phases were the characteristic dikes of porphyry and aplite. The first mentioned type are of peculiar interest in this region on account of the well known "spotted" dike of the Rainbow mine. This particular rock is described under the description of that mine.

The heat of the intrusion as well as the emanations from it contributed further to the metamorphism of the overlying rock. During the cooling of the magma the region was under stress and the resulting fissures were filled with molten material which upon solidifying formed the dikes that have just been mentioned. Later when much of the magma had solidified the fissures which were formed at this time were filled with ascending quartz solutions. These solutions deposited their quartz in the veins, and the precious metals and other minerals also. In this particular region movement took place during vein deposition as is shown by cemented vein breccia in many of the veins.

The mineralization of the veins in Mormon Basin varies. In some a large percentage of the gold is free; in others it is contained in sulphides which are chiefly arsenopyrite, and pyrite with minor amounts of sphalerite and galena.

After the veins were formed there was a period of erosion. Then came the outpourings of Tertiary lavas and the formation of lake beds during the same age. Both acid and basic lavas are to be found in this vicinity. The former which were probably earlier are repre-

sented by rhyolites and trachytes. In the Humbolt mine there is a dike of altered rock that was probably a feeder to one of these later flows.

Lake beds were formed in the lower part of the basin and probably have a thickness of a hundred feet or more. In places they are interbedded with altered trachytic flows. The lake beds vary in character from coarse gravel to clay. It is probable that the placers of today were at least partly formed by the reconcentration of gold bearing Tertiary gravel beds by present day streams.

The basic lavas are represented by basalt as in other parts of the eastern Oregon region. They are probably somewhat later than the lake beds. Basalt is found on many of the ridges.

Since the Tertiary series of lake beds and lava flows were laid down considerable movement has taken place, as is shown by the tilting and faulting of them.

Recent erosion has taken away much of the Tertiary covering. The present day placers have been formed by the wearing away of auriferous veins and the consequent deposition of the gold in the stream channels and also by the reconcentration of gold-bearing gravels of the lake bed formation.

This region is a particularly difficult one to prospect as is evident by the many abandoned tunnels. The cause of this difficulty is the close resemblance in places of the lake beds to the older altered rocks. Fragments of gold-bearing quartz in the coarser deposits of the lake beds entice the prospector to drive underneath ore at the surface which is not in place. The amount of wash or mantle rock is often such as to hide the true character of the bedrock. In some parts of the Basin faulting and shattering is particularly prevalent and here even when a true vein is found care must be taken to find it beyond the fault.

The foregoing remarks are made not to discourage prospecting in a region so well mineralized that it has the greatest producing mine in the state, but to show the especial need here of very careful geological work.

THE RAINBOW MINE

This is the principal mine of the district and is situated on the eastern rim of the Basin. It has been producing for a number of years and is at present operated by the United States Smelting, Refining and Mining Company of 55 Congress street, Boston, Massachusetts.

Fig. 94. Rainbow mine and mill.

The geology of the Rainbow mine is comparatively simple, the country rocks are chiefly slate with some granitic intrusives on the hanging wall side and some limestone and greenstones on the foot wall side. The greenstone is an intensely altered rock with an excessive development of secondary hornblende; its original character is difficult to make out.

The vein fissure has a strike of N. 60° E. and in the upper levels a dip of 66° N., while in the lower levels a dip of 54° N. Before the period of vein formation the fissure was filled with a porphyry dike locally known as the "spotted dike." A petrographic description of this rock is as follows:

It is dark brown and has a dense porphyritic texture. There are a few gash veins of quartz and minute reticulate veins of pyrite present. In thin section the predominant phenocrysts are badly formed feldspar crystals which for the most part owe their irregular outlines to resorption, or partial melting after they were formed. In composition the feldspars are of the soda-lime variety and the few that were capable of accurate measurement were found to be andesine. Some show zonal growth to a certain extent, thus indicating a change in the composition of the magma. The ferro-magnesian phenocrysts are hornblende and hypersthene, both occurring in very badly formed crystals, and intergrown with them are small crystals of biotite, some grains of pyrrhotite, and a little magnetite. The groundmass is seen to be made up of very minute feldspar crystals with some quartz. The intergrowth of these minerals is in some places so close that it approaches a micrographic or micropegmatitic texture. The rock has suffered some alteration of the deep-seated type. Many of the feldspar phenocrysts show fracturing and sometimes a development of sericite in these fractures. Other alteration minerals present are: uralitic hornblende, secondary quartz, some actinolite, and a small amount of chlorite.

Judging hastily from the hand specimen alone one might possibly call this rock an andesite. But even then the dull appearance and irregular outlines of the majority of the feldspar phenocrysts are indicative of its intrusive rather than extrusive nature. In thin section the mineral composition at a hasty glance might also appear to be that of an andesite. But, on closer inspection the amount of primary quartz in the groundmass, the microgranitic texture even approaching micrographic in places, and the predominance of feldspar make it clearly evident that this rock is a porphyry genetically related to an intrusive

magma that is probably a basic granodiorite or quartz-diorite or perhaps even a diorite in composition. Of course the structural occurrence of this rock is that of an intrusive dike and for this reason unless it were evident that the dike was a feeder to an andesite flow it could not be called an andesite.

The Rainbow vein is not of the fissure type but of the brecciated zone type. The fractured zone varies from a few feet in width in

Fig. 95. Underground in the Rainbow mine.

some places to over 50 feet in others. It is made up of fragments of country rock cemented by quartz. The porphyry dike is included in the brecciated zone to a large extent. On both walls of the lode there is a quartz vein. The foot wall vein of the lode is the best developed and has been the most worked. The vein quartz is fine-grained and contains but a very small amount of arsenopyrite and pyrite in which there is some gold. Some of the free gold in the vein is large enough to be distinctly visible, but for the most part it can not be seen. A small amount of actinolite and a little chlorite occur with the quartz, and when these minerals are present the gold values are said to be greater. This is noteworthy as it points toward the precipitating action of the ferro-magnesian silicates.

There has been some movement since ore deposition, as is shown by the gouge and slickensides. The quartz, however, is not fractured to any great extent.

The genesis of this vein is simple, that of ascending thermal solutions from the underlying magma. The presence of the porphyry dike shows that the vein fissure followed this line of weakness.

The mine is worked through a shaft about 500 feet deep but most of the development has been done on the 200 level where the vein has been drifted upon for 1,700 feet. Mine and mill are operated by electricity with power furnished by the Idaho-Oregon Light and Power Company.

The mill has 15 stamps and handles over 100 tons a day. Forty-five per cent of the ore is free-milling. The stamps crush to about 12 mesh from which the pulp goes to a tube mill. From the tube mill it passes over amalgamating plates and then to a Dorr classifier. The sands are returned to the tube mill for regrinding from which the pulp goes to the Dorr thickener and then to Pachuca tanks. After agitation in cyanide solution the pulp goes to a Kelly filter press, from which the cake is sluiced to the tailing pond and the clear solution going to gold solution tanks. Precipitation is made with zinc dust and a Merrill filter press is used. The mill is very compact and is a model for this type of ore. The recovery is about 97 per cent. In addition to the mill there is a complete assay and experimental laboratory and also furnaces for refining the precipitate and bullion.

A very complete system of costs is maintained both for mine and mill, so that one may tell at a glance the cost of the different operations. This may vary with the time of year or on account of irregularity of the power. Assay stope maps are kept up to date. Both mine and mill are run in a thoroughly business-like manner.

THE HUMBOLDT MINE

This mine is situated in the southwestern part of the Basin in Malheur county in the northwestern quarter of Sec. 20, T. 13 S., R. 42 E. It is operated by the Oregon-Idaho Investment Company. It has been producing for several years.

Formerly the mine had four levels and was worked by means of a vertical shaft. Recently the shaft has been sunk 100 feet deeper and a crosscut driven to the vein upon which drifting has been started.

There is a 20-stamp mill upon the property in which recovery is by amalgamation and concentration with Wilfleys and vanners. A considerable percentage of the gold is free milling. The concentrates are shipped to smelters, but it is proposed to instal a cyanide plant to treat the tailings.

Fig. 96. Humboldt mine and mill.

Fig. 97. Faulted quartz vein in the Humboldt lode.

The many movements that have taken place in this immediate vicinity have caused the geology to be confusing. The chief country rock is slate with diorite porphyry in the foot wall. In the upper levels trachyte is said to form a large part of the hanging wall. This trachyte was probably a feeder to some of the recent acidic lava flows.

The lode has an east-west strike and a dip of 75° N. in the upper levels but with a steeper dip below. In some places the lode is as much as 40 feet wide, but the actual quartz veins are rarely more than a few feet thick.

The chief gangue mineral is quartz and much of it is in a sugary condition, due to crushing by later movements. Some calcite is present in the vein. The ore, especially in the upper levels, is free gold, and many fine specimens have been taken from the mine. In the lower levels more sulphides are found. They are chiefly arsenopyrite, pyrite, galena and sphalerite. The galena and sphalerite are said to contain high values in gold.

The Humboldt lode is situated in a zone of weakness where fracturing and movement have taken place many times. The first break allowed the injection of the diorite porphyry that is found on the foot wall. Then came the fracturing that made the opportunity for the hot ascending silica solutions to deposit their burden of quartz and metallic sulphides. Movement took place during the period of vein formation as is evidenced by the recementing of broken quartz fragments. Considerable post mineral movement has taken place, as is shown by the sugary quartz, the gouge, and the actual faulting of the vein in the lode. The presence of a trachyte dike goes to show further how great a zone of weakness there is here. A certain amount of pressure may still exist as a partial explanation for the bad ground in some parts of the mine where large sized stulls are crushed in a short period of time. On account of the faulting that has taken place in this mine a careful geological map combined with an assay map would be of considerable value as a guide to future development.

OTHER PROSPECTS

Besides the Rainbow and Humboldt mines that have been described briefly above, there are several prospects in the Mormon basin district. A failure to correctly gauge the time required for the work, caused even less time to be devoted here than elsewhere although it is one of the newer and most productive camps.

No description of these prospects will be given here because detailed work is especially necessary in this region to insure a proper degree of accuracy.

PRODUCTION

The production of the Mormon basin district from its placer mines is not known although the amount is quite large. The production from quartz mines is almost confined to the last seven years. The total production for the seven years is approximately $1,400,000.

OTHER PLACER AND QUARTZ PROPERTIES

Willow creek is one of the largest tributaries of Snake river and enters it a short distance above Huntington. A bare ridge, 1000 to 2000 feet high separates Burnt river and Willow creek. On the slopes of this ridge and from 6 to 12 miles west of Rye valley are a number of well known old placer camps—Clarks creek and Bridgeport on Burnt river and Mormon basin, Amelia, Malheur and Eldorado on the Willow creek side. The operations have largely ceased in most of these camps. Except Mormon basin, they were not visited.

The Rye valley placers were discovered shortly after 1862 and have been worked up to the present time with a total production of more than $1,000,000. Water is available for only a few months in the year.

Dixie creek has been placered for 3 miles above the town but the high gravel bars have produced by far the most gold. Years ago it was proposed to dredge the stream bed but a depth of 90 feet has discouraged the attempt although borings are said to show an average value of 30 cents a yard.

A number of quartz veins have been found near Malheur but as yet none of them have become steady producers. The Red, White and Blue vein near Malheur has been developed by a shaft and has produced at times. It is said to be a vein 2 feet wide contained in a clay slate which is cut by diorite dikes.

A number of quartz veins containing silver have been found on Pedro mountain and attracted attention 40 years ago. The veins were rich in silver. But little has been done upon them in the last few years.

The Gold Ridge Mine.—This mine is situated 4 miles south of Durkee. It is an old discovery that has been operated at times for many years but is now idle, full of water and with adits caved. The total production is said to be $210,000, practically all extracted from 1881 to 1886.

The country rock has a medium-grained texture and undoubtedly belongs to the granodiorite clan, but owing to the fact that probably not more than 10 per cent quartz is present it might better be called a quartz diorite.

According to Lindgren there are three principal veins, two of them having a strike of N. 51° W. and dipping 65° SW. A third strikes more nearly east-west and dips south. The veins cross the ridge

about 200 feet above the shaft, but their outcrops are inconspicuous and for the most part concealed by wash. The ore above the tunnel had a value of $12-$15 per ton, the largest part of it free-milling.

The Gold Coin Placer.—This property is located about two miles southwest of the Gold Ridge, about one-half mile north of the Rye valley wagon road and eight miles from Durkee. It is almost at the summit of the ridge that lies between the Rye valley road and the Gold Ridge mine. It occupies the southern side of the hill and reaches an elevation of about 500 feet above the road.

The gold is found in gravel beds belonging to the Tertiary Lake Bed formation. The beds are tilted and somewhat faulted. They consist of pebbles of quartz, flint, greenstone, granite, rhyolite, and volcanic tuff. The pebbles are rounded and vary in size from 3 to 4 inches down to sand. The finer material is usually granular, although some clay is present in places interbedded with the gravels.

There are many other placers in this vicinity, but for the most part they have been worked in a small way.