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THE ORE DEPOSITS
OF
NORTHEASTERN WASHINGTON

BY

HOWLAND BANCROFT

INCLUDING A SECTION ON

THE REPUBLIC MINING DISTRICT

BY

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CONTENTS.

	Page.
Introduction	1
Area examined	1
Field work and acknowledgments	1
Literature	2
Climate and vegetation	2
History of mining activity	3
Mining and metallurgy	5
General conditions	5
Transportation	5
Methods of mining	6
Treatment of ores	6
Smelters	6
Mills	6
Costs	8
Topography	9
Geology	10
General features	10
Pre-Cambrian (?) rocks	11
Paleozoic rocks	12
Sedimentary series	12
Igneous rocks	15
Mesozoic rocks	16
Tertiary rocks	18
Lake beds	18
Lava flows	18
Intrusive rocks	19
Breccia-conglomerate	19
Quaternary deposits	20
Geologic history	20
Pre-Cambrian (?) conditions	20
Paleozoic conditions	20
Mesozoic conditions	21
Tertiary and Quaternary conditions	21
Effects of metamorphism	21
Regional metamorphism	21
Contact metamorphism	22
The mineral deposits	22
Periods of mineralization	22
Kinds of deposits	23
Gold deposits	23
Shear zones in quartz latite	23
Fissure veins in andesite and quartz latite porphyry	23
Fissure veins and shear zones in metamorphosed sediments and diabase	24
Silver deposits	25

The mineral deposits—Continued. Page.
Lead-zinc deposits 26
Disseminated replacements in metamorphosed sediments 26
Fissure veins 26
Copper deposits 27
Copper-bearing quartz veins 27
Replacement deposits in metamorphic rocks 27
Disseminated deposits in schist and granite 28
Other metalliferous deposits 28
Iron 28
Tungsten 29
Antimony 30
Molybdenite 30
Nickel 30
Ores mined chiefly for use as a flux in smelting 30
Placer deposits 31
The mining districts and ore deposits 39
Stevens County 40
Metaline district 40
Location and extent 40
Means of access 40
Condition of mining industry 41
Topography 41
Geology 42
Ore deposits 43
Distribution and character 43
Origin of the ores 45
Future of the district 45
Prospects on the west side of Clark Fork 46
Oriole 46
Clark 47
Lead King 48
Cliff 49
Prospects on the east side of Clark Fork 49
Schellenburg 49
Riverside 50
Meade 51
Northport district 51
Location and extent 51
Condition of mining activity 52
Transportation of ores 52
Topography 53
Geology 53
Ore deposits 54
Mines and prospects southeast of Columbia River 54
Last Chance 54
Treadwell 56
Scaman 57
Anaconda 57
Copper King 57
Frisco Standard 58
Keough 59
W. J. Bryan 59

The mining districts and ore deposits—Continued.
Stevens County—Continued.
Northport district—Continued. Page.
Mines and prospects northwest of Columbia River 59
Sunset 59
Great Republic 60
Double Standard 61
Mines and prospects near Bossburg 62
Young America 62
Bonanza 63
Orient district 64
Location and extent 64
Condition of mining activity 65
Topography 66
Geology 66
Pre-Cambrian (?) rocks 66
Paleozoic (?) rocks 67
Mesozoic rocks 68
Tertiary rocks 68
Ore deposits 69
Mines and prospects on First Thought Mountain 71
First Thought 71
Second Thought 76
North Star 77
Prospects on Toulou Mountain 77
Globe 78
Scotia 78
Copper Butte 79
Orient 79
Defender 80
Trojan 81
Prospects east of Pierre Lake 82
Big Iron 82
Pomeroy 83
Easter Sunday 83
McNally 84
Other mines and prospects 85
Kettle River 85
Little Giant 87
Swamp King 88
Beecher 88
McKinley 88
Napoleon 89
Chewelah district 92
Location and extent 92
Condition of mining activity 92
Topography 92
Geology 93
Kinds of rock 93
Sedimentary rocks 94
Igneous rocks 95
Ore deposits 95

The mining districts and ore deposits—Continued.
Stevens County—Continued.
Chewelah district—Continued. Page.
Mines and prospects on the east side of Colville Valley 98
United Copper 98
Chewelah Copper King 102
Strobeck 104
Delmonico (Enterprise) 105
Blue Star (Eagle) 105
Jay Gould 106
U. S. Copper Gold 107
Windfall 108
Copper Queen 108
Prospects on the west side of Colville Valley 109
Hartford 109
Liberty 110
Nevada 111
Deertrail (Cedar Canyon) district 111
Location 111
Condition of mining activity 112
Topography 112
Geology 113
Sedimentary rocks 113
Igneous rocks 114
Ore deposits 114
Distribution and character 114
Origin of the ores 115
Lead-silver deposits 116
Brooks 116
Sunday Morning 116
Little Frank 117
Hoodoo 117
Germania tungsten deposit 118
Location and means of access 118
History and production 118
Equipment 119
Development 119
Topography 119
Geology 119
Ore deposits 120
Character and distribution 120
Origin of the ores 122
Treatment of ores 122
Other deposits in Stevens County 124
Columbia River Gold Mining Co 124
Silver Queen 125
Old Dominion 126
Tungsten King 130
Ferry County 133
Republic (Eureka) district, by Waldemar Lindgren and Howland Bancroft 133
Location and extent 133
Means of access 134

The mining districts and ore deposits—Continued.
Ferry County—Continued.
Republic (Eureka) district—Continued. Page.
History of the district and condition of mining industry..... 134
Production..... 135
Mining..... 136
Metallurgy..... 136
Topography..... 137
Geology..... 138
Rocks exposed..... 138
Geologic history..... 138
Paleozoic rocks..... 139
Mesozoic rocks..... 140
Tertiary rocks..... 140
General character..... 140
Lake beds..... 141
Lava flows..... 142
Quartz latite porphyry..... 143
Breccia-conglomerate..... 144
Quaternary deposits..... 144
Glacial drift and stream gravels..... 144
Alluvial deposits..... 145
Ore deposits..... 145
The older veins..... 145
The younger veins..... 146
General features..... 146
Gangue minerals..... 147
The ore in general..... 150
The ore in depth..... 151
Alteration of the wall rock..... 152
Genesis of the deposits..... 152
Mines and prospects..... 153
Southern Republic (Princess Maude)..... 153
Chico..... 154
Republic..... 154
Quilp..... 157
Blacktail..... 159
Surprise, Lone Pine, and Pearl..... 159
Insurgent..... 162
Sanpoil..... 162
Ben Hur..... 163
Trade Dollar..... 163
Knob Hill..... 164
Mountain Lion..... 164
Morning Glory..... 165
Other prospects on Flag Hill..... 165
Tom Thumb..... 166
Belcher district..... 166
Location and extent..... 166
Condition of mining activity..... 167
Topography..... 167
Geology..... 168
Ore deposits..... 169

The mining districts and ore deposits—Continued.
Ferry County—Continued.
Belcher district—Continued. Page.
Mines and prospects 170
Oversight 170
Copper Key 173
Belcher 175
Sanpoil district 179
Location and extent 179
Condition of mining activity 180
Topography 180
Geology 181
Ore deposits 181
Mines and prospects 182
Congress 182
Manila 185
Polepick 186
Covada or Meteor (Enterprise) district 187
Location and extent 187
Condition of mining activity 188
Topography 188
Geology 188
Ore deposits 189
Mines and prospects 191
Meteor 191
Stray Dog 193
Advance 193
Keystone 195
Longstreet 195
R. E. Lee 196
Silver Leaf 197
Other deposits in Ferry County 197
Lone Star and Washington 197
Deposits near Danville 199
California 200
Iron Mountain 201
Laurier 201
Jenny 202
Okanogan County 203
Park City district 203
Location and means of access 203
Condition of mining activity 204
Topography 204
Geology 204
Ore deposits 204
Mines and prospects 205
Castle Creek Mining Co's. prospects 205
Location and general features 205
Ore deposits 205
Summit 205
Snowshoe 206
Mountain Boy 207
Ramore Mining Co.'s claims 207
Wasco 209
Index 211

ILLUSTRATIONS.

		Page.
PLATE I.	*A*, Glaciated surface of shale containing many quartz lenses; *B*, Section of vein from Anaconda No. 1 property	56
II.	*A*, Minor folding in limestone country rock at Copper King property, Northport district; *B*, Section of vein from Frisco-Standard mine	57
III.	*A*, Lens of limestone included in shale, Globe prospect; *B*, Mass of quartzite surrounded by intrusive porphyry, Second Thought group	66
IV.	Plan of First Thought mine	72
V.	*A*, First Thought mine; *B*, Part of United Copper camp	74
VI.	Specimen showing structure of the United Copper vein	100
VII.	*A*, View in United Copper mine; *B*, Faulted vein No. 2, Germania mine	101
VIII.	Plan of the Germania camp	118
IX.	Occurrence of wolframite in quartz, Germania mine	120
X.	Quartz ledge in quartz-mica schist, Tungsten King mine	132
XI.	Panorama of Republic, Wash	133
XII.	Geologic map and sections of the Republic mining camp	134
XIII.	Map showing mining claims in Republic district	136
XIV.	*A*, Glory hole of New Republic mine; *B*, Southern Republic vein	146
XV.	Photomicrograph of quartz from Southern Republic vein	146
XVI.	Republic mill	154
XVII.	Plan and sections of Republic mine	156
XVIII.	*A*, Republic vein on fourth level; *B*, Polished section from Republic vein, third level	156
XIX.	*A*, Pearl vein; *B*, Stope in upper level, Surprise mine	157
FIGURE 1.	Index map of Washington, showing location of area examined	1
2.	Map of northeastern Washington, showing the location of the principal towns in several of the mining districts examined	39
3.	Sketch map of First Thought and Toulou mountains, showing the location of the mines and prospects visited	72
4.	Longitudinal section of the First Thought mine	73
5.	Geologic and topographic sketch map of the area about the First Thought mine	74
6.	Sketch map of Eagle and Quartzite mountains	94
7.	Longitudinal and cross sections of the United Copper mine	99
8.	Sketch map showing the approximate position of some of the claims in the vicinity of the Deertrail camp	117
9.	Section through the ridge in which the main workings of the Germania mine are located	119
10.	Flow sheet of Germania mill	123
11.	Flow sheet showing proposed plan of treatment in the mill of the Germania Co	123
12.	Longitudinal section and plan of the Old Dominion workings	128
13.	Sketch showing the relative position of the Tungsten King prospect and Big Blue Grouse Mountain	131

Page.

FIGURE 14. Republic vein, sketched from third level 155
15. Republic vein, sketched from fourth level 155
16. Diagram showing relations of veins on Surprise, Lone Pine, and Pearl claims 161
17. Topographic map of a part of the Belcher mining district 168
18. Sketch map of a part of the Oversight group of claims, showing the location of the workings 171
19. Plan of the Copper Key workings 174
20. Plan of the Belcher mine workings 177
21. Section through the Belcher mine looking southwest 178
22. Sketch map of the area in which the Congress property is located, near Bridge Creek, Sanpoil mining district 182
23. Sketch map showing the location of some of the properties visited in the Meteor or Covada (Enterprise) mining district 190
24. Plan of main level of Meteor prospect, Enterprise district 192
25. Plan of the Advance workings, Enterprise mining district 194
26. Map of the northeastern part of the Republic quadrangle, Wash 198

THE ORE DEPOSITS OF NORTHEASTERN WASHINGTON.

By HOWLAND BANCROFT.

INTRODUCTION.

AREA EXAMINED.

The area investigated in the reconnaissance whose results are here set forth is situated in the extreme northeastern part of the State of Washington, containing within its boundaries the whole of Stevens and Ferry counties, which cover approximately 6,000 square miles.

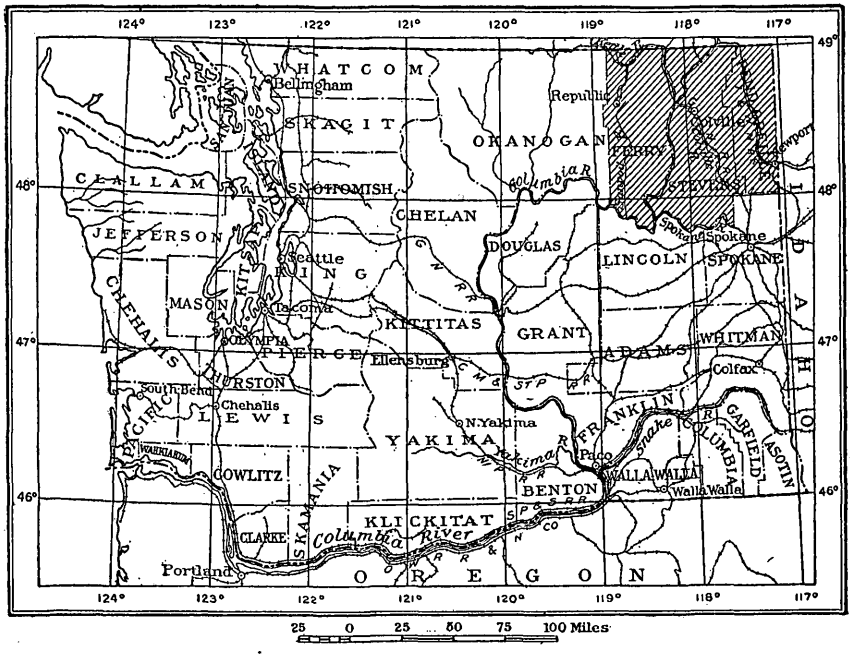


FIGURE 1.—Index map of Washington, showing (by shading) location of area examined.

(See fig. 1.) Brief mention is also made of the ore deposits in the Park City district, in Okanogan County, near the boundary between this and Ferry County.

FIELD WORK AND ACKNOWLEDGMENTS.

The field work in this area was done by the writer during parts of the summers of 1909 and 1910, a total of four and one-half months having been spent in the several districts. Mr. Waldemar Lindgren

spent the month of September, 1909, in the field with the writer. At that time the Republic (Eureka) district was studied in some detail and the report on this district has been prepared by Mr. Lindgren and the writer jointly. Thanks are due to Mr. Lindgren for many valuable suggestions pertaining to geologic conditions in this area and for criticisms of various kinds during the preparation of the report.

The writer takes this opportunity to thank also the men interested in the development of the mining industry in this part of Washington, who generously gave him their time and information while he was in the region. Especially does he feel indebted to Messrs. Alexander Sharp, Conrad Wolfle, William Scheck, H. J. Lycett, S. H. Richardson, J. L. Harper, Harry Newton, L. L. Tower, E. W. Scothorn, August Krug, Jens Jensen, James T. Dolan, and officials of Stevens and Ferry counties.

LITERATURE.

The literature on the geology and ore deposits in Stevens and Ferry counties is scanty. Articles and brief notes on the different districts have appeared in the Northwest Mining News and in other mining papers. Among these may be mentioned articles on the Republic camp in volumes 66, 68, 78, 81, and 85 of the Engineering and Mining Journal. The Mining Bureau of the State of Washington and the Geological Survey of Washington have paid more or less attention to this part of the State, their annual reports containing brief articles upon the ore deposits, and Bulletin 1 of the Geological Survey being devoted to a discussion of the Republic mining district. Bulletins 285 and 315 of the United States Geological Survey contain brief articles on the "Iron ores of Washington" and the "Gold-bearing river sands of northeastern Washington," respectively. Volume 30 of the Transactions of the American Institute of Mining Engineers contains an article entitled "An examination of the ores of the Republic gold mine, Washington." The volumes of Mineral Resources published by the United States Geological Survey give statistical information on the production and deposits of this area. Mining in the Pacific Northwest, published by the Post-Intelligencer, of Seattle, contains brief notes on several of the mining districts.

CLIMATE AND VEGETATION.

Throughout the major part of the year the climate in northeastern Washington is delightful. The summer heat is not intense and the winters are not very severe, although snow lies on parts of the mountain ranges until late spring. The United States Weather Bureau [1] reports that "The rainfall over the Columbia, Spokane, Colville, [and]

[1] Summary of the climatological data for the United States.

Pend Oreille valleys is sufficient to grow crops without the necessity of irrigation." The mean annual precipitation recorded at Cusick, near the eastern border of the area covered by this reconnaissance, at an elevation of 2,050 feet, is 24.94 inches, while that at Republic, near the western border of the area, at an elevation of 2,628 feet, is 17.42 inches. The maximum temperature recorded at Colville, which is practically in the center of the area, at an elevation of 1,635 feet, is 103° F. The minimum temperature recorded at the same place is −29° F., and the mean annual temperature covering a period of 28 years is given as 45.5° F. Republic has a maximum recorded temperature of 102° F., a minimum of −32° F., and a mean annual temperature over a period of eight years of 43.9° F. The prevailing wind direction at Colville is stated to be southwest and at Republic northwest. The average date of the last killing frost in spring is given as June 15 for both places, although such frosts have occurred in the later part of July. For Republic September 3 is given as the average date of the first killing frost in autumn and for Colville September 7 is the average date. Frosts have occurred in both these places during the later part of August.

Most of the mountain ranges are more or less covered by a good growth of evergreen trees of several species, yellow and jack pine predominating, but tamarack and cedar are prominent in parts of the area. Underbrush grows profusely in certain localities and hinders prospecting to some extent. Willows line the smaller streams and in places are so thick that they effectively prohibit the crossing of a valley bottom, so that it becomes necessary to cut a passageway through them.

The timber-covered slopes afford an abundant supply of wood for mine timbers, mine buildings, and corduroy roads, and for use as fuel in boilers. Probably only a small part of the wood cut each year from this area is used here in mining operations. Much of the timber is owned by lumber companies that ship their products out of the district.

HISTORY OF MINING ACTIVITY.

Mineral discoveries were not reported from northeastern Washington prior to 1865, and this seems odd in view of the fact that one of the principal distributing points for the Hudson Bay Co. was located as early as 1826 [1] near the place now known as Kettle Falls, around which mineral deposits have since been found in several different localities. Placers are reported to have been found on O'Sullivan Creek in 1865 and these are said [2] to represent the first metalliferous deposits discovered in the northeastern part of Washington. H. F. Smith is reported [3] to have found gold on July 4, 1871, near the base

[1] Mining Bur. Washington First Ann. Rept., p. 30, 1892.
[2] Bethune, G. A., Mines and minerals of Washington, p. 8, 1891.
[3] Idem, p. 10.

of Mount Chapaka, in the Moses Reservation. The first stamp mill[1] erected in Washington was built in 1878 to treat the ores from deposits discovered during that year on Peshastin River. The year 1883 marks the first mineral discovery in the Colville district,[2] and the beginning of active work in April, 1885, on the Old Dominion mine[3] probably stimulated prospecting in this locality. The total production of the Old Dominion mine to 1909 is about $610,000, the chief values being in lead and silver. Both the Bonanza and the Young America[4] were located in October, 1885, although the Bonanza was not actively developed until February, 1890.[5] These properties are reported[5] to have produced to 1909 over $100,000 in lead and silver. Several properties were actively worked in the Deertrail district, and the total production from this camp to 1909 is reported to have been more than $1,000,000 from lead-silver ores. The United Copper mine was located about 1891 but was not actively developed until 1906. Its production from 1906 to 1909 has been over $50,000, chiefly in copper and silver. The Germania tungsten mine was located in 1894.

As Columbia River formed the eastern boundary of the Colville Indian Reservation, and as the north half of this reservation was not thrown open to entry until February 21, 1896, and the south half was not thrown open to mineral location until July 1, 1898, much of the area discussed in this report was not prospected prior to 1896. Immediately after the opening of the north half of the reservation many claims in the Eureka (now called Republic) camp were located, among which may be mentioned the Iron Mask, Lone Pine, Sanpoil, Quilp, Black Trail, Republic, Mountain Lion, Surprise, Knob Hill, Princess Maud, Tom Thumb, Morning Glory, and Ben Hur. The production from few of the individual mines of the Republic camp is known to the writer. Probably the total production (Jan. 1, 1912) exceeds $5,000,000, chiefly from gold ore. The First Thought mine, located soon after the opening of the reservation in a district now known as the Orient, has produced to 1910 over $600,000, gold being the chief precious metal contained in the ores. After the opening of the south half of the reservation many claims were staked out in the Sanpoil, Park City, and Enterprise (Meteor and Covada) districts. The exact dates of these locations are not known to the writer, and the total production from this part of the area has been small.

During the present investigation (1909–10) the Republic camp was more active than any other in the area examined, and several of its mines were making regular shipments. The First Thought mine,

[1] Bethune, G. A., Mines and minerals of Washington, p. 11, 1891.
[2] Idem, p. 12.
[3] Idem, p. 72.
[4] Idem, pp. 75–76.
[5] Mining Bur. Washington First Ann. Rept., pp. 29–30, 1892.

in the Orient district, was shipping continuously, and the United Copper and others in the Chewelah district were intermittent producers. The Germania tungsten mine, in the Deertrail district, was shipping some ore. In the Northport, Metaline, Belcher, Sanpoil, and Park City districts only development work was being carried on during the investigation, and in the Covada or Meteor (Enterprise) district no property was active.

MINING AND METALLURGY.

GENERAL CONDITIONS.

In northeastern Washington conditions for mining are particularly favorable. Water and timber are plentiful throughout a large part of the area, and in places in all the districts the generation of hydroelectric power is possible. Wood is the chief fuel, an abundant supply being available near most of the properties, and many of the food products consumed in the area are grown within it. Although the timber and dense underbrush which grow over parts of the mountain ranges militate to some extent against prospecting, their beneficent effects are far in excess of their hindrances. Because of the glaciation which the region has undergone most of the veins show slight oxidation, and the upper portions of many of them contain sulphide ores. Glacial débris, varying in depth from a few inches to 40 feet on some of the mountain slopes and in places even on their tops, hides the outcrops of the veins below, and consequently the area doubtless contains many undiscovered ore deposits.

TRANSPORTATION.

Transportation is afforded by the Great Northern (formerly Spokane Falls & Northern), Idaho & Washington Northern, and Spokane & British Columbia (formerly Republic & Kettle River) railways, the location of which can be seen by reference to figure 2 (p. 39). Branches or spurs of the Great Northern Railway and the Spokane & British Columbia Railway serve practically all the mines in the Republic district, and a few other branches in parts of northeastern Washington have been projected but are not yet completed. A narrow-gage line known as the Belcher Mountain Railroad extends from the Belcher camp 7 or 8 miles northwestward to the ore bins located above the Great Northern Railway. A survey down Sanpoil River has been projected by the Spokane & British Columbia Railway, and if a railroad is completed along this route it will make the Sanpoil district as accessible as any other mining district in this part of the State. The Washington Water Power Co. is reported to be building a steam railroad from Springdale to Spokane River, which, when completed, will facilitate transportation from the southwestern part of Stevens County.

River transportation has been available in the past on parts of Columbia River within this area, and during the period of the writer's investigation steamboats were plying the Clark Fork (Pend Oreille) between Newport and Ione. Parts of Spokane River are said to be navigable. Fair wagon roads have been built from most of the properties in the area to the nearest railroad or other shipping point. At the time of the investigation the Meteor or Covada (Enterprise), Sanpoil, and Park City districts were the farthest removed from railroad transportation.

METHODS OF MINING.

Most of the ore deposits in this part of the State have been exploited by means of adit tunnels and drifts on the veins. As none of the deposits have been developed to depths exceeding a few hundred feet below the gulch levels, few shafts have been necessary, and as water is found near the surface in most of the localities the problem of draining the workings has prohibited extensive sinking. Wire-rope tramways are used to convey ore from the First Thought and Napoleon mines to the railroad sidings, and a gravity tramway has been built by the Belcher operators.

TREATMENT OF ORES.

Smelters.—Ore has been shipped from this area to smelters at Northport, Tacoma, and Everett, Wash.; Granby, Greenwood, and Trail, British Columbia; and Joplin, Mo. Some ore has gone to other smelters, but most of it has been treated at Northport, Granby, Greenwood, and Trail.

Within this area only one smelter has been successfully operated, and it was closed when the present investigation was in progress. This is the Northport copper smelter, of 1,200 tons daily capacity, which is controlled through stock ownership by the Le Roi Mining Co. (Ltd.). Small smelters have been erected at Keller and Turk, but the one at Keller was never blown in and the one at Turk proved a failure. The Colville smelter, operated for a time by the Mutual Smelting & Mining Co. of Washington, was erected at Colville in 1888 and smelted ore from the Old Dominion, Bonanza, Young America, and other properties. The success of the operations of this smelter is not known to the writer.[1]

Mills.—The only active mill in the district at the time of the writer's investigation was the one located at the Germania camp, described on page 119. The Napoleon mine is reported to have a mill erected in 1910 for the extraction of gold from superficially oxidized iron ores. A small mill was being constructed in 1910 by the Kettle River Mining Co. and is described on pages 85–86.

[1] For a brief description of the Colville smelter, see Bethune, G. A., Mines and minerals of Washington,

Several elaborate mills have been erected near Republic but have failed to treat successfully the ores of that district.[1]

Other mills in the Republic district are the Mountain Lion [2] and the New Republic. In May, 1911, a new mill was in process of erection by the Republic Mines Corporation. The following description is taken directly from a personal communication from H. W. Newton, the metallurgist for the company:

The mill is designed for the treatment of 1,000 tons of ore in 24 hours and will consist of eight units of 125 tons each, two of which will be put into operation as soon as the construction work is finished. In addition to the main mill building, there will be a crushing plant, refinery, assay office, pumping station, warehouse, and office. Electric power will be used to drive all the mill machinery and will be generated at the company's power plant at Similkameen Falls, near Oroville, Wash.

Ore will be delivered to the storage bins of the crusher plant by Great Northern ore trains, over the spur which connects the mines and mill. In the process of milling the ore goes through the following stages of treatment:

1. From the storage bins the ore gravitates over grizzly bars, spaced 1½ inches, the oversize going to Blake crushers set to crush 1½ inches, the undersize passing through the grizzlies and gravitating to a revolving screen, where it joins the product from the crushers.

2. In the revolving screen all the material passing a ½-inch ring is removed, the oversize passing to rolls set to crush ½-inch.

3. The product of the rolls with the undersize from the screens is carried by a conveyor belt to the mill bins, where an automatic sampler removes a cut for assay, the reject falling to a second conveyor belt, which automatically distributes the ore to the bins.

4. From the mill bins the ore is fed by plunger feeders to Trent Chilean mills, where it is ground in cyanide solution to pass 16-mesh screens.

5. The product of these mills flows to Akins classifiers, where all the material fine enough for cyanide treatment overflows to Trent agitators, the classified sands dropping to the feed box of the tube mill.

6. In the tube mills these sands are reground so that approximately 85 per cent will pass 200-mesh, after which they flow to the elevator sumps.

7. From the elevator sumps bucket elevators return the pulp to the Akins classifiers, where any remaining unfinished product is removed, the finished pulp going directly to the Trent agitators.

8. In the Trent agitators, which are connected in series, the pulp is agitated, passing through the series of tanks by displacement to the disk thickeners.

9. In the disk thickeners the pulp is relieved of a portion of its enriched solution, which passes to the precipitation department, the thickened pulp flowing to Oliver continuous filters.

10. The Oliver filters now separate the remaining solution from the ore by vacuum filtration, the solution passing to the precipitation department and the ore to the tailings dump.

11. In the precipitation department the solution is mixed with the amount of zinc dust necessary for the precipitation of the gold and silver and is pumped to the refinery, where the gold and silver precipitates are removed in a filter press, the barren solution again entering the mill circulation.

[1] For a description of the Republic mill and the process of treatment there used, see Joseph, M. H., Eng. and Min. Jour., Nov. 5, 1898. See also Bethune, G. A., Mines and minerals of Washington, p. 147; Eng. and Min. Jour., Dec. 16, 1899, and Feb. 1, 1908.

[2] See also Bethune, G. A., Mines and minerals of Washington, p. 149; Eng. and Min. Jour., Feb. 1, 1908.

12. Periodically the precipitates are removed from the press, melted, cast into bars, assayed, and sold, thus completing the cycle of treatment.

In the preparation of this treatment everything possible has been done to insure a maximum recovery at a minimum cost. In designing the mill I have made every possible employment of gravity, and in the selection of equipment I have tried to secure the most efficient of standard milling machinery. No radical departure from the standard practice has been made, but it has been possible to bring together collectively in one system the several labor-saving, cost-reducing devices which individually have been the features of the different mills where they were conceived and perfected.

Several small mills have been erected by different companies, among which may be mentioned the Jupiter Lead Co.'s mill at the Last Chance mine, the Robena (Young America) mill, and the mill of the Spokane Lead Co. A 2-stamp mill has been erected on the Easter Sunday property, where a small experimental cyanide mill was also in operation for a short time in 1909. The erection of reduction works, consisting of two Medbury rotary smelting furnaces with the necessary power equipment and crushing machinery, was commenced by the Colville Mining & Smelting Co. near Park City, but they were never completed or put into operation. A mill was also erected by the Old Dominion Co. (p. 127),[1] but it was not accessible to examination and its present condition is unknown.

COSTS.

Considering the facts that there are only a few producing mines in the area and that these are situated in widely separated localities and are mining different ores under diverse conditions, it is evident that such data as can be given on the costs of mining will afford a rather unsatisfactory analysis of the situation that confronts prospective operators in the area.

Some of the mining companies own sawmills and their timber costs them only the actual expense of cutting, hauling, and sawing. Wood is used for fuel in most of the boilers and steam is used in operating the plants. Distillate is utilized to run many of the compressor engines and small hoists. It costs 13½ cents a gallon in Spokane and several cents more for freight to the mine, usually including railroad freight and hauling charge. Distillate used at the First Thought mine costs 21½ cents a gallon delivered at the engine house, about 3½ miles from Orient, the nearest railroad station.

Labor charges are about the same as those paid in other mining districts throughout the Western States.

The cost of mining gold ore in the First Thought mine ranges from $3.57 to $3.87 a ton; in the United Copper and Copper King mines the cost of mining copper ore is estimated at $1.50 a ton, and in the

[1] Bethune, G. A., Mines and minerals of Washington, p. 157.

Germania mine the cost of mining tungsten ore is estimated at $2.50 a ton.

Freight costs for hauling ore from the mines to railroad points vary considerably according to the distance of the haul, character of the country traversed, quantity of ore shipped, back haul, and many other local conditions. The First Thought mine, using a wire-rope tramway, transports the ore and loads it into cars for shipment for 33½ cents a ton. The United Copper mine estimates a cost of $1.50 a ton for transporting ore by wagons a distance of 5½ miles and loading into cars for shipment. The Germania Co. reports a cost of $10 a ton for hauling sacked concentrates to the railroad, about 25 miles from the mill.

Railroad freight rates vary according to the value of the ore shipped. The rates from points in this area to smelters in the same area or in adjacent parts of British Columbia range from $1 a ton for ores not exceeding a valuation of $10 a ton (or less for very short hauls) to $3 or $4 for ores having a valuation of $100 a ton. Freight rates to Puget Sound smelters range from $2.75 to $8 a ton.

Because of the diverse character of the ores treated by the smelters, no general treatment charge can be given. As a rule this item covers also the railroad freight charge. In general the charge for treating the siliceous ores of the Republic camp and the First Thought mine, in the Orient district, is $6 to $7 a ton, including freight. The ore from the United Copper has been smelted for $1.50 a ton, excluding the freight rate of $1 a ton, and the same rate was given to the Copper King. A penalty of 5 cents a unit excess silica over iron is charged by most of the smelters. Treatment charges, exclusive of freight, on lead-silver ore shipped from the Old Dominion mine near Colville to plants at Tacoma and Everett, Wash., and Omaha, Nebr., varied from $9 to $15 a ton.

TOPOGRAPHY.

The general direction of the ranges of older rocks in northeastern Washington is from north to south. One prominent ridge called the Calispell Range extends in a north-south direction through the eastern part of Stevens County, following the line of Clark Fork,[1] and rises in Calispell Peak to an elevation of 6,905 feet above sea level; this is one of the most conspicuous mountains in northeastern Washington. Another ridge follows the east side of Columbia River. The eastern part of the Colville Reservation and the area between the reservation and the international boundary on the west side of Columbia River constitute an elevated region rising to heights of 5,000 to 6,000 feet. The deeply eroded canyon of Sanpoil River

[1] This stream is known locally as Pend Oreille River.

divides this mountainous region into two roughly parallel north-south ridges.

Throughout the region orographic features have been modified to a great extent by the effects of long-continued erosion, both fluviatile and glacial. The imprints of the Quaternary glaciation on the whole region are strongly marked by river terraces and moraines, and there are also many small glacial lakes. The glacial deposits fill many of the valleys to considerable depths. In general the valleys lie from 1,000 to 2,000 feet below the average elevation of the mountain ridges. In the southern part of the area the mountains are not nearly so steep and the valleys are correspondingly broad. In places along the lower part of the Columbia recent basalt flows have changed the direction of the river, and the valley cut by it in the extreme southwestern part of the area is flanked on both sides by steep cliffs which rise abruptly 1,000 feet or more above the river channel.

Sanpoil River, which is located near the western border of the area covered by this reconnaissance, flows southward from Curlew Lake, some 25 miles south of the international boundary, to Columbia River and throughout the greater part of its course occupies a valley whose width is out of all proportion to the size of the stream. Clark Fork, flowing northward near the eastern border of the State, occupies a broad flat valley in the southeastern part of the area, becomes more confined toward the central eastern part, and along its northern course is flanked on both sides by sheer cliffs rising 1,000 feet above the channel. The valley of the Columbia is broad and flat throughout the central part of the area, but in the northern and southwestern parts the river is confined between precipitous walls. The Columbia and its affluents drain the whole area. Numerous fresh-water lakes exist within this region, some of which are several miles long. Most of these lakes have been formed by the damming of the valleys by glacial débris.

GEOLOGY.

GENERAL FEATURES.

The interpretation of the older rocks which appear in this area is difficult owing to the general absence of fossils. As a consequence the geologic age of few of the rocks can be determined without doubt, and it was found necessary to classify them on the basis of similarity with fossiliferous formations outside of this area but in the same geologic province.

The rocks are referred to the Proterozoic, Paleozoic, Mesozoic, and Cenozoic eras. The rocks classified provisionally as pre-Cambrian are the crystalline schists and metamorphosed limestones and quartzites found between Laurier and Orient. The larger part of the region is occupied by an extensive series of more or less dynamometamor-

phosed argillites, lime shales, limestones, and quartzites. Because of its general similarity to rocks farther west in Washington, which in places are fossiliferous, this series has been referred to the Paleozoic era. In places these rocks were intruded by diabase or it flowed out over their surfaces and was metamorphosed along with the rest of the series so that it is now represented by greenstone. In the Orient and Chewelah districts greenstones are prominent, and doubtless greenstone exists in localities that were not visited by the writer. One of the most conspicuous rocks of northeastern Washington is intrusive granite, which was seen in all the districts except the Metaline and which doubtless is exposed in places in that district. The granite was accompanied by numerous dikes. It is thought that large batholiths intruded the sedimentary series during Mesozoic time, parts of the batholiths having been subsequently exposed by erosion. The presence of monzonite porphyry in most of the mining districts is believed to be due to later eruptions of the granitic magma, and these may have taken place at intervals from late Mesozoic to early Tertiary time. Lava flows of various types fill many of the depressions caused by the erosion of the older rocks, and in places these volcanic rocks form high mountains. Their eruption is thought to have taken place during Tertiary time. Still later flows of basalt, probably of late Tertiary age, are prominent in the extreme southern part of the area investigated, although some were seen in the Republic district.

PRE-CAMBRIAN (?) ROCKS.

In the vicinity of Rockcut is exposed a series of medium to coarse grained crystalline limestone, quartzite, and schist. These rocks extend northward into British Columbia and southward to Orient, where they dip under the supposed Paleozoic rocks and pass from view. The thickness of that part of the section contained within the area of this reconnaissance probably exceeds 2,000 feet, but definite measurements of the individual formations have not been obtained. Strata of limestone and quartzite several feet thick and schist formations of one type or another several hundred feet thick were seen. The general strike of the series is north-south and the dip is rather flat, being only about 15° E. or SE. Although the series appears to be conformable throughout, the relations between the schists and the rocks that are clearly of sedimentary origin are difficult to determine. The upper part of Huckleberry Mountain, just south of Laurier, is composed of schists that are clearly sheared granites and diorites, and a large part of the section exposed near Rockcut is formed of schists that appear to be dynamometamorphosed quartz diorite or related rocks. These rocks may represent former intrusions into a sedimentary series which have been sheared along with the rest of the rocks. Dikes of much later age cut these formations.

The limestone is dark brown on weathered surfaces and cream-white on fresh surfaces and is highly crystalline, forming a good marble. A pronounced schistose structure is noticeable in the quartzites, which are of fine to coarse grained texture and of white, yellow, pink, and red colors. Schists of several kinds were seen, and all of them are highly foliated. Those near Rockcut have a general gray tone, are medium to coarse grained, and show little chemical alteration. Viewed in thin section under the microscope they show about equal amounts of plagioclase feldspar and hornblende associated with much biotite and quartz. Pyrite and calcite occur in some of these schists. The prevailing rocks over the upper portions of Huckleberry Mountain are schists that appear to be clearly sheared granite. Two distinct varieties were seen, one dark and the other light. Both contain quartz and hornblende, with orthoclase, oligoclase, and albite, the dark tone of one variety being due to the large amount of hornblende. These schists are hard and compact and show evidence of igneous origin.

PALEOZOIC ROCKS.

The rocks that are thought to be of Paleozoic age consist of apparently conformable strata of argillite, lime shale, limestone, dolomite, quartzite, quartz-mica schist, mica schist, hornblende schist, and amphibolite, and they form the major part of the mountain ranges in this area. Greenstone, resulting from the metamorphism of basic rocks which were intruded into these strata or which flowed out over the sediments during their deposition, is prominent in parts of the Paleozoic section.

SEDIMENTARY SERIES.

The sedimentary rocks are dynamometamorphosed and, with the exception of the limestone and dolomite and some of the quartzite, show more or less clearly defined schistose structure. The general strike of these formations is north-south, although local changes in this direction occur throughout the area, and they dip at all angles, in general being more nearly vertical than horizontal. The thickness of the whole series is several thousand feet. Measurements of the individual formations were not obtained, but they were seen in thicknesses ranging from a few feet to several hundred. Probably argillite and quartz-mica schist occupy a larger part of the area than any other two formations, limestone or dolomite comes next in order of abundance, and lime shale is also widely distributed throughout northeastern Washington. Quartzite, mica schist, hornblende schist, and amphibolite occur in several of the mining districts, but they form only a small part of the metamorphic series. Certain schists of probable igneous origin occur in some parts

of the area and probably represent dikes intruded into the sediments prior to the metamorphism. As their occurrence is distinctly local they will be described in the sections on the several mining districts.

The argillites have a fine-grained, even texture and are generally dark blue or black, though some light-gray argillites were seen. Although as a rule rather soft, they are cherty in some places and closely resemble phyllite in others, the degree of hardness probably depending on the amount of pressure applied during the dynamo-metamorphism. They are composed chiefly of quartz, feldspar, and carbonaceous matter, some of them containing a high percentage of the last. The feldspar in many of the argillites is largely altered to white mica.

The lime shales that occur in this area closely resemble the argillites. They are generally of a lighter color and in places on their weathered surfaces have a thin coating of calcium carbonate. These rocks represent a very impure, shaly variety of limestone.

Blue, white, yellow, and green coarsely crystalline to fine-grained limestones occur in this area. They have a varying composition, some of them being exceptionally pure while others contain a high percentage of material other than calcium carbonate. Where magnesium is present in large proportions the rock is a dolomite, and this phase is probably as widely distributed throughout northeastern Washington as the purer limestone. The dolomite has a glistening surface and its colors in general closely resemble those of the limestones in the area, but a few black and dark-brown dolomites were seen. Below are a few partial analyses, made in the chemical laboratory of the United States Geological Survey, of dolomite and limestone specimens collected in different parts of the area investigated:

Partial analyses of dolomite and limestone from northeastern Washington.

Locality.	CaO.	MgO.	Analyst.
Chewelah district: Southwest slope of Eagle Mountain	27.5	23.0	J. G. Fairchild.
Northport district:			
Last Chance mine	(a)	21.0	George Steiger.
Between Keough's and Frisco Standard	(a)	21.0	Do.
Deertrail district: Sunday Morning claim	18.0	22	J. G. Fairchild.
Covada or Meteor (Enterprise) district: East side of Rattlesnake Mountain	50.3	(b)	Do.
Metaline district:			
Oriole prospect	(a)	17	George Steiger.
Lead King prospect	27.9	21.5	J. G. Fairchild.
Belcher district:			
West side of Cooke Mountain, near top	31.41	20.0	Do.
South slope of Cooke Mountain, near top	41.22	11.15	Do.
Southwest slope of Cooke Mountain, near top	31.96	17.60	Do.

a Large. b Trace, if any.

The quartzites of this area vary in texture from fine grained to coarse grained and in places show some schistosity. White, yellow red, gray, and gray-blue quartzites were seen. In general they appear to be nearly free from material other than silica, the colors

resulting from iron oxides and other impurities contained in the rocks.

The quartz-mica schists of this area are of two distinct kinds—a hard, compact variety in which quartz seems to predominate and a softer variety in which mica seems to be the major constituent. In both varieties the principal constituents, quartz and mica, are prominent, but the harder variety contains also some mica which is not a product of the alteration of feldspar. Roughly, the hard variety occurs in localities to the west of that part of the section occupied by the softer type. The colors of these schists are many, the more prominent being a lustrous silvery white and a reddish black, due largely to the white mica and iron oxide present in the rocks.

The mica schist and hornblende schist probably represent sheared igneous dikes in which the chief constituents have been altered to mica and hornblende. These rocks are of local occurrence only. The former is a somewhat lustrous gray rock of fine-grained texture and the latter is a medium to fine-grained green rock.

Few fossils were found in this series of metamorphic rocks, and consequently the age determinations are not positive. David White writes as follows in regard to certain fossils collected from the limestone strata in the Covada district, which were sent to him for examination:

I have examined the fossils collected in northeastern Washington and transmitted to me for examination.

Although the superficial aspect of the fragments encourages the hope that they will reveal good structural details, the thin slides show that the tissues of the organic matter have been almost entirely obliterated. The fossils consist of extremely fine grained white material, possibly siliceous, interspersed with small particles of golden-brown matter, irregular in form and size, which are clearly of organic origin. They apparently constitute vestigial fragments of the more resistant of the cells and possibly of lignocellulosic origin. Scattered through the granular groundmass of the fossils are numerous elongated bodies, roundish or oval in cross section, associated with some aggregation of the golden-brown organic matter. The aspect of these bodies, which appear to have been longitudinal in the fossil, is at first glance suggestive of lycopodiaceous bundles, each within its sheath transversing a middle cortex. The size and number of these further suggest Bothrodendron, a Carboniferous lycopodiaceous tree, but in the absence of any definite structure which may be identified with the cells of the bundle or the tissue of a sheath, and in view both of the large area of translucent, golden-brown, resinous-appearing matter seen within the periphery of the longitudinal tracts, and also of their very irregular arrangement, it seems slightly more probable that these tracts really represent vessels of ferns which may have been more or less filled with resins or other plant products such as are found in the petioles of various ferns and such as were conspicuously prominent in the petioles of many so-called ferns of the Carboniferous. Without recognizable cell structures it is impossible to determine this question or to decide even approximately as to the nature of the fossil, which seems, however, to be vegetable. I am disposed, nevertheless, on account of the aspect of the material, to compare it with the vessel residues of some of the petioles of Paleozoic ferns; and in view of the large size of the fossils it is

probable that if really petioles they belong to the Carboniferous period, and most likely to the older Pennsylvanian. I therefore suggest that as a working hypothesis the fossiliferous rocks might be, in a most guarded and provisional way, treated as Pennsylvanian, frankly admitting that the structure is at present indeterminable and that further investigations may show the organisms to be of different nature and date.

As already stated, it is on the basis of general similarity of these rocks to rocks farther west in Washington, which in places are fossiliferous, that the series has been referred to the Paleozoic.

IGNEOUS ROCKS.

Amphibolite is prominent in certain parts of the Orient and Chewelah districts and to a considerably less extent occurs in nearly every mining district within the area. The origin of the amphibolite is somewhat in doubt. Some of it may represent limestone strata changed to amphibolite by igneous metamorphism, some of it may be dynamometamorphosed diabase or related rock magma, and some of it is undoubtedly the result of faulting along zones of movement. The amphibolite resulting from either or both of the first two causes is of a light to dark green color, appears to be of fairly even texture, and is composed essentially of hornblende. The age of the amphibolite is uncertain. It may have been formed in Paleozoic time, or it may be connected with the intrusion of the monzonite porphyry, which is believed to have occurred in late Mesozoic or even early Tertiary time. Amphibolite formed along zones of movement constitutes only a small part of that found within the area and probably represents several different periods of formation.

Into the sediments which are thought to be of Paleozoic age were intruded basic rocks having the general composition of diabase, gabbro, or a related rock magma, or else these rocks flowed out on the surface of the sediments during their deposition. The sedimentary rocks and the greenstone are intimately associated, the latter having resulted from the metamorphism of the basic rocks. In places the greenstones resemble amphibolite, although in general they have the appearance of a more or less altered diabase. They are of a fine-grained, even texture and are light to dark green in color. They are composed essentially of chlorite, hornblende, feldspar, and some quartz.

Although the diabase is thought to be intrusive into the sedimentary series, it may represent old surface flows, and the age and relations of this rock to the greenstone found in the same general localities have not yet been worked out. Diabase of light to dark green color was seen in several different parts of the area. In general the rock has a fine-grained, even texture, and in places it shows a little schistosity. Viewed in thin section under the microscope the

rock is seen to be composed chiefly of labradorite and augite, having a typical diabasic (ophitic) texture. A more or less parallel arrangement of the constituent minerals is noticeable in the rocks which have undergone some shearing, and alteration has changed the augite to hornblende and subsequently to chlorite.

MESOZOIC ROCKS.

Granular intrusives into the older Paleozoic rocks were seen in every mining district in this area except the Metaline, and there is good evidence of the presence of such rocks in that district, although no granite was observed in the part of it investigated. All the intrusive granite masses in this part of Washington are believed to be connected with a parent magma which invaded the sedimentary series in the form of several batholiths that have been exposed by subsequent erosion. In some places where the intrusions occurred the overlying sediments were not of great weight; elsewhere there is evidence that the sediments were more deeply buried. The size of the several intrusive masses could not be determined, because no detailed mapping of the whole area was done. Several exposures of granite were seen that are 3 miles or more in length and width. Dikes of granite were observed that range in width from a few feet to several hundred feet, and these are believed to represent later eruptive phases of the same magma. No fossil evidence was obtained by which the age of the rocks through which the magma forced its way could be definitely fixed, but because of the fact that so many granitic intrusions took place throughout the Pacific States during Mesozoic time the intrusion of the granite in this area is provisionally assigned to that era. J. B. Umpleby[1] has pointed out that the intrusive granites in this general region are probably pre-Eocene, for they are truncated by a peneplain of Eocene age.

The granular intrusives have a general similarity in appearance and composition, but a few local variations were observed. In the Republic district granodiorite is present, and the Covada or Meteor district contains quartz diorite and quartz monzonite, both probably representing later and more basic phases of the same magma.

Of uncertain relation to the granite magma are innumerable dikes of monzonite porphyry which are as widely distributed as the granite, although the two rocks were not seen in contact. These dikes range from a few inches to several hundred feet in width and extend for long distances along the strike of the intrusions. It seems probable that they represent a still later phase of the magma from which the granite masses were derived. The intrusion of monzonite porphyry may have taken place during late Mesozoic time, or perhaps early

[1] Jour. Geology, vol. 20, pp. 139–147, 1912.

in the Tertiary, and probably occurred at several periods covering a long time.

In general the granite masses are coarsely crystalline, showing phenocrysts of orthoclase, oligoclase, and quartz. Fine-grained varieties were seen in only a few localities. Fresh surfaces of the granite have a general gray tone, although some pinkish-gray granite was observed. Viewed in thin section under the microscope the rock is seen to be composed of a large proportion of orthoclase with some oligoclase, a little microcline, much quartz, and hornblende or biotite. Some albite is present in a few of the rock specimens. Magnetite, zircon, and titanite occur in variable amounts. Epidote and chlorite have resulted from the alteration of the ferromagnesian minerals in some of the rocks, and white mica has likewise resulted from the alteration of the feldspars.

Fresh surfaces of the granodiorite show distinct white and black minerals, which give it a gray appearance. The rock is inequigranular. The microscope shows that the main constituents are andesine and orthoclase, with quartz and some microperthite, microcline, biotite, and partly uralitized augite. The accessory minerals are pyrite, apatite, titanite, and magnetite. The plagioclase is idiomorphic, and between the crystals lie grains of quartz and orthoclase. Rock of this character occupies a considerable area near Republic.

Although only a few exposures of rock that could be correctly termed quartz diorite were seen in this area, there are doubtless many dikes present throughout the geologic section in northeastern Washington which could be so classed. The quartz diorite resembles the granite in texture. It is of a darker color, and fresh surfaces are a medium to dark green. In composition it is somewhat similar to the granite except that plagioclase feldspar predominates rather than orthoclase. Hornblende is the chief ferromagnesian mineral and is accompanied by some biotite. Zircon, titanite, and magnetite are variable in amount.

The monzonite porphyry is commonly of finer texture than the granite, although some coarse-grained varieties were seen. It has a general gray color. Phenocrysts of feldspar and hornblende are visible in it without the aid of a glass. Viewed in thin section under the microscope the rock is seen to be composed essentially of andesine, orthoclase, hornblende, and some quartz. Certain varieties contain phenocrysts of quartz, and the rock that contains them in sufficient quantities is termed quartz monzonite porphyry. The hornblende phenocrysts are in places largely altered to chlorite, and the feldspars have formed white mica.

Lamprophyre dikes, commonly accompanying granitic intrusive rocks, were seen in the vicinity of most of the workings visited except

those in the Metaline district. They are composed of some ferromagnesian mineral, such as augite, hornblende, or biotite, and feldspar. Quartz is present in some of the dikes. They are of various types, kersantite, camptonite, minette, and vogesite dikes having been observed. The distinction between the varieties lies chiefly in the relative abundance of plagioclase and orthoclase feldspars and the ferromagnesian mineral present. If the feldspars are predominantly plagioclase then the rock is either kersantite (if biotite predominates over hornblende or augite) or camptonite (if hornblende or augite forms the chief ferromagnesian mineral). If orthoclase is the predominant feldspar, the rock is minette or vogesite, the distinction being made in the same way. The dikes are generally dark colored; and the biotite, hornblende, or augite is easily recognized without the aid of a microscope.

TERTIARY ROCKS.

Although Tertiary rocks were seen in several of the mining districts, they were studied in connection with the ore deposits in but two districts, the Orient and the Republic. More detailed descriptions will be found in the sections on those districts (pp. 68–69 and 140–144).

LAKE BEDS.

In the Republic camp, lake beds, which are tuffaceous in part, occupy an old erosional valley in the underlying Paleozoic rocks, but rest in part on andesite. In places the thickness of the lake beds exceeds 800 feet, and they outcrop for several miles. In general they dip to the east and underlie andesite and basalt flows of later Tertiary age.

These beds are commonly of a buff or gray color and include strata of fine-grained sandstone, shale, and andesitic tuff. F. H. Knowlton has provisionally classed these rocks as upper Miocene in age. (See pp. 141–142.)

LAVA FLOWS.

Two distinct varieties of andesite are present in the Republic camp—hornblende andesite and pyroxene andesite. These are thought to overlie the lake beds conformably and are exposed in sections over 1,300 feet thick.

The hornblende andesite has a fine to medium grained texture and is of a blue-gray color when fresh. When altered it very much resembles a holocrystalline porphyry. Viewed in thin section under the microscope it is seen to be composed of labradorite, hornblende, augite, and some biotite.

The pyroxene andesite is dark colored, has a porphyritic texture, and is composed chiefly of pyroxene and feldspar. The microscope shows that labradorite or bytownite and augite are the chief mineral

constituents. This rock is so basic that it might almost be classed as a basalt. (See pp. 142–143.)

A part of the andesite series is represented in the Republic camp by a flow breccia. In this formation some of the fragments are several feet in diameter. In general the matrix of the breccia is andesitic, although inclusions of other materials, such as granodiorite and metamorphic shale, are reported [1] to form a part of the breccia. This breccia, in part at least, underlies the lake beds.

On First Thought Mountain, in the Orient district, quartz latite has been poured out over the eroded surface of the Paleozoic rocks. This forms the country rock of the ore deposits of the First Thought mine and others in this vicinity. Fresh surfaces of the quartz latite are of a gray-green color, and the phenocrysts of hornblende and biotite, which are now largely altered to a dark green chlorite, give it a mottled appearance. The rock is composed of orthoclase and andesine, with quartz, hornblende, and biotite, the last two being almost entirely altered to chlorite. The groundmass is aphanitic.

In the Republic camp basalt flows unconformably overlie the eroded surfaces of lake beds and andesitic flows and were seen in a section the base of which was 600 feet below the top. They are dark brown to black in color and from fine-grained to glassy in texture, and some phases of the rock are vesicular. Viewed in thin section under the microscope the basalt is seen to be composed of laths of labradorite with grains of augite and olivine embedded in a glassy base. The olivine is almost entirely altered to serpentine.

INTRUSIVE ROCKS.

Intruded into the series of andesitic lava flows and lake beds in the Republic camp is a porphyritic rock which has been determined as quartz latite porphyry. Fresh specimens of this rock are light to dark gray in color, and altered samples show every variation from gray to white. The rock has a holocrystalline groundmass of quartz and orthoclase, in which are phenocrysts of andesine, altered hornblende, biotite, and some quartz.

Rhyolite porphyry is intruded into the quartz latite in the Orient district. The rock is gray-brown to gray-blue in color and contains phenocrysts of pink and white orthoclase, green hornblende, and quartz. The microscope shows that it contains also much chlorite and calcite, with some epidote and limonite.

BRECCIA-CONGLOMERATE.

In the Republic camp was found a peculiar rock which has been classed as a breccia-conglomerate. This rock shows a dark-gray color on fresh surfaces and apparently has a porphyritic texture. In

[1] Umpleby, J. B., Washington State Geol. Survey Bull. 1, p. 23, 1910.

all the exposures seen it contained rounded pebbles and fragments of shale. Viewed in thin section under the microscope the rock is seen to have a clastic structure, containing fragments of a holocrystalline porphyritic rock. The phenocrysts are andesine and quartz, and the outlines of formerly existing biotite crystals may be seen. Fragments of shale are prominent. It is thought that there may be some genetic connection between this rock and the intrusive quartz latite porphyry occurring in the Republic camp. For a more complete description of this rock see page 144.

QUATERNARY DEPOSITS.

Throughout northeastern Washington glacial débris is found in all the valleys, on many of the mountain slopes, and on some of the mountain tops. In places the deposits attain a thickness of over 100 feet, and detailed study of the moraines would doubtless bring forth some interesting data pertaining to glaciation in this region. The major part of the area studied in this reconnaissance was covered by an ice sheet, and glacial bowlders were seen on the tops of some of the high mountains in several of the mining districts.

The most recent geologic formation within the area studied is the alluvium that has been deposited along the flood plains of the streams.

GEOLOGIC HISTORY.

PRE-CAMBRIAN (?) CONDITIONS.

Granitic and dioritic schists overlain by a coarsely crystalline limestone and quartzite are exposed in the northern part of the Orient district, and these rocks are believed to have been formed by dynamometamorphism during pre-Cambrian time, when schistose structure was induced, the limestone was made coarsely crystalline, and quartzite was formed. The relations between these several rocks have not been worked out, although it is probable that the limestone and quartzite were deposited upon the submerged and eroded surface of the granite and diorite, one of the last two probably being intrusive into the other. Later the country was elevated and the rocks were regionally metamorphosed and eroded.

PALEOZOIC CONDITIONS.

After the crystalline schists, limestones, and quartzites had been severely eroded and partly base-leveled, the area was submerged and several thousand feet of sediments that formed arenaceous shales, limestone, dolomite, and sandstone were deposited. Basic and other rocks were intruded into or flowed out over these sediments. The

less resistant rocks of this series were made schistose by a second regional metamorphism, which is supposed to have taken place in Paleozoic time. More or less schistose rocks resulted from the metamorphism of the sediments; and greenstone, mica schist, and hornblende schist resulted from the metamorphism of basic and other rocks that were intruded into the sediments or flowed out over them during their deposition. The sandstones were changed to quartzite and the limestone and dolomite assumed a crystalline structure. The pre-Cambrian (?) formations were again sheared, and schistose structure was induced in the older quartzites.

MESOZOIC CONDITIONS.

Before the intrusion of the granite and the several kinds of rock that are believed to have been derived from the same magma, all of which are provisionally treated as of Mesozoic age, the Paleozoic rocks had been elevated and erosional processes had been at work. The granite, quartz diorite, and monzonite porphyry and the many dikes which are adjuncts of these rocks appear to have been intruded under no great weight of overlying sediments. Locally the dip and strike of the formations were considerably changed, and the strata appear to have been pushed aside in all directions to make way for the invading magmas. In general, however, they have retained a north-south strike, and the dip ranges from vertical to horizontal, the former dip prevailing where intrusive masses are absent. The contact metamorphism caused by the intrusion is discussed below.

TERTIARY AND QUATERNARY CONDITIONS.

Extensive erosion and volcanic activity mark the Cenozoic history of this area. Flows of quartz latite, andesite, and basalt are prominent in parts of the area, where they occupy erosional depressions in the older rocks and in places form high mountains. These flows are in places intruded by rhyolite porphyry and quartz latite porphyry. The effects of glacial action on the physiography of the area have not been studied in detail, although this region affords an interesting field for such studies. Certainly the courses of Clark Fork, Colville, Columbia, and Kettle rivers were greatly altered as a result of the glaciation.

EFFECTS OF METAMORPHISM.

REGIONAL METAMORPHISM.

Dynamometamorphism is thought to have occurred in this area during two periods. The first was in pre-Cambrian time, when the schists were formed from granite and diorite, the limestones in the vicinity of Rockcut were made coarsely crystalline, and the quartz-

ites were formed. In the second period of dynamometamorphism the clays and arenaceous shales that had been deposited during Paleozoic time were transformed into lime shales, argillites, and quartz-mica schists, the limestones and dolomites assumed crystalline structure, the sandstones became quartzites, and the pre-Cambrian rocks were again sheared. Greenstone resulted from the metamorphism of basic flows or intrusive rocks in this series, and mica and hornblende schists were formed from rocks that had been intruded into or poured out over the sediments during Paleozoic time.

CONTACT METAMORPHISM.

The principal results of contact metamorphism in this area are those connected with the intrusion of the Mesozoic rocks. In places epidote, garnet, actinolite, diopside, hornblende, augite, biotite, sphalerite, magnetite, pyrrhotite, chalcopyrite, and pyrite have been developed along the contact of the intrusive rocks and those through which they cut. Some of the amphibolite within the area is thought to be dolomite altered by contact metamorphism. The rocks as a whole have suffered little through contact-metamorphic agencies, and it is thought that when they were intruded they were not under the weight of overlying beds of considerable thickness.

THE MINERAL DEPOSITS.

PERIODS OF MINERALIZATION.

The gold-quartz veins of the Republic (Eureka) district and the First Thought gold deposits, in the Orient district, were formed during Tertiary time.

The period in which the granite, quartz diorite, quartz monzonite porphyry, and monzonite porphyry and the accompanying dikes were intruded was that of the most extensive mineralization. With the exception of the comparatively few deposits formed during Tertiary time and some that may possibly have been formed during Paleozoic time, the major part of the ore deposits described in this report are believed to be of Mesozoic age, and they owe their origin to the after effects of igneous intrusion.

During the Paleozoic period of dynamometamorphism, while the greenstones were being formed, some of the metallic ores may have been concentrated from the basic rocks, so that a few of the ore deposits in the area may be of Paleozoic age. However, intrusive rocks thought to be of Mesozoic age were found in the vicinity of the greenstones, and it is more likely that the deposits associated with the greenstones are due to the Mesozoic intrusions.

KINDS OF DEPOSITS.

Ore deposits of several different kinds occur within this area. Because of their diversity, it has been thought advisable to discuss them by groups, according to the metals most sought for in the respective workings. They are consequently divided into gold, silver, lead-zinc, copper, iron, tungsten, nickel, antimony, and molybdenite deposits, and deposits mined chiefly for the use of the ore as a flux in smelting. A brief sketch of deposits of each group follows.

GOLD DEPOSITS.

SHEAR ZONES IN QUARTZ LATITE.

The shear zones in quartz latite are well illustrated by the First Thought ore body, in the Orient district, where rhyolite porphyry has intruded the quartz latite and fault planes and brecciated zones of fractured country rock are present along the contact. Pyrite, containing gold, occurs with a gangue of silica and calcite in these shear zones, also impregnating the country rock near its contact with the intrusive rhyolite porphyry. The four fracture zones which had been explored up to July, 1910, were found to vary in width from a few feet to 110 feet and to extend beyond the limits of the present workings (see Pl. IV, p. 72) along the strike and along the dip. As the ore shoots became too lean for profitable extraction under present mining conditions, the workings were not pushed to the extremities of the fault zone. A total of 38,180 tons of ore had been mined up to June, 1910. This averaged $15.50 in gold and half an ounce of silver to the ton. Solutions accompanying or following the intrusion of the rhyolite porphyry are thought to have caused the mineralization in this locality.

FISSURE VEINS IN ANDESITE AND QUARTZ LATITE PORPHYRY.

The Republic district is by far the most productive locality in the region covered by this reconnaissance. The deposits in this district are also different from those occurring elsewhere in this part of the State and form a type of peculiar interest. The veins, which are fairly regular, are contained in Tertiary andesites and lake beds and in porphyritic rocks that are intrusive into those formations. These veins are composed principally of quartz, with subordinate calcite. The quartz is unusually fine grained and is often called chalcedonic, although true chalcedony is found only here and there in vugs in the quartz. The veins are as a rule prominently banded in delicate concentric arrangement, caused by alternation of calcite and quartz of varying grain. Other minerals, such as adularia and laumontite, are only locally abundant. The ore minerals are present in extremely

fine distribution. In the ordinary kinds of ore the only indication of metallic mineral consists in a thin black streak, usually near the walls of the vein and in places delicately curved and banded. Visible gold is rarely observed. The principal ore mineral appears to be a selenide of gold, which, however, is so finely distributed that it has not yet been isolated. In some rich spots of the ore small masses of metallic minerals appear and can be identified as chalcopyrite and tetrahedrite. Such aggregates are usually very rich in gold and silver. Pyrite is generally not present in the quartz but appears in the altered country rock. The rocks in which the veins are contained have been subjected to propylitization over considerable areas, and the propylitic rock usually adjoins quartz without further alteration or sericitization. The veins bear evidence of an earlier epoch of calcite deposition, and locally the calcite of this epoch has been replaced by a fine-grained aggregate of quartz and adularia. This earlier calcite usually assumes a lamellar aspect by the prevalence of the basal plane in its crystal form. The latest phenomenon in the vein formation was apparently the local solution of quartz, followed by a deposition of laumontite with concentration of silver. Some ore of very high grade has been mined from these veins. The tenor of the ores shipped in 1910 ranged from $15 to $53 a ton. The relation of gold to silver by weight ranges from 1:3 to 1:8. Much difficulty has been experienced in the reduction of these ores, probably owing to the minute distribution of the selenide of gold.

FISSURE VEINS AND SHEAR ZONES IN METAMORPHOSED SEDIMENTS AND DIABASE.

The deposits of which the California, located southeast of Republic; the Swamp King, Little Giant, and Beecher, in the Orient district; the Columbia River Gold Mining Co.'s prospect, near Meyers Falls; and Keough's prospect, in the Northport district, are typical examples are fissure veins and shear zones in metamorphosed sediments and diabase. The California is the only one of these deposits which has produced much gold, the others being for the most part prospects. Free gold is reported to have been found in the Swamp King, the Beecher, and Keough's.

Quartz is the chief gangue mineral of these deposits and is in places accompanied by some calcite. One or more of the ore minerals, galena, sphalerite, tetrahedrite, pyrite, pyrrhotite, and chalcopyrite, are present in all the gold-bearing deposits of this type. Except the California, which was practically inaccessible to examination, the deposits of this type have received little development, and consequently few data on the genesis of the ores are available. In general the gold-bearing deposits of this kind greatly resemble other deposits found in the same rocks. Several of these deposits in the Orient dis-

trict, among them the Defender, have been prospected with the hope of finding gold ores. The ores are usually found in the vicinity of intrusive rocks thought to be of Mesozoic age, and it seems reasonable to suppose that these deposits are the result of after effects of igneous intrusion, the entrance of the solutions that bore the ore and gangue minerals having followed the injection of the several magmas.

Many of these deposits, as well as the silver deposits described below, follow dark basic dikes of lamprophyric character.

SILVER DEPOSITS.

Silver-bearing quartz veins in the metamorphic rocks and the intrusive Mesozoic rocks occur in nearly every mining district within the area, and as most of the lead-zinc-copper ores carry also some silver, the grouping of the deposits which have been worked primarily for their silver content is rather difficult. In many of the so-called silver deposits in this area superficial alteration of the silver-bearing ores and the formation of native silver and rich secondary silver sulphides have made possible under present mining conditions the profitable extraction of the upper portions of the lodes. As few of these deposits have been explored to depths below the gulch levels, little can be said about the persistence of the silver content, but in general it is likely to become considerably less as depth increases.

Some of the ore bodies in the Deertrail, Meteor or Covada (Enterprise), and Park City districts well illustrate this type of deposits. The quartz veins in shear zones in the metamorphic rocks are more common than similar quartz veins in the intrusive rocks.

Post-mineral faulting is a prominent feature of many of these deposits and has in places seriously interfered with the continuity of the veins. A roughly banded structure is noticeable in some of the ore bodies, many of which are lenticular in form.

In general the vein filling is remarkably uniform, consisting of quartz with varying amounts of brecciated country rock. Calcite, barite, fluorite, and a carbonate composed of magnesium, calcium, manganese, and iron are found in some of the veins. Two or more of the ore minerals galena, sphalerite, chalcopyrite, pyrite, pyrrhotite, arsenopyrite, tetrahedrite, and stibnite, locally accompanied by subordinate amounts of argentite, pyrargyrite, and native silver, are found in the different veins. Limonite, azurite, and malachite occur in many of the outcrops, and cerusite, anglesite, and smithsonite were seen in a few of the upper workings of the deposits of this type. These deposits are believed to be due to the after effects of the intrusion of Mesozoic rocks.

LEAD-ZINC DEPOSITS.

As the ores of lead and zinc are closely associated in the several deposits examined within the area, they will be discussed under a single heading. To the writer's knowledge not one of these deposits has been worked for its zinc values alone.

DISSEMINATED REPLACEMENTS IN METAMORPHOSED SEDIMENTS.

In the Metaline, Northport, and Chewelah districts and in the Old Dominion mine, east of Colville, are deposits of lead and zinc which in general occur as irregular disseminated replacements along shear zones and fracture planes in metamorphosed sedimentary rocks. Where the movements have been most intense the ore deposits have been correspondingly increased in size. Along the shear zones, in the brecciated country rock, and locally replacing the contiguous strata are varying amounts of the ore minerals galena and sphalerite, which give way to pyrite below. Associated with the ore minerals in the shear zones and the brecciated country rock are varying amounts of quartz and calcite. The extent of these deposits has not been proved. In general the lead ores, together with some zinc ores, occupy the upper zone, which is not likely to extend more than 100 or 200 feet below the surface, and it is probable that the lead content will become less and less as the lower limit of this zone is reached. In some deposits the vertical sequence of galena, sphalerite, and pyrite is very regular, galena occurring near the surface, zinc ore gradually becoming more and more abundant, and, at 300 to 500 feet from the surface, pyrite predominating, with some sphalerite and hardly any galena. Most of the ore shipped from the Last Chance, Old Dominion, and Young America properties was mined near the surface, where cerusite and anglesite are found, as well as the sulphide ores. In the Metaline district smithsonite occurs in the ore and calamine is reported to have been found. Good surface ores are found on many of the properties within the region, and in places these extend over large areas. Although developments have not been extensive enough to warrant much speculation on the possibilities of these ore bodies, it seems probable that deep exploration will yield chiefly pyrite. The ore deposits of this class are all thought to owe their origin to the after effects of igneous intrusion.

FISSURE VEINS.

The deposit worked by the Kettle River Mining Co. in the Orient district is representative of lead-zinc deposits in fissure veins. Here small, irregular quartz veins occur near the contact of intrusive diorite dikes into a metamorphic series of crystalline schists, limestone, and quartzite. Some contact metamorphism is evident in the

intruded rocks, epidote, garnet, diopside, actinolite, and biotite having been developed on a large scale. Galena and sphalerite, with subordinate amounts of chalcopyrite, in a gangue of quartz, calcite, and dolomite, are found in irregular shoots in small fissures cutting across the schistose rocks. The ores are thought to have been introduced by solutions which accompanied or followed the intrusion of the diorite dikes, and they may be of contact-metamorphic origin.

COPPER DEPOSITS.

All the copper deposits in the region carry also some gold and silver, and in several of them the silver content makes profitable exploitation possible. Some copper is also contained in the ores that are worked primarily for fluxes, discussed on page 30.

COPPER-BEARING QUARTZ VEINS.

The copper-bearing quartz veins are best illustrated by a short discussion of the United Copper deposit, in the Chewelah mining district. This ore body occupies lenticular receptacles of varying dimensions in the bulged strata of quartz-mica schist, argillite, and lime shale, which are cut by kersantite dikes, adjuncts of a granitic intrusion. Plate VI (p. 100) shows on a small scale the mode of occurrence of these veins and the shape of the ore and gangue filled receptacles on each side of the main vein. The ore-bearing zone has been proved to extend 750 feet along the strike and 425 feet along the dip plane. Further exploration will doubtless increase these dimensions. The ore zone ranges in width from a few inches to 20 feet, pinches and swells being a prominent feature of the deposit. The gangue is chiefly quartz, with much calcite and siderite. Pyrite and chalcopyrite are the principal ore minerals in the unoxidized portion of the deposit. These are accompanied by varying amounts of tetrahedrite, which in places carries considerable silver. In the zone of oxidation limonite, malachite, and azurite are prominent. In general, the ore minerals are rather sparsely distributed through the vein, although rich shoots have been worked. The ore shipped from the United Copper mine carries about 0.1 ounce of gold and 5.35 ounces of silver to the ton and 2.5 per cent of copper.

Ore-bearing solutions accompanying or following the intrusion of kersantite dikes are thought to have caused the mineralization in deposits of this type.

REPLACEMENT DEPOSITS IN METAMORPHIC ROCKS.

The Big Iron deposit, in the Orient district, is a zone of sulphide impregnation and replacement in schists of probable igneous origin, which are intruded by monzonite porphyry. Pyrite is the chief ore mineral and is accompanied by some chalcopyrite. Both of these

minerals have been altered on the surface, causing the formation of a shallow gossan. Developments are not extensive enough to prove the size of the mineralized zone, but it has been shown to be over 100 feet wide and to extend several hundred feet along the strike of the schists.

The Lone Star and Washington deposits, in Ferry County, occur in a somewhat similar series of rocks, containing also some intercalated strata of limestone, argillite, and lime shale. These metamorphic rocks are also intruded by monzonite porphyry, and the ore minerals chalcopyrite, pyrite, and pyrrhotite, together with quartz, are more or less disseminated through the schists and here and there partly replace limestone near the intrusive masses. Limonite with some malachite occurs in the upper portions of the deposits. A small amount of chalcocite enrichment was seen, which appeared to be of shallow depth. The mineralization was scattered and the deposits do not occur in well-defined shoots but follow the planes of schistosity and the bedding planes of the metamorphic rocks.

The unaltered ores contain a lower percentage of copper, with some gold and silver. The entrance of the ore-bearing solutions forming these deposits is thought to have followed the intrusion of the monzonite porphyry, and the deposits represent the after effect of the intrusion.

DISSEMINATED DEPOSITS IN SCHIST AND GRANITE.

The only copper deposit examined which could be properly classed as a disseminated deposit is the Manila, although the ore bodies discussed in the preceding section have many characteristics in common with it. In this deposit chalcopyrite and pyrite are disseminated sparingly through schists and still more sparsely through parts of the granitic rock intrusive into them. The limits of the dissemination have not been definitely determined and the ores are of low value. A trace of gold and from half an ounce to 4 ounces of silver to the ton are reported to be shown by assays of that part of the ore body which has been developed. The copper content is probably under 1.5 per cent. The mineralization here was probably an after effect of the intrusion of granite.

OTHER METALLIFEROUS DEPOSITS.

Iron.—Deposits exploited principally for their iron content were not examined. References to descriptions of the iron resources of northeastern Washington will be found in the paragraph on "Literature" (p. 2). Magnetite of good grade occurs in the Copper Key mine, in the Belcher district, as a replacement in limestone. An analysis of the ore and a description of the Copper Key deposit is

given on pages 174–175. Probably many of the so-called iron deposits in the region represent gossans resulting from the alteration of sulphide ores.

Tungsten.—Tungsten deposits have been reported from several localities within the area covered by this reconnaissance, but only two were visited—the Germania, in the Deertrail district, and the Tungsten King, north of Deer Park. Tungsten ores are said to occur in the Metaline district and in several places in the vicinity of the properties which were examined. Doubtless future prospecting in northeastern Washington will reveal the presence of many other tungsten-bearing ore bodies.

The deposits worked by the Germania Co. in the Deertrail district are representative of the tungsten-bearing quartz veins in granite and quartz-mica schist. Here deposits have been exploited in both kinds of rock, but most of the development work has been done on veins in granite. The principal workings expose a quartz vein, containing also some fluorite and tourmaline, which has an average width of 24 inches and which has been proved to extend 400 feet along its strike and 200 feet on the supposed continuation of the vein. The vertical depth to which this deposit has been explored is 193 feet. Some faulting is evident in the workings, the vein having been displaced both to the east and to the west. Where exposed in the workings the displacement is only a few feet. The chief ore mineral is wolframite, which forms about 5½ per cent of the vein filling. With this are associated some scheelite, ferritungstite,[1] galenobismutite, pyrite, chalcopyrite, molybdenite, and arsenopyrite. Limonite is prominent in the upper workings and some tungstic ocher was seen.

The Tungsten King deposits, 10 miles north of Deer Park, are similar in many respects to those of the Germania. Here, however, the veins that have been explored are in arenaceous shales which have been metamorphosed to quartz-mica schist. Granite has been found a short distance to the northeast and is probably intrusive into the sedimentary rocks. The ores occur in quartz lenses which follow in general the bedding planes of the shale. The lenses range in width from 1 to 6 feet and are exposed along the outcrop for a hundred feet or more, glacial débris hiding much of the country rock from view. When the deposits were visited (1909) enough development work had not been done on the property to outline the extent of the ore bodies. The chief ore mineral in these deposits is hübnerite, which is accompanied by pyrite and argentiferous cosalite.

The ores in both deposits are thought to have been introduced by solutions after the intrusion of the granite, and they represent the after effects of igneous intrusion.

[1] For a description of this new mineral see U. S. Geol. Survey Bull. 509, pp. 83–84, 1912.

Antimony.—In the Meteor or Covada (Enterprise) district a prospect known as the R. E. Lee contains a series of small veins carrying stibnite, possibly with some berthierite. These veins occur in quartz monzonite porphyry, which is intrusive into the sedimentary rocks, and they probably represent the after effects of igneous intrusion. They range from half an inch to 3 inches in width and have been exposed for only a few feet along the strike and dip. The mineral is nearly pure antimony sulphide and is practically barren of gold and silver.

Molybdenite.—No deposits of molybdenite are known to have been extensively worked in this region. However, molybdenite occurs in several of the deposits.

Nickel.—The only deposit containing appreciable quantities of nickel ore examined during the investigation is that of the Congress property, in the Sanpoil district. The deposit occupies a shear zone or fault plane in a schistose series of amphibolite, lime shale, quartz-mica schist, and a rock which resembles sheared granite. These rocks are intruded by quartz monzonite porphyry, which has caused some contact metamorphism in the contiguous strata. The vein filling is chiefly jointed and fractured quartz of a bluish-white color, accompanied by some talc and barite. Sparsely scattered through the quartz are small veinlets and aggregates of pyrite associated with some chalcopyrite. The pyrite is slightly nickeliferous, and where oxidation has been active the sulphides have been altered and their oxidation products, limonite, malachite, and a carbonate of nickel, have been deposited as a thin film along the joint planes and fractures in the quartz. The oxidized portions of the vein contain 0.12 to 0.246 per cent of nickel and 0.013 to 0.034 per cent of cobalt. A picked specimen of sulphide ore showed 5.71 per cent of nickel and 0.35 per cent of cobalt.

Ores mined chiefly for use as a flux in smelting.—The Napoleon, in the Orient district, and the Belcher, in the Belcher district, are the chief representatives of the deposits mined chiefly for flux. Both are irregular and more or less complete replacements in metamorphic rocks, the former of amphibolite and the latter of limestone or dolomite. Intrusive monzonite porphyry occurs in both localities. Pyrrhotite, pyrite, magnetite, and some chalcopyrite are the ores in these deposits. Low assays in gold, usually less than $1 a ton, are reported from the unaltered ores. The upper portions of the deposits have been oxidized and the resulting limonite is reported to carry more gold than the unoxidized ore. Both deposits show evidence of contact-metamorphic origin, although contact-metamorphic silicate minerals have not been developed on a large scale in either place.

PLACER DEPOSITS.

Placer deposits were not being worked during the investigation of the area and little or no attention was given to deposits of this type by the writer. For convenience of those interested in the placer deposits of this part of the State the following extracts from a report by A. J. Collier [1] are here republished:

RELATION OF GOLD DEPOSITS TO TERRACES.

Where observed the placer gold along the Columbia is confined to the lower benches and river bars, a condition which may reasonably be expected if the sediments of the upper terraces are lake deposits and those of the lower terraces have been worked over and concentrated by the river. Moreover, the later benches and the modern river bars are progressively richer in gold, since they are the product of repeated concentrations of the various upper terraces which have fallen into the river and been washed away.

The terraces on which deposits of placer gold occur are all within 200 feet of the level of the river. They are in the main covered with a sandy soil from a few inches to 12 feet or more thick, containing some disseminated gold, below which is a pay streak from 1 inch to 4 feet thick, consisting of sandy clay and gravel resting on a thin bed of clay. Below this pay streak there is generally barren sand, gravel, or in some places clay, to the level of the river. It is reported that a second or a third lower pay streak occurs at a few places, but no attempts have been made to mine such deposits, and our investigations indicate that they invariably contain less gold than the upper placers. The pay streak is as a rule stained by oxide of iron and easily distinguished from the overlying silts by its color. The gold tenor varies from a fraction of a cent to a possible maximum of $1.50 per ton, the average being not more than 4 or 5 cents per cubic yard. These gold deposits were tested by carefully panning samples taken from prospect holes and such natural exposures as cut banks of streams and upturned tree roots. The colors of gold in each pan were counted, the number recorded, and specimens from the various localities weighed on an assayer's balance to determine their average value. To check these results 31 samples of pay dirt were collected and sent to the United States Geological Survey concentrating pavilion at Portland, Oreg., where they were treated by fire assay. In making the assays about five times the ordinary amount was taken for fusion, and quantitative determinations were made where, by ordinary methods, nothing but traces could have been reported. The colors of gold were found to range in value from less than 0.0005 to 0.02 cent, the average being about 0.002 cent. Nearly all of this is flour rather than flake gold and although very fine it is usually not difficult to save in panning. Some of the colors which appear to be larger, however, are thin flakes and scales that are very hard to separate from the black sand.

There is a noticeable difference in the size of the colors at various points along the river, some of the bars being characterized by very fine gold and that of others being comparatively coarse. Generally the colors of any particular bar or pay streak are nearly uniform in size and appearance, but there are a few notable exceptions to this rule, some of the localities affording coarse flakes as well as uniformly fine flour gold, seeming to indicate a local source of supply for part of the gold.

[1] Collier, A. J., Gold-bearing river sands of northeastern Washington: U. S. Geol. Survey Bull. 315, pp. 56–70, 1907.

ASSOCIATED MINERALS.

The gold is associated with black sand containing a large amount of magnetite and somewhat smaller amounts of ilmenite, zircon, garnet, and other heavy minerals. Platinum probably also occurs in small quantities, though its presence was not detected in the field.

An average sample of sand was run over the Wetherill separator at the concentrating pavilion and its mineral constituents were determined as follows:

Mineralogical composition of average sand from Columbia River terraces.

Magnetite	0.3
Ilmenite	.1
Garnet	.1
Zircon	.1
Quartz	39.4
Others	60.0
	100.0

One large color of gold and 16 to 20 small colors of platinum.

The amount of black sand in the pay streaks is much greater than in this sample, in some places reaching 3 or 4 per cent.

TYPICAL LOCALITIES.

Although there is probably some gold in the sands of the river throughout its length, the gold-bearing terraces on either side, which are called bars, are not continuous. Those adjacent to the right bank that were examined are Nespelem Bar, at the mouth of Nespelem River; Hell Gate Bar, a few miles above Sanpoil; Peach Bar, opposite Peach post office; Sixmile and Ninemile bars, 6 and 9 miles, respectively, above Spokane River; Wilmot Bar, opposite Jerome post office; Rogers Bar, a few miles below Hunter; Blue and Turtle Rapids bars, about 5 miles above Hunter; Stranger Creek Bar, opposite Gifford; and a bar about 6 miles above Daisy. In the Sanpoil Valley there are no indications that placer gold has ever been produced or exists in commercial amounts except on one or two of its tributaries. The more important of the deposits named above will be described in detail as follows:

Columbia Valley.—Nespelem Bar is a terrace half a mile wide, 100 feet above the Columbia at the mouth of the Nespelem, which flows across the bar in a narrow canyon. Two miles above its mouth the Nespelem is incised in an upper terrace more than 1,000 feet above the Columbia, to which it descends in a series of falls caused by outcropping crystalline rocks. The lower terrace has a nearly level surface and where cut by the canyons presents the following section:

Section of lower terrace on Columbia River at mouth of the Nespelem.

	Feet.
Sandy loam	8–15
Gravel	$\frac{1}{6}$– 1
Stratified clay, locally called soapstone	80

Although 320 acres of land situated here have been secured by patent for placer-mining purposes, gold was found at only one locality in a thin pay streak, consisting of iron-stained sandy clay resting on sand, somewhat above the general level and covering about 2 acres of ground. No gold was found by panning in any of the beds composing the foregoing section. Similar tests of the sands from the beds of gullies cutting through to the clay bedrock and of material from the bed of Nespelem River also gave negative results. It was estimated that there is no ground on this bar which can be expected to yield as much as 0.01 cent per cubic yard by placer-mining methods.

Hell Gate Bar, situated on the north side of Columbia River, between the mouth of the Sanpoil and Hell Gate Rapids, is a strip of land about 2 miles long and from 300 feet to half a mile wide. The placer gold is confined to a low bench, which is probably overflowed at times of extreme high water. Much of its surface is covered with river bowlders from a few inches to a foot in diameter, and the pay dirt is contained either in the crevices between these bowlders or in a well-defined pay streak consisting of iron-stained gravel from a few inches to a foot thick within 3 feet of the surface. There is little overburden and the gold-bearing layer is easily reached. The average value of this pay streak is estimated by panning to be 5 cents per cubic yard. The colors of gold are all fine, averaging not more than 0.00125 cent in value. A sample of the richest material found was tested at the concentrating pavilion in Portland, Oreg., showing approximately the same result as to gold tenor. It was estimated that on this bar there is a deposit of pay dirt 6 inches thick, from 100 to 600 yards wide, and 2 miles long, which will average between 1 and 5 cents per cubic yard. Some of the richest of this ground was taken up by Chinese, who attempted to work it mechanically with water pumped from Columbia River, but their efforts were abandoned several years ago for the reason, as reported, that wages could not be obtained. The Columbia at Hell Gate Rapids is obstructed by a ledge of rocks that crosses from north to south. This ledge has been worn down by the river, but has probably always presented an obstruction to the current. The concentration of the gold below the rapids is probably due in part to this obstruction, an eddy being formed here in which the fine gold settled from the swiftly moving currents.

Between Hell Gate and the mouth of the Spokane there is comparatively little level land adjoining the river on the Colville Reservation. All of it is comprised in a low bench at the mouth of White Stone Creek, containing over 300 acres, a similar bench opposite Creston Ferry, and a bench and bar opposite the town of Peach. The White Stone lands are entirely embraced in Indian ranches and were not examined for evidences of placer gold. A portion of the bench at Creston Ferry has been worked by placer miners, but the old workings are now abandoned and were not tested. Opposite Peach there is a bench about 300 feet above Columbia River which extends upstream to the mouth of the Spokane. A number of placer-mining claims have been located on this terrace, and it was examined critically. Where undermined by the river it presents the following section:

Section on Columbia River opposite Peach.

	Feet.
Light-colored sandy loam	12
Sand and gravel	1–2
Sandy clay, above which there is water seepage	6
Open cross-bedded gravel, containing many basalt pebbles one-quarter inch to 2 inches in diameter	200

No colors of gold could be obtained by panning from any part of this section, either from the sandy loam at the top or the gravel layer above the clay seam.

Between Peach and the mouth of Spokane River there is a large island in Columbia River that is overflowed at extreme high water. The upper end of this island was formerly worked by Chinese, their excavations reaching a depth of 3 or 4 feet. No mining is in progress there at the present time, and a part of the island is under cultivation.

From a point 3 miles above the mouth of the Spokane old Chinese excavations and ditches occur at short intervals for about 6 miles to the mouth of Ninemile Creek. None of these old workings extended more than 100 yards from the river.

Three miles above the Spokane is a bench about 20 feet above the river that contains an accumulation of large angular bowlders having the appearance of a moraine.

It is probably the deposit mentioned by Salisbury as the terminal moraine of the Columbia River glacier.[1] It extends along the river about one-half mile. The pay streak, formerly worked by Chinese, occupies the spaces between these bowlders, which probably served as riffles to concentrate the fine gold. Some virgin ground found under a stump in the old workings yielded a fair result from panning, the colors being of two types—large thin flakes averaging 0.01 cent in value and the ordinary flour gold of the river averaging not over 0.002 cent in value. A sample tested by fusion at the concentrating pavilion gave $1.60 per ton in gold, but owing to the prevalence of bowlders not included in the sample this result should naturally be reduced about one-half.

At the mouth of Sixmile Creek, a mile above the point just mentioned, the glacial bowlders are no longer to be seen and a section of the terrace deposit was found to be about as follows:

Section on Columbia River at mouth of Sixmile Creek.

	Feet.
Silt and gravel, containing some clay	2
Gravel and clay	1½
Coarse open-textured gravel, pebbles mostly from older rocks and 4 inches or less in diameter	20

The pay streak here is confined to the upper 2 feet of the section and was found by panning to have a value of 8 cents per cubic yard. The gold obtained includes some large thin flakes averaging 0.01 cent in value and much fine flour gold. A sample tested by fusion at the concentrating pavilion yielded only 4 cents per ton. There is a pay streak 2 feet thick here, extending back from the river possibly 800 or 900 feet, which will yield from 4 to 8 cents per cubic yard.

Two miles farther up the river, near the mouth of Ninemile Creek, there are over 300 acres of land in two benches, one about 30 and the other 100 feet above Columbia River. The section on the lower bench is approximately as follows:

Section of lower bench on Columbia River near Ninemile Creek.

	Feet.
Sandy silt, from a few inches to	7
Iron-stained sand, gravel, and clay (pay streak)	1
Open-textured gravel	20

Old Chinese workings extend about 200 feet back and three-fourths of a mile along the river. The limit of the workings back from the river was evidently determined in some places by the thickness of the overburden and in others by the thinning out of the pay streak. The gold contains some large flakes worth 0.02 cent and much fine flour gold, bringing the average down to 0.0067 cent. The pay streak probably averaged a little over 40 cents to the cubic yard. A sample tested by fire assay at the concentrating pavilion gave 16 cents per ton.

The upper terrace, 100 feet above the river, presents a somewhat similar section, comprising from 1 to 3 feet of iron-stained gravel, sand, and clay, resting on more than 90 feet of cross-bedded gravel and sand. Panning tests showed that the upper layer carries a small fraction of a cent in flour gold per cubic yard, while the gravel and sand below show no trace of gold.

Wilmot Bar is about 6 miles farther up the river, opposite Jerome post office. As at Sixmile Bar, there are two terraces here—one 20 feet, the other about 100 feet above the river. The lower terrace is situated just below a series of rock ledges forming an obstruction to the current somewhat similar to that at Hell Gate, and the concentration of gold on the bar is probably due in part to this cause. On the lower terrace

[1] Salisbury, R. D., Jour. Geology, vol. 9, p. 722, 1901.

there is a surficial deposit from 1 to 5 feet thick that contains flour gold and rests on open-textured gravel and sand. Panning tests indicate a possible value of 10 to 14 cents per cubic yard on the lower bench and a small fraction of a cent per cubic yard on the upper one.

Rogers Bar, on the west bank of the Columbia 2 miles below the town of Hunter, contains approximately 1,500 acres of nearly level land that lies from 20 to 100 feet above high water and extends for 3 miles along the river. It includes three distinct benches—one 30, another 75, and a third 100 feet above the river. Near the middle of the bar two men are still working with rockers on the river bank, following the edge of the water as it falls. They report that the best pay is found on bars exposed only at low water. Half a mile below their workings there is a low gravel bar that is scarcely above the level of the river at ordinary stages; this was nearly all worked over by Chinese. A miner working here reported that under favorable conditions he could make as high as $3 per day. Near the lower end of Rogers Bar is a large island in the river known as Hog Island. The channel between it and the mainland is dry at low water and its bed has all been worked by Chinese.

The section of the deposit forming the lower terrace at Rogers Bar is as follows:

Section of lower terrace on Columbia River at Rogers Bar.

	Feet.
Sandy silt	2–8
Gravel and clay (pay streak)	⅛–1
Open-textured cross-bedded sand and gravel	20

The section in the next higher bench is similar except that the underlying gravel contains more sand and there is a greater thickness exposed. On the lower bench flour gold to the value of 1 to 50 cents per cubic yard was found in the pay streak and a much smaller amount disseminated through the overburden. Tests by fusion at the concentrating plant gave somewhat higher values and would seem to indicate that there is a considerable amount of finer gold which could not be saved by ordinary panning. In some instances traces of platinum were reported by the assayer, but the amount was not determined. No gold was found on the uppermost terrace, which as noted lies 100 feet above the river. The bars below the level of ordinary high water carry values in gold somewhat higher than those of the terraces, the indicated value being more than 30 cents per cubic yard. The colors of gold at Rogers Bar have an average value of about 0.00125 cent and the samples contained at least one color worth 0.01 cent.

Blue Bar, situated on the right bank of Columbia River, about 4 miles above Hunter, consists of a terrace from 100 to 1,000 feet wide and 20 feet above the river. Opposite the bar in the river lies Blue Bar Island, with an area of about 100 acres. Mining was done by Chinese at the upper end of this island, as well as at the edge of the terrace, to which water was brought in a ditch from a small stream known as Stray Dog Creek. The section of the deposit making up the terrace at Blue Bar is approximately as follows:

Section on Columbia River at Blue Bar.

	Feet.
Sandy loam	½–7
Iron-stained gravel, containing some clay (pay streak)	⅛–½
Open-textured gravel and sand	15

Nearly all the gold is confined to the pay streak, though scattering colors can be found in the overburden. The results of panning this pay streak indicate values ranging from less than a cent to 6 cents per cubic yard. Samples tested by fusion at the concentrating pavilion yielded from 2 to 41 cents per ton.

Two miles above Blue Bar, near Turtle Rapids, a bench 60 feet above high water extends along the river for several miles. Old Chinese workings here expose a nearly barren layer of sandy silt several feet thick, resting on a pay streak a few inches thick, consisting of gravel and clay, below which is open-textured gravel and sand. These old workings indicate that the pay streak was followed back from the river bank until the overburden became too thick to permit further mining in that direction. Some of the original pay dirt was panned, indicating an approximate value of 30 cents per cubic yard, one pan containing upward of 300 fine colors of gold, the average value of which was 0.00143 cent.

At the upper end of these old Chinese workings an attempt was made last summer to hydraulic this deposit, a small stream of water under a 30-foot head being used. The pay streak was estimated from panning to contain about 9 cents per cubic yard. Two fusions were made of the sample sent to the concentrating pavilion, giving from 1 to 13 cents per ton. Half a mile above this point a pay streak 2 feet thick lies on the surface of the bench with no overburden. It extends back from the river 300 feet to the foot of the escarpment from a higher bench. Panning here indicates that this pay streak has a placer value as high as 9.5 cents per cubic yard. Two fusions were made of the sample taken from this place, one showing no trace and the other 15.5 cents per ton.

Attempts at mining have been made on the lower terrace at intervals above this point for several miles, but the workings are now abandoned. Mining by hydraulicking was in progress on a bench at the mouth of Stranger Creek, which enters the Columbia opposite Gifford. The section exposed here is as follows:

Section on Columbia River at mouth of Stranger Creek.

	Feet.
Sandy soil	7
Pay dirt, consisting of clay and gravel	1–3
Loose open-textured gravel and sand	20

The pay streak was tested by panning at several places and is estimated to contain from 40 cents per cubic yard at the richest spot to 5½ cents at the poorest. The sandy silt above the pay streak carries a small amount of gold, which is concentrated with that from the pay streak in hydraulicking. Prospect holes at other places on this bench seem to indicate that the pay streak is not of very great extent. A sample cut from the top of the overburden across the pay streak at its thickest part, thus including pay streak and overburden, was tested by fusion at the concentrating pavilion and gave results varying from 14 to 32 cents per ton. This placer is located on the bank of the river just below a ledge of rock, which must have always acted as an obstruction to the current, and the rich deposit here bears the same relation to this obstruction as do the deposits at Hell Gate and Wilmot Bar to similar ledges.

For several miles above the Stranger Creek placer a terrace at the same level that extends back from the river a distance of 800 or 900 feet has been located for placer-mining purposes. The sections exposed in the river bank and in prospect holes indicate a deposit of gravelly soil about 2 feet thick, resting on an iron-stained pay streak, below which there is open-textured gravel. Panning tests of these deposits indicate a possible value of a fraction of a cent per cubic yard, to a depth of 2½ feet, but samples tested by fusion at the concentrating pavilion showed no trace of gold. Back of the lower terrace there is a higher one about 300 feet above the river, containing 300 or 400 acres of land that has also been included in placer claims. These lands, as far as could be ascertained, have a light sandy soil to a depth of 1 or 2 feet, underlain by tough clay to an unknown depth. No traces of gold could be found in either the surface soil or the clay.

Benches lying 20 to 30 feet above the river level and similar to those which have been described extend along the left bank from this point nearly to Kettle Falls. One

of these, 2 miles above Daisy, presents the following section in the cut bank of the river:

Section on Columbia River 2 miles above Daisy.

	Feet.
Soil	1
Iron-stained pay streak	½
Open-textured gravel and sand	18

Fragments of shells of river mollusks were found in the silt just below the pay streak. A sample from the pay streak was panned, showing a value of 2 or 3 cents to the cubic yard, but the assays made at the concentrating pavilion showed only a trace of gold.

A low bar in the river several miles above Daisy, formerly known as China Bar and reported to have been worked out by the Chinese, was also tested, and the upper layer of sand and gravel yielded about the same result—2 or 3 cents to the cubic yard.

Sanpoil Valley.—The Sanpoil Valley is disproportionately large for the stream which it contains. Its walls are terraced to almost the same elevations as those of the Columbia Valley and it was probably occupied by an arm of the same lake as filled the Columbia. It also resembles the Columbia in that the lower terraces and benches are more irregular than the upper ones. Although colors of gold were found at intervals along this river, they are not as uniformly distributed as along the Columbia and are not concentrated in pay streaks to the same extent. A great many placer claims have been located near the mouth of West Fork, in the vicinity of Alkire post office. Tests with the gold pan indicated a value of about 4 cents per cubic yard in one or two small spots, outside of which colors of gold were very rarely found. These colors are rougher than those along the Columbia and average 0.0055 cent in value. A sample representing 13 prospect holes, all of which were well located to find placer gold if present, was tested by fusion at the concentrating pavilion and showed no trace of gold. About 3 miles above its mouth West Fork of the Sanpoil receives a tributary called Gold Creek, and several miles up the latter Strawberry Creek enters. Reports of miners indicate fair prospects of gold on each of these latter streams, and an imperfect examination of them confirms the reports. The deposits along Strawberry Creek are said to be of the normal creek-placer type. They are confined to the bed and the immediate flood plain of the stream, and the gold is of local origin. Below Alkire the sands of the Sanpoil Valley were tested at a number of places, almost invariably with negative results, though a few colors of gold were obtained near Keller. No deposits of gold-bearing gravel that will justify the expectation of successful development occur along Sanpoil River at any point except those noted on West Fork.

ORIGIN OF THE GOLD.

The ultimate source of the Columbia River gold is to be found in the areas of crystalline and metamorphic rocks to the north and east, which are known to contain gold-bearing quartz veins, as well as other ore bodies of various kinds containing gold. Millions of tons of such rocks were washed away in the formation of the river valley, and the deposits with which the valley was filled during the glacial period represent many millions more, the gold content of which has been concentrated in river bars. Much of the gold has doubtless been carried many miles, but that some of it is of comparatively local origin is indicated by the coarse flake gold found on some of the bars. Somewhat coarser and rougher colors of gold were obtained from the bed of a small creek several miles from the Columbia. It is probable that there are many such tributary streams in which colors of gold can be found which have added small amounts to the gold deposits of the river.

METHODS OF MINING.

The mining and collecting of finely divided gold like that along the Columbia is inevitably more difficult and requires greater care and skill than ordinary placer mining. The appliances which have been used are rather simple forms of rocker or sluice box equipped with blanket, carpet, or burlap riffles. Neither quicksilver nor copper plates are used in the boxes. In sluicing the material is invariably passed over some form of grizzly which screens out the finer part and drops it to an undercurrent or spreads it over tables where the gold is collected. The Chinese probably ground sluiced before shoveling the pay dirt into the boxes. In two places where white men were mining last summer the whole deposit above the pay streak was hydraulicked and washed into the sluice with water under a small head from a canvas hose. One of the principal difficulties in mining this gold is encountered at the clean-up. The gold is associated with such great quantities of black sand that it is almost impossible to separate it. The usual method of collecting the gold with quicksilver is laborious and expensive, often fails to extract much of the gold, and utterly fails to collect platinum if it is present. Experiments made at the concentrating pavilion at Portland have demonstrated that this separation can be accomplished economically by means of a Wilfley concentrator, but even by this means the expense of mining would probably not be greatly reduced.

CONCLUSIONS REGARDING COLUMBIA RIVER GOLD.

Nearly all the sands in the bed of Columbia River and on the adjoining terraces and benches throughout the region covered by this examination carry some fine gold. The relative amounts have not been accurately determined, though the statements of miners and prospectors indicate that the low bars in the river bed contain more gold than the deposits on the benches.

The average width of the river is about 1,500 feet, and it is probable that a considerable part of its bed from one side to the other is covered by sands and gravels containing some gold. The gold-bearing terraces are not continuous on either side, being absent for long stretches, and it may be safely estimated that if distributed so as to be continuous they would make a strip of land not exceeding 300 feet on each side of the river.

Many of the richer spots were discovered and worked out by Chinese, and there is no record of the amount of gold they obtained. Moreover, the observations described in this report were not sufficient to justify a close estimate of the amount of gold remaining. It would seem a liberal estimate, however, to put the average width of the gold-bearing areas, including the river bed and benches, at 2,400 feet, the thickness of the gold-bearing deposit at 6 feet, and the amount of placer gold originally contained within such limits as 1 cent per cubic yard. On these terms the total amount of gold contained in the river bed and adjacent benches did not exceed $28,000 per linear mile, and the total amount in the 90 miles between Kettle Falls and Nespelem did not exceed $2,500,000.

This gold is not uniformly distributed but in very small areas is concentrated enough to justify mining, especially where rich deposits occur in the bed of the Columbia, since the comparatively cheap process of dredging is here available. The bench lands, however, are not adapted to any relatively inexpensive process of mining. Hydraulicking on a large scale is ruled out by the absence of bedrock and the scarcity of water at sufficient elevation; dredging, by the height of these deposits above the river and the impossibility of floating machinery over them. Moreover, the possible profits from mining the bench lands would undoubtedly be less than the value of these lands for agricultural purposes.

THE MINING DISTRICTS AND ORE DEPOSITS.

The following pages contain, besides a general discussion of the mining districts and detailed descriptions of the more prominent properties, brief mention of many smaller prospects, examined primarily because of their proximity to more fully developed workings. The shortness of the time spent in this large area prohibited a careful

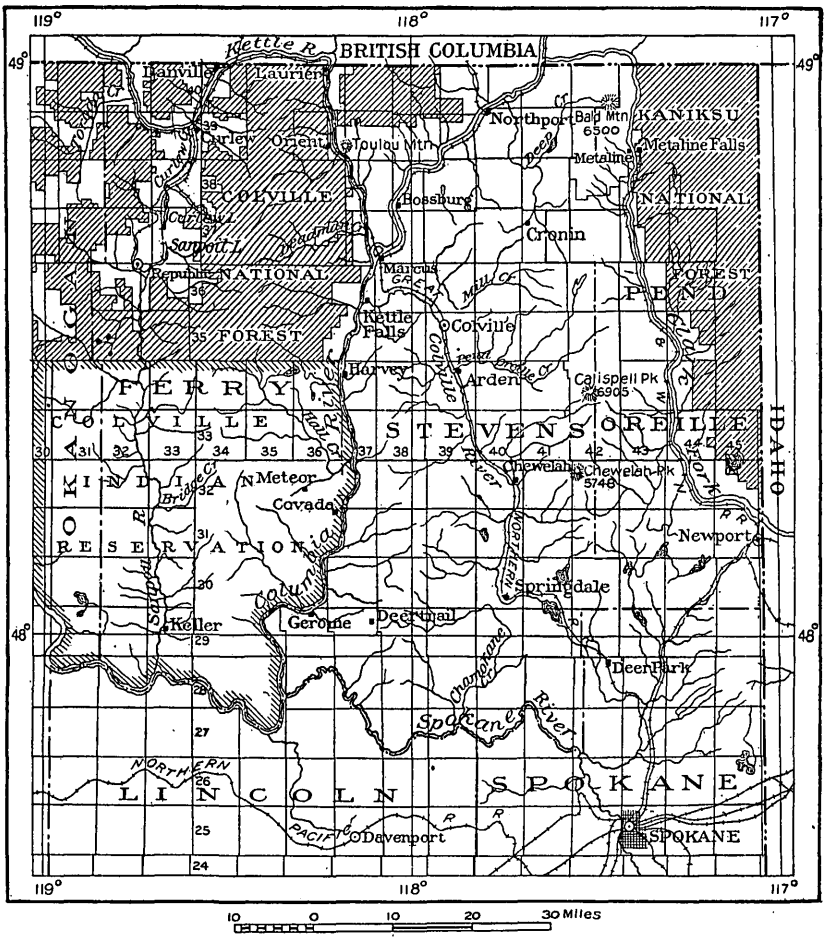


FIGURE 2.—Map of northeastern Washington, showing the location of many points within the mining districts examined.

survey of every prospect. However, it is hoped that a study of the mode of occurrence of the ore deposits described may be of use in leading to an understanding of similar ore bodies in contiguous or other localities. Figure 2 shows the area in which lie most of the districts described.

STEVENS COUNTY.

METALINE DISTRICT.[1]

LOCATION AND EXTENT.

The Metaline mining district has the following boundary, as recorded in the office of the county clerk of Stevens County:

Beginning at the northeast corner of township 40 and the southeast corner of range 45; thence south along the east line of range 45 to the south line of township 38; thence west along the south line of township 38 to the west line of range 42; thence north along the west line of range 42 to the south line of township 40; thence east along the south line of range 40 to the east line of range 42; thence north on the east line of range 42 to the international boundary line; thence east on the international boundary line to place of beginning.

The district, which covers about 400 square miles of unsurveyed land, occupies a corner in the extreme northeastern part of the State of Washington, the State of Idaho lying to the east and British Columbia to the north. (See fig. 2.) The western part of the district is cut by the valley of Clark Fork of Columbia River, and the most accessible and probably the best-developed properties lie within a mile or two of this stream. The elevations in the district range from about 2,000 feet at the river to 6,000 feet or more on top of the highest peaks.

The town of Metaline is on the west bank of Clark Fork, some 2 miles south and 4 miles west of the center of the district, and is 79 miles in an air line due north of Spokane. Just across the river, on the east bank, the new town of Metaline Falls has recently been built near a partly completed cement plant. In each place accommodations can be obtained and general-merchandise stores are numerous. The population of both towns in July, 1910, probably did not exceed 500.

MEANS OF ACCESS.

Until 1910 the Metaline mining district was one of the most isolated in northeastern Washington, being more remote from railroad transportation than any other part of Stevens County. Previous to 1910 craft on Clark Fork were used for transporting materials and supplies between Newport, which is 9 miles north of the southeast corner of Stevens County, and the Metaline district. Stages, launches, and tugboats were necessary features of the last 7 miles of the journey northward from Ione to Metaline as late as October, 1910, the total distance between Newport and Metaline being about 60 miles by the route traveled. A stage road from Colville was also used to reach the district, but this route involved about 50 miles of travel over rather poor roads.

[1] Largely reprinted from Bancroft, Howland, Lead and zinc deposits in the Metaline mining district, northeastern Washington: U. S. Geol. Survey Bull. 470, pp. 188–200, 1911.

With the completion of the Idaho & Washington Northern Railroad to Metaline Falls in October, 1910, a much cheaper and more efficient means of transportation was afforded throughout the district, the properties located on the east side of the river being especially benefited.

CONDITION OF MINING INDUSTRY.

Lack of transportation and the prevalence of low-grade base ores have no doubt had much to do with the small progress made in developing the several properties in the Metaline district. Although there are many prospects in the area, only a few have 300 feet or more of underground development, and no one of these is reported to have shipped over a few tons of ore. In general, the district has been explored by means of surface cuts and trenches. Where these have uncovered ore bodies persistent enough to warrant deeper exploration it has been attempted. The results thus far have not been gratifying, but the developments are still too meager to warrant final conclusions concerning the extent of the ore bodies.

Wagon roads are scarce in the district, practically all the claims being reached by trails, and at the time of the writer's visit it was almost impossible to obtain saddle horses or any other means of conveyance. With the completion of the cement plant and the extension of the railroad many improvements may be expected in the district. At the time of the investigation this was the least-developed camp in Stevens County. One small concentrating mill had been erected to work the ores of the Spokane Lead Co., and this mill is reported to have been a failure.

TOPOGRAPHY.

The most prominent topographic feature in the Metaline district is the valley of Clark Fork. This stream, which flows northward in a course that lies 6 miles west of the center of the district, is far-famed for its waterfalls, swift eddies, and box canyons, all of which prohibit extensive water transportation on the river north of Metaline Falls. The cliffs along the river become prominent near the southern boundary of the Metaline district and grow more conspicuous throughout the northward course of the stream, which, though a mile wide in part of its course farther south, is in this region confined in one place between walls reported to be only 18 feet apart. The rocks that form the banks of the river rise rather abruptly to benches ranging in height from 150 to 350 feet, and above these benches rise steep timber-covered mountains, the highest of which attain altitudes of 6,000 to 7,000 feet above sea level, or 4,000 to 5,000 feet above the river. The mountains on the west side of the river form a continuation of the Calispell Range; the mountains on the east side are not known by any generally accepted name.

Smaller mountain streams, tributary to Clark Fork, are numerous in this district, the more prominent being Sullivan and Slate creeks on the east side, flowing approximately west; and Flume, Evarts, and Perry creeks on the west side, flowing east or southeast. These streams are exceedingly valuable for generating power and for many other purposes, their valleys having in places extremely high gradients.

GEOLOGY.

The geologic section exposed by the erosion of Clark Fork and its affluents, so far as it was seen in a visit to the prospects from Metaline some 8 or 10 miles northward, consists of a thick series of more or less dynamometamorphosed sedimentary rocks composed essentially of shale and dolomite. The rocks are believed to be of Paleozoic age, although no fossils were found to substantiate this conclusion. Igneous rocks were not observed in the localities visited. The beds throughout a large part of the section examined have a more or less general north-south strike and a fairly constant westward dip at a steep angle. In many places the strike is several degrees east of north and the dip is to the northwest or southeast. Local changes in the direction of strike and dip were observed, and there is some intricate folding on a small scale.

Observations of the rock formations in the district were practically confined to a narrow strip of country near Clark Fork, but investigations in the contiguous Northport district and elsewhere in northeastern Washington indicate that these metamorphosed sedimentary rocks are simply a continuation of the series so universally present in the eastern part of Stevens County. Accurate measurements of these sedimentary beds were not made, but it is certain that they are several thousand feet thick. The rocks observed are mainly lime shales or slaty argillites, with intercalated dolomite which is in places completely silicified. These rocks occur in alternating beds of shale and dolomite, which appear to be conformably interbedded, the thickness of the intercalated shale or dolomite strata varying from a few inches to several hundred feet. In general thin beds of dolomite occur between beds of shale, though the reverse arrangement is seen in some places, and the shale probably occupies the greater part of the Metaline district. On the west side of the river dolomite is prominent, and in several places it extends across the valley and forms high cliffs and mountains on the east side. Much of the dolomite resembles limestone and some of it was regarded as limestone in the field. However, analyses of three specimens collected from widely separated localities showed the presence of 17 per cent or more of MgO, and therefore all these rocks are termed dolomites, although there are probably in the area pure limestone strata which the writer did not recognize as such. Some cliffs in

the vicinity of the Clark property are composed of nearly pure calcium carbonate. Here huge blue and white calcite crystals, some of them 3 inches long, form strata several feet in width and over 100 feet in height. The formation appears to be the result of a complete recrystallization of limestone under rather exceptional conditions.

As the rocks strike generally north and south the river has in many places cut its channel nearly parallel to the direction of the strike, and the steep cliffs and box canyons suggest faulting or slipping along the cleavage planes of the shales. Faulting and brecciation of the country rock are common and are important factors to be considered in connection with the ore deposits, having controlled to a large degree the extent and location of the mineralized areas.

The dolomite is in general of fine, even texture and varies in color from the predominating bluish-gray tone to white and in places to a dense black.

The dark variety contains 21.5 per cent of MgO and 27.9 per cent of CaO, as shown by the analysis of a sample taken from the vicinity of the Lead King prospect. The lighter-colored dolomites contain approximately 17 per cent of MgO and 30 per cent of CaO. The shales are in general dark blue or black in color and are finely cleavable, the planes of lamination being distinct and close together. In places greenish shales were noted, which may be chloritic. The Inland Portland Cement Co., of Allentown, Pa., has kindly furnished the following analyses made by it of the shales in the vicinity of Metaline Falls:

Analyses of shales from Sullivan Creek, Metaline Falls.

	1	2	3	4	5
Silica	25.72	15.62	37.40	20.32	32.22
Alumina and iron oxide	15.72	9.82	25.14	12.20	20.52
Lime carbonate	53.02	68.66	29.71	62.11	39.11
Magnesia carbonate	3.66	4.81	2.93	3.66	3.87
Ignition loss	25.64	32.82	16.20	29.66	20.34

Analyses of shales from Sand Creek, 5 miles south of Metaline Falls.

	1	2	3	4	5
Silica	71.00	81.16	78.00	65.72	66.50
Alumina and iron oxide	13.20	11.06	11.24	17.84	13.32
Lime carbonate	5.95	1.41	2.19	4.37	8.12
Magnesia carbonate	6.61	2.70	3.41	3.80	8.71
Ignition loss	6.40	2.04	3.80	7.44	8.42

ORE DEPOSITS.

DISTRIBUTION AND CHARACTER.

Because of the small amount of development work done on prospects in the Metaline district and the general unsettled conditions which exist there, the character and distribution of the ore deposits

are rather difficult to ascertain. Examinations were made of the Schellenburg, Riverside, and Meade properties, on the east side of Clark Fork, and of the Cliff, Lead King, Clark, and Oriole prospects, on the west side. The deposits on these properties are reported to be typical of the lead and zinc deposits in the Metaline district. They are all within a short distance of Clark Fork, extending from Metaline 10 miles northward.

In general the deposits are irregular disseminated replacements of lead and zinc ores in dolomite. Scattered bunches and pockets of galena also occur. One large fissure vein was seen. There is no visible connection between the pockets of galena and any given gangue mineral, but the zinc ores in this district almost invariably accompany a silicified rock that was either dolomite or limestone, it being impossible to determine its original character. Especially worthy of note is the relation of the mineralized areas to the brecciated and faulted zones, marked disturbances in the sedimentary rocks having been noted in all the deposits examined. Where brecciation was the most severe mineralization appears to be correspondingly high. That these zones of movement indicate the former existence of channels in irregular fractures through which mineralizing solutions have passed is clearly shown by the intimate association of the ores of the district with such fracture zones and cemented breccias.

The principal minerals occurring in these disseminated deposits are cube galena and light-colored sphalerite, the latter in places possibly containing some cadmium. The resemblance of much of the sphalerite to that of the Joplin district, Missouri, is noteworthy. "Steel" galena and the ordinary dark-colored sphalerite, "black-jack," are also present in some of the ores. Pyrite and marcasite are found in many of the deposits, the quantity present varying greatly from place to place. As a rule the pyrite appears to occupy fissure veins rather than to be generally disseminated through the sedimentary rocks. Some chalcopyrite occurs in a few of the deposits. The oxidation products of the sulphides above mentioned are common, smithsonite and anglesite having been seen in the ores from many of the workings. Calamine was not definitely recognized, but it has been reported from the district and there is no reason to doubt that it is present. Cerusite also forms a part of the ore. Malachite, azurite, and limonite are less conspicuous minerals in the disseminated deposits.

In the property whose vein occupies a large fissure, the mineralization by pyrite is much more profuse; and the iron sulphides, which elsewhere but sparingly replace the country rock, here occur in a vein from 2 to 8 feet in width. The amount of galena and sphalerite is scanty, and secondary oxidized products fill some of the small fissures and fractures in the country rock adjoining the vein.

ORIGIN OF THE ORES.

About 7 miles west of Clark Fork, near the border between the Metaline and Northport mining districts, is a great area of granite similar in many respects to that in the Old Dominion mine, 7 miles east of Colville, and in fact resembling the granite found in places throughout northeastern Washington. Specimens of molybdenite which have been sent to the United States Geological Survey from a prospect located 4 miles east of Clark Fork, in sec. 18, T. 37 N., R. 43 E., suggest a pegmatitic origin, which also implies the presence of a granitic magma in this part of the area. The silicified zones of dolomite or limestone are evidently the results of siliceous solutions. These solutions may have accompanied the granitic intrusions seen throughout a large part of northeastern Washington, tongues of which probably extend into the Metaline district.

The light-colored sphalerite is almost invariably found in silicified zones in this district. As the lead and zinc ores are commonly associated in this locality, it seems only reasonable to suppose that the siliceous solutions brought also the lead ores. The apparent uniformity of the deposits and the geologic section throughout the portion of the area examined and the probability that a similar geologic series extends over a greater part of the district seem to justify the conclusion that deposits elsewhere in the Metaline region are of the same general nature as those examined.

FUTURE OF THE DISTRICT.

At the time of the investigation (August, 1910) the Metaline district was more sparsely settled than any other locality investigated in northeastern Washington. In December, 1910, direct railroad transportation was available for some of the properties on the east side of Clark Fork. Practically the whole district is without wagon roads, and the trails to the several properties do not afford an economical means for shipping out the ore.

All the deposits examined were of extremely low grade, none of them showing over a small percentage of lead or zinc, so that shipping without concentration would probably be unprofitable even with railroad transportation at the properties. One mill has been built, which proved a failure. Whether others can be constructed so that the ore minerals can be economically saved is an open question. Many tons of ore would have to be mined to produce 1 ton of concentrates containing roughly, say, 50 per cent of lead and zinc. It is the writer's impression that in most of the prospects examined the ratio of crude ore to such a concentrate would be about 30 or 40 to 1, which means a high initial expense of installation and much wear and tear on the milling machinery. The mineralization is scattered

and irregular, and at present the boundaries of the mineralized areas are unknown.

In prospecting other areas in the Metaline district it would be well to look for zones of intense brecciation and faulting in the country rock, accompanied by local silicification. The lead and zinc ores seem to have been introduced by solutions accompanying the intrusion of the granite batholith, and it is highly probable that mineralization has taken place along fissures and fracture zones that have been more or less closely followed by the solutions accompanying the acidic magma. Some operators in the district believe that contacts between light and dark dolomite or between dolomite and shale are favorable places to look for ore bodies.

Comprehensive smelter and mill tests have not, to the writer's knowledge, been made on ores from this district, and it is essential, before erecting plants to treat the ores, to make a thorough investigation of the chemical and physical properties of the constituent minerals of the ore bodies. Until recently it was not generally known that zinc minerals occurred in this district. From observation the zinc minerals seem to be as widely disseminated in the ore deposits as the lead ores, although heretofore the district has been considered as principally a lead camp.

PROSPECTS ON THE WEST SIDE OF CLARK FORK.

ORIOLE.

The Oriole property is located about 1 mile due west of Metaline and some 700 feet above it, the camp being at an elevation of 2,750 feet. The workings start near the base of steep dolomite cliffs which flank mountains that attain altitudes of several thousand feet, forming some of the highest peaks in the vicinity. These mountains are about a mile back from the river and form the eastern front of the Calispell Range. The camp is located on a small flat near the head of a minor gulch. The equipment consists essentially of a small compressor plant and a boiler.

The rocks encountered in the workings are fine to medium grained grayish-blue dolomites, which are locally more or less silicified. They strike approximately north and south and dip about 45° W. or NW. The main level has been started at a point several hundred feet south of the camp and approximately 100 feet higher. It consists of an adit tunnel some 250 feet long, driven in a westerly direction in the east slope of the ridge above referred to. A slip or fault in the country rock was encountered at this distance from the portal, and a drift reported to be 250 feet long has been driven on this slip, which trends N. 70° W. and dips 70° NE.

The mineralization in the prospect has been confined to the fault plane, the width of which varies from practically nothing up to 12

inches, or in places perhaps a little more. The gangue is principally gouge, with here and there some irregular stringers of quartz, which in places nearly fill the space between walls. Some calcite was noted in parts of the vein. The ore minerals appear to be chiefly sphalerite and galena, but some pyrite is scattered in a very irregular pockety manner throughout the quartz, the vein as a whole being exceptionally lean. A few fairly massive pockets of ore were seen, one of which measured as much as 12 inches across. A winze, said to be 65 feet deep, is located near the center of the drift. At the time of the investigation this winze was nearly filled with waste rock. Near the top of it are two small quartz veins, separated from each other by 12 inches of country rock, the total width of the veins, including the horse, being about 30 inches at this place. This lens of ore exposed in the top of the winze is of uncertain relation to the main fault seen in the drift above referred to. The country rock contains many small fractures that traverse it in all directions.

The upper workings, located at an elevation of 2,950 feet, a little north of the lower level, consist of a 30-foot adit tunnel and a 20-foot drift on a slip in the country rock which strikes N. 70° E. and dips 45° NW. Here a vein having an average width of 6 inches but attaining a maximum of 24 inches in the bottom of an 8-foot winze shows some mineralization by galena, sphalerite, chalcopyrite, pyrite, and the oxidation products limonite, azurite, and malachite in a gangue of quartz and gouge.

The ore is reported to carry appreciable values in silver and a little gold in addition to the lead and zinc. In general, the ore body is lenticular and not at all persistent. This property has more underground development than any of the others visited in the Metaline district by the writer.

CLARK.

About 2½ miles north of Metaline, on Flume Creek near its confluence with Clark Fork, is a group of claims known locally as the Clark property, controlled by the Metaline Lead Co. A wagon road extends northward from Metaline to Flume Creek half a mile west of the prospects, and good trails have been built from this place to the workings along the north side of the creek. Exploration, principally by means of stripping, trenching, and open cuts, is being carried on along the cliffs which lie directly northwest of the junction of Flume Creek and Clark Fork. These cliffs rise rather steeply from an elevation of 1,970 feet at the river channel to 2,800 feet or more on top of the first prominent bench or ridge and are cut by gorges from 100 to 500 feet deep, through the most precipitous of which courses Flume Creek. Because of its relatively steep fall in the distance traversed, Flume Creek affords an excellent opportunity for generating power.

The claims constituting the Clark property number about 20. The principal surface development is on the Josephine claim, which includes within its boundaries part of one of the high cliffs above referred to. On this claim there are 18 or more surface cuts, a short tunnel, and a shallow shaft. About 400 feet lower, just above the stream bed of Flume Creek on the Hidden Falls claim, are two adit tunnels, one on each side of the creek, driven in opposite directions some 270 and 340 feet. These have been started with a view to prospecting the cliffs and possible ore bodies at this depth. So far, however, mineralized rock is not reported to have been encountered. Still farther down, near the level of Clark Fork, are an open cut and an adit tunnel some 300 feet long on the Chickahominy claim. This tunnel has been driven on a fault plane in the dolomite series, near which occur scattered pockets of the ordinary lead and zinc ores found in the district. On each of the other claims in the group a small amount of work has been done, consisting mainly in sinking the discovery shafts, the title of the whole group being held by work concentrated on one or two claims.

The rocks exposed by the workings are the light-colored dolomites and dark shales referred to in the general description of the geology of the district. The strike and dip of these strata are difficult to ascertain. The general direction of the strike is northeast and of the dip northwest.

The ore minerals are chiefly sphalerite and galena; the oxidation products smithsonite, cerusite, and anglesite are prominent in certain parts of the outcropping strata. No regular veins of ore-bearing material were found, and the extent of replacement in the country rock is undetermined. The ores occur as pockets in dolomite and disseminated through brecciated and silicified country rock, and it is impossible to give authentic data on their probable extent. In places the mineralized zone appears to be at least 10 to 20 feet wide and to extend 50 to 100 feet along the strike of the strata.

The mineral-bearing rock contains little silver and is of low grade, so that concentration would be necessary; during this operation a partial separation of the lead and zinc minerals would be effected. It is an expensive ore to handle, and for profitable mining considerable machinery would have to be installed; this means a large initial outlay of money.

LEAD KING.

The Lead King property, also controlled by the Metaline Lead Co., is located on the west side of Clark Fork, some 6 miles north of Metaline, at an elevation of approximately 2,600 feet. The wagon road built by the company has been partly completed for a distance of about 4 miles and is connected by trail with the prospect. A small bunk house is located near the south end of the claim.

The country in the immediate vicinity of this property, unlike that near most of the other prospects of the district, is rather flat, the main workings being located on top of a small ridge which rises a few feet above the first high bench west of Clark Fork.

The principal developments consist of shallow shafts, surface cuts and trenches, and two short tunnels, the longer one having been driven about 200 feet. The rocks in the vicinity are dolomites, similar in many respects to those found in other parts of the Metaline district. They appear to strike northeast and to dip northwest at a steep angle. One peculiarity of the geologic section exposed in this vicinity is the presence of a very fine-grained black dolomite, containing 21.5 per cent of MgO and 27.9 per cent of CaO. This rock appears to be nearly barren of mineral values. The mineralization by galena and zinc blende seems here to be very sparse, and the minerals are irregularly disseminated through the dolomite. In places calcite accompanies the ores. As exposed by the surface workings in this property the lead ores seem to predominate.

All of the work done here is of so superficial a nature that few data were obtained as to the extent of the mineralized area.

CLIFF.

The Cliff is the most northerly deposit examined by the writer in the Metaline district and is located some 7 miles north of Metaline, on the west side of the first high bench west of Clark Fork. The workings are situated at an elevation of 2,730 feet and are approximately three-eighths of a mile southeast of Carmichael's ranch. The developments consist of a 30-foot trench in dolomitic limestone, this formation apparently dipping northwest at a rather steep angle. One shipment is reported to have been made from this property, but the returns were not accessible to the writer. There are no surface improvements, and the property is in the early prospecting stage.

The mineralization seems to be confined to a zone of brecciated limestone, the extent of which is indeterminable. As exposed on the surface the apparent width of this partly silicified zone is not over 8 or 10 feet and the mineralization is scattered and of uncertain extent. Galena and perhaps a little sphalerite form the ores. In general there seems to be less replacement of the country rock than in the Josephine claim of the Clark group and more segregation in vugs along the siliceous zone.

PROSPECTS ON THE EAST SIDE OF CLARK FORK.

SCHELLENBURG.

The Schellenburg prospects are located about 2½ miles north of Metaline Falls, on the east side of Clark Fork, at an elevation of 2,550 feet. They are reached by trail or wagon road from Metaline

Falls and up to 1910 had not made any shipments of note. The developments consist of surface trenches from 1 to 5 feet deep and from 6 to 100 feet long. From their proximity to the new railroad which is built to Metaline Falls, these properties are perhaps more accessible than any others in the district.

The rocks in which the mineralization occurs are dolomitic limestones, which strike northeast and dip 70°–80° NW. They are typical of the series found in this district and show in the most highly mineralized belt considerable brecciation.

The workings on this group expose a number of fault planes which have general northeast-southwest and northwest-southeast directions. Much of the mineralization throughout the area is found along the fault planes and appears to have accompanied or followed the more intense movements. The present developments are superficial and little can be said about the future of these deposits.

RIVERSIDE.

The workings of the Riverside property, some 6 miles north of Metaline Falls, are situated on the face of a cliff which rises almost vertically above Clark Fork. The camp is located on top of the first bench, about 300 feet above the river. The developments consist of several short tunnels or drifts on or near the vein, which show in an uncertain manner the lateral extent of the replacement of the sedimentary series. Outside of the mineralized zone fresh medium to fine grained blue and gray dolomitic limestones form the country rock. A few hundred feet to the east blackish shales appear in the series and extend eastward for some distance. These rocks strike N. 55° E. and dip 70°–80° NW.

The deposit constitutes a fissure vein in dolomitic limestone, the vein being exposed for a vertical distance of about 250 feet. The country rock is partly replaced on each side over a distance of several feet, and parallel fissures extend from the main vein for 15 to 20 feet. These lateral stringers are much smaller than the main vein, which is in general from 2 to 8 feet wide. The trend of the vein is N. 55° E. and the dip 70°–80° NW.

The vein filling is principally pyrite with a little galena, the mineral aggregate showing concentric or kidney structure representing alternate replacement of the limestone by pyrite and galena. A radial structure is also developed in the pyrite. The iron minerals have been partly decomposed, so that a very heavy gossan caps the vein and extends downward for a distance of 100 feet or so. Gypsum crystals occur in abundance along the small cracks and fissures and are no doubt derived from the alteration of the dolomitic limestone by the action of sulphuric acid liberated in the oxidation of pyrite. Some "steel" galena was noted in a small tunnel halfway down the

cliff, but farther down this mineral seems to be absent. Chalcopyrite was seen in the lower levels. Because of the highly oxidized condition of the iron ores in this deposit, the strata on both sides of the fissure are very much stained and form a noticeable red and yellow zone which extends for a great distance.

Although the fissure seems to be well defined and to have a persistent bearing, the vein filling is of such a nature that the lead ores may not occur in sufficient quantities to warrant mining. It is possible, however, that developments along the vein proper may uncover larger quantities of the lead ores which form only a small part of the vein filling so far exposed.

MEADE.

The Meade prospects are situated at an elevation of 2,300 feet on a small hill just north of Slate Creek, about 7 miles north of Metaline Falls. The developments consist of two short tunnels driven on opposite sides of the hill, each one being approximately 110 feet long. The country rock is dolomite or limestone similar to that noted in the vicinity of other prospects in the district. The mineralization seems to consist principally in the introduction of pyrite, with here and there a bunch of galena, the latter apparently occurring along the bedding planes of the dolomite. The pyrite or marcasite has a radial structure. The main pockets of ore have been found along a slip in the country rock, which strikes N. 20° E. and dips 50° SE. A small amount of chalcopyrite is present in the ore. Calcite and quartz form the gangue, which is locally brecciated.

Because of the slight amount of development on the slip in which these pockets of galena occur, it is impossible to state the extent of the ore body. It seems highly probable, however, that this deposit is small and that future developments will show only a continuation of the irregularly spaced aggregates of ore minerals.

NORTHPORT DISTRICT.

LOCATION AND EXTENT.

The Northport mining district is situated in the northwestern part of Stevens County, being bounded by the international boundary line on the north and the west line of the Metaline district on the east. The logical western boundary seems to be the eastern edge of the Orient district, rather than Kettle River, which is recorded as the western limit. In the following discussion the district will be treated as extending westward to the eastern boundary of the Orient district, or a short distance west of the one hundred and eighteenth meridian.

Northport, the principal town, is 3 miles north of the center of the district and has a population variously estimated at 500 to 1,500

inhabitants. The Northport copper smelter, controlled through stock ownership by the Le Roi Mining Co. (Ltd.), has a daily capacity of 1,200 tons. At the time of the investigation this smelter was closed. Timber and water are plentiful in the district, and the falls on Sheep Creek afford a good site for the generation of power. Water is piped to the Northport smelter from Deep Creek.

CONDITION OF MINING ACTIVITY.

At the time of the investigation of the district little or no active development was in progress; the smelter had closed a few weeks prior to the writer's visit, and the mining industry seemed to be on the wane. Some work was being carried on by the Jupiter Lead Co. on the Last Chance property, 5 miles southeast of Northport; several men were at work for the Monumental Lead Co., near Deep Lake, and a small crew were operating the Sunset property, half a mile north of Northport, on the northwest side of Columbia River. So far as the writer knows, shipments were not being made from any of these properties at the time of the investigation. The Bonanza mine, 3½ miles southeast of Bossburg, was being unwatered with a view to further development. Thus, of the 13 properties examined in the Northport district, only 3 were active, most of the deposits not having been consistently and actively operated for a number of years.

The impression of some of the local mining men seemed to be that the closing of the smelter had much to do with the inactivity existing in the district, but this is unlikely, as the only large shippers within the district had been the Bonanza, Young America, and Last Chance, and neither of these had shipped ore to the Northport smelter, as it was not equipped to treat lead ores. The Last Chance ore was shipped to the Pitcher Lead Co., in Missouri; and the Bonanza mine at one time shipped its product to Everett, Wash.

TRANSPORTATION OF ORES.

Transportation for the ores in this district is afforded by the Nelson branch of the Great Northern Railway, which traverses the district from Bossburg, in the southwest corner, to Boundary, 4 miles west of the eastern edge. Wagon roads connect most of the properties examined with Northport.

The Frisco-Standard group of prospects, near the British Columbia boundary, about 17 miles in an air line northeast of Northport, are at the present time the most inaccessible in this general locality. With a comparatively small amount of work the road to these prospects could again be opened and ore hauled 9 miles to Boundary, the nearest railroad point.

TOPOGRAPHY.

Columbia River flows through the Northport mining district in a broad, flat glacial valley trending southwestward. Tributary streams to this river flow southeastward and northwestward from the adjoining hills, the general elevation of which is approximately 3,000 feet above sea level. That part of the valley of the Columbia contained in this district is about 1,300 feet above the sea.

There seems to be no general trend to the ridges in this district, unless it is northwest and southeast. The ridges terminate in benches forming several tiers or steps, separated from one another by vertical distances of about 500 feet. The ascent from the Columbia to the highest point on the ridges is marked by several steep rises separated by comparatively flat stretches of country.

Because of the character of the material which forms the mountains in this district, erosion has carved gulches and valleys similar to those in the Metaline district, where Clark Fork occupies somewhat similar relations to the surrounding country. Recent gravel benches on each side of the Columbia rise to heights of approximately 50 feet above the present stream level, and above them stand cliffs of limestone and shale.

GEOLOGY.

The rocks in the Northport area are similar in many respects to those in the Metaline district. (See pp. 42–43.) Dark-gray, blue, and white dolomites and limestones, alternating with blackish shale, quartz-mica schist, and quartzite, constitute the geologic section in this vicinity, the series showing more or less dynamometamorphism in different parts of the area. (See Pl. I, *A*, p. 56.)

The strata stand almost vertical and strike nearly north and south, or a little to the east of north.

Some 7 miles southeast of Northport occurs a large granitic intrusive in the sedimentary rocks, and solutions accompanying this magma have locally silicified the sediments in a manner comparable to that noted in the Metaline district. Near the contact of this intrusive rock the sediments show little or no evidence of contact metamorphism, a fact which is indicative of intrusion near the surface. Farther southwest, at the Old Dominion mine, 7 miles east of Colville (outside of this mining district), contact metamorphic minerals have been developed to some extent. If it is supposed that parts of the granitic magma are continuous from the Old Dominion mine north to Deep Lake, a distance of 18 miles, we have here evidence that the southwestern continuations of these sedimentary rocks were more deeply buried than those found in the vicinity of Northport prospects.

ORE DEPOSITS.

Because of the heavy glacial covering on most of the hills and the timber and dense underbrush prevalent in this area, the rocks are mostly unexposed. Hence the district has not been thoroughly prospected, and it is impossible to outline the real extent of the ore deposits.

While there are, no doubt, many prospects in the locality which the writer did not have the opportunity of visiting, those which are here described are reported to include the more fully developed properties in the district. At the time of the investigation developments were so scanty that it was impossible to obtain a clear conception of the real nature of the various ore deposits. Because of glaciation and the heavy soil covering already mentioned oxidation and concentration of ore minerals have not proceeded to a great depth, and sulphides occur abundantly in the croppings of the veins.

The district contains three distinct types of ore deposits—replacement deposits of the Anaconda type; veins along the contact of intrusive lamprophyre dikes, of which the Great Republic is typical; and shear zones in dolomite, limestone, and other metamorphic rocks, of which the Last Chance, Bonanza, and Young America are good examples.

Lead ores carrying more or less silver have been found in practically all the deposits examined in the southeastern portion of the Northport mining district. These ores are almost invariably accompanied by sphalerite or other zinc ores, tetrahedrite, and some pyrite. In the northwestern portion of the district pyrrhotite seems to be the prevalent ore mineral. This is accompanied by chalcopyrite, tetrahedrite, galena, and sphalerite, and the ores carry some gold and silver.

MINES AND PROSPECTS SOUTHEAST OF COLUMBIA RIVER.

The deposits examined southeast of Columbia River, with the exception of those near Bossburg, are within a short distance of the road which runs southeastward from Northport to Deep Lake and thence northward to the British Columbia line, a total distance of about 26 miles.

LAST CHANCE.

The property belonging to the Jupiter Lead Co., locally known as the Last Chance, is situated in the SW. ¼ SE. ¼ sec. 24, T. 39 N., R. 40 E. The lowest adit tunnel is at an elevation of 2,690 feet, or some 250 feet below the camp. A fair wagon road connects the property with Northport, 5 miles to the northwest, and in the past all the ore has been hauled out over this road. Deep Creek affords an abundant supply of water, and timber is plentiful in the vicinity.

The Last Chance ground is developed by four principal adit tunnels and several open cuts, comprising in all several hundred feet of development work. Stopes connect the levels. The total production, counted as metallic lead, is reported to be more than 5,000,000 pounds. Of the ore 3 per cent is said to have been in the form of carbonate ores, which contained 42 per cent of lead, and the rest in the form of galena ore, which is reported to have averaged 55 per cent of lead without concentration. According to the company the ore did not average more than 1 ounce of silver to the ton. The zinc content in this particular deposit is exceptionally low, only one penalty for excess content of zinc having been exacted and the shipments in general containing less than 15 per cent.

The rocks in the immediate vicinity of the deposit are dolomites, varying in color from light gray to dark blue or in places to almost black. Dark-colored carbonaceous shales form a part of the sedimentary series a short distance northeast of the workings. No intrusive rock of any nature was observed near by. A partial analysis of a specimen of dolomite rock taken near the Last Chance showed the presence of 21 per cent of MgO. The dark-colored shales contain a high percentage of silica and much organic matter.

As exposed in the workings, the ore deposit occupies a shear zone in the sedimentary rocks and is in part an irregular pockety replacement of the adjoining rock. The ore zone strikes northeast and dips approximately 67° NW. It ranges in width from a few inches to several feet, and the ore shoots in the property did not appear to be continuous, rather taking the form of lenses. Faulting on a minor scale is prominent, and pinches and swells are a notable feature in the ore shoots. It is possible that the ore was deposited along the slipping planes of dolomite, and that later movement took place on the same plane with the ore bodies—that is, horizontally along the strike—thus throwing the ore body along and emphasizing the lenticular form.

Specimens from this vein show massive bunches of galena in a gangue of brecciated country rock, calcite, and quartz. Associated with the galena are some pyrite and sphalerite, and near the surface limonite, cerusite, and anglesite. Some ferric sulphate has been formed by the action of sulphuric acid on the inclosing dolomitic walls. The ore minerals were probably deposited during one period of mineralization. This was followed by some faulting and the subsequent deposition of secondary iron and lead minerals derived from the alteration of the primary constituents. Where the country rock has been more or less replaced, a concentric structure is noticeable in the ore, alternate bands of dolomite and lead ores having been noted. The ore bodies above the lower tunnel level have largely been worked

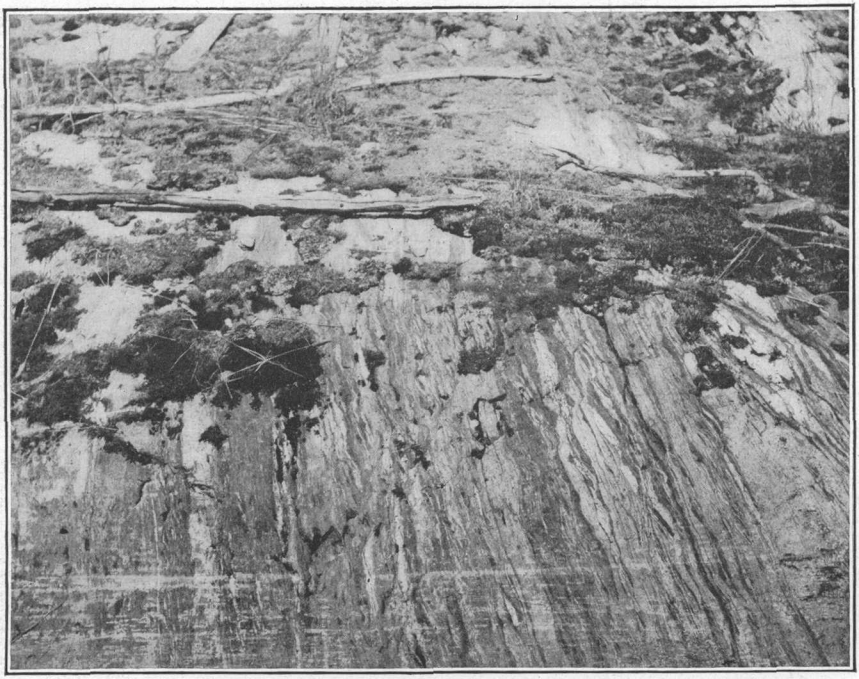
out. It is thought that the mineralization here, as elsewhere in the northern part of the Metaline and Northport districts, is due to mineral-bearing solutions accompanying the granitic batholith noted in many places in northeastern Washington.

TREADWELL.

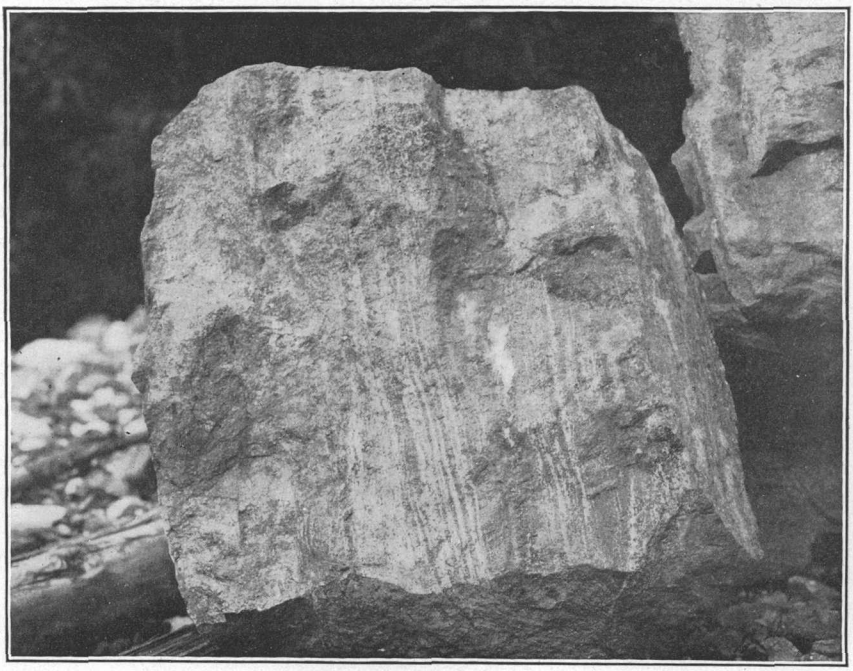
The Treadwell claims, owned by the Monumental Lead Co., are located near Silver Creek, about a mile east of Deep Creek, on the west side of one of the low mountains which flank the Calispell Range on the west. The claims are about 17 miles distant from Northport by wagon road, and are situated near a supply of water and timber. They have been developed by means of open cuts and short tunnels scattered over several claims, the workings having been started within a vertical range of approximately 300 feet. Two cabins constitute the surface improvements on the property, no machinery having been installed. No large shipments are reported from this property.

The rocks in the vicinity of the prospects are dolomites and limestones, with a few intercalated shale beds. The sedimentary rocks at the highest workings (3,500 feet in elevation) dip 33° S. 60° W. Intrusive dikes greatly resembling those found in conjunction with granitic intrusions are more or less prominent throughout the area. These dikes contain large crystals of albite, with some biotite in a groundmass composed essentially of orthoclase and plagioclase feldspar with quartz. White mica, resulting from the alteration of the feldspars, is a prominent constituent of the altered dikes, and associated with it is much chlorite. The dikes range in thickness from a few inches to several feet. Fresh specimens are whitish blue in color, and the weathered surfaces have a general brownish tone. They may represent a certain phase of minette dikes. Apparently the dolomites have not been greatly altered by the intrusion of these dikes, only a few crystals of pyrite being noted, accompanied by considerable chlorite. The shales, which are blackish in color, show evidence of extreme movement, being broken and faulted in many places. Several slips of small magnitude were noted in one of the tunnels. The joint planes seem to have general southeasterly and northeasterly directions, and one of the intrusive dikes strikes northeast.

The ore as exposed by the workings consists of small scattered pockets or bunches of galena in dolomite, the general conditions greatly resembling those in the Metaline district. There is not enough development on any of the claims to warrant speculation on the future prospects of the ore bodies.



A. GLACIATED SURFACE OF SHALE CONTAINING MANY QUARTZ LENSES.



B. SECTION OF VEIN FROM ANACONDA NO. 1 PROPERTY.

Shows parallel banding in the replaced limestone by galena, sphalerite, and tetrahedrite.

A. MINOR FOLDING IN LIMESTONE COUNTRY ROCK AT COPPER KING PROPERTY, NORTHPORT DISTRICT.

B. SECTION OF VEIN FROM FRISCO, STANDARD MINE.

Shows mineralized black shales, the dark streaks in general representing galena and tetrahedrite and the light spots quartz.

SCAMAN.

The Scaman claim is located near the Treadwell claims, in a similar geologic section. In a tunnel about 200 feet lower than the upper workings on the property is an intrusive dike similar to those at the Treadwell deposits. The vein worked on this property dips 53° S. 30° E., seems to be fairly continuous along its strike, and has an average width of perhaps 3 feet. The ore occurs as pockets of galena in the vein, which is directly southeast of the intrusive dike. The relations of the vein and the intrusive dike exposed in the tunnel point to the conclusion that the mineralization was effected by solutions accompanying the dike.

ANACONDA.

The Anaconda prospect, belonging to Mr. Flugal, is 1 mile east of Cedar Lake, on the east side of Red Top Mountain at an elevation of 4,000 feet, and is about 5 miles from Boundary, the nearest railroad point. A shallow shaft constitutes the development work, and so far as the writer knows shipments have not been made from this property.

The rocks in the vicinity are light-colored, probably dolomitic limestones and fine-grained greenish quartz-mica schists. The Anaconda deposit, which occurs between the two formations, strikes S. 35° W. and dips 53° N. 55° W. It is in general about 18 inches wide and consists of partly replaced country rock, which shows ribbon structure, galena, sphalerite, and tetrahedrite being distributed through the rock in distinct bands. (See Pl. I, *B*.) Some quartz is present in the vein.

COPPER KING.

The Copper King prospect is several hundred feet southwest of the Anaconda and has been developed by a shallow shaft at an elevation of 3,700 feet and an adit tunnel about 160 feet long at an elevation of 3,600 feet; another adit tunnel has been started 100 feet below the first.

The rocks in the vicinity are blue and white limestones, possibly dolomitic, with some intercalated shale, the whole series being traversed by small stringers of quartz in which there is some evidence of mineralization by galena, sphalerite, and tetrahedrite. Intrusive dikes similar to those in the Treadwell and other deposits were also found in this vicinity. In the upper adit, near the contact of an intrusive dike in the limestone, was noted mineralization by galena, sphalerite, and tetrahedrite.

The vein exposed in the upper adit workings is composed of quartz and seems to conform to the trend of the sedimentary rocks, which strike N. 35°–45° E. and dip 45°–50° NW. For the most part the

vein is frozen to the walls, and the limestones on each side do not show much replacement by the ore minerals, although local silicification of the strata is pronounced. The width of the vein ranges from 6 or 7 inches up to 1 foot or more. Some faulting is indicated by the gouge seen along the contact of the intrusive dikes and the limestone, and minor folding was noted in several places. Plate II, *A*, shows a small fold in the sedimentary rocks near the portal of the lower adit tunnel.

FRISCO-STANDARD.

The Frisco-Standard claims,[1] belonging to the Buffalo Syndicate, are located at an elevation of 3,600 feet within a few miles of the international boundary on the north and the Metaline mining district on the east, being about 12 miles northeast of Deep Lake and 9 miles by wagon road from Boundary, the nearest shipping point.

The wagon road which has been built to the claims was, at the time of the investigation (August, 1909), impassable in places, but could doubtless be reconstructed at a nominal cost. A few old buildings in poor repair constitute the surface improvements on the property. Only small shipments are known to have been made from this property, the returns of which are not accessible.

The rocks in the vicinity of the Frisco-Standard claims are similar in many respects to those of the Northport district, consisting of light-colored blue and white dolomites and lime shales with intercalated black carbonaceous shales. These rocks strike S. 63° E. and dip 30°–50° S. 27° W. near the upper workings, but are at right angles to these directions near the No. 6 adit. The dolomites are characterized by broken fragments of the same material, which have been cemented in the deposition of the sediments. At first sight these fragments somewhat resemble fossils. A partial analysis of a specimen of this material showed the presence of 21 per cent of MgO. Minor folding is prominent in the sedimentary rocks in this vicinity. A minette dike was noted in the No. 6 adit tunnel 160 feet from the portal and about 75 feet from the breast of the adit.

The chief developments on this group of claims consist of three short tunnels, with short drifts on the veins, aggregating about 800 feet. As exposed by the underground workings the ore bodies are quartz lenses, from several inches to 3 or 4 feet wide. These lenses occupy spaces between the bedding planes of the sedimentary rocks, so that pinches and swells are prominent features of them. The quartz in general seems to be sparsely mineralized, although in places there are comparatively small pockets (see Pl. II, *B*) of galena, sphalerite, and tetrahedrite, while copper stains and the black oxide of manganese are prominent in the outcrops. The walls appear to lack notable

[1] These claims are outside of the Northport district and apparently do not fall into any of the officially recorded districts. For convenience they are discussed as belonging in this district.

amounts of gouge, and water runs freely through the fissures occupied by the quartz lenses. Solutions accompanying the intrusion of minette dikes may have effected the mineralization in this vicinity.

KEOUGH.

The Keough prospect is about 1 mile south of the Frisco-Standard group, in the NE. ¼ sec. 14, T. 40 N., R. 42 E., a few hundred yards northeast of Mr. Keough's cabin and about 100 feet higher. A few open cuts expose quartz lenses in dolomite near its contact with shale. These lenses are slightly mineralized with galena, sphalerite, and tetrahedrite and are supposed to contain some free gold.

W. J. BRYAN.

The W. J. Bryan prospect is located at an elevation of 2,770 feet just east of the south end of Deep Lake and about 380 feet above it. Here the dolomite, limestone, and shale series is traversed by small fissures filled with broken fragments of the same rocks recemented by solutions carrying much lime. Hardly any mineralization was noted in the workings, which are of slight extent. A little galena was found in places scattered through the country rock.

MINES AND PROSPECTS NORTHWEST OF COLUMBIA RIVER.

SUNSET.

The Sunset prospect is located in the southwestern part of sec. 30, T. 40 N., R. 40 E., about half a mile north of Northport, near the west bank of Columbia River, at an elevation of 1,350 feet. It is developed by a few surface cuts and an inclined shaft about 400 feet deep, with short drifts run from this shaft at 100-foot intervals. A diamond drill was in operation at the time of the writer's visit (August 5, 1909) and had then drilled 283 feet, crosscutting the strata from the 400-foot level.

The rocks in the vicinity are limestones, probably dolomitic, and medium-grained quartz-mica schists, which appear to be conformably interbedded with highly metamorphosed shales. The strata have been deformed by folding and faulting. In general the strata strike northeast and dip about 60° NW., although marked local changes were seen. These sedimentary rocks are cut by rather fine grained micaceous dikes that have the composition of kersantite, and are somewhat similar to those seen in the vicinity of deep Lake. The limestones are bluish white and in general of a fine-grained texture, although in places a few strata of white marble were noted. The schists are stained various colors by the oxides of iron. The shales are predominantly lime shales, although some argillites were noted.

The mineralized rock occurs along the contact of the intrusive dikes with the metamorphosed sediments, galena, sphalerite, pyrite, and tetrahedrite in moderate quantities being associated with much pyrrhotite. The ores are said to carry from a trace to an ounce of gold and from an ounce to 20 ounces of silver to the ton, with a fair percentage of lead. The sedimentary rocks contain veins of quartz which in general appeared to be lenticular, ranging in width from a few inches to several feet. The vein exposed in the main shaft gave out below the 100-foot level, below which only small stringers were seen. As a fold was noted between levels No. 1 and No. 4, it is possible that the vein follows the trend of the sediments, or else that it occupies only a lenticular opening which is perhaps closed below level No. 1. The cores from the diamond drill show an alternating succession of limestone, shale, and kersantite dikes, with some mineralization in the limestones, chiefly by pyrrhotite. This seems to occur in general at or near the contact of the sediments and the intrusive dikes. It seems reasonable to suppose that solutions accompanying or following the intrusion of these dikes have deposited the ores as replacements in the sedimentary rocks.

GREAT REPUBLIC.

The Great Republic prospect, owned by C. C. Knutson, of Northport, is located within a few hundred yards of the international boundary, in sec. 3, T. 40 N., R. 39 E., close to the Red Mountain Railway or the Rossland branch of the Great Northern Railway.

A 40-horsepower hoist, a 60-horsepower boiler, a pump having a capacity of 100 gallons a minute, and a small blower have been installed in the main tunnel. At the time of the investigation the property was not in active operation.

The principal development on the Great Republic consists of a crosscut tunnel 400 feet long, the portal of which is at an elevation of 2,200 feet. A station has been cut 190 feet from the portal and a winze 110 feet deep has been sunk at this point. Other developments consist of a 120-foot inclined shaft sunk on a ledge exposed 50 feet above and a short distance northeast of the portal of the tunnel and shallow surface cuts on other parts of the claim.

The rocks in the vicinity of the prospect are dark-gray limestones or dolomites, with intercalated black shales, and fine-grained quartz-mica schists of various colors, the whole series apparently being conformable and traversed by numerous micaceous dikes. In general the strike of the sedimentary rocks is a few degrees west of north and the dip is about 30° E.

On the Great Republic ground two veins have been explored. One is at an elevation of 2,250 feet, where a quartz ledge containing much pyrrhotite and some chalcopyrite on the footwall dips about 60° E.

and strikes approximately north and south. This ledge has been explored by an inclined shaft 120 feet deep, pitching 45° E. Although the ledge seems to dip in the same direction as the shaft, the pyrrhotite that occurs next to the footwall in the outcrop appears to form a separate vein a short distance below the surface, which dips about 60° E., whereas the quartz ledge dips only 45°. According to Mr. Knutson a picked sample of the pyrrhotite vein contains 11.25 per cent of copper and $2.40 in gold and 12 ounces in silver to the ton.

A deposit on the same property, located at an elevation of 10 or 15 feet below and about 300 feet north of the one just described, has been developed by a small open cut on the surface. In this cut can be seen the contact of a micaceous dike with the lime shale. More or less mineralization has occurred along the contact, and the ledge, which strikes N. 10° W. and dips about 30° E., contains considerable iron ore in the form of pyrrhotite, with a little galena and some chalcopyrite. A picked sample from this ledge is said to have assayed 12.5 per cent of copper and 19 ounces of silver and $4 in gold to the ton.

The main adit tunnel extends through limestone for the first 190 feet of its course. At this point it encounters a micaceous dike (kersantite) through which it has been driven for a distance of 190 feet, to another contact with the sedimentary rocks. The tunnel extends only a few feet beyond the dike. The first contact of the dike with the sedimentary rock is heavily mineralized and the quartz vein which occurs between the two ranges in width from several inches to 4 feet. Pyrrhotite is the predominant ore mineral and is associated with some chalcopyrite, a little sphalerite, and a few crystals of galena. The gangue is composed almost entirely of quartz but contains some calcite and recemented fragments of brecciated country rock. The ore from the winze sunk on this contact is reported to assay from 2.5 to 8.5 per cent of copper and 19 ounces silver and from a trace to $8 in gold to the ton.

The second contact of the intrusive dike with the sedimentary rock is also mineralized. Here a quartz vein about 12 inches in width shows the same ore minerals in about the same proportions.

The presence of these veins on both sides of the kersantite dike leads to the conclusion that the dike has been the dominant factor in their formation.

DOUBLE STANDARD.

The Double Standard prospect is a few hundred feet north of the Great Republic, within 700 feet of the international boundary. It is also convenient to railroad transportation, and small ore bins have been erected near the railroad track.

The main workings consist of a crosscut tunnel 760 feet long, at an elevation of approximately 2,200 feet, and a short inclined shaft,

the collar of which is several hundred feet northeast of the portal of the tunnel, at an elevation of 2,420 feet. A shallow winze has been sunk 210 feet from the portal of the tunnel.

The rocks in the vicinity of the Double Standard are similar to those near the Great Republic, just described. Here, however, intrusive dikes are more numerous and displace the sedimentary rocks to a notable extent. The general trend of the limestones, shales, and schists is north and south, and the dip is 30°–70° E.

The most notable feature in the Double Standard prospect is the occurrence of a mineralized quartz vein in an intrusive dike rather than along the contact of the dike with a sedimentary formation, the general mode of occurrence elsewhere in this vicinity. The inclined shaft is sunk on a quartz vein which occurs in the shale and accords with it in strike and dip. The ore and gangue minerals are similar to those in the Great Republic.

MINES AND PROSPECTS NEAR BOSSBURG.

YOUNG AMERICA.

The Young America mine, owned by William Vessey, of Spokane, is reported to have been one of the earliest discoveries in the Northport district. It is about a quarter of a mile N. 61° E. of Bossburg, a town on the Great Northern Railway.

The underground developments consist of four short tunnels. The lowest of these is at an elevation of 1,600 feet. Tunnel No. 1 is 100 feet higher, tunnel No. 2 is about 30 feet above No. 1, and tunnel No. 3 is a few feet below No. 2. A small amount of drifting and some stoping have been done in the upper workings.

The rocks in the vicinity of this deposit are massive limestones, showing no pronounced bedding and little or no dynamometamorphism. Joint planes are prominent in the country rock and seem to follow the general direction of the mineralized section, striking N. 75° E. and dipping 15° N. 15° W. The limestone forms almost vertical cliffs, the tops of which are 400 feet above Columbia River. The sedimentary rocks are cut by an intrusive dike that is exposed by an open cut on top of the principal hill, the elevation of which is 1,960 feet. The dike trends N. 21° W., dips approximately 60° W., and is about 4 feet wide. Some gold and copper are reported to have been found along the contact of this dike and the limestones. The dike material is greatly altered. One thin section reveals the former existence of much feldspar, now almost entirely altered to white mica, and some ferromagnesian mineral, now entirely altered to chlorite. Pyrite is a prominent constituent of the dike. The rock is evidently a very much altered lamprophyre.

The ore deposits occupy a shear zone in the limestone which dips at a flat angle a little west of north. Apparently the zone of min-

eralization is not over 6 feet wide and contains as partial replacements in the limestone irregularly scattered pockets of ore reported to be of a high grade. Specimens show a predominance of galena, minute specks of sphalerite, and some pyrite. A little quartz is associated with the ore. No well-defined mineralized fissure was noted in the deposits, although the presence of considerable calcite in fissures cutting directly across the mineralized zone indicates solutions which were later than those carrying the lead ores.

According to report, several thousand dollars' worth of ore has been shipped from this mine. It is said to have averaged about 25 to 30 per cent of lead and 20 to 50 ounces of silver to the ton.

The mineralization in this vicinity possibly accompanied the intrusion of the lamprophyre dike, which, no doubt, is an accessory of the intrusive granitic magma common to this part of the State of Washington.

As the underground development is slight, a fair conception of the extent of the deposits is impossible. Small pockets of lead and zinc ore appear to have irregularly replaced the limestones along an indefinite shear zone and certain joint or bedding planes in the sedimentary rocks. The width of the replacement, as exposed by the workings, is only a few feet, and the horizontal extent appears to be slight. If, however, the dike exposed on top of the hill has any real connection with the mineralization, it seems probable that future drifting on the mineralized zone to its contact with this dike might uncover other ore bodies.

BONANZA.

The Bonanza mine is situated at an elevation of 2,200 feet, in the NE. ¼ NW. ¼ sec. 11, T. 37 N., R. 38 E., approximately 3 miles east of Bossburg. The ore body was discovered in 1885. Shipments aggregating several thousand tons of ore are reported to have been made from this mine, the returns from which are not accessible.

The ore body has been developed by an inclined shaft pitching at a low angle and six levels, constituting in all over 3,000 feet of underground workings. At the time of the writer's visit all the levels below the fourth were under water and the information on the lower levels was furnished by Mr. F. J. Davey, who at that time had a lease and bond on the mine.

The rocks in the vicinity of this deposit are limestones, lime shales, carbonaceous shales, and fine-grained quartz-mica schists. These are intruded by lamprophyre dikes, similar to those found in the vicinity of practically all the deposits in the Northport district. A fine-grained gray intrusive rock has the same attitude as the sedimentary formation. This rock is so altered that its original character

is indeterminable. Plagioclase feldspar forms the main part of the rock, which contains also much sericite.

The strata appear to be conformably interbedded and the general trend of the formations exposed in the workings is N. 40° W., and the dip is 40°–50° N. 50° E.

In general the deposit seems to be lenticular and occupies a shear zone lying conformably with the sedimentary rocks and varying in width from a few inches to 4 feet. This zone shows evidence of considerable movement; gouge occurs in places in widths ranging from a few inches to 3 feet. Apparently the fault planes occupied by this deposit served as water channels for solutions which subsequently deposited the ore minerals. At the present time water is circulating through this shear zone, and the country rock on each side of the vein is loose and caves frequently. The vein itself does not seem to be continuous all the way down the shaft, although in the drifts and stopes to the northeast a continuous shear zone may be seen.

As the water was nearly up to the No. 4 level it was impossible to examine the greater part of the mine. Above the No. 4 level the vein appears to contain siderite as the principal gangue mineral, associated with much brecciated and partly silicified country rock. "Steel" galena, some sphalerite, and a little pyrite form the chief ore minerals.

According to Mr. Davey the ore contains from 21 to 22 per cent of lead, 30 per cent of iron, 2.7 per cent of silica, 10.5 per cent of sulphur, and 4.7 ounces of silver to the ton.

At the time of the writer's visit so small a part of the mine was accessible for examination that a clear conception of the extent of the ore body was impossible. Above the No. 4 level the visible ore shoots have been worked out. Because of the uncertain nature of the shear zone it is impossible to speculate on its lateral extension. It does not seem improbable that this fault plane may extend for some distance in either direction from the shaft, and the future of the deposit may lie in finding other ore shoots along the lateral extension of the shear zone. Solutions following or accompanying the intrusion of the micaceous dike near the No. 4 level may have effected the mineralization.

ORIENT DISTRICT (STEVENS COUNTY PORTION).

LOCATION AND EXTENT.

The Orient mining district, known also as the Pierre Lake mining district, occupies the extreme northwestern part of Stevens County and the northeast corner of Ferry County, lying between the international boundary on the north and the ninth standard parallel on the south. As recorded in the office of the county clerk of Ferry County, under date of February 6, 1909, the boundary is as follows:

Beginning at a point where the township line between Tps. 36 and 37 N. in R. 37 E. Willamette meridian intersects the west shore of Columbia River; thence northeasterly along the west bank of said Columbia River to a point where the north line of T. 38 N., R. 38 E. Willamette meridian, intersects the said river; thence west on said township line to the section corner between secs. 4 and 5 of said T. 38; thence north to the international boundary line; thence west on said international boundary line to the section line between secs. 3 and 4 in T. 40 N., R. 35 E. Willamette meridian; thence south to section corner between secs. 33 and 34 on the south line of T. 37 N., R. 35 E. Willamette meridian; thence east on said township line to place of beginning.

As thus outlined the district covers about 400 square miles, a little over half of which is in Ferry County.

The town of Orient, which is the largest settlement in the district, is located in Ferry County only a few miles northwest of the center of the area on the Great Northern Railway, and is the shipping point for most of the mines within the district. Although the larger portion of the Orient district is in Ferry County, most of the claims in this district are located east of Kettle River, in Stevens County. The mines and prospects in the Ferry County portion of the district are described on pages 201–202.

The Great Northern Railway follows Kettle River, which crosses the district from north to south. The town of Marcus is located near the confluence of the Kettle and the Columbia just outside of the Orient district. Rockcut, about 3 miles north of Orient, and Boyds, about 11 miles south-southeast of Orient, are other railroad shipping points for the district.

CONDITION OF MINING ACTIVITY.

Of the 19 mines and prospects examined by the writer in the Stevens County part of the Orient district, seven were active, but only one, the First Thought, was a regular shipper. This mine and the Napoleon are the only ones in the district that have been developed beyond a prospecting stage, the remaining 17 usually being worked simply enough to comply with the annual assessment requirements. This condition, however, is not limited to the Orient camp but is equally prevalent in most of the other districts in northeastern Washington. The lack of extensive developments on most of the prospects and their general inactive condition tended to make the investigation rather difficult.

Wagon roads have been built to nearly all the mines from the nearest railroad stations, and aerial tramways have been installed at the First Thought and Napoleon mines.

Two mills had been built in this district up to the time of the writer's last visit (July, 1910)—a 2-stamp mill at the Easter Sunday mine and a small concentrating plant at the Kettle River mine. A third mill is reported to be in process of construction, to treat the surficially decomposed ores of the Napoleon mine.

TOPOGRAPHY.

The portion of the Orient mining district lying in Stevens County includes a part of the divide between Columbia River on the east and Kettle River on the west. This divide is formed chiefly by one main mountain range, which rises from an elevation of over 1,000 feet at the confluence of the two rivers near the southern border of the district to maximum heights of approximately 5,000 feet, the general elevation of the range, however, being about 3,000 feet. The axis of this main mountain mass has a general north-south trend, and the range is cut by deep valleys through which flow the affluents of Columbia and Kettle rivers in directions respectively southeast and south. Consequently, the axes of the offshoots from the principal range trend either northwest-southeast or north-south. This range seems to have no generally accepted name but is a continuation of the Huckleberry Range, 36 miles to the south.

Glaciation has been active here as elsewhere in Stevens County, and broad valleys have been carved out of the mountain mass. The valley occupied by Pierre Creek, which empties into Toulou Creek, is a striking example of a broad, deep valley whose size is out of all proportion to the small stream that flows through it. Detrital material fills many of the gulches and is spread out on the tops of some of the mountains, offering in some places more or less hindrance to prospecting.

GEOLOGY.

Within the Orient district are exposed rocks thought to represent the Proterozoic, Paleozoic, Mesozoic, and Cenozoic eras.

PRE-CAMBRIAN ROCKS.

The lowest and oldest rocks are schists conformably interlaminated with coarse crystalline limestone and quartzite and are thought to be of pre-Cambrian age. These rocks occur in the northwestern part of the district, where they have a general north-south strike and a dip of 15°–20° E. or SE. They are prominent from Laurier southward to Orient, where they pass out of view, dipping under the younger rocks, though the contact was not observed. The thickness of that part of the series exposed to view in the Orient district probably reaches 2,500 or 3,000 feet. The schists are highly foliated, are of general pink and gray tones, are medium to coarse grained, and show little chemical alteration. Viewed in thin section under the microscope the dark schists are found to contain about equal amounts of plagioclase feldspar and hornblende, with much biotite and quartz, locally accompanied by subordinate amounts of pyrite and calcite and are probably dynamometamorphosed intrusive masses of quartz diorite. The pink schists contain orthoclase, oligoclase, albite, and biotite and are probably derived from granite. The limestones are

A. LENS OF LIMESTONE INCLUDED IN SHALE, GLOBE PROSPECT.

B. MASS OF QUARTZITE SURROUNDED BY INTRUSIVE PORPHYRY, SECOND THOUGHT GROUP.

coarsely crystalline. On weathered surfaces they are dark brown in color and on fresh surfaces cream-white. The quartzites show a pronounced schistose structure, are fine to coarse grained, and are white, yellow, pink, and red in color. The several rock formations vary greatly in thickness. Aplite and diorite dikes are common throughout the section.

PALEOZOIC (?) ROCKS.

The rocks thought to be of Paleozoic age occupy a large part of Toulou Mountain and extend southward to the edge of the district and eastward beyond the eastern boundary. They comprise a sedimentary series of interbedded argillaceous shale, limestone, quartzite, and schist, together with basic and other igneous rocks that have been intruded into the sediments or poured out over their surface during their deposition. The rocks are much deformed by later intrusives and it is impossible to state their dip and strike. In a general way the sedimentary beds trend north and south and their dip varies from horizontal to vertical and may be in almost any direction. Because of the large area occupied by later intrusions it is impossible to state the thickness of that part of this sedimentary series which is contained within the Orient mining district. Certainly it is several thousand feet. The argillaceous shales are fine grained, have a general dark-blue to black color, though in places light gray, and are composed largely of quartz, feldspar, and carbonaceous matter. Locally, as at the Easter Sunday mine, these shales are cherty, and in the vicinity of the Trojan prospect they include bands of a bluish-white material resembling tuff, which contains minute phenocrysts of plagioclase and orthoclase feldspar and quartz. These shales near the Trojan may represent a much later period of deposition than the Paleozoic era. The limestone occurs as lenses in the shale (see Pl. III, *A*) and apparently occupies only a small part of the section as exposed in this district. It is gray on weathered surfaces and white on fresh fracture, and its texture is medium to coarsely crystalline. The quartzite also has a rather scanty occurrence. What was seen was of a brownish color and had a fairly coarse texture. Quartz-mica and hornblende schists are present in different parts of the area, and both kinds occur on Toulou Mountain. They are medium grained, and the color of the former is reddish and of the latter green.

Basic rocks having the composition of gabbro or diabase or a related rock magma intruded the sediments or flowed out over them during their deposition and have been metamorphosed along with the rest of the series, forming greenstone. The intimate association of the greenstone and the sediments is a notable feature of the geology of this region. On Toulou Mountain the greenstone is

widely distributed. In places it resembles amphibolite, but in general it has the appearance of a more or less altered diabase. Its color, as the name implies, is green, its texture is medium to fine grained, and its principal constituents are chlorite, hornblende, feldspar, and quartz. Diabase of a fine-grained, even texture was seen in many parts of the area. The relations of this rock to the greenstone have not been worked out. The diabase is thought to have been intrusive, although it may represent old surface flows.

MESOZOIC ROCKS.

Quartz monzonite porphyry in the form of dikes and large intrusive masses is present near most of the ore deposits visited in this district. Fresh specimens of this rock are of a general gray color and contain phenocrysts of hornblende, andesine and orthoclase feldspar, and quartz, but in certain parts of the area the quartz is lacking. The texture of the rock is medium to coarse grained. On alteration the hornblende changes to chlorite and the feldspars form white mica. The age of this intrusive rock is unknown, but it is thought to belong to the late Mesozoic or early Tertiary.

TERTIARY ROCKS.

Lava flows were poured out over the eroded surface of the Paleozoic sediments probably in Tertiary time. In places these lavas fill large pre-Tertiary depressions, but were poured out in such volume that they now form some of the principal mountains in the district. As the flow best exposed on First Thought Mountain is the only one that is directly connected with the ore deposits of the district, a detailed description of the others will be omitted. Lava flows were seen on top of Toulou Mountain, cover a large part of First Thought Mountain, and probably form the upper parts of Sulphide and Jumbo mountains. The lava flow in which occur some of the deposits on First Thought Mountain is a quartz latite. Fresh surfaces of this rock are of a gray-green color, but the phenocrysts of hornblende and biotite, which are now largely altered to a dark-green chlorite, produce a mottled appearance. The groundmass is exceedingly fine grained, and except for the altered femic minerals and a few quartz phenocrysts the rock appears aphanitic in texture. On weathering this rock becomes bluish in color, and because of this fact the rock in the First Thought mine is locally known as "blue andesite." Latites and andesites are closely related, the former name being given to porphyritic or felsitic rocks which contain appreciable quantities of orthoclase as well as plagioclase feldspar, together with one or more ferromagnesian minerals—in this rock biotite and hornblende (now altered to chlorite).

Intruded into the quartz latite is a porphyritic rock consisting largely of orthoclase feldspar and quartz—a rhyolite porphyry. (See fig. 5, p. 74.) This rock is gray-brown to gray-blue in color and contains phenocrysts of pink and white orthoclase, some of which are 5 millimeters long, green hornblende, and quartz. Viewed under the microscope in thin section the rock is seen to contain also the secondary minerals chlorite and calcite, with some epidote and limonite.

The district contains also certain schists of probable igneous origin of which no positive conclusion as to age is obtainable. Such of of these rocks as occur in connection with ore deposits are mentioned in the detailed descriptions.

ORE DEPOSITS.

In that part of the Orient district included within Stevens County ore deposits are fairly well distributed, although producing mines are few. The detailed description of the deposits which follows is for convenience arranged by five general localities. Many small prospects which the writer did not have the opportunity of visiting are scattered over the district.

The ore deposits of the Orient district are all more or less closely associated with igneous intrusion. They may be divided, according to character, into six classes, described briefly in the following paragraphs:

The first class, consisting of deposits in shear zones in quartz latite, is well illustrated by the First Thought ore body. Pyrite containing gold in a gangue of silica and calcite impregnates fractured quartz latite along fault planes and brecciated zones near the contact with intrusive rhyolite porphyry, which forms the hanging wall of the upper part of the deposit. Four large fractured zones have been explored by the First Thought workings and have been found to range in width from a few feet to 110 feet and to extend along the strike and along the dip beyond the limits of the present workings. As the ore shoots became too lean for profitable extraction under present mining conditions, the workings were not pushed to the extremities of the fault zone. The ore mined (38,180.5 tons up to June, 1910) has averaged $15.50 in gold and half an ounce of silver to the ton. Solutions accompanying the intrusion of the rhyolite porphyry are thought to have effected the mineralization.

The second class, including segregations and partial replacements in amphibolite, is illustrated by the Napoleon ore body. This deposit is an amphibolite mass in a sedimentary series cut by intrusive monzonite porphyry. Scattered through the amphibolite and replacing it to a greater or less extent are pyrrhotite, pyrite, magnetite, and

some chalcopyrite. The mineralized zone as developed by underground workings is about 60 feet wide and 300 feet long, and it extends upward 250 feet to the surface. The ores are thought to have been brought in by solutions which accompanied or followed the intrusive monzonite porphyry. Much garnet has been developed in the amphibolite and the ores may be the result of contact-metamorphic origin, the deposit being similar in many respects to those of the sixth class.

The third class, comprising small fissure veins and slightly mineralized fault planes, in the several formations, includes most of the prospects in the Orient district. The fissure filling in general is quartz, with some brecciated country rock, calcite, and in places siderite, the predominating ore minerals being pyrite, chalcopyrite, and pyrrhotite. Some of the veins contain galena, sphalerite, and tetrahedrite, and in the Pomeroy and Easter Sunday veins a mineral containing lead, antimony, and sulphur was also found, the species being indeterminable because of the massive condition of the ore. Free gold has been reported from the Swamp King and Beecher prospects. In general the veins of this class are small and are not heavily mineralized. These deposits are represented in certain workings on the Second Thought, North Star, Globe, Copper Butte, Orient, Defender, Easter Sunday, Pomeroy, Kettle River, Little Giant, Swamp King, Beecher, and McKinley.

The fourth class comprises ores deposited along the joint planes in the country rock in the vicinity of most of the other deposits. In places these deposits have been explored, and some of the prospects fail to reveal other forms of ore bodies. The mineralization along joint planes is scanty in all the prospects visited, and under the present conditions of mining such deposits have no commercial value. This class includes some deposits on the Globe, Scotia, Orient, Defender, and Trojan properties.

The fifth class of deposits is represented by the Big Iron ore body, where schists of probable igneous origin, somewhat resembling amphibolite, and an included gray rock composed of quartz and feldspar are impregnated and partly replaced by pyrite and some chalcopyrite. Quartz monzonite porphyry has intruded these rocks. As exposed by surface workings the zone of impregnation and replacement is over 100 feet wide, and its extent along the strike of the schists has not been determined, although developments have shown it to be several hundred feet. The genesis of these ores is doubtful. They were possibly formed by solutions accompanying or following the intrusion of the quartz monzonite porphyry.

The sixth class comprises the contact-metamorphic deposits and is illustrated by the McNally and the deposits exposed by the upper

workings of the Orient. Both show some mineralization which is the direct result of igneous injection. In the McNally limestone has been intruded by a rock having the general appearance of diabase, with the result that chalcopyrite and pyrite replace the limestone in an irregular manner. Epidote and serpentine have been developed in considerable quantities along the contact of the intruding magma. At the Orient prospect garnet and epidote, together with some pyrite, have been developed along the contact of an intrusive quartz-orthoclase-hornblende rock in a sedimentary series of shale, limestone, etc. The mineral association is indicative of intrusion near the surface.

MINES AND PROSPECTS ON FIRST THOUGHT MOUNTAIN.

FIRST THOUGHT.

General features and history.—Of the three properties visited by the writer on First Thought Mountain, the First Thought is the only one that has been systematically developed and has made regular shipments. Consequently in the following pages this mine will be more fully discussed than the other two. Rhyolite porphyry intrudes quartz latite in many places on First Thought Mountain, and the latite is more or less impregnated with pyrite for some distance away from the intrusive rock. Larger deposits could, however, form only where, as at the First Thought mine, the presence of a suitable fractured zone offered a proper receptacle for the deposition of ore minerals.

The First Thought camp is located at an elevation of 2,900 feet on the southeastern slope of the mountain, just 2½ miles in an air line northeast of Orient, the nearest railroad station. (See fig. 3.) Supplies are brought from Orient over a fair wagon road, the haul of about 3½ miles involving a rise of some 600 feet between the town and the camp. Water and timber are plentiful in the vicinity.

Soon after the Colville Indian Reservation was thrown open to location, the First Thought claim was staked out. It is reported that the discoverers sold their location to a Bossburg prospector for a day's wages. This man and his associates did a small amount of work on the claim and later sold it to P. Burns for $25,000. Development was then started systematically and continued for two years, when the mine became inactive through litigation which lasted three years. Since 1904 the mine has been a continuous shipper, and up to June, 1910, it had produced 38,180.5 tons of ore, having a gross value of approximately $612,000.

Equipment.—The surface improvements and mine equipment consist of necessary houses and a 60-horsepower gasoline engine, which runs a 7-drill compressor; a 15-horsepower gasoline hoist installed on the No. 4 level; a 15-horsepower gasoline engine, which runs the tramway; a diamond drill having a capacity of 500 feet; and an aerial tramway 12,880 feet long.

Costs.—The tramway, which can handle 75 tons a day, cost $11,000 and has reduced the transportation charges on ore between the mine and shipping point from $1.50 to 33½ cents a ton. The average freight

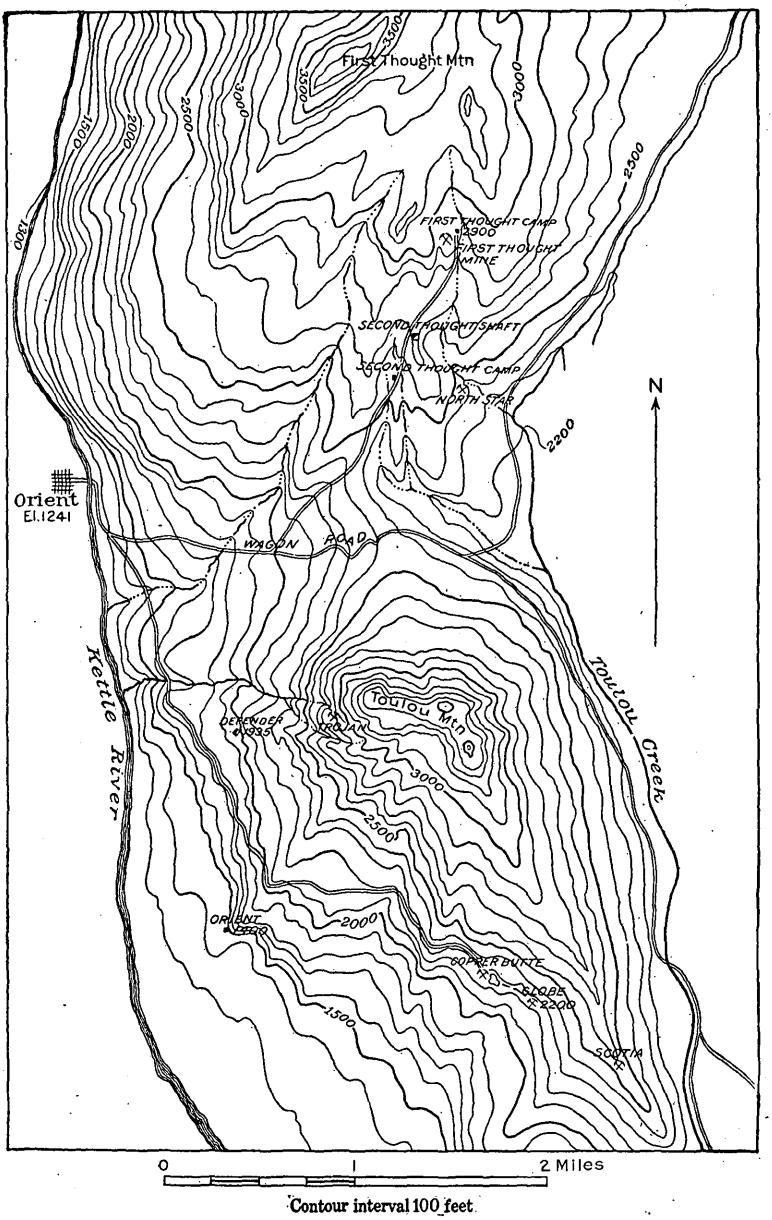
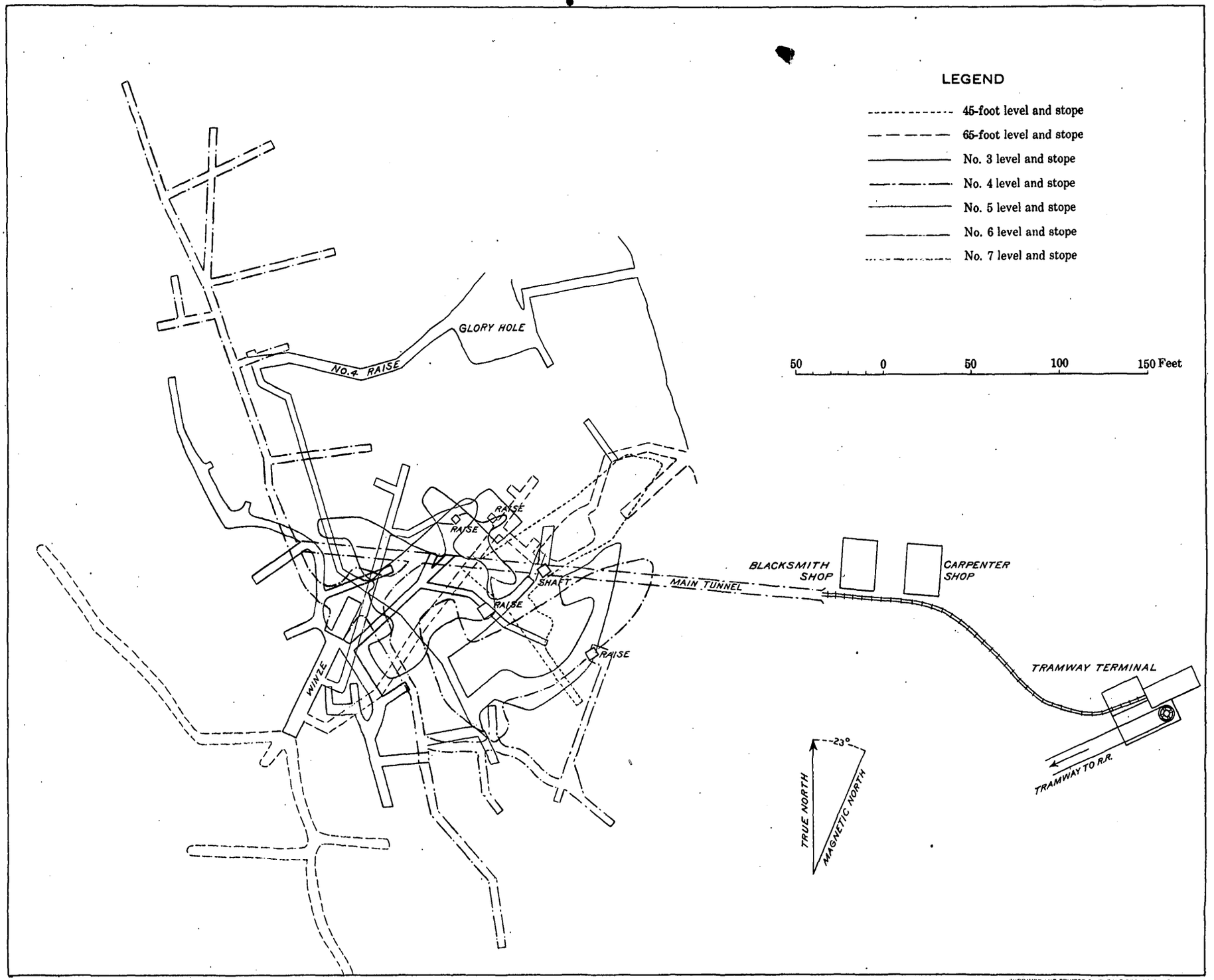


FIGURE 3.—Sketch map of First Thought and Toulou mountains, showing the location of the mines and prospects visited.

charge on supplies hauled from Orient is 30 cents a hundred pounds. Distillate is used in running all the engines and costs 13½ cents a gallon in Spokane, or 21 cents a gallon delivered at the mine. Dur-



PLAN OF FIRST THOUGHT MINE, STEVENS COUNTY, WASHINGTON

Adapted from company maps, June, 1910

ENGRAVED AND PRINTED BY THE U.S.GEOLOGICAL SURVEY

House Doc. : 63d Cong., 2d Sess.

ing the year 1909 the distillate consumed in running the compressor plant cost $3,084. This makes the annual cost per horsepower (running 10 hours a day) $51.41.[1] The total cost of mining the ore and putting it on the cars for shipment varies between $3.90 and $4.20 a ton. Freight and treatment charges in January, 1911, were $6 a ton, the total production being then shipped to the smelter at Trail, British Columbia. The operating expenses at the mine range from $2,000 to $3,000 a month, not including the general manager's salary.

Development.—The ground has been developed by three adit tunnels, one main shaft extending from the surface to the No. 4 level, one main winze extending from the No. 4 to the No. 7 level, drifts, cross-

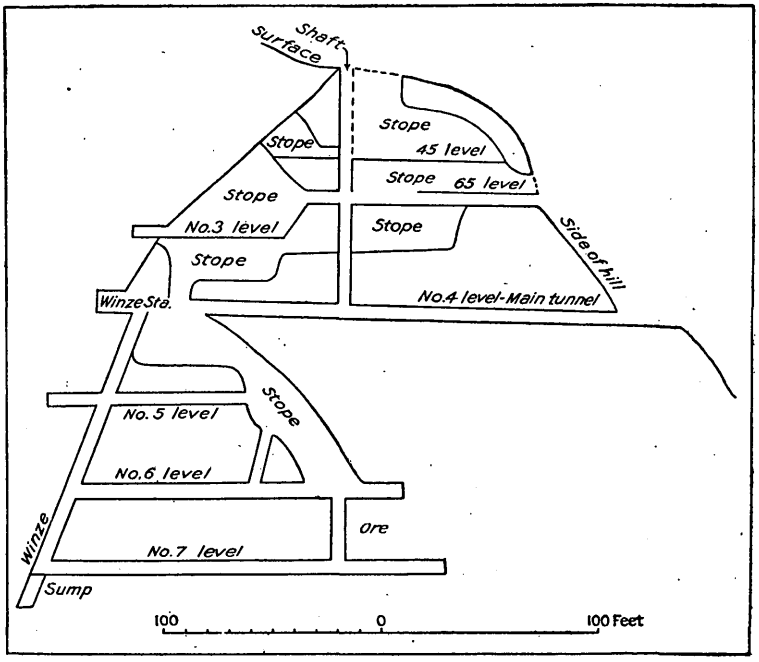


FIGURE 4.—Longitudinal section of the First Thought mine.

cuts, raises, etc. The main tunnel of the mine is level No. 4, above which are level No. 3, the 65 level, and the 45 level. These are all connected with the surface by tunnels and also with the main level by a vertical shaft. Levels Nos. 5, 6, and 7 are reached by the winze and are, respectively, 45, 90, and 130 feet below the No. 4 level. Plate IV gives a plan of the workings and figure 4 a section of the mine.

Geology.—Igneous rocks of two distinct kinds are exposed in the vicinity and in the workings of the mine. The approximate distri-

[1] The Kootenai Power Co. charges $42 per horsepower per annum for power at Rossland, British Columbia, and this can be used continuously 24 hours a day.

bution of these rocks in this locality may be seen by referring to figure 5. The ridge just west of the workings is composed of a rhyolite porphyry, which forms the main hanging wall of the First Thought ore body. Just east of the rhyolite porphyry occurs a rock here described as quartz latite. It is known locally as "blue andesite," the resemblance of the weathered rock to andesite being pronounced. Its general altered condition in the workings makes exact determination impossible, but rocks thought to form a continuation of those encountered in the mine were determined as quartz latite. While the relation between these two kinds of rock is not proved, the rhyolite porphyry appears to have been intruded into the quartz latite, and subsequent faulting along the contact has caused considerable brecciation, which was apparently much more severe in the quartz latite than in the rhyolite porphyry. Faults at right angles to the main fault have occurred, three of large magnitude having been exposed by the underground workings.

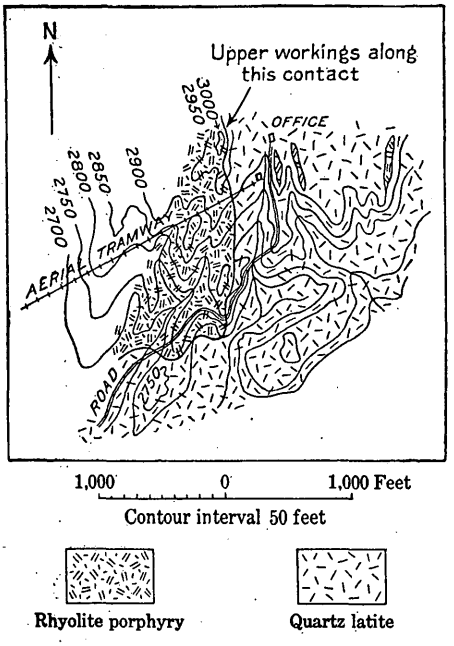
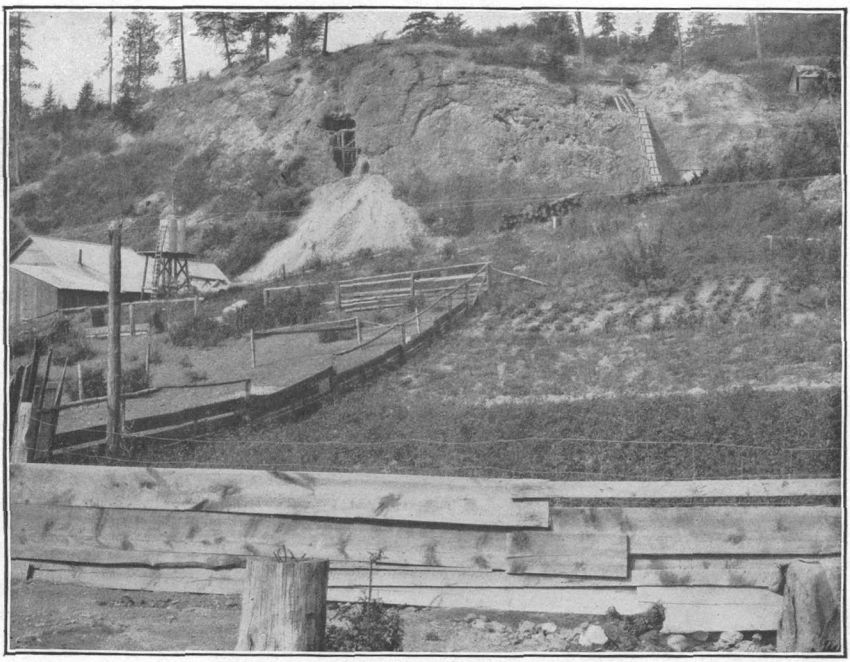


FIGURE 5.—Geologic and topographic sketch map of the area about the First Thought mine.

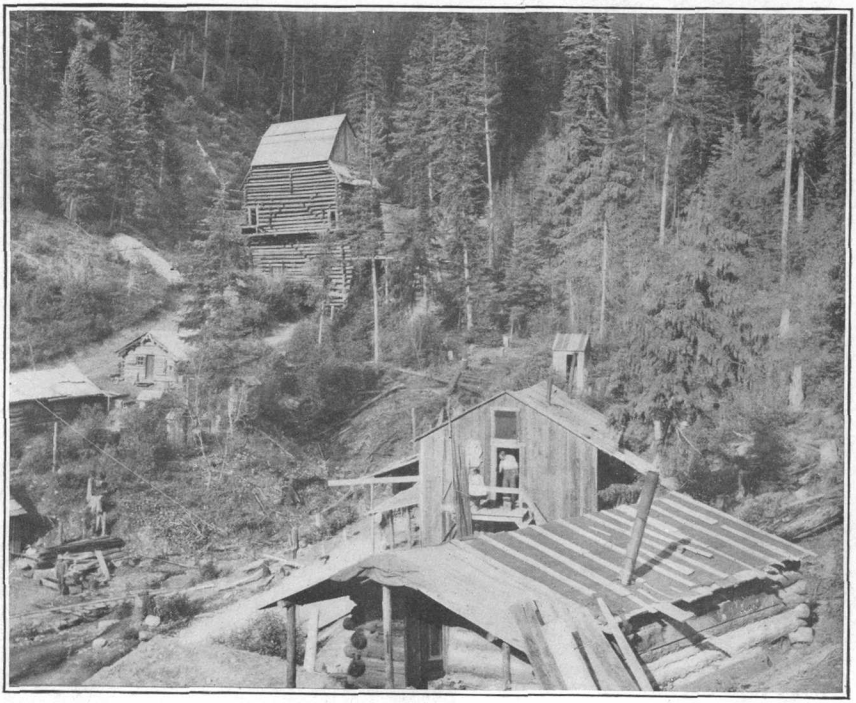
In several places in the main area of quartz latite are small patches of rhyolite porphyry, apparently intrusive into the quartz latite. Three small areas of rhyolite porphyry are represented on figure 5 and many others were seen in the general locality. The rhyolite porphyry may be another phase of the quartz monzonite porphyry so widely distributed in the Orient district.

Ore deposit.—The ore deposit of the First Thought mine is a series of mineralized fault-breccia planes, the principal one of which lies along the contact between rhyolite porphyry and quartz latite. (See fig. 5.) The general direction of this fault plane (which for convenience is designated the "contact fault") is northwest and the dip is to the southwest, ranging from 40° S. 50° W. in the 45 stope (see Pl. V, *A*) to 70° S. 80° W. on the No. 3 level, below which the dip is more or less constant. This fault zone varies in width from 15 to 110 feet, and it has been explored by underground workings for more than 500 feet along the strike and probably continues some distance farther. Its length as measured along the dip is known to



A. FIRST THOUGHT MINE.

Showing 65 stope and steep bluff in which upper workings are situated.



B. PART OF UNITED COPPER CAMP.

Ore bin of the Copper King in the background.

be over 300 feet. It is probable that this fault continues down beyond the present limits of exploration. Three faults of smaller magnitude occur in the quartz latite and adjoin the main contact fault. These may be called the apex fault, the No. 3 fault, and the No. 4 fault. The first and second strike approximately north-south and dip 40°–50° E. The junction of these with the main fault causes considerable widening of the brecciated zone, which in places extends back from the hanging wall 110 feet. The length of these two faults along their dip has never been determined, as the ore shoots they contained became of too low grade for profitable extraction above the main (No. 4) level, and large quantities of low-grade ore still remain in these fault breccia planes. Above the gulch level the length of these minor faults along their strike is limited on the north by a precipitous cliff (see fig. 5 and Pl. IV, p. 72), and on the south these lesser shear zones seem to terminate in the main contact fault.

The No. 4 fault joins the main contact fault some 10 feet above the No. 4 level. It strikes N. 70° E. and dips 40°–50° N. 20° W. It has been explored along the dip to a point a few feet above the No. 7 level and has been found to extend along the strike for over 100 feet. The average width of this fault zone is approximately 25 feet.

Extensive brecciation of the country rock has accompanied the faulting in this locality. The shear zones are now represented by fragments of rock ranging from a quarter of an inch to 1 foot or more in diameter, which have been cemented by siliceous and calcareous solutions. The result somewhat resembles a flow breccia. Accompanying the zones of more intense movement are numerous fissures extending out into the adjoining rock for various distances.

Siliceous solutions carrying pyrite have permeated the shear zones, depositing silica and pyrite and in places impregnating and replacing the quartz latite for short distances. Subsequent movements caused a shattering of the mineralized mass, and calcareous solutions were introduced which deposited calcium carbonate, this being especially prominent in the workings below the No. 4 level. The silica is a dense creamy-white mineral which does not closely resemble quartz, while the calcium carbonate is massive and bears little resemblance to calcite. The valuable metals are contained in the pyrite that impregnates the quartz latite and occurs in minute quantities in the dense white silica. In the upper workings the silica has been iron-stained to some extent through the decomposition of pyrite, and the glory hole shows throughout the country rock numberless stringers of silica, locally stained a dull-yellow color by limonite. Analyses of the ore from this mine are given below.

Analyses of ore from First Thought mine.

	1	2
Silica	65.5	72.30
Lime	8	1.10
Iron	10	3.60
Aluminum	14	17.70
Sulphur	2.10	3.90
Arsenic	.....	Trace.
Tellurium	.....	Trace.
	99.60	99.60

1. Analysis of ore from mine for year 1908, furnished by Alexander Sharpe, manager.
2. Analysis made by Horace G. Nichols, of Ymir, British Columbia, for Mr. Sharpe. Mr. Nichols reported the approximate composition of the ore as follows: Rock, 90; FeS_2, 7.5; $CaCO_3$, 1.96; total, 99.46.

The ore that has been mined and shipped has averaged $15.50 in gold and 0.5 ounce of silver to the ton.

The richer portions of the ore shoots in all but the No. 4 fault zone have pitched to the southeast, the pitch in the No. 4 zone being to the northwest. No marked change in tenor has been noted as depth has been attained in the mine. In this connection it should be remembered that the deepest workings (in July, 1910) were only 260 feet in a vertical direction below the outcrop. In the zone of superficial alteration oxidation is incomplete and there has been little mechanical concentration of gold. Primary pyrite is present in the deposit up to the surface.

Origin of the ores.—The ores are thought to have originated in the siliceous solutions accompanying the intrusion of the rhyolite porphyry, which forms the hanging wall of the upper part of the deposit. As this hanging wall has been found in the lowest workings and as the richer ore shoots have invariably been found at the junction of the main contact shear zone and an offshooting fault, it does not seem unreasonable to suppose that other offshoots from the main contact fault exist below the No. 7 level. As the ore has been invariably richer at the junctions of the faults, it is natural to suppose that if other branches of the main fault or of offshoots from the main fault are found they will also contain rich ore shoots.

SECOND THOUGHT.

The Second Thought group of claims is located just south of the First Thought camp, the north side line of the Second Thought claim joining the south end of a part of the First Thought group. Figure 3 (p. 72) shows the approximate location of the Second Thought camp and the main shaft. The developments consist of a 50-foot vertical shaft on the Second Thought claim and several small open cuts on other claims. No production is reported from this group.

The rocks in the vicinity are mainly quartz latite intruded by rhyolite porphyry or quartz monzonite porphyry. A succession of intrusive masses, having a general north-south trend, were seen in

walking across the claims toward the North Star prospect. Plate III, *B* (p. 66) shows a lens of quartzite included in a mass of intrusive quartz monzonite porphyry.

Some mineralization by pyrite has taken place at and near the contact of the intruding magmas. Where small fault zones are present, as exposed in the shaft on the Second Thought claim and in a shallow shaft on the Searchlight claim, the pyrite is more abundant. The deposits are not well defined and represent a local impregnation of the country rock by pyrite, together with a partial filling of joint planes and small fault fissures by pyrite and limonite. The strike of the faults is in general north and south and the dip is about 70° E. Assays of the pyritiferous material are reported to show about $2 in gold to the ton, and some of the ore from the surface on the Searchlight claim is said to have assayed $8 a ton. Some calcite is present in the fracture zones.

NORTH STAR.

The North Star prospect is located on the southeastern slope of First Thought Mountain at an elevation of 2,400 feet, just east of the Second Thought group and southwest of the First Thought group. The principal development consists of a 400-foot drift on the vein and a 90-foot crosscut from the end of the drift. The general direction of the drift is N. 50°–60° W. No production is reported from this property.

In general, the rocks are similar to those in the vicinity of the First Thought group, and where the quartz latite is exposed by the underground workings on the North Star property it shows evidence of considerable faulting. Rhyolite porphyry and quartz monzonite porphyry are not conspicuous in the territory explored by the main drift, although outcrops of the latter are plentiful near by.

The vein exposed by the main drift has a general strike of N. 50°–60° W. and a dip ranging from 70° NE. to 70° SW. and occupies a fault plane in quartz latite. The width of the shear zone averages about 6 feet, and the vein filling is principally gouge, with some calcite and quartz. A small amount of pyrite is scattered through the vein, assays of which are reported to have showed $1.50 in gold to the ton.

PROSPECTS ON TOULOU MOUNTAIN.

At the time of the writer's investigation none of the prospects examined on Toulou Mountain had reached the producing stage, although of the six visited three were carrying on more or less development work. The locations of these prospects on figure 3 (p. 72) represent only in a general way the positions of the prospects, as the workings on practically all the groups extend over several claims.

GLOBE.

The Globe group of claims is located about 3½ miles southeast of Orient, on the southwestern slope of Toulou Mountain. A secondary road connects these prospects with the town of Orient, the nearest railroad point. Water is obtained in the vicinity, and timber is plentiful.

The underground developments are three adit tunnels on the patented Eva B. claim, and a 50-foot shaft on the Hattie R. claim. The portals of the tunnels are at elevations of 2,295, 2,500, and 2,700 feet, and the shaft is located a short distance west of the lowest adit at an elevation of 2,275 feet. The two upper adits are short, but 900 feet of work has been done on the lowest one.

The rocks in the vicinity are similar to those already described in the paragraphs on the geology of the Orient district. A sedimentary series of argillaceous shale and some included strata of limestone containing sills of rock resembling a very fine grained quartz latite, has been severely intruded by monzonite porphyry, which occupies a considerable portion of the ground covered by the claims. The rock that resembles quartz latite is locally more or less silicified and near the intrusive porphyry masses shows much pyrite.

The upper tunnel does not expose any well-defined vein, but in the joint planes of the rock are a few stringers of hematite carrying a small amount of galena. These stringers are irrregular and terminate within a few inches. The middle tunnel exposes some pyrite in the sedimentary rock near its contact with the intrusive monzonite porphyry. The lowest tunnel exposes only calcite veinlets in the monzonite porphyry and some pyrite in the country rock near its contact with the intrusive.

The shaft has been sunk on a small fissure which strikes N. 60° W. near the collar of the shaft and N. 87° W. 35 feet below. The dip is approximately 76° NE. The fissure is only a few inches wide and is filled with gangue and brecciated country rock containing a little pyrite, chalcopyrite, and pyrrhotite. Assays of ore from this shaft are reported to show only small values in copper.

SCOTIA.

The Scotia prospect is about half a mile a little east of south of the Globe prospect and is connected with it by trail. The developments consist of an open cut at an elevation of 2,600 feet, a 150-foot adit tunnel 100 feet higher, another open cut at an elevation of 2,825 feet, and a shaft still higher on the south end of Toulou Mountain. At the time of the writer's visit the shaft house and the timbering in the shaft were burning, having been ignited by a forest fire.

The rocks in the vicinity of the workings form a continuation of the series found near the Globe prospects. Here, however, two other kinds of rock are present—schist and a sedimentary rock which much resembles quartzite. The schist is greenish and contains phenocrysts of quartz, feldspar, and hornblende. It may be a partly metamorphosed intrusive igneous dike in the sedimentary series. The hornblende in the rock is secondary, and the feldspars are indeterminable. The schist contains small veinlets of pyrrhotite in which are included scattered aggregates of pyrite and chalcopyrite. The quartzitic rock is of a brownish tone and has a fairly coarse grained texture. Near its contact with the common intrusive of the area (the monzonite porphyry) it contains small amounts of chalcopyrite, pyrrhotite, and pyrite.

The open cut, at an elevation of 2,600 feet, is approximately 8 by 10 by 15 feet in size. It has revealed small veinlets in joint planes, mineralized by pyrrhotite, chalcopyrite, pyrite, and their oxidized products. The adit tunnel exposes the same ore minerals along joint planes in the sedimentary rock, and at the contact of this rock with the intrusive monzonite porphyry. The small open cut located at an elevation of 2,825 feet is in schist, traversed by small veinlets containing the same association of minerals. The shaft was inaccessible.

COPPER BUTTE.

Less than half a mile northeast of the Globe prospect and at approximately the same elevation is the Copper Butte prospect, which has been developed by an inclined shaft about 200 feet deep. A small amount of drifting has been accomplished, and a short tunnel taps the shaft on the 100-foot level. A 15-horsepower hoist has been installed in the shaft house.

The rocks in the vicinity are very similar to those found near the Globe workings, and the mineralization occurs along a fault of small magnitude. Some chalcopyrite, pyrite, and pyrrhotite in a gangue of brecciated country rock and gouge form the vein, which strikes N. 35° W. and dips 20°–70° NE.

ORIENT.

The workings on the Orient prospects are located on a spur which projects southwestward from the central part of Toulou Mountain. They are easily accessible by wagon road from the town of Orient, which is only 2½ miles a little west of north of the prospects. At the time of the writer's visit this property was inactive. The developments consist of three shallow shafts and an adit tunnel.

The rocks in the vicinity are a part of the sedimentary series already referred to, intruded by monzonite porphyry and a greenish rock resembling vogesite, which may be a basic phase of the intrusive

mass so common to this part of the Orient district or which may represent a part of the diabase magma that has invaded the sedimentary rocks. Included in the green rock are fragments which appear to be silicified limestone. A thin section of this rock viewed under the microscope reveals the presence of phenocrysts of hornblende (which may also be seen megascopically), orthoclase, and silica, the last presumably representing the fragments of silicified limestone included in the rock. Near the contact of the greenish rock and the sedimentary beds garnet and epidote have been extensively developed.

The adit tunnel, the lowest working examined, is located at an elevation of 1,700 feet, or 300 feet above the camp. It has been driven N. 12½° E. for a distance of about 300 or 400 feet. Several faults, having a general northwest strike, were seen in the tunnel. Little ore was observed in the workings, but some pyrite sparsely scattered through the country rock was seen on the dump. About 135 feet above the tunnel a shallow shaft has been sunk on a series of veins which trend almost due east and west. These veins occur at and near the contact of the intrusive green rock with the silicified limestone and contain some pyrite. The joint planes in the country rock also contain the same mineral. All the ore-bearing fissures and joints are small. Another shallow shaft, located at an elevation of 1,900 feet, or 65 feet above the one just described, exposes a similar association of rocks with perhaps less mineralization. A third shaft, located at an elevation of 2,100 feet, has been sunk on a small fissure which strikes east and west. Another vein outcrops a few feet north of this and strikes N. 75° W. Both veins show pyrite and limonite in their outcrops, but the ore on the dump is principally pyrite.

DEFENDER.

The Defender group of claims is about 1½ miles southeast of Orient, on the western slope of Toulou Mountain. It comprises 11 claims and a fraction, two claims being owned outright and the rest held by annual assessment work. A shaft house containing a one-horse whim has been built on the Denver claim. The locality marked "Defender" on figure 3 is that of the Denver shaft, which is about 1,000 feet southeast of the center of the group of claims. Water and timber are plentiful in this locality.

The principal developments consist of small open cuts and shallow discovery shafts on all the claims and a 106-foot inclined shaft on the Denver claim.

The geology in the vicinity of these claims is somewhat similar to that of the contiguous camps, the most notable feature being the presence of a sheared phase of the greenish hornblende rock found in the Orient workings. This rock, which contains hornblende, quartz, and feldspar phenocrysts, has been more or less meta-

morphosed, and somewhat resembles amphibolite. On the Snowflake claim, immediately southeast of the Denver claim, at an elevation of 1,900 feet, a shallow shaft has been sunk on a fissure vein in this rock. The vein is about 18 inches wide, strikes N. 45° W., and dips 65° N. 45° E. This vein is supposed to be a continuation of that worked in the Denver shaft. Siderite, calcite, sphalerite, and quartz are prominent constituents of the vein. As the Denver shaft was partly full of water, an examination of the vein exposed in it was impossible. The shaft pitches at an angle of 65° N. 45° E., this direction being the same as the dip of the vein exposed on the Snowflake claim. The discovery shaft on this claim, located at an elevation of 2,200 feet, has been sunk in the intrusive monzonite porphyry common in this part of the Orient district. Some of the joint planes in this rock are slightly mineralized by sulphides and oxides of iron. The discovery shaft on the Gold Crown claim is about 1,200 feet a little east of north of the Denver shaft, at an elevation of 2,415 feet. It is said to be 22 feet deep and is now practically filled with water. This opening is in monzonite porphyry near its contact with the sedimentary rock, the shaft passing out of the intrusive mass a short distance below the collar. Small fissures in the intrusive rock are mineralized by pyrite, pyrrhotite, a little chalcopyrite, and their accompanying oxidized products. The intrusive dike, which is here about 60 feet wide, is said to carry $3 to $4 in gold to the ton.

TROJAN.

The Trojan prospect is located just below the western edge of the top of Toulou Mountain, the camp and lowest adit tunnel level being situated at an elevation of 2,850 feet and the highest workings examined 400 feet higher. The tunnels may be reached by a trail along Bear Creek, the distance from Orient being about 2 miles. The developments consist of three tunnels and a shallow shaft, making in all several hundred feet of work.

The rocks in the vicinity represent a higher and apparently a less disturbed portion of the sedimentary series than that found elsewhere on Toulou Mountain and they may belong to an era much later than the Paleozoic. Shales with included strata of tuff and tuff fragments constitute the rocks in the lower tunnel. These strike S. 85° W. and dip 15° N. From 100 to 200 feet higher strata of bluish-white tuff are prominent. This rock contains fragments of plagioclase and orthoclase feldspar and quartz, with some small pieces of rock resembling slate. Apparently resting on top of it is a dense, compact greenish rock that contains phenocrysts of plagioclase feldspar and much chlorite. It is impossible to determine the exact nature of this highest rock, as the ferromagnesian minerals have been

entirely altered to chlorite and the feldspars are largely changed to sericite and calcite. The rock is no doubt of igneous origin and probably represents a flow upon the top of the sedimentary series. Monzonite porphyry cuts the sediments here as elsewhere on Toulou Mountain. The relation of the intrusive porphyry to the green rock occurring above the sediments could not be definitely determined.

Mineralization is practically absent in the rocks explored by the workings visited by the writer. In the upper tunnel small quantities of pyrite and a little pyrrhotite were seen in the gouge formed between the contact of the sedimentary rocks and the intrusive magma.

PROSPECTS EAST OF PIERRE LAKE.

Of the prospects examined east of Pierre Lake only one, the Easter Sunday, was active at the time of the writer's visit. Since that time this property also has closed. Shipments of ore from this vicinity have been small, only about 20 tons having been sent out from the Easter Sunday and none from the other prospects. The Big Iron is the most northeasterly deposit examined in the Orient mining district and the farthest from a shipping point, as well as the most inaccessible.

BIG IRON.

The Big Iron prospect is located at an elevation of 3,600 feet on the east side of Sulphide Mountain and is about 15 miles by a poor wagon road from Orient and 12 miles from Rockcut, the two nearest railroad points. The grade is not an easy one and involves several steep hauls.

The ground has been developed by means of shallow shafts and several open cuts, all the shafts being inaccessible because of the presence of water. No ore is known to have been shipped from this prospect.

The rocks in the vicinity consist of a series of schists of probable igneous origin, which strike east and west and stand nearly vertical. These evince considerable dynamometamorphism and contain intercalated dikes of a less sheared igneous rock having a fine-grained, even texture and a gray color. These rocks have been intruded by monzonite porphyry. The schists are distinctly cleavable, are very much jointed, have a medium to fine-grained texture, are green, yellow, and gray in color, and are more or less similar to amphibolites resulting from the metamorphism of diabase or related rocks. Small veinlets of quartz are included in the lamination planes in the schists, and chalcopyrite and pyrite are scattered throughout the rock, occupying small openings along the lines of fissility and the joint planes. The included gray rock is composed essentially of feldspar and quartz, with much pyrite, chlorite, and calcite. Its original character is indeterminable. The intrusive monzonite porphyry is similar to that found throughout the Orient district.

The ore deposit represents a zone of sulphide impregnation and replacement in the schists and the included gray rock. As exposed by the workings the zone is over 100 feet wide and may have greater dimensions. The full extent of the mineralization along the strike of the schists (east-west) is not known but developments have proved it to be at least several hundred feet. Pyrite is the principal ore mineral and is accompanied by some chalcopyrite. Both minerals have weathered on the surface, forming a small gossan of limonite.

It is possible that future developments might show that this zone of impregnation and replacement is large enough to be worked on the scale of the low-grade disseminated copper deposits in other parts of the country.

POMEROY.

The Pomeroy prospect is a mile and a half due west of the Big Iron, on the south slope of Sulphide Mountain, at an elevation of 3,550 feet. It is about a quarter of a mile south of the Easter Sunday, on the same wagon road, which is in much better condition between these properties and Orient than it is farther east, toward the Big Iron.

The ground has been developed by a vertical shaft, which at the time of the writer's visit was nearly full of water. Shipments of ore are not reported from this prospect.

The rock in which the vein occurs appears to be a schist derived from metamorphosed diabase or related rock. A fine-grained greenish rock resembling meta-andesite was also found on the dump. The ore on the dump contains much quartz, with sphalerite as the predominant ore mineral, accompanied by pyrite, galena, chalcopyrite, and a mineral containing lead, antimony, and sulphur, the species not being easily determinable owing to the fine-grained intergrowth of the ore. Details of the vein can not be given, as it was not exposed.

EASTER SUNDAY.

The Easter Sunday is 9 miles due northeast of Orient, or by the wagon road about 12 miles. At the time of the writer's visit the deposit was being worked by the Forest Mining & Milling Co., which was carrying on experiments with the ore to determine its amenability to cyanidation. One shipment of a little less than 20 tons of ore is reported to have been made from a shallow shaft about 200 feet north of the main working shaft. A partial analysis of this ore is as follows:

Partial analysis of ore shipped from Easter Sunday mine.

Fe	per cent..	6.5
SiO_2	do....	68.9
CaO	do....	6
Cu	do....	1.21
Au	ounces to the ton..	.44
Ag	do....	12.4

The property is equipped with two 100-horsepower boilers, one 100-horsepower Corliss engine, one Gates crusher, two 1,000-pound stamps, one Wilfley table, and small experimental cyanide tanks, zinc boxes, etc. The underground developments are a 130-foot inclined shaft pitching about 50°–55° N. 65° E., and two short levels run at 70 and 100 feet from the collar, making in all some 550 feet of workings. A diamond-drill hole, started 185 feet east of the collar of the shaft, has been sunk vertically to a depth of 480 feet.

The rocks in the vicinity are dark, distinctly banded cherty argillites which are impregnated with pyrite. Intruded into this shale series is the monzonite porphyry commonly found throughout the Orient district.

The ore body consists of a quartz vein parallel to the direction of schistosity of the shales, which strike N. 25° W. and dip 20°–60° N. 65° E. The vein ranges from 2 to 6 feet in width and appears to follow the curves of the inclosing strata, dipping about 50° N. 65° E. down to the 70-foot level, where it flattens out for a distance of 50 feet and then pitches northeast at a steep angle. An examination of the vein below the 70-foot level was impossible because of the presence of water in the shaft. Near the 70-foot level the main vein breaks up into several parallel stringers a few inches in width which traverse the shales. On the 70-foot level an intrusion of monzonite porphyry cuts off the vein. The ledge is reported to have been found again in the 100-foot level. In general the quartz appears to be rather barren, containing some pyrite, chalcopyrite, sphalerite, galena, and an indeterminable massive gray mineral containing lead, antimony, and sulphur.

Cyanide tests were discontinued during the summer of 1909, and presumably because of the scarcity of the ore no further shipments were made to smelters. According to the records the diamond drill penetrated a large ore body at a vertical depth of 146 feet. Assays of the contents of the ledge at this depth are not at hand. The company reports that the drill passed through 64 feet of vein material.

MCNALLY.

The McNally prospect is approximately 3 miles northeast of Pierre Lake, on the north side of Pierre Creek, at an elevation of 2,600 feet. Rockcut, the nearest shipping point, is 5 or 6 miles distant by wagon road. The prospect was idle when visited by the writer, and no ore is reported to have been shipped from it.

The developments consist of a small open cut and two short adit tunnels, one located at an elevation of 2,650 feet, or 50 feet above the cabin, and the other at an elevation of 2,800 feet. These workings are situated at or near the contact of a fine-grained grayish-green intrusive rock, probably a diabase, in crystalline limestone. The

general strike of the intrusive body is east and west. Faults having a general northwest trend were noted in both rocks, and fissures filled with calcite are prominent. Epidote and serpentine have been developed in considerable quantities along the contact of the intruding magma.

The ore body is an irregular replacement in the limestone by chalcopyrite and pyrite, the latter probably predominating. The extent of this replacement has thus far not been determined. Oxidation of the sulphides has taken place and hematite has been deposited along joints and fissures in the limestones. This deposit has evidently been formed by contact metamorphism near the surface.

OTHER MINES AND PROSPECTS.

Of the six deposits examined in the vicinity of Rockcut, five are in Stevens County. The Jenny prospect, in Ferry County, is described on pages 202–203. Only one of these prospects, the Kettle River, was active at the time of the investigation. All are in an early prospecting state, and only small shipments are reported to have been made from the Little Giant, Swamp King, and Beecher. Rockcut is the nearest and most convenient railroad point and fair wagon roads lead to most of the camps.

Napoleon mine, near Boyds, in the southeastern part of the district, is the only one examined in that vicinity.

KETTLE RIVER.

The Kettle River group of claims is located about a quarter of a mile north of Rockcut, on the east bank of Kettle River. Three of the claims in this group have their end lines on the river and extend eastward 1,500 feet, taking in a considerable portion of the steep hillside directly east of the river. The camp and the principal workings, including a small mill, are all situated near the river and 30 to 100 feet above it. An ample supply of water is afforded for all milling purposes and timber is plentiful in the vicinity. Wood is used for fuel for the boilers. At the time of the writer's investigation the property was being developed underground and a small concentrating mill had been nearly completed. Shipments of ore or concentrates had not then been made.

In the mill the ore is dumped from the hoisting bucket over a 4 by 7 foot grizzly with 1½-inch spaces, the oversize going direct to a Blake breaker reported to be capable of crushing 100 tons to 1½-inch cubes in 24 hours. From the breaker the ore (with the undersize from the grizzly) goes into an ore bin and thence by an automatic feeder into a set of 24 by 24 inch rolls, from which it goes into two 3-cell jigs, 23 by 26 inches, thence through fine-grinding rolls into four hydraulic classifiers, and thence over a vanner and a table. Water

is obtained from Kettle River by a pump, the capacity of which is reported to be 10,000 gallons an hour, and is stored in a tank. Other machinery consists of a vertical engine, a Lidgerwood steam hoist, a high-speed automatic engine, said to be capable of developing 40 to 50 horsepower, a 50-horsepower boiler, and a 9 by 11 inch compressor, which will develop enough air to run four drills.

The claims have been developed by a vertical shaft, which in July, 1910, was 150 feet deep. From this a 20-foot drift and a 15-foot crosscut had been run. On the surface near the collar of the shaft a 60-foot drift had been driven along the contact of an intrusive dike and schist.

The rocks in this vicinity are older than any others so far mentioned in the detailed descriptions and probably represent the upper part of the lowest geologic unit within the area. Schists showing pronounced foliation are interlaminated with coarse crystalline limestone and quartzite, the whole series being traversed by dioritic dikes of varying composition and proportions. The different strata appear to be conformable and the whole series in this vicinity strikes approximately north and south and dips 15°–30° E.

The schists are of a general gray tone, are medium to coarse grained, and show little chemical alteration. They are probably derived from dynamometamorphism of masses of quartz diorite intruded into the sedimentary rocks, although they may be sedimentary schists resulting from the erosion of quartz diorite. Viewed under a microscope thin sections of the schist show about equal amounts of plagioclase feldspar and hornblende, with much biotite and quartz. Pyrite and calcite are subordinate constituents of the rock. The quartzites are white to pink in color, are fine to coarse grained, and show in some places a pronounced schistose structure. The strata of quartzite range from a few inches to several feet in thickness. The limestones are coarsely crystalline, forming a good marble, and are apparently quite free from impurities. Weathered surfaces are dark brown in color, but fresh fractures are cream-white. Where observed the thickness of the limestones ranged from 2 to 6 feet.

The intrusive dikes of diorite which cut directly across the lamination planes have caused considerable metamorphism along their contacts, epidote, garnet, diopside, actinolite, and biotite having been developed on a large scale.

Near the collar of the shaft a vein is exposed by a 60-foot drift along the contact of an intrusive diorite dike and schists. This vein, which has a strike of N. 60° E. and a dip of 80° N. 30° W., has an average width of several inches and contains some galena, sphalerite, chalcopyrite, and pyrite in a gangue of quartz, calcite, and dolomite. A small cross fissure has a strike of N. 35° W. and a dip of 61° N. 55° E. The shaft was started on a vein which pitches

out of the shaft's course a few feet below the collar. In the downward course of the shaft several small veins were encountered, one of which strikes S. 70° E. and dips approximately 45° S. 20° W., and another, exposed on the 150-foot level, strikes east and west and dips 60° S. These veins all show considerable displacement and represent filled fissures at or near the contact of intrusive diorite dikes. Those observed were of small magnitude, the largest being 5 feet wide and the ore course less than 12 inches, while the general average was considerably less. For the most part the fissures are closed, although vugs were noted, some of them filled with quartz and dolomite crystals. Specimens of ore show an original deposition of sphalerite, chalcopyrite, and pyrite, followed by fracturing and brecciation of the country rock and vein material and later by deposition of galena, chalcopyrite, and pyrite. The gangue is principally quartz and brecciated country rock, with some calcite and a little dolomite.

So little drifting has been done on the veins that it is impossible to gain a clear conception of the extent of the ore deposits. Where exposed the ore shoots appeared to be pockety, and the veins were small and of rather uncertain persistence. The mineralization in this locality is probably due to solutions accompanying the intrusion of the diorite dikes.

LITTLE GIANT.

The Little Giant prospect is located at an elevation of 2,460 feet about 2 miles northeast of Rockcut and a quarter of a mile east of the north fork of Sand Creek. A wagon road has been built to the camp. In the shaft house is installed a donkey hoist and a boiler. Some prospecting has been done by diamond drilling, the results of which are not accessible. Small shipments of ore are reported to have been made from the prospect, but at the time of the investigation it was idle.

A shaft, practically full of water at the time of the writer's visit, constitutes the principal development. In a small open cut a few feet from the shaft house a more or less sheared diorite strikes approximately east and west and dips slightly to the south. A dike rock having the composition of camptonite cuts the diorite in a northeast-southwest direction. In places the metamorphism of the diorite has resulted in the formation of amphibolite. On the dump was found a dark-colored rock having a felsitic groundmass and large phenocrysts of orthoclase and plagioclase feldspar with much biotite. This is probably a dike rock connected with some granitic intrusion.

Galena, pyrite, and a little chalcopyrite in a gangue of quartz, calcite, and some siderite occur in small fissures in the sheared diorite. Some epidote was noted and the carbonates of copper are present in small amounts.

SWAMP KING.

Adjoining the Little Giant on the east is the Swamp King, which was also inactive when visited. A small amount of ore is said to have been shipped from this prospect. The developments, which expose diabase cut by camptonite dikes, consist of a short tunnel in which a shallow winze has been sunk pitching 45° E. Faulting is prominent and two veins, separated from each other by a horse near the portal, join to form one vein a short distance beyond. The strike of the vein is N. 20° E. and the dip approximately 60°–80° E. Quartz containing some pyrite forms the filling of the vein, in which free gold is reported to have been found.

BEECHER.

The Beecher prospect, located at an elevation of 2,400 feet, is about 2 miles a little northeast of Rockcut, just south and 200 feet above the east branch of Sand Creek. It was idle when visited. A wagon road extends within a short distance of the shaft house. The developments consist of a shallow vertical shaft and some drifting on the vein. A whim constitutes the only machinery on the ground. Two shipments are reported from this prospect, aggregating about 22 tons of ore carrying a fraction over 1 ounce of gold to the ton and a trace of silver.

The shaft and drifts have revealed a tight quartz vein in diabase. The vein strikes N. 47½° E. and stands about vertical in the stopes about 50 feet below the collar of the shaft. The average width of the vein is about a foot, although on the northeast and southwest extension of the stopes only a few feet each side of the shaft it almost pinches out, and midway in the stopes it is in places as much as 2 feet wide. The vein as exposed in August, 1909, appeared to have been nearly stoped out. Quartz is the main gangue mineral and is accompanied by some calcite, and the vein contains some galena and limonite, the latter presumably having resulted from the oxidation of pyrite, which is doubtless also the source of the free gold reported to have been found.

In an open cut a few feet west of the shaft two small veins are exposed, striking at right angles, one north-south and the other east-west. The former dips to the west and the latter to the south. At the junction of the two a noticeable quantity of limonite is present.

MCKINLEY.

The McKinley group of claims is about 2½ miles a little east of north of Rockcut in a direct line, the distance by wagon road and trail being somewhat greater. The claims have been prospected by several shafts to depths of 10 to 40 feet and by small open cuts. No

machinery is installed on the ground and shipments are not reported from the property, which was idle when visited by the writer.

The prevailing rock in the vicinity is medium to fine grained diabase. This rock is locally sheared, and amphibolite has been formed near the zones of movement. Vogesite dikes containing some pyrite cut the diabase.

On claim No. 6, at an elevation of 3,050 feet, a shaft has been sunk 38 feet on the incline and exposes a vein in a fault fissure in diabase. The vein strikes N. 60° W., dips 45°–60° NE., and ranges from a few inches to 1 foot in width. Near the bottom of the shaft the vein splits up into several stringers. The footwall is sheared and the resulting amphibolite is called slate by the prospectors. The vein filling is quartz, with gouge and limonite. Small quantities of gold are said to have been found in the vein. Another shallow shaft on the same claim, on a vein which strikes N. 15° W. and stands about vertical, shows the same relations of country rock and vein filling.

Several hundred feet south of claim No. 6, toward claim No. 1, is a small exposure of reddish-green shale. Because of the dense underbrush and the mantle of other rock covering it, no definite conclusions could be reached as to the relation of the shale and the diabase.

On claim No. 1, at an elevation of 2,850 feet, a quartz vein in diabase has been stripped for a distance of 24 feet. The vein strikes N. 20° W. and dips 30°–40° N. 70° E. It contains some pyrite, specks of azurite and malachite, and a little calcite, and is reported to have yielded small quantities of gold.

NAPOLEON.

General features.—The Napoleon mine is located near the south end and on the west side of the ridge which lies between Kettle River and the Columbia, near their confluence. Boyds is the nearest railroad point, and a wagon road has been built to the mine from the main route along Kettle River. Marcus, about 6 miles to the south, is the nearest settled town.

The claim is reported to have been among the first located after the opening of the Indian reservation to mining operations, and it has since shipped a large quantity of low-grade ore. The various owners were bought out in 1905 by P. Burns & Co., who controlled the mine for a time, later selling it to the British Columbia Copper Co. At the time of the writer's investigation the mine was just being opened again for a few months' run. The ore is shipped to the company's smelter at Greenwood, British Columbia, where it is used as a flux. The mine is worked only part of the time, enough ore being mined in a few months to supply the smelters' need for a fluxing ore of this kind for a much longer period.

An aerial tramway with one terminal at the main level of the mine and another at the railroad siding, more than 1,000 feet lower and about a mile west of the camp, affords an easy and economical means of handling the ore for shipment. The machinery installed in the power house and in the mine is efficient and the cost of mining operations is low.

A mill is reported to be under construction for extracting the gold found in the superficially decomposed iron sulphide ores, of which there is a large amount, limonite being prominent in the upper parts of the hill in which the workings are located. A permanent camp with ample accommodations for the miners has been built at the mine.

Development.—The ore body has been developed by three principal tunnels. The lowest or main level is at an elevation of 2,350 feet, the altitude of the camp. Crosscuts and drifts have been run, and a quarry or glory hole has been excavated near the top of the hill, at an elevation of 2,600 feet. Some diamond drilling has been done. On the main level there is about 800 feet of work, including drifts and the adit tunnel. Surface workings and workings in oxidized ores amount to 1,230 feet, while shafts, raises, and winzes approximate 310 feet. About 4,000 cubic yards of surface stripping has also been accomplished.

The portals of the three main levels are situated on the north side of the hill, that of level No. 2 being 300 feet southeast of the portal of the main level, and that of No. 3 about 200 feet southeast of No. 2 and 160 feet above. The quarry is 450 feet south of and 250 feet above the portal of the main adit tunnel.

Geology.—The oldest rocks in the vicinity of the Napoleon mine are probably members of the sedimentary series found on Toulou Mountain, which are thought to be of Paleozoic age. In this vicinity, however, the sedimentary rocks have been so altered by metamorphic processes and by the intrusion of monzonite porphyry that they occupy only a small portion of the hill in which the workings are located, and unaltered phases of the rock could not be found. As exposed by the quarry workings, amphibolite, which is the ore carrier, occupies a part of the section of the older rocks and trends in a general east-west direction. Other exposures of the amphibolite were seen, however, which trend approximately north and south. The sediments have been so disturbed that they are not now definitely recognizable, nor can their original positions or directions of dip and strike be determined. Lamprophyre dikes, adjuncts of monzonitic or granitic intrusion, were also found in the workings.

The amphibolite is of a fine-grained, even texture, is green, and contains irregular patches of ore. Actinolite has been developed

along faults in the amphibolite, and throughout the rock the augite is largely changed to hornblende. This amphibolite may represent a metamorphosed diabase intrusive into the sedimentary rocks or it may be the result of contact metamorphism of limestone caused by the intrusion of monzonite porphyry. Garnet is found in irregular patches through the ore. The monzonite porphyry is medium to coarse grained, is grayish blue, and is composed of phenocrysts of andesine and hornblende (now partly altered to chlorite) in a groundmass of orthoclase and quartz. Near the intrusive contacts of this rock some pyrite is found in the porphyry and a further alteration of the hornblende phenocrysts is noticeable.

The ore body.—Scattered through the amphibolite and replacing it to a greater or less extent are pyrrhotite, pyrite, some magnetite, and a very small amount of chalcopyrite. These unaltered ore minerals unaccompanied by their oxidized products, extend for a distance of 135 feet or more above the floor of the main stope in level No. 1, above which more or less limonite is associated with the iron sulphides, which extend in places clear up to the glory hole. The general trend of the ore body, like that of the main mass of amphibolite, is east and west. As developed by underground workings the mineralized zone is approximately 60 feet wide and 300 feet long. The vertical distance from the top of the glory hole to the main level is 250 feet, but the extent of the ore body below this level has not yet been definitely determined. The ore shoot seems to pitch to the east, but not enough data on the extent of the mineralized section are obtainable to warrant any definite conclusion on this subject. Solid masses of iron sulphides are not so common as partly replaced amphibolite, and as the replacement is rather irregular, it is not possible with present developments to determine the general trend of the shoots. A large part of the ore body above level No. 1 has already been stoped out.

Above level No. 2 there is a great deal of limonite, resulting from the oxidation of the iron sulphides. As it is reported to contain appreciable quantities of gold, liberated by the process of oxidation, it may prove a source of considerable revenue. The run of mine ore is said to contain approximately 33 per cent iron, 12 per cent sulphur, 10 per cent lime, 30 per cent silica, 0.3 per cent copper, a trace of silver, and from 0.05 to 0.1 ounce of gold to the ton.

Origin of the ores.—The intimate association of the ores with amphibolite and especially the presence of garnet in the ores point to contact-metamorphic action, and it is thought that the ore may have been deposited by solutions accompanying or following the intrusion of the monzonite porphyry.

CHEWELAH DISTRICT.

LOCATION AND EXTENT.

The Chewelah mining district occupies about 432 square miles in the south-central part of Stevens County, its northern border lying midway between the northern and southern extremities of the county. (See fig. 2, p. 39.) As recorded in the office of the mayor of the town of Chewelah the boundaries of this district are as follows:

Commencing at the southwest corner of sec. 31, T. 31 N., R. 39 E., Willamette meridian; thence running north along the range line between Rs. 38 and 39 to the township line between Tps. 33 and 34; thence east along said township line to the range line between Rs. 42 and 43; thence south along said range line to the township line between Tps. 30 and 31; thence along said township line to the place of beginning.

Chewelah, the largest town, is about 2 miles west of the center of the district, on the Great Northern Railway, which traverses the western half of the district. The towns of Addy, Blue Creek, and Valley are also located on the railway and afford shipping points for the mines and prospects in their vicinity. Practically all the ore shipped from the Chewelah district has been sent out from Chewelah.

CONDITION OF MINING ACTIVITY.

When the writer was in the Chewelah district in July, 1909, of the twelve properties examined, only one, the United Copper, was making regular shipments and these were rather small. On five of the others a small amount of development work was in progress, but this was mainly to cover the annual assessment requirements, and doubtless most of the other properties are similarly active during a part of the year. The railway is not far from any of the properties visited, and the smallness of the shipments from this camp must be credited to some cause other than lack of transportation facilities. Of all the properties examined only the United Copper had a large tonnage of ore blocked out ready for mining. On the Copper King considerable underground work has been done, but little of it has been confined to developing ore bodies. The other mines that have shipped ore have been gouged of the rich portions of the shoots, and little was being done to uncover or block out other ore bodies. The rest of the properties examined are in a prospecting state.

No mills or smelters had been erected in the Chewelah district.

TOPOGRAPHY.

The Chewelah district lies between the Calispell Range on the east and the Huckleberry Range on the west, in the Colville Valley, through which Colville River meanders in a general northwesterly course. The valley is in some places several miles wide; elsewhere the foothills of the two ranges are separated from each other by less

than a mile. Chewelah Creek and Cottonwood Creek are the chief tributaries to Colville River from the eastern part of the district, and Dunn Creek (also called Stranger Creek) and Wright Creek from the western part. No one of these streams has a large flow of water.

The elevation of that part of the Colville Valley contained in the Chewelah district is about 1,600 to 1,700 feet. The mountain ranges on each side have a general elevation of 3,000 to 4,000 feet, though individual peaks rise to more than 5,000 feet. The slopes of all the mountains are gentle and the mountain tops are rounded, showing the results of glacial action. Débris fills many of the smaller valleys and in places covers the tops of the mountains to a depth of 30 or 40 feet, making prospecting exceedingly difficult.

GEOLOGY.

KINDS OF ROCKS.

The rocks in the Chewelah district consist of a thick series of apparently conformably interbedded argillite, quartz-mica schist, limestone, lime shale, dolomite, and quartzite, all thought to be of Paleozoic age. These rocks have a general north-south strike, and they dip at various angles between 20° E. and 20° W., locally standing vertical. The total thickness of the sedimentary rocks exposed in the district is probably several thousand feet. Because of the poor exposures and the lack of detailed work it is impossible to state the thickness of the individual rock formations, but it probably varies from several feet to several hundred feet, the argillite, lime shale, and quartz-mica schist occupying the larger part of the area.

On the west side of the valley, in the locality of the Hartford group of claims, a diabase magma has invaded the sedimentary rocks and displaced them to a considerable extent. Diabase is present in other parts of the area, but was not definitely recognized in connection with deposits visited elsewhere in the Chewelah district. The age of this rock is very uncertain. It is later than the sediments which it intrudes and probably earlier than the granite intrusion found in parts of the district.

In the vicinity of Eagle and Quartzite mountains (see fig. 6), on the east side of Colville Valley, is a large mass of intrusive granite. Dikes that presumably accompanied the granitic magma are present throughout the sedimentary series. No positive evidence as to the age of this intrusion was found, but it is thought to be Mesozoic, because of the great number of granite intrusions which took place throughout the Pacific States during the Mesozoic era. Still later intrusive rocks were seen in the vicinity of the Windfall and Nevada properties. As these and some others have only a local significance, they will be described in the detailed discussion of the mines and prospects.

SEDIMENTARY ROCKS.

The argillites occurring in the Chewelah district are fine grained and in places closely resemble slates. They are dark gray to black in color and have a slaty cleavage. Their composition varies considerably, the chief constituents being quartz, feldspar (now largely altered to white mica), and carbonaceous matter. Some chlorite is present in places and this tends to give the rocks a greenish color.

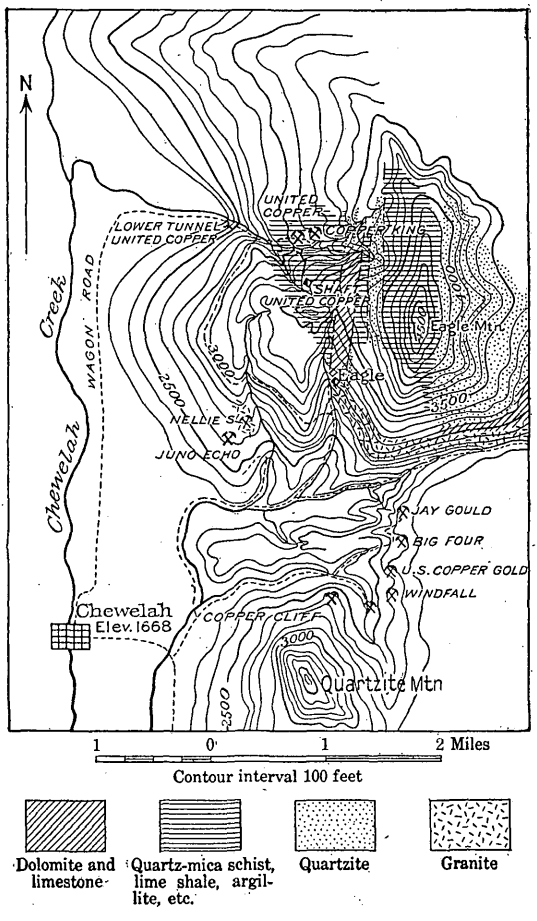


FIGURE 6.—Sketch map of Eagle and Quartzite mountains.

Quartz-mica schists are present in many varieties and in diverse colors, the most prevalent being a lustrous silvery white, though darker schists are also found. The varying amount of iron oxide in the rocks has much to do with the diversity of color. In general, these rocks have a fine-grained texture and on cleavage surfaces feel smooth and are easily scratched with a knife blade. This characteristic is due to the presence of mica, oriented in a direction parallel to the planes of schistosity. Other varieties are harder and contain more quartz. The relative abundance of quartz and mica to a large extent determines the texture and general appearance of the rock. The quartz-mica schists in this locality are closely related to the argillites in texture and cleavage, and with the addition of carbonaceous matter they would be closely similar in composition also.

The lime shales very closely resemble the argillites, but are distinguished by a lighter color and the presence of much calcium carbonate, which on weathered surfaces is rather prominent. These rocks are a variety of impure shaly limestone.

Coarsely crystalline to fine-grained blue, white, yellow, and green limestones occur in this district. In the vicinity of the Blue Star mine and elsewhere near the base of Eagle Mountain is a coarsely crystalline white rock resembling marble. An analysis of a specimen of this rock by J. G. Fairchild, of the United States Geological Survey, showed it to contain 27.5 per cent CaO and 23 per cent MgO. It is thus a typical dolomite.

The quartzite varies in texture from very fine grained to coarse grained and in color from white to yellow, red, and a dark gray or black. A quartzite conglomerate composed of small quartzite fragments cemented by calcium carbonate was seen in the Copper Queen workings, 10 miles north of Chewelah.

IGNEOUS ROCKS.

The diabase is of a fine-grained, even texture, and in places showed some schistosity. Light to dark green colors are characteristic of the rock, and where exposed in the vicinity of the Hartford group it appeared fresh. The chief constituents are plagioclase and augite, and the structure is typically diabasic. Where the rocks have undergone some shearing the constituent minerals have assumed a more or less parallel arrangement, and alteration has changed the augite to hornblende and subsequently to chlorite.

The granite occurring near the base of Eagle Mountain is of medium to coarse grained texture, and of a general pinkish-gray color. Viewed in thin section under the microscope the rock is seen to contain a large proportion of orthoclase, a little microcline, and still less oligoclase, also much quartz and hornblende, the last-named mineral having been largely altered to epidote and chlorite. Some white mica has been developed in the feldspars, and a small amount of magnetite is present.

Lamprophyre dikes, adjuncts of a granitic intrusion, are found throughout the area. These are composed of a ferromagnesian mineral (such as augite, hornblende, or biotite) and feldspar, and some of them contain a small amount of quartz. Plagioclase feldspar also forms a large percentage of the rock. Various kinds of dike rock were seen within the district, although kersantite is probably more common than any other. The dikes are readily distinguished by their high content of biotite. Where augite or hornblende is the predominant basic mineral associated with plagioclase the rock is called camptonite. The dikes are generally dark colored, and the biotite, augite, or hornblende is usually easily recognized without the aid of a microscope.

ORE DEPOSITS.

All the ore deposits examined in the Chewelah district are thought to be more or less closely associated with igneous intrusion, and they have many characteristics in common. For convenience of

discussion they are grouped in four classes, which are described in the following paragraphs:

The first class, consisting of quartz veins in the lamination planes of schists, can be illustrated best by a brief discussion of the United Copper and Copper King. These deposits occupy lenticular receptacles of varying dimensions in the bulged strata of quartz-mica schist, argillite, lime shale, etc. Plate VI (p. 100) shows on a very small scale the mode of occurrence of these veins and the similarity in the shape of the receptacles now occupied by ore and gangue minerals on each side of the main vein. As exposed in the United Copper workings the vein has been proved for a length of 750 feet and for a vertical distance of 425 feet, and it is probable that these dimensions will be increased by further exploration. The width of the ore-bearing zone ranges from a few inches to 20 feet, pinching and swelling of the vein having been noticed in many places, so that no average can be stated. The gangue is composed chiefly of quartz, with which are associated much calcite and siderite. Gouge is not prominent in the United Copper vein, although it is noticeable in the one vein which has been opened in the Copper King. The ore minerals in both deposits are similar in the oxidized zone, but leaching has proceeded to a greater depth in the Copper King, because of the open character of that vein, than in the United Copper. The ore minerals in the zone of oxidation are limonite, malachite, and some azurite. Chalcopyrite and pyrite are the chief ore minerals in the unoxidized portions of the two deposits, and in the major part of the United Copper vein exposed in workings from the main level these minerals are accompanied by arsenopyrite and tetrahedrite in varying amounts. In general the ore minerals are rather sparsely scattered through the vein filling, although in places rich shoots were seen. Some of the tetrahedrite is thought to be the result of enrichment by leaching of the upper portions of the vein and subsequent deposition below. The ore in the United Copper vein carries about 0.01 ounce of gold and 5.35 ounces of silver to the ton and 2.5 per cent of copper. That shipped during 1908 had a gross value of approximately $9.59 a ton. Solutions accompanying or following the intrusion of the kersantite dikes formed as adjuncts of granitic intrusion in several localities not far removed from these mines are thought to have brought in the gangue and ore minerals which now fill the veins.

The second class, consisting of irregular replacements along shear zones and fault planes in dolomite and limestone, is represented by the Blue Star and Nevada deposits, with which the Delmonico (Enterprise) has also many characteristics in common. The Blue Star and Nevada occur near igneous contacts, and the Delmonico is prob-

ably closely related to igneous intrusion, although no intrusive rock was seen in its immediate vicinity. The mineralization was scanty and irregular, forming small pockets scattered through the dolomite and limestone. Because of this fact much dead work is involved in mining the ore, and the future of the deposits is uncertain. Galena, tetrahedrite, and sphalerite constitute the chief ore minerals in all these deposits. In the Blue Star they are accompanied by chalcopyrite, pyrite, and pyrrhotite, with some azurite, malachite, cerusite, and anglesite. The gangue minerals are chiefly quartz and some brecciated country rock, with calcite. Barite forms an important part of the gangue in the Blue Star. Contact-metamorphic minerals are not prominent in the strata through which the intrusive rocks have cut. Some actinolite associated with the ore minerals was seen in the limestones in the vicinity of the Nevada deposit. The ores of this class are thought to owe their origin to solutions accompanying or following the intrusions already referred to.

Deposits of the third class, quartz veins in diabase, limestone, schist, and associated rocks, are common in the Chewelah district. In general these deposits very much resemble those of the first class, but because of their small size and the diversity in the vein filling and country rock they are grouped separately. The Hartford, Liberty, Jay Gould, Delmonico, U. S. Copper Gold, and Windfall are included in this class. These veins range from a few inches to 3 or 4 feet in width and are all more or less lenticular. They are sparsely mineralized by one or more of the ore minerals galena, tetrahedrite, sphalerite, chalcopyrite, pyrite, and arsenopyrite, and the accompanying oxidized products limonite, chrysocolla, azurite, and malachite. All the ores are said to yield some gold, silver, and copper. They are thought to owe their origin to solutions accompanying or following the dikes (adjuncts of granitic intrusion), which are so widespread throughout the Chewelah district.

The fourth class, comprising small quartz veins and partial replacements in a conglomerate of quartzite fragments cemented by calcium carbonate, is represented by only one deposit examined by the writer in the Chewelah district. In the workings on the Copper Queen ground, 10 miles north of Chewelah, small quartz veins occur in some of the fault and joint openings in the conglomerate, and a small amount of the calcium carbonate cement has been replaced. Pyrite, chalcopyrite, and a little tetrahedrite, together with the oxidation products limonite, malachite, and azurite, are sparingly scattered through the quartz veins, and to a minor extent replace the calcium carbonate cement. The mineralization is scanty and the veins are irregular, so that the ore deposits have little continuity.

MINES AND PROSPECTS ON THE EAST SIDE OF COLVILLE VALLEY.

Of the twelve mines and prospects examined in the Chewelah mining district, nine are located on the east side of Colville Valley. Of these only one, the United Copper, was being actively developed at the time of the investigation. Considerable work, however, has been done on the Copper King, Blue Star (Eagle), and Jay Gould, from which fairly large shipments of ore have been made. The other deposits examined on the east side of the valley have not been extensively developed.

UNITED COPPER.

General features.—The United Copper mine is located 4 miles in an air line northeast of Chewelah, or by wagon road about 5½ miles. The camp is situated in a steep draw on the western slope of Eagle Mountain, at an elevation of 3,000 feet. Plate V, *B* (p. 74) shows a part of the United Copper camp and the Copper King ore house, and figure 6 (p. 94) shows the general location of the United Copper vein and its relative position on Eagle Mountain. Grading for a railroad spur from Chewelah to the portal of a lower crosscut tunnel had been partly finished in 1909. On the completion of the tunnel and the railroad spur ore transportation will be simple and economical. As the camp is about 1,300 feet above Chewelah and no divides have to be crossed in going to it, the freight haul is not very expensive. Timber is plentiful in the vicinity, and wood is used as fuel in the boilers. Water sufficient for domestic use and present mining purposes is found in the immediate locality of the camp.

History and production.—The United Copper holds title by assessment work to seven full claims and five fractions, none of which were patented up to July, 1910. The original claim of this group is said to have belonged to Mr. Sheppler, of Chewelah, who held it for 15 years. On August 1, 1906, he sold it for $20,000 to the present company, which has developed the ground under the direction of Conrad Wolfle, of Spokane. The production of the United Copper mine to 1910 is reported to be about 5,000 tons of ore having a gross value of approximately $50,000.

Equipment.—Bunk houses, a power house, and an ore house constitute the principal surface improvements on the property, and the machinery installed comprises two steam boilers of 40 and 125 horsepower; one compressor, capable of furnishing 600 cubic feet a minute, and engine; one compressor, capable of furnishing 300 cubic feet a minute, and engine; a small hoist, drills, and accessories.

Development.—The underground developments consist of a main adit tunnel started at the level of the camp and driven southeastward some 700 feet to the vein, which in July, 1910, had been followed for

a distance of about 750 feet in a direction S. 21° W.[1] From a point 50 feet back from the breast of the drift a 300-foot crosscut had been run in a westerly direction. Some 200 feet beyond the point where the vein is first encountered there is an upraise of 275 feet to the surface. Some stoping has been done in connection with the upraise and a 122-foot drift has been run on the vein 100 feet above the main level. (See fig. 7.) A 150-foot winze has been sunk below the main level from a point a few feet northeast of the upraise, and 50-foot drifts run in both directions along the vein some 60 feet below the main level. This winze slowly fills with water up to the tunnel level if not pumped out. The ground-water level is locally within the range

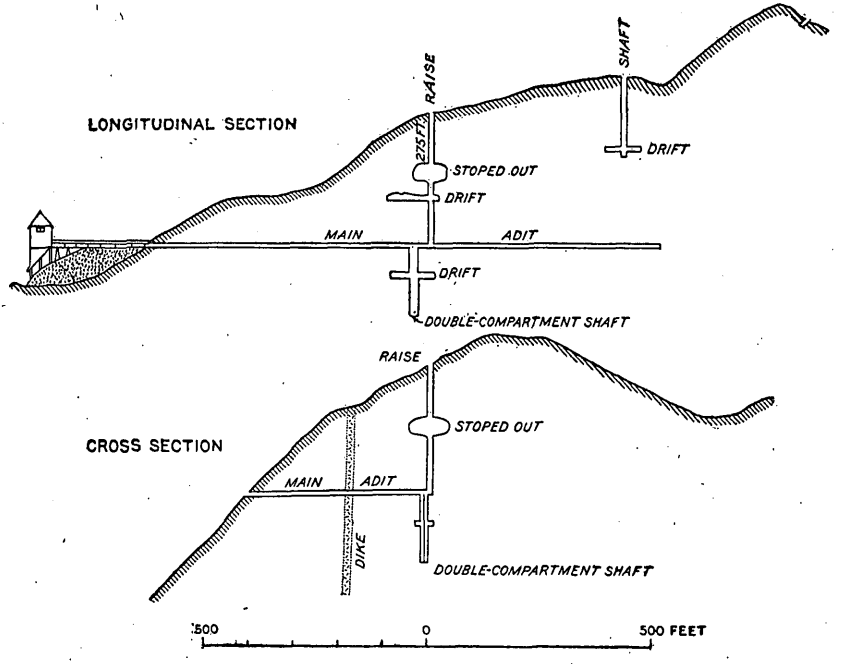


FIGURE 7.—Longitudinal and cross sections of the United Copper mine.

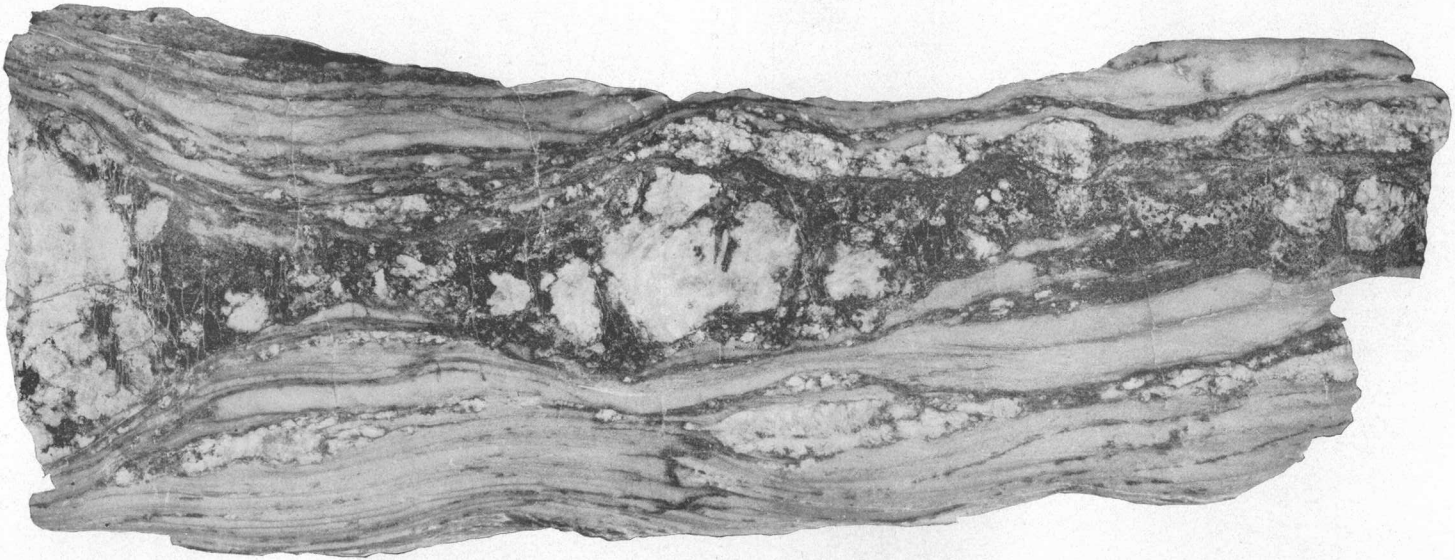
of the depth of the winze. A shaft whose collar is at an elevation of 3,375 feet has been sunk in the hill just south of camp (see fig. 6, p. 94) and is reported to be down 150 feet. Short drifts have been run on the 100-foot level. Water is said to have been encountered in the lower part of this shaft. A new working tunnel is now being driven from a point in the gulch (see fig. 6) to tap the vein some 600 feet below the present main level. In March, 1911, this tunnel had been carried in 500 feet. The company expects to tap the extension of the United Copper vein 3,500 feet from the portal of the lower crosscut.

[1] A personal communication from Mr. Wolfle, dated Mar. 27, 1911, states that this drift was then 200 feet longer and that an ore shoot extended 100 feet along it. An upraise to the old shaft (see fig. 7) is also reported to have been finished.

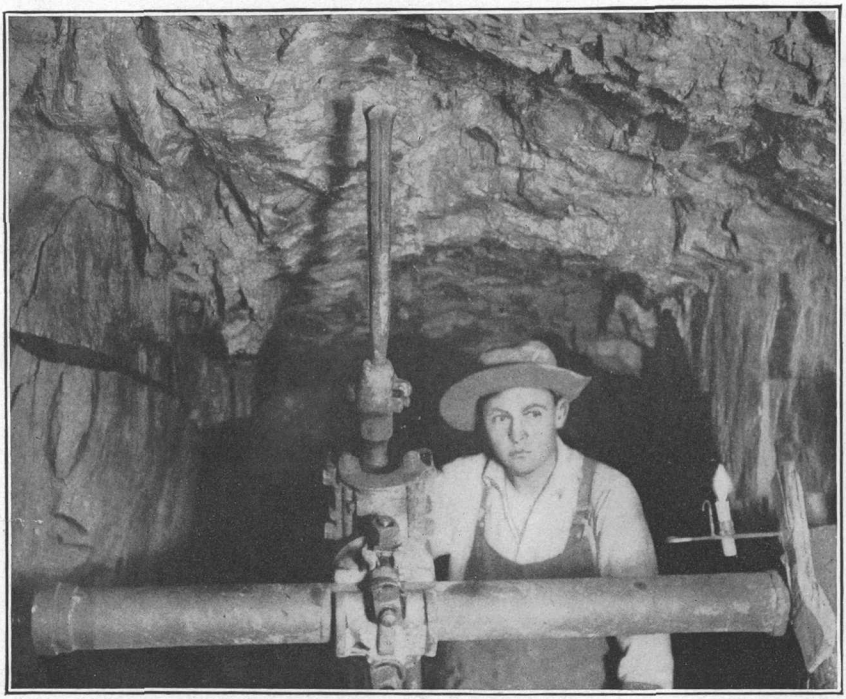
Costs.—The cost of mining is placed by the company at $1.50 a ton of ore mined. This probably does not include exploration and development work. The freight rate on ore assaying $10 a ton or less is $1 a ton. The charge for treatment of this ore at the Granby smelter is $1.75 a ton, and when the United Copper shipped to Northport the charge was $1.50 a ton. The cost of transportation of ore from the mine and loading into cars for shipment is estimated at $1.50 a ton. This makes a total cost of $5.75 or $6 a ton of ore mined, shipped, and smelted. On the completion of the railroad to the lower level the transportation charge on the ore from the mine to Chewelah ought to be considerably reduced.

Geology.—The rocks exposed by the workings on the United Copper ground are a part of the sedimentary series so prevalent in the eastern portion of the Chewelah district, comprising very fissile lime shales, quartz-mica schists, and argillites, showing every range in color from silvery white to gray, red, and black. In general the rocks are fine grained and show along cleavage planes a lustrous surface. More or less cubical jointing is pronounced in the schists. The rocks have a general north-south trend and stand nearly vertical. In the vicinity of the vein along the main level the shales strike N. 21° E. Intruded into this formation, as a rule nearly parallel to the schistosity of the shales, are dikes of kersantite, adjuncts of granitic intrusion. These range in texture from medium to coarse grained, in color from a bluish white to almost black, and in width from a few feet to 100 feet or more. They are composed chiefly of plagioclase feldspar and biotite. The dike exposed in the United Copper mine is 30 feet wide where cut about 600 feet from the portal of the main adit tunnel.

Ore deposit.—Along the lamination planes of the schists bulging has taken place, with the consequent formation of lens-shaped openings of various dimensions, a series of which are occupied by the vein exploited by the United Copper Co. Plate VI, which is a reproduction of a photograph of part of the vein, shows on a very small scale the walls of schist, the small stringers on each side of the principal lens, and the similarity in the shape of the receptacles now occupied by the gangue and ore minerals. The length of this lens or series of veinlets and roughly parallel lenses as explored by the underground workings is 750 feet. The upraise to the surface extends through 275 feet of vein matter, and the winze below the level is said to extend 150 feet through similar material, but as it was filled with water within 30 feet of the main level at the time of visit, only the upper portion was accessible for examination. The highest part of the hill through which the vein would trend if continuous has an elevation of 3,500 feet (see fig. 6, p. 94), and this would give a possible vertical range of 500 feet above the main level. The upper workings, located at an elevation of 3,375 feet, are presumably on the same

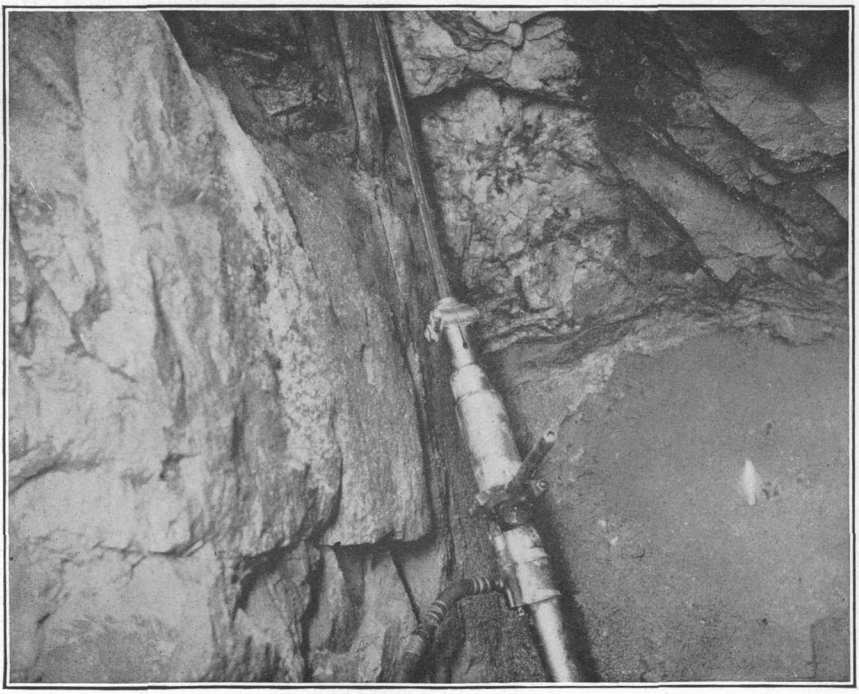


SPECIMEN SHOWING STRUCTURE OF THE UNITED COPPER VEIN.



A. VIEW IN UNITED COPPER MINE.

Shows a quartz vein included between walls of shale, the shale on each side showing some mineralization by tetrahedrite, in which the vein itself is rich.



B. FAULTED VEIN NO. 2, GERMANIA MINE.

A true fissure vein in granite. Shows some mineralization by wolframite.

mineralized zone and the breast of the drift (July, 1910) was approximately under these workings. The vertical distance actually explored is 425 feet, and it is probable that the vein continues through a vertical range of 525 feet and possible that it extends on up the hill, having thus a vertical range of 125 feet more. As the workings below the main level are confined to the single winze, which was nearly full of water when visited, they furnished few data regarding the continuity of the vein in depth. Because of the type of receptacles for the vein filling, the width of the ore zone is irregular, pinches and swells being common. Where the walls of the bulged portions of the openings along the lamination planes of the schists have by movement been brought into juxtaposition, the receptacle for the vein filling has been enlarged, and by the same movement other parts of the vein are pinched. (See Pl. VI.) In places the mineralization extends several feet out into the country rock on each side of the well-defined ore zone, occupying small stringers and lenses along the lamination planes of the schist. Plate VII, *A*, from a photograph taken in a small stope about 15 feet above the adit tunnel level, shows the main vein and small quartz lenses on each side. In width the ore zone ranges from practically nothing to 20 feet, the average being indeterminable because only a relatively small part of the zone has been explored. As exposed in the main drift the average width is about 4 feet, while in the stope above the main level the average width of that part exposed to view is approximately 10 to 12 feet. Only a small part of the ore body has been stoped out. The vein filling is principally quartz, with which are associated calcite and siderite, the latter minerals in places predominating. Gouge is not prominent, although it occurs here and there along the vein and is especially noticeable in some cross fractures that are older than the mineralization. The principal ore minerals are chalcopyrite and pyrite, accompanied by arsenopyrite and tetrahedrite (gray copper) in varying amounts. The ores from the upper workings are chiefly limonite and malachite, the latter in places having a beautiful radial structure. In general the ore minerals are rather sparsely distributed through the vein filling, although in places rich shoots have been uncovered for short distances. The general alignment of the ore minerals is parallel to the lamination planes of the schist, but vein structure of this sort is not uniformly present, the patches of sulphides occurring irregularly spaced throughout the vein. The more or less leached condition of the upper part of the vein and the presence of much tetrahedrite in the workings above the main level point to the conclusion that the tetrahedrite is in part the result of enrichment. Below permanent ground-water level this mineral will probably become less and less prominent as the workings grow deeper. Some assays of picked specimens of this gray copper ore showed 27.2 per cent of copper and 0.1

ounce of gold and 326.8 ounces of silver to the ton. These figures, of course, are not representative of the run of mine ore, the average of which, according to smelter returns for 10 months during 1908, is shown below.

Average assay of run-of-mine ore shipped to Northport smelter by United Copper Co. during 1908.

Gold	ounces to the ton	0.0105
Silver	do	5.35
Copper	per cent	2.481
Iron	do	14.182
Silica	do	35.55
Sulphur	do	3.101
Lime	do	10.638
Alumina	do	7.827

With gold at $20.67 a fine ounce, silver at 53 cents a fine ounce, and copper at 13.2 cents a pound, the average gross value of the ore shipped during 1908 was $9.596 a ton.

Origin of the ore deposits.—The numerous kersantite dikes throughout the area are presumably adjuncts of the intrusive magma which formed the granite seen in the vicinity of the Blue Star and Redwood and elsewhere on Eagle Mountain. Solutions accompanying or following this intrusive magma are thought to have effected the mineralization in the area. The intrusive kersantite dike cut in the main workings of the United Copper mine may have caused the disturbance in the strata which formed the receptacles for the ore deposits, or the strata may have been bulged by other pressures and subsequently filled by solutions accompanying or following the intrusion.

CHEWELAH COPPER KING.

General features.—As the Chewelah Copper King mine is located only a few hundred feet east of the United Copper, in a similar geologic section, containing more or less similar veins, the description of means of access, water, timber, costs, and geology need not be repeated. The camp consists of the usual buildings necessary for mining on a small scale. When visited the Copper King mine was inactive.

About 5,000 tons of ore is said to have been shipped from this property, the contents of which averaged 0.01 to 0.02 ounce of gold and 3.1 to 3.4 ounces of silver to the ton, 2.5 per cent of copper, 14 to 30 per cent of silica, 5 to 38 per cent of iron, 5 to 20 per cent of lime, and 2 to 5 per cent of sulphur. The cost of mining, shipping, and smelting this ore, exclusive of development costs, should approximate that of the United Copper—$5.75 to $6 a ton.

Development.—The chief underground developments are confined to one working, which for convenience may be called the main level.

This starts near the creek level (see fig. 6, p. 94) on a vein and extends some 60 feet in a direction N. 15° E. Beyond this point it turns to the west and extends for a short distance, and then zigzags in a general northerly direction for several hundred feet. In one of the numerous crosscuts run from this main working a mineralized zone was cut on the west and drifted on for about 100 feet and stoped to a height of over 100 feet above the floor of the main level. This is the only large stope in the mine. Two winzes whose depth is unknown, as they were filled with water when the mine was visited, have been sunk below the main level—one at the portal and another under the stope. A shaft said to be about 90 feet deep has been sunk on a vein some 300 feet above this level, and short crosscuts have been run east and west from the bottom of this shaft. An adit tunnel, known as the new Copper King tunnel, has been started about a quarter of a mile west of the camp and 200 feet lower than the main level. At the time of the writer's visit (July, 1909) 500 feet of work had been done on this tunnel.

Geology.—The rocks exposed by the Copper King workings are similar in most respects to those in the vicinity of the United Copper; in fact, they form a continuation of the same series. More faulting is evident in rocks exposed in the Copper King workings and many slips and shear zones were seen. These are filled with gouge, and some are probably postmineral. Kersantite dikes are exposed in the main level of the Copper King, and in one place the dike has been faulted.

Ore deposit.—The ore deposit explored by the stope above the main level is similar in many respects to that exposed in the upper workings of the United Copper. Because of the postmineral movements channels for the circulation of water have been afforded, and consequently the sulphide minerals have been more or less thoroughly leached from the upper part of the deposit. The ore body that has been stoped is exposed by underground workings for a length of 100 feet and to a height of more than 100 feet above the main level. This ore body probably extends up to the surface (about 300 feet) and in each direction along the strike beyond the present limits of exploration. In width the mineralized zone ranges from a few inches up to several feet, but the average is not determinable because of the small amount of development on the ore body proper. Other exposures of veins were seen, but these veins were merely crosscut and not drifted on nor stoped, so that little information is available as to their extent. The deposits stand nearly vertical and occupy shear zones and bulged receptacles along the lamination planes of the country rock. (See Pl. VI.)

The vein filling is chiefly quartz, calcite, gouge, and siderite, the last-named mineral occurring generally in separate veins parallel to

the general trend of the deposit, although in places it is scattered through the vein. Chalcopyrite, pyrite, and tetrahedrite are distributed through the vein in small quantities. Some vugs in the vein are lined with beautiful greenish calcite crystals. The deposit that has been stoped shows chiefly the oxidized minerals, limonite and malachite, the former very profusely and the latter but sparingly distributed through the vein.

Origin of the ores.—The ores owe their origin to exactly the same agencies as those which formed the United Copper deposit, the Copper King representing a continuation of the same vein system. Local physical factors have controlled the impoverishment and enrichment of the veins to such an extent that the deposits as viewed from the workings on the main levels appear somewhat dissimilar. If the veins are persistent below ground-water level, they doubtless assume many more characteristics in common.

Future of the mine.—If the veins exposed are continuous into the United Copper ground, the first two veins cut in the United Copper adit tunnel, which were quite barren of ore minerals, probably represent the continuation of the Copper King veins.

Because of the leached condition of the vein that is stoped in the Copper King mine, it seems reasonable to suppose that some enriched ore will be found at a greater depth in the same vein. The ore so far found in the other veins could easily be concentrated, and if gray copper should be developed by future explorations the introduction of flotation processes or canvas tables for concentration would save this mineral, which is often lost by ordinary methods of concentration.

STROBECK.

Several prospects belonging to or under the management of Mr. Strobeck were examined because of their proximity to the United Copper and Copper King mines. On most of these prospects the developments consist of small shallow surface cuts through the glacial débris. These cuts expose the geologic relations of the underlying beds, and by their aid several of the geologic boundaries have been roughly outlined on figure 6 (p. 94). Ore minerals are scarce or entirely lacking in almost all these prospects.

The most extensively developed prospect in this group is the Keystone, several hundred feet east of the United Copper mine, on the south side of the same gulch. On this prospect an adit tunnel having one branch crosscut is located at an elevation of 3,150 feet and has been driven for a distance of 312 feet. The rocks exposed are quartz-mica schists and lime shales similar in many respects to those of the United Copper and Copper King. These rocks strike N. 15° E. and dip 75°–80° S. 75° E. and the adit tunnel follows the general strike of the formation in a direction S. 13½° W. Quartz and

calcite stringers are present in lenses along the lamination planes of the schists but appear to be barren of ore minerals. An intrusive kersantite dike exposed in the workings somewhat resembles those in the United Copper and Copper King, though biotite is much more prevalent and forms a large part of the dike. This dike is also an adjunct of granitic intrusion.

DELMONICO (ENTERPRISE).

The Delmonico or Enterprise prospect is on the northwestern slope of Eagle Mountain, a few hundred feet south of the main road to the United Copper and Copper King mines, about 4 miles by wagon road northeast of Chewelah. A shallow shaft (locked at the time of the writer's visit) constitutes the principal underground development. Small shipments are reported to have been made from this prospect.

Yellowish crystalline limestones are the only rocks exposed in the immediate vicinity of the camp. These have a general north-south strike and a steep dip and are traversed by joint planes, the principal ones having a northwest-southeast direction. Small quartz stringers from a fraction of an inch to several inches in width traverse the limestone in all directions. The limestone on each side of the quartz stringers is silicified for short distances. Galena, tetrahedrite (gray copper), and sphalerite, associated with some chrysocolla, azurite, and malachite, are rather sparsely distributed in the quartz stringers. The ores are reported to carry considerable silver, which is probably contained in the tetrahedrite.

Although no intrusive rocks were seen in this immediate locality, similar mineral associations were observed in quartz veins in limestone of the same type near igneous contacts at no great distance away.

BLUE STAR (EAGLE).

The Blue Star mine is on the western slope of Eagle Mountain at an elevation of about 3,000 feet and is 3¼ miles in an air line northeast of Chewelah, or about 4½ miles by wagon road. (See fig. 6, p. 94.) This mine is reported to have been among the first producers in the district, and the statement is current in Chewelah that $80,000 worth of ore has been shipped from it.

As the mine was inactive when visited and the shaft full of water it was impossible to obtain authentic information on many of the features which should be noted in this sketch. The developments consist of a shaft said to be more than 200 feet deep and a main level on which there are about 1,000 feet of crosscuts and drifts and above which there is a small amount of stoping.

Coarsely crystalline white dolomite, resembling marble, fine to medium grained blue limestone, and medium to fine grained gray-

blue quartzite are the sedimentary rocks in this locality. These rocks are apparently conformable, strike in a general northwest direction, and dip about 65° SW. at this particular locality, although a north-south strike and a nearly vertical dip prevail generally throughout the sedimentary series on Eagle Mountain. Dikes of kersantite, adjuncts of granitic intrusion, cut the sedimentary rocks in the Blue Star workings.

As exposed in the main level the ore occurs in pockets and irregular replacements along shear zones and fault planes in dolomitic limestone. To judge from the small stopes above the main level the ore shoots ranged from a few inches to 3 or 4 feet in width and from several feet to 50 feet or more in length. The ore is not continuous along any one zone but is irregularly scattered through the dolomitic limestone and appears to be absent in the quartzite exposed in the workings. Galena, tetrahedrite, sphalerite, chalcopyrite, pyrite, and pyrrhotite constitute the chief ore minerals and are associated with cerusite, anglesite, malachite, azurite, limonite, and other oxidized products. The gangue minerals are quartz, barite, calcite, and more or less brecciated country rock. The distribution of these ores is not even and they form irregular shoots, so that much dead work is involved in their extraction. A few shipments of ore aggregating 315 tons, made to the Tacoma smelter several years ago, are reported[1] to have averaged 0.068 ounce of gold and 27.4 ounces of silver to the ton and 39.6 per cent of lead; the copper content was not determined.

JAY GOULD.

The Jay Gould mine is 3½ or 4 miles by wagon road a little north of east of Chewelah, at an elevation of 2,700 feet. It was idle when visited but was more accessible to examination than most of the other inactive properties. Several shipments of ore are reported to have been made from the Jay Gould.

The developments consist of several surface cuts and an inclined shaft some 200 feet deep, from which two levels several hundred feet long and 100 feet apart have been run. The property is equipped with a hoist and a small amount of machinery.

Limestone, quartz-mica schist, argillite, and lime shales constitute the major part of the geologic section in this locality and represent a continuation of the sedimentary series found on Eagle Mountain. These rocks are intruded by granite similar to that found in many other parts of the Chewelah district. Some of the dikes accompanying the granitic intrusion and containing a high percentage of ferromagnesian minerals contain also some pyrite which is reported to carry 60 cents a ton or less in gold. During 1910 much talk was current in Chewelah and vicinity regarding these "peculiar ore

[1] Northwest Mining News, vol. 2, No. 6, p. 122.

bodies," and several persons were tempted to try to mine the dike for its gold content.

The sedimentary rocks have a general east-west strike and dip 20°–50° S. 10°–20° W. In places near the workings the strata strike northeast and stand nearly vertical. The intrusion of the granite has caused numerous local changes in the strike and dip of the sedimentary rocks, and they are cut by many faults.

In the faulted limestones are large veins of quartz, some of which are several feet wide and several hundred feet long. Running in all directions through the country rock are small veinlets of quartz, in places occupying small lenses between the lamination planes of the schists and shales and elsewhere filling small fractures that cut directly across the planes of schistosity. In the Jay Gould workings two large quartz veins are exposed, one that extends from the surface to a depth of 130 feet, and another that is explored on the 200-foot level. Innumerable quartz veinlets are to be seen throughout the workings. The quartz is sparsely mineralized by pyrite, sphalerite, galena, and chalcopyrite, with which is associated some tetrahedrite. The ore minerals also replace the country rock to a slight degree, forming small pockets. The workings are not extensive enough to warrant conclusions regarding the size of the ore shoots.

U. S. COPPER GOLD.

The U. S. Copper Gold prospect is about 3 miles a little north of east of Chewelah, half a mile south of the Jay Gould. A wagon road has been built from the prospect to a road running into Chewelah, and the distance between the two places by this route is about 3½ or 4 miles.

The developments consist of a 340-foot adit tunnel, the portal of which is at an elevation of 2,550 feet, and a short adit tunnel 100 feet higher. The rocks are silicified limestone, shaly in part, and quartz-mica schist, in places resembling quartzite. These rocks strike northwest and dip at a steep angle northeast. Intruded into the sediments are dikes of quartz diorite and quartz monzonite porphyry. The quartz diorite, which has been locally sheared, is a medium-grained gray rock containing much quartz, plagioclase feldspar, hornblende, and small patches of garnet. The quartz monzonite porphyry is a medium-grained gray rock containing quartz, orthoclase and plagioclase feldspar, and hornblende.

Small veins of quartz are irregularly scattered through the silicified limestone and contain some chalcopyrite and pyrite and the oxidized products malachite, azurite, and limonite. The ore is reported to carry some gold as well as copper. Developments on the mineralized zone are so scanty that few data are available as to the extent of the ore deposit.

WINDFALL.

The Windfall prospect is about a quarter of a mile south of the U. S. Copper Gold. It has been developed by an adit tunnel 600 feet long, the portal of which is at an elevation of 2,600 feet, and a small open cut 175 feet higher. The rocks containing the deposit are silicified limestones. Quartzite also forms a part of the geologic section in this locality. These formations strike approximately north and south, and stand nearly vertical. Quartz diorite, containing a small amount of pyrite and a few crystals of garnet, and quartz monzonite porphyry have intruded the formations, and where exposed in the adit tunnel these rocks occupy a large part of the working.

In the silicified limestone in the upper workings is exposed a quartz vein about 3 feet wide. This vein strikes north and south and stands nearly vertical. It is sparsely mineralized by arsenopyrite, pyrite, and chalcopyrite, which have been more or less oxidized so that in places the vein is highly stained by limonite and malachite. Developments on the vein proper are so meager that speculations in regard to the future of the deposit are futile.

COPPER QUEEN.[1]

The Copper Queen prospect, on Chewelah Creek about 10 miles almost due north of Chewelah, is the most northerly deposit examined by the writer in the Chewelah mining district. A wagon road extends to a cabin on the prospect, at an elevation of 2,300 feet.

The developments consist of several short adit tunnels, short drifts, and shallow winzes, aggregating about 600 feet of underground workings. The portals of three adit tunnels are at elevations of 2,360, 2,425, and 2,500 feet.

Quartzite and a conglomerate formed of quartzite fragments cemented by calcium carbonate are the prevailing rocks in this immediate vicinity. These rocks strike N. 50° E. and stand nearly vertical. Included in the quartzite conglomerate is a fine-grained dark bluish-green rock, showing slight schistosity and composed almost entirely of feldspar, now altered to sericite, and a ferromagnesian mineral, now altered to chlorite. Small veinlets filled with dolomite traverse this rock.

In the underground workings many faults were seen and joints are prominent. Small quartz veins are present along some of the fault and joint planes in the conglomerate. These veins are sparingly mineralized by pyrite associated with a little chalcopyrite and some tetrahedrite (gray copper). The calcium carbonate cement in the quartzite conglomerate has also been replaced to some extent by

[1] This prospect should not be confused with the Copper Queen near the Copper King, on Eagle Mountain.

ore minerals. The oxidation products malachite, azurite, and limonite stain much of the conglomerate in the vicinity of the faults and joint planes. The veins are lenticular and irregularly spaced, so that the ore deposits have little continuity.

PROSPECTS ON THE WEST SIDE OF COLVILLE VALLEY.

The three properties examined on the west side of Colville Valley were all doing a small amount of development work when visited, although none of them had reached the producing stage. Blue Creek, 6 miles northwest of Chewelah, is the nearest shipping point.

HARTFORD.

The Hartford group of claims, comprising four full claims and a fraction, owned by the Krug Gold & Copper Mining Co., is 1½ miles northwest of Blue Creek, on the eastern foothills of the Huckleberry Range. A wagon road extends between the claims and Blue Creek. No large shipments of ore are reported from this group. Water and timber are plentiful in the locality. The developments consist of an adit tunnel 340 feet long (August, 1910), the portal of which is at an elevation of approximately 2,300 feet, numerous shallow surface cuts or trenches on quartz veins, and a shaft 35 feet deep.

The rocks in the vicinity are a part of the sedimentary series of limestone, quartzite, argillite, lime shale, etc., which prevails throughout most of that part of the Chewelah district examined by the writer. In the vicinity of the deposits, however, these rocks have been so intruded by diabase and a rock now altered to chlorite schist that they occupy only a small area, the diabase covering the larger portion of the surface. Subsequent metamorphic processes have sheared the whole series, and the result is a very intimate association of intrusives and sediments, all of which show some schistosity in the vicinity of the ore deposits. Later dikes such as commonly accompany dioritic or granitic intrusions are found throughout the section. In the small exposures of limestone seen the strike is north and south and the dip approximately vertical. A high bluff of quartzite about half a mile north of the Hartford group extends for several miles east and west.

More or less pyrite with a little chalcopyrite is disseminated through the zones of movement in the diabase and the associated sediments, but the ore deposits which the company is trying to develop are quartz veins occurring in several places on the claims. The adit tunnel is being driven for the further development of one of these veins and the possibility of crosscutting others. One open cut at an elevation of 2,500 feet, on top of the first high ridge east of the portal of the adit tunnel and approximately 200 feet above it, shows a series of quartz veinlets in limestone which is included between sheared

diabase on the east and chlorite schist on the west. The chlorite schist is only a few feet wide, and beyond it is more sheared diabase. Other open cuts and trenches show quartz veins in diabase, having an average width of 3 feet, an average north-south strike, and a westerly dip at a small angle. One vein was seen that dipped to the east. As water fills all the excavations after they are several feet deep, further sinking has not been attempted. These quartz veins are in general sparsely mineralized, but are reported to contain small amounts of gold, silver, and copper.

The vein which near the surface appeared to contain more ore minerals than the others is opened by a shallow shaft on the Bismark claim. This opening is about 900 feet northwest of the portal of the adit tunnel and exposes a quartz vein 2 to 3 feet wide that is fairly well mineralized by galena and tetrahedrite, associated with some pyrite, chalcopyrite, and sphalerite and the oxidized products azurite, malachite, and limonite. An assay of a specimen from this vein, by Lewis & Walker, of Butte, Mont., for Mr. August Krug, general manager of the Hartford group, showed the ore to contain 0.49 ounce of gold and 94.2 ounces of silver to the ton and 4.8 per cent of copper.

LIBERTY.

The Liberty Copper Co.'s prospect is located at an elevation of 2,300 feet, 2½ miles southwest of Blue Creek, on the northern slope of a small spur which extends northeastward from the lower part of the Huckleberry Range. The developments consist of an adit tunnel 528 feet long (July, 1909), an 80-foot drift, and several shallow surface cuts. Shipments of ore are not reported from this prospect.

Argillites, lime shales, and quartz-mica schists constitute the major part of the geologic section in this locality. Where exposed by the underground workings these rocks show considerable faulting, strike approximately north and south, and stand nearly vertical. In one of the open cuts, however, at an elevation of 2,550 feet, the sedimentary rocks strike southeast and northwest. Dark-colored medium to coarse grained diorite dikes containing a large percentage of augite intrude the sedimentary series in a direction almost at right angles to their planes of schistosity.

Small quartz veins are included in the schist and shale and, though in general barren where exposed, are in places slightly mineralized by pyrite, chalcopyrite, and a small amount of tetrahedrite. One larger quartz vein was encountered at the breast of the 80-foot drift which branches off from the main adit tunnel some 30 feet from its portal. This vein in places carries some ore minerals. Small quantities of gold, silver, and copper are reported to occur in these ores.

NEVADA.

The Nevada prospect is located at an elevation of 3,000 feet about 5 miles southwest of Blue Creek. A wagon road extends within a mile of the prospect, and from the end of it a trail has been built to the camp. Shipments are not reported from this prospect. The developments consist of a shallow shaft about 30 feet deep and a few feet of drifts from the bottom of the shaft.

Quartz-mica schist and intercalated strata of limestone, quartzite, and lime shale occupy a large part of the area in the immediate vicinity of the Nevada workings. These rocks have a general northeast strike and dip about 45° NW. Some 600 feet east of the workings a light-colored fine-grained felsitic intrusive rock containing some phenocrysts of biotite and plagioclase feldspar cuts the sedimentary rocks in a general northeast-southwest direction. This rock, which greatly resembles aplite, was seen for a distance of 2,000 feet along its contact with the sedimentary series. Contact metamorphic minerals, such as epidote and actinolite, have been developed to some extent in the limestone. Sphalerite and galena, associated with quartz, actinolite, and a small amount of tetrahedrite, replace the limestone in an irregular manner. The pockets of ore thus formed range from a few inches to a foot or more in diameter, but no continuous ore shoots were observed in the Nevada workings. Some pyrite was seen along joint planes and small fractures in the quartzite east of the workings. The ore is reported to carry an appreciable quantity of silver, besides the lead and zinc.

Because of their irregularity in size and distribution, the mining of the ore pockets found in the Nevada workings is uncertain. Ore is much more abundant in the limestone than elsewhere in this particular series, although quartz lenses in the lime shale may also be mineralized. Solutions accompanying or following the intrusion just east of the camp have no doubt effected the replacement of the limestone and the deposition of ore in this vicinity.

DEERTRAIL (CEDAR CANYON) DISTRICT.

LOCATION.

The Deertrail (Cedar Canyon) mining district is just north of the Spokane Indian Reservation and occupies the extreme southwestern part of Stevens County. The writer was unable to find any definitely recorded boundaries for this district.

Springdale, on the Great Northern Railway, 25 miles by wagon road from Deertrail, is at present the nearest railroad station and is the shipping point for the district. Turk, a small settlement about 2 miles northwest of the Deertrail camp, is the present post office, the

one at Deertrail having been discontinued. The completion of the proposed railroad along Spokane River will make parts of this district much more accessible and afford cheaper transportation of ores.

CONDITION OF MINING ACTIVITY.

The Germania tungsten mine was the only active property in the Deertrail mining district in the summer of 1910, when the writer made his investigation. Deertrail, 2 miles north of the Germania camp, was once the center of much mining activity, and large shipments of silver ore are reported to have been made from the veins exploited by the several mining companies, but most of the richer ore has no doubt been extracted. Most of the mines that have shipped in the past, among them the Deertrail, Elephant, Legal Tender, Providence, Victor, Seal, and Queen, are on patented claims. Hence annual assessment work is not necessary and as the tenor of the ores does not justify mining under present conditions the workings have been in disuse for several years and are now for the most part inaccessible. The charred remains of some of the buildings that have been partly destroyed by a forest fire add desolation to the general abandoned appearance of the camp.

The lead-silver deposits here described are not those of the mines which in the past have been the more prominent shippers, but those which could be seen. All the workings visited are of small extent.

The account of the Germania tungsten deposits and vicinity is more complete, as the workings were all in good condition, the deposits were being actively developed, and much information of general interest was obtained through the courtesy of the operators.

A small copper smelter has been erected at Turk to treat the ores from the Copper Butte mine but has never been successfully operated. The mill located on the Germania ground was in successful operation at the time of the investigation. The process of treatment of the ores is described in detail on pages 122–123.

TOPOGRAPHY.

The part of the Deertrail district examined is situated on a series of ridges having a general north-south trend and forming the southern part of the Huckleberry Range. These ridges slope gradually down to Columbia River on the west, Spokane River on the south, and the Colville Valley on the east. The general elevation of the tops of the ridges in this vicinity is approximately 3,800 feet, or 1,200 to 1,600 feet above the valleys. In general the gulches have gentle slopes and the valleys between the ridges are usually broad and show the result of glacial action. Water is plentiful in most parts of the district and the small streams that flow through many of the gulches afford an abundant supply for domestic use. The hillsides are largely covered by evergreen trees, which furnish a supply of timber.

GEOLOGY.

Argillite, lime shale, quartz-mica schist, limestone, dolomite, and quartzite intruded by a large mass of granite and many accompanying dikes occupy the part of the Deertrail district examined by the writer. The sedimentary rocks are thought to be of Paleozoic age, and the granite is believed to have been intruded during Mesozoic time. The sedimentary rocks are slightly dynamometamorphosed and bear marked resemblances to most of the sedimentary rocks occurring in other parts of northeastern Washington. The intrusive granite is also very similar to that found in many of the other mining districts in this part of the State.

SEDIMENTARY ROCKS.

The general trend of the sedimentary rocks is north and south, but in the immediate vicinity of the Germania and Deertrail camps it is about N. 21° E. The dip ranges from 45° to 90° and may be to the east or west. The rocks appear to be conformably interbedded, and the thickness of any one formation ranges from a few feet to 100 feet or more. The quartz-mica schists and argillites probably occupy the largest part of the geologic section, the total thickness of which is several thousand feet.

The argillites and lime shales in this district have many characteristics in common. They are of a fine-grained texture, somewhat resemble slates, and are very fissile. The colors which predominate are gray-green and black, although lighter shades were seen here and there. The argillites are composed essentially of quartz, feldspar (now largely altered to white mica), and carbonaceous matter. Chlorite is so abundant in some of the shales as to make them in reality chloritic schists. The lime shale represents very impure shaly limestone or argillite containing a high percentage of calcium carbonate.

The quartz-mica schists form much of the second prominent ridge west of the Germania camp and a part of the ridge in which the Germania workings are located. They are medium to coarse grained in texture and are highly schistose. The prevailing color is dark gray, although some red, yellow, and pink schists were seen. They are harder than the quartz-mica schists in the eastern part of the Chewelah district, but closely resemble those on Huckleberry Mountain several miles west of Chewelah, about 12 miles northeast of Deertrail.

Coarsely crystalline blue-white, white, and yellow limestones and dolomites were seen in this district. Some of the limestone contains much serpentine, and the dolomites contain as much as 22 per cent of MgO.[1]

[1] Analysis by J. G. Fairchild, chemical laboratory, United States Geological Survey

The quartzite is a medium to coarse grained pink rock which shows no schistosity. It does not appear to be as widely distributed in the vicinity of the ore bodies as the sediments already described.

IGNEOUS ROCKS.

As in many other places throughout northeastern Washington the sedimentary rocks of the Deertrail district are intruded by large masses of granite. In the vicinity of the Germania camp granite is more prominent than farther to the north in the Deertrail camp. Granite is also reported to occur a short distance east of the Germania camp. A thin section of a fresh specimen of the granite viewed under the microscope showed the rock to contain large proportions of quartz, orthoclase, oligoclase, and biotite, with a little microcline and some albite. The feldspars have been slightly altered to white mica, although the rock in general is remarkably fresh.

Dikes, presumably later eruptive phases of the same magma, are present in all parts of the sedimentary series. They contain more of the ferromagnesian minerals, augite, biotite, and hornblende, and the feldspars are predominantly plagioclase. Some of the dikes found in the Deertrail camp may be classed as camptonite.

ORE DEPOSITS.

DISTRIBUTION AND CHARACTER.

The deposits examined in the Deertrail district and those which have been the most productive in the past are confined mainly to a narrow strip of country not over 2 miles wide and extending in a general north-south direction about 5 miles. (See fig. 8, p. 117.) Other deposits are located outside of this belt, and there is no reason to believe that they should not be as well mineralized as those within it, but lack of time prevented an examination of the whole district.

All the deposits seen may be classed as quartz-filled fissure veins, but because of the diversity of vein filling they will be discussed in three groups, according to the chief metals in the ores—tungsten, lead-silver, and copper.

1. The veins carrying tungsten ores are represented by the deposits on the Germania ground. These deposits occur in granite and the hard, compact variety of quartz-mica schist. The main workings are located in granite and expose a quartz vein having an average width of 2 feet, which has been proved for a length of 400 feet along its strike and 200 feet on the supposed continuation of the vein, and to a depth of 193 feet. This vein has been faulted both to the east and to the west. Where exposed in the workings, the displacements have been only a few feet. Fluorite and tourmaline also form a small part of the gangue. The chief ore minerals are wolframite, which forms

about 5.5 per cent of the vein filling, and scheelite. Galenobismutite in small quantities is scattered through the quartz and occurs in fractures in the wolframite and carries about 1 ounce of silver to the ton. Other minerals in the vein are pyrite, chalcopyrite, molybdenite, and arsenopyrite. Limonite is prominent in the upper workings and some secondary ferritungstite [1] was seen.

2. The group of veins carrying lead-silver ores in reality comprises all the deposits within the area, even the tungsten veins containing some lead-silver ores in the form of galenobismutite. The chief deposits of this group, however, are different in nature from the tungsten veins. They range from a few inches to 6 or 7 feet in width and are reported to continue along their strike for long distances. Faulting of the veins was noticed in several of the workings, but the displacements were in general only a few feet. Most of these lead-silver quartz veins occupy fissures or shear zones along the lamination planes of the sedimentary rocks. The Orchid, however, which is reported to be a lead-silver deposit, occurs in granite. The vein filling is mainly quartz, with which are associated some barite and a little calcite. The chief ore minerals are galena, sphalerite, and tetrahedrite. Sphalerite is said to increase in proportion toward the lower levels of the mines. Pyrite and chalcopyrite are also present in the ores. The croppings almost invariably show some malachite and much limonite. Native silver has been found in the upper levels of some of the mines.

3. The writer did not have an opportuntity to examine any considerable copper deposit in the Deertrail district. One prospect near the gulch level, about 4,000 feet southeast of Cedarville, showed a deposit having many characteristics in common with the lead-silver veins explored higher on the mountain side.

ORIGIN OF THE ORES.

The minerals in the tungsten deposits and the lead-silver veins are thought to owe their origin to the granite magma, evidences of the intrusion of which are found throughout the district. Solutions accompanying or following its intrusion or that of the dikes which are adjuncts of it are believed to have effected the mineralization. At least two periods of mineralization can be recognized in these deposits. The tungsten veins were probably the first formed. In the fractures of the wolframite some galenobismutite is found, showing a second period of mineralization. The formation of the fissures that are now filled with the lead-silver quartz veins may have accompanied the intrusion of the dikes which appear to be closely related to the main granite mass. Solutions accompanying or following the intrusion of

[1] This new mineral, ferritungstite, has been described by W. T. Schaller in U. S. Geol. Survey Bull. 509, pp. 83–84, 1912.

these dikes are believed to have brought in galena and sphalerite and perhaps tetrahedrite, although this last mineral may represent a third period of deposition. Superficial alteration has enriched the upper portions of the lead-silver veins by the formation of rich secondary silver sulphides. As there was no opportunity of studying the copper deposits in this district, little can be said regarding them.

LEAD-SILVER DEPOSITS.

The following detailed descriptions represent prospects from which little or no ore has been shipped, the larger properties having been inaccessible to examination for reasons stated on page 112. The vein worked in the Seal and Queen mines is thought by persons in the Deertrail district to extend some distance northeast of those mines, and several prospects have been located along its supposed northeast continuation.

BROOKS.

The Brooks claim adjoins the Queen on the northeast (see fig. 8) and has been prospected by a 50-foot shaft whose collar is at an elevation of 3,900 feet, a small open cut 600 feet northeast of the shaft and 75 feet lower, and an apex open cut. The shaft has been sunk in greenish-black lime shale, and at the depth of 50 feet had not encountered a vein. The first open cut is on a quartz vein 5 to 7 feet wide, which strikes with the formation—that is, N. 25° E. In the immediate vicinity of the open cut the sedimentary rocks dip 45° SE., but a short distance beyond they stand nearly vertical. A camptonite dike 2 or 3 feet wide intrudes the lime shale and limestone 3 feet east of the quartz vein. The limestone in the immediate vicinity contains some serpentine. Ore minerals are scarce in the quartz vein, which is stained by malachite and limonite. Probably some sphalerite, galena, and gray copper have been leached from the cropping of this ledge.

SUNDAY MORNING.

On the Sunday Morning claim, which joins the Saturday Night on the northeast, 460 feet of development work has been accomplished. A 20-foot crosscut at an elevation of 3,525 feet leads to a 180-foot drift on a quartz vein. Another crosscut 50 to 100 feet lower and northeast of this working is said to be 260 feet long. In July, 1910, the prospective vein had not been encountered in this crosscut. Where exposed in the upper working the quartz vein is about 18 inches wide, and on each side of it are small stringers of quartz separated from the main vein by 6 to 24 inches of country rock. The strike of this vein is to the northeast and the dip about 80° NW. Some gouge was noted on each side of the vein. The quartz is cellular and contains small patches of galena, sphalerite, and tetrahedrite. Limonite and malachite stain parts of the vein. Many vugs in the vein are partly filled with quartz crystals, and some barite is present.

LITTLE FRANK.

On the Little Frank, a fractional claim just north of the Sunday Morning, an 8 to 10 foot crosscut taps a 12-inch quartz vein contained in the limestone and shale series. No drifting has been done on this vein. Some galena, sphalerite, and tetrahedrite are present in the ores, together with malachite and limonite.

HOODOO.

On some of the larger properties several hundred feet of crosscuts could be examined, but most of those workings were found to be caved before the vein which had been worked in the past was reached. The Hoodoo workings, however, were in good condition, and a vein was well exposed in them and will be described here.

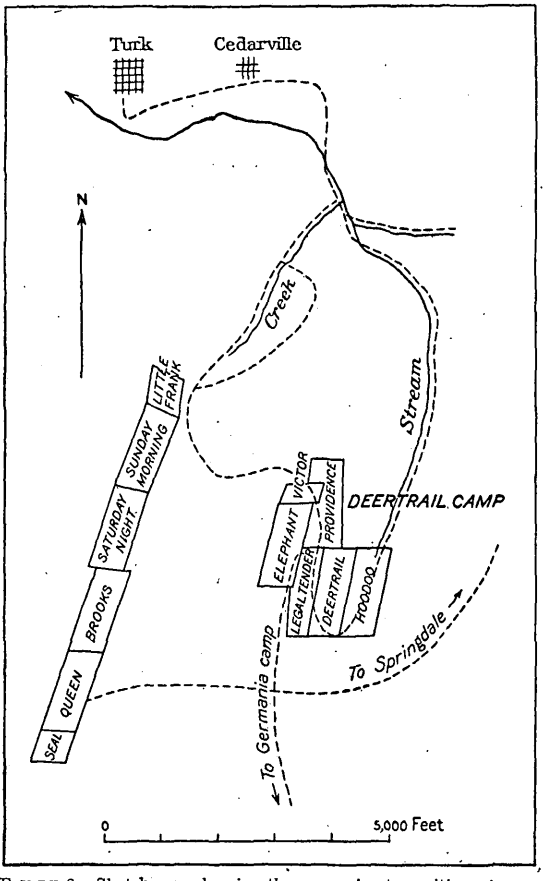


FIGURE 8.—Sketch map showing the approximate position of some of the claims in the vicinity of the Deertrail camp.

The west side line of the Hoodoo claim adjoins the east side line of the Deertrail. (See fig. 8.) The portal of the adit tunnel is located at an elevation of 3,610 feet. The rocks through which the workings penetrate are a part of the metamorphosed sedimentary series which occupies a large portion of the Deertrail district. These rocks appear to be much more contorted in the vicinity of the Deertrail camp than they are 1 mile to the west. They have a general northeast strike and dip from 45° SE. to 90°. Intruded into these rocks, apparently along the lamination planes, are dikes of camptonite and other more or less basic phases of the granitic magma. A quartz vein 2 to 3 feet wide is exposed in both branches of the Hoodoo crosscut. In the north branch the vein is about 3 feet west of an intrusive dike, and in the south branch it is about 30 feet west of the dike. A few feet of

drifting beyond the intersection of this vein with the crosscut has shown the vein to be faulted to the west about 6 feet. The vein has the same trend as the sedimentary rocks, striking N. 50°–60° E., and dipping 45° SE. It has been but slightly developed.

Quartz forms the principal vein filling and is associated with some barite and brecciated country rock. The vein is sparingly mineralized by pyrite, chalcopyrite, sphalerite, galena, and some tetrahedrite. The ores on the dump show also some malachite and limonite.

GERMANIA TUNGSTEN DEPOSIT.

LOCATION AND MEANS OF ACCESS.

The Germania camp is, in an air line, just 3 miles south of Turk and 17 miles a little south of west of Springdale, the distance by wagon road from Turk being about 4 miles and from Springdale about 25 miles. The former Deertrail post office and the Deertrail mining camp are 2 miles north of the Germania camp. Springdale, a town on the Great Northern Railway, is at present the most accessible shipping point. A railroad down Spokane River has been projected for some time, and if built will probably pass within 7 miles (in an air line) of the Germania camp. As only concentrates are shipped from the Germania and as the shipments up to the time of writing (April, 1911) had not exceeded 30 tons every two months, the transportation of ore has not been a very important factor in the growth of the mine. However, with better facilities for shipment, the costs will naturally be somewhat reduced, and hauling in supplies of all sorts will be less expensive and more easily accomplished. The office, mill, and lower workings are at an elevation of approximately 3,400 feet in a small draw on the east side of a long timber-covered ridge which projects southeastward from the southern part of the Huckleberry Range.

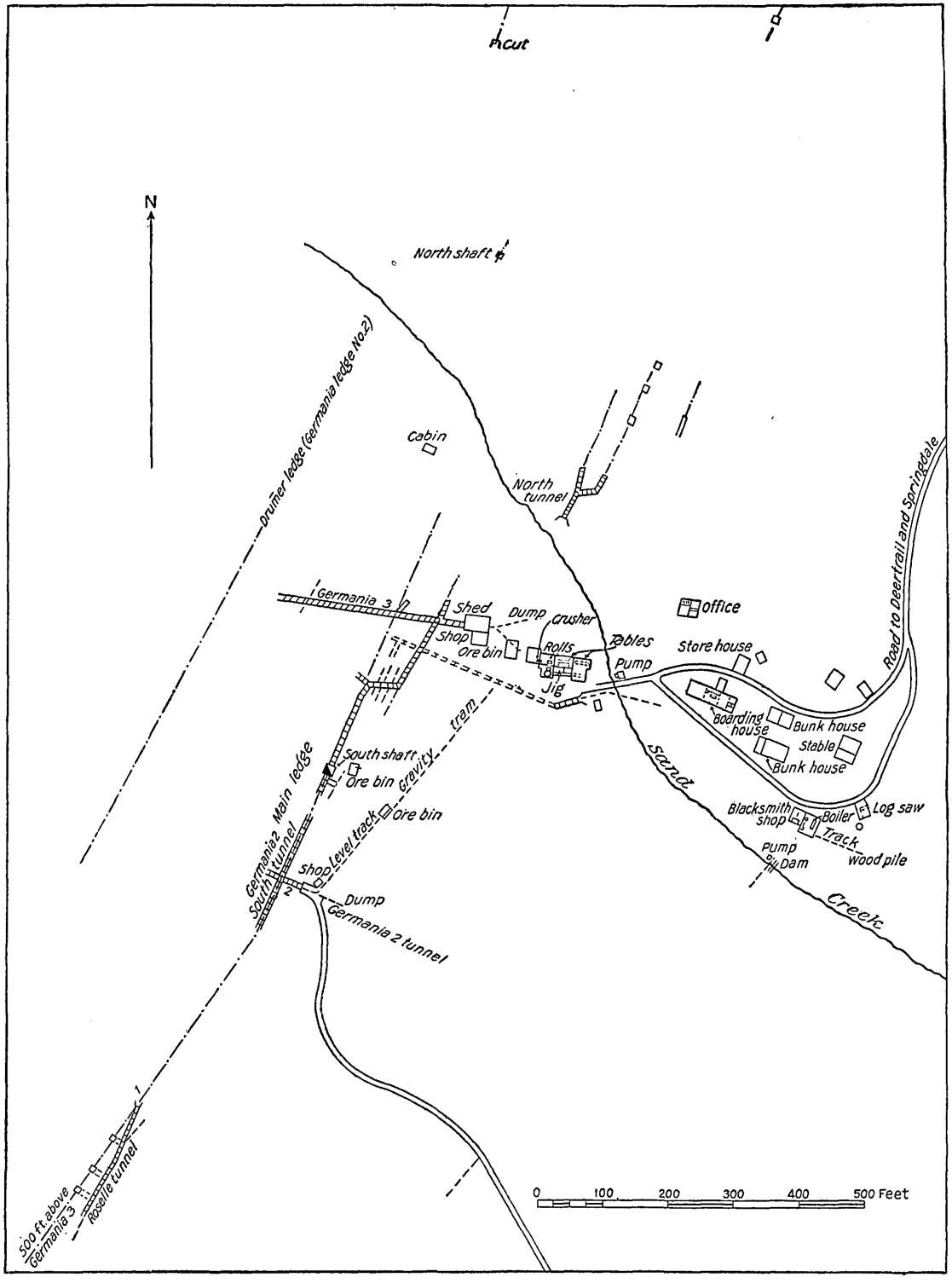
Wood for fuel, mine timbering, building, and other purposes is plentiful in this locality and enough water for domestic use and milling is available near by.

The company owns sec. 13, T. 29 N., R. 38 E., and holds title by annual assessment work (concentrated chiefly on the main workings) to about 50 other claims scattered over parts of secs. 12, 14, 23, and 24, T. 29 N., R. 37 E., and sec. 18, T. 29 N., R. 38 E.

HISTORY AND PRODUCTION.

The claim known as the Bismarck was located by John Horn in 1894. The present company, after two years of litigation, bought sec. 13 and four-fifths interest in the claims of Horn's successors.

Up to the end of December, 1910, the Germania Co. had mined and concentrated 1,647 tons of crude ore, which produced 82.35 tons of concentrates containing 70 per cent of WO_3. These figures are said to represent mining operations covering a period of about five months.



PLAN OF THE GERMANIA CAMP, SHOWING THE MAIN LEVELS AND THE LOCATION OF SOME OF THE LESSER WORKINGS.

EQUIPMENT.

The mine is equipped with a small concentrating plant, described on pages 122–123. The power house contains an 80-horsepower boiler, a compressor and engine, a 15-horsepower induction motor, a small slide-valve engine, and numerous accessories. The camp and mine are lighted by electricity.

DEVELOPMENT.

The principal developments (see fig. 9 and Pl. VIII) consist of three levels. The portal of the lowest, No. 3, is at an elevation of 3,400 feet, that of No. 2 at an elevation of 3,472 feet, and that of No. 1 at an elevation of 3,593 feet. The bottom level is 431 feet below the top of the ridge into the east side of which these levels have been run. On these levels 570 feet of crosscutting and 520 feet of drifting have been accomplished, and between the levels and the surface there are four shafts constituting over 300 feet of work. Small stopes have been made at several places in the mine. Besides these main workings there are numerous short adit tunnels, drifts, shallow shafts, open cuts, and crosscuts, the locations of some of which are shown in Plate VIII, others being scattered over the claims some distance away from the main camp.

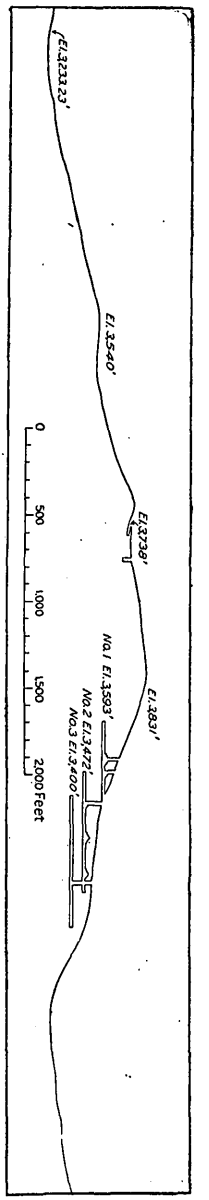


FIGURE 9.—Section through the ridge in which the main workings of the Germania mine are located.

TOPOGRAPHY.

Advantageous tunnel sites are afforded by the long, narrow ridge which rises rather abruptly above the camp on the west. This ridge is one of a series of ridges that project from the main backbone of the Huckleberry Range and terminate in lower ridges which extend down to Spokane River, 7 to 12 miles to the south. Offshoots from these ridges are numerous, and the valleys between them are narrow draws and gulches, which toward their lower parts widen out to form relatively smooth and rolling country. The highest peaks in this locality are from 4,500 to 5,000 feet above sea level; 8 miles to the west Columbia River is only 1,500 feet above the sea.

GEOLOGY.

The rocks of this locality have been discussed at length on pages 113–114. The only rock encountered in the main Germania workings

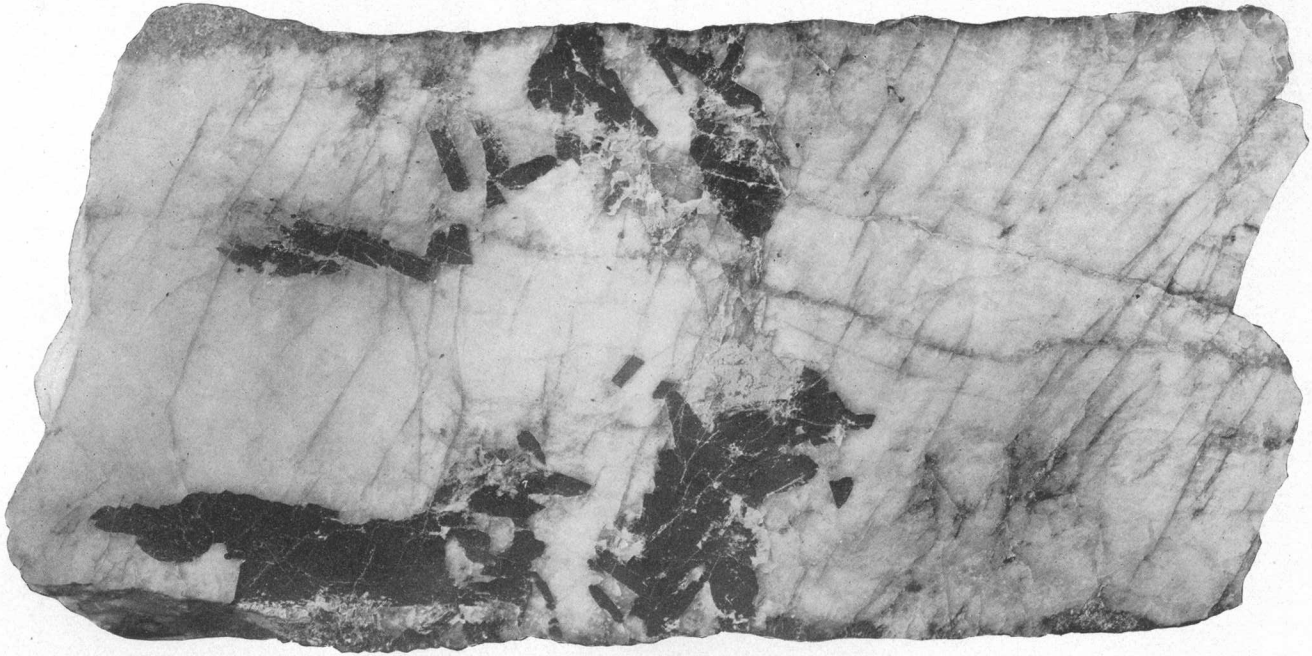
is a biotite-quartz-orthoclase granite, thought to be of Mesozoic age, intruded into the sedimentary quartz-mica schist, quartzite, dolomite, limestone, and argillite which extend throughout a large portion of the Deertrail district. (See pp. 10–22.) South and north of the Germania camp these sediments have a general north-south strike and a dip of 45° E. to 45° W. Veins carrying tungsten ore have been found in the granite and in the quartz-mica schist.

ORE DEPOSITS.

Character and distribution.—As exposed by the main workings on the Germania ground the ore deposit occupies a fissure in granite (see Pl. VII, *B*, p. 101) and has been developed underground for a distance of 400 feet along its strike and 200 feet on the supposed continuation of the vein. Its vertical extent has been proved for a distance of 193 feet and it probably extends up to the top of the ridge. Only a small part of the ore body has been stoped out. The average width of the deposit is about 2 feet, though in some places is over 3 feet wide and in others it nearly pinches out. Postmineral faulting has in several places broken the continuity of the vein. Where the movements have been transverse to the strike of the vein the faulting has apparently thrown the vein to the west, although it is said to have been thrown to the east at one place. The displacements have ranged from 7 to 30 feet. The granite exposed in the mine workings is very much jointed, and a series of block faults may exist, in which case displacements to the east would be as likely to occur as those to the west. Some faults extend parallel to the strike of the veins. Along all the fault planes more or less gouge has been developed and some secondary pyrite has been deposited.

The general strike of the vein is N. 17°–25° E. and the dip 65°–70° S. 65°–73° E. The vein filling is chiefly quartz of a massive variety which is mostly pure white but in places has a slight bluish tint. It contains also some black tourmaline and green fluorite. The vein is mineralized in an irregular, more or less pockety manner by wolframite, with which are associated considerable pyrite, some chalcopyrite, arsenopyrite, galenobismutite, molybdenite, pure-white scheelite, and secondary ferritungstite. Plate IX reproduces a piece of polished ore from this vein and shows the distribution of the wolframite and pyrite in quartz.

Quartz veins occur in several of the other workings and a few of them carry some tungsten minerals in their outcrops. These veins range from a few inches to 3 or 4 feet in width, but could not be traced continuously along their outcrops for any considerable dis-



OCCURRENCE OF WOLFRAMITE IN QUARTZ, GERMANIA MINE.

The dark crystals are wolframite, the gray pyrite, and the white quartz.

tance, owing in part to the overburden which is prevalent in this country, and in part to the lenticular character of some of the veins and to the faults which displace them. Two of the veins seen consisted almost wholly of ore minerals, containing only a little quartz and other gangue. One of these veins, 2 inches wide, is in the north tunnel (fig. 10), and the other, 4 to 6 inches wide, in an adit tunnel whose portal is located on the south side of the ridge just across the line of the Spokane Indian Reservation. Wolframite and pyrite constitute the chief minerals in both of these veins, neither of which has thus far been shown to have any considerable extent.

The ore in parts of the stopes above the main workings concentrates 20 into 1, representing a recovery said to be 88 to 90 per cent. From these figures the distribution of the tungsten minerals in parts of the vein can be fairly well appreciated. In other words, the tungsten minerals in the ore shoots represent 5.5 per cent of the vein filling. As the scheelite and ferritungstite occur in very subordinate quantities, and as the ferritungstite is a product of alteration of other tungsten minerals, the percentage given may be taken as representative of the distribution of wolframite in the ore shoots. Next to wolframite in order of abundance comes pyrite. In the portions of the vein exposed to view pyrite appeared more abundant in the upper workings than lower down.

The wolframite occurring in these veins is a brownish-black tungstate of iron and manganese. An analysis of some of the wolframite, by R. C. Wells, of the United States Geological Survey, showed it to have the following composition:

Analysis of wolframite from Germania tungsten mine.

[R. C. Wells, analyst.]

SiO_2	0.36
MnO	4.93
Fe_2O_3 as FeO	18.68
WO_3	75.73
Undetermined in Fe_2O_3	.22

This mineral inclines to ferberite and, like true ferberite, carries an excess of iron oxide. Mr. Wells states that CaO, MgO, MoO_3, and rare earths are not present in the specimens analyzed by him. The concentrates from the jigs are said to contain 68 to 72 per cent WO_3, those from the tables 60 to 65 per cent, and those from the vanner 55 to 60 per cent.

The scheelite occurring in the ores is of uncommon whiteness and appears to have crystallized contemporaneously with the wolframite, with which it is intimately associated in some of the specimens examined. Scattered through small fractures in the tungsten ores

and more noticeably through the quartz are small stringers and aggregates of thin, needle-like crystals of a mineral determined by Mr. Wells to be galenobismutite or cosalite, the mineral composition being nearer that of galenobismutite. Analyses made by Mr. Wells show the composition of this mineral to be Pb 25.24, Bi 56.92, S 17.03. As the galenobismutite carries also some silver and occurs in appreciable quantities in the vein, it might pay to save this mineral, which is now lost in concentration. An assay made by E. E. Burlingame & Co., of Denver, of run of mine quartz carrying some of this mineral showed the presence of 1 ounce of silver and 0.02 ounce of gold to the ton.

Origin of the ores.—The quartz veins containing the ores which have just been described are thought to have been derived from the intrusive granite magma. After or during the cooling of the intrusive mass fissures were formed, and these have been filled with quartz, wolframite, fluorite, and pyrite, with smaller quantities of tourmaline, scheelite, galenobismutite, molybdenite, chalcopyrite, and arsenopyrite. These minerals in the main probably crystallized about contemporaneously, and subsequent fractures have been filled to some extent by galenobismutite and secondary pyrite. The deposition of the primary minerals probably marks the close of one period of igneous activity in connection with this granite magma. The association with tourmaline is indicative of deposition under considerable heat and pressure.

TREATMENT OF ORES.

The ore goes directly from the ore bins to a 7 by 10 inch Blake breaker, where it is crushed to 1½ inches or less, thence to 10 by 16 inch rolls, and thence to revolving screens of 8 and 4 mesh. Ore which passes through the 8-mesh screen goes to a classifier; thence the sands go to a jig. The overflow goes to another classifier, the first sands from this going to a four-compartment 3-inch Richards pulsator jig, the second sands to a Card table, and the overflow to a Wilfley table. The material that will not pass the 8-mesh screen passes the 4 mesh and goes to two jigs, where coarse concentrates and middlings are made. The middlings, together with the middlings from the first jig, are elevated to Gates 10 by 16 inch recrushing rolls and thence sent through the revolving screens again. The flow sheet (fig. 10) illustrates diagrammatically the process of treatment. The drop of the first jig is 1¼ inches and of the other two 1 inch.

The company at present is considering a change in the process of treatment of these ores that will involve the substitution of revolving screens of 3, 10, 6, and 4 mesh for the 8 and 4 mesh, the addition of a sorting table, grizzlies, a larger crusher (15 by 9 inches), another ore bin, a feeder, another set of rolls, another jig, a Frue vanner, and a

Bartlett table. The flow sheet of the proposed mill is shown in figure 11, and the machinery for it is reported to be on the ground.

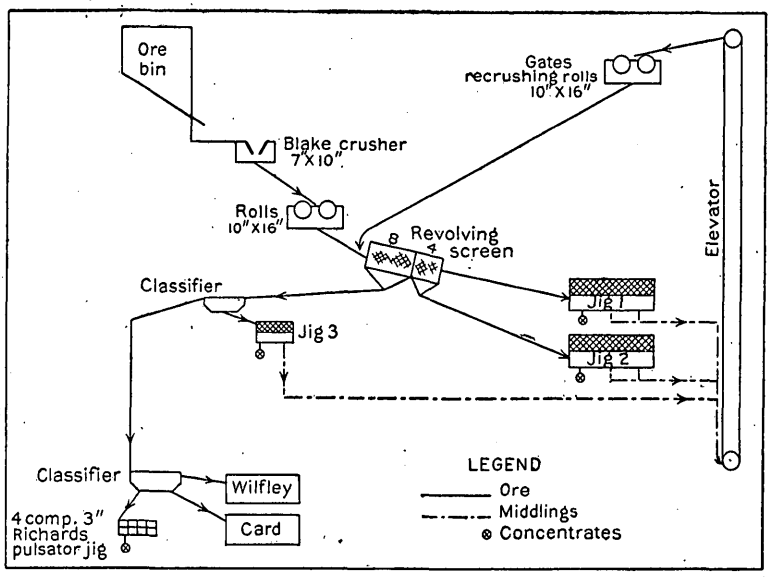


FIGURE 10.—Flow sheet of Germania mill.

The costs of mining and milling the ore are estimated by the company at $8.75 a ton of crude ore. The concentrates are shipped to

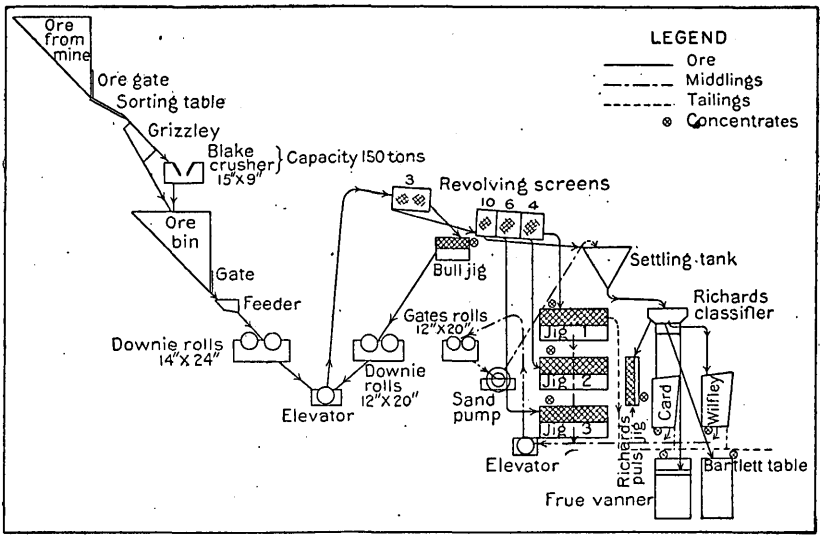


FIGURE 11.—Flow sheet showing proposed plan of treatment in the mill of the Germania Co.

Cassel, Germany, in lots of 25 to 30 tons, at a cost of $16 a ton.[1] This makes the cost of producing 1 ton of concentrates about $200.

[1] This is only $2 a ton more than the freight rate to New York City.

OTHER DEPOSITS IN STEVENS COUNTY.

The deposits described under the above heading are more or less isolated in that other deposits of note had not (up to July, 1909) been actively developed in their vicinity. As they represent widely separated localities and are mined under diverse conditions, no attempt will be made to present a general discussion of the geology and ore deposits, which will be treated in the individual descriptions.

COLUMBIA RIVER GOLD MINING CO.

General features.—The claims of the Columbia River Gold Mining Co. are located on the northwest side of Gold Hill, a domelike mountain which rises over 1,000 feet above the town of Meyers Falls, on the Great Northern Railway, 3 miles east of Columbia River and about the same distance southeast of Marcus. The lower workings, consisting of an adit tunnel and several laterals, are located at an elevation of 1,675 feet, about half a mile northeast of Meyers Falls. Water and timber are to be had in the vicinity.

Work is said to have been done on these claims intermittently since 1899 and continuously during the years 1905 to 1908. The property was idle when visited (August, 1909). Three shipments of sorted ore are said to have been made from the upper workings, 850 feet above the adit tunnel—one of 15 tons to the Granby smelter and one of 20 tons and another of 18 tons to the Northport smelter. These shipments are said to represent a total gross production of about $1,505 from this prospect.

A 50-horsepower engine and compressor, two drills, and a blower constitute the machinery at the lower workings, and a 25-horsepower hoist and a skip are installed at the upper workings.

The ore deposit has been developed by an inclined shaft, the collar of which is located near the top of Gold Hill on its southeast side, at an elevation of 2,525 feet. The shaft pitches 45° NW. and is said to be 300 feet deep and to have a 50-foot drift 150 feet below the collar. At the time of visit water filled the shaft within 130 feet of the top. An adit tunnel at an elevation of 1,675 feet on the west or northwest side of Gold Hill, near its base, has been driven 2,300 feet in a direction N. 80° E. Some 2,000 feet from the portal a crosscut has been driven at right angles to the adit for 265 feet, and from this there are several short drifts.

Geology.—The rocks exposed in the workings are a thick series of black carbonaceous shales, which strike approximately N. 60° E. and dip 45°–80° NW., the steeper inclination being more prevalent. Intercalated in these shales are strata of limestone, lime shale, and conglomerate composed of fragments of carbonaceous shale. The whole series is apparently conformable, has suffered some

dynamometamorphism, and has been locally silicified. It forms a part of the sedimentary series of rocks present throughout Stevens County. Intruded into these rocks, apparently along the lamination planes, are light and dark colored dikes having essentially a granitic composition. The dark-colored dikes are fine grained and contain also much carbonaceous matter and minute fragments of shale. The light-colored dikes are coarse grained and resemble silicified granite. Quartz and feldspar are the chief constituents of both rocks, and they are thought to have accompanied or followed the intrusive granite which is present throughout northeastern Washington. Small fragments of the rock through which these dikes have passed were taken up by the invading magma.

Ore deposit.—In August, 1909, the long crosscut tunnel had not cut the continuation of the vein which it had been driven to intersect, unless one or more of the small barren quartz veins seen in the drifts from this crosscut represent its continuation. In the 850 feet of vertical distance between the two workings the vein may have pinched out, been faulted, or changed its course completely. Not enough work had been done on the vein in the shaft to prove its persistence in any direction.

As exposed in the shaft, the vein ranges from 3 to 6 feet in width and contains lenticular ore shoots that are from less than an inch to several inches in width and from a few inches to several feet in length. The strike of the vein is N. 18° E. and the dip 45° N. 72° W., although the directions of both change to some extent in the short distance the vein was exposed. The hanging wall of the deposit is the light-colored porphyritic rock already referred to and the footwall is black carbonaceous shale. Faulting is indicated by the formation of gouge on the footwall. The gangue is chiefly brecciated country rock and gouge cemented by quartz, with some siderite and calcite. The ore minerals are chiefly chalcopyrite, pyrite, and tetrahedrite. Some molybdenite was seen in fractures in the rock.

The ores are thought to owe their origin to solutions which accompanied or followed the intrusion of the dikes, adjuncts of granitic intrusion, which cut the sedimentary rocks.

SILVER QUEEN.

The Silver Queen workings are about 3 miles south of Kettle Falls, which is on the east bank of Columbia River, and 3 miles southwest of Meyers Falls, a station on the Great Northern Railway and the nearest shipping point. The property was idle when visited and nothing is known of its early history. As only a small amount of development work has been done, the shipments must have been small, if any were made. A small compressor plant, hoist, and pump constitute the machinery installed in the shaft house.

The workings are located at an elevation of 1,970 feet on the western slope of the extreme northwestern projection of the Huckleberry Range, where it slopes gradually down to the confluence of Colville and Columbia rivers. The developments consist of an inclined shaft about 100 feet deep, which pitches 45° SE., and three short drifts from the shaft, two at the bottom and one 30 feet from the collar.

Blue and white medium to fine grained limestone and intercalated lime shale and argillite constitute the rocks in which the workings are located. These rocks are similar in many respects to those found in other parts of the area and form a part of the sedimentary series which prevails throughout northeastern Washington. They have a general northeast strike and dip about 45° SW. Minor folds were seen in the workings, so that a part of the strata stand vertical and other beds are more or less inclined. The sedimentary rocks are cut by dikes of the kind that commonly accompany granitic intrusion, and less than a quarter of a mile away from the workings is a fine-grained light-colored granite. This rock is probably also intrusive into the sedimentary series, although no actual contacts were seen.

The ore deposit occurs in quartz lenses following the lamination planes of the sedimentary rocks and ranging from a few inches to 3 or 4 feet in width. The mineralization is scanty and in general the quartz is barren, although some tetrahedrite, sphalerite, galena, chalcopyrite, and pyrite occur here and there in the quartz. The ores are thought to have accompanied solutions which were introduced by the intrusion of the granite and granitic dikes common in this part of Washington.

OLD DOMINION.

The Old Dominion Mining & Milling Co. has in the past produced about $610,000 worth of lead-silver ore. Most of this has come from the Old Dominion and Ella mines, which represent workings on claims bearing these names. For convenience the property as a whole will be referred to as the Old Dominion.

Location.—The claims are located 6½ miles almost due east of Colville, one of the largest towns on the Great Northern Railway, 89 miles north of Spokane. By wagon road they are about 7½ miles from Colville, and the elevation of the lowest level is 1,300 feet higher, or 2,925 feet. Hauling freight between the two places offers no serious difficulties, and water and timber are abundant in the vicinity.

Ten patented claims are owned by the company, and in the past it has controlled 43 others by development work concentrated on one or more of the patented claims.

History.—Patrick and William Kearney, J. Z. Alexander, and Alfred Bernoit discovered ore on this ground in 1883, while they were

descending the slope from Dominion Mountain, which they had ascended to find out their position in relation to the surrounding country. Assays of the material which they took to Spokane were encouraging and they returned and located several claims. These locations are said to represent the first recorded mineral discovery in this part of the country. Ore was packed into Spokane on horses at a cost of $100 a ton, and later was hauled in wagons at a cost of $40 a ton. It was then shipped by rail to Tacoma, Wash., or Helena, Mont. These men are said to have obtained about $400,000, almost entirely from ground within 75 feet of the surface. About 1899 the mine was transferred to E. G. Brickel, then president of the Traders National Bank of Spokane, who had lent money to the former owners. Mr. Brickel caused a mill to be erected on the ground, and during the period of his ownership the production of the mine is said to have had a value of about $100,000. After his death G. B. Dennis, of Spokane, the present owner, bought the mine from the Brickel estate in 1892 for $160,000. Mr. Dennis has informed the writer that he took out $100,000 worth of ore and has invested funds in the property, including the purchase price, to the extent of $506,000.

Equipment and development.—As the mine was idle when visited, the mill and power house were not open to inspection, and it is therefore impossible to give authentic information pertaining to the equipment of the plant. The mill is reported to have had a daily capacity of 60 tons and to have been equipped with a crusher, jigs, tables, and vanners. The power house is said to have contained an 80-horsepower boiler, an 80-horsepower engine, a 6-drill air compressor, and a blower.

The chief developments on the ore bodies consist of extensive workings on the Old Dominion and Ella claims, but these do not reach much more than 100 feet below the surface. The general elevation of these upper workings is approximately 3,375 feet, and they are 450 feet vertically above the lowest adit tunnel, which has been driven for a distance of 2,127 feet northeastward from a point just above the gulch level. The breast of this adit tunnel (September, 1909) is about 300 feet south of and a little more than 450 feet below the shaft on the Ella claim. (See fig. 12.) From the breast nearly 3,000 feet of crosscutting has been accomplished. Level No. 2, which is 157 feet above No. 1, is about 500 feet long, and level No. 3, which is 93 feet above No. 2, has also about 500 feet of work. A prospectus issued by the company states that over 13,000 feet of development work has been done.

Topography.—Dominion Mountain is the most prominent peak in the vicinity of Colville and forms one of the noticeable landmarks in this part of the Calispell Range. Its sides are bare, and as it is

rather isolated, its domelike form is very conspicuous. The elevation of the summit has been stated to be about 4,500 feet above sea level, but no accurate surveys have been made. Certainly it rises several hundred feet above the highest workings on the Old Dominion group. Dominion Mountain forms one of the western outliers of the Calispell Range, with which it is connected by a series of ridges and less prominent peaks.

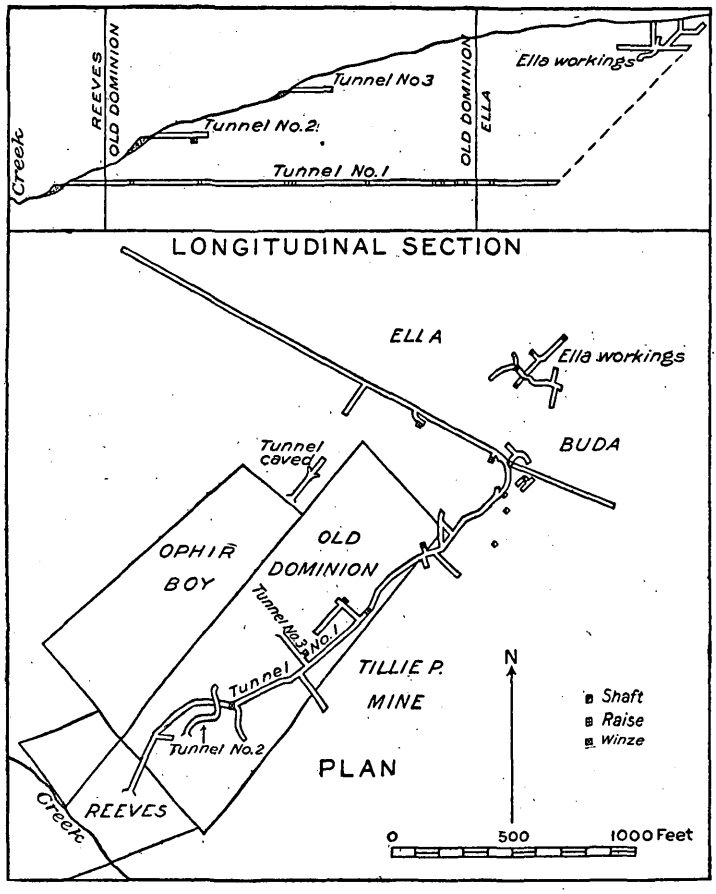


FIGURE 12.—Longitudinal section and plan of the Old Dominion workings, adapted from prospectus issued by the company.

Geology.—The rocks seen between Colville and the Old Dominion mine are a part of the sedimentary series of argillite, lime shale, limestone, dolomite, etc., which prevail over a larger portion of northeastern Washington. In the immediate vicinity of the Old Dominion mine limestone and dolomite are the only representatives of this series. These rocks are intruded by dikes of normal biotite-orthoclase-quartz granite, which is remarkably similar to the granite intruding the sediments in most of the other mining districts within the area studied.

Pure white marmarized limestone seems to be the predominant rock. It is highly recrystallized and in places is very siliceous, having been almost completely replaced by silica. Some of the limestone is highly magnesian and could be classed as a dolomite. The strata have retained their original bedding planes throughout the dynamometamorphism which has greatly changed their original texture and position. They now strike northwest-southeast and stand nearly vertical, and their planes of lamination are parallel to the intrusive granite on the northeast. The limestone is considerably broken up near the contact with the granite and the brecciated fragments are cemented by silica. Contact-metamorphic silicate minerals are absent, and this fact suggests that the intrusion of the granite took place at no great depth.

Various phases of the intrusive granite are present near the Old Dominion workings. In the vicinity of the surface cuts on the Ella and Old Dominion claims the intrusive rock is considerably altered, consisting of quartz, very much altered feldspar, and entirely altered ferromagnesian minerals, present only as chlorite and limonite, which stain the granite to a greenish or yellowish color. Lower down, in the fresher phases, the alteration is confined chiefly to the ferromagnesian minerals, which are completely changed to chlorite. Still lower down, in the No. 1 adit tunnel, fresh granite is found. Viewed in thin section under the microscope the fresh rock is seen to consist of orthoclase and oligoclase, with some albite, quartz, and biotite, all the mineral constituents showing only slight alteration. Some white mica and chlorite are present, the former resulting from the alteration of the feldspars and the latter from biotite.

Ore deposit.—Ore bodies in limestone, having an irregular lenticular shape and generally pitching only about 20° into the hill, have been stoped out in various workings located on the Old Dominion and Ella claims. These deposits and others have been found at places 2,500 feet apart along the strike of the granite intrusion, within a horizontal distance of 125 feet of the contact. The richest deposits occurred within 100 feet of the surface. Other deposits were nearly vertical, following the general trend of the intrusive granite. Some of the stopes extend for 300 feet along the strike of the contact; others are smaller. They have an average width of 6 to 8 feet. In horizontal extent at right angles to the contact the flat-lying ore bodies average less than 30 feet. All the ore bodies were connected by a network of fissures and joints, the fissures being largely filled with brecciated limestone fragments cemented by silica. Post-mineral faults are reported but were not seen because it was impossible to inspect many of the workings. Adit tunnels Nos. 1, 2, and 3 were mostly inaccessible. It was possible to examine No. 1 to a point 500 feet from the portal, but at that point the tunnel was caved.

The mineralization was an irregular replacement of the limestone, which was more highly mineralized along fractures than elsewhere. The ores in the upper workings are said to have been galena and rich secondary silver sulphides, together with cerusite and anglesite. Sphalerite was found in the lower levels, and an ore body containing chiefly pyrite is reported to have been found in the lowest level. The gangue minerals are quartz, calcite, and siderite. Shipments from the upper workings showed the ore to contain 100 to 400 ounces of silver to the ton and 13 to 60 per cent of lead.

Solutions accompanying or following the intrusive granite no doubt formed these deposits. They are exceptionally rich near the surface and if they extend to any considerable depth will probably be found to decrease greatly in value. They are also not likely to prove continuous over great distances. In the vicinity of the intrusive granite dikes there may be other rich deposits near the surface, which have not yet been discovered. Sphalerite will probably increase in proportion if deposits lower down are worked, and this in turn will probably give way to pyrite. (See discussion on the genesis of the lead and zinc ores, pp. 26–27.) The future of the mine lies in finding other replacements and mineralized fractures in the limestone near the surface along the strike of the intrusive granite dikes.

TUNGSTEN KING.[1]

The Tungsten King claims are 30 miles a little west of north of Spokane, in the SE. ¼ sec. 16, T. 30 N., R. 42 E. This is about 10 miles almost due north of Deer Park and 5 or 6 miles northeast of Loon Lake, both of which are stations on the Great Northern Railway. There is a good wagon road from Deer Park to a point within 2 or 3 miles of the deposits, and from this point a road has been constructed to the claims.

The topography of the region is characterized by broad valleys and gentle slopes. Glacial débris is scattered over most of the mountains, and the valleys are choked with it. The country is well timbered and watered.

The deposits are located at an elevation of 3,500 feet near the head of a small gulch on the southeast side of Big Blue Grouse Mountain. (See fig. 13.)

A continuation of the mountain extends eastward for about a mile and forms Little Grouse Peak. These two peaks constitute the southwestern extension of the dividing range between Burnt Canyon and Ecks Creek and are a part of the Calispell Range. The top of Big Blue Grouse, the highest mountain in the immediate vicinity, is probably not over 3,800 feet above sea level; the elevation of the valley in which Deer Park and Loon Lake are located is approximately 2,200 feet.

[1] Reprinted largely from Bancroft, Howland, Notes on tungsten deposits near Deer Park, Wash.: U. S. Geol. Survey Bull. 430, pp. 214–216, 1910.

The rocks in the vicinity of the deposits are principally arenaceous shales, probably of Paleozoic age, metamorphosed to quartz-mica schists of various colors. The original bedding planes of the rocks do not appear to have been greatly changed, being very even, with fairly uniform structure. The rocks are deeply oxidized and the various colors, from white to red and yellow, seem to be due to the amount and degree of oxidation of the iron present in the schists. The dip of the rocks is about 30°–60° SW., and the strike is to the northwest, but there are many minor and in places abrupt changes in both strike and dip.

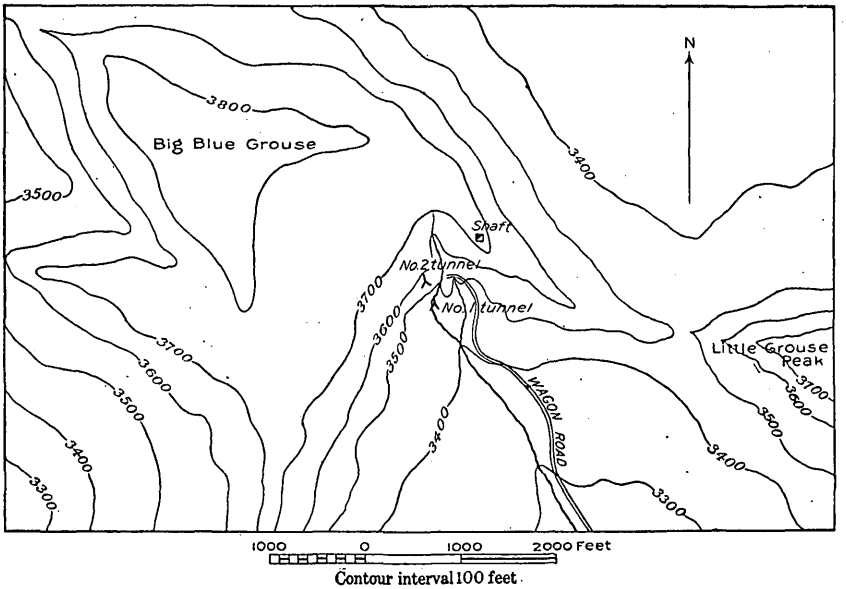


FIGURE 13.—Sketch showing the relative position of the Tungsten King prospect and Big Blue Grouse Mountain.

A short distance to the northeast granite has been found, but no contacts of this rock and the schist were visible, so that the true relations of the two can not be positively stated. The schists are said to dip away from this granite in all directions, the granite probably being an intrusive mass.

The Tungsten King claims have been opened by two short prospect tunnels about 50 feet apart vertically, an 80-foot inclined shaft 250 feet above the lower tunnel, and several shallow open cuts. (See fig. 13.) The workings are scattered, and so far no large shipments have been made.

The ores occur in lenses of quartz which follow in general the bedding planes of the shales and in small fissures similarly filled that cut across the country rock. A number of the quartz lenses are opened in the workings, and, as exposed along the outcrop, they show a thickness of 1 to 6 feet. The outcrops are largely covered by débris but a few of the quartz lenses can be followed on the surface for a hundred

feet or more. The gangue is composed entirely of quartz, generally white but here and there smoky and in many places iron stained.

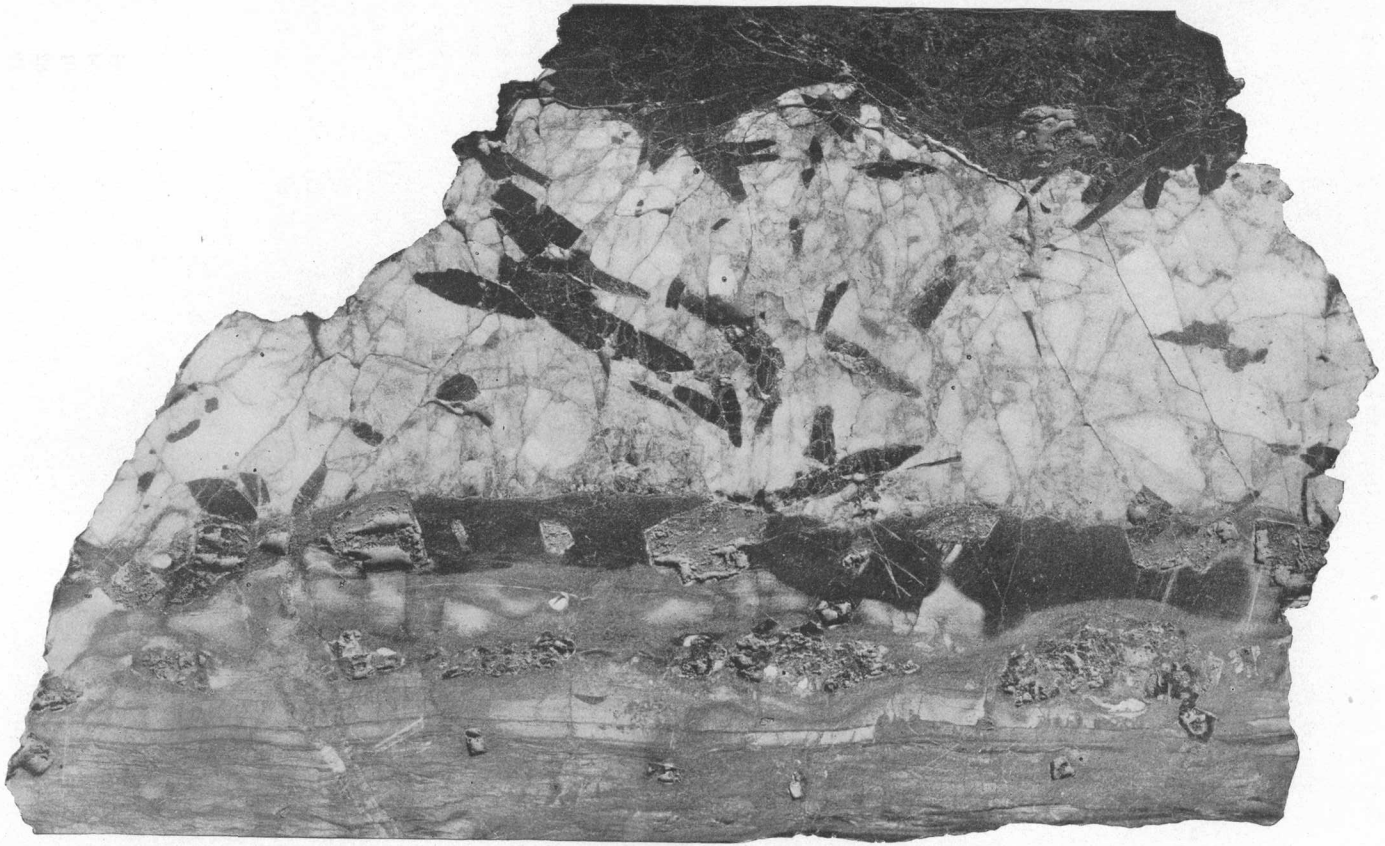
A partial analysis of the tungsten mineral, by R. C. Wells, of the United States Geological Survey, showed the presence of 23.9 per cent of MnO, which indicates a typical hübnerite.[1] The crystals of hübnerite are commonly twinned and form in places along the walls of the vein in bunches over an inch thick, smaller crystals being scattered through the quartz in an irregular fashion. They are also present in most of the outcrops of the lenses. Plate X is reproduced from a photograph of a part of one of the veins. The crystals of hübnerite are easily distinguished, and their occurrence in the quartz vein is clearly shown. The country rock seems to be quite free from hübnerite. In general the quartz lenses are rather lean. Here and there, however, fairly massive bunches of hübnerite can be seen; the most conspicuous of these noted in July, 1909, was at the foot of an inclined shaft, where a small shoot 2 inches wide extended across the bottom of the vein for a distance of 6 feet. The quartz veins have been broken and fractured since the deposition of the minerals, and minute fissures extend across the ledges and country rock.

The other metallic minerals present are pyrite and argentiferous cosalite, of which the latter might possibly be economically important. Although in places the hübnerite and cosalite occur together, this association is not common, the bismuth mineral, it is said, being found mainly in the lenses, which are down in the gulch, and not occurring in the workings high up on the hill, although there seems to be no logical reason for its absence in these outcrops. Like the hübnerite, the cosalite is scattered through the quartz, though apparently not so abundant. The crystals are long and fibrous and have about the hardness of gypsum, the weathered surfaces of the bismuth mineral being rather yellow and resembling antimony oxide. A picked specimen of ore contained, according to an assay made by Ledoux & Co. for the United States Geological Survey, 27.20 ounces of silver and $2.48 in gold to the ton. A specimen of cosalite was examined by R. C. Wells, of the Survey, who has furnished the following analysis. The second column represents the analysis reduced to gangue-free basis, without moisture.

Analysis of cosalite from Tungsten King claims.

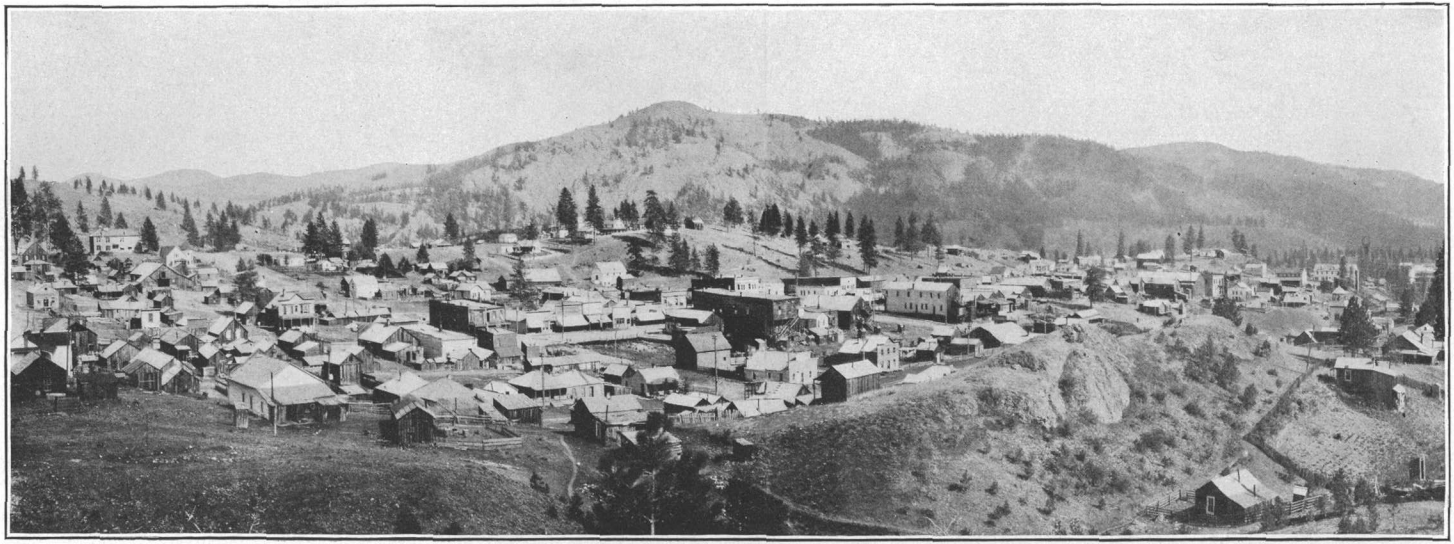
Moisture	0.17	
Gangue	2.19	
Bismuth	45.25	46.44
Lead	33.66	34.54
Sulphur	16.58	17.01
Silver	.80	.82
Copper	1.16	1.19
	99.81	100.00

[1] The theoretical limit is 23.4 per cent MnO. This specimen may have contained some oxide.



QUARTZ LEDGE IN QUARTZ-MICA SCHIST, TUNGSTEN KING MINE.

Showing distribution of hübnerite in the vein



PANORAMA OF REPUBLIC, WASH.

The composition above given is intermediate between that of galenobismutite and that of cosalite, but nearer cosalite, whose theoretical composition is $2PbS.Bi_2S_3$ (S 16.1, Pb 41.8, Bi 42.2). Galenobismutite has the formula $PbS.Bi_2S_3$ (S 17.08, Pb 27.6, Bi 55.40). Mr. Wells thinks it doubtful if the molecular ration has any definite meaning in minerals of this character, and says: "Possibly the two sulphides, PbS and Bi_2S_3, are capable of forming solid solutions of one in the other or have been precipitated together from a state of colloidal solution."

Pseudomorphs of hematite and limonite after pyrite are present in large numbers in the wall rock and in the quartz lenses. These crystals vary from those of microscopic size to 2-inch cubes, and the pyrite is in all stages of alteration. In places the pseudomorph itself is nearly decomposed and only the skeleton of the crystal remains. These cubes are developed on a larger scale in the vein than in the wall rock, into which they seem to extend only a foot or so. In the immediate vicinity of the quartz ledges the country rock is locally silicified and highly stained with iron oxides.

The origin of the deposits is probably due to the waters which accompanied the intrusion of the granitic rock a short distance to the northeast.

In view of the scattered nature of the ore and the haul of 10 miles to the railroad station, concentration at the claims would probably be advisable.

FERRY COUNTY.

REPUBLIC (EUREKA) DISTRICT.

By WALDEMAR LINDGREN and HOWLAND BANCROFT.

LOCATION AND EXTENT.

The Republic mining district, formerly known as the Eureka district, is located in Ferry County, near the western border of the area covered by this reconnaissance. (See fig. 2, p. 39.) Republic, the principal town in the district (Pl. XI), is 24 miles south of the international boundary. The boundaries of the district are recorded in the office of the county clerk of Stevens County and are reported from that office as follows:

> Beginning at the dividing line of Stevens and Okanogan counties at a point where the said county line leaves the dividing line between the north half of the Colville Indian Reservation, thence north on said county line 21 miles, thence due east to the summit of the highest range of mountains dividing the watersheds of Kettle River and Columbia River on the east side and Curlew Creek and the Sanpoil River on the west side, following the summit south to the dividing line of the north half and the south half of the Colville Indian Reservation, thence west to place of beginning.

As thus outlined the district occupies an area of about 440 square miles. This includes the area occupied by the Belcher mining district (described on pp. 166–179). Much of the Republic district was not studied in detail in the present investigation.

Plate XII is a geologic and topographic map of an area of 32.8 square miles, which forms a part of the Republic quadrangle as mapped by the United States Geological Survey and includes within its boundaries the principal mines in the Republic district.

MEANS OF ACCESS.

Republic, the principal town of the district and the county seat of Ferry County, is located about 1 mile southeast of the center of the area mapped on Plate XII, just east of the confluence of Eureka Gulch and Granite Creek, the latter emptying into Sanpoil River about a mile southeast of the center of the town. Along Eureka Gulch, which has a direction approximately north and south, and the lower part of Granite Creek, for 6 miles northward from the Sanpoil, are located the principal producing mines of the district.

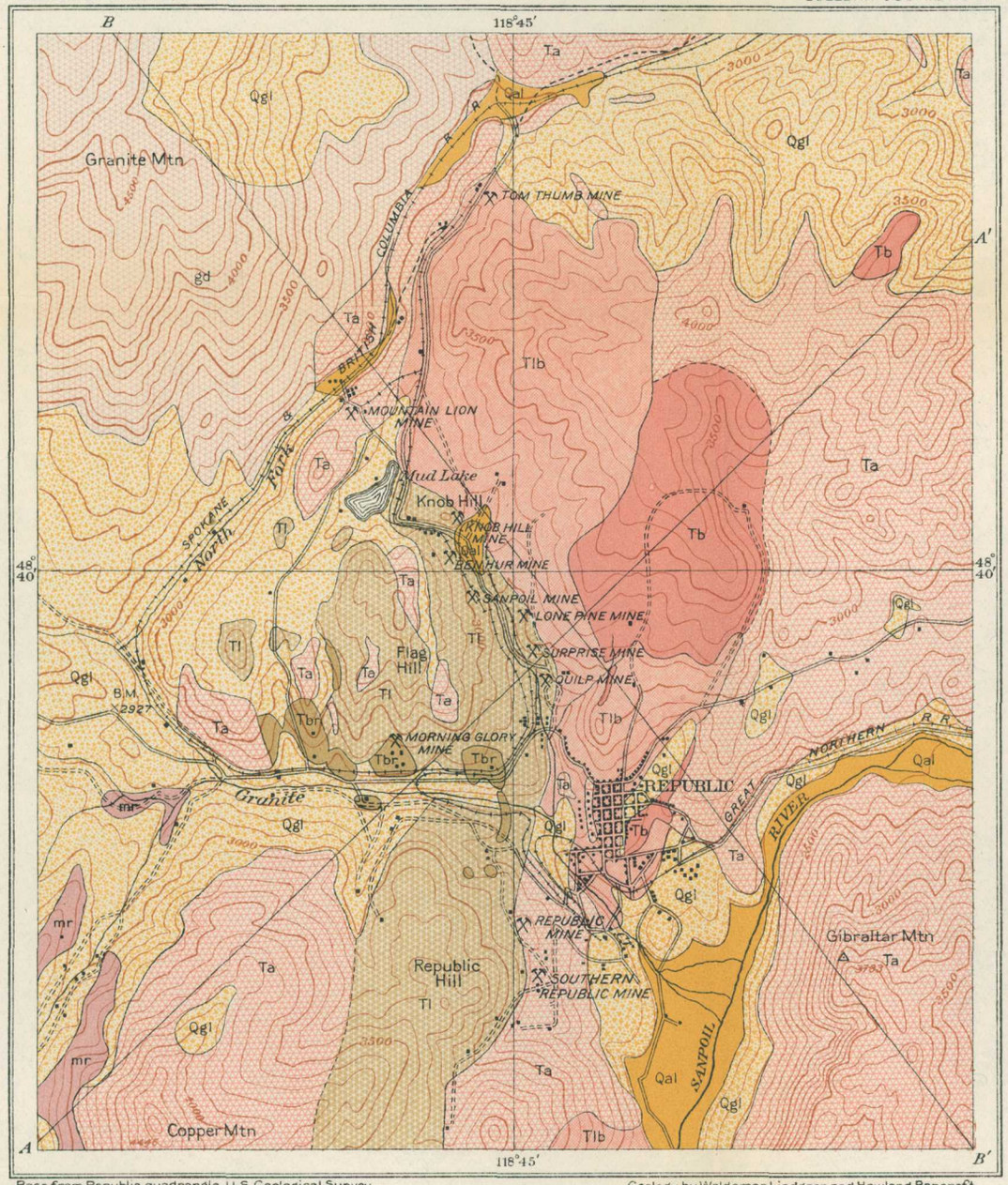
The Great Northern Railway runs daily freight and passenger trains to Republic, and the Spokane & British Columbia Railway maintains a triweekly service between Republic and Danville. A railroad has been surveyed down Sanpoil River, and if completed will place the district in more direct communication with Spokane.

During the investigation Republic was said to have a population of 1,500 inhabitants. Electric light and water are supplied to the town by the North Washington Power & Reduction Co.

HISTORY OF THE DISTRICT AND CONDITION OF MINING INDUSTRY.

M. H. Joseph, who has long been a resident of Republic, has written several papers on the camp. The following historical data are taken mainly from Mr. Joseph's article "Mines in Ferry County," published in the Republic News-Miner August 27, 1909, and from Bulletin 1 of the Washington Geological Survey, written by Joseph B. Umpleby in 1910.

The Republic camp first became actively prospected immediately after the opening of the north half of the Colville Indian Reservation, February 21, 1896. Although it was locally well known that this district contained some prominent lodes, few people were on hand to stake out claims when this part of the reservation was formally thrown open to mineral locations. On February 21 the Black Tail, Sanpoil, Lost Lode, Copper Bell, Iron Mask, Lone Pine, Last Chance, Trail, Tenderfoot, and Macawber were staked out. Four of these are said to have been staked by Philip Creasor and Thomas Ryan, who were among the first to locate claims. On March 5 these men located the Republic. The Mountain Lion, Quilp, Pearl, Surprise, Black Tail, North Sanpoil, Ben Hur, Trade Dollar, Little Cove, Knob Hill, Princess Maud, Morning Glory, and many other locations were made in the early days of the camp.



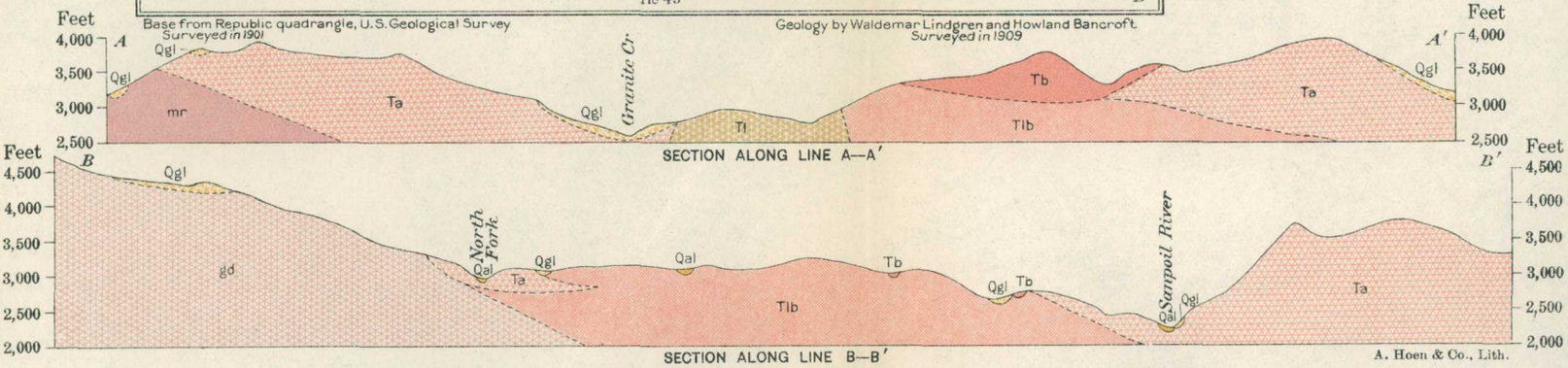
LEGEND

- Qal — Alluvial deposits
- Qgl — Glacial deposits and stream gravels
- Tb — Basalt, *Lava flow*
- Tbr — Breccia-conglomerate of sedimentary and igneous rocks
- Tl — Quartz latite porphyry, *Intrusive*
- Ta — Andesite, *Lava flows and breccia*
- Tlb — Lake beds, *Tuffaceous in part*
- gd — Granodiorite
- mr — Metamorphic rocks (*Shales, limestone, quartzite, and greenstone*)
- Mine

QUATERNARY; TERTIARY; CENOZOIC; MESOZOIC; PALEOZOIC

Base from Republic quadrangle, U.S. Geological Survey
Surveyed in 1901

Geology by Waldemar Lindgren and Howland Bancroft
Surveyed in 1909



A. Hoen & Co., Lith.

GEOLOGIC MAP AND SECTIONS OF THE REPUBLIC MINING CAMP, FERRY COUNTY, WASHINGTON

Scale 1/62,500

1 ½ 0 1 2 Miles

Contour interval 100 feet
Datum is mean sea level

1914

Although the results of the assays on the first samples taken from the district are reported to have been rather discouraging, a little further prospecting uncovered ore which gave returns showing higher values. Within a few years three mills had been erected in the district, treating rather unsuccessfully much of the ore from the camp. A "boom" was inaugurated and the activity in stock manipulation was at its height in 1899. The collapse soon followed.

Umpleby[1] says:

> Active mining continued up to the spring of 1901, when the large custom mill and also the Republic mine were closed down. From that time until the coming of the railroads in 1902 and 1903 little work was done. But with ready transportation to British Columbia and coast smelters operations revived, and for some time shipments approximating 1,000 tons a week were made. This did not continue long, however.

Operations were spasmodic until 1909, when more or less favorable contracts were made with various smelters, and operations were resumed in a more systematic manner. In 1910 work was commenced on the construction of a mill by the North Washington Power & Reduction Co., a description of which will be found on page 7. At the time of writing (December, 1911) the Republic camp is attracting considerable attention, and regular shipments are being made by several mining companies.

PRODUCTION.

The production of the Republic camp was estimated by M. H. Joseph in August, 1909, to be $3,051,000. In Mineral Resources, published by the United States Geological Survey, the production from the Republic district for the year 1910 is given as $813,686, and the total gold production for the State for the same year as $788,145. It was estimated that the production for the camp for 1911 would approximate $1,000,000. This makes an estimated total production up to January 1, 1912, of about $5,000,000. Of this probably 83 per cent represents gold and the remainder silver. The chief producer in the early days was the Republic mine. At the present time the Republic Mines Corporation, controlling the Pearl Consolidated group of mines (Pearl, Surprise, Lone Pine, etc.), leads in output. Other important producers are the Knob Hill, Insurgent, Imperator, Quilp, Sanpoil, and Hope.

The statistical records of the Geological Survey from 1903 show the production following.

[1] Umpleby, J. B., Washington Geol. Survey Bull. 1, p. 33, 1910.

Production of gold and silver in Republic district, 1903–1912.

Year.	Gold.	Silver (fine ounces).	Total value.	Crude ore (short tons).
1903	$270,377	148,570	$348,841	35,284
1904	104,114	36,411	133,091	22,448
1905	86,053	34,945	87,157	9,540
1906	69,957	26,348	87,620	6,263
1907	1,500	10,933	8,825	195
1908	16,365	4,977	19,533	584
1909	209,114	53,644	237,931	11,299
1910	713,604	185,312	813,686	33,781
1911	772,874	181,574	868,108	44,322
1912	594,873	149,752	686,971	40,775
	2,838,831	832,466	3,291,763	204,491

Besides the silver and gold a little copper and lead are reported, but these metals were probably derived from deposits outside of the district proper.

MINING.

In 1912[1] ore amounting to 27,442 short tons was shipped to the smelters and averaged $20.26 a ton. The remainder of the ore mined, 13,353 tons, was cyanided with an average recovery of $10.03 a ton. Two mills were in operation in the district.

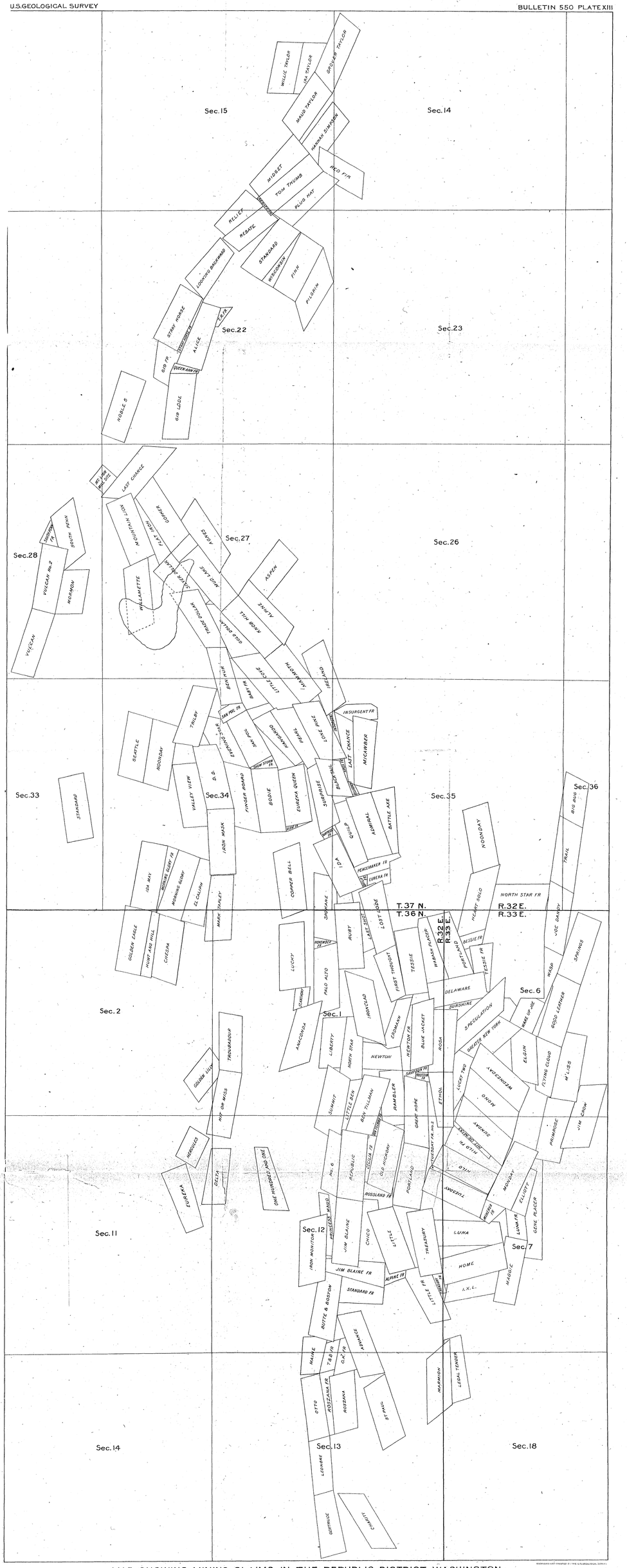
In 1913 only one mill, the Sanpoil, was in operation. The producers in the district during the year were the Ben Hur, Sanpoil, Knob Hill, Republic Mines Corporation, Hope, Old Republic, and Quilp.

In that part of the Republic district which has been most thoroughly prospected the topography is not rugged, the slopes of the hills along Eureka Gulch are not very precipitous, and the highest parts of the principal veins that have been worked are from 200 to 400 feet above the gulch. Mining by adit tunnels is effective only for those parts of the veins which lie above the gulch levels. In the past much of the development has been carried on by means of crosscut tunnels, although many of the claims have been worked by vertical shafts and a few by inclined shafts. As the producing mines in this locality have been fairly well explored above the gulch level, future operations will necessarily be carried on by means of shafts. The ground-water level is roughly that of the gulch bottoms, and operations below this level must therefore be accompanied by pumping or hoisting water. The universal method of extracting ore in this district consists in drifting on the veins and subsequent overhand stoping. Plate XIII shows the mining claims in the Republic district.

METALLURGY.

The subject of treating the ores of the Republic district has evoked considerable discussion among the local mining men, who have made

[1] Gerry, C. N., U. S. Geol. Survey Mineral Resources, 1912, pt. 1, p. 920, 1913.



MAP SHOWING MINING CLAIMS IN THE REPUBLIC DISTRICT, WASHINGTON

REDUCED FROM OFFICIAL MAP BY S. RICHARDSON

1000 0 1000 2000 Feet

numerous milling experiments. Thus far, for one reason or another, the processes adopted have proved inadequate in that they effected too low a saving in the separation of the precious metal contents from the gangue.

The following articles represent the available published data on the milling practice of this camp:

Joseph, M. H., The Republic mine, Washington: Eng. and Min. Jour., Nov. 5, 1898; Dec. 16, 1899.

Chatard, T. M., and Whitehead, Cabell, An examination of the ores of the Republic gold mine, Washington: Am. Inst. Min. Eng. Trans., vol. 30, pp. 419–423, 1901.

Cirkel, Fritz, Treatment problem of the Republic (Wash.) gold ores: Eng. and Min. Jour., Feb. 1, 1908.

Umpleby, J. B., Washington Geol. Survey Bull. 1, pp. 35–37, 1910.

Morse, E. C., The Sanpoil mine, Republic, Wash.: Am. Inst. Min. Eng. Trans., vol. 43, p. 697, 1913.

Thomson, F. A., Ore treatment at Republic, Wash.: Am. Inst. Min. Eng. Trans., vol. 43, p. 672, 1913.

Mining and Scientific Press, Aug. 24, 1912, p. 235.

A study of the ore from the Republic camp indicates that little trouble would be experienced in separating the precious metals from the gangue if the ore could be more finely ground than it has been in previous treatment. The mill of the North Washington Power Co. has been designed with this feature of the process as an important if not the dominant factor, and it is to be expected that the savings will exceed 94 per cent of the total gold. A description of this mill is given on page 7.[1]

TOPOGRAPHY.

With the exception of the west side of Gibraltar Mountain, which is rather steep, the slopes in this area are not precipitous. There is much evidence of glacial activity within the district. Sanpoil River and Curlew Creek drain that part of the area here discussed, the chief tributaries to these streams being Deer Creek and Granite Creek. Sanpoil Lake, located just east of the area mapped, is unique in that streams flow from it in opposite directions, this lake being the head of Sanpoil River, which flows south, and Curlew Creek, which flows north.

Granite, Copper, and Gibraltar mountains are the three highest peaks in the area, their tops being respectively 5,326, 4,446, and 3,783 feet above sea level. The stream valleys within this area have a minimum elevation of 2,250 feet and a maximum of 3,000 feet, showing the gradient to be rather steep. The fall in Granite Creek is 750 feet in less than 7 miles. (See Pl. XII, p. 134.)

[1] The results obtained in the two new mills since the above was written have justified the hopes expressed, and recoveries of over 90 per cent are reported. However, the North Washington mill was not operated in 1913.

Many interesting physiographic problems are presented by this area. Stream courses have been changed, lakes have been formed as the result of glacial activity, and the area seems to afford much information on the correlation of the Eocene peneplain. As a discussion of these problems is beyond the scope of a bulletin devoted primarily to a study of the ore deposits, the reader is referred to the following publications for information on the physiography of northeastern Washington:

DAWSON, G. M., Royal Soc. Canada Trans., 1890.
SMITH, G. O., and WILLIS, BAILEY, U. S. Geol. Survey Prof. Paper 19, 1903.
SMITH, G. O., and CALKINS, F. C., U. S. Geol. Survey Bull. 235, 1904.
UMPLEBY, J. B., Washington Geol. Survey Bull. 1, 1910.
——— Jour. Geology, vol. 20, pp. 139–147, 1912.
——— U. S. Geol. Survey Bull. 528, 1913.

GEOLOGY.

ROCKS EXPOSED.

Within that part of the Republic area mapped on Plate XII are rocks that are thought to belong to the Paleozoic, Mesozoic, and Cenozoic eras. The Paleozoic rocks consist of metamorphic shale, limestone, marble, quartzite, and greenstone. These form a part of the series that is so prevalent throughout northeastern Washington and are tentatively assigned to the Carboniferous period.

The granular intrusive rocks throughout the northeastern part of the State have been classed as Mesozoic and are probably of Cretaceous age. In the Republic district Granite Mountain is thought to represent a batholithic intrusion that probably took place during late Cretaceous time.

Cenozoic rocks are more prominent in the vicinity of Republic than those of any other era. These rocks include a succession of Tertiary lava flows, lake beds, and intrusive rocks, probably of Miocene and Pliocene age, and Quaternary detrital material of glacial and stream origin.

GEOLOGIC HISTORY.

The events of Paleozoic time are recorded in this area by interbedded shales, limestones, quartzites, and greenstones, all but the last of which were formed by sedimentation in deep water. The greenstones may represent flows that were contemporaneous with the sedimentation or later rocks intrusive into the beds of this series. Elevation of the land and the subsequent erosion of broad valleys mark the close of this era. In Mesozoic time the granodiorite batholith was intruded into the Paleozoic rocks and was severely eroded before the formation of the Tertiary lake beds and eruptive and intrusive rocks. Consequently, the Tertiary rocks occupy uneven eroded surfaces and their outlines probably conform in a rough way

to the preexisting valleys. Extensive lake beds, andesitic flows, intrusive quartz latite porphyry, and breccia-conglomerate mark the upper Miocene epoch. Erosion of these formations was followed by a flow of basalt, which is of widespread occurrence in northeastern Washington. During the Quaternary period occurred extensive glaciation followed by stream erosion.

A more detailed account of the geologic history is given in the general section on the geology of northeastern Washington (pp. 20–21).

PALEOZOIC ROCKS.

Within the area studied in detail the Paleozoic rocks are found in the southwest corner and outcrop over less than 1 square mile, being surrounded on all sides by glacial débris or andesite. This series extends several miles to the southwest, and metamorphic rocks are known to extend several miles beyond the eastern border of the area with a general north-south strike, and in fact they occupy the larger part of the Republic quadrangle. Below the Tertiary rocks the Paleozoic metamorphic rocks undoubtedly extend beneath the whole of the Republic camp, the late Tertiary lavas occupying an old erosional valley in the Paleozoic rocks. Mining developments have not yet pierced the bottom of the Tertiary flows, so that it is impossible to state to what depth the metamorphic rocks are buried below the present gulch levels. The east side of the trough is marked by the outcrops of Paleozoic metamorphic rocks on the east side of Sanpoil River a short distance beyond the limit of the area here mapped.

The metamorphic rocks near Republic form a part of the great series of Paleozoic strata which occupies the major portion of northeastern Washington. In general the series is composed of interbedded shales, limestones, in places marmarized, and quartzites, with a few greenstones. The shales range from fine to medium grained in texture and are represented by quartz-mica schist or clay shales. In color these rocks when fresh range from dark gray or black to lighter grays and dull green. The series strikes north and south; the dips, which can in few places be observed, with local variations, seem to be at 40°–60° E. or NNE. The series is limited on the west by the granodiorite intrusive, the contact of which lies a short distance west of the boundary of the area mapped. The actual contact is obscured by glacial débris, but no strong contact metamorphism was observed, and a limestone lens that lies within a few hundred feet of the contact on the south side of Granite Creek presents little evidence of alteration.

Black clay slate is exposed along the bluffs of Granite Creek, due north of Copper Mountain. Close by is a dull-greenish rock with large crystals of dark-green hornblende which proves to be a uralitic

and chloritic diorite. The large exposures in the southwest corner of the area mapped consist mainly of dark-green diorite, quartz diorite, and amphibolite.

Limestones are exposed in two lenses probably not connected. One lies just west of the boundary line south of Granite Creek; it is about 125 feet wide and can be traced for 600 feet southward. A limekiln erected here provides the district with quicklime. The limestone is light gray, fine grained, and so fractured that it is difficult to procure good specimens. The second lens lies just east of Middle Copper Lake and rises 150 feet above its surface, forming a prominent light-gray shoulder or bluff projecting from the slope of Copper Mountain. Its width is about 200 feet and it is traceable for about 300 feet. On both sides it is adjoined by clay slate. Imperfect crinoid stems were found in this rock. In appearance this lens is similar to that described above.

MESOZOIC ROCKS.

The granular intrusive rock which forms Granite Mountain is probably contemporaneous with the many other batholithic granular rocks found throughout northeastern Washington. A more complete description of these rocks will be found on pages 16–18. The southeastern portion of Granite Mountain, an area of about 4 square miles, lies within the area mapped.

The weathered surfaces of this rock are dark gray to brown in color, the altered femic minerals in places having stained the decomposed upper portions to a brownish or reddish hue. The rock is not of even grain, the feldspar phenocrysts ranging from less than one-sixteenth inch to over 1 inch in length and the whole rock mass varying correspondingly in texture. At some localities on Granite Mountain the rock is extremely fine grained and elsewhere it is coarsely granular. Besides feldspar and quartz it contains much biotite and some hornblende. Under the microscope the main constituents are seen to be andesine and orthoclase with some microperthite and microcline, quartz, biotite, and partly uralitized augite. The accessory minerals are pyrite, apatite, titanite, and magnetite. The plagioclase is idiomorphic and between these crystals lie grains of quartz and orthoclase. The rock is classed as a granodiorite.

The intrusion of granodiorite took place in pre-Tertiary time, and an interval sufficient for deep erosion elapsed before the advent of the Tertiary lavas. It seems probable that the batholith is of Cretaceous age.

TERTIARY ROCKS.

General character.—The abundant lava flows, porphyritic intrusions, lake beds, and breccias in the Republic camp are of Tertiary age. These formations represent over three-fourths of the out-

cropping rocks in the area mapped and cover roughly 23 square miles. As the economic geology of the Republic camp is intimately connected with the Tertiary flows and intrusive rocks they will necessarily be described more in detail than the other formations. Only at one other locality in northeastern Washington, the First Thought, in the Orient district, is the mineralization definitely connected with Tertiary volcanism, but it is impossible to correlate the rocks in the two districts. However, they are thought to be closely related and they have many characteristics in common. The rhyolite porphyry of the First Thought camp is similar in many respects to the quartz latite porphyry of the Republic district, needing only a little more plagioclase to throw it into the quartz latite porphyry class. Although the andesitic flows are rather widely distributed in the Republic district the intrusive quartz latite porphyry seems to have been confined to comparatively small areas.

As will be shown in the following paragraphs the andesitic series of flows and the latite porphyry intrusive in it constitute a closely allied series of intermediate rocks that are decidedly too rich in potash for normal andesites. It is now well known, however, that this peculiarity is shared by most of the so-called andesites in the Cordilleran region.

The andesite flows of the Republic district fill an old pre-Tertiary erosion valley and probably continue northward far beyond the Canadian boundary. They are conspicuous west of Curlew Creek, and appear to follow the Kettle River valley to the boundary. They have been mapped for 12 miles north of this line, the belt here lying west of Boundary Falls and Greenwood.[1]

Lake beds.—Lake beds, in part tuffaceous, are exposed throughout much of the central portion of the area mapped, where they occupy a north-south zone having a maximum width of 1⅓ miles as exposed on the surface. In two places the thickness of these beds as mapped exceeds 800 feet. They dip in general to the northeast and are thought to extend for some distance under the andesite and basalt flows, filling the old erosional valley. In places they overlie some of the older rocks of the andesitic series. In general these beds are of a buff or gray color and include strata of sandstone, shale, and andesitic tuff. The material is generally fine grained.

Fossils collected from the lake beds were determined by F. H. Knowlton as *Sequoia langsdorfii* (Brongniart) Heer, Carpinus, Ulmus, Aralia, and Ficus. Mr. Knowlton comments on these fossils as follows:

> This material I presume to be from the lake beds of this vicinity—in any event it is quite different from and apparently younger than the coal-bearing rocks of the

[1] Geologic and topographic map of Boundary Creek mining district, British Columbia, geology by R. W. Brock, Geol. Survey Canada, 1905.

region. With the exception of the conifer the material seems to be new to science and hence is difficult to place satisfactorily. Without being very positive about it, I should incline to regard the age as probably upper Miocene.

Lava flows.—The Tertiary lavas are made up in greater part of a number of flows probably aggregating at least 1,000 feet in thickness, which may be collectively termed andesites, although there is considerable diversity in their composition. All of them are of the andesitic type—that is, they contain chiefly soda-lime feldspars and ferromagnesian silicates in a cryptocrystalline to glassy groundmass. There is no free quartz, and the alkali feldspars are inconspicuous.

Considered in detail there are two varieties contrasting strongly—a dark rock having the appearance of an augite andesite and a much lighter andesite which contains both augite and hornblende. Some partial analyses serve to show that the andesitic flows are really a series ranging from latites to dacite and andesite. The detailed study of these rocks and their separation in the field was not practicable, and the term "andesite" is here retained as a general term, just as "granite" is often used to include many allied and intermediate coarse-grained rocks.

The most typical hornblende dacite was found on the west side of Eureka Gulch and the Sanpoil Valley below Republic. Here it is exposed from the valley bottom to the top of a mountain which rises over 1,200 feet above the Sanpoil. Fresh surfaces of the rock are blue-gray in color; altered specimens assume various shades and have conspicuous decomposed feldspar phenocrysts. The texture of these rocks ranges from fine grained to porphyritic. In general they are composed of plagioclase feldspar with hornblende, augite, and biotite. The rock has a cryptocrystalline groundmass in which rods of feldspar are contained and which must be rich in silica. The phenocrysts are labradorite, hornblende, augite, and biotite, the hornblende exceeding the augite. Chalcedony and quartz occur in minute vugs in the rock, and some pleochroic apatite crystals are present. The hornblende is largely resorbed and the augite is stained a brownish hue by iron oxide. A partial analysis by George Steiger of a specimen of this rock showed the presence of 64.42 per cent SiO_2, 4.82 per cent CaO, 3.02 per cent Na_2O, and 2.26 per cent K_2O.

Pyroxene latites are more prominent on the east side of the Republic camp than on the west. Gibraltar Mountain is made up of flows of this rock, which are exposed over a section extending 1,300 feet above the Sanpoil. The latites are dark colored, have a porphyritic texture in general, and are composed chiefly of pyroxene and feldspar. They have a texture which ranges from aphanitic to porphyritic. The phenocrysts are composed of labradorite or bytownite with augite. Both pyroxene and amphibole phases of the rock occur within the area, and the two may grade into each other. The

pyroxene latites represent a rock type which is very basic and which is a typical latite. The groundmass is evidently rich in potash. Analysis by George Steiger of the silica, lime, and alkali contents of a specimen of this rock shows it to contain 50.96 per cent SiO_2, 6 per cent CaO, 3 per cent Na_2O, and 4.36 per cent K_2O.

A part of the andesite series is represented by a flow breccia which is particularly conspicuous in the main tunnel of the New Republic mine, where fragments that attain several feet in diameter are contained in the andesite. In general the matrix of the flow breccia is andesitic, although inclusions of granodiorite, metamorphic shale, etc., are reported [1] to form a part of the breccia.

Resting unconformably on the eroded surface of the lake beds and andesites, and clearly younger than the quartz latite porphyry, is the remnant of a basalt flow which forms a noticeable feature of the geology in the vicinity of the Republic camp. The most conspicuous part of the flow is from 1 to 3 miles north of Republic, on the ridge projecting southeastward from the main divide between Deer Creek and the Sanpoil. This flow covers an area of about 2 square miles and is exposed in a section whose top is 600 feet above the base. Other smaller exposures of basalt were seen in different parts of the area.

In color the basalts vary from a dark brown to black; in texture they are fine grained to glassy, and some vesicular phases of the rock were seen. The rock is composed of laths of labradorite with grains of augite and olivine (altered to serpentine) embedded in a glassy base. Rods of apatite and some magnetite are accessory minerals of this rock, and secondary magnetite has been developed by the alteration of the olivine.

Quartz latite porphyry.—Intruded into the series of andesitic lava flows and the lake beds, but older than the basalt just described, is a porphyritic rock which has been determined as quartz latite porphyry. Typical exposures of this rock occur on Flag Hill and Republic Hill, and it is undoubtedly continuous under the mantle of glacial débris. The maximum width of this intrusive stock is exposed just north of Granite Creek, where it occupies an area 1¼ miles wide. Small knobs of the same rock protrude through the glacial drift east of the main mass, and it is probable that branches extend under the present surface in various directions.

Fresh specimens of the rock are light to dark gray in color, but altered samples show every variation of shade from greenish gray to white. Viewed in thin section under the microscope the rock is seen to have a holocrystalline groundmass composed of quartz and orthoclase. The phenocrysts are andesine, a very highly altered hornblende, biotite, and quartz. The hornblende and biotite are

[1] Umpleby, J. B., Washington Geol. Survey, Bull. 1, p. 23, 1910.

almost entirely resorbed. The rock may have contained augite. Apatite occurs as an accessory mineral. The hornblende is altered to calcite and chlorite and the augite to calcite. These rocks may be difficult to distinguish from propylitic andesite, which shows weathered feldspar crystals that give the appearance of a porphyry.

A partial analysis by George Steiger of the typical porphyry gave the following result: SiO_2, 62.18 per cent; CaO, 5.05 per cent; Na_2O, 3.63 per cent; K_2O, 2.46 per cent. This composition is approximately that of a granodiorite porphyry, but as the rock was intruded near the surface it may be considered as closely associated with the effusive series of latite rocks, and the name quartz latite porphyry may be more appropriate.

The ore deposits are believed to be genetically connected with the intrusion of this porphyry.

Breccia-conglomerate.—Within the area mapped, on both sides of Granite Creek, are numerous exposures of a rock that has been classed as a breccia-conglomerate. As this rock has little or no connection with the ore deposits within the district, only a brief space will be given to its description, although many interesting problems are presented in connection with its origin. Umpleby[1] has called this formation a dacite flow conglomerate, and he believes that "the series is made up of lava flows which have picked up a great quantity of stream gravels, etc." A study of the specimens and thin sections leads to the conclusion that the breccia-conglomerate is definitely related to the quartz latite porphyry. Fresh phases of the breccia-conglomerate are dark gray and altered specimens are in general white or greenish white. All the exposures of this rock seen contain rounded pebbles and fragments of shale, and some clearly contain material of granitic origin. As seen under the microscope the rock has a clastic structure, with fragments of a holocrystalline porphyritic rock. The phenocrysts are andesine and quartz, and the outlines of formerly existing biotite crystals may be seen. Fragments of shale are prominent and material of granitic origin was recognized in some sections. Sericite and calcite are conspicuous secondary minerals.

It is believed that this rock was produced during the intrusion of the quartz latite porphyry. In breaking through the sediments that filled the bottom of the old valley the magma in certain parts became admixed with rounded fragments and sand. In the area studied there is little evidence to support the view that the breccia-conglomerate is an effusive rock older than the rest of the volcanic formations.

QUATERNARY DEPOSITS.

Glacial drift and stream gravels.—On the map glacial drift and stream gravels are designated by one color and deposits that are clearly

[1] Umpleby, J. B., Washington Geol. Survey Bull. 1, pp. 20–22, 1910.

alluvial by another. Glacial débris is scattered over many of the mountain slopes within the area and forms a conspicuous feature of the topography in the vicinity of the Republic camp. In depth these deposits range from a few feet to perhaps 200 feet, but the average must be considerably less than the maximum. The material varies in size, ranging from rather fine glacial till to large bowlders, and represents the remnants of ground, terminal, and lateral moraines and valley trains. Some of this material has been reworked by stream action and gravels of this type are included in the mapping of the glacial deposits. Umpleby[1] gives a more detailed account of the glacial deposits.

Alluvial deposits.—Along the flood plain of the Sanpoil and in places along Granite, Eureka, and Deer creeks small alluvial gravel deposits have been formed.

ORE DEPOSITS.

The ore deposits of the Republic district belong to two widely separated epochs. The first metallization followed the intrusion of the granodiorite and thus is placed in the Cretaceous. The second followed the volcanic eruptions of the Miocene and is therefore of middle or late Tertiary age. Extensive erosion and glaciation have dissected and covered the veins, so that their age is assuredly pre-Quaternary.

THE OLDER VEINS.

The economically important deposits all belong to the later epoch. Deposits of the first epoch, abundantly represented elsewhere in Washington, are scantily exposed in the small areas of metamorphic rocks near the granitic contact in the southwest corner of the area mapped. Absolute proofs that these deposits are connected with the intrusion of granodiorite can not be given, but in their coarse quartz and abundant sulphides the ores stand in so great contrast to the mode of development of the Tertiary veins and are so similar to known Cretaceous deposits that the age assignment appears justified.

The ridge of amphibolite and diorite at the margin of the area about a mile south of Granite Creek contains several prospects showing pyrite and quartz stringers. The principal development was noted on the east slope of this ridge, where the claim known at one time as the Bryan & Sewell and later as the Boston & Maine is located. The shaft, now filled with water, is said to be about 200 feet deep and to be sunk on stringers and seams of coarse quartz and dolomitic carbonate with granular pyrite, arsenopyrite, zinc blende, and galena. The ore is said to carry some silver and a little gold.

[1] Umpleby, J. B., op. cit., pp. 29-30.

Farther up the valley, half a mile northwest of Copper Mountain, a short distance below the contact of the metamorphic rocks with the andesite, is another prospect on a quartz vein in diorite and amphibolite. The tunnel by which it is developed was not accessible. At the dump are veinlets of coarse milky quartz about 8 inches wide which contain granular pyrite, zinc blende, and galena.

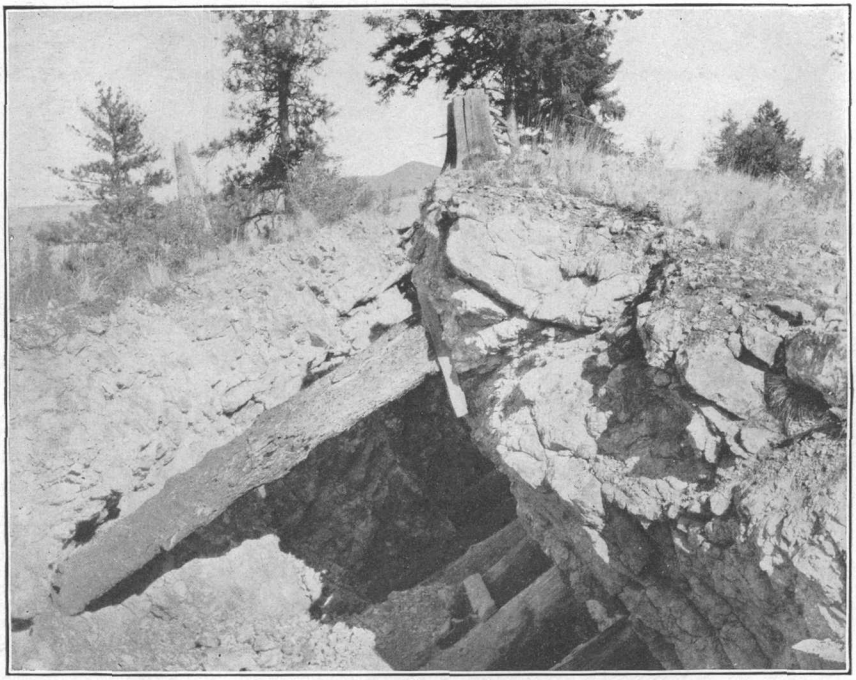
THE YOUNGER VEINS.

General features.—The productive deposits all belong to the younger series, which are more recent than the andesites and later beds and were probably formed shortly after the intrusion of the quartz latite porphyry. These veins extend through the district in a belt 6 miles in length, beginning with a northerly direction south of the town of Republic, turning north-northwest in Eureka Gulch, and bending to the northeast in the north end of the belt. The system consists of one to four approximately parallel veins, almost all of which dip to the east at angles of 45° to 80°. A second system of short cross veins, best developed near the Lone Pine claim, strike northeast and have a steep southerly dip. The veins form conspicuous outcrops of white quartz. They are usually straight and well defined, as illustrated on Plate XIV, *B*, which is reproduced from a photograph taken in the Southern Republic mine. Their width reaches a maximum of 50 feet but averages 3 feet. The quartz filling is usually sharply defined against the green propylitized wall rock, which may be an andesite or quartz latite porphyry.

The structure of the quartz is massive to brecciated. Inclusions or horses of little-altered wall rock are common, but no valuable minerals are contained in the altered rock. The most prominent texture is a delicate banding parallel to the walls and produced by alternating layers of coarser and finer quartz and calcite, here and there with narrow black bands of finely distributed ore minerals. Large vugs coated with rich crusts are not uncommon and in many places are filled with coarse calcite.

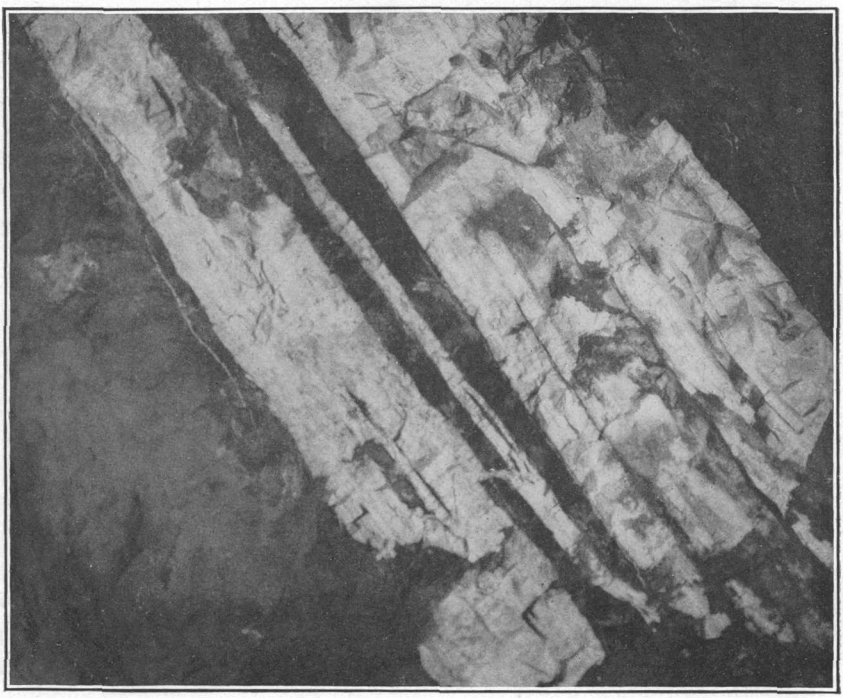
The veins have been followed to a vertical depth of 700 feet below the croppings. In the Republic mine a crosscut tunnel opens the vein 563 feet below the outcrop, and in the Surprise mine the shaft was sunk to a depth of 600 feet in 1911 and is now doubtless deeper. The most productive areas are at the Republic mine, south of the town, and in Eureka Gulch to the northwest.

The ore shoots, which usually include the whole width of the vein, are of irregular form. Some of them pitch to the south at steep angles. In the Republic mine the ore shoot is 300 feet long at the surface and pitches about 50° S., gradually narrowing to small dimensions on the lowest level, 560 feet below the croppings. In the Surprise vein the ore shoot was not prominent at the surface, though of



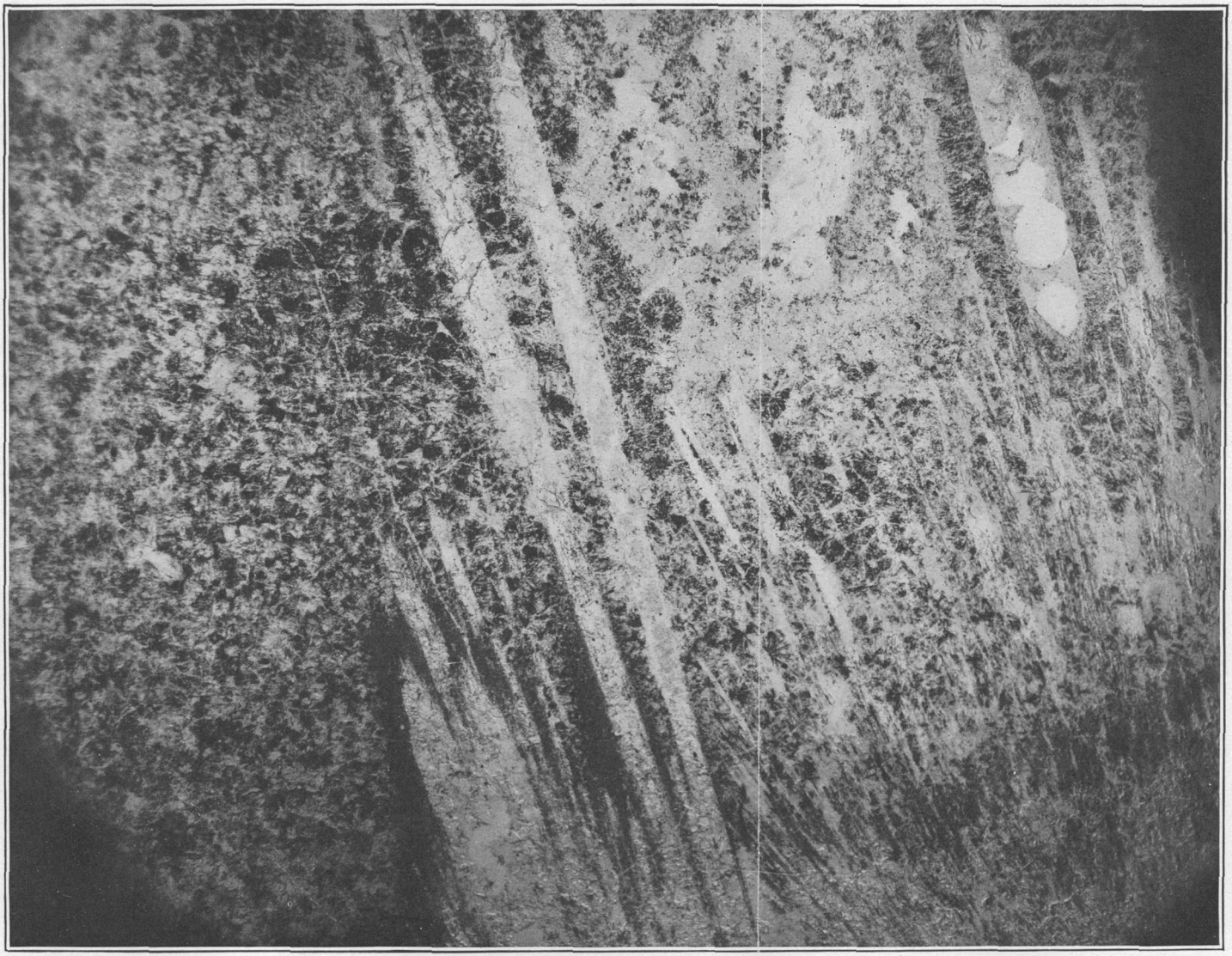
A. GLORY HOLE OF NEW REPUBLIC MINE.

View taken in stope on top of Republic knoll.



B. SOUTHERN REPUBLIC VEIN.

Shows banding in the quartz vein and included stringers of country rock.



PHOTOMICROGRAPH OF QUARTZ FROM SOUTHERN REPUBLIC VEIN.

Showing replacement of calcite (?) by quartz ("radial quartz"). Crossed nicols. Magnified 30 diameters.

good tenor, but it widened considerably on the lower levels. Many of the shoots are narrow and of small dimensions. Except for the narrow black streaks of ore minerals, the quartz in the shoots is not very different in appearance from that which has little value. The ores of highest grade coat large vugs or occur as small lenticular masses within the shoots.

Gangue minerals.—Quartz of milky-white to bluish-white color is the predominant mineral, though some calcite is usually present intergrown in concentric bands with the quartz (Pl. XIV, *B*). Seen under the microscope the texture of the quartz appears fine grained, but the size of the grains varies considerably in the different bands. There is a strong tendency to the development of crystal form and locally the texture is drusy, the cavities being filled with brownish chalcedony. Fluid inclusions of irregular form are abundant in the quartz, and many of them contain mostly gas with only a film of fluid.

Specimens from the Southern Republic and Republic mines show under the microscope that some of the quartz bands have replaced another mineral, probably calcite, developed in lamellar form with predominant base and flat rhombohedrous. This feature is particularly noticeable near the walls on which the lamellar crystals originally formed a coating. The replacing material consists of fine granular quartz with more or less adularia in rhomb-shaped crystals. (See Pl. XV.)

Closely associated with the quartz is a dark-gray cherty material, which forms part of the filling in many veins but is apparently older than the quartz. Under the microscope it resolves itself into an extremely fine grained mass of quartz in which are embedded minute, apparently clastic fragments of quartz. The dark color is caused by small crystals of pyrite, uniformly distributed, and also by black inclusions which look like graphite or carbon, though a qualitative analysis failed to show the presence of carbonaceous matter.

In some places in the Republic mine the wall rock is silicified, and transitions between this rock and the chert seemed to exist, but the chert can not, on the whole, be considered as a replaced rock. No adularia was observed in the cherty quartz, which is not believed to contain gold and silver in commercial quantities.

Adularia, an orthoclase with little of no sodium and peculiar crystallographic habit, is not uncommon in the Republic veins and, indeed, is frequently found in veins formed near the surface in volcanic rocks. No large crystals were observed, but much of the quartz contains well-developed microscopic crystals of rhombic outlines. Adularia is particularly common where calcite has been replaced by quartz. In one place microscopic crystals were embedded in brownish chalcedony filling a vug in quartz. Adularia is also found in the propylitic or altered andesites or porphyries, near the deposits, either in veinlets with quartz or replacing feldspars.

Calcite is a common vein material and is in many places intergrown with quartz or occurs in alternating bands with it. It is usually coarse grained and locally makes up 25 to 50 per cent of the gangue. Little or no gold appears to occur in the calcite.

Fluorite is mentioned by J. B. Umpleby[1] as occurring in one place. F. A. Thomson[2] also refers to one occurrence of this mineral in the Republic mine.

Laumontite,[3] a hydrous calcium-aluminum silicate of the zeolite group, occurs as one of the latest gangue minerals in the Princess Maude or Southern Republic mine. This occurrence is noteworthy because zeolites are rare in mineral veins.

Marcasite, in arborescent forms and well-defined crystals, was observed in a propylitic andesite breccia from the Republic mine.

Galena and zinc blende are exceedingly rare, if they occur at all, in the normal type of ore.

The richest parts of the veins and practically all the metallic minerals are found in the narrow black streaks which usually follow the walls as concentric bands or cover the inner side of drusy cavities in the ore. Rarely can any definite minerals be identified. At some places, particularly in the Republic mine, such crusts were thicker and richer than elsewhere, and here the assays would run very high. Some of this picked high-grade material contained 2,530 ounces of gold and 2,080 ounces of silver to the ton; other assays show, for instance, 1,810 ounces of gold and 1,320 ounces of silver, or 22 ounces of gold and 515 ounces of silver.

On close examination these high-grade bands are found to consist mainly of a dark-gray to black tetrahedrite with minor amounts of chalcopyrite and flakes of native gold. Some of this material was examined by metallographic methods, but no other minerals than those mentioned could be found. The minerals by their intergrowth indicate contemporaneous deposition. As the material contains some selenium, a special but fruitless search was made for selenium minerals. Chemical examinations were made by Chase Palmer in the United States Geological Survey laboratory, and the results are outlined below. In brief, the dark mineral is allied to tetrahedrite, but contains also much silver and some arsenic and zinc. Selenium was present to the amount of 2 per cent, but no tellurium was found. By eliminating the free gold as described below, Mr. Palmer found that the ratio of gold to selenium was approximately constant and equal to 2 : 3. This would indicate a gold selenide, Au_2Se_3, but, as stated, no definite selenium mineral could be identified under the microscope. F. A. Thomson[4] has also made some examinations of this peculiar

[1] Washington Geol. Survey Bull. 1, 1910.
[2] Am. Inst. Min. Eng. Trans., vol. 43, p. 676, 1913.
[3] Canadian Min. Inst. Trans., vol. 15, p. 189, 1912.
[4] Am. Inst. Min. Eng. Trans., vol. 43, p. 677, 1913.

material and found that the dark-gray mineral contained the following constituents: Sulphur, 15.4 per cent; antimony, 31.4 per cent; copper, 43.3 per cent; iron 4.8 per cent; silver, 5.2 per cent. The iron should probably be combined with sulphur and copper to form chalcopyrite. Thomson also mentions finding small crystals of pyramidal habit which gave reaction for selenium, but which were not finally identified. He suggests the possibility of a selen-antimonide of silver analogous to rittingenite, the corresponding arsenic compound. The presence of comparatively large amounts of selenium connects the Republic veins with the small group of selenide veins, representatives of which are found at Radjang Lebong, in Sumatra, and Tonopah, in Nevada.[1] These selenium-bearing veins appear to be everywhere characterized by narrow black concentric bands along the walls, and in these bands the selenium is concentrated. In fact the great similarity of this ore to the Radjang Lebong ore prompted the authors to have the material examined for selenium.[2]

Mr. Palmer's notes are given below.

The object of these experiments was to learn, if possible, whether gold and selenium are chemically associated in this ore. The ore minerals are intergrown with the gangue so closely that it was necessary to determine their constituents in the presence of much foreign material. The analysis is given below.

Analysis of a gold-selenium ore found in the Republic mine, Washington.

	Analysis.	Metallic mineral constituents recalculated to 100 per cent.
Cu	15.72	22.90
Ag	14.01	20.41
Fe	3.75	5.46
Zn	1.12	1.63
S	15.40	22.43
Sb	12.06	17.57
As	1.80	2.62
Au	2.99	4.36
Se	1.80	2.62
Gangue (calculated)	31.35	.....
	100.00	100.00

The ore thus appears to be a mixture of several minerals, among which are presumably chalcopyrite and tetrahedrite. The atomic ratio of gold and selenium, as deduced from their respective percentage weights (gold, 4.36÷197.2=0.022; selenium,

[1] Lindgren, Waldemar, Mineral deposits, p. 493, 1913.

[2] The presence of selenium as well as that of adularia was established in 1909, as stated in Science, new ser., vol. 30, No. 783, p. 972, Dec. 31, 1909, and also in a note in Mining and Scientific Press about the same time. This small part of the literature seems to be overlooked in Bulletin 1 of the Washington Geological Survey, the manuscript of which was transmitted in July, 1910. That publication contains an analysis of the ore which shows the presence in the high-grade material of 5.26 per cent of selenium and 0.4 to 2.12 per cent of tellurium. No other chemist has been able to discover tellurium in the ore or to find as much as 5 per cent of selenium. In a letter to the Mining and Scientific Press, dated Mar. 21, 1910, M. H. Joseph, of Republic, calls attention to the fact that he reported the presence of "selenide of silver" in an article in Engineering and Mining Journal Nov. 25, 1899. The mineral is enumerated with others occurring in the camp, but no details or analyses are given.

2.62÷79.2=0.33), suggests the possibility that normal gold selenide (Au_2Se_3 is present in the ore. Normal auric selenide is said to be capable of existence. H. Uelsmann [1] reports that he obtained it as a precipitate by passing hydrogen selenide gas through a solution of auric chloride.

From A. Terreil's experiments [2] on natural sulphides, tellurides, and selenides it appears that sodium sulphide solution readily attacks many sulphide minerals, but that it does not affect tetrahedrite. Terreil also states that the tellurides of lead and gold are not attacked by sodium sulphide solution and that the selenides of lead and silver yield their selenium very slowly to sodium sulphide solution.

The action of alkaline sulphide solutions on a specimen of the Republic mine ore containing 2.99 per cent gold and 1.80 per cent selenium was also observed. In this specimen free gold was not visible. The powdered mineral (0.94 gram) was leached with warm 10 per cent sodium sulphide solution containing a little hydrogen sulphide. After three hours the filtered solution was colorless. It contained no gold, no selenium, nor any other constituent of the ore. The same material was afterward warmed for three hours in contact with a 10 per cent sodium sulphydrate solution. In the first extract traces of gold were found. The second extract also contained a trace of gold. The third extract contained no gold. Selenium was not present in any one of the three extracts. Alkaline sulphide solutions therefore are incapable of changing the Au_2Se_3 ratio as found in the ore.

Another specimen of gold-selenium ore in which free gold was distinctly visible was leached in the same manner with alkaline sulphide solution. The first extract contained abundant gold, but no selenium. The second extract contained little gold and no selenium. The third extract contained no gold nor selenium. After the third extraction with alkaline sulphide solution the residual ore contained 1.75 per cent of gold and 1.12 per cent of selenium.

The atomic ratio (gold, 0.887; selenium, 1.414) corresponds very closely to the empirical formula Au_2Se_3.

It thus appears that the action of alkaline sulphide solution on the metallic minerals of this ore is confined to gold, and to that gold which exceeds the amount required to constitute normal gold selenide.

As the ore minerals could not be mechanically separated from one another, it is impossible with the data in hand to decide whether the residual gold and the selenium in these two specimens constitute an integral substance or are otherwise associated in the ore minerals. Nevertheless, the effectual resistance offered by gold and selenium, proportioned as Au_2Se_3, to the solvent action of alkaline sulphide solutions points to an intimate association of these two elements in the gold ore of the Republic mine.

The ore in general.—The quartz of the Republic camp is usually banded and fine grained, is commonly chalcedonic or porcelain-like in appearance, and bears some resemblance to many hot-spring deposits of siliceous sinter. Free gold is very rarely visible in the quartz but is more common in the narrow black concentric bands along the walls. All the flakes of gold are deep yellow, even the "high-grade" material that is very rich in silver. The silver is

[1] Annalen d. Chemie, vol. 116, fig. 125. [2] Compt. Rend., vol. 69, pt. 2, p. 1360, 1869.

therefore in chemical combination probably with the tetrahedrite, or less probably with the selenium. There is no reason to believe that the gold is present entirely as a selenide or allied mineral. Most of it is probably native, though in so fine a state of division that crushing through a 200-mesh screen is necessary to set it free.

The ore in depth.—The water level is high at Republic and the zone of oxidation shallow. Oxidized copper minerals and native silver and probably cerargyrite occur in this oxidized zone, but at 50 to 150 feet below the surface the effects of oxidation are slight, and it is not believed that any secondary concentration of importance has taken place by the influence of surface waters.

Although the ore yields chiefly gold the silver production is not insignificant. The output in 1912 was $600,000 in gold and $80,000 in silver. At some places the ore runs higher in silver than elsewhere, and J. B. Umpleby[1] has suggested that "within a given shoot the ratio of gold to silver usually decreases in depth." This conclusion seems to apply to the Republic shoot and that of the Princess Maude, but there may well be doubt whether it is of general applicability. In the Republic shoot the calcite increases greatly in depth, and in the Princess Maude there has been a replacement of calcite by laumontite, a zeolite. In the other shoots as far as explored to depths below the surface of 500 to 600 feet, no such progressive change in mineralization seems to appear. It is well known in the camp that a calcite gangue is unfavorable to the deposition of gold, and it is probable that calcite rather favors the precipitation of silver. J. L. Harper, of the Republic Mines Corporation, writes as follows in relation to this question:

> Mr. Umpleby's sketch shows total values decreasing with depth, the silver values increasing in a slight degree. No doubt he gained this impression from the conditions of the lower workings of the Republic mine, where the silver values appear to predominate. You will recall that in the lower workings of the Republic mine only a very small area of ground is opened for inspection. Our experience up the gulch has demonstrated that the sudden increase of silver is due to causes not related in any way to vertical depth. In driving our No. 4 drift north from Quilp territory into and under the Surprise ore shoot we encountered a most erratic condition as to the ratio between gold and silver values. At times the silver would suddenly increase, with a corresponding decrease of gold, while a few rounds of shots would change this condition entirely and in ore running say $20 per ton less than $1 in silver would be found. All the lower workings of the camp's properties, excepting the Republic and Princess Maude, show gold to be the predominating metal. The best-grade ore now being mined in the Quilp mine comes from the 500-foot level, and the content is practically all gold. On the other hand, last week we opened a small bonanza zone on the 50-foot level of the Quilp, from which the richest specimens of silver ore, containing native silver in beads, threads, and films, were taken. A few feet from this zone the gold and silver conformed to the old ratio.
>
> It would appear that silver concentrations are due to local causes and have no relation whatever with depth from the surface.

[1] Washington Geol. Survey Bull. 1, p. 88, 1910.

It is true that in some districts similar to that of Republic camp, as near Waihi, New Zealand, the gangue in depth has changed to calcite, with lowering of the grade of the ore. It is possible that this may be the condition at Republic, but it is not likely, for in the New Zealand mines referred to the surface zone had become quartzose and enriched by solution of the calcite in a quartz-calcite gangue, whereas at Republic such a surface enrichment on a large scale has not taken place, and the possibility of finding good ore at much greater depths than those now attained must be conceded.

Alteration of the wall rock.—Over a considerable area along the vein system and spreading half a mile or more from the veins themselves a process of alteration has gone on during the epoch of vein formation. It has affected both andesite and quartz latite porphyry, making the two rocks in places difficult to distinguish. The alteration has changed the color of these rocks to a dull green and has peppered them with small crystals of pyrite. The alteration is typically propylitic. The secondary products are calcite, chlorite, epidote, and pyrite; sericite is less prominent, though many feldspar crystals are partly replaced by it. In places the alteration of the feldspars has resulted in adularia. The groundmass of the rocks is usually least altered. Calcite is the most prominent mineral. This greenish rock usually adjoins the quartz veins and bleaching due to complete sericitization is rarely if ever observed. In places a silicification has occurred for a short distance from the vein. The altered and "propylitic" rock contains practically no gold.

Genesis of the deposits.—The veins were formed shortly after the close of the andesitic epoch of eruption, which ended by the intrusion of the quartz latite porphyry. They were probably already formed when the basalt was erupted. J. B. Umpleby [1] has pointed out that as the veins cut a series of formations that accumulated in a post-Eocene valley eroded in a peneplain which rose only 1,800 to 2,300 feet above the present elevation of the veins, they could not have been formed at a greater depth than 2,500 feet below the surface, the average present elevation being taken as 3,200 feet. In all probability the present outcrops were less than 1,000 feet below the surface of the lavas at the time of vein formation.

Little definite information was obtained as to the actual genesis of the ore, but the marked similarity of these deposits to so many other gold-bearing deposits in volcanic Tertiary rocks points clearly to deposition by ascending hot waters.[2] The character of the minerals, the fine grain of the quartz and sulphides, the beautiful crustification, and the propylitic alteration indicate unmistakably deposition by hot ascending waters, which probably were derived, in part, at least, from the cooling intrusive mass.

[1] Washington Geol. Survey Bull. 1, p. 42, 1910. [2] Lindgren, Waldemar, Mineral deposits, ch. 22, 1913.

The last effects of the hot waters were the alteration and replacement of some of the earlier deposits. Calcite was in places altered to quartz and adularia, and at one locality the calcite was again replaced by laumontite. Except in the zone of oxidation the descending surface waters have changed the vein filling but little.

MINES AND PROSPECTS.

SOUTHERN REPUBLIC (PRINCESS MAUDE).

The Princess Maude or Southern Republic vein outcrops about half a mile south of the Republic vein (see p. 156) and lies approximately in its strike, though the direct connection can not be traced. The vein shows a prominent outcrop of hard barren quartz 250 feet above the tunnel level. The developments consist of a 70-foot incline from the croppings and a main tunnel which intersects the vein about 200 feet from the portal. The drifts follow the vein for 200 feet northward and 300 feet southward; at the south end is an incline 300 feet deep following the vein. In 1909 water stood 100 feet below the collar in this incline at the time of visit but was pumped out later in the season. Some ore had been shipped from the mine previous to 1901, averaging, it is stated, $25 a ton. The mine was closed in 1906 and reopened in 1909. The country rock is throughout a propylitic andesite, dark green in color and containing much pyrite and calcite but practically no gold and silver.

The strike of the vein is a few degrees east of north; the dip 56° E. The outcrops of the vein are strong but can not be traced far. Where intersected by the crosscut the vein is 2½ feet wide and composed of banded hard fine-grained quartz without druses or recognizable crystals, with but little calcite, tightly frozen to the walls of hard greenish propylitic andesite. A small raise shows the vein 2 feet wide and banded in an exceptionally beautiful way (Pl. XIV, *B*). Some black streaks rich in gold follow the banding of the vein and probably contain gold selenide. No sulphides are visible and the ore between the tunnel and the croppings is of low grade. A few stringers of quartz show in the hanging wall. Near the north end of the drift the vein splits. Toward the south end of the level, near the incline, the vein makes a sharp turn to the west but within a short distance regains its course.

Some stoping has been done on the vein above the tunnel level and from these small stopes returns of $12 to $14 a ton are reported, mostly in gold. The vein in the incline differs considerably from that exposed elsewhere and the best ore is found in this vicinity. Near the shaft are stringers in the hanging wall containing a loose cellular platy calcite with a younger sugary aggregate of laumontite in minute crystals. Calcite seams cutting across the vein were noted elsewhere in this level. The first and second short levels are turned from the

incline. On the second level the vein is in places wide and scattered, and assays of it are said to run up to $14 a ton. On the second level, at the north side, the vein becomes loose and open at one place where good ore is reported. The vein matter from the third and fourth levels differs from that in the tunnel level, being loose and sugary with much calcite and containing good ore. The fourth level shows much calcite filling vugs and fissures, and some of the calcite plates are 4 inches across. The filling consists largely of calcite and floury laumontite with black stains and much residuary banded quartz. The width is 3 to 4 feet. This material is said to average $12 to $20 a ton, 60 per cent or more of which is in silver, some very high silver assays being reported. Soft gouge is abundant where calcite is prominent. The honeycombed part of the vein seems to start just above the first level south of the shaft and continues down, crossing the shaft and pitching north, to attain its greatest development in the good ore of the third and fourth levels.

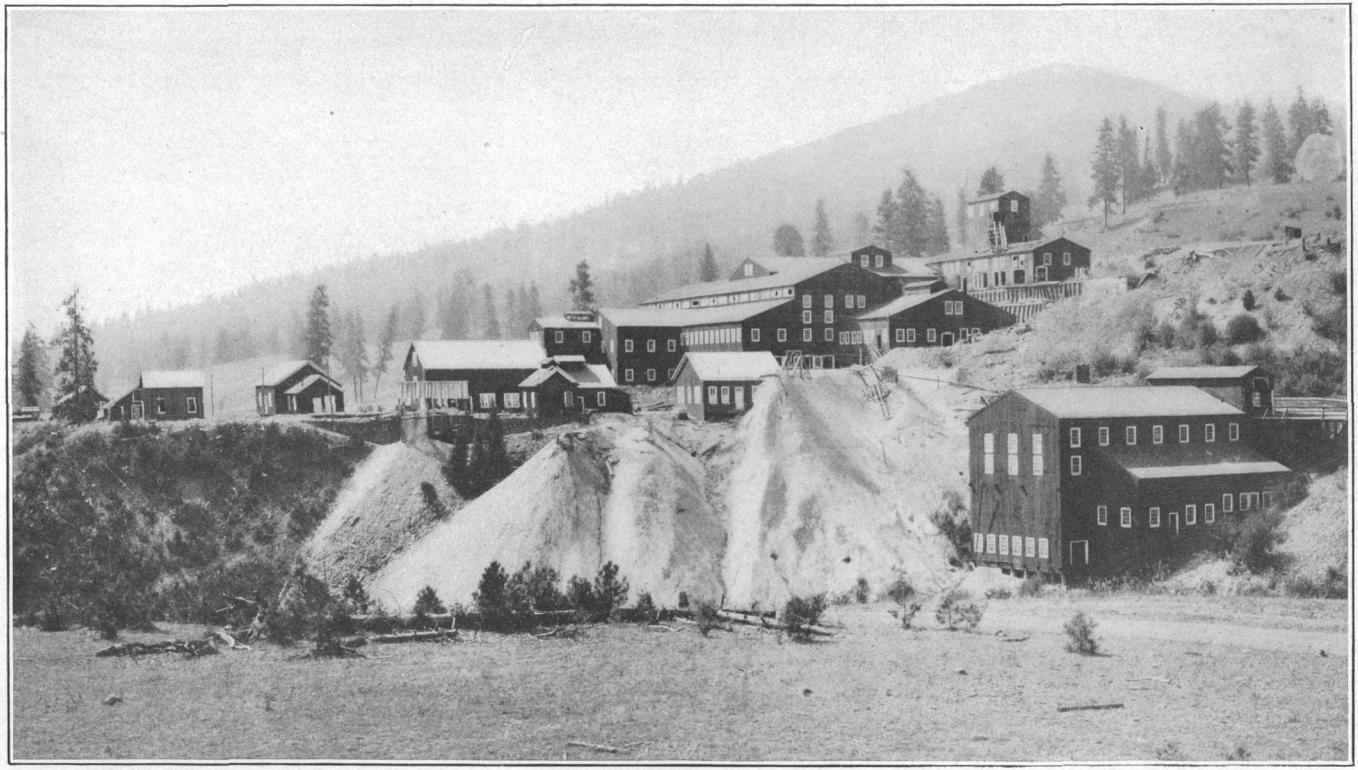
These conditions indicate a concentration of silver during the latest epoch of vein formation, accompanied by the development of calcite and laumontite. Such zeolitization and accompanying enrichment of a vein is an uncommon occurrence, and it was probably not caused by descending surface waters.

CHICO.

A few hundred feet south of the tunnel of the Southern Republic is the Chico tunnel, which within a short distance from the portal exposes what is probably the same vein but narrower and more split up. Just east of the tunnel is the Butte & Boston incline, which is now filled with water and is said to have cut the same vein at no great depth. The incline is stated to be about 400 feet long. The Chico shaft, a short distance southeast of the Southern Republic, is said to be about 300 feet deep and, to judge from the dump, intersected a small quartz vein concerning which no further information is available.

REPUBLIC.

History, production, and development.—The Republic claim is situated about half a mile southwest of the Republic railroad station, on the west side of Granite Creek near its confluence with Sanpoil River. The elevation of the highest croppings is 3,900 feet and that of the foot of the mill dump is 3,300 feet. For a long time—in fact, until the recent developments in 1910—the Republic was the most prominent and productive mine in the district. It was located in 1896. Good ore was found close to the surface and a rich shoot extending from the outcrops nearly to creek level was exploited. At first the ore was shipped to the smelter, but later a small cyanide plant was built in which some ore was treated. In 1898 a roasting and cyanide plant (Pl. XVI) with a capacity of 200 tons was erected on the



REPUBLIC MILL.

property, but the extraction proved disappointing. About 20,000 tons of Republic ore was milled during the first 2½ years of operation, up to 1899, and under unfavorable conditions the dividends paid are said to have amounted to $395,000. In 1898 or 1899 the property passed from the Republic Gold Mining & Milling Co. to the Republic Consolidated Gold Mining Co., and in 1901 theplant was closed, owing partly to the lack of ore and partly to the unsatisfactory extraction. The total productionof the new mill had been $300,000in less than a year, about 37,000 tons having been milled. Soon afterward the property was taken over by the county officers on account of unpaid taxes, and nothing was done until 1909, when the property was reopened by the New Republic Co., under lease from the county. Exploration in the old workings soon disclosed rich ore, and for the next two years the output was large and some of the shipments to the smelter were of high grade.

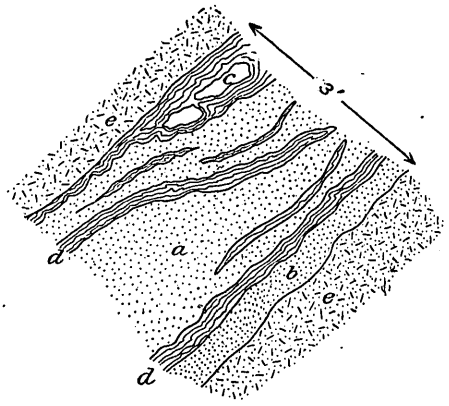


FIGURE 14.—Republic vein, sketched from third level. *a*, Dark-gray chert; *b*, gray chert; *c*, vug; *d*, banded quartz, rich ore; *e*, propylitic andesite.

The production of Ferry County in 1909 was $210,437 in gold and 53,677 ounces of silver, the average grade being $20.92 a ton. Of this a large part came from the Republic mine. In 1910 the production continued but on a less extensive scale. The total production of the mine to the end of 1910 is estimated at $1,400,000, of which $1,000,000 was produced between the years 1897 and 1902. During recent years the production has been overshadowed by that of other mines in the camp.

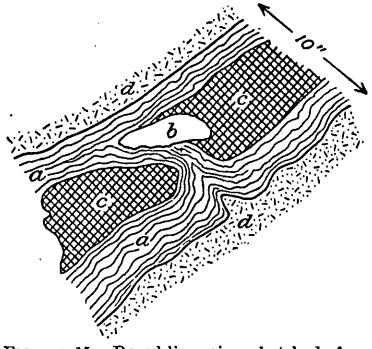


FIGURE 15.—Republic vein, sketched from fourth level. *a*, Banded quartz, rich ore; *b*, cavity; *c*, calcite; *d*, propylitic andesite.

The main developments consist of four tunnels. No. 1 cuts the vein 125 feet below the croppings, No. 2 is 78 feet lower, No. 3 intersects the vein 383 feet, and No. 4, near the mill, 563 feet below the croppings. No. 4 tunnel is 2,400 feet long, and from it a winze sunk on the vein extends to the lowest or No. 5 level, which at the time of examination was under water, the water level standing at the top of the winze. The total development in linear feet is estimated at about 2 miles. (See figs. 14 and 15 and Pls. XIV, *A*, p. 146, and XVII.)

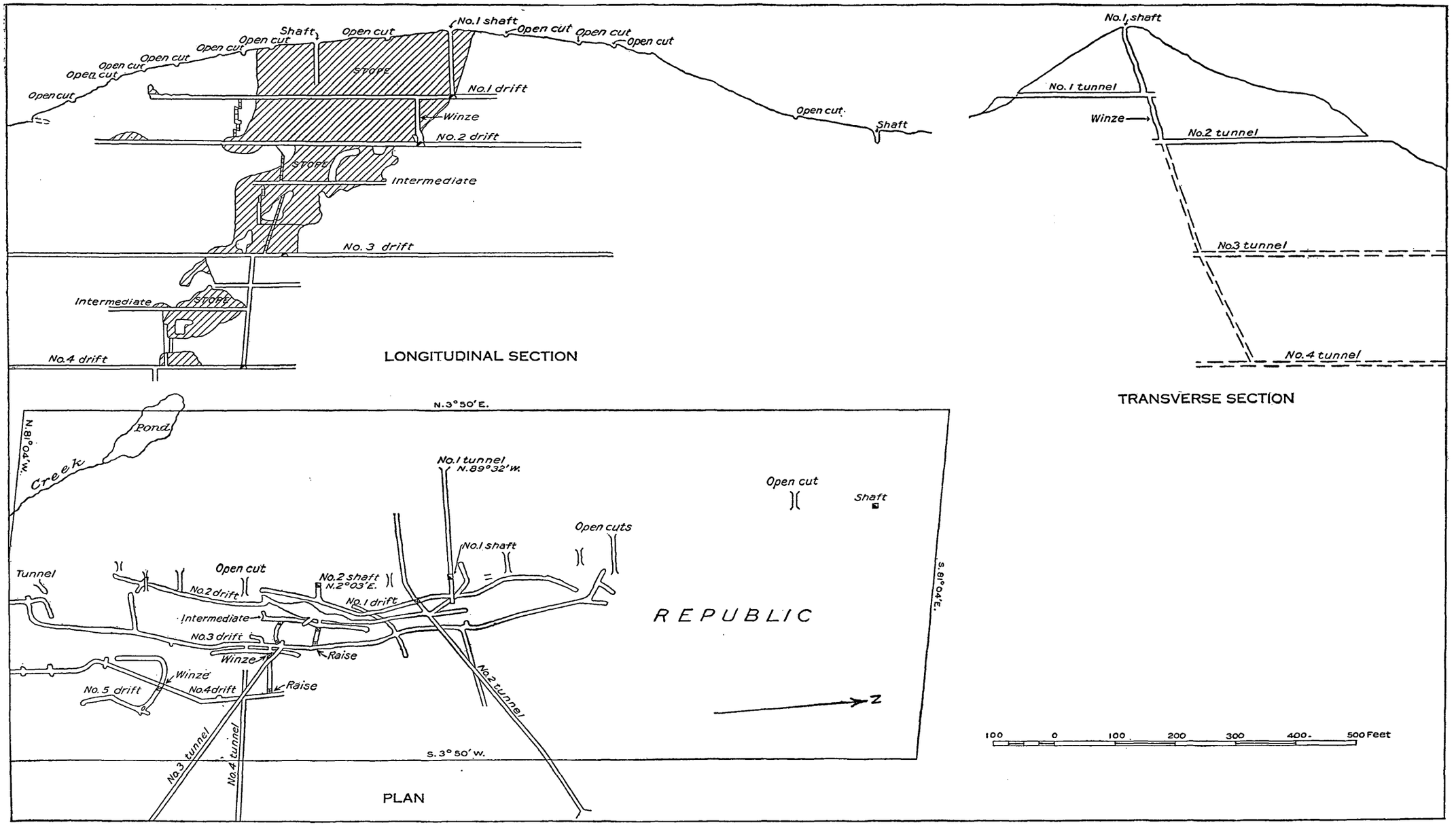
Geology.—In general the vein intersects the andesitic rocks and breccias and the associated lake beds on the lower slopes of the ridge southwest of Republic. Few of the exposures at the surface are satisfactory, and the tunnels give the best evidence of the geologic relations. The contact of the andesite with the quartz latite porphyry begins a short distance west of the croppings, and at some places the porphyry is encountered in the footwall and hanging wall of the vein. The best exposures of porphyry are found at the portal of No. 1 tunnel, west of the croppings. Both andesite and porphyry in the vicinity of the vein contain chlorite, pyrite, and calcite, and as is usual in such cases the distinction between the two kinds of rock may be difficult.

Tunnel No. 3, which crosscuts the vein from the east at about 600 feet from the portal, shows in the first 300 feet a series of well-stratified tuft, sandstone, and shale dipping 20° NE. Smaller beds of flow breccia are interbedded. The next 300 feet is in the underlying andesite breccia, which continues to the vein and close to it becomes very soft.

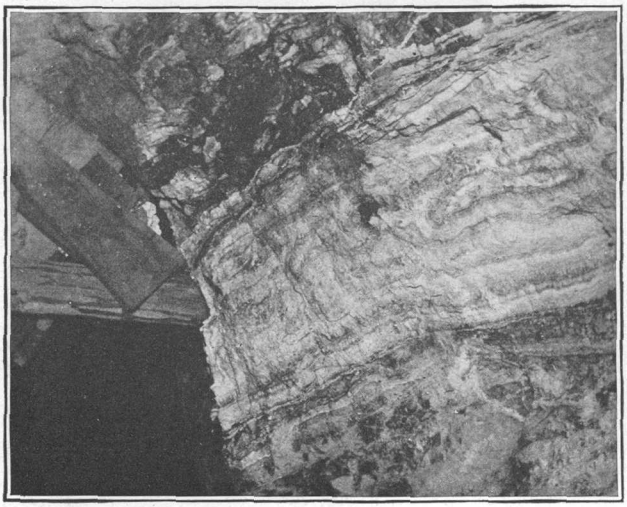
Tunnel No. 4 starts 80 feet above the creek and intersects the vein at 2,400 feet. For a distance of 300 feet from the portal the tunnel is in andesitic breccia. Tuffs, shales, and sandstones with some layers of tuff-breccia, all dipping 20° NE., then appear and continue to a point about 840 feet from the portal. In places these strata are parted by seams of gypsum. From the last-mentioned point the tuffs gradually change to andesitic flow breccias and these in turn to massive andesite. At 1,400 to 1,580 feet from the portal occur bedded tuffs with coaly vegetable remains, and from the last point propylitic andesite, in places brecciated or tuffaceous, continues up to the vein.

On the whole, then, the vein is contained in a series of tuffs, sedimentary beds, flow breccias, and andesite flows. In most places andesitic breccia forms the hanging wall of the vein; the porphyry is usually some distance in the footwall.

The deposit.—The Republic vein (Pl. XVIII) strikes a few degrees east of north and dips about 60° E. The croppings are prominent and follow the crest of a wooded hill for about 1,500 feet into the Blaine claim, adjoining on the south. On the north side the vein is not so easily traceable and its connection with the producing deposits on the north side of Granite Creek is problematic. The width of the main vein is in places as much as 8 or 10 feet, but the ordinary width is 2 or 3 feet and in places it pinches down to a narrow seam. At the surface the pay shoot is about 300 feet long. It pitches 50° S., gradually narrowing to small dimensions at the winze on level 4. After the mine was supposed to be exhausted ore was found by the New Republic Mining Co. on both the north and south sides of the old pay shoot, as well as in certain spur veins of the main deposit. At the



PLAN AND SECTIONS OF REPUBLIC MINE.



A. REPUBLIC VEIN ON FOURTH LEVEL.

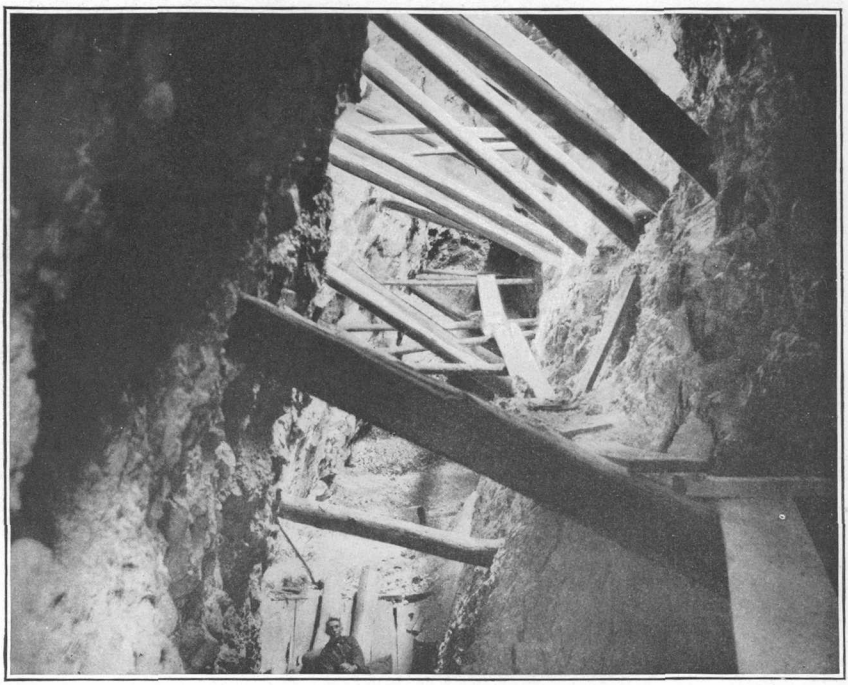
Showing banding. Vein is about 4 feet wide.

B. POLISHED SECTION FROM REPUBLIC VEIN, THIRD LEVEL.

Natural scale.

A. PEARL VEIN.

A quartz fissure vein, somewhat brecciated and lenticular.



B. STOPE IN UPPER LEVEL, SURPRISE MINE.

south end of level 1, near the surface, the vein appeared as two seams, each 1 foot thick or less, separated by a horse of andesite 4 feet thick. The ore in both seams assayed about $100 a ton when hand picked.

On level 3 the ore shoot begins just south of the point where the vein is intersected by the crosscut and is here only about 100 feet long. Stopes continue, though smaller, down to level 4, where the vein is from 2 to 8 feet thick. Some of the old stopes above level 3 are said to have been 20 feet wide.

In the intermediate level between Nos. 3 and 2 the New Republic Co. continued the drift southward for 150 feet beyond the ore shoot. At the face the vein is 3 feet wide, has fairly well defined walls, and shows several seams of the typical quartz with concentric crustification. The vein at this place is said to average $4 a ton. At the south end of the shoot on this level the vein, as worked in 1909, was 2 feet thick, with rich seams on the footwall. Farther up, above the intermediate level and 20 feet back of the regular vein, the New Republic Co. encountered a wide body of ore, probably constituting the expansion of a stringer that joined the vein farther down.

On level 4 the vein is poor and scattered where intersected and continues so to the north end of the deposit. South of the crosscut the vein worked above branches, and one branch has been stoped up to the third level. The vein is about 5 feet wide and beautifully banded (Pl. XVIII, *A*). Disturbance and brecciation followed by repeated deposition of quartz can be made out above the fourth level.

A second vein 10 feet wide lies in the footwall at the engine station on the fourth level. It shows quartz seams as much as 1 foot in width, with calcite centers. Calcite is far more abundant on the fourth level than above it and is generally considered barren material.

Good ore containing about $20 a ton, mostly in silver, is reported from a point near the top of the winze, and it is stated that the vein at the bottom is 15 feet wide and carries considerable silver.

Above the third level the ore contains mainly gold with but little silver; a sample yielding $20 a ton in gold will give $2 or $3 in silver. Below the third level the silver tenor is much higher, though the ore has the same appearance and texture. For the whole of the fourth level the assays show comparatively large quantities of silver.

QUILP.

The Quilp claim, now the property of the Imperator-Quilp Mining Co., is a mile northwest of the Republic railroad station, on the east side of Eureka Gulch. It is the first productive property north of the Republic mine, about 1 mile distant, and is immediately adjoined on the north by the Surprise mine.

Strong croppings of the vein can be seen on the hillside about 100 feet above the gulch. The main developments consist of a 400-foot

shaft sunk from the adit level, with drifts and stopes along the several levels. A winze is sunk from the 400-foot level to the 500-foot level.

The production in the early history of the mine, up to July, 1906, amounted to about 24,000 tons of ore having an average assay value of 0.4 ounce of gold and 5 ounces of silver. This ore was shipped to a smelter and yielded a total value of $263,000. Freight and treatment costs are said to have amounted to about $140,000. Shipments were resumed in 1909, when the average assay was 0.5 ounce of gold and 4 ounces of silver to the ton and the freight and treatment costs $6.25 a ton. In 1910 the shipments continued at the rate of about 80 tons a month, the smelters accepting only a limited amount of the highly siliceous ore at a time. Production continued during 1911 and 1912.

The vein outcrops 200 feet north of the shaft in greenish propylitic andesite. The contact of the porphyry is close by, but the exact line between the two is difficult to determine. The strike of the vein is north-northwest, and the dip steep to the east. The outcrops are prominent and wide but can not be traced far south of the shafts. On the north side the vein continues into the Surprise ground. The gangue is the usual fine-grained quartz, much of the vein consisting of the pure mineral, more or less clearly banded and evidently deposited in open spaces. Here and there are horses and fragments of included greenish propylitic rock. Slight copper stains are noted, and in places there are narrow concentric black bands which indicate the richest ore. The ore shoot, which pitches about 60° S. on the plane of the vein, reaches the surface in the bluff 100 feet above the adit north of the shaft, and rich ore has been stoped up to the grass roots. On the first level the stopes are 10 to 15 feet wide. On the second level, 300 feet below the croppings, the shoot is 150 feet long and lies south of the shaft. Before reaching the third level the ore shoot appears to come to an end. The lower levels were under water at the time of examination.

On the first level, at 200 feet from the vein on the footwall side, lies another vein with much calcite.

In the main shoot the average relation of gold and silver by weight was 1 to 10, but there was somewhat more silver in the uppermost levels, within the zone of oxidation. Some native silver was found near the surface.

In 1911 work was continued and the mine was drained to the bottom level. The fourth level, which is the longest in the mine, was extended, following the vein in a north-northwesterly direction into the Surprise ground. Some good ore is said to have been shipped from the 500-foot level.

BLACKTAIL.

The Blacktail claim lies south of the Lone Pine and north of the Quilp. In 1909 the developments on this claim consisted mainly of a crosscut tunnel from Eureka Gulch and drifts on the vein. A shaft was sunk on the vein in 1910 and had attained in 1911, it is stated, a depth of 600 feet on the incline. Some ore has been shipped from a shoot above and below the tunnel level. In December, 1911, it was reported that the company was stoping on a lateral vein 3 to 8 feet thick. The total production is not large. The claim is owned by the Hope Mining Co.

The country rock consists of quartz latite porphyry and probably also some andesite, but the rocks are difficult to distinguish owing to propylitic alteration. The eastern half of the claim lies within the area of the Tertiary tuffs and lake beds, in which the mineralization has in places spread widely and formed large irregular outcrops of quartz. The main tunnel enters the claim from the north end of the Surprise claim and at 80 feet from the portal intersects the Surprise vein. About 300 feet farther east the crosscut intersects the main Blacktail vein, which continues into this claim, with north-northwesterly strike, from the Lone Pine claim. (See fig. 16, p. 161.) The dip of this vein is 45° ENE., and in the southern part of the claim the vein turns to a nearly east-westerly direction. Most of the ore from the tunnel level was found near this bend in the vein. The stopes indicate a width of quartz of 2 to 6 feet. Horses of country rock are common in the vein.

Near the north end line of the claim, on the hill about 150 feet above Eureka Gulch, another vein outcrops, parallel to the cross veins in the Lone Pine claim and striking N. 60° E. It stands nearly vertical and is a well-defined quartz vein 2 to 3 feet wide.

SURPRISE, LONE PINE, AND PEARL.

In 1910 the Surprise, Lone Pine, and Pearl claims were owned by the Pearl Consolidated Mining Co. and the operations were carried on mainly by lessees. Later the properties were taken over by the Republic Mines Corporation.

Pearl claim.—In 1909 on the Pearl claim there were only about 160 feet of crosscuts and drifts and a shaft 45 feet deep sunk on the vein (Pl. XIX, *A*), which is here 12 feet wide and is said to assay $4.60 a ton. No large ore shoot has thus far been proved in the Pearl claim, but the Surprise vein continues through this claim with a north-northwesterly strike for the entire distance of 1,500 feet. The country rock is a propylitic quartz latite porphyry.

Surprise claim.—The Surprise claim lies between the Quilp on the south and the Pearl on the north, the Surprise vein continuing

through its entire length. In 1909 the developments on this claim consisted only of 1,100 linear feet of drifts and crosscuts. The main crosscut from Eureka Gulch intersects the vein near the middle of the claim at a point 160 feet from the portal and 50 feet below the croppings, and drifts extend 160 feet north and 260 feet south. The vein is from 8 to 15 feet wide. Good ore was found in the croppings. In the north drift the ore is of low value, but in the south drift stringers and bunches of ore assaying about $25 a ton were found. A winze sunk 35 feet near the end of the south drift showed in the upper 25 feet a 3½-foot vein of quartz of grade like that just mentioned, but a drift from the bottom of this winze is in low-grade material. At the south end of the claim is a tunnel which intersects the vein at 80 feet from the portal, or 110 feet below the croppings. A drift extended north from this tunnel to the shaft gave low assays from $2 to $6 to the ton.

The production to the end of 1909 is given by Mr. Charles P. Robbins in a personal letter as 2,400 tons, yielding 12,194 ounces of gold and 2,301 ounces of silver.

Such were the conditions—not altogether promising—when in 1910 the new company began operations by sinking on the ore shoot in the central part of the claim. The ore shoot was found to increase in size and value, and during the year a large tonnage yielding several hundred thousand dollars were extracted. The shaft was deepened to 400 feet on the incline and successful operations were continued on the same scale in 1911 and 1912. In 1912 the shaft was 540 feet deep on the incline.

The country rock is propylitic quartz latite, which is difficult to distinguish from the adjoining andesite. The vein strikes N. 30° W. and dips about 70° ENE. As a rule it fills a clean-cut fissure and consists of the usual banded quartz 4 to 8 feet thick, but in places fragments of country rock are abundant in the vein. The shoot is about 100 feet long on the surface and appears to pitch to the south. (See Pl. XIX, *B*.)

Lone Pine claim.—The Lone Pine claim, which adjoins the Pearl on the west, had in 1909 only 2,500 linear feet of developments, principally tunnels. The production up to October, 1909, is given as 8,924 tons of ore yielding 30,256 ounces of silver and 5,436 ounces of gold, or about $124,000. Active development in 1910 resulted in the production of about 6,000 tons of ore having an average value of about $9 a ton.

The veins are contained in the usual dark-green propylitic rock. In the southern part of the claim the Blacktail vein outcrops, continuing northward from the Blacktail claim, but is traceable for only a few hundred feet. It is parallel to the Surprise vein and strikes N. 30° W. The productive veins belong to another system, striking

northeast and having a steep southerly dip. There are four of these veins and none of them continue to join the Surprise vein; in fact, none of them appear west of the Blacktail vein.

Some of the following data are taken from a report on the property by C. P. Robbins:

Cross vein No. 1 outcrops in Lone Pine Gulch and has not been extensively developed or worked. It is 6 feet wide and the quartz from it is said to assay $2 to $4 a ton.

Cross vein No. 2, dipping 80° SE., has been opened by tunnel No. 1, which runs longitudinally near the center line of the claim, farther north cutting veins Nos. 2, 3, and 4. It has been stoped in places both from this tunnel level and from tunnel No. 2, which is 75 feet lower and enters near the bottom of Eureka Gulch (fig. 16). At the intersection by tunnel No. 1 the vein is 13 feet wide and is

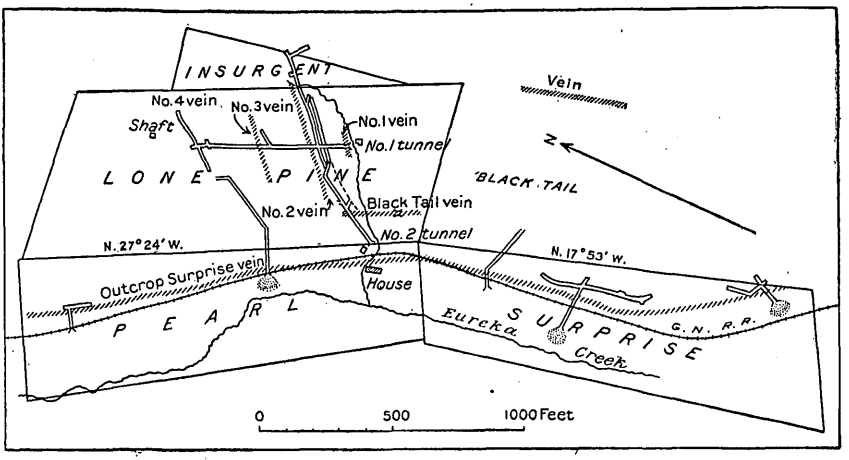


FIGURE 16.—Diagram showing relations of veins on Surprise, Lone Pine, and Pearl claims.

said to average $4 to $6 a ton. Farther east the vein narrows to 3 feet and forms an ore shoot 80 feet long, averaging $15 to the ton, which has been stoped for some distance upward. From this shoot to the east side line the vein ranges from a few inches to 5 feet in width. One narrow shoot was stoped within 20 feet of the surface, and the ore from it averaged, it is said, $16 a ton. Tunnel No. 2 intersects this vein at 300 feet from the portal and underneath the ore shoot in tunnel No. 1 encountered a shoot 225 feet long, which was stoped to No. 1, gradually decreasing in width. The average thickness of the ore in this shoot was 4 feet. From this part of the mine, between tunnels No. 1 and No. 2, 3,500 tons of ore was taken, averaging, it is stated, $15.76 to the ton.

The ore mined since 1909 is probably derived from the downward continuation of this ore shoot. The quartz is of the usual banded character, being white in color with narrow concentric ribbons of

black dense material which evidently carries the valuable metals. Small druses are common, coated with crystals of quartz and tabular crystals of calcite. In places the vein also contains much dark-gray cherty material (p. 147). Some of the bands are distinguished by coarse granular calcite. The ratio of gold to silver, by weight, varies from 1:5 to 1:8. According to Umpleby,[1] the ore found above No. 2 tunnel contains less silver than that below it.

No. 3 vein, opened by the upper tunnel, has been but little explored. It lies 200 feet north of No. 2 vein. No. 4 vein, likewise disclosed by the upper tunnel, is 200 feet north of No. 3 vein and 160 feet below the surface. A total of 717 tons is stated to have been stoped above this tunnel averaging $13 to the ton, but nearer the surface the ore is poorer. The width of No. 4 vein is about 5 feet, and the dip is 65° SE. The proportion of gold to silver was 1 to 4. The vein has smooth walls in which banded quartz 1½ to 2 feet thick is exposed. The same vein is exposed by a tunnel starting from creek level near the middle of the Pearl claim.

INSURGENT.

The Insurgent claim is a narrow wedge-shaped fraction lying east of the Lone Pine claim. The principal developments are on a vein closely associated with No. 1 vein on the Lone Pine and opened by the same tunnels. The vein lies on the footwall side of the Lone Pine vein, about 10 feet from it, and is probably a branch or offshoot from that vein. The ore shoot lies partly in the Lone Pine claim and is stoped in part up to the surface. The stope length is about 30 feet and the width of the vein averages 2½ feet.

At 70 feet west of the east line of the claim the Insurgent vein runs up against a heavy dark-gray slickensided clay gouge which contains a little pyrite. The vein continues for a few feet into this clay, but becomes small and finally disappears. This clay gouge is held to mark a considerable dislocation, not traceable on the surface, along the contact between quartz latite porphyry and andesite and lake beds.

Production was continued in 1910 from the Insurgent shoot. The proportion of gold to silver is 1 to 7.

SANPOIL.

The Sanpoil claim is situated on the west side of Eureka Gulch south of the Ben Hur, described below. The croppings of the prominent vein worked on this claim appear 250 feet above the bottom of the gulch, or 100 feet above the upper tunnel. The vein is in all probability the same as that exposed on the Ben Hur. It dips 70° E. A lower crosscut intersects the vein 200 feet below the croppings, and

[1] Op. cit., p. 61.

drifts extend along it for 500 feet north and south. No large shoots had been found in 1909, but some ore from the upper tunnel just north of the crosscut was being shipped, containing, it is stated, 0.7 ounce of gold and 4 ounces of silver to the ton. It is reported that in 1911 also ore from the shoots in the upper tunnel level was shipped.

About 165 feet south of the crosscut in the upper tunnel a shoot of low-grade ore about 3 feet thick, carrying from $4 to $9 a ton, is said to have been exposed. The ore contains much calcite, which is considered as waste and sorted out when possible. Several small cross faults displace the vein, one of them as much as 10 feet.

BEN HUR.

The Ben Hur mine lies on the west side of Eureka Gulch and the vein outcrops 200 feet above it, at an elevation of about 3,000 feet. Development work began here in 1898 and some ore was shipped in 1905 and 1906. The mine was reopened and shipments of ore were resumed in 1909. The production to the end of that year is said to have been about $65,000. The mine continued to produce ore in 1911 and 1912.

In 1909 the developments consisted of a vertical shaft 300 feet deep and a winze sunk 75 feet below the third level. The drifts were short except that run north on the 115-foot level, which in a distance of 500 feet along the vein reaches the surface close to Eureka Gulch. A considerable amount of ore, worth from $6 to $10 a ton, is said to have been developed. The highest average tenor was 1 ounce of gold and 5 ounces of silver to the ton, but in places the silver content was considerably higher. In 1909 stoping was carried on above the second level. The country rock is a propylitic quartz latite porphyry which adjoins the vein without much further alteration. The vein, which is traceable for 1,000 feet and is sharply defined, strikes N. 30° W., but turns to the east of north close to the north end line. The dip is 65° E., and its average width is 4 feet. The vein consists of the usual fine-grained, faintly banded quartz and contains from 10 to 30 per cent of calcite. Very little pyrite is present, nor is any free gold visible. There are several ore shoots not yet well defined.

The outcrops of the vein show 7 feet wide above the shaft and are said to yield good returns. Smelter assays of some ore shipped in 1905 and 1906 show about $15 in gold and 4.5 ounces of silver to the ton.

TRADE DOLLAR.

The Trade Dollar claim adjoins the Ben Hur on the north. The vein is opened by a shaft 300 feet deep, with short drifts on the second and third levels. The total shipments are said to amount to 1,000 tons, averaging about $17 a ton. The silver content ran about 10 or 12 ounces to the ton. The solid quartz is said to be 13 feet wide on the second level, but narrows to 20 inches on the third level.

KNOB HILL.

The Knob Hill claim, at the head of Eureka Gulch, covers the northern extension of the main vein system. Knob Hill rises as an abrupt point to an elevation of 3,100 feet just east of the point where the road ascends to cross the divide to Mud Lake. Along a north-south line this hill is made up of quartz stringers and silicified and altered quartz latite porphyry. A small pocket of rich ore on the surface is said to have been taken out in 1904. The strike of the vein is about N. 30° W. and the dip 50° ENE. The developments—about 700 feet of tunnels—have shown a vein 3 to 5 feet thick along which a little overhand stoping has been done. The ore is of low grade, but there is probably a considerable amount of it.

North of Knob Hill the outcrop is covered by morainal material, but the line of strike carries it into the tuffaceous lake beds on the low hill east of Mud Lake. On the Mud Lake claim is a shaft 60 feet deep, not now accessible, but a thickness of 63 feet of quartz is said to show in a crosscut. It is probable that general silicification and spreading of the quartz have taken place where the vein intersects the lake beds.

Active prospecting of the Knob Hill mine during 1911 on three tunnel levels developed shipping ore in several places. A fourth tunnel was started at the foot of the hill and shipments were begun in the same year. According to a statement recently issued by the company, the production from August 1, 1910, to January 1, 1912, was 7,142 tons of shipping ore having a gross value of $224,795. This ore yielded 10,850 ounces of gold and 31,914 ounces of silver, and the net returns were $149,005.

North of the Pearl and south of the Knob Hill claim lies the Little Cove claim. Immediately south of the steep point of Knob Hill is a small flat formed by the alluvium of Eureka Gulch. Below this no explorations have been made, though the vein doubtless continues under its surface. The Surprise vein outcrops in a railroad cut just south of the flat on the Little Cove claim, where it is 12 feet wide. The vein material is more or less mixed with propylitic porphyry. Close by is a shaft 100 feet deep and it is stated that 150 tons of ore were shipped from this locality. This ore was doubtless of low or medium grade.

MOUNTAIN LION.

The Mountain Lion mine lies about 3 miles north-northwest of Republic, on the North Fork of Granite Creek, at an elevation of 3,000 feet. It was worked rather extensively in the early days of the camp and is said to have had a production of about $200,000. A mill planned for stamps, roasting, and cyanidation was erected about 1900, but the recovery is reported to have been 65 per cent,

which was unsatisfactory. Little work has been done in the last five years and, as the property was closed, not much information could be obtained.

Umpleby[1] says that the "tunnel starts from a point near the level of the North Fork and cuts the vein 1,260 feet from the portal, giving a depth on the vein of 310 feet. A double-compartment vertical shaft, which passes near the inner end of the tunnel, reaches a depth of about 700 feet from the surface. Drifts and crosscuts leave the shaft at various levels. The ore milled came largely from stopes above the tunnel level."

The country rock is andesite, with pyrite and chlorite. Near the vein it is bleached by the development of sericite.

The principal vein, which is traceable on the surface for 800 feet or more, is well exposed in several open cuts 400 feet southwest of the shaft. The strike is a little east of north and the dip 68° W. The open cuts show a vein 10 to 12 feet wide, consisting of the usual fine-grained and banded quartz and dark-gray jasperoid material. The decomposed and crumbling andesite contained much pyrite.

Smelter assays of some ore extracted in 1904 and 1905, probably for converter lining, show an average of $5 in gold and 2 ounces of silver to the ton.

MORNING GLORY.

The Morning Glory mine is situated on Flag Hill about 4,000 feet west of the Quilp mine, and its veins have no obvious connection with the main vein system. No work was done here for a number of years and a large part of the workings are not accessible. Some very rich ore was shipped, but the total production is not large. The mine was reopened in 1911 and some rich ore extracted. The main developments consist of a tunnel and an air shaft with drifts, the whole said to aggregate about 1,700 feet. The country rock is quartz latite porphyry, which appears to be intruded in the peculiar breccia-conglomerate described on page 144.

The main vein strikes N. 70° E. and dips 60° NNW. Its width in the stoped portion is only a few inches. The ore consists of a white-banded and drusy quartz. The country rock is altered and bleached by the introduction of sericite and calcite with pyrite. There are a number of other narrow veins also dipping north-northwest and the country rock is greatly fractured and traversed by gouge seams.

OTHER PROSPECTS ON FLAG HILL.

There are a number of other prospects on Flag Hill, especially on the south side, but no ore of consequence is reported to have been developed in them. Specimens from one of these prospects shows a

[1] Washington Geol. Survey Bull. 1, 1910.

type of mineralization different from that of the ordinary veins in the district, the greenish propylitic porphyry containing irregular bunches of pale rose-colored quartz of coarse texture, together with small masses and grains of chalcopyrite and galena.

TOM THUMB.

The Tom Thumb property, including six patented claims owned by the Midget Gold Mining & Milling Co., is situated near the head of the North Fork of Granite Creek, about 4 miles due north of the Republic railroad station. It lies in the main belt of mineralization which, at first striking north and north-northwest, finally bends around to a northeasterly direction. There are many indications of mineralization between this mine and Knob Hill, but the quartz spreads widely through the lake beds and forms no well-defined lodes. Previous to 1909 considerable development work, estimated at 1,600 feet, had been done, and ore had been shipped, but the production could not be ascertained. Preparations were made to unwater the mine in 1909 by the New Republic Mining Co., and some ore was shipped in 1909 and 1910. The following notes regarding underground work are taken from a report on the property by Mr. Downey:

The croppings of quartz are prominently exposed on the Tom Thumb claim and apparently are from 50 to 100 feet wide, but the appearance is due to collapse by erosion of the surrounding soft rocks and the real width of the quartz vein does not average more than 8 feet. The outcrop is situated on the slope 200 feet above the creek and about 1,200 feet distant from it, in andesitic country rock. A short distance to the south the andesite is overlain by tuffaceous lake beds.

The vein strikes northeast and dips 40°–50° NW. It has been opened by three vertical shafts, the deepest of which attains 300 feet. In the lower levels the vein is considerably faulted. The value of the ore is said to range from $10 to $15 a ton, though some shipments have yielded $23. The proportion of gold to silver by weight is 1 to 5.

BELCHER DISTRICT.

LOCATION AND EXTENT.

As recorded in the office of the county clerk of Ferry County under date of December 15, 1906, the boundaries of the Belcher mining district are outlined as follows:

Starting from the mouth of St. Peters Creek, thence in a southerly direction and following the county wagon road to the brewery on O'Brien Creek; thence in an easterly direction and following O'Brien Creek and its north fork to the head of the latter and from there and still in an easterly direction across and 5 miles beyond the summit of the main range of mountains; thence in a northerly direction on a line paralleling

and keeping within 5 miles of the summit of said mountain range to a point easterly and opposite the head of the north fork of St. Peters Creek; thence in a westerly direction down and following the course of the latter on the main St. Peters Creek back to the starting point.

This district occupies approximately 140 square miles in the northeastern part of the Republic mining district, just described. There are no large towns or settlements within the boundaries of the Belcher district, Curlew being the most accessible supply station for the northern part of the district and Republic for the southern part. When the Belcher mine is operating and the narrow-gage Belcher Mountain Railroad is running, the properties are all more accessible. The Granby smelter is less than 20 miles from the point where the narrow-gage railroad terminates, just above the Great Northern Railway. The Spokane & British Columbia Railway is only a short distance (across Curlew Creek) from this point, so that transportation of the ores from a part of the district can easily be accomplished. Timber and water are plentiful over a large part of the district.

CONDITION OF MINING ACTIVITY.

During the investigation of this district, in July, 1910, only one of the three properties visited was active. The Oversight group is in an early prospecting stage, and not much ore has been shipped from the Copper Key, which was being developed when examined. The Belcher mine has made a good many shipments of ore in the past but was idle when visited. The location of these properties and their relative position on Cooke and Belcher mountains can be seen by reference to figure 17. No smelters or mills have been constructed in the district, and the ores extracted have been used principally as a flux in smelting at Granby and Trail, British Columbia.

TOPOGRAPHY.

The Belcher mining district occupies a part of the western slope of the divide between Curlew Creek and Sanpoil River on the west and Kettle River on the east. The mountains rise rather precipitously from the stream valleys on the west, which have a general elevation of 2,200 feet, to altitudes of 6,000 feet in the higher peaks on the divide. Belcher Mountain, the top of which is 4,950 feet above sea level, is the most prominent mountain in the district, although there are several ridges in the vicinity which are higher. The general trend of the mountain masses is north and south and the minor drainage channels flow in general at right angles to this direction. The principal creeks within the district are the north fork of O'Brien Creek and Lambert Creek. Large parts of the mountain masses have been worn away by glaciation and stream erosion and the peaks which are left are all the more conspicuous.

GEOLOGY.

A sedimentary series of limestone, dolomite, argillite, and lime shale, more or less metamorphosed, constitutes the major part of the geologic section in this district. These rocks have a general north-south strike and dip to the west or east at angles ranging from 15° to 60°. In the immediate vicinity of Belcher Mountain the strike is in general a few degrees west of north and the prevailing dip is a little south of west. The thickness of these sedimentary rocks in the

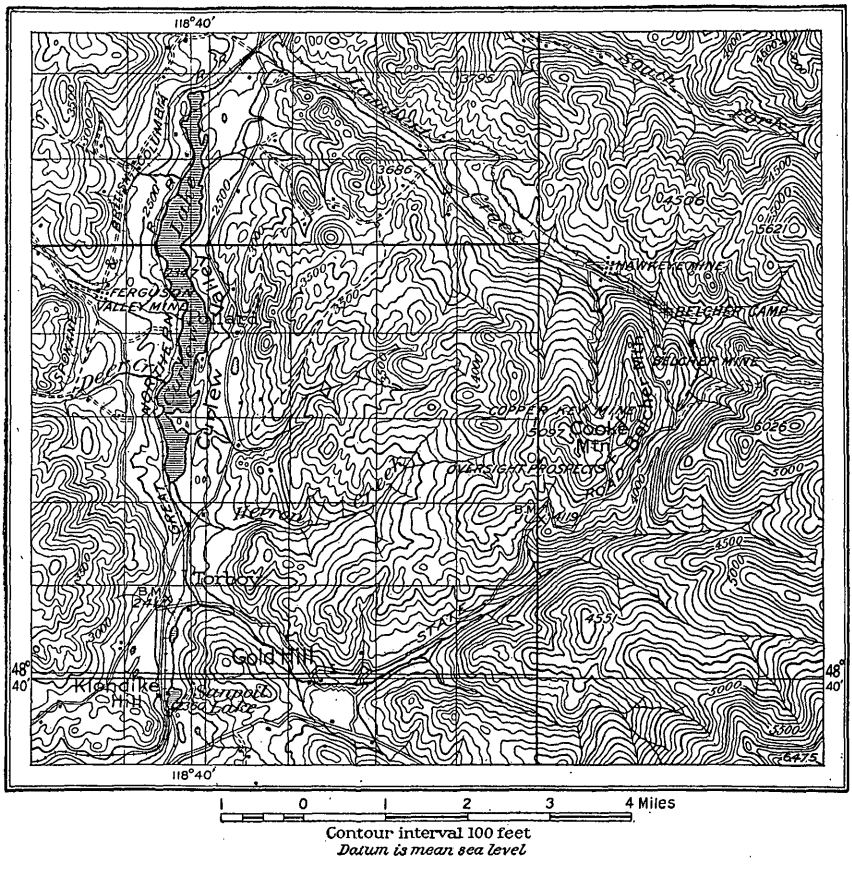


FIGURE 17.—Topographic map of a part of the Belcher mining district. From map of the Republic quadrangle, United States Geological Survey.

Belcher district is several thousand feet, and that of the individual formations from a few feet to 100 feet or more.

Blue and white limestones predominate, although limestones of various other colors are present. They are in general of a fine-grained crystalline texture, but some are coarsely crystalline and highly marmarized. They contain various amounts of magnesia, and some of the strata are dolomites. A dark-brown variety found in the Copper Key workings is exceptionally high in MgO. Three

analyses of specimens taken from different parts of Cooke Mountain show the following results:

Partial analyses of limestone and dolomite from Cooke Mountain, near top.

[J. G. Fairchild, analyst.]

	CaO.	MgO.
West side	31.41	20.00
South slope	41.22	11.15
Southwest slope	31.96	17.60

Other varieties seen are apparently nearly pure calcium carbonate.

The lime shales and argillites are more prominent in the vicinity of the Oversight and Copper Key properties than farther northeast. The lime shales are rather fine grained and are of various colors—yellow, brown, gray, or red. The argillites are generally very fissile, have a slaty-blue color, and are composed chiefly of quartz, feldspar, and carbonaceous matter. In places they have been metamorphosed to phyllites.

Dikes of monzonite porphyry have been intruded into the sedimentary series in many places and form a network of intrusive rock in the underground workings of the mines. These dikes range from a few feet to 100 feet or more in width. They have generally been intruded parallel to the bedding planes of the sediments, although in places they cut directly across the strike. Fresh specimens are of a light gray-blue color and show phenocrysts of feldspar, hornblende, and biotite. Various phases of the same magma, containing different proportions of the mineral constituents, occur in the district. The rock resembles closely the monzonite porphyry found in many parts of Stevens County. The microscope shows that it is composed of phenocrysts of andesine, with subordinate hornblende and biotite, in a groundmass of quartz and orthoclase. In many of the specimens the ferromagnesian minerals have been entirely altered to chlorite. Although garnet, tremolite, and epidote have been developed to some extent in the strata, contact-metamorphic minerals are not very abundant—a fact which indicates that the intrusion took place when the sediments were at no great depth.

ORE DEPOSITS.

The deposits examined by the writer in the Belcher mining district are all located within a few miles of one another and occupy a belt about a mile wide extending north and south through the center of the district. Several deposits on which more or less work has been done in the past could not be visited for lack of time, and there are doubtless similarly mineralized portions of the sedimentary series in this general locality which are yet undiscovered.

The ore occurs as irregular and more or less complete replacements of the limestone and dolomite strata in the vicinity of intrusive masses of monzonite porphyry. The replaced strata range from a few feet to 25 feet or more in thickness. Their extent along the strike and dip of the ore bodies has in few places been determined, but these dimensions have been proved to exceed 100 feet and are probably considerably greater. The ore is chiefly in the form of magnetite and pyrite, with considerable quantities of pyrrhotite and a little chalcopyrite. It is reported to carry a little gold, and the gossans contain 80 cents' worth of gold or more to the ton. These ores at present are economically important as a flux for smelting other ores, the chief consumers in the past having been the Granby and Trail smelters, in British Columbia.

The ores are thought to have been formed by solutions that accompanied the monzonite porphyry which is so common as an intrusive in the sedimentary series of this region, and they may be considered as clearly of contact-metamorphic origin. The pyrite, magnetite, pyrrhotite, and chalcopyrite were probably deposited contemporaneously, the ratio of the iron and sulphur constituents having determined to a large degree the kind of iron ore formed.

A deposit of another type is worked in the Pin Money claim of the Oversight group. It is a quartz vein of small dimensions, which contains some arsenopyrite, pyrrhotite, pyrite, and tetrahedrite, ores that are thought to owe their origin to mineralization at another time, though this also was induced by the intrusion of the monzonite porphyry.

MINES AND PROSPECTS.

OVERSIGHT.

General features.—The Oversight group of claims, on the southeast side of Cooke Mountain, at an elevation of about 4,650 feet, is in an air line just 9½ miles northeast of Republic, the nearest town. (See fig. 2, p. 39.) By wagon road the distance is 3 or 4 miles farther. The Great Northern Railway runs within 5 miles of the claims, but can not be reached by wagon road in less than 7 or 8 miles. The terminal of the narrow-gage railroad at the Belcher camp is just 3 miles due north, and the wagon haul to this place is only a short distance farther but involves a very steep grade which would seriously hinder the back haul. Up to the time of the writer's investigation (July, 1910) surface cuts, short adit tunnels, and shallow shafts constituted the principal developments. The location of these workings can be seen by reference to figure 18. The equipment consists of a 15-horsepower gasoline engine, a compressor, and a small hoist. No shipments are reported from this property.

Geology.—The rocks that form this part of Cooke Mountain belong to the sedimentary series of limestone, dolomite, lime shale, and

argillite, which occupies a large part of northeastern Washington. These rocks are intruded by a monzonite porphyry that is similar in many respects to that found in the Orient mining district, in Stevens County, some 20 miles to the east, and to the intrusive por-

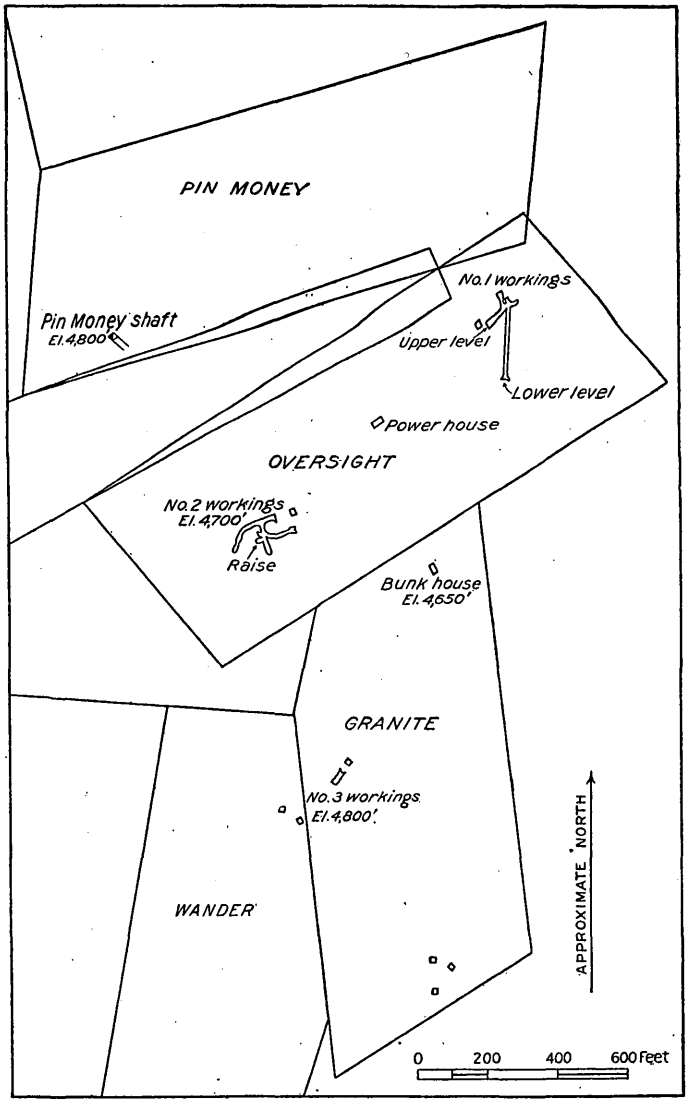


FIGURE 18.—Sketch map of a part of the Oversight group of claims, showing the location of the workings.

phyry masses in many parts of the Republic and Danville districts. This rock occurs in various positions in the sediments, although it generally follows the bedding planes. Where the sediments lie rather flat the porphyry occurs as a sill; where they have been tilted to an upright position the intrusives are in the form of dikes. Con-

tact-metamorphic minerals are singularly absent in this locality, and the invading magma has in general suffered little alteration. In places the rock is somewhat leached, and elsewhere the ferromagnesian minerals have been changed to chlorite and the feldspar entirely altered to white mica. In the main, however, the rock is remarkably fresh.

Ore deposits.—Most of the surface cuts, shallow shafts, and short adit tunnels have been made with a view to prospecting replacement deposits of iron in dolomite and limestone, but the workings on the Pin Money claim disclose an ore body of different type, which will be discussed in a separate paragraph. As the developments on the several claims are not connected the conditions existing in each opening will be discussed separately.

The No. 3 workings are located on the Wander claim, just west of the Granite side line and about 800 feet southwest of the Oversight camp or bunk house. (See fig. 18.) Here a shaft, the collar of which is about 100 feet higher than the camp, has been sunk vertically for 35 feet. Water covered the workings below this point when examined by the writer, but it is said that the shaft continues for 60 feet at an angle of 35° and that from the bottom an upraise has been started. The vertical portion of the shaft goes through 8 feet of soil covering 10 feet of limonite, below which it passes into an ore body of almost completely replaced dolomite. This ore body extends to the bottom of the vertical part of the shaft, and the incline is said to pitch under it. The replacement was effected chiefly by pyrite, pyrrhotite, and magnetite, with a very small amount of chalcopyrite. Slight quantities of gold are reported from these ores. An analysis of some of this ore,[1] by J. G. Fairchild, of the United States Geological Survey, is given below:

Analysis of ore from Wander claim.

CaO	14.71
MgO	12.91
S	8.90
Fe	26.97
P_2O_5	.164
As	None.

The ore body appears to be lenticular and to represent an irregular replacement of the dolomitic limestone. The extent of the ore body could not be measured for lack of development, nor could it be accurately estimated.

The No. 2 workings are located 400 feet a little north of due west of the camp and about 50 feet higher. (See fig. 18.) They show a partly replaced limestone stratum between walls of lime shale. The

[1] This is not a general average of the ore in the Oversight workings. Some of it is nearly pure magnetite.

general strike of the ore body is north and south and the dip 5°–10° E. This ore body has been opened for 40 to 50 feet and the average thickness is 3 or 4 feet. The workings beyond the first drift, running southeast and northwest, are barren of ore and show only a succession of dikes intrusive into the sedimentary series.

Other minor workings show the same relations. The developments have been so scattered and so meager that it is impossible to determine whether one body of ore has any connection with another or not. It seems probable that there are several distinct ore horizons, whose positions depend largely on their proximity to intrusive masses.

On the Pin Money claim an inclined shaft has been sunk at an angle of 25°–30° SE. to a depth of 80 feet along a small quartz vein lying between a hanging wall of impure limestone and a footwall of clay shale or slate, which closely resembles phyllite. The vein strikes N. 30°–40° E. and dips 25°–30° SE. It does not average over 6 inches in width and in places nearly pinches out. Much gouge is present on both sides of the vein, and the zone of movement is locally 24 inches wide. In a 60 to 70 foot drift to the southwest from the bottom of the shaft the vein nearly pinches out where monzonite porphyry intrudes the sedimentary rocks. In a 15-foot drift to the northeast the vein is well exposed. The ore minerals are arsenopyrite, pyrrhotite, pyrite, and tetrahedrite. Gold, silver, nickel, and cobalt are reported from these ores, although careful analyses by R. C. Wells, of the Geological Survey, failed to reveal the presence of either cobalt or nickel. The ores were probably not formed at the same time as the other ores of this group, though the mineralization was due to the same intrusive monzonite porphyry.

COPPER KEY.

The Copper Key mine is about half a mile almost due north of the Oversight group, at an elevation of 4,650 feet, on the west side and near the top of Belcher Mountain. It is connected by wagon road with the Belcher camp, and there has been some talk of building a gravity tram between the two places for the purpose of shipping out ores by way of the narrow-gage railroad. Shipments amounting to 3,195 tons of oxidized ore are reported to have been made from the stope above the No. 1 level, and 154 tons of ore has been shipped from the No. 3 level. The equipment consists of several cabins, a 32-horsepower engine, an 8 by 8 by 16 inch compressor, and four drills. Three levels, two upraises, a winze, and a stope, making about 1,600 feet of underground workings, constitute the principal developments. (See fig. 19.)

The rocks in the vicinity are limestone, dolomite, lime shales, and argillite, very similar to those found in other parts of the Belcher

mining district. These rocks strike northwest and dip 15°–30° SW. They are intruded in several places by monzonite porphyry, which has caused some contact metamorphism in the contiguous strata.

As exposed by the workings on the Copper Key, the ore bodies represent an irregular replacement of limestone or dolomite by pyrite, pyrrhotite, and magnetite, with some chalcopyrite. They follow the general trend of the strata which they replace, and locally they lie directly above or beneath the intrusive porphyry. One ore body exposed by the upper workings has been developed for a length of 100 feet or more along its strike and for over 100 feet along the plane of the dip. Its width is approximately 25 feet. It is possible, or even probable, that this ore body is a continuation of the one exposed on No. 2 level, where an ore body has been shown to continue at least 90 feet along its strike and to be 25 feet thick, but no work has been done to show its extent along the dip plane.

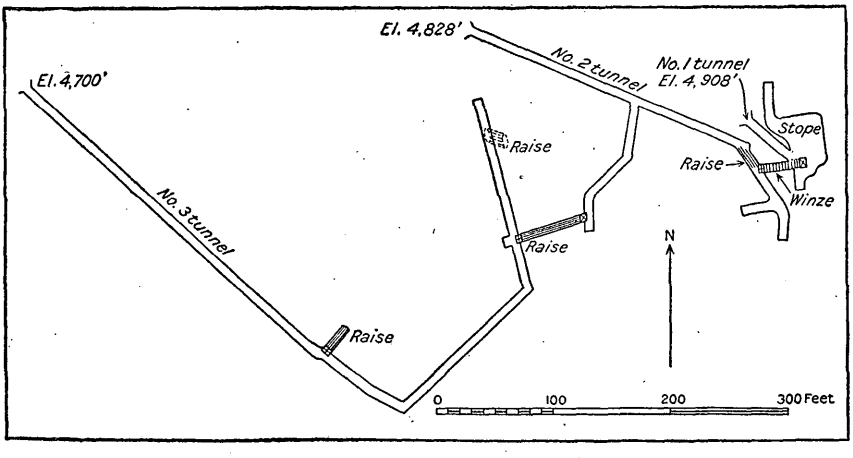


FIGURE 19.—Plan of the Copper Key workings.

No. 3 level cuts an ore body which extends as a more or less complete replacement for 30 feet along the strike, the mineralization beyond becoming scattered and less prominent until it almost entirely disappears. This ore body, as developed, seems to be only 4 to 6 feet thick. Its extent along the dip has not been determined. Probably it represents a distinct ore body, having no immediate connection with the ore exposed in the level above. It is possible, though improbable, that the ore body exposed above has been faulted down. At the time of visit not enough work had been done to show the containing walls of this lower ore body.

The unoxidized ores carry from 0.08 to 0.25 ounce of gold and 0.14 to 0.46 ounce of silver to the ton and less than 1 per cent of copper. In the upper parts of the deposit, where there is a heavy gossan of limonite about 20 feet thick, the gold content is about the same, but the copper content is lower. An analysis of a specimen of magnetite

ore by J. G. Fairchild, of the United States Geological Survey, is given below.

Analysis of magnetite ore from Copper Key mine.

SiO_2	0.64
CaO	8.78
MgO	1.10
S	.08
Fe_3O_4 (Fe, 63.21)	87.28
P_2O_5	.164
As	None.
	98.044

As a large quantity of this magnetite is present in the ore body and as in places it is remarkably free from pyrite and pyrrhotite, it may possibly be of economic importance.

The general relations existing in this mine point to the conclusion that one or more intrusive sheets of monzonite porphyry have invaded the sedimentary rocks in a direction approximately parallel to their bedding planes—that is, striking northwest and dipping 15° to 30°, or perhaps more, to the southwest. On each side of the intrusive body the strata have been replaced to a greater or less extent by ore-bearing solutions that accompanied or followed the intrusion. The replacement was irregular, being much more pronounced in the limestone or dolomite than in the other sediments. The gossans of these deposits can probably be profitably mined and milled for their gold contents, but it is rather doubtful if under existing mining conditions the unaltered portions of the deposits are commercially valuable, except for use as a flux in smelting ores.

BELCHER.

Location, equipment, and development.—The Belcher camp is located on Lambert Creek at an elevation of 3,550 feet, 7 or 8 miles up the creek in a southeasterly direction from its mouth. (See fig. 2, p. 39.) Lambert Creek flows into Curlew Creek near one terminal of the Belcher Mountain Railroad, which is above the tracks of the Great Northern Railway. The Spokane & British Columbia Railway also runs within a few feet of this terminal. A good wagon road has been constructed up Lambert Creek and continues along the east side of Belcher Mountain, connecting with a road leading to Republic. While the problem of transportation of ores has been solved in a way, the facilities are unsatisfactory. The narrow-gage railroad is difficult of operation, the grade is steep, and derailments have been of frequent occurrence.

Due south of and about 500 feet above the camp are the lower workings of the mine. These workings extend through a vertical distance of 450 feet, the highest shaft being near the top of the northern part of Belcher Mountain. The ore is trammed out from

the lowest level and sent down to the Belcher camp by a gravity tramway. It is then transferred to the narrow-gage railroad, hauled to the ore bins located above the Great Northern Railway tracks, and again transferred for final shipment to the smelters. As the camp was idle when visited, not much general information could be obtained and little is known to the writer of the early history of the mine or its total production. The ores are chiefly pyrite and magnetite with some pyrrhotite, and contain only a small precious-metal content—from 40 cents to $1 a ton in gold. The copper content is low. The oxidized outcrop of the ore body is altered to limonite and is reported to contain more gold. The Trail smelter is said to have paid $4 a ton for this ore, and the Granby smelter is reported to have bought large quantities of the sulphide ore for $2.50 a ton. Presumably the magnetite ore has no market at present.

The mine has been operated by several managers, who have installed different equipment according to their ideas of general efficiency. A complete set of electrical apparatus was at one time installed, the mine being lighted and the drills operated by electricity. When the mine was last operated the machinery used was a 32-horsepower engine, a 10 by 10 inch compressor, drills, and other accessories. The 7 or 8 mile narrow-gage railroad and equipment, together with the gravity tramway connecting the lower workings of the mine with the ore bins at camp, form a part of the improvements. The camp is well supplied with water and timber.

Three levels make up the principal underground developments on the Belcher claim. These, with a shallow shaft, a short drift, an upraise from No. 1 level to workings on the Hidden Treasure claim, and a glory hole on the Belcher claim, constitute the mine workings. Figure 20 shows a plan of the underground development and figure 21 a section through the mine. In all there are about 4,000 feet of crosscuts, drifts, upraises, winzes, and other openings. Of this total a very small part has been confined to developing ore bodies. These workings are all located on the northeast side of Belcher Mountain, which, because of its relatively steep slope, affords ideal tunnel sites.

Geology.—The rocks in the vicinity form a continuation of those occurring near the Oversight and Copper Key properties and are a part of the metamorphic sedimentary series that occupies a large part of northeastern Washington. White and blue crystalline limestone and dolomite are the principal rocks exposed by the Belcher workings. These rocks are in places medium to coarse grained, forming a good marble, and are apparently conformably interbedded with lime shale and argillite. These last two kinds of rock are not so prominent in this vicinity as they are a mile or more to the south. The sediments strike a little west of north and dip 15° to 60° a little south of west. They are intruded by dikes of monzonite porphyry from a few feet to several hundred feet thick. These dikes generally

follow the bedding planes of the sediments, but in places cut across them. Fine-grained varieties of the same rock seem to be present

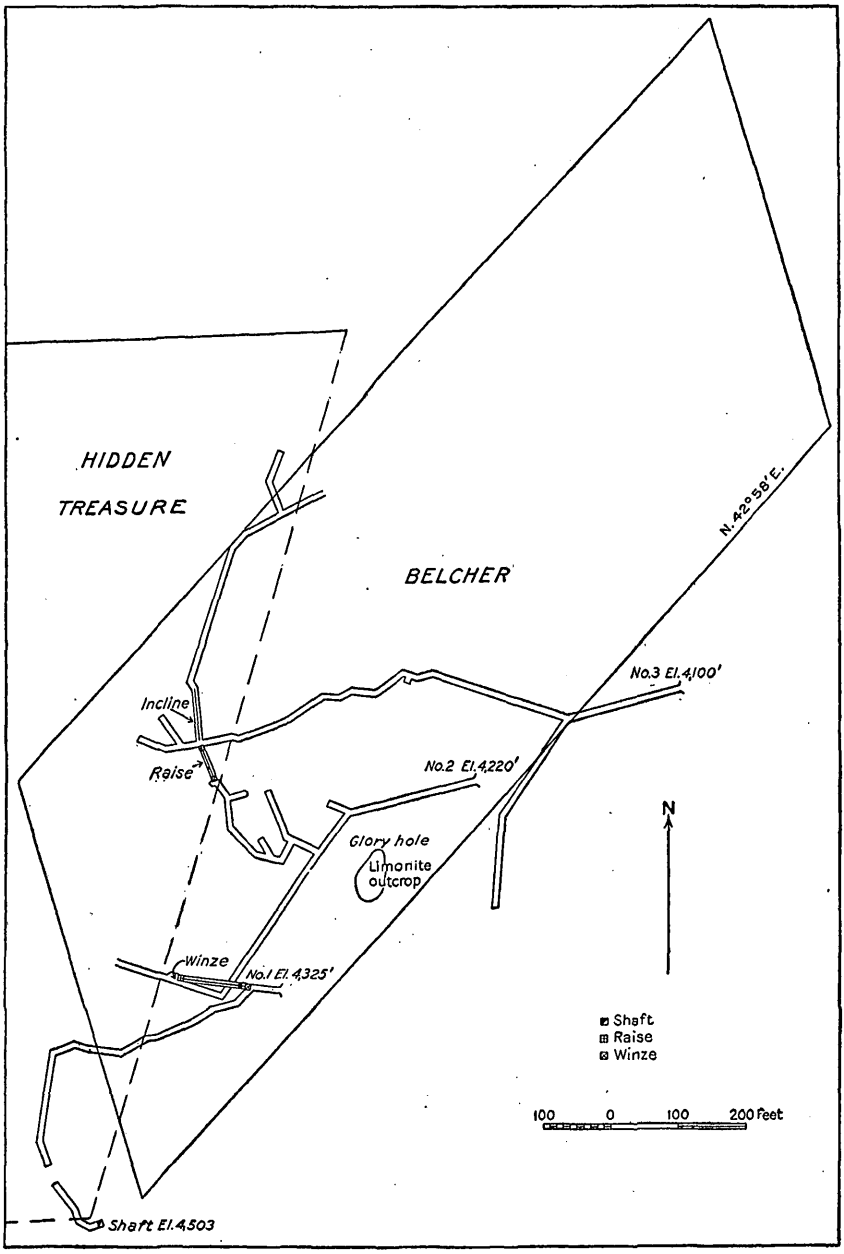


FIGURE 20.—Plan of the Belcher mine workings.

in places, although they could not be definitely recognized as connected with the same magma. Contact-metamorphic minerals are not abundant; garnet, tremolite, and epidote were seen in small

amounts. Much chlorite, resulting from the alteration of the ferromagnesian constituents of the monzonite porphyry, is present and stains some of the rocks a dark green. The oxidized outcrops of the ore bodies are yellow, and limonite discolors the rocks in the immediate vicinity.

Ore deposit.—The Belcher deposits have many characteristics in common with those of the Copper Key, both representing irregular replacements in limestone and dolomite. The sulphide ore in the Belcher mine is chiefly pyrite, and magnetite is not nearly so prominent as in the Copper Key. Associated with the ores are garnet, epidote, and tremolite, of contact-metamorphic origin. The outcrops of the deposits are very similar, being composed mainly of limonite. On the No. 1 level only scattered patches of ore were seen

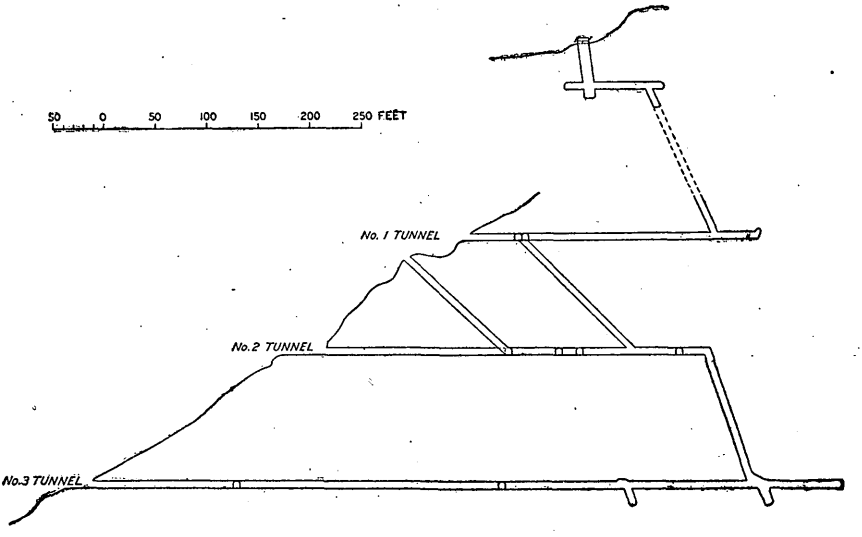


FIGURE 21.—Section through the Belcher mine, looking southwest.

near the winze on the north side. On the No. 2 level a drift follows an ore body for about 75 feet—40 feet through solid ore and 35 feet through more or less replaced country rock. The replaced stratum has been shown to be at least 20 feet thick and may be thicker. On the No. 3 level ore is exposed beyond a small winze on the north. It is more or less irregular except near the place where the incline has been sunk below No. 3 level. This incline is reported to be in ore, some of which is said to contain 4 per cent of copper. As the incline was full of water when visited, it was inaccessible. Not enough work has been done on this ore body to determine its size. In fact, the developments show in only a very poor way the relation of the ore deposits to the rocks on each side. To judge from the exposures and outcrop on the surface, the deposit should be from 5 to 20 feet thick and should extend downward along the dip plane for some distance. The length along the strike has not been determined.

Origin of the ores.—Here, as in the Oversight and Copper Key properties, the deposition of the ores is thought to have accompanied or followed the intrusion of the monzonite porphyry, and the ores are clearly of contact-metamorphic origin. The formation of large quantities of pyrite, with pyrrhotite in minor quantities, is indicative of an abundance of sulphur, so that the iron present could combine with sulphur to form FeS_2, rather than Fe_nS_{n+1}, as in the Oversight and Copper Key deposits. The absence of a high percentage of magnetite in the Belcher area substantiates this view when it is considered that magnetite forms a large part of the ore bodies in the Oversight and Copper Key, where pyrite is about equally prominent and pyrrhotite forms a considerable part of the ore.

Occurrence of replacements.—It seems highly probable that the developments in this mine reveal at least two ore bodies and perhaps three. These ore bodies, which are separated from one another by varying thicknesses of the metamorphosed sediments and intrusive dikes of porphyry, range in width or thickness from 4 to 20 feet or perhaps more. Their extent along the strike and dip planes has not been determined. As these ore bodies represent the irregular and more or less complete replacement of limestone or dolomite, their general trend will accord with that of the formations. The dimensions and positions of shoots can be determined only by exploration. The sedimentary rocks are somewhat disturbed in this locality, yet they strike in general a little west of north and dip to the west or a little south of west at angles between 15° and 60°. Hence no great difficulty should be encountered in following these ore shoots to their extremities. As the replacements occur in strata on both sides of the intrusive mass, the encountering of a dike of porphyry does not necessarily mean that the ground on the other side of the dike is barren. On the other hand, some of these dikes are several hundred feet thick and are expensive to crosscut. In such places drilling is much more economical for purposes of exploration.

SANPOIL DISTRICT.

LOCATION AND EXTENT.

The Sanpoil district occupies about 600 square miles in the southern portion of Ferry County. (See fig. 2, p. 39.) As a whole it is the most inaccessible district in the county, and up to the summer of 1910 it had been less developed than any other well-recognized mining district in northeastern Washington except the Metaline district. On July 1, 1898, the following boundaries were recorded for the Sanpoil mining district:

The district begins at the confluence of the Sanpoil with the Columbia River; thence westward to the intersection of Columbia River with the Okanogan County line; thence northerly along the line 25 miles; thence easterly 25 miles; thence southerly to the Columbia River; thence in a westerly direction along the Columbia to the place of beginning.

Transportation is afforded by wagons and pack animals, as no railroad runs through the area. Wilbur, on the Northern Pacific Railway, is about 12 miles south of the southern border of the district, and Republic, on the Great Northern and Spokane & British Columbia railways, is about 24 miles north of the northern border. These two stations are the most accessible and are the supply points for the Sanpoil district. A railroad route has been surveyed down Sanpoil River, but in April, 1911, construction had not been started. Keller (formerly Harlinda) is the largest settlement in the district and contains a few houses, general merchandise stores, a stable, a post office, and a lodging house. A stage runs triweekly between Keller and Wilbur.

CONDITION OF MINING ACTIVITY.

General inactivity prevailed throughout the Sanpoil district during the summer of 1910, and little or no development work was in progress. The three properties visited in this district represent deposits of different types, and, although the district contains many prospects which the writer could not visit for lack of time, it is highly probable that they are comparable in many respects to deposits described here or in different parts of this report. Some of the Ninemile Creek deposits are doubtless similar to those described in the section on the Meteor or Covada (Enterprise) district (pp. 187–197). Others doubtless represent irregular replacements in limestone caused by igneous and contact metamorphism, some of which are rich in lead and silver. Lead-silver ores are reported from the vicinity of Silver Creek, 3 to 4 miles south of Keller. The Meadow Creek locality, 3 miles north of Keller, on the west side of the Sanpoil, is reported to contain gold-quartz veins and lead-silver ores.

A small copper smelter erected at Keller had not been blown in at the time of the writer's investigation. It was built by the Keller & Indiana Smelting Co. to smelt the ores from the Manila mine, 7 miles west of Keller.

Water is obtained throughout the district from the Sanpoil and its many smaller tributary creeks, and timber is abundant in a large part of the district.

TOPOGRAPHY.

The Sanpoil district is traversed by two main north-south mountain ranges, one on each side of Sanpoil River, which flows southward a little west of the center of the district. Within the limits of this district the Sanpoil drops from an elevation of 1,800 feet to 1,100 feet at its confluence with the Columbia. The highest mountains rise over 5,000 feet above sea level, but the general elevation of the ranges is about 3,500 feet and the mountain masses slope gradually down toward the Columbia on the south, so that in that part of the

district the tops of the higher peaks are less than 2,500 feet above sea level. The Sanpoil has many small tributary creeks, among which may be mentioned Bridge, Copper, and Rattlesnake creeks, flowing southwestward. The names of the creeks which flow south, eastward into the river do not appear upon the general maps of the region. Ninemile Creek flows into the Columbia in a southeasterly direction from the east side of the range east of the Sanpoil. The area drained by this stream is known as the Ninemile district.

GEOLOGY.

As only a small part of the Sanpoil district was examined, it is impossible to give a very definite account of the rocks which occupy the major part of the district. A sedimentary series of limestone, argillite, lime shale, quartzite, and quartz-mica schist covers a large part of the area. In places these rocks are accompanied by amphibolitic schists and sheared igneous rocks of varied composition. The general strike of these rocks is north and south, although many local divergences were seen. The whole series is thought to be of Paleozoic age. It evinces considerable dynamometamorphism and, in the vicinity of intrusive granite and monzonite porphyry, some contact metamorphism. The intrusive rocks were seen in widely separated localities within the district and one or more of the varieties are reported to occur in the vicinity of most of the ore deposits. The intrusions of granite are thought to have taken place during late Mesozoic time, and the monzonite, which is perhaps a phase of the same magma, is believed to have directly followed this intrusion or to have been injected in early Tertiary time. Lava flows, probably of Tertiary age, cap many of the mountains and in places extend down to the level of the valleys.

ORE DEPOSITS.

Although only three properties were visited in the Sanpoil district, prospects have been worked in many parts of it and mineral deposits are doubtless present in every township. The writer regrets that lack of time prohibited a more extensive examination of this locality. However, the geologic conditions existing in the Sanpoil district are not dissimilar to those in other parts of northeastern Washington, and probably it will be found to contain the same types of deposits.

The deposits examined are of three kinds—a quartz vein carrying nickel ore in a shear zone in schists, a deposit of disseminated chalcopyrite and pyrite in quartz-mica schists, and a lead-silver quartz vein in altered porphyry, possibly monzonite. Deposits of other kinds are doubtless present in the area, and among them lead-silver quartz veins and irregular replacements of limestone by lead and zinc ores are probably numerous.

MINES AND PROSPECTS.

CONGRESS.

Location and development.—Nickel ore has been exposed by the workings on the Congress prospect, on the north side of Bridge Creek, 3½ miles east of Sanpoil River. The camp is at an elevation of 2,500 feet, and a rough wagon road has been built from the main Sanpoil road to the deposit. Republic and Wilbur are each about 30 to 35 miles from the camp, the former being a little west of north of it and the latter a little west of due south. The building of a railroad down the Sanpoil would of course make the deposits much more accessible. Timber and water are plentiful in the immediate vicinity of the camp.

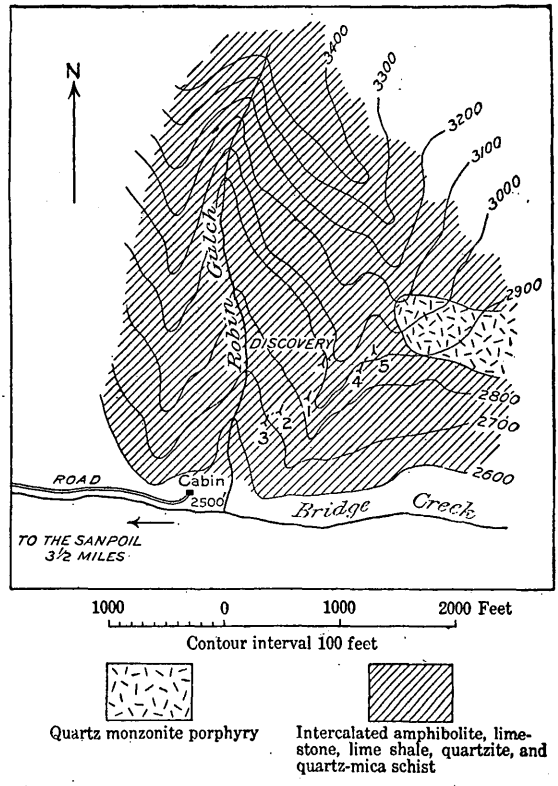


FIGURE 22.—Sketch map of the area in which the Congress prospect is located, near Bridge Creek, Sanpoil mining district. 1 to 5, Adit tunnels.

The developments on the prospect consist of five adit tunnels with drifts and crosscuts and a shallow discovery hole, aggregating about 1,500 feet of underground workings. The levels are separated by vertical distances of 50 to 100 feet and the deposit has been explored through a vertical range of approximately 300 feet. The work has been done by hand, no machinery having been installed. No shipments are reported from the prospect.

Figure 22 shows the general geologic and topographic features of the vicinity. The workings are located on a northeast-southwest offshoot of a ridge which projects southeastward from the principal mountain mass and slopes rather precipitously down to Bridge Creek, about 1,000 feet below the crest of the ridge.

Geology.—Schistose rocks of both sedimentary and igneous origin, showing considerable dynamometamorphism, constitute the principal part of the geologic section exposed in this locality. These rocks are believed to be of Paleozoic age and have been intruded by a large dike

of quartz monzonite porphyry, which is exposed on the southern slope of the main ridge at an elevation of 2,900 feet and which is thought to be of Mesozoic age. Lava flows, probably of Tertiary age, cap some of the ridges and in places extend down to the level of the valleys in the vicinity of Bridge Creek.

The schistose rocks have a general northeast strike and dip at angles varying from 45° NW. to 90°. They are composed of apparently conformable strata of amphibolitic schists with interlaminated lime shale, quartz-mica schist, and a rock which resembles sheared granite. Beds of limestone and quartzite are also included in the series. As the soil covering and underbrush conceal part of the geologic section, it is impossible to give the thickness of the several formations, which as a whole are probably several thousand feet in width. Faulting is pronounced in the schistose series, and shear zones of considerable size were seen in the Congress workings. The principal faults appear to trend in a northeast-southwest direction, parallel to the foliation in the schists.

The amphibolite has probably resulted from the dynamometamorphism of a basic rock having the composition of a gabbro or related rock magma, intruded into the sedimentary limestone, shale, and quartzite prior to the metamorphism. The lime shale and limestone are fine grained and of a dark-gray color, and the former represents a more or less impure platy limestone. Veinlets of siderite are present in the limestone. The quartzite is a fine-grained grayish-white rock showing distinct schistose structure. The rock which now resembles sheared granite is of a yellowish-brown color and is in places distinctly schistose, especially where it forms the footwall of the deposit in the Congress workings. This rock contains phenocrysts of white mica with some biotite and much talc. Magnetite, barite, and epidote are present in the rock near its contact with the schists. It may represent limestone intruded by quartz monzonite porphyry which has subsequently been severely faulted. The intrusive quartz monzonite porphyry, a boundary of which is roughly shown on figure 22, probably extends over a larger area than is represented on the map, and offshoots from the main dike are no doubt present in various parts of the schistose series. This rock has a typical porphyritic texture, is of a general gray color, and contains phenocrysts of andesine and orthoclase feldspar, with some biotite and quartz, in a cryptocrystalline groundmass. Epidotization accompanied the intrusion of the porphyry, and the limestones contain large quantities of epidote, with which are associated magnetite and tremolite. The tremolite in places along shear zones is asbestiform.

Ore deposit.—The deposit occupies a shear zone or fault plane in the schistose series and consists of a quartz vein from 6 to 32 feet in

width, which has an average strike of N. 50°–70° E. and a dip of 45° NW. to 90°. The strike and dip of the vein conform to the planes of schistosity of the inclosing walls. The quartz filling the vein is of a bluish-white color, is fine grained and compact, and is cut by joints into cubical and rectangular blocks measuring from a fraction of an inch to a foot or more. The portion of the vein explored by the Congress workings is somewhat cellular, the small vugs present being filled with quartz crystals and some malachite. Talc and barite form a small part of the vein filling. Sparsely scattered through the quartz are small veinlets and aggregates of pyrite associated with some chalcopyrite. These veinlets of pyrite range from a fraction of an inch to an inch or more in width, and the quartz with scattered aggregates of pyrite may extend over a larger portion of the vein. The pyrite is nickeliferous, and where oxidation has been active the sulphides have been altered and their oxidation products have been deposited as thin films along the joint planes and fractures and in fact along all the openings in the quartz veins. Limonite, malachite, and a carbonate of nickel are present in thin films, with the result that the whole vein is discolored, the predominant color being reddish brown with scattered patches of light and dark green. Samples were taken by the writer to determine the approximate average tenor of parts of the vein, and the results of assays of this material should not be taken as indicative of a thorough sampling of the deposit, a matter which is quite beyond the scope of the work of the United States Geological Survey. A sample from a crosscut of the vein in the lowest or No. 1 level, 390 feet from the portal of the adit tunnel and 90 feet beyond the intersection of the adit with the vein (at this place 23 feet wide), contained 0.17 per cent of nickel and 0.013 per cent of cobalt.[1] On the No. 2 level, where the vein is cut 40 feet from the portal of the adit and then followed by a drift for 160 feet or more, a sample of 14 feet of the vein was taken along the drift. This sample contained 0.246 per cent of nickel and 0.034 per cent of cobalt. A crosscut at the end of this drift shows the vein to be approximately 32 feet wide at that place. A third sample was taken in No. 3 level in a crosscut on the vein 90 feet from the portal, where the vein is encountered. This sample extended across 20 feet of the vein from the hanging wall toward the footwall and contained 0.12 per cent of nickel and 0.016 per cent of cobalt. The silver and gold contents were determined from a composite of the three samples. The results of this assay[2] show 5.5 ounces of silver to the ton and a trace of gold. A picked specimen of sulphide ore containing chiefly pyrite was analyzed for nickel and cobalt by Mr. Fairchild and found to contain 5.71 per cent of nickel and 0.35 per cent of cobalt.

[1] Analyses for nickel and cobalt were made by J. G. Fairchild, of the United States Geological Survey.
[2] By Ledoux & Co., of New York.

In the oxidized ores the nickel content is low, but as the picked specimen of sulphide ore showed over 5 per cent of nickel it seems possible that this deposit might be profitably worked below water level, where oxidized material would be practically absent and where sulphides should predominate. Because of the scanty distribution of the nickel-bearing sulphide ores in the quartz vein the ore would have to be concentrated.

This ore deposit was probably formed by solutions accompanying the intrusion of the quartz monzonite porphyry, which caused more or less contact metamorphism in the adjacent rocks. The evidence for this conclusion lies in the presence of magnetite, epidote, and barite in the contiguous strata.

MANILA.

The Manila mine is 4 miles in an air line S. 87½° W. of Keller, the distance by wagon road being about 7 miles. A smelter consisting of two 100-ton blast furnaces has been constructed at Keller by the Keller & Indiana Consolidated Smelting Co. to treat the ores from this mine. A small sampling mill is connected with the smelter. Power is to be generated by electricity from hydroelectric installation. Up to the time of the writer's visit (July, 1910) the smelter had not been blown in. Timber is plentiful at no great distance from the mine, and enough water for domestic purposes is available near by. The claims are held by annual assessment work, and none of them are patented.

Lee Farr is said to be the principal owner of this mine, and although it has several times been under lease and bond he still holds the title. The production consists of 1,500 tons of ore, which is reported to have been mined and hauled to the smelter at Keller where it has remained unsmelted.

Two levels, separated from each other by a vertical distance of 150 feet, constitute the principal developments on the property. The lower level, at an elevation of 2,675 feet, is 1,415 feet above Keller. This is a crosscut between 250 and 300 feet long with a 100-foot drift from the end of it, from which another crosscut has been driven about 75 feet. The upper level consists of a 50-foot crosscut and a stope about 45 by 25 by 14 feet, which is connected with the surface by an air shaft 20 or 30 feet long. Three 10 to 20 foot crosscuts have been run from the stope. The workings are located on a narrow ridge which has a general northeast-southwest trend and rises several hundred feet above the gulches on each side. The levels have been run from the east side of the ridge in a direction transverse to its trend—that is, westerly.

The rocks in this vicinity are medium to coarse grained quartz-mica schists with intercalated amphibolite and quartzite, and the

whole series is intruded by coarse-grained granite, which now occupies the major part of the ridge. The schists appear to strike northeast and to dip northwest at a steep angle. In this immediate vicinity they are not over 500 feet thick and are cut off on the southwest and northeast by granite, so that their linear extent along the strike is not over 500 or 600 feet. Doubtless the continuation of the schists could be found beyond the intrusive granite.

The quartz-mica schists are in the main hard, compact, generally dark-colored rocks, but some varieties are softer and contain less quartz and more mica. The amphibolite is a medium to fine grained light to dark green rock which is composed essentially of hornblende and may have resulted by the metamorphism of limestone strata or may be an altered diabase. The quartzite is a medium to coarse grained rock which shows some schistose structure. The granite is composed essentially of orthoclase and quartz with subordinate biotite. Fresh specimens of this rock are pinkish blue, but the altered rock shows a dirty brownish-white color. Contact-metamorphic minerals were not seen in the strata through which the granite has cut.

Chalcopyrite and pyrite are sparingly disseminated through the schists and still more sparsely through parts of the granitic intrusive. Mineralization seems to be a little more extensive in the stope above the upper workings than in the workings below. The whole ore body, as exposed by these workings, probably contains less than 1.5 per cent of copper. A trace of gold and from 0.5 to 4 ounces of silver to the ton are reported to be shown by assays of this ore. The extent of the mineralized zone has not been definitely determined. The maximum boundaries for this one ore body are the limits of the schist in the locality and the actual width is probably considerably less than the distance between these boundaries.

Solutions accompanying the intrusion of the granite doubtless effected the mineralization in this locality. The ore is of low grade, the mine is a long way from railroad transportation, and facilities for smelting are poor. The future of the deposit depends on the actual extent of the ore zone. If this is large enough to warrant the erection of a concentrator, the mine might be made to pay. Smelting the ore under present conditions would probably prove unprofitable.

POLEPICK.

The Polepick prospect is 1 mile north of Keller, on the east side of the ridge west of the Sanpoil, at an elevation of 1,660 feet, or about 400 feet above the valley. The developments consist of a main level on which about 700 feet of work has been done and small surface cuts some distance above. No large shipments are reported from this prospect.

Light-colored coarse-grained orthoclase-quartz-biotite granite, showing pronounced jointing and fracturing, has been intruded by a greenish-blue porphyritic rock which is now so altered that it is hard to identify. The chief constituents of the intrusive rock seem to be feldspar and hornblende, together with much chlorite and pyrite, and the rock may be a monzonite. Along and near the contact of these two rocks some faulting has taken place and quartz veins have been formed. The general strike of the contact is S. 10° W. and the dip 50°–60° E. Quartz veins having a total width of several feet, separated from one another by thin bands of country rock and gouge, show some scattered mineralization by chalcopyrite, sphalerite, and galena, with subordinate pyrite and a little tetrahedrite. Molybdenite was found in some of the fractures in the granite. The ores are thought to have been introduced by solutions that accompanied or followed the intrusion of the greenish porphyry.

COVADA OR METEOR (ENTERPRISE) DISTRICT.

LOCATION AND EXTENT.

The towns of Covada and Meteor are small settlements in a district which has been recorded in the office of the clerk of Ferry County as the Enterprise mining district but which is perhaps better known by the name of either of these towns than by the official name. As outlined in the county clerk's office, under date of February 22, 1908, the district has the following boundaries:

> Beginning at the mouth of Wilmot Creek, thence up the Columbia River to the north line of the south half of the Colville Reservation; thence following the north line of the south half of the Colville Reservation west to the summit of the range or divide between the Sanpoil and the Columbia River; thence in a southerly direction to the headwaters of Wilmot Creek; thence following Wilmot Creek to the mouth, or place of beginning.

The district covers about 250 square miles in the central eastern part of Ferry County and includes within its boundary a small area in the northeast corner of the Sanpoil mining district. Only a small part of the Enterprise district—that in the vicinity of Covada and Meteor—was examined by the writer. These settlements can be reached by fair wagon roads from Addy and Blue Creek, two towns on the Great Northern Railway, by ferrying across the Columbia at Daisy or Gifford, or they can be reached by a long stage journey down the Columbia from Meyers Falls, another station on the Great Northern Railway. Probably the most convenient method is by wagon from Addy or Blue Creek, the distance by the shortest wagon route from either of these places to Covada or Meteor being about 30 miles. In an air line Covada is 18½ miles a little south of due west of Blue Creek. As the Huckleberry Range has to be crossed in going from one place to the other, the hauling of ore is very expensive and only small shipments have been made from this district.

CONDITION OF MINING ACTIVITY.

This district was the only totally inactive camp visited during the writer's investigation. The lack of economical transportation facilities, the scarcity of large deposits of high-grade ore, and the absence of capital have had the effect of retarding operations in a locality which lies quite out of the ordinary routes of travel in this part of the State. No reduction works have been erected within the district, the small quantity of ore produced in the camp having been sent outside for treatment.

Although there are numberless veins within that part of the district examined, few of them show anything but scanty and irregular mineralization, and the rich portions seem to be confined to the superficial parts of the deposits. There are no deep workings in the camp, and consequently it is hazardous to predict what future developments will disclose. However, it seems highly probable that these deposits are analogous to others seen in northeastern Washington, and if so the tenor of the ore is likely to decrease materially as depth below the gulch levels is attained.

TOPOGRAPHY.

Columbia River bounds this district on the east and the drainage from the district flows in general toward that stream. The mountains rise gradually from the Columbia, along which the elevations are about 1,500 feet, to heights of 3,500 to 4,500 feet on the divide between this river and the Sanpoil. Glaciation has been extensive here as elsewhere in this part of Washington, with the result that the mountains are rounded off and broad valleys have been carved out between the ridges. In places the valleys are filled with glacial débris, although on the whole the district is more free from material of this sort than the districts that lie farther north. Four spurs extending eastward and southeastward from the main mountain mass form the most prominent topographic features within the district. Small streams flow through the valleys between these ridges and afford an abundant supply of water. The slopes of the mountains are covered with a good growth of several varieties of evergreen timber, which is available for use in mining operations.

GEOLOGY.

Quartz-mica schist, limestone, and shale, intruded by quartz monzonite porphyry, quartz diorite, and allied dikes, together with dikes of a still later age, constitute the geologic section exposed in that part of the district examined. The schists are in places highly foliated, but elsewhere they show only imperfect schistosity, the dynamometamorphism of the series having been irregular. Faulting is prominent, and in places the schists have been so ground up

by movement that they resemble carbonaceous shales. Some contact metamorphism has accompanied the intrusion of the porphyritic rocks into the limestone, garnet having been seen in the vicinity of the Silver Leaf prospect.

A general north-south strike prevails throughout the metamorphic series, and the dip more nearly approaches the vertical than the horizontal. The schists are medium grained, dark red to black, hard and compact and are composed essentially of quartz and white mica. The limestone seen is of a pure-white variety and is highly crystalline. An analysis of a specimen of limestone from Rattlesnake Mountain, 1½ miles northeast of Covada, showed the presence of 50.3 per cent CaO. The shales are light to dark blue or black in color, are fine grained, and are composed essentially of quartz, feldspar, and carbonaceous matter. These sedimentary rocks form a part of the metamorphic series which prevails over a large part of northeastern Washington and are thought to be of Paleozoic age.

The monzonite porphyry is a coarse-grained gray rock which closely resembles granite in general appearance. Phenocrysts of quartz, feldspar, hornblende, and biotite are visible without the aid of a lens. Under the microscope the rock is seen to be composed essentially of quartz, biotite, hornblende, orthoclase, and andesine. Zircon, titanite, and magnetite are prominent accessory minerals, and some of the rock contains sericite resulting from the alteration of the feldspars and chlorite and epidote from the breaking down of the ferromagnesian minerals. The quartz diorite closely resembles the quartz monzonite in texture, but in the former rock the ferromagnesian minerals are much more prominent, and orthoclase gives way to plagioclase feldspars. The dikes that have accompanied the intrusion of these rocks contain still greater amounts of ferromagnesian minerals. One fine-grained dike seen in the Keystone workings shows phenocrysts of biotite and quartz, the feldspars being entirely altered to or replaced by calcite.

ORE DEPOSITS.

Distribution and character.—A large number of veins were seen in the small part of this district examined, and it does not seem unreasonable to suppose that there are others outside of the area prospected in the vicinity of Covada and Meteor.

Figure 23 shows the location of some of the properties visited in this district. There are about 60 other prospects in this general vicinity on which more or less work has been done, most of them, however, representing simply surface locations with only a few feet of development work. The Meteor and the Silver Leaf are, respectively, the most westerly and most easterly deposits examined in the district, and in the area between them the geologic section and the general

conditions governing the deposition of the ores have in the main varied but little. Local differences in the deposits are noted in the detailed descriptions which follow.

The ore deposits of this district are irregular and scantily mineralized quartz lenses occupying shear zones, fissures, and silicified fault-breccia planes in the metamorphic series and the intrusive porphyritic rocks. One vein of stibnite was seen in the R. E. Lee prospect, and the Longstreet represents a deposit of a different kind. With these exceptions the deposits examined are remarkably similar, the chief differences being in the size and continuity of the ore bodies,

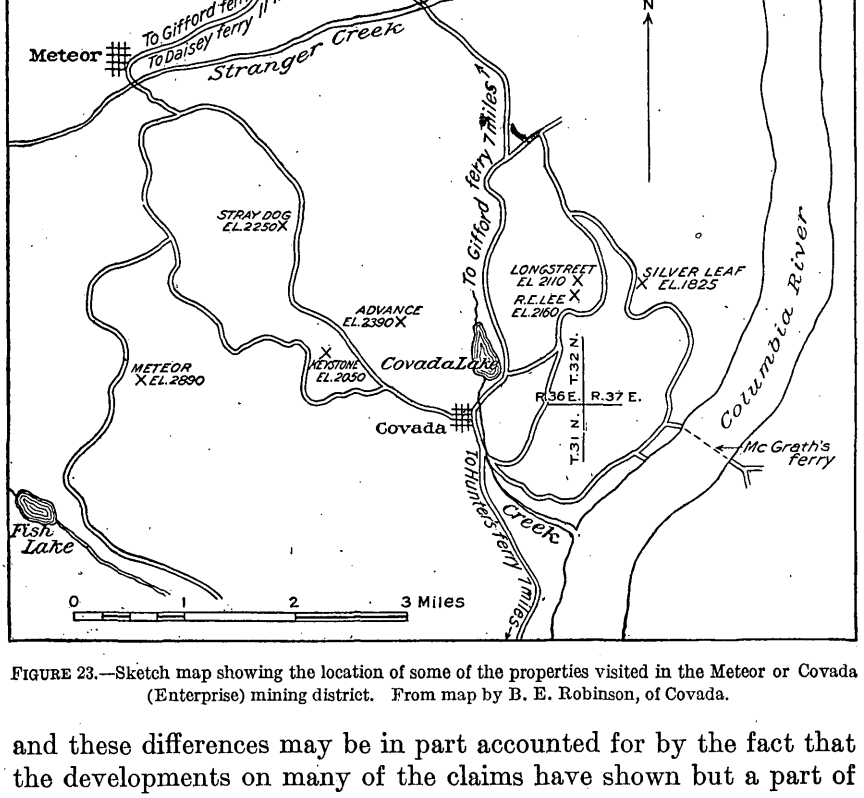


FIGURE 23.—Sketch map showing the location of some of the properties visited in the Meteor or Covada (Enterprise) mining district. From map by B. E. Robinson, of Covada.

and these differences may be in part accounted for by the fact that the developments on many of the claims have shown but a part of the deposits.

The shear zones range from a few inches to 15 or 20 feet in width, the average being about 3 feet. Their length along the strike has not been determined but in some of the deposits is several hundred feet. The length along the dip plane of the faults has been proved to be at least as extensive, but the continuity of the veins in this direction has in places been cut off by postmineral faulting. The vein fillings are more irregular in size than the shear zones. In general they

range in width from less than 1 inch to 2 feet, but the average is considerably less than the maximum. Most of the deposits were found to be decidedly lenticular and to extend only a few feet along the strike. In many of the workings drifting along the strike of the shear zones has disclosed the presence of other lenses. Banding is noticeable in some of the deposits, and comb structure is prominent in the veins which have been subjected to postmineral movement.

The gangue in all the deposits consists chiefly of quartz and brecciated country rock, with some calcite of various colors and a pinkish-yellow carbonate composed of iron, manganese, magnesium, and calcium. Postmineral faulting is a prominent feature of the deposits, silica and calcite having recemented the vein filling. The ore minerals are galena, sphalerite, chalcopyrite, pyrite, and arsenopyrite, accompanied by subordinate amounts of pyrrhotite, tetrahedrite, stibnite, argentite, pyrargyrite, and native silver. Limonite, azurite, and malachite were seen in the outcrops of some of the veins.

Origin.—Mineral-bearing solutions following the intrusion of the quartz monzonite porphyry and the quartz diorite are thought to have formed the ore deposits in this district. After the intrusion and subsequent cooling of the quartz monzonite, openings were formed in the metamorphic and intrusive rocks. The quartz diorite which was intruded later, probably representing a second phase of the same magma, was accompanied or followed by solutions that have caused the mineralization in this locality. Some of the ore is of contact-metamorphic origin, but the greater part is due to the after effects of igneous intrusion. Postmineral movement and the development of native silver and rich secondary silver sulphide minerals have made some of the deposits workable. Below ground-water level the deposits are likely to become too lean to be profitably worked under existing mining conditions.

MINES AND PROSPECTS.

METEOR.

The Meteor prospect, located 3 miles almost due south of Meteor, is the most westerly deposit examined in the Enterprise district. In an air line Covada is the same distance east, but the wagon road between the two places is some 2 miles longer. Two small shipments of ore, the returns of which are not known to the writer, are reported from this prospect, which was idle when visited.

The developments consist of an inclined shaft at an angle of 80° N. 55° W., said to be 125 feet deep, the collar of which is at an elevation of 3,125 feet. The shaft was not accessible to examination. The shaft house is about 1,500 feet N. 62½° W. of the top of Meteor Mountain and approximately 200 feet lower. The main level, a plan

of which is shown in figure 24, is located at an elevation of 2,890 feet, and consists of a 700-foot crosscut, with 175 feet of drifting on the vein and small stopes above the drift.

Medium-grained dark-colored quartz-mica schists intruded by quartz monzonite porphyry and allied dikes form the geologic section in this locality. The schists have a general northwest-southeast strike, but local changes are so numerous that no one direction is continuous. Faulting is pronounced, and is probably due in large part to the intrusion of the monzonite.

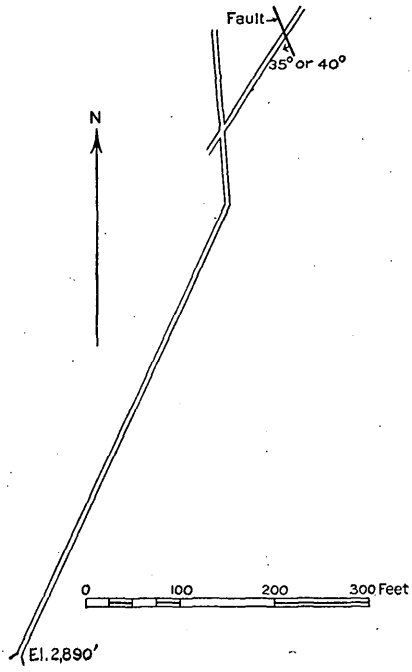


FIGURE 24.—Plan of main level of Meteor prospect, Enterprise district.

The ore deposit occupies a fault plane or shear zone in the quartz-mica schist and apparently trends parallel to the planes of schistosity. Where this fault plane has been exposed by the underground workings from the adit tunnel the vein strikes N. 35° E. and dips 75° NW. In width the shear zone ranges from a few inches up to 3 feet. The vein filling is mostly gouge with 1 to 12 inches of more or less sparsely mineralized quartz. The quartz veins are lenticular, pinching and swelling every few feet. In the small stopes above the drift on the vein two ore shoots 6 to 8 feet apart extend along the strike of the shear zone. Both shoots were only 12 to 15 feet in length as measured along the strike, and neither had been worked to a height of over 30 feet above the floor of the drift. A fault striking N. 20°–30° W. and dipping 35°–40° SW. cuts off the vein 125 feet northeast of the point where the ore body is first encountered by the crosscut.

Chalcopyrite, pyrite, sphalerite, and galena constitute the chief ore minerals. These are accompanied by some arsenopyrite, argentite, pyrargyrite, and tetrahedrite. Quartz is the principal gangue mineral and is accompanied by calcite and a pinkish-yellow carbonate containing chiefly iron, manganese, calcium, and magnesium. Native silver is reported to have been found in the ore from this mine, and the average silver content of the ore shipped is said to have been from 75 to 90 ounces to the ton. As only small shipments have been made, and as these doubtless consisted of sorted ore, it is difficult to ascertain the average silver content of the deposit.

Postmineral movement in the vein is indicated by the slickensided surfaces and brecciated gangue and ore minerals. Comb structure is noticeable in parts of the vein.

STRAY DOG.

The Stray Dog is located about midway between Meteor and Covada on the west side of the road. No work was being done on it when visited. Two shipments of 20 tons each are reported, and these are said to have assayed, respectively, 0.3 and 0.6 ounce of gold and 5 and 66 ounces of silver to the ton. The wide range in the silver content indicates that one shipment was probably assorted ore and the other run of mine.

The developments consist of a main level at an elevation of 2,250 feet, on which there is a 260-foot crosscut, a 300-foot drift, a 75-foot winze, and a 108-foot upraise; an intermediate level, at an elevation of 2,300 feet, on which 100 feet of work is reported to have been done; an upper level, at an elevation of 2,360 feet, on which some 50 feet of work has been done; and a shaft, said to be 100 feet deep, on top of the ridge.

A small quartz vein, having a general northeast strike and a dip of 75°–90° NW. and occupying a shear zone or fault plane in quartz monzonite porphyry shows some scattered mineralization by pyrite, chalcopyrite, sphalerite, galena, tetrahedrite, and lesser quantities of pyrargyrite, argentite, and arsenopyrite. Native silver is reported from this deposit and calcite forms part of the vein filling. The shear zone ranges from 18 inches to 4 feet in width and contains talc, gouge, and brecciated country rock, besides the quartz vein, which is in some places 2 feet wide and in others pinches out. The deposit is lenticular and only sparingly mineralized. Postmineral faulting is indicated by the attrition marks on the ore minerals and the brecciated condition of the vein.

ADVANCE.

The Advance property is located 1 mile northwest of Covada, on the northeast side of the gulch. It was idle when visited, and no shipments of ore are reported.

The developments consist of two main levels connected by an upraise. (See fig. 25.) The lower level, at an elevation of 2,390 feet, comprises an 849-foot crosscut, a 350-foot drift, and a 37-foot winze. The upraise between the two levels extends 180 feet on the vein, the vertical difference in elevation being about 170 feet. The workings on the upper level consist of a 200-foot drift, a 40-foot upraise, a 35-foot winze, and a 350-foot crosscut.

Quartz-mica schists showing ill-defined schistose structure are the rocks in which the ore deposits occur. These appear to strike northeast and dip 15°–60° NW.

Dikes of a fine-grained grayish rock showing phenocrysts of biotite and very much altered by metamorphic processes, yet evidently of igneous origin, intrude the sedimentary series. This rock was seen in the upraise from the lower level and in the drift on the upper level, and in places it occurs in the ore body. The microscope shows that the feldspar constituents are entirely altered to or replaced by calcite. Phenocrysts of quartz can be seen in places in the rock. Its general appearance is that of a dike accompanying the eruption of lavas, although it may be a phase of monzonitic intrusion. Because

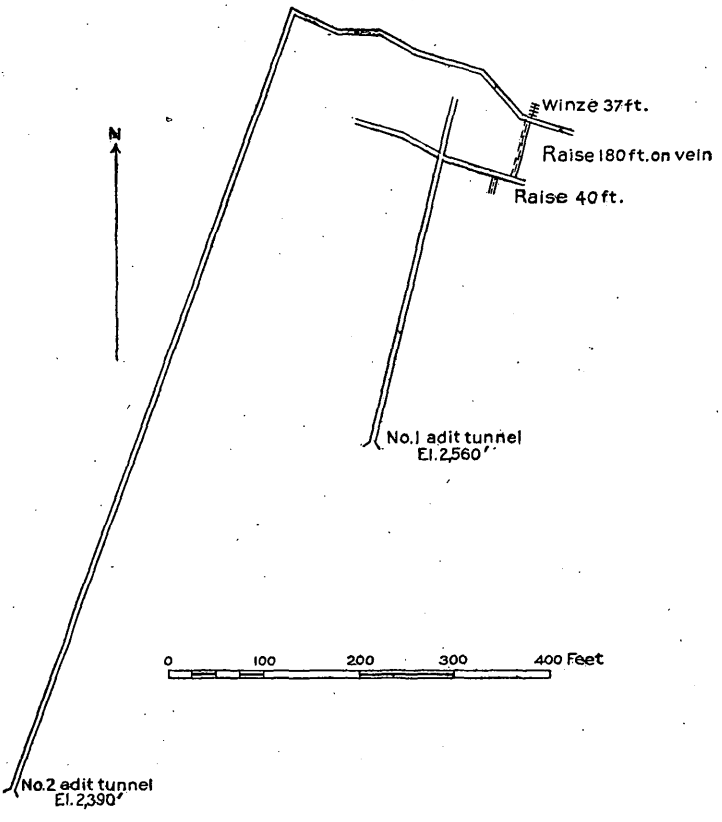


FIGURE 25.—Plan of the Advance workings, Enterprise mining district.

of the alteration which the rock has undergone identification is impossible.

The main developed ore deposit consists of lenticular masses of quartz from 1 inch to 16 inches in width, contained in a shear zone in the schists. This zone has an average width of 2 or 3 feet, strikes northwest, and dips 60°–70° N. 15° E. It is filled mainly with gouge and brecciated country rock, together with the quartz lenses or veins and some calcite. The mineralization was more or less scattered and the association of pyrite, chalcopyrite, galena, and

sphalerite so common in the deposits of this district is also found here. Some pyrrhotite, associated with pyrite, was seen, and native silver and pyrargarite are reported to have been found in the veins.

A smaller vein was cut 150 feet from the portal of the lower tunnel and followed by drifts for 10 feet on each side of the crosscut. This vein is 9 to 12 inches wide, strikes where exposed N. 55° W., and dips 45° NE. The vein filling is quartz, gouge, and brecciated country rock, sparingly mineralized by the usual association of ore minerals found in the camp.

KEYSTONE.

The Keystone prospect is about 1½ miles a little north of west of Covada, on the northwest side of the main road between Covada and Meteor. The prospect was idle when visited, and no shipments are reported from it. The only development is an adit tunnel or drift 383 feet long on a shear zone in the sedimentary rocks—fine-grained dark-colored quartz-mica schists that have a general northeast strike and a dip of 45°–60° NW. Much faulting is evident in the workings, and the rocks east of the drift seem to dip at right angles to those on the west or hanging-wall side. The slickensided surfaces of the quartz-mica schists are black and appear to contain much carbonaceous matter. The shear zone is from 2 to 6 feet in width and contains irregular lenticular masses of quartz associated with more or less calcite. In general these quartz lenses are small and contain only scattered patches of the ore minerals, galena, sphalerite, chalcopyrite, and pyrite. Native silver and pyrargyrite are also reported from the prospect. These minerals show some banded structure, and postmineral faulting is indicated by brecciated vein material cemented by quartz and calcite.

LONGSTREET.

The Longstreet prospect, 1½ miles northeast of Covada, was also idle when visited, although small shipments are reported from it. The developments consist of a 120-foot adit tunnel at an elevation of 2,110 feet, a small glory hole or open cut 60 or 70 feet higher, and one or two still smaller workings.

In this vicinity quartz-mica schists and lime shales have been intruded by quartz diorite or quartz monzonite porphyry and allied dikes to such an extent that the sedimentary series is entirely displaced. The dikes appear to have been later phases of the intrusive magma and contain more ferromagnesian minerals than the main masses of diorite or monzonite. A breccia resulting from their intrusion forms a noticeable part of the Longstreet ore deposit. It is in places entirely cemented by silica, somewhat resembling a conglomerate. These silicified zones of breccia are 8 to 30 feet wide, have a

general north-south strike, and stand nearly vertical, although many local variations were seen. Faulting along the intrusive dikes has been pronounced and one zone of selvage 30 feet wide was seen in the lower level.

The solutions which brought in the silica that has cemented the breccia deposited also some ore minerals in the brecciated zones and fractures in the country rock. Some of the mineralized country rock has been explored by the Longstreet workings. The ore minerals tetrahedrite, sphalerite, chalcopyrite, galena, and stibnite are sparsely and irregularly scattered through the siliceous gangue, and no definite ore shoots have been exposed for any but very short distances. Oxide of antimony is profusely disseminated through the small fractures and over the surface of the rocks on the outcrop of the mineralized zone, so that a yellowish-green color prevails over a large part of the upper workings on this claim.

As the mineral-bearing solutions followed zones of fracture, and as these in general follow the contacts of the intrusive diorite or monzonite, future explorations along these zones may reveal the presence of other ore bodies.

R. E. LEE.

The R. E. Lee prospect is located 1¼ miles northeast of Covada, about a quarter of a mile south of the Longstreet. It is interesting mainly because of the occurrence of small veins of stibnite or berthierite, which are exposed in the workings. This prospect also was idle when visited and no shipments are reported. The developments consist of a 76-foot crosscut, at an elevation of 2,160 feet, in which there is a 5-foot winze 30 feet from the portal.

Quartz monzonite porphyry is the country rock. In the winze are exposed small veins or fractures containing stibnite or berthierite. One stringer 3 inches wide completely filled with this mineral is the widest; others range from half an inch to an inch in width and are separated from one another by barren country rock, the whole mineralized zone being about 2 feet wide. This zone has been exposed for only a few feet along the strike and dip, and its extent in these directions is uncertain. The strike of the ore body is N. 30° E. and the dip 40°–50° NW. An analysis of this ore by R. C. Wells, of the United States Geological Survey, showed it to be composed almost wholly of antimony sulphide with a little iron and a trace of arsenic. Copper and zinc are reported to be absent, and Mr. Wells suggests that the mineral conforms more nearly in composition to berthierite than to stibnite. An assay of a picked sample of this mineral by Burlingame & Co., of Denver, Colo., showed it to contain traces of gold and silver.

SILVER LEAF.

The Silver Leaf prospect is 2 miles northeast of Covada, or by wagon road about 3½ miles, on the southwestern slope of Rattlesnake Mountain, at an elevation of 1,825 feet. No large shipments are reported from the prospect, which was inactive when visited. The developments consist of an 8 to 10 foot shaft at an elevation of 1,860 feet, several short open cuts, and a 200-foot adit tunnel at an elevation of 1,825 feet.

Intercalated limestone, quartz-mica schist, and shales constitute the geologic section in this immediate vicinity, but about 60 feet west of the open cuts is a large mass of intrusive quartz monzonite or quartz diorite which is over 500 feet thick and extends in a general north-south direction. The limestones have been largely changed to marble and show the results of contact metamorphism by the presence of garnet and other contact-metamorphic silicate minerals. The strata strike N. 9° W. and dip 80° N. 81° E.

Quartz veins having the same trend as the sedimentary rocks have been exposed by the open cuts. These veins are lenticular, are from 3 to 12 inches wide, and are sparsely mineralized by pyrite, chalcopyrite, sphalerite, galena, tetrahedrite, and stibnite. More or less pyrite is also present in the country rock, which in places is brecciated and cemented by silica carrying some ore minerals. The stibnite is prominent as a yellowish-green stain in some parts of the mineralized section. Malachite, azurite, and limonite are also present in smaller amounts.

OTHER DEPOSITS IN FERRY COUNTY.

A few deposits situated in widely separated localities in Ferry County were visited by Mr. Lindgren and the writer and will be described here. As they have no uniformity, no general descriptions of the geology and ore deposits can be given.

LONE STAR AND WASHINGTON.

Location and development.—The Lone Star and Washington mines, belonging to the British Columbia Copper Co., are located within half a mile of the international boundary, 4½ miles a little north of due west of Danville, the nearest town and railroad station. By wagon road they are 7 or 9 miles from Danville. (See fig. 26.) Water and timber are obtained in the vicinity. The mines were inactive when visited, but some ore has been shipped in the past.

The Lone Star mine has over 2,500 feet of drifts, crosscuts, inclines, winzes, and other workings; the Washington less than 700 feet. Of the Lone Star workings 750 feet is on a level known as No. 1, and

the remainder, exclusive of two upraises to the surface and an 80-foot shaft, on the No. 3 level, 35 feet below No. 1. Diamond drilling to the extent of 3,590 feet has been done on the property in 26 holes.

Geology.—In the vicinity of these mines sericite schist with intercalated limestone, lime shale, and argillite, all showing considerable dynamometamorphism are intruded by sheets and dikes of monzonite porphyry and dikes accompanying this intrusion. In places the schists and sedimentary rocks are folded in an intricate fashion, and in places they are crushed and broken, showing evidence of severe deformation. Amphibolite has been developed along many of the

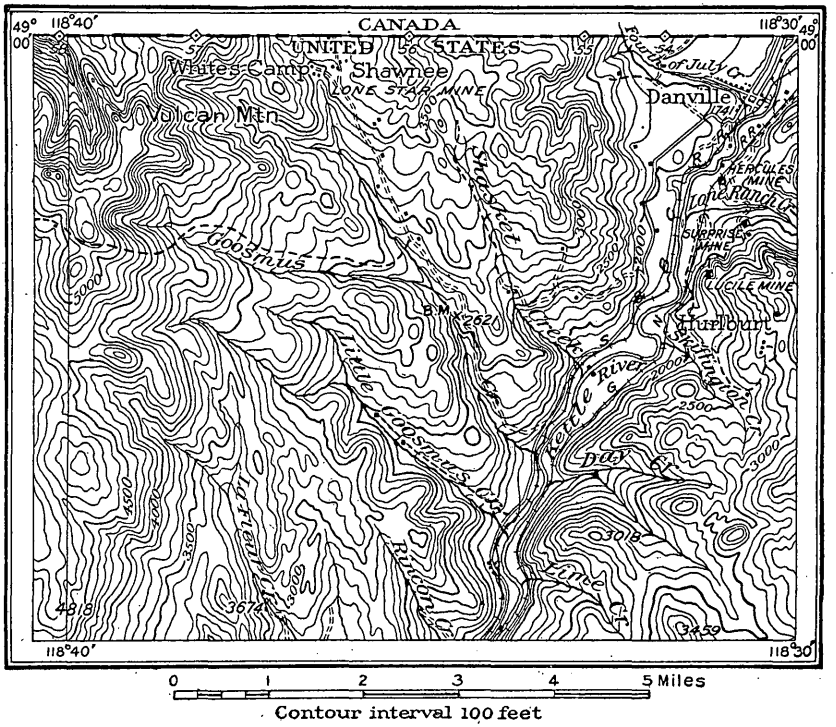


FIGURE 26.—Map of the northeastern part of the Republic quadrangle, Wash., showing the location of several mines and prospects in Ferry County.

slipping planes and elsewhere in the rocks. Some of it is possibly the result of contact metamorphism induced by the intrusion of the monzonite porphyry in the limestone. It is impossible to tell whether the sericite schist is of igneous or sedimentary origin. Under the microscope it appears to be composed entirely of sericite which has probably resulted from the alteration of feldspars, and the faint outlines of crystals which may represent the borders of phenocrysts of feldspar point to the conclusion that this schist is not of clastic origin. It may represent intrusions into the sedimentary series prior to the regional metamorphism. Two or three miles southeast of the

Lone Star mine garnet and epidote were seen in limestone strata along the contact of the intrusive monzonite porphyry. The general strike of the sedimentary series is north-south and the dip is east, but both strike and dip change their directions in very short distances. In general, the angle of dip is nearer 45° than vertical. The monzonite porphyry is similar to that seen in the Belcher mining district, 20 miles south of this place, and in fact similar to the monzonite porphyry occurring in many localities throughout northeastern Washington.

Ore deposit.—The ore minerals chalcopyrite, pyrite, and pyrrhotite, together with the gangue minerals quartz, dolomite, and calcite, are more or less widely disseminated through the schists and in places near intrusive masses of monzonite porphyry partly replace the limestone. The ore is scattered and does not occur in well-defined shoots. Where the schists abut against porphyry the ore-bearing zone terminates abruptly, but it has been found on the other side of the intrusion. In general the mineralized zone follows the planes of schistosity and bedding in the metamorphic rocks. In width or thickness the dissemination and replacement probably range from a few inches to several feet, but little authentic information is available on this point. Where exposed on the surface the mineralized schists have been greatly discolored by limonite derived from the oxidation of pyrite. Malachite is also prominent in the oxidized ores, and a small amount of shallow chalcocite enrichment was seen. The unaltered ores are said to contain a low percentage of copper (probably under 4 per cent) and about 50 per cent of silica. The precious-metal contents are unknown, but are probably considerably lower in the sulphide than in the oxidized ores.

In general the deposit appears to be but scantily mineralized, the ore being sparsely distributed over a large area of metamorphic rocks and the boundaries of the ore zone not yet having been determined. The mineralization in the metamorphic rocks is thought to owe its origin to ore-bearing solutions accompanying the intrusion of monzonite porphyry and the related dike rocks.

DEPOSITS NEAR DANVILLE.

Danville (Nelson) is situated in the Kettle River valley half a mile south of the international boundary. The region north of that line in this vicinity has been mapped by R. W. Brock [1] and shows, north of Danville, mainly Paleozoic slates and gneisses with smaller masses of serpentine and limestone. South of Danville, on the east side of Kettle River, are several prospects and mines, the more important of which are mentioned below.

[1] Geologic and topographic map of the Boundary Creek mining district, B. C. (No. 828), to accompany Canada Geol. Survey Ann. Rept., vol. 15.

The slopes rising from Kettle River south of Danville contain some diorite and gabbro and much serpentine and serpentinoid rock. Probably all these rocks are intruded into black carbonaceous shale and quartzitic sandstone with lenses of limestone. The intrusive rocks predominate.

Hercules prospect.—About half a mile south of Danville, just north of Lone Ranch Creek, is the Hercules prospect. The country rock is yellowish, normal serpentine, and some dioritic rock occurs close by. A number of irregular stringers of quartz, calcite, and siderite are here exposed, with some massive pyrite and chalcopyrite.

Surprise mine.—Just south of Lone Ranch Creek, half a mile from the river, is the Surprise gold mine, which has been opened on a quartz vein about 2 feet wide, striking north and dipping east. The country rock is serpentine with some black slate and diorite. A small pay shoot has been developed on this vein, 300 feet from the portal of the upper tunnel. The quartz contained coarse yellow gold. Small shipments of ore, in all probably less than 50 tons, have been made. Some of the ore shipped was of high grade; other shipments averaged $17 a ton.

Lucile Dreyfuss mine.—About 3 miles south of Danville, on the steep slope a few hundred feet above Kettle River, at an elevation of about 2,300 feet, is the Lucile Dreyfuss mine. It is in a low-grade pyrite-chalcopyrite deposit, apparently contained in serpentine. No examination of the underground workings could be made. The deposit, which seems to be a replacement shear zone, is in places 25 feet wide and dips 45° E. The main tunnel is 1,300 feet long and intersects the deposit at 1,200 feet from the portal. It is reported that at 700 feet from the portal a small quartz vein was cut which contained some gold near the surface. The croppings of the pyritic deposit were found 500 feet above the tunnel portal.

From this deposit ore was shipped in 1902 and in 1909, possibly also at other times. The total value of the output is believed to be about $15,000. Two companies have been working this deposit—the Lucile Dreyfuss Mining Co. and the Mineral Hill Tunnel & Copper Mining Co.

The Minnehaha Mining Co. has driven a tunnel 1,300 feet long 70 feet above the river to tap these deposits. The tunnel is in a dioritic rock. The deposit, dipping 45° E., is believed to have been cut 1,200 feet from the portal but is barren at the intersection. Beyond this point the tunnel enters serpentine rock.

CALIFORNIA.

The California mine is 8 miles southeast of Republic in an air line, the distance by wagon road being about 3 miles more. It is just south of the Belcher mining district and is included within the

boundaries of the Republic (Eureka) district, although it lies quite outside of the Republic camp and in a different geologic section.

The developments consist of an inclined shaft, the collar of which is at an elevation of 4,200 feet. This shaft is said to be 525 feet deep, and from it extend four levels. At the time of visit water flooded the workings within 75 feet of the collar of the shaft, so that they were for the most part inaccessible. The mine is said to have produced over $98,000 worth of ore, and the ore body is reported to have been practically worked out.

Metamorphic lime shales intruded by rocks that now resemble greenstone form the geologic section in the vicinity. The shales have a general northeast strike and a dip of 45°–90° NW. The vein explored by the shaft strikes approximately northeast and dips 60° NW. As only a small part of the workings were accessible, observations of the ore body were not possible. Ore seen on the dump showed a quartzose gangue material containing galena, sphalerite, and chalcopyrite, with the oxidized products limonite, malachite, and some azurite. The shipments are reported to have averaged about $60 a ton, mostly in gold, but including about 3 ounces to the ton in silver.

IRON MOUNTAIN.

The prospects on Iron Mountain are 3 miles south of the California mine and 11 miles south-southwest of the Belcher mine. Iron Mountain rises to an elevation of 4,807 feet and is a westerly spur of Bald Mountain, 6,946 feet in elevation, one of the highest points of the ridges east of Sanpoil River. The prospects, which were not visited, lie on the east slope of the mountain, and are in part owned by W. C. Zutt, of Republic. The general sequence of rocks appears to be the same as at the California mine. Limestone, lime shale, and intrusive diorite are reported from this vicinity. The strata dip steeply to the west, and the ore deposits are said to be quartz veins with steep dip, approximately following the intrusive contact. The principal claims named are the Blue Jacket, Blue Horse, Silver Tip, and Juno. It is stated that some ore has been shipped from the Blue Horse. The ore minerals, which contain mainly silver with a little gold, are galena, pyrite, and arsenopyrite.

LAURIER.

The Laurier prospect is located in the Orient mining district, on the north side of Huckleberry Mountain near its top, 1½ miles in an air line S. 34° W. of Laurier and about 1,600 to 1,700 feet above that place. It has not reached the producing stage, and at the time of examination some contract work was being performed on the main adit tunnel. Supplies are brought by pack animals over a steep trail which zigzags up over the southern and less precipitous slope of Huckleberry Mountain. That part of the north side of this mountain in

which the Laurier workings are located rises almost vertically over 1,600 feet above the valley of Kettle River. A shaft 60 or 70 feet deep at an elevation of 3,620 feet, a few surface cuts, and an adit tunnel 340 feet long, at an elevation of 3,400 feet, driven in a direction S. 31° W., constitute the principal developments on the Laurier.

The rocks in the vicinity are medium to coarse grained schists, which have probably resulted from the dynamometamorphism of granite and diorite. They are believed to be of pre-Cambrian age and probably represent the oldest rocks in northeastern Washington. Schistosity is well developed in these rocks, and in the vicinity of the open cuts the lamination planes have a general northwest strike and a dip of 15° SW. to 90°. The prevailing rock in the adit tunnel is a hard, compact, dark-colored schist, composed chiefly of hornblende and feldspar. Elsewhere a pink granitic schist is prominent. These rocks are intruded by dikes of white medium-grained granite composed essentially of orthoclase, quartz, and biotite. These dikes are believed to have been intruded during Mesozoic time and were probably a part of the granite magma, of which dikes are present in nearly every mining district in this part of the State. Its intrusion has caused considerable contact metamorphism in the contiguous schists, epidote, quartz, sphalerite, magnetite, and chalcopyrite having been formed, all probably of contact-metamorphic origin. The mineralized zone extends for several feet on each side of one dike exposed by the surface cuts and the shaft. The adit tunnel driven to cut this zone had not accomplished this result at the time of the writer's visit (September, 1909). Postmineral faulting, the uncertain distribution of the ore minerals, and the probability of only local impregnations in the schists, combined with the peculiar association of ore minerals and the small amount of chalcopyrite present in the ore, all militate against the profitable working of this deposit.

JENNY.

The Jenny prospect is the only other property visited in that part of the Orient mining district which lies in Ferry County. (See fig. 2, p. 39.) It is about 2 miles northwest of Rockcut, in a small draw near the base of the range on the west side of Kettle River, and the camp can be reached by wagon road. The lower adit tunnel is 265 feet above the cabin and is reached by trail. No large shipments are reported from this prospect.

The developments consist of two adit tunnels, one comprising 500 feet of drifts, crosscuts, and other workings, and the other, 75 feet higher, at an elevation of 2,175 feet, comprising 250 feet of workings.

Medium to coarse grained schists having the general appearance of sheared granite and diorite, with intercalated strata of coarsely crystalline limestone and quartzite, have been intruded by lamprophyre

dikes which probably accompanied a granitic intrusion. The schists strike approximately east and dip about 15° S. or SE. Faulting is pronounced in the country rock and is particularly well exposed in the underground workings on the Jenny.

The lower level consists of drifts on both sides of a shear zone, which is about 35 feet wide and is largely filled with brecciated country rock, gouge, and quartz, carrying scattered patches of pyrite, galena, and sphalerite. Gypsum accompanies the gangue and in places the quartz is sugary. The general strike of the fault zone is east and the dip is 45°–65° S. The upper level exposes a 4-foot quartz vein, in places several feet wide, containing stringers of country rock and sparse amounts of the same ore minerals. The total value of the ore in gold, silver, copper, and lead is said to be only $3 to $15 to the ton.

Enough development had not been done to determine the size of the ore body, which, where exposed, showed scanty and irregular distribution of the ore minerals through the gangue.

OKANOGAN COUNTY.

PARK CITY DISTRICT.

LOCATION AND MEANS OF ACCESS.

A small natural park located about 22 miles S. 18° W. of Republic, the nearest railroad station, has given the name Park City to the mining district in which it lies. As several claims in this vicinity which had received more or less development lie not far west of the boundary between Ferry and Okanogan counties, a hurried trip was made to the properties belonging to the Castle Creek Mining Co., the Ramore Mining Co., and the Wasco group, all of which are within a few miles of Park City. The extent of this district is at present (May, 1911) unknown and doubtless only a few of the deposits in it were visited. Consequently, no attempt will be made to give a general description of the whole district, and most of the remarks which follow deal specifically with conditions existing in the vicinity of the deposits examined.

Until the projected railroad down the Sanpoil is completed the district will continue to be reached by wagon road from Republic, the distance by this route being about 28 or 30 miles. The journey involves a trip down the Sanpoil Valley of about 13 miles to the junction of the West Fork with the main stream, thence up the West Fork about 6 miles to Gold Creek, and thence up Gold Creek 8 or 10 miles to Park City. The completion of the railroad down the Sanpoil will eliminate the haul of 13 miles between Republic and West Fork, and it is possible that an even more direct connection can be made between the district and the Sanpoil.

CONDITION OF MINING ACTIVITY.

Some work was being done by the Castle Creek Mining Co. at the time of the writer's visit to this locality, but the other two groups were inactive. No large shipments of ore have been made, the high cost of transportation prohibiting shipping under present mining conditions. Reduction works started by the Colville Mining & Smelting Co. and now controlled by the Castle Creek Mining Co. were never completed, and all the ore has to be hauled long distances to a railroad point for shipment to smelters.

TOPOGRAPHY.

That part of the Park City district examined by the writer consists of a portion of a mountain range which lies between Sanpoil River on the east and the headwaters of Gold Creek and Nespelem Creek on the west. The general elevation of the tops of the mountain peaks in this locality is about 4,500 feet, the headwaters of the two creeks just mentioned are about 1,000 to 1,500 feet lower, and the valley of the Sanpoil at a point 6 or 8 miles due east of Park City is approximately 1,800 feet above sea level. The range slopes rather precipitously down to the Sanpoil on the east and is more or less dissected by the smaller creeks on the west, although the main mass of the mountains extends some little distance west of Park City before it slopes down to the valley of the Nespelem.

GEOLOGY.

The rocks exposed in the vicinity of the deposits examined consist of a series of metamorphic quartz-mica schist, lime shale, argillite, and limestone intruded by granite. The sediments are a part of the metamorphic series prevalent throughout northeastern Washington and are thought to be of Paleozoic age. The granite is provisionally classed as of Mesozoic age and it is believed to be contemporaneous with other granitic batholiths in this part of the State. The metamorphic rocks appear to be conformable and have a general north-south strike, although this direction does not hold over the whole of that part of the district examined, local variations being numerous. The dip in general more nearly approaches the horizontal than the vertical, although strata that stand nearly vertical were seen. The intrusive granite masses are so numerous that no continuity exists in the dip and strike of the metamorphic rocks.

Faulting is a conspicuous feature of the geology in this vicinity, and the displacements along the intrusive contact of the granite and the metamorphic rocks are especially prominent.

ORE DEPOSITS.

Along the shear zones, fault planes, and fissures in the metamorphic rocks and in the intrusive granite lenticular quartz veins are more or less sparsely mineralized by galena, pyrite, chalcopyrite, sphalerite,

and tetrahedrite, and these minerals also replace to a minor extent the country rock in the vicinity of some of the veins. The ores are reported to carry appreciable quantities of silver and some gold, as well as copper, lead, and zinc. Where the shear zones have been of large size the ore bodies appear to be correspondingly large. Enough development work has not been done upon the ore bodies proper to warrant speculation on the future of the district, and the reader is referred to subsequent pages for a detailed description of the ore bodies examined.

MINES AND PROSPECTS.

CASTLE CREEK MINING CO.'S PROSPECTS.

Location and general features.—Several prospects belonging to the Castle Creek Mining Co. are located within a few miles of the company's camp, and the ore deposits occurring on three of the claims will be described under separate headings. The camp is at an elevation of approximately 3,700 feet, in the SW. ¼ SW. ¼ sec. 1, T. 33 N., R. 31 E., about a mile east of Gold Creek and 7 miles south of its junction with the West Fork of the Sanpoil. The mouth of Gold Creek is 13 miles south of Republic, the nearest railroad point and the present base of supplies. By wagon road the distance from Republic to the camp is 28 or 30 miles. If the proposed railroad is built down the valley of the Sanpoil, the problem of transportation will become less difficult than it now is. Timber and water are plentiful in the vicinity. The erection of reduction works consisting of two Medbury rotary smelting furnaces and the necessary power equipment and crushing machinery was started by the Colville Mining & Smelting Co. but never completed. No large shipments are reported to have been made from any of the prospects.

Ore deposits.—In general the ore deposits explored by the Castle Creek Mining Co. are lenticular quartz masses containing scattered patches of galena, sphalerite, chalcopyrite, pyrite, and a little tetrahedrite. Some silver and traces of gold are reported to occur in these ore minerals. The ore bodies have not been proved to be of large dimensions, but there are a great number of small, sparsely mineralized quartz lenses. No large, well-mineralized veins were seen, and the country rock is very much broken up, postmineral faulting having been noticed in many places. Replacements of the limestone strata are not prominent features of the deposits, most of the ore minerals apparently being confined to the quartz lenses. Mining these small scattered ore pockets is expensive, and it is doubtful if operations can be made to pay under present mining conditions.

Summit.—Workings on the Summit claim consist of numerous surface cuts and one adit tunnel which was 350 feet long in July, 1910. These workings are located near the top of Castle Mountain and are the highest workings of note on the ground of the Castle Creek Mining

Co. The portal of the adit tunnel is a little less than a mile south of west of camp, at an elevation of 4,360 feet.

A sedimentary series of argillite, limestone, quartz-mica schist, and lime shale intruded by dikes of granite of varying dimensions constitute the geologic section in this locality. In general the sedimentary rocks appear to dip at flat angles and only minor folding was seen. It was impossible to ascertain the general dip and strike of the formations because of the disturbances caused by the many intrusions of granite. This rock prevails throughout the adit tunnel. Along a fault plane in the granite much shearing has taken place, and in a 50-foot drift on this shear zone, which is 150 feet from the portal of the adit tunnel, the rock greatly resembles shale. In this shear zone, which contains much gouge and is about 18 inches wide, are lenticular masses of quartz containing scattered patches of galena, pyrite, chalcopyrite, sphalerite, and tetrahedrite. The ore from a small stope in this short drift is said to contain 0.06 to 0.12 ounce of gold and 35 to 90 ounces of silver to the ton, and 30 to 40 per cent of lead. The ore and gangue minerals occur in pockets that do not appear to be very extensive.

The surface cuts expose quartz veins in the limestone and shale series, and these appear to be more numerous in the vicinity of the intrusive granite dikes than elsewhere. The veins are all more or less lenticular and are broken up by postmineral faulting. Some were seen which had a very flat dip, and in general they appear to have the same attitude as the sedimentary formations. Galena, sphalerite, chalcopyrite, pyrite, and gray copper are sparingly distributed through the quartz, and near the surface the oxidized products limonite, malachite, azurite, and anglesite were seen.

Snowshoe.—The workings on the Snowshoe claim are about four-fifths of a mile southeast of the camp, a little less than a claim's length southwest of the portal of the adit tunnel on the Summit. The original discovery hole and an abandoned adit are located at an elevation of 4,225 feet, and an adit tunnel 35 feet above these workings has been driven southeastward for a distance of 180 feet. This adit tunnel exposes a shale and limestone series which strikes about east and dips 25° S. No mineralized veins had been cut when the adit was examined in July, 1910. The discovery hole or open cut exposes a quartz vein 2 to 3 feet wide between a footwall of granite and a hanging wall of lime shale or limestone. The vein has a dip of 5°–10° S. and strikes with the strata—that is, east. As only a small portion of the vein was exposed in this discovery hole, it is impossible to give much information as to the size and continuity of the ore body. Galena and some sphalerite seem to be fairly well distributed through the outcrop of the vein. Limonite, resulting from the alteration of pyrite, is prominent and stains the outcrop a dull reddish-yellow color.

Mountain Boy.—Three adit tunnels with short drifts, inclines, and other workings are located near one another on the Mountain Boy claim, about half a mile southwest of the camp. Another adit tunnel, which is about 950 feet long, has been driven through the Copper King claim southeastward into the Mountain Boy claim. The portal of this adit tunnel (No. 4) is about 200 feet lower than the highest working on the Mountain Boy. The rocks explored in all these workings are a part of the limestone and shale series which prevails over a large portion of Castle Mountain and the ridges projecting from it. The rocks have a general northeast strike in the vicinity of the Mountain Boy workings and dip 30°–60° NW., although many local variations from these directions were seen.

Only two of the four tunnels represent development on ore bodies, Nos. 3 and 4 having been driven to open ground under the ore shoots above. The No. 1 and No. 2 workings are within 75 or 100 feet of one another and on practically the same level.

No. 1 tunnel is located at an elevation of 3,920 feet. A crosscut adit extends 30 feet, beyond which point a gentle incline 75 feet long and a steep pitch of 50 feet lead to a level known as No. 3, which is connected with the No. 2 and No. 3 workings. Short drifts of various sizes have been run off from the main level in all directions, having resulted from gutting the small irregular ore-bearing quartz lenses that occur along the planes of schistosity of the sedimentary rocks. Underground developments show that these quartz lenses vary in width from half an inch to 18 inches and in length along the dip and strike from 2 inches to 30 feet, and some of them may have greater dimensions. They contain irregularly scattered patches of galena, sphalerite, chalcopyrite, pyrite, and tetrahedrite. The ores show some banding and are brecciated by post-mineral movement. Both the ore bodies and the sediments are traversed by innumerable veinlets of calcite.

The sedimentary rocks are less disturbed in the No. 2 workings, where a quartz vein about 18 inches wide has been explored for a short distance. This vein strikes N. 47° E. and dips 60° NW. and contains the same association of minerals as the quartz lenses explored in the No. 1 workings.

RAMORE MINING CO.'S CLAIMS.

Four patented claims belonging to the Ramore Mining Co. are located about 3 miles south of the Castle Creek Mining Co.'s camp. The developments consist of two main levels, one on the Hercules claim and another on the Ramore. The portal of the adit tunnel on the Ramore claim is about 1,600 feet northeast of and 350 feet higher than the level on the Hercules claim. No large shipments of ore are reported from either of these claims.

Limestone, lime shale, argillite, and quartz-mica schist intruded by granite are the prevailing rocks in this locality. The sedimentary series has a general north-south strike, although variations from this direction were seen in many places. The dip ranges from east to west and is not constant over great distances. Faulting is a prominent feature of the geology in this vicinity, especially along the intrusive contacts of the granite and the sedimentary rocks.

The adit tunnel on the Hercules claim, at an elevation of 3,600 feet, has been driven due east for a distance of 430 feet and this part of the level is almost entirely granite. A contact between the metamorphic sedimentary series and granite is encountered 120 feet from the portal of the adit. On this contact, which runs northeastward, a drift has been run for a distance of 180 feet. Near the end of the drift is a 100-foot crosscut. Along the contact between the two kinds of rock is a zone of intense movement which has an average width of about 5 feet and a dip from 45° NW. to vertical. Galena, sphalerite, chalcopyrite, pyrite, pyrrhotite, and tetrahedrite are more or less disseminated through the sedimentary rocks in the vicinity of the intrusive granite, and some of limestone strata are replaced by these minerals. In the crosscut from the drift is a small vein in granite. This vein strikes N. 65° W., dips 65° SW., and is only a few inches wide. It contains similar association of ore minerals, together with quartz and fluorite. As exposed by the workings on this level the major part of the mineralization is scattered through the metamorphic sedimentary series near igneous contacts in small veinlets containing also some quartz, calcite, and fluorite and as irregular partial replacements in the limestone and lime shale. The extent of the mineralization has not been determined, but as exposed in the drift along the main contact it appears to have been pockety and irregular.

The Ramore adit tunnel has been driven N. 4½° E. for a distance of 440 feet. About 40 feet from the breast a branch crosscut extends northeastward for 600 feet, and from this branch several short crosscuts have been run. On a good-sized vein cut 220 feet from the portal a short drift has been run and a winze sunk for 45 feet on the footwall. This vein is the only ore body of note exposed in these workings. It strikes N. 20° W., dips 30° NE., and is about 10 feet wide. It has been explored along the strike for about 70 feet. The hanging wall of the vein is granite and the footwall is a part of the metamorphic series. The vein filling is chiefly quartz, with which is associated some fluorite and calcite. Sphalerite, galena, pyrite, chalcopyrite, pyrrhotite, and tetrahedrite are irregularly scattered through the quartz and disseminated through the sedimentary series, locally replacing the limestone, and these minerals are also

found in small fractures in the granite. The ores are reported to contain appreciable amounts of lead, silver, and copper, with some gold and zinc. Four analyses by H. J. Armstrong, of the Republic Gold Mining & Milling Co., show the presence of 2.7 to 9.6 per cent of lead and 13 to 59 ounces of silver and 0.05 to 0.07 ounce of gold to the ton. The intrusion of the granite which has so promiscuously invaded the sedimentary series was accompanied by severe dislocations. The fractures thus caused and the contiguous limestone strata have been more or less mineralized by ore-bearing solutions, which followed the intrusion. The limits of the ore bodies have not been ascertained, and much work has been done on this level that has not tended to develop the main ore body exposed 220 feet from the portal. In fact, the developments have been carried away from rather than along the course of the ore deposit. If the ore body is as persistent as its general appearance where exposed seems to indicate, it does not seem unreasonable to suppose that the deposit could be profitably exploited by concentration on the ground.

WASCO.

Several claims about 3 miles a little south of west of the camp of the Castle Creek Mining Co., on top of the first ridge west of the main course of Gold Creek, constitute the Wasco group. On these claims a shallow shaft, several small surface cuts, and a short adit tunnel represent the development work. No shipments are reported to have been made from this group.

Medium to fine grained quartz-mica schists intruded by granite form the ridge in which the Wasco workings are located. The general strike of the sedimentary rocks is north and the dip is about 60° E. The intrusive dikes of granite follow the general direction of the strike of the schists and range in width from a few feet to several hundred feet or more. Molybdenite and the oxidized product molybdic ocher, together with large crystals of muscovite, occur in many of the granite dikes in this locality.

As no connected development exists on the ore deposits in this group the ore bodies exposed in the different workings will be described separately. A shaft at an elevation of 3,900 feet and said to be 40 feet deep, but practically full of water when seen, exposes a quartz vein about 12 inches wide which strikes N. 30°–40° W. and dips 15°–40° NE. The vein is in granite and is sparsely mineralized by galena, sphalerite, chalcopyrite, and pyrite.

An open cut 300 to 400 feet north of the shaft and about 50 feet higher exposes a contact of the granite and schist along which occurs a quartz vein about 3 feet wide, sparsely mineralized by chalcopyrite, pyrite, and sphalerite and the oxidized products malachite, azurite,

and limonite. These ore minerals occur in pockets. The vein strikes northwest and dips 65° NE. An opening on the same vein 50 feet northwest of this open cut and 25 feet lower shows the vein between walls of granite. No ore minerals are visible in the main vein, but three small cross fissures which strike northeast and dip 40° SE. are filled with quartz carrying some chalcopyrite and sphalerite. Other small workings show the same general scattered mineralization in quartz veins in granite and schist or between the two kinds of rock.

An adit tunnel, from which there are several short drifts and crosscuts, has been driven for a distance of 350 feet at an elevation of about 3,900 feet. In this working a vein has been exposed for short distances in two places. Where seen the vein appeared to strike N. 60°–70° W. and to dip 45°–55° NE. The vein is 24 inches wide and is composed mainly of quartz with the ore minerals "steel" galena, chalcopyrite, pyrite, sphalerite, and tetrahedrite sparsely distributed through it. The ores are said to contain appreciable quantities of silver and copper and some gold.

The scattered distribution of the ore minerals in these veins, their lenticular character, and the general conditions under which mining is carried on in this district, at present far away from direct railroad transportation, all militate against the economical production of ore from these deposits.

INDEX.

A.

Page.

Acknowledgments to those aiding 1-2
Advance, description of 193-195
plan of, figure showing 194
Alkire, placers near 37
Amphibolite, occurrence of 15
Anaconda prospect, description of 57
vein in, section of, view of 56
Andesite, gold deposits in 23-24
occurrence and character of 18-19
use of term 142
See also Lava flows.
Antimony, deposits of 30
Area, location of 1
location of, map showing 1
Argillite, occurrence and character of .. 12-13, 93, 94

B.

Bancroft, H., and Lindgren, W., on Republic district 133-166
Basalt, occurrence and character of 11, 19
Batholiths, intrusion of 11, 16
Beecher claim, description of 70, 88
Belcher district, access to 167
fluxing ores from 30, 167, 170
geology of 168-169
iron in 28
location of 166-167
mining in 167
ores of 28, 30, 169-170
prospects and mines in 170-179
topography of 167
map showing 168
Belcher mine, description of 167, 175-179
ores of 178-179
plan of, figure showing 177
section of, figure showing 178
Belcher Mountain, rocks of and near 167, 168
Ben Hur claim, description of 163
Bibliography 2
Big Iron mine, description of 70, 82-83
ores of 27-28, 70, 83
Blacktail mine, description of 159
Blue Bar, placers at 35
section at 35
Blue Star mine, description of 96-97, 98, 105-106
Bonanza mine, description of 52, 54, 63-64
discovery of 4
production of 4
Bossburg, mines and prospects near 62-64
Boston & Maine mine, description of 145
Breccia-conglomerate, occurrence and character of 19-20, 144
Brock, R. W., work of 199
Brooks mine, description of 116

C.

Page.

California mine, description of 200-201
ores of 24, 201
Castle Creek Mining Co., prospects of .. 204, 205-207
Cedar Canyon. *See* Deertrail district.
Chewelah, description of 92
Chewelah Copper King mine, description of 92, 96, 98, 102-104
view of 74
Chewelah district, future of 104
geology of 93-95
location of 92
mining in 92
ore deposits of 26, 27, 95-98
prospects and mines in 98-111
topography of 92-93
Chico mine, description of 154
Clark claims, description of 47-48
Clark Fork, description of 10, 41
prospects east of 49-51
prospects west of 46-49
Cliff claim, description of 49
Climate, character of 2-3
Collier, A. J., on placer deposits 31-38
Columbia River, mines and prospects northwest of 59-62
mines and prospects southeast of 54-59
valley of, description of 10
gold placers in 32-37
Columbia River Gold Mining Co., claims of. 124-125
Colville, climate at 3
mineral discovery at 4
smelter at 6
Colville Indian Reservation, opening of 4-5
Colville Valley, description of 92-93
prospects east of 98-109
prospects west of 109-111
Congress mine, description of 182-185
nickel in 30, 182, 184-185
vicinity of, geologic map of 182
Contact metamorphism, effects of 22, 70-71
See also Ores.
Cooke Mountain, limestone from .. 168-169, 170-171
limestone from, analyses of 169
Copper, deposits of 27-28
Copper Butte mine, description of 79
Copper Key mine, description of ... 167, 168, 173-175
magnetite ore from, analysis of 175
ores of 28-29, 174-175
plan of, figure showing 174
Copper King (Chewelah district). *See* Chewelah Copper King.
Copper King mine (Northport district), description of 57-58
rocks at, view of 57

Page.
Copper Queen mine, description of.. 95, 97, 108–109
Cosalite, analysis of..... 132
Costs of mining, data on..... 8–9
Covada district, access to..... 189
antimony in..... 30
fossils from..... 14
geology of..... 188–189
location of..... 187
map of..... 190
mining in..... 188
ore deposits of..... 25, 30, 189–191
prospects and mines of..... 191–197
topography of..... 188
Cusick, precipitation at..... 3

D.

Daisy, placers near..... 37
section near..... 37
Danville, deposits near..... 199–200
Deertrail district, copper of..... 115
geology of..... 113–114, 119–120
location of..... 111–112
mills in..... 112
mining in..... 112
ore deposits in..... 25, 114–116, 120–122
origin of..... 115–116
treatment in..... 122–123
production in..... 4
prospects and mines in..... 116–120
location of, map showing..... 117
silver-lead deposits at..... 112, 116–118
topography of..... 112, 119
tungsten in..... 29
Defender claims, description of..... 80–81
Delmonico (Enterprise) mine, description of..... 96–97, 105
Diabase, occurrence and character of. 11, 15–16, 93, 95
ores in..... 24–25
Dikes, occurrence and character of..... 11, 16–18
Disseminated ore deposits, occurrence of.... 28
Distillate, cost of..... 8, 72–73
Double Standard mine, description of..... 61–62
Drainage, description of..... 10

E.

Eagle mine. *See* Blue Star mine.
Eagle Mountain, geology near..... 93, 95
geology near, map showing..... 94
Easter Sunday mine, description of. 65, 67, 70, 83–84
ore of, analysis of..... 83
Enterprise district. *See* Covada district.
Enterprise mine. *See* Delmonico mine.
Eureka district. *See* Republic district.

F.

Ferry County, mining districts and deposits in..... 133–203
mining districts and deposits in, map showing..... 198
production of..... 155
Field work, extent of..... 1–2
First Thought mine, costs at..... 9, 72–73
description of..... 65, 71–76
geology at..... 73–74
map of..... 74
ores of..... 23, 69, 74–76
analyses of..... 76

Page.
First Thought Mine, production of.. 4, 23, 65, 69, 71
section of, figure showing..... 73
First Thought Mountain, geology of..... 68
map of..... 72
prospects on..... 71–77
rocks at, view of..... 66
view of..... 72
Fissure veins, mineral deposits in..... 23–24, 26–27, 70, 114–115
view of..... 101
Flag Hill, prospects on..... 165–166
Flux, ores mined for..... 30
Fossils, lack of..... 10, 14–15, 16
Freighting, rates for..... 9
Frisco-Standard claims, description of.... 52, 58–59
vein in, section of, view of..... 57
Fuel, abundance of..... 5

G.

Galena. *See* Lead-zinc.
Geologic history, outline of..... 20–22
Geology, description of..... 10–20
See also particular districts.
Germania Co., claims of, description of. 112, 118–119
discovery of..... 4, 118
location of..... 118
map of..... 118
mills at..... 6
diagrams of..... 123
ore deposits of..... 29, 114–115, 120–123
origin of..... 122
treatment of..... 122–123
section at, figure showing..... 119
tungsten in..... 29, 114–115, 120–123
analysis of..... 121
view of..... 120
vein of, view of..... 101
Gibraltar Mountain, rocks of..... 142
Glacial débris, effects of..... 21, 66
occurrence and character of..... 10, 20, 188
Globe claims, description of..... 78
rocks at, view of..... 66
Gold, deposits of..... 23–25
discovery of..... 3–4
Granite, occurrence and character of..... 11, 16, 93
Granite Mountain, rocks of..... 140
Granodiorite, occurrence and character of.. 17
Great Republic mine, description of..... 60–61
Greenstones, mineral deposits associated with..... 22
occurrence and character of..... 11, 12
origin of..... 15, 22

H.

Harper, J. L., on Republic ores..... 151
Hartford group, description of..... 97, 109–110
geology near..... 93, 95
Hell Gate Bar, placers at..... 33
Hercules claim (Park City district), description of..... 208
Hercules prospect (Ferry County), description of..... 200
History, geologic, outline of..... 20–22
Hoodoo mine, description of..... 117–18
Huckleberry Mountain, rocks of..... 11, 12
Hydroelectric power, generation of..... 5

I.

Page.

Igneous rocks, occurrence and character of .. 15-16, 19, 95, 114
Index map showing location of area 1
Insurgent claim, description of 162
Intrusive rocks, occurrence and character of .. 11, 16, 19, 93, 95
Iron, deposits of 28-29
Iron Mountain mine, description of 201

J.

Jay Gould mine, description of 97, 98, 106-107
Jenny prospect, description of 202-203

K.

Keller, description of 180
smelter at 6, 180, 185
Keough claim, description of 59
Kersantite dikes, relation of ores and 27, 102
Kettle Falls, settlement at 3
Kettle River group, description of 6, 65, 85-87
Keystone mine (Chewelah district), description of 104-105
Keystone mine (Covada district), description of 189, 195
Knob Hill, description of 164
Knowlton, F. H., on lake-bed fossils 141-142

L.

Labor, cost of 8
Lake beds, fossils from 141-142
occurrence and character of 18, 141
Lamprophyre dikes, occurrence and character of 17-18, 95
Last Chance mine, description of 52, 54-56
Laurier prospect, description of 201-202
rocks near 11, 202
Lava flows, occurrence and character of 11, 18-19, 142-143
Lead King claim, description of 48-49
Lead-silver, ore deposits of, occurrence of 54, 116-118, 180, 181
ore deposits of, origin of 115-116
treatment of, cost of 9
See also particular districts, mines, etc.
Lead-zinc, deposits of 26-27, 44-51
See also particular districts, mines, etc.
Liberty mine, description of 97, 110
Limestones, analyses of 13, 95
folding in, view of 57
occurrence and character of 12, 13, 95
view of 66
Lindgren, Waldemar, aid of 1-2, 197
Lindgren, W., and Bancroft, H., on Republic district 133-166
Literature, list of 2
Little Frank mine, description of 117
Little Giant prospect, description of 87
Lone Pine claim, description of 159, 160-162
Lone Star mine, description of 197-199
ores of 28, 199
Longstreet mine, description of 195-196
Lucile Dreyfuss mine, description of 200

M.

McKinley group, description of 88-89
McNally prospect, description of 70-71, 84-85
Manila mine, description of 185-186
ores of 28, 186

Page.

Map of northeastern Washington 39
Marble, occurrence of 12
Meade claims, description of 51
Mesozoic rocks, deposition of 21
mineral deposits in 22
occurrence and character of 11, 16-18, 68, 140
ores in 25
Metaline, description of 40
Metaline district, access to 40-41
future of 45-46
geology of 42-43
lead and zinc deposits of 44-51
location and extent of 40
mills in 41
mining in 41
ore deposits of 26, 43-45
origin of 45
prospects in 46-51
shales from, analyses of 43
topography of 41-42
Metallurgy. *See* Ores, treatment of.
Metamorphism, effects of 21-23
Meteor mine, description of 191-193
plan of, figure showing 192
Mills, stamp, construction of 4
operation of 6-7
Mineral deposits, formation of, periods of 22
kinds of 23
See also Placer deposits *and particular places, mines, and metals.*
Mines and prospects, description of 39-210
See also particular mines.
Mining, economic conditions of 5-6, 8-9
history of 3-5
methods of 6, 38
Mining districts, description of 39-210
See also particular districts.
Molybdenite, occurrence of 30, 45
Monzonite porphyry, occurrence and character of 11, 16-17, 68, 169, 189
Morning Glory mine, description of 165
Mountain Boy claim, description of 207
Mountain Lion mine, description of 164-165

N.

Napoleon mine, description of 65, 89-91
fluxing ores from 30, 89
mill at 6
ores of 69-70, 91
Nespelem Bar, placers at 32
section at 32
Nevada mine, description of 96-97, 111
New Republic mine, description of 143
glory hole in, view of 146
Newton, H. W., on operation of mill 7-8
Nickel, deposits of 30, 181
Ninemile Creek, deposits on 180
placers at 34
section at 34
Northport, description of 51-52
rocks near 53
smelter at 6, 52
Northport district, geology of 53
location of 51-52
mining in 52

Page.

Northport district, ore deposits of 24, 26, 54
prospects in 54–64
topography of 53
transportation in 52
North Star mine, description of 77

O.

Okanogan County, mines and prospects in. 203–201
Old Dominion mine, description of 126–130
geology near 53, 128–129
ores of 26, 129–130
plan and section of, figure showing 128
Orchid mine, description of 115
Ores, change in, with depth 25, 26, 151–152
treatment of 6–8
cost of 9
See also Mineral deposits.
Orient, description of 65
Orient district, access to 65
fluxing ores of 30
geology of 19, 66–69
location of 64–65
mills in 65, 90
mining in 65
ore deposits of 23, 24, 26–28, 30, 69–71
prospects and mines of 71–91
topography of 66
Orient prospect, description of 70, 71, 79–80
Oriole claim, description of 46–47
O'Sullivan Creek, placers at, discovery of 3
Oversight group, description of 167, 170–173
plan of, figure showing 171

P.

Paleozoic rocks, deposition and metamorphism of 20–21
mineral deposits in 22
occurrence and character of 11, 12–16, 42, 67–68, 139–140
Palmer, Chase, on Republic ores 148–150
Park City district, access to 203
geology of 204
location of 203
mining in 204
ore deposits of 25, 204–205
prospects and mines in 205–210
topography of 204
Peach Bar, placers at 33
section at 33
Pearl claim, description of 159
veins in, figures showing 157, 161
Pierre Creek, glaciation of 66
Pierre Lake, prospects east of 82–85
Pin Money claim, description of 170, 173
Placer deposits, description of 32–37
gold of, minerals associated with 32
origin of 37
mining of, methods of 38
relation of, to terraces 31
tenor of 31
Polepick mine, description of 186–187
Pomeroy mine, description of 70, 83
Pre-Cambrian rocks, deposition and metamorphism of 20, 21
occurrence and character of 10, 11–12, 66–67

Page.

Princess Maude mine. *See* Southern Republic mine.
Prospects and mines, description of 39–210
See also particular prospects, etc.

Q.

Quartz diorite, occurrence and character of .. 17
Quartzite in porphyry, view of 66
Quartzite Mountain, geology near 93
geology near, map showing 94
Quartz latite, gold deposits in 23–24, 69, 144, 146–153
occurrence and character of 19, 68, 143–144
Quartz veins, copper in 27, 96, 97
Quaternary deposits, deposition of 21
occurrence and character of 20, 144–145
Quilp claim, description of 157–158

R.

Railroads, construction of 5, 40–41
Ramore Mining Co., claims of 207–209
R. E. Lee prospect, description of 196
ores of 30, 196
Relief, details of 9–10
Replacement deposits, occurrence and character of 26–28, 96–97, 179, 180
view of 56
Republic, description of 3, 4–5, 9, 133
mills at 7–8
view of 154
panorama of 133
sections at, plate showing 134
Republic district, access to 134
bibliography of 137, 138
geology of 18, 19, 138–145
map showing 134
history of 134–135
location of 133–134
map of 136
mining in 135, 136
ores of 23–24, 137
treatment of 136–137
production of 4, 135–136, 151
prospects and mines in 153–166
map showing 136
topography of 137–138
vein of, views of 156
Republic mine, description of 146, 154–157
ores of 148, 151, 156–157
plan of, plate showing 156
production of 155
sections of, plate showing 156
veins of, figures showing 146, 155, 156
Rhyolite, occurrence and character of 19, 68
Rivers, transportation on 6
Riverside claim, description of 50–51
Rockcut, rocks near 11, 12
Rogers Bar, placers at 35
section at 35

S.

Sand Creek, shales from, analyses of 43
Sanpoil district, access to 180
geology of 181
location of 180

Page.
Sanpoil district, mining in 179–180
ore deposits of 181
prospects and mines in 182–187
topography of 180–181
Sanpoil mine, description of 162–163
Sanpoil River, description of 10, 180–181
geology near 142
placers on 37
Scaman claim, description of 57
Schellenburg claims, description of 49–50
Scotia prospect, description of 78–79
Second Thought claims, description of 76–77
rocks at, view of 66
Sedimentary rocks, metamorphism of 12
occurrence and character of 11–15
Sediments, metamorphosed, ores in 24–25, 26
Selenium, occurrence of 148–150
Shale, analyses of 43
glaciated surface of, view of 56
Shale, mineralized, view of 57
Shear zones, mineral deposits in 23, 24–25
Siliceous ores, treatment of, cost of 9
Silver, deposits of 25
Silver-lead ore. *See* Lead-silver ore.
Silver Leaf mine, description of 197
Silver Queen mine, description of 125–126
Sixmile Creek, placers at 34
section at 34
Smelters, operation of 6
Smith, H. F., gold found by 3–4
Snowshoe claim, description of 206
Southern Republic mine, description of 153–154
ore of 151, 153
views of 146
Stevens County, mining districts and ore deposits in 40–133
Stranger Creek Bar, placers at 36
section at 36
Strawberry Creek, placers on 37
Stray Dog mine, description of 193
Strobeck mine, description of 104–105
Sullivan Creek, shales from, analyses of 43
Summit claim, description of 205–206
Sunday Morning mine, description of 116
Sunset mine, description of 52, 59–60
Surprise claim (Republic district), description of 146–147, 159–160
veins in, figure showing 157, 161
Surprise mine, description of 200
Swamp King claim, description of 70, 88

T.

Terraces, placer gold in 31
Terrell, A., cited 150
Tertiary rocks, deposition of 21
mineral deposits in 22, 23, 68, 141, 145, 146–153
occurrence and character of 11, 18–20, 68–69, 140–144
Thomson, F. A., on Republic ores 148–149
Timber, growth of 3

Page.
Tom Thumb claims, description of 166
Topography, description of 9–10
See also particular districts.
Toulou Mountain, geology at 67–68, 90
map of 72
prospects on 77–82
Trade Dollar claim, description of 163
Transportation, cost of 9
means of 5–6
Treadwell mine, description of 56
Trojan prospect, description of 67, 81–82
Tungsten, deposits of 29
deposits of, origin of 115–116
See also Germania mine; Tungsten King mine.
Tungsten King mine, description of 130–133
location of, map showing 131
ores of 29, 131–133
analysis of 132
rocks in, view of 132
Turk, smelter at 6, 112
Turtle Rapids Bar, placers at 36

U.

Umpleby, J. B., on granite intensives 16
on Republic district 135, 144, 151, 152
United Copper mine, costs at 9, 100
description of 92, 98–102
discovery of 4, 98
ore deposits of 27, 92, 96, 100–102
origin of 102
ores of, assay of 102
section in, figure showing 99
vein of, view of 100
views of and in 74, 101
U. S. Copper Gold mine, description of 97, 107

V.

Vegetation, character of 3

W.

Wander claim, ore from 172
ore from, analysis of 172
Wasco mine, description of 209–210
Washington mine, description of 197–199
ores of 28, 199
White, David, *on fossils* 14–15
W. J. Bryan claim, description of 59
Wilmot Bar, placers at 34–35
Windfall mine 97, 108
Wolframite, analysis of 121
occurrence of, view of 120

Y.

Young America, mine, description of 52, 54, 62–63
discovery of 4
production of 4

Z.

Zinc. *See* Lead-zinc.

29122°—Bull. 550—14——15