WASHINGTON GEOLOGICAL SURVEY

HENRY LANDES, State Geologist

BULLETIN No. 5

PART I

Geology and Ore Deposits of the Myers Creek Mining District

PART II

Geology and Ore Deposits of the Oroville-Nighthawk Mining District

By JOSEPH B. UMPLEBY

OLYMPIA, WASH.:
E. L. BOARDMAN, PUBLIC PRINTER
1911

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LETTER OF TRANSMITTAL.

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

GENTLEMEN—I have the honor to submit herewith a report by Joseph B. Umpleby, with the recommendation that it be printed as Bulletin No. 5 of the survey reports. It is in two parts, viz., Part I, Geology and Ore Deposits of the Myers Creek Mining District, and Part II, Geology and Ore Deposits of the Oroville-Nighthawk Mining District.

Very respectfully,

HENRY LANDES,
State Geologist.

University Station, Seattle, July 1, 1911.

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PART I.

GEOLOGY AND ORE DEPOSITS OF THE MYERS CREEK MINING DISTRICT.

GEOLOGY AND ORE DEPOSITS OF THE MYERS CREEK MINING DISTRICT.

INTRODUCTION.

LOCATION.

The Myers Creek mining district is situated in eastern Washington, in the northeast corner of Okanogan county, and has for its northern border the international line. Definite boundaries for the area are not on record, but the accompanying map (Plate I) which represents about thirty-six square miles and centers about the town of Chesaw, includes most of that part of the district which has afforded reasonable encouragement to the prospector. Chesaw, the principal town, is a little village of about 500 population and is accessible by stage from Myncaster, a small settlement on the Oroville branch of the Great Northern railway, five miles distant.

FIELD-WORK AND ACKNOWLEDGMENTS.

Field-work was begun August 25, 1909, and continued until September 3, 1909. Throughout the investigation Mr. Olaf Stromme rendered valuable assistance, especially in the areal mapping. For courtesies in the field the writer is indebted to the citizens and mining men of the district, especially to Honorable M. A. Smalley; to James P. Blaine, local assayer; and to Mr. Aaron Anderson.

PREVIOUS WORK.

In 1904 the United States Geological Survey published a topographic map of the Osoyoos quadrangle, which includes the west part of Myers Creek district. In the same year the topographic map of Republic quadrangle was published, this including the eastern portion of the area. Both are on the scale of 1-125,000 and with 100-foot contour interval.

Save for occasional mention in technical journals and a brief statement in an early publication of the Washington Geological Survey (*a*), there is no literature on the district.

References to work in adjoining areas are made in the text.

GENERAL CONDITIONS.

A fairly uniform growth of medium-sized evergreen trees covers most of the western part of the district. Although it is a region of but moderate rainfall (about 18 inches), most of the streams live throughout the year, supplying an abundance of water for mining and other purposes.

Glacial drift is widely distributed, and is especially conspicuous west of Myers creek, where due to its persistence but few rock exposures appear. The general concealment of bedrock makes detailed work in the district very difficult, and since so short a time was spent in field-work it is probably unnecessary to suggest that the accompanying map covers only incompletely those features which are of general interest to the mining community.

(*a*) Wash. Geol. Survey, Annual Report, Vol. 1, Pt. II, pp. 26-28, 1902, Henry Landes.

CHAPTER I.

PHYSIOGRAPHY.

TOPOGRAPHY.

The Myers Creek Mining District is situated in the northeastern part of Okanogan county, in eastern Washington. That part of the district included on the map comprises an area of five miles north and south by about seven miles east and west, the northern line of the area mapped being one mile south of the international boundary.

As will be seen by an inspection of Plate I, elevations range from about 2,650 feet in the valley flat north of Bolster, up to 5,580 feet at the summit of Buckhorn mountain. The valley of Myers creek, which is the central drainage line of the area, divides the district into two parts with dissimilar topography. The eastern division is much higher, more precipitous and rugged, with some deep ravines and gorges; while the country to the west of Myers creek is more gently rolling, and characterized by open valleys. The maximum elevation of the west side is 4,041 feet, in contrast to 5,584 feet on the east side.

In the eastern division of the area the steep slopes are interrupted at frequent intervals by jutting ledges of metamorphosed limestone, which form low cliffs and scarps. Ravines cut in the various formations present little or no difference in topographic expression, and even the area of hornblende syenite to the northeast does not bear any particular relation to topography.

In places west of Myers creek metamorphic rocks protrude through the glacial material either as low ridges or as ledges. The few isolated areas of limestone form little ridges flanked by metamorphic rocks or drift, while the granite represented in the north central portion of the map has no special topographic expression.

The area is drained by short streams of high gradient, nearly all tributary to Myers creek, the largest stream in the district. Myers creek, itself a small stream, flows north into British Columbia through an open valley with a flat which varies from one-fourth to one-half mile in width and with an average fall of a little less than one foot to the hundred. The largest tributary valley is that of Mary Ann creek, which joins Myers creek valley at Chesaw and drains most of the west half of the district. Ethel creek, flowing in a narrow valley, with steep sides much of the distance and rocky gorges part of the way, joins Myers creek from the east a mile south of Chesaw. Lost creek, which drains some of the rugged country in the northeast part of the district, occupies a narrow steep-sided valley and joins Myers creek at Bolster.

SOILS AND CULTURE.

The uplands of the western portion of the district possess deep, rich black soils, derived from the weathering of glacial material. They are of varying texture, though seldom very coarse, and support a fine growth of wild grasses. Timber occurs in scattered groves but is nowhere an important asset, standing thereby in striking contrast to the eastern part of the area which, with a very similar soil and similarly derived, supports a fine forest growth, especially on the north and east slopes.

The soils of Myers creek valley and the valley of Mary Ann creek are very fertile and well adapted to agriculture, but along the other valleys there is only a small area level enough for cultivation.

The principal occupations pursued in the district are farming, mining and stock raising. Wheat yields heavily and is grown in all the larger valleys, and on the uplands of much of the western portion of the area. Vegetables and small fruit are also grown successfully. Owing to the elevation and latitude, the season is short, the nights cold and only the hardier crops of the north temperate zone will mature. Mining is carried on intermittently. The higher reaches of ground and

those areas below, in which the topography is not favorable for cultivation, are largely utilized for grazing.

The district is well dissected by wagon roads, but no railroad enters the area. Myncaster, a small station on a branch of the Great Northern railway, is situated about one-fourth mile north of the international boundry, and is reached by stage from Chesaw, a distance of five miles.

GLACIAL FEATURES.

Prior to the advance of the Cordilleran ice sheet the surface possessed that maximum slope known to physiographers as maturity. The uplands were cut by deep "V-shaped" valleys, separated by narrow ridges. The topography then, as now, was more rugged in the eastern than the western portion of the area. With the deposition of drift in the Pleistocene, erosion of the rock surface was temporarily arrested and much of the area assumed the rough topography, which when accompanied by poor drainage, is characterized as youth. Both ground and terminal moraines occur, but are thicker west of Myers creek than east of it. This, however, is likely to be accounted for by the steeper slopes and higher altitudes prevailing in the eastern part of the area, affording greater erosion activity and hence a more extensive removal of the drift. South of Mary Ann creek there is a well-marked terminal moraine, probably formed during the period of general ice retreat. It is particularly striking as seen in section 25, township 40 north, range 29 east, which it largely covers. The moraine is very rough with a most intricate variation from ridges and hillocks to kettles and troughs, differences in elevation being from forty to seventy-five and rarely more than one hundred feet. South of this moraine is a broad expanse of unstratified drift indicating that it was formed during a time of rest in the general period of ice recession.

CORRELATION OF EROSION PERIODS.

The general topography of the country, although not a striking feature within the small area mapped, is that of a broad

plateau so intricately dissected by erosion that the remnants of the original surface may be seen only in a few places, its original presence being indicated by the general accordance in summit levels.

Interpreted largely in the light of observations in adjoining areas and the general continuity of the topography to the east into the adjoining Republic district where fossil evidence (*a*) was obtained which dated the old erosion surface as very probably Eocene, it is concluded that the principal topographic features of the Myers creek district are carved from an Eocene surface and hence are post-Eocene in age.

The region is generally known as the Okanogan highlands and is probably to be considered a southward extension of the interior plateau of British Columbia which Dawson (*b*) describes as an erosion surface of Eocene age. (*c*)

(*a*) Wash. Geol. Survey, Bull. I, pp. 12 and 24, 1910.

(*b*) Trans. Royal Society of Canada, pp. 11-13, 1890, G. M. Dawson.

(*c*) These relations are considered in greater detail in a paper by the writer. Wash. Geol. Survey, Bul. No. 1, pp. 11-14, 1910.

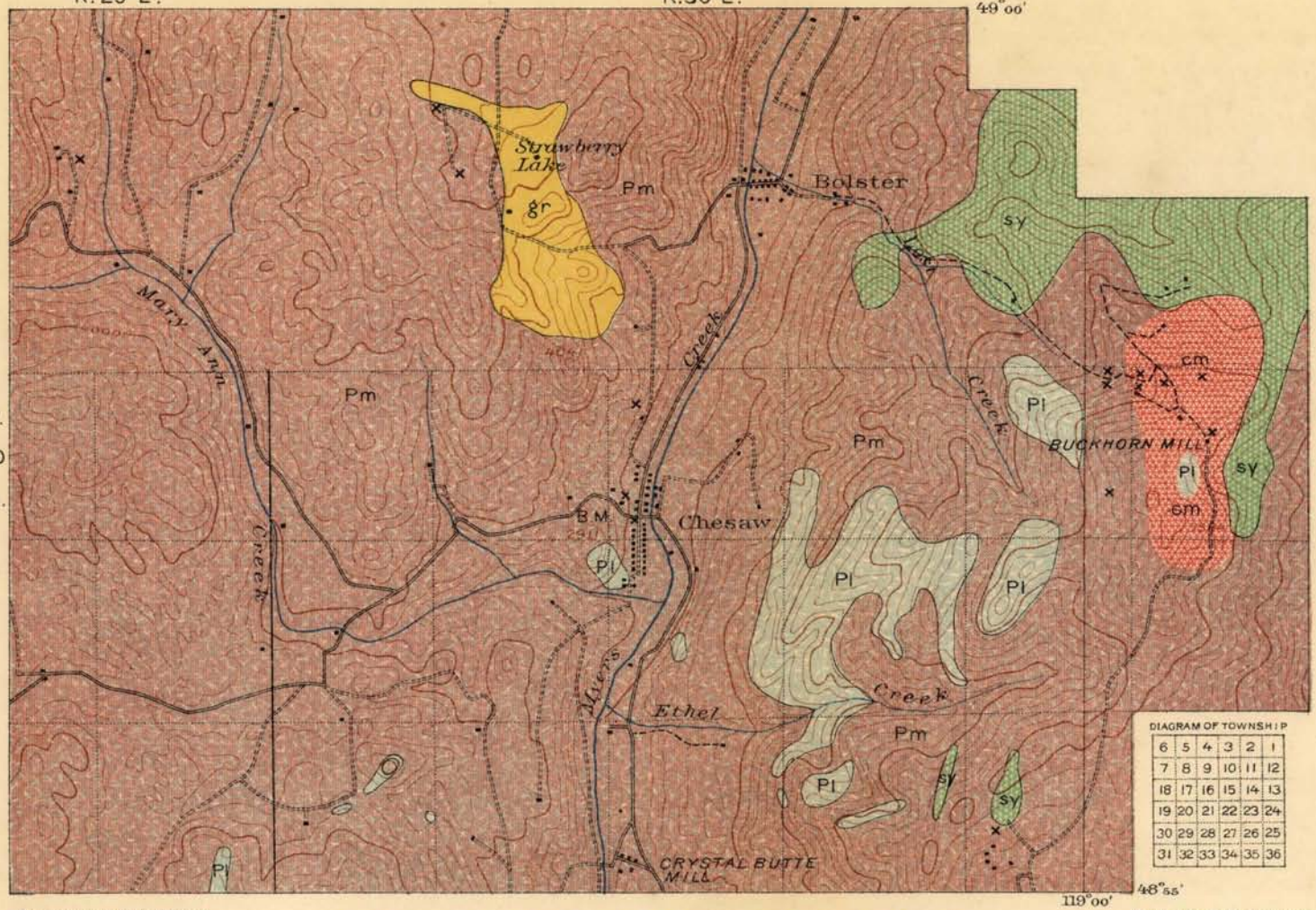


DIAGRAM OF TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

LEGEND

MESOZOIC (?)

- **gr** — Granite
- **cm** — Contact metamorphic area, consisting of garnet, epidote, etc., largely replacing original limestone
- **sy** — Quartz bearing hornblende syenite

PALEOZOIC

- **Pm** — Quartzites; schists and greenstones
- **Pl** — Limestone, crushed and metamorphosed
- **×** — Prospects and Mines

Topography by United States Geological Survey
Surveyed in 1902

GEOLOGIC MAP OF MYERS CREEK DISTRICT

BY JOSEPH B. UMPLEBY

ASSISTED IN THE FIELD BY OLAF STROMME

Geology by J. B. Umpleby and Olaf Stromme
Washington Geological Survey
Surveyed in 1909

Scale

1 ½ 0 1 2 Miles

Contour interval 100 feet

Datum is mean sea level

CHAPTER II.

GENERAL GEOLOGY.

GENERAL STATEMENT.

The broader features of the geologic history of Myers creek district include sedimentation and igneous activity in the Paleozoic, with great diastrophic movement possibly at its close; batholithic intrusion with accompanying contact metamorphism and mineralization in the late Mesozoic; and erosion and glaciation in the Cenozoic.

The oldest rocks in the area are probably of Paleozoic age and consist of quartzites, slates, schists and limestones with intimately associated intrusive and extrusive igneous rocks of basic composition, all of which have been subjected to a great period of diastrophic movement which resulted in their regional metamorphism. At least part of the series is thought to be Carboniferous. Intruded into these are two great batholiths of acid granular rock which show no evidence of having passed through a period of intense crustal movement and are for that reason, together with other considerations taken up later, assigned provisionally to the late Mesozoic. Erosion was the dominant feature of the Tertiary with possibly a period of movement resulting in elevation, at about the close of the Eocene. In the Pleistocene a southward extension of the Cordilleran ice sheet covered the entire area leaving a heavy mantle of drift, much of which remains in situ, especially west of Myers creek.

DESCRIPTION OF ROCK FORMATIONS.

PALEOZOIC SERIES.

Distribution.

Distributed widely in the Myers creek district is a series of metamorphic rocks; quartzites, slates, greenstones, limestones and schists, named in descending order of importance. They form the bedrock over all the area except that occupied by the quartz-bearing hornblende syenite on the north slope of Buck-

horn mountain, and the granite mass northwest of Chesaw. Owing to their general striking appearance and topographic position the limestone beds are represented on the map by special color, while the other members are grouped, and represented by a uniform shade. To differentiate the slates, schists and greenstones would require far more detailed work than the present studies permitted.

Characteristics.

The series as a whole is distinctly, though not intensely, metamorphosed. Foliated schists are seldom seen; the limestone although greatly crushed is seldom converted into marble; and the quartzites seldom present complete recrystallization. On the other hand exposures which show distinct bedding are rare, while in many places secondary structure is the pronounced feature. In point of structure the area may be separated into two parts with Myers creek valley as the dividing line. West of the valley the beds dip, with few exceptions, to the west, while on the east side the dip is in the opposite direction. A section across the western portion from the Molson mine to Chesaw, a distance of about three and one-half miles, presents a persistent dip to the west varying from twenty to seventy degrees but averaging thirty or thirty-five degrees. In the western half-mile of the distance the rock is a pearly, carbonaceous clay slate which is uniformly metamorphosed. It overlies a great thickness of greenstone and micaceous schist which continue to be the predominant rocks for about two miles further east, where the schists give way to quartzites, which with greenstone, prevail to the bluffs near Chesaw. This area is so concealed by drift, and exposures are so scattered, that it is not thought safe to make an estimate of thickness on the strength of the above observation, although the traverse was undertaken with that end in view. Suffice it to say, that the section represents a very considerable thickness of beds with the general transition of the sedimentary part, from quartzites below through schists to clay slates above.

East of Myers creek valley the clastic and igneous parts of

the series seem to be very similar to those on the west except that there is much more quartzite and less greenstone, while limestone is vastly more abundant. The prevailing strike is a little east of north with dips to the east at angles varying from ten to sixty degrees but averaging about thirty degrees. The best section of the formations that was found, is in the west half of section 34, township 40 north, range 30 east, where several small outcrops of metamorphic rocks are exposed as occasional low ledges for several hundred feet up the slope. The beds strike in a direction varying from north to a little west of north, and dip easterly at angles ranging from thirty-five to sixty degrees. A pace-traverse across the strike from west to east presented for the first six hundred feet, an alternation, beginning and ending with schists, of six beds of coarsely crumpled micaceous schist with five beds of gray to greenish quartzite of medium texture, the several beds of each being of about the same thickness. The most easterly of the schist members encloses a tabular body of basic porphyry which seems to conform with it in dip and strike. Above this schist is quartzite which grades from brown at the bottom through red and pink to white at the top. It is about 100 feet thick and is overlaid by an equal thickness of mica schist which gives way to a thin bed of marble. Greenstone next outcrops for twenty feet or so with about fifty feet of marble beyond. Then follows one hundred feet of schist with a thin body of greenstone included. Greenstone is next above and forms the most easterly exposure.

A feature that is characteristic of the entire area is well illustrated in the above exposures where many beds which are strong and well defined can not be traced for more than a few hundred feet along the strike. In the case of limestone they seem to pinch out, while with the clastic rocks the breaks are probably due in large measure to cross faulting, and sharp bends along the strike which have resulted in increasing or decreasing the resistance of the bed to weathering.

The limestone beds are fairly free from impurities but in places tend to be siliceous with occasional bands of scattered

chert nodules. The average rock is dark gray to dove color on exposed surface, but on fresh fracture is either uniformly bluish gray or shows alternating blue and white bands. In a few places the more solid color is mottled by blue spots. Usually the limestone is greatly crushed although not recrystallized, but in places beautiful marble occurs in parts of a bed. It is thought that such local instances of marbleization can in each case be traced to the contact influence of a nearby igneous rock.

The lenses of limestone are usually small in horizontal extent

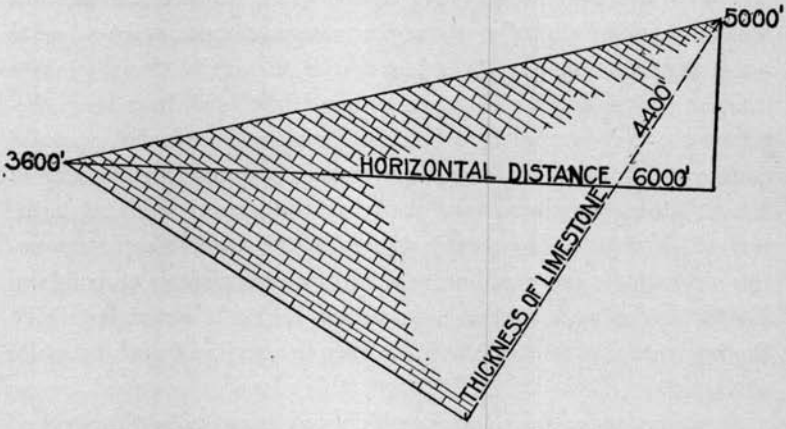


FIG. 1.—Method used in determining thickness of limestone occurring on the west face of Buckhorn Mountain.

and less than a hundred feet thick. One bed outcrops on the west face of Buckhorn mountain which is much larger than the others and because of its peculiar outlines justifies special mention. It begins in the bluffs east of Chesaw at an elevation of 3,600 feet and continues up the mountainside to a height of 5,000 feet, throughout the entire distance dipping east at an average angle of about 30 degrees. Since the horizontal distance between the western or lower exposure and the eastern or higher, is a little more than one mile, it will readily be seen either by computation or plotting (Fig. 1) that this bed, if its lower part continues on its dip under the mountain, is approximately 4,000 feet thick. The bedding planes within

the mass are usually distinct and since the dip recorded above is a conservative average of several dips taken at different points, there seems little room to doubt that the above estimate of thickness follows from field relations. Attempt to harmonize this thickness, however, with the distribution to the north and south and it is obvious at once that special relations exist. An inspection of the map shows that to the south along the strike the lower part of the deposit pinches out within one and one-fourth miles from the longest east-west axis of the outcrop; half-way up the mountain a southward tongue extends for about a half-mile; and at the top a narrow tongue extends in the same direction about three-fourths of a mile. On the north margin the boundary is more regular but even here two protuberances extend for about one-half mile each. It does not appear that faulting will explain these irregularities in outline. The relations then are, that the bed of limestone is about 4,000 feet thick with a horizontal extent in its lower portion along the axis which corresponds to the present strike, of only about 8,000 feet. On horizons successively higher stratigraphically, the horizontal extent of the mass presents striking and irregular variations.

It would seem that the deposit must have taken its present form either by the crushing together of a more widely distributed limestone bed during the period of crustal movements, or by peculiar conditions of deposition whereby a reef of lime-bearing organisms continued to exist for a long time while clastic sedimentation was going on around it. The degree of preservation of the bedding structure seems to favor the latter view.

The igneous rocks intimately associated with the sedimentary series are basic in composition and so completely altered that the original mineralogical composition was not determined satisfactorily. They fall either in the gabbro or the diorite family, although in their present forms they may well be designated by the term greenstones. In many of the specimens the secondary minerals have been developed in part from a glassy ground mass, remnants of which remain. In others distinct

outlines of original crystals remain in most parts of the section. It seems, therefore, that the original rock varied in texture from glassy or slightly porphyritic to holocrystalline, thus implying the presence of both extrusive and intrusive types. That some of the rocks are intrusive is in keeping with the above section where the limestone both above and below the body of basic igneous rock is changed to marble. Although it is thought that the extrusive phase is far more extensive than the intrusive, their relative importance is not definitely known.

Age.

The only fossils found in the series were from the limestone outcrops in the northwest quarter of section 26, township 40 north, range 30 east. These consist entirely of crinoid stems which, although quite abundant, are fragmentary. They were of little value in age determination although in harmony with a correlation with known areas in Canada. Lithologically and structurally the series is very similar to the Cache creek series of Dawson, which is of known Carboniferous age, (*a*) and largely on the strength of this analogy the series is provisionlly assigned to the Carboniferous although there seems little doubt that beds of more than one age are present.

In this connection one feature was noted which may have special bearing when the conditions of sedimentation are studied in greater detail. In the southeast quarter of section 10, township 40 north, range 30 east, is a prospect tunnel about 150 feet deep which is driven in a metamorphosed conglomerate. The individual boulders vary in size up to about ten inches in diameter and consist of slate, schist and quartzite, with perhaps some meta-igneous material, in the ratio of about 1 : 1 : 7. This conglomerate was not seen elsewhere in the area, although the general concealment of bedrock by glacial drift and residual soil makes this statement of little significance.

(*a*) Annual Report, Geol. Survey, Canada, New Series, Vol. 7, 1894, pp. 37-B to 49-B.

MESOZOIC ROCKS.

Distribution.

The Mesozoic history of the district seems to be that of erosion and intrusive igneous activity. There are two great batholithic masses of slightly different composition within the area. The larger is a quartz-bearing hornblende syenite and outcrops over an irregular extent of about four square miles in the northeast part of the area. The other mass is granite and occupies about two square miles northwest of Chesaw.

Characteristics of Syenite.

The average specimen from the quartz-bearing hornblende syenite mass is a dark bluish gray rock of inequigranular to equigranular texture and megascopically consisting of hornblende and feldspar with local development of biotite and an occasional grain of quartz. The texture varies considerably, in places being uniformly about equigranular while in others hornblende crystals are far larger than the feldspars and yet again feldspars of two distinct sizes appear. Quartz and hornblende both have a considerable range of variation, the former running from one-half of one per cent. to about seven per cent. of an entire thin section although in one instance twenty-five per cent. of quartz was noted, while the hornblende varies between eight or ten per cent. and twenty per cent. In thin sections the feldspar is shown to be about one-fifth albite and four-fifths orthoclase with occasional microcline crystals.

The syenite is in the form of a batholith very irregular in outline as exposed at the surface and having an areal distribution of about four square miles. The mass has been thrust up into the sediments without having very appreciably influenced their dip. It is probable that in general outlines the batholith is much more regular than the surface outcrop indicates, *i. e.*, that many of the sedimentary tongues which extend into its general area simply represent portions of the cover not yet removed by erosion.

Along the margins of the igneous mass intense metamorphic action has taken place locally. The localization of the alteration

seems to depend in large part on the character of the adjacent material, for at the point of most pronounced metamorphism an entire bed of limestone has been changed while quartzites adjacent to the limestones and even closer to the syenite, have suffered no appreciable metamorphism. It is also noteworthy that the only altered area is at the same time the only limestone bed in contact with the syenite. Where schists or slates come in contact, occasional garnet and epidote crystals have been formed but within the limestone they are about equal in amount to the calcite, which is probably residual from the original rock. Diopside, actinolite, tremolite and titanite are developed in amounts which vary from place to place. The texture of the altered rock is never coarse and it is frequently impossible to ditinguish the outlines of individual crystals with the unaided eye. In thin sections the garnets are seen to be scattered heterogeneously through the slide both as isolated crystals of four, six, or eight sides, and as groups of irregular outlines. The epidote (green) occurs as prisms and grains, frequently with interrupted boundaries. Calcite forms the matrix for the metamorphic crystals. Actinolite occurs as long prismatic crystals clustered in more or less radiating groups, while tremolite has a similar distribution but is much less abundant. Diopside is locally very conspicuous although it does not appear in many of the slides. Titanite, which is found as small automorphic crystals and as rims surrounding magnetite, is quite uniformly distributed but there are never more than one or two occurrences in any one specimen. The metallic minerals developed in the area are magnetite (which forms the principal surface rock over an extent of several acres), chalcopyrite the chief ore mineral, and pyrite, a common associate of both of the others.

Within the igneous rock itself the hornblende is commonly altered to epidote and chlorite, and the feldspars to epidote, zoisite and sericite. In both hornblende and feldspar green epidote is the chief alteration product. Pyrite is usually developed as cubes irregularly distributed. Magnetite is present but not conspicuous. Since the minerals developed in the

contact rock and within the mass itself are so similar and do not have the balance usually found in the common weathering of an igneous rock, it appears that both were subject in part to the same metamorphosing agencies, indicating thereby that part of the metamorphosing action took place after the solidification of the outer shell of the batholith. This phase of the alteration is known as hydrothermal metamorphism and probably resulted from escaping vapors and gases which emanated through both the outer part of the igneous mass and through its sedimentary cover, during the period of solidification of the inner part.

Characteristics of Granite.

The average specimen from the granite area differs from that of the syenite mass only in a greater amount of quartz and a lesser amount of hornblende. It is possible to secure specimens in this area which would undoubtedly be classed as syenite, as it is also possible to secure some from the other which would be classed as granite. The typical specimen is a light gray rock varying in texture from granular to inequigranular, and composed of orthoclase with about one-third as much albite, quartz, hornblende and biotite. The last two minerals named are about equally important and together make up from four to ten per cent. of the rock, varying in amount in different places. Chlorite and sericite are the more important secondary minerals, although pyrite has been extensively formed in a few places.

As far as observed the granite did not produce much alteration in the rock which it intrudes. This may be due to the absence of limestone along the contact, since in the syenite area it was the only type that was greatly altered.

The granite has a surface exposure of about two square miles, and like the syenite was intruded into the Paleozoic series as a batholithic mass which apparently had little effect on the general structure of the formations which it entered.

Age of the Batholiths.

These batholithic masses are clearly younger than the Paleozoic series which incloses them, and since they are not schis-

tose, evidently are younger than the period of structural movements which metamorphosed that series. From an analogy to adjoining areas it is suggested that probably this area was peneplained in the Eocene. If this is true it is noteworthy that syenite outcrops up to an elevation of 4,900 feet on the east margin of the area, whereas the peneplain surface varies from 5,000 to 6,000 feet. This will scarcely allow enough cover to produce the granite texture characteristic of the mass unless the intrusion be dated as pre-peneplain. From the foregoing evidence the batholithic masses are provisionally assigned to the late Mesozoic.

CENOZOIC DEPOSITS.

The Cenozoic era seems to have been a time of erosion, continuous save for the comparatively short period when glacial ice covered the area. Glacial drift is found in all parts of the district although it is much more pronounced on the west side of Myers creek valley than on the east. This is probably due rather to a greater amount of post-glacial erosion on the east due to steeper slopes, than to any original difference in amount of the deposits. An irregular terminal moraine extends east and west across the southwest part of the area mapped. South of it a heavy mantle of unstratified drift extends well beyond the limits of the district, indicating that the terminal moraine simply represents a time of rest during the general period of ice retreat. Ground moraine material is far and away the most widespread type of glacial deposits. Along Mary Ann creek are local terraces composed of stratified glacial material which was probably deposited in a small lake formed in front of the ice after it had retreated north over the divide between Myers creek and Antoine creek or possibly between Myers creek and Beaver creek (*a*).

(*a*) See the topographic sheets of U. S. Geol. Survey, Osoyoos and Republic Quadrangles.

CHAPTER III.

ECONOMIC GEOLOGY.

LOCATION AND CONDITIONS.

The Myers Creek mining district is situated in the northeast part of the Osoyoos quadrangle, in eastern Washington. Like most of the mining districts of this part of the boundary country, it is unorganized. The accompanying map, which includes about thirty-five square miles, covers most of the area and indeed all of that part which has afforded reasonable encouragement to the prospector.

Elevations within the area vary from about 2,650 feet in the valley flat north of Bolster, up to 5,584 feet at the highest point on Buckhorn mountain. Myers creek, which is a small stream crossing the area near its center and flowing north into Canada, is the principal drainage line, and from it the mining district receives its name. The stream occupies an open valley with a flat from ten to fifteen rods wide and has an average gradient of a little less than one hundred feet per mile. Ethel creek, a small westerly flowing stream with a gradient of between six and seven hundred feet to the mile, occupies a comparatively narrow valley and joins the main stream about one mile north of the south boundary of the area mapped. Three-quarters of a mile farther north Mary Ann creek enters the main stream through an open valley from the west. At Bolster, Lost creek, draining a precipitous country to the east, joins Myers creek.

The central drainage line divides the area into two topographic types; that to the east being precipitous and largely covered with a dense forest growth, especially on the north and east slopes, while to the west the topography is made up of high, rolling hills reaching a maximum elevation 1,543 feet lower than to the east, and supporting only scattered and in many instances, isolated trees.

The Great Northern railway, giving ready communication

with Spokane and various British Columbia points, reaches Myncaster, a small settlement in British Columbia about five miles north of Chesaw. At present wagon roads extend to most parts of the area and all of the remaining parts can be entered by roads at very reasonable cost if mining developments make them necessary.

As a whole the district is well supplied with timber. No water power sites of economic importance occur within the area although there is an abundance of water for milling and domestic purposes. Climatic conditions on the average are more favorable to mining than in most of the camps in the northwest states.

HISTORY AND PRODUCTION.

The district is comparatively young, the principal locations having been made since the reconnaissance by the Washington Geological Survey, recorded in its annual report of 1902. (*a*) The production has not been great, probably falling within $100,000, about $40,000 of which came from the placers on Mary Ann creek, $15,000 from the contact metamorphic deposits on Buckhorn mountain and the remainder from the Butcher Boy and other veins of the area.

Development has been largely by tunnel, although there are a few shafts. There are no deep workings, the Grant tunnel, which at the face is about 400 feet vertically below the surface, probably being the deepest. It must not be inferred from this statement, however, that exploration in depth, beyond the limit of surface alteration, which is always shallow (fifteen to fifty feet) in this area, will reveal values greater than those immediately below the lower limit of oxidation, for although a prevalent view among prospectors, it is not supported by the geologic relations here existing. There may be special exceptions to this on Buckhorn mountain but these will be taken up later under the head of contact metamorphic replacement deposits.

Most of the development has been done without the aid of power-drills. Four small amalgamation mills are situated in the

(*a*) Washington Geological Survey, Vol. I, part II, page 26.

area but have not proven very satisfactory, due to low extraction and the general pyritic nature of the ore; and since there is usually too much copper for satisfactory cyanidation, it is probable that smelting will prove to be the most feasible treatment.

GEOLOGIC RELATIONS.

The rock formations of the area are a great series of Paleozoic sediments, lava flows and porphyries, which have been intruded, probably in Mesozoic times, by batholiths of igneous rock—quartz-bearing hornblende syenite and granite. Along the contact of these intrusive masses with the sediments there are in a few places areas of intensely metamorphosed material which carry copper, gold, and silver, commercially important in the order named.

The igneous rocks of the district are of two ages, the earlier being basic flows, dikes and sills, of Paleozoic age, and the latter acid granitic rocks, tentatively assigned to the Mesozoic. The basic rocks are widespread in the district and outcrop as ledges and cliffs where the enclosing rock is slate or schist, while their presence is indicated only by float where the enclosing rock is quartzite. In the one exposure where they were found in contact with the limestone, the latter had been changed to marble both above and below the igneous rock, thus indicating in that particular instance an intrusive origin. Microscopically the rock is largely made up of secondary hornblende, although epidote, zoisite, sericite, magnetite and pyrite have been developed in decreasing importance in the order named. Outlines of olivine and augite, together with chance unaltered or partially altered fragments, appear in the slides. The feldspars are nearly always completely altered but from rare fragments remaining in a determinable form, it appears that andesine was possibly the prevailing type. Quartz is present but is largely secondary. The above balance of mineralogical composition, in so far as it is comprehensive, places the rock on the border line between andesite and basalt; although it is not certain that the primary texture, at least locally, was not coarser than these types imply.

Greenstone is probably the most appropriate name for the rock in its present form.

Of the two acid granular rocks, the quartz-bearing hornblende syenite occupies a larger area than the granite. It is bluish gray, with equigranular texture, and outcrops in the eastern part of the area over an irregular extent of about four square miles. Structurally, it is a great batholith intruded into the sediments without having noticeably influenced their dips. The mass is probably much more regular in outline than the contact shown on the map would indicate, it being thought that in large part the tongues of older rock which extend into its general field are comparatively thin portions of the original cover not yet removed by erosion. It is noteworthy that near the southern limit of the area mapped two small areas of syenite are exposed which are possibly spurs from the same underlying batholith, the northern exposure of which has just been described.

Adjacent to this igneous unit extensive contact metamorphism has occurred wherever the adjoining rock is limestone and much less where it is schist or slate, while the effect has not been important when greenstone, and even less when quartzite, is the rock in contact. The age of the quartz-bearing hornblende syenite is discussed in the chapter on General Geology, and is there provisionally assigned to the late Mesozoic.

A batholith of light gray granite outcrops over an irregular area of about two square miles in the north central part of the district. As is true of the syenite above discussed this batholith seems to have had little influence on the general structure of the sedimentary beds which it intruded. Microscopically examined, the rock is equigranular, consisting of orthoclase, quartz, albite, hornblende and biotite as principal constituents, with accessory pyrite, magnetite, titanite and apatite. Sericite, chlorite, zoisite and titanite are secondary. Contact metamorphic action is not conspicuous with the hand lens and was only noted in one or two places where thin beds of limestone were cut by the intrusive body. The ore deposits in the vicinity are usually in the Paleozoic series, but near the granite.

The sedimentary rocks of the area are of varying character, and have been metamorphosed to slates, schists and quartzites, with intermediate phases. Quartzite is the most common type, and varies in texture from large angular to subangular grains, firmly cemented and in places recrystallized by additions to the original grains, to small irregular to rounded grains also firmly cemented; and in color from bluish white through gray and various shades of brown to slate black. Gray quartzites of medium texture are most common. The slates of the series are usually black and very siliceous while the schists present all gradations from incipient schistosity to intricate foliation. Schists are not a conspicuous element in the series. The limestones of the district are very largely confined to the southeastern part where they occur over areas of peculiar shapes, probably signifying both special conditions of formation and a certain crushing together at the time when dynamic movements and stresses caused the general regional metamorphism. Their present form is that of great lenses, very irregular in thickness and extent.

It is very probable that more detailed study would make possible the division of this series into parts, but the present work merely suggests that the great group of massive gray quartzites and basic porphyries which exclusively occupy the northwestern part of the area are younger than the limestones and accompanying slates and schists in the southeast portion.

The series is of doubtful age, although that part represented by limestone bears crinoid stems which are in perfect harmony with an assignment to the Carboniferous, which is also suggested by analogy to known areas in British Columbia. (*a*)

Both the primary and secondary structure of the region is complex. In the western part of the area the prevailing dip is in a westerly direction while in the eastern part it is easterly. Myers creek valley represents approximately the dividing line between the easterly and westerly dipping beds. In a few places an unconformity in dip between the limestones and under-

(*a*) Annual Report, Geological Survey, Canada, New Series, Vol. 7, 1894, pp. 37 Btd.-39-B.

lying beds is suggested, but by no means demonstrated, due to inability to find exposures in sufficiently close proximity.

The entire series of sedimentary rocks and the accompanying basic porphyries are metamorphosed to a greater or less degree. Superimposed on this general regional metamorphism is intense local contact and hydrothermal metamorphism due to the granite and syenite bodies, while the latter masses do not present evidences of diastrophic disturbances. The regional metamorphism took place, therefore, after both sedimentation and the period represented by basic igneous activity, but prior to the acidic intrusions. As discussed elsewhere, it is thought probable that the dynamic forces which caused the regional metamorphism are to be assigned to that great period of general diastrophic activity which closed the Paleozoic era.

ORE DEPOSITS.

Within the Myers Creek mining district two great classes of ore deposits are represented; namely: (a) contact metamorphic replacement deposits, and (b) fissure veins. The region may be considered a copper-gold district, the copper being largely in the contact zones and subordinately in veins, while the gold is principally in veins and subordinately in the contact deposits. As is usually true in similar camps, it is in some instances impossible to draw the line between the two types of deposits. In places the solutions have acted directly on the adjacent rock, thus producing the irregularities typical of contact metamorphism. In others they have encountered directions of easy passage and deposited along fracture zones, thus giving the tabular form typical of vein deposits. All gradations exist between the two types and indeed there are instances in the area where both extremes occur in the same deposit. In the following discussion only the two types are recognized and gradational phases are included in the class nearest to which they approach.

CONTACT METAMORPHIC REPLACEMENT DEPOSITS.

Location and Characteristics.

The contact metamorphic replacement deposits occur chiefly in the eastern part of the area along the west side of the south ex-

tension of the quartz-bearing hornblende syenite. The outcrops which prevail here are seldom oxidized for more than a few feet below the surface and in many places unaltered pyrite, magnetite and chalcopyrite can be found at the grass roots. It follows of course that with little oxidation there has been little leaching, and hence little or no secondary enrichment may be expected as development proceeds.

The ore bodies are of irregular shape, varying in size from small isolated bunches to masses which afford large stopes. Development has not proceeded far enough to make a tabulation of the eccentricities of the deposits feasible, but it is probable that they will be found to have a north-south trend, and easterly dip since both the limestone bedding and the jointing of the area incline in that direction, although the jointing is nearly vertical while the bedding seldom has a dip higher than 40 degrees and usually less than 20 degrees.

The contact metamorphism here described has resulted from the intrusion of the quartz-bearing hornblende syenite into the Paleozoic series. An inspection of the map (Plate I), where the principal area of alteration is indicated as a separate unit, portrays the peculiar localization of the metamorphic action. This is to be accounted for largely by the presence originally of a bed of limestone at this point which was essentially co-extensive with the altered area, while elsewhere along the contact the adjacent rock was of clastic origin with occasional greenstones interbedded. It is noteworthy that the syenite lying east of the mineralized area is a narrow band extending along the east face of the mountain and in places widening in the valleys and narrowing on the divides; whereas on the north it swings west and is the rock in contact along that border of the metamorphic body. This general relation suggests that the mineralized and altered limestone is, in part at least, a capping over a portion of the syenite batholith. The intensive alteration here, in contrast to the inconspicuous change elsewhere, is likely due to the absence of limestone in juxtaposition at other points and

is in keeping with the observation made in many localities that limestone is much more susceptible to contact influences than clay slates and quartzites.

It follows from the above that those beds of limestone which lie west of the syenite area and dip toward it offer ground which is worthy of prospecting wherever the contact between the two can be reached without too great expense. It is probable that there are bodies of ore on Buckhorn mountain which have no surface indication and can only be located by determining the probable position of the contact of a limestone bed with the syenite and then prospecting that ground. Such prospecting will be expensive and should not be undertaken until the merits of the mineralized body which is exposed at the surface and is now being worked, are more fully determined.

Minerals.

The mineralogy of the contact ores as here set forth, is undoubtedly far from complete, due both to the limited number of exposures available and to the hurried nature of the examination. Far and away the most conspicuous metamorphic silicates are garnet and epidote. Accompanying them are zoisite, diopside, actinolite and tremolite. Calcite is always present and in greatly varying amounts, while a little titanite appears in most of the slides. More typical specimens from the metamorphic area are of dense, fine-grained rock of yellowish to brownish green color and resinous to vitreous luster, consisting of calcite and small grains of garnet and epidote, with occasional needles of actinolite.

Calcite. In the thin sections calcite is the most important mineral, occurring in the interstices between the other crystals and as irregular patches frequently surrounding isolated groups of garnet and epidote. It represents about thirty per cent. of the average slide.

Garnet. Next in importance is a light green to colorless garnet (grossularite, $Ca_3Al_2(SiO_4)_3$) which, as seen in the sections, has four, six or eight sides. It is distributed both as isolated crystals scattered irregularly through parts of the slide,

and as groups in which the individuals are as grains with many variations in outline. Garnet comprises about twenty per cent. of most sections.

Green Epidote. Green epidote (pistacite, $Ca_2(AlOH)$ $(Al\ Fe)_2$ $(SiO_4)_3$) is almost as important in amount as garnet, and has much the same distribution. It occurs as prisms, rods and grains, the latter being readily distinguished from grains of garnet by cleavage, pleochroism and birefringence.

Zoisite. Zoisite $(Ca_2AlOH)Al_2(SiO_4)_3)$ is much less important than epidote and occurs as rods and leaves which in most sections are readily distinguished from the epidote by their parallel extinction. When the section of the epidote is at right angles to the cleavage the distinction is more difficult.

Actinolite. This calcium, iron, magnesium silicate $(Ca(MgFe)_3(SiO_3)_4)$ which is very largely limited to the contact metamorphic replacement deposits, constitutes about ten per cent. of some slides. It occurs in thin prismatic crystals clustered in more or less completely radiating groups which are scattered irregularly through the slides.

Diopside. Diopside $(CaMgSi_2O_6)$ is absent from all the slides save one, but in that, it constitutes about seventy-five per cent. of the entire section. The individual crystals occur as grains and short prisms which seldom have their complete crystal outline. The garnets appearing in the same slide are bounded by definite crystal faces except where an individual of the same species is in contact, when one of them usually is complete in form at the expense of the other.

Chalcopyrite. Although less important quantitatively than magnetite, this is the chief ore mineral of the area. In places it occurs as a scattered intergrowth with the other metamorphic minerals, but in most instances is in bunches of considerable extent with pyrite, magnetite, and quartz as the chief accompanying minerals. In the light of present studies no law of probability regarding the position of the chalcopyrite bodies within the altered area, can be stated. The chalcopyrite carries small amounts of gold and silver.

Magnetite. This mineral occurs in great bodies near the central part of the metamorphosed zone, almost to the exclusion of other minerals. Some specimens show pyrite and chalcopyrite intergrown with it. The magnetite usually is accompanied by gold in amounts varying from seventy-five or eighty cents up to seven dollars per ton.

Pyrite. No considerable mass in which pyrite predominates was noted, but probably no mineral is present in so many different exposures. In the veins near the contact metamorphic area pyrite carries gold and it is likely that part of the gold in the contact deposits is associated with it. Its occurrence is in crystalline masses which may be any shape, and less commonly, as cubes and octahedrons.

Titanite. Titanite ($CaSiTiO_5$) occurs in all the slides, but only in rare instances reaches as much as one per cent. of the total content. Rhombs, prisms and grains, all with clearly defined boundaries, are the rule, although in a few instances the titanite surrounds a grain of magnetite as a narrow band, apparently derived from it.

Quartz. This is common in all the altered rock, although seldom reaching as much as five per cent. and usually not more than one or two per cent.

Secondary Alteration.

Within these deposits secondary alteration of the original minerals is a very inconspicuous feature. Copper and iron stains occur at the surface in most exposures but never extend to a depth of more than a few feet. This is in keeping with the general impervious character of the deposits shown by the retention of water, even in shallow shafts, throughout the entire dry season. As a result of these conditions, which evidently have prevailed since the deposits were formed, it follows that zones of secondary concentration cannot be expected in the area.

Genesis.

The genesis of the ores of the garnet-epidote area is well defined by the peculiar association of minerals and geologic re-

lations which in recent years have become commonly known as definite criteria for the identification of contact metamorphic deposits. The minerals which are exclusively of contact metamorphic origin are few and rare, but there is a considerable list which, when found more or less complete to the exclusion of other minerals which accompany them individually under different conditions, are typical of such deposits. The assemblage above noted, namely: of garnet, epidote, zoisite, actinolite, tremolite, diopside and titanite is conclusive proof of such origin. Magnetite, chalcopyrite and pyrite, although not in any measure peculiar to contact deposits, are very common in them. A local relation pointing to the same conclusion is that the particular limestone bed, which of the several mapped, shows intense alteration, is also the only one which lies in contact with a large igneous mass. Further, the irregular outlines of the deposits themselves, impregnation of minerals in the surrounding material, and isolated bunches of ore, all point in the same direction.

The solutions, probably in part emanating as gas and hot liquids from the syenite both at the time of its injection and during the period of cooling when gases and possibly magmatic waters were being eliminated probably by the selective forces of crystallization, and in part ground water made potent by proximity to the igneous mass, penetrated the adjacent rock wherever possible. They removed some of the mineral present and introduced new material in its place, at the same time making it possible for part of the old material to enter into combination with the new, thus forming the minerals before mentioned.

The present conception of most investigators regarding the formation of the contact metamorphic minerals is that in part they are due to the rearrangement of impurities in the limestone remaining after a part has been eliminated by heat, largely as carbon dioxide gas. In larger part, however, they are considered as the result of a combination of added material with residual material on the one hand, and of direct addition on the other. In this particular case the small amount of iron in the

other lime areas and the great amount of iron present in the metamorphosed bed, leaves little room for doubt that iron was introduced. Second to iron, copper and sulphur are important additions. The studies were not sufficiently refined to justify a conclusion concerning the introduction or otherwise of the aluminum, magnesium and silicon present in the various silicates. The presence of silica in all the specimens and as a gangue in the nearby vein deposits, suggests that it was introduced, at least in part. Titanium and gold are rarer elements which may or may not have been introduced.

VEIN DEPOSITS.

Distribution and Characteristics.

Veins found in widely separated parts of the district have been opened in all the types of rock present. They are irregular in strike and dip, having, however, a prevailing north and south direction. The dip seems to have no relation to the bedding, although the prevailing strike corresponds in general to that of the structural features of the region. The lodes vary greatly in width in different deposits, and from place to place in the same deposit. They are usually much faulted, and can never be relied upon to carry their width or metal content for a distance of more than a few feet either along the strike or the dip. In some instances commercial ores are limited to well-defined shoots, although for the region as a whole, the irregularities in width and persistence of the deposits themselves are more pronounced than variations in metallization from place to place in the same vein. The walls are usually well defined although spurs and swells into them are common.

The minerals noted are free gold, chalcopyrite, pyrite, galena, sphalerite, arsenopyrite, and occasionally pyrrhotite in a gangue which varies in composition from quartz-calcite to quartz. The quartz is usually coarsely crystalline and of bluish cast while the calcite is white to colorless and, although of irregular outline in the vein, when coarsely crushed reveals its rhombohedral crystallization. Within the vein the metallic minerals have great variations in arrangement, presenting a rough banded structure

in places and a succession of irregular aggregates in others, both types frequently being in the same vein. Crustification is rarely seen. Of the several metallic minerals above noted all or a part may occur in any given deposit, pyrite, however, being always present and usually leading in amount.

Oxidation extends only to very moderate depths, primary sulphides predominating below a point fifteen or twenty feet beneath the surface. As would be expected from the above, the level of groundwater is very near the surface throughout most of the area, even shallow prospect pits on the hillsides being partially filled with water during the dry season.

Veins in the western part of the area have given rise to placer deposits along Mary Ann creek which have yielded about $40,000. The placer gold is of medium to coarse size and occurs in gravels, part of which are glacial.

Genesis.

The veins on Buckhorn mountain are in very intimate association with the contact deposits; indeed the gradation between the two can be traced step by step, for in places a vein will make out into the wall from an irregular body of unmistakable contact origin, while in others the reverse relation exists. An instance was noted in the south end of the principal stope of the Grant Mine where the large irregular body narrows within a few feet to a vein about forty inches wide which stands between well-defined walls. This being true and since the contact deposits here found, as already discussed, are genetically related to the quartz-bearing hornblende syenite, there seems little room for doubt that the vein solutions also were dependant on that mass for their activity. Accepting, therefore, the genetic relation of the veins on Buckhorn mountain to the igneous mass there found, it is worthy of note that the deposits north of Chesaw with one exception, are all within one mile of an extensive outcrop of granite. The Molson mine in the northwestern part of the area is about two miles distant. This general distribution of deposits near the granite and their complete similarity in internal char-

acteristics to those found on Buckhorn mountain, which by their gradation into the contact type clearly indicate a genetic relation to the syenite, seems to afford ample justification for considering these deposits as genetically related to the granite batholith.

Pyrrhotite, although never abundant, occurs in several of the veins. It is a sulphide of iron which forms only under very intense conditions of heat and pressure, and thus when found in a vein, may be considered as indicating deposition at great depth, and the deposit in which it occurs should be assigned to the deep vein zone. This mineral, then, occurring near the surface at present, suggests a vast amount of erosion, possibly half a mile or more, since the veins were formed. Extensive erosion since mineralization is also indicated by the surface exposure of granite—if we accept a genetic relation between the two—because its holocrystalline nature implies slow cooling, and slow cooling necessitates a considerable cover at the time of intrusion. The other vein minerals found are not of special significance in determining depth of deposition for they may occur in both the deep and moderately deep zones.

Briefly stated, it is concluded that the veins were formed at great depth and by hot solutions either emanating from or made potent by the nearby igneous masses both at the time of their injection and during the period of crystallization immediately following.

PLACERS.

Placer gold was discovered on Mary Ann creek in 1888 and placers have been worked intermittently and by crude methods ever since. The work has extended along the creek for about one and one-half miles in sections 1 and 2, township 40 north, range 29 east. The ground is now owned by the Allen Mining Company, with a western office at Chesaw. Gold is fairly evenly distributed through the gravel, which varies from two to six or seven feet in thickness. The gold is coarse, no mercury being necessary to save nearly all of it. Many of the boulders in the deposits are distinctly of glacial origin, indicating that the deposits, at least in their present form, are of post-glacial age.

Mining on the creek will probably never be pursued on a large scale because of the very limited supply of water during most of the year. The creek has produced about $40,000.

MINERALS OF DISTRICT.

The list of minerals recorded in a reconnaissance report must obviously be incomplete, but for purposes of reference those noted are arranged in alphabetical order and their modes of occurrence briefly given.

Actinolite. This mineral is widely distributed in the contact area on Buckhorn mountain, but was not found elsewhere. It seldom constitutes more than a small fraction of a specimen and occurs as irregularly scattered groups of more or less completely radiating needle-like crystals.

Azurite. Copper carbonate is limited to the upper few feet of the copper deposits and even here is not conspicuous. It occurs as films lining the fracture planes of copper sulphides, and as stains on nearby rock.

Bornite. This frequently occurs as an alteration product intermixed with chalcopyrite in the upper levels of the copper properties. It is not an important ore.

Calcite. Calcium carbonate is found in many of the vein deposits as a part of the gangue and in the contact deposits as residual from the replaced limestone.

Chalcocite. A single plate-like deposit of copper glance was noted along a small joint in the Grant mine. Chalcocite was not seen elsewhere.

Chalcopyrite. Chalcopyrite is the chief ore of copper. It is largely found in the contact zone, although occurring in the veins in amounts which vary from place to place.

Chlorite. This common secondary mineral is widely distributed in various rocks in the area.

Diopside. Diopside is locally very abundant in the contact zone and was also noted in some of the slides of regionally metamorphosed rock.

Epidote (Green). Green epidote occurs very extensively as a contact mineral on Buckhorn mountain and as an alteration product from feldspar and hornblende in much of the syenite and granite. It was also noted in some of the specimens of regionally metamorphosed rock.

Galena. Many of the veins carry galena, although no lead deposits of commercial extent are known in the area.

Garnet. This mineral, as far as observed, is confined to the contact metamorphic area on Buckhorn mountain. Here it frequently constitutes a quarter or more of the entire mass. No slide from the contact area was studied which did not contain it. The crystals are usually very small and in many of the specimens their individual outline cannot be distinguished by the unaided eye.

Gold. Gold occurs in association with magnetite and chalcopyrite in the contact deposits, and with chalcopyrite and pyrite in the veins. There seems to be no relation between the amount of galena or sphalerite and the gold value. Placer gold occurs along the upper part of Mary Ann creek.

Hematite. This oxide of iron was only noted as a product of surface oxidation of magnetite and other iron-bearing minerals.

Limonite. The hydrated oxide of iron occurs as a heavy stain on the vein outcrops and on surface exposures of many of the rocks in the area.

Malachite. Stains of the green copper carbonate are widespread in the surface portions of some of the ore deposits, although seldom found at a depth of more than a few feet.

Marcasite. An iron sulphide which is very similar to pyrite but has a crystal form strongly suggestive of the orthorhombic system, is found in the Molson mine, intimately associated with pyrite. The grains are very small and seldom bounded by crystal outlines.

Pyrite. Pyrite occurs in all the deposits of the area.

Pyrrhotite. This sulphide of iron ($Fe_n S_{n+1}$) was noted in the Myers creek, Crystal Butte and Butcher Boy properties. It is never conspicuous in amount.

Quartz. This is the common gangue mineral of the vein deposits and is nearly always present in the contact area. It is generally coarsely crystallized and of bluish color.

Sericite. White mica is strongly developed as a secondary mineral in the wall rock of many of the veins and is also widespread in the granite and syenite, although present here in much less conspicuous amounts. It occurs in a fibrous felted form.

Serpentine. This mineral is limited largely to the surface exposures of regionally metamorphosed basic porphyries where it occurs as an alteration product of pyroxenes and amphiboles.

Silver. Silver occurs in most of the deposits, although never in sufficient amounts to make the ore valuable for silver. In places it seems to vary in amount with the quantity of lead, as in the Apex mine.

Sphalerite. This mineral occurs in several of the veins west of Myers creek but is never important. In all places noted it was accompanied by galena.

Tetrahedrite. A few crystals of gray copper were noted on the dump of the Olentangy shaft. It is not known at what depth they were encountered. The crystals are small, of tetrahedral form and yield heavy white fumes before the blowpipe.

Titanite. Titanite occurs as automorphic crystals and less frequently as bands surrounding magnetite. It is most conspicuous in slides from the contact metamorphic area.

Tremolite. This has the same general distribution as actinolite.

Zoisite. Zoisite is a very common associate of epidote in the contact of metamorphic area, and in many of the specimens of the regionally metamorphosed schists and basic porphyries.

CHAPTER IV.

DESCRIPTION OF PROPERTIES.

In the description of individual properties which follows it is not intended to attempt an exhaustive statement concerning any individual property, nor is it possible to include all of the properties in the district, but rather to record the more important observations made on the several claims which were visited, in order to give the studies as concrete a bearing as is possible in a reconnaissance report.

GRANT PROPERTY.

The Grant property is located on the east slope of Buckhorn mountain near the summit and about four miles on a direct line a little north of east of Chesaw, although by wagon road the distance is about nine miles. Six claims, three of which were located in 1901 and three in 1902, are included in the group. The property is owned by the Grant Consolidated Mining Company, with offices at 516 and 517 Peyton Block, Spokane. Twelve carloads of hand-sorted ore have been hauled to the railroad at Myncaster, 15 miles distant and from there shipped to the smelter. The returns ran from $22.00 to $28.00 per ton, the principal value being in copper, although two to four dollars were in gold and about the same in silver. The copper content varied from seven to nine per cent.

The workings consist of a tunnel 800 feet long and a few surface openings. The rock formations exposed on the property are the regionally metamorphosed limestones, shales and sandstones of the Paleozoic series, intruded by a quartz-bearing hornblende syenite which has caused very intense contact metamorphism, resulting in extensive zones of garnet and epidote so that certain areas have been locally called "epidote rock" and others "garnet rock." The igneous mass which caused the metamorphism is a dark bluish gray, medium grained granular rock composed chiefly of feldspar and hornblende crystals, with

biotite and quartz in very subordinate amounts. Microscopically examined the rock is seen to be largely orthoclase, hornblende, quartz, and biotite with some albite and minor accessory minerals. Many of the feldspars have been partially replaced by epidote and sericite, which are developed around the margins of the crystal and along cleavage planes.

Adjacent to the igneous mass the alteration has resulted in an extensive development of garnet (grossularite) as small, clear to light green grains, which in thin sections are of four, six or eight sides, and are scattered irregularly through the slides. Calcite, residuary from the former limestone, constitutes about 30 per cent. of most of the specimens studied. Quartz locally replaces the calcite and is also intergrown with various secondary minerals. Green epidote (pistacite) occurs as prisms and grains with irregular outlines and is nearly always intergrown with zoisite which, however, never equals it in amount. Actinolite locally makes up as much as ten per cent. of hand specimen although in general it is not conspicuous and was not found in some of the slides. It occurs as needle-like crystals clustered in more or less radiating groups. Tremolite, differing from actinolite in composition only in that it contains no iron, is developed locally in small amounts. A few automorphic crystals of titanite were noted in one of the slides. Magnetite, though absent from many parts of the contact zone, is developed in places almost to the exclusion of other minerals. Chalcopyrite and pyrite are locally developed in a manner similar to magnetite, although of less quantitative importance.

The ore bodies are irregular replacement deposits in limestone and beds of calcareous shale, and although development is not sufficiently advanced to determine the extent or peculiarities of the various bodies, yet it is quite certain that future work will encounter irregularities characteristic of such deposits. Past work has met variations similar to those which will be encountered in the future. The only mass of ore which has been worked, and the one from which the shipments before mentioned

were made, came from an irregular deposit 28 feet deep by 40 feet long, by 20 feet wide. Within the stope the ore was badly mixed with country rock in which contact metamorphic minerals prevailed. The ore body has no well defined strike or dip and the walls are poorly defined, there being frequent extensions out into the country rock from the main mass. Adjacent to the large stope were small bunches of ore usually connected with it by feeders but in places isolated. A tunnel 800 feet long cuts the normal position of the ore body on a level 400 feet lower, but in it no ore corresponding to the above was found. About 250 feet from the portal, however, a ledge of magnetite carrying about $7 in gold and silver, was encountered. In conclusion, it is probable that many other bodies of ore similar to the one which has been removed will be found on the property, but the irregularities which characterized it will probably also characterize them.

The mine has been worked for copper, although gold and silver totaling $2 to $7 per ton are said to be nearly always present and in about equal values. The ore is unaltered, and consists of chalcopyrite, magnetite and pyrite. Only in a few places were any of the secondary copper minerals noted. This being true, a zone of secondary enrichment with depth cannot be expected.

MONTEREY PROPERTY.

The Monterey group consists of six patented claims situated in the northwest quarter of section 24, township 40 north, range 30 east. Development consists of a tunnel 800 feet long and shaft 65 feet deep. The workings are located near the contact between the Paleozoic formations and the quartz-bearing hornblende syenite which intrudes them. The syenite has caused extensive contact metamorphism and the ores are irregular bodies resulting therefrom. Judged from the surface exposures this group lies to the west of the most intense contact metamorphic action, although the ore is similar to that in the Grant mine and the metals are said to be about the same. At this point the syenite itself seems to be more highly altered than at

most other places, many of the feldspars being completely replaced by epidote, while sericite and chlorite are also extensively developed.

NIP AND TUCK PROPERTY.

The Nip and Tuck property is situated in the northeast quarter of section 23, township 40 north, range 30 east. The property is owned by John N. Evans of Bolster, Washington. The country rock in immediate contact with the ore was concealed by vegetation but in a small prospect a body of ore composed almost entirely of pyrite and chalcopyrite, and over ten feet wide, with neither wall exposed, is laid bare. The ore is said to assay $32 in gold, silver and copper combined.

MYERS CREEK MINING CO.'S PROPERTY.

The Myers Creek Mining Company own two patented claims in the southeast quarter of section 23, township 40 north, range 30 east. The principal exposure of ore is near the bottom of a deep valley which cuts across the ore body. Here an ore mass about forty feet wide is enclosed in quartzite. The ore is quite uniformly bronze yellow in color and made up of fine-grained pyrite and pyrrhotite in about equal amounts, with some chalcopyrite and magnetite. As is especially true of all deposits of similar origin, however, the size of the ore body cannot be determined from a single exposure. Whether it will increase or decrease in size with depth can only be determined by exploration, but it is altogther probable that its width will not remain constant for any considerable distance.

NUMBER NINE PROPERTY.

Number Nine Claim is situated in the northwest quarter of section 24, township 40 north, range 30 east, and is another of the claims which are located in the contact metamorphic area on Buckhorn mountain. The property is near the contact between the intrusive hornblende syenite and the Paleozoic series. The contact metamorphic action has been very intense, changing the limestone and calcareous shales of the Paleozoic into great masses of intimately associated garnet, epidote, cal-

cite, quartz, actinolite, tremolite, diopside and magnetite with lesser amounts of pyrite, chalcopyrite and some little titanite.

NEUTRAL PROPERTY.

The Neutral property is situated near the center of the north line of section 24, township 40 north, range 30 east. Aside from several surface workings there is a tunnel 135 feet long, which throughout the last 100 feet of its extent is in magnetite. Associated with the magnetite is pyrite and a little chalcopyrite and pyrrhotite. The magnetite mass outcrops along the trail for 1,500 feet and more east and west from the tunnel, although in places it gives way to garnet and epidote rock. The property was prospected by the British Columbia Copper Company in the hope of securing a flux that would carry sufficient precious metal to pay mining and transportation expenses. Since assays gave values of only 80 and 85 cents in gold, the work was abandoned.

The prospects to the southeast from this location show successively more and more pyrite and chalcopyrite intermixed with the magnetite.

RAINBOW PROPERTY.

The Rainbow group consists of three claims in the northeast quarter of section 23, township 40 north, range 30 east. The development consists of three small shafts, and a tunnel about 400 feet long from which a little drifting has been done. The country rock is largely quartzite and schist, although some garnet and epidote rock, probably corresponding to an original thin layer of limestone, is present.

AZTEC PROPERTY.

The Aztec claim is situated in the northwest quarter of section 24, township 40 north, range 30 east. The property has a tunnel 80 feet long which is largely in magnetite with pyrite and chalcopyrite intermixed.

CRYSTAL BUTTE PROPERTY.

The Crystal Butte group is situated in the southeast quarter of section 35, township 40 north, range 30 east. Develop-

ment consists of four tunnels and a shaft, two of the tunnels being over 800 feet long. The ore body is a flat-lying quartz vein enclosed in schists and quartzites which are intruded by hornblende syenite. The vein proved very irregular in width and value and has never produced sufficiently to encourage the operators in further development. Contact metamorphism does not appear to be extensive on this property but a short distance east a great magnetite zone is prospected by several open cuts. A mill was built on Myers creek by the owners of the property.

APEX MINING COMPANY.

The Apex Gold Mining Company was formed on a lease from the Ben Harrison Gold and Copper Mining Company. The latter company have six claims situated about one-half mile north of Chesaw but the Apex lease covers only one of them. Development consists of a shaft and several small surface openings. The shaft follows the ore down and is 286 feet deep on an incline of 55 degrees to the south. From the bottom short drifts extend to the east and west and a cross-cut south. The vein, which is enclosed in schists and quartzites, is very variable in width, and extensively broken by slips. In places it reaches a width of about six feet. Blue gray quartz is penetrated along the joints and crevices by fine-grained iron and copper pyrite with occasional patches of galena and blende. Separate assays of the different elements in the ore have been made and indicate that the chalcopyrite carries most of the gold, although pyrite is but little less important, with lead and blende of very minor importance. When lead predominates a little silver is nearly always present. Carefully hand-sorted the ore is said to run about two ounces of gold per ton.

A mill, equipped with rolls and Frue-vanners, which is capable of handling about ten tons of ore per day, is in connection with the property.

BUTCHER BOY PROPERTY.

The Butcher Boy group comprises two claims situated in the northwest quarter of section 21, township 40 north, range

30 east. Eleven carloads of ore have been shipped from the property and the returns from these have been sufficient essentially to pay for the development, which consists of a tunnel about 400 feet long and a shaft connecting with it. The vein, which is an irregular fissure deposit varying from a stringer up to several feet in width and striking north 50 degrees west and dipping 74 degrees northeast, is enclosed in rocks of Paleozoic age. Both limestone and clastic formations are present but the predominant type is a fine-grained basic porphyry thought to be interbedded with the Paleozoic sediments. The ore is white to cream colored quartz-bearing pyrite, pyrrhotite, sphalerite and galena. The pyrite in most instances is distributed as ribbons in the quartz, although isolated cubes and aggregates of cubes were noted in a few places. Pyrrhotite is very common and in places represents the entire mineralization. Its occurrence is very similar to pyrite. Sphalerite, or blackjack, is usually present but galena is rare. Gold is chiefly in the pyrite of massive blotchlike form, although the cube form is not altogether barren. The heavy pyrite ore carries from one to five ounces in gold per ton.

MOLSON GOLD MINING CO.'S PROPERTY.

The Molson Gold Mining Company now owns the old Poland China group of claims which are situated about four miles northeast of Chesaw. Various buildings are on the property, including a mill equipped with six Nissen stamps. About 1,500 feet of development work has been done, consisting of a tunnel 436 feet long, and various shafts and cross-cuts.

The country rock is carbonaceous shale of the Paleozoic series. An analysis of this rock made by Mr. R. I. Plomert, superintendent for the company, shows the following:

SiO_2	71.00
Al_2O_3	15.60
$CaCO_3$	4.94
CaO	5.79
MgO	.65
	97.98%

The formation is badly broken by slips which, although most conspicuous in a north-south zone, run in various directions. Assays of the wall rock give returns of $.63 to $2.27 per ton in gold.

The vein runs northeast-southwest and dips 26 degrees northwest. It is very irregular, in places being some 14 feet across, while in others it pinches down to a stringer, which in many instances is offset by faulting. In places the fresh ore reaches the surface, but in others the oxidized zone extends to a depth of 18 or 20 feet. The average ore is dense blue quartz, bearing pyrite and probably some marcasite. Spots of galena occur. Gold is the metal sought although some silver is present.

The average ore of the property runs about $4.75 per ton with about one ounce silver to be added. Superintendent Plomert states that the ore can be mined and milled, according to a test made on some 300 tons, for a little less than $4.00 per ton. This estimate, however, does not allow for any dead work.

MAD RIVER MINING CO.'S PROPERTY.

The Mad River Mining Company's property consists of seven patented claims situated in sections 7 and 8, township 40 north, range 30 east. There are various open cuts and shafts on the property exposing several strong quartz veins, which in general strike 10 degrees to 20 degrees east of north. The property is along the contact between granite and Paleozoic beds. The granite is light gray in color, showing the usual association of crystals for a granite, plus some pyrite and intrudes schist, quartzite, greenstones and some limestone. In places small limestone areas have been metamorphosed but at no point noted was the action intensive or extensive.

OLENTANGY GROUP.

The Olentangy group comprises four patented claims situated in the west part of sections 8 and 17, township 40 north, range 30 east. Development consists of a shaft 160 feet deep with drifts on the 100 and 150 foot levels. The ores, which are enclosed in calcareous quartzite, occur along the brecciated zone

accompanying a fault-line which strikes north 35 degrees east and dips 55 degrees southeast. A number of stringers of quartz lie in the hanging wall parallel to the main ore body. The productive vein matter is loose breccia cemented by quartz and carrying chalcopyrite, traces of gray copper, pyrite, some arsenopyrite, blende and galena. Gold, which varies in amount from traces to high grade, is the metal sought.

DELATE CLAIM.

The Delate claim is situated in the southeast quarter of section 8, township 40 north, range 30 east. Development consists of a short tunnel with drifts to the east and west totaling about 300 feet. The ore encountered has been as limited fillings along joints and fractures instead of a true lead of commercial extent. The vein minerals noted were pyrite, galena and bornite included in a quartz-calcite gangue. The enclosing rock is massive gray to slate-black quartzite.

PART II.

GEOLOGY AND ORE DEPOSITS OF THE OROVILLE-NIGHTHAWK MINING DISTRICT.

GEOLOGY AND ORE DEPOSITS OF THE OROVILLE-NIGHTHAWK MINING DISTRICT.

INTRODUCTION.

LOCATION.

The area considered in Part II of this bulletin includes six mining districts, no one of which has been assigned definite boundaries while in some instances two or more names are locally applied to the same district. For purposes of convenience in this paper the designation "Oroville-Nighthawk" has been applied to the entire area since these are the two principal towns and by their geographic position imply more accurately than the name of an individual district the scope of the territory studied.

Oroville, a little town of 500 population situated at the south end of Lake Osoyoos, is the principal settlement in the area. Nighthawk, twelve miles west of Oroville, and Loomis, about fifteen miles southwest are both small settlements, each with a postoffice and hotel. There is a small store and postoffice at Wehesville. A branch line of the Great Northern railway extending northward and westward from Spokane, traverses the area along the valley of Similkameen river. Right-of-way has been secured for an electric road along Sinlahekin creek which, when completed, will afford ready transportation to Conconully and other points south.

FIELD WORK AND ACKNOWLEDGMENTS.

Field work occupied the interval from August 4 to August 27, 1909, the mines and principal prospects being visited and examined in such detail as time permitted and a map of the general geology prepared. Through the field season the writer was ably assisted by Mr. Olaf Stromme, most of the areal geol-

ogy being mapped by him. Mr. Stromme also assisted in the preparation of parts of the report. Courtesies extended by the many mining men in the area were too numerous to permit of individual mention.

EARLIER WORK.

The Oroville-Nighthawk district being a part of the area under consideration at the time of the survey of the international boundary, was visited and examined in a general way by geologists of both Canada and the United States. For the United States Messrs. George Otis Smith and Frank C. Calkins undertook, in 1901, a reconnaissance from Osoyoos Lake westward. Although the major portion of their work was topographic and connected with the examination of the boundary, yet considerable information on the general geology of the country traversed was accumulated and is recorded in a special bulletin of the United States Geological Survey. (*a*).

The work by the Canadian government corresponding to the above was carried out by Dr. Reginald A. Daly. Several articles have appeared as a result of his studies, both in the publications of the Geological Survey of Canada and in technical journals. The paper, however, having the most intimate bearing on the area herein considered is entitled "The Okanogan Composite Batholith of the Cascade Mountain System," in which Mr. Daly discusses in great detail the composition and relations of the intrusive masses of the area. (*b*)

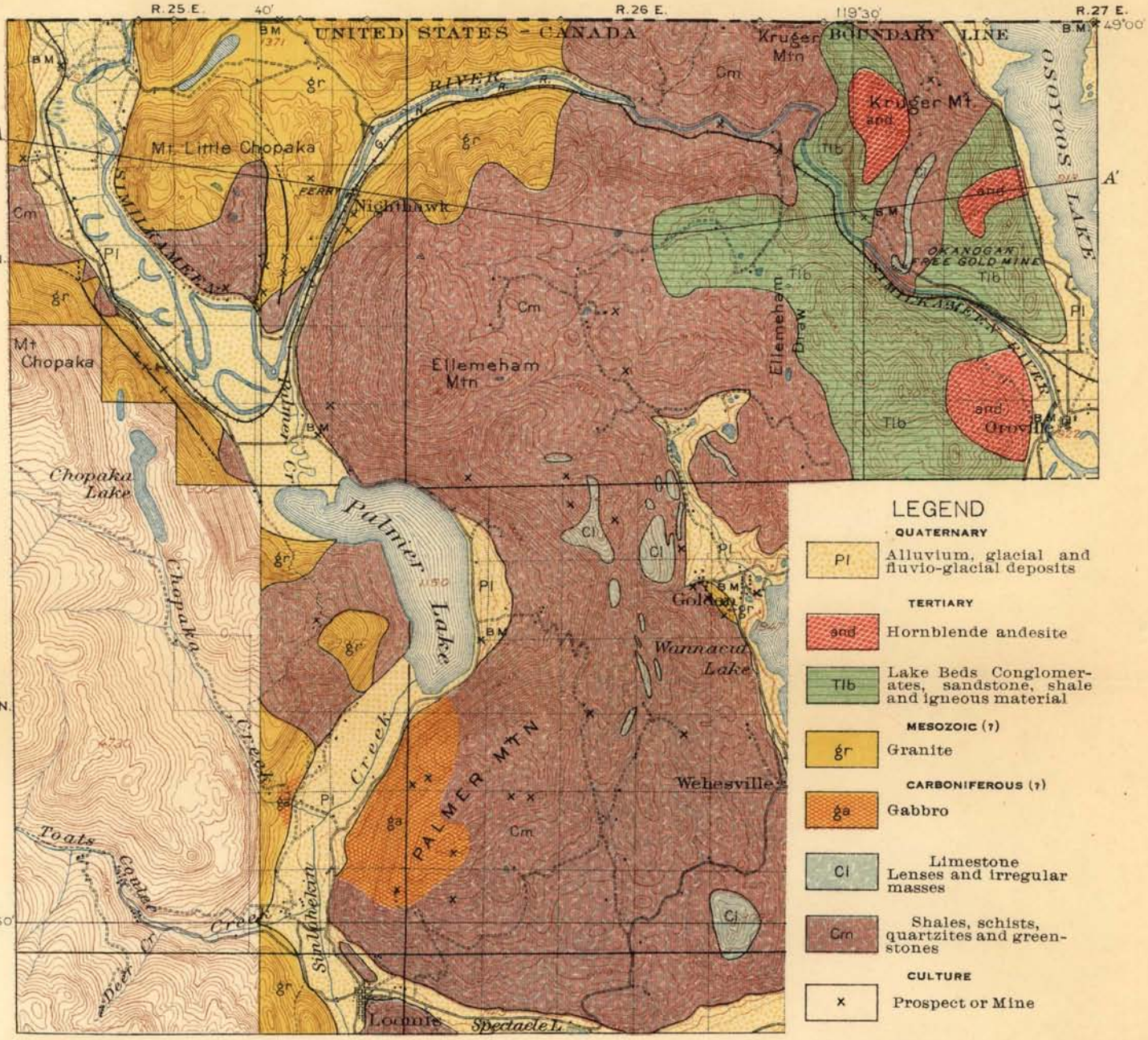
Mr. Baily Willis passed through the district in 1887, making many notes on the physiographic features. (*c*)

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

(*a*) Smith, G. O., and Calkins, F. C., A geological reconnaissance across the Cascade range near the forty-ninth parallel. Bull. U. S. Geol. Survey No. 235, 1904.

(*b*) Bull. G. S. A., Vol. 17, 1906, pp. 329-376.

(*c*) Willis, Bailey, Changes in river courses in Washington territory due to glaciation. Bull. U. S. Geol. Survey No. 40, 1887.



Topography by United States Geological Survey Surveyed in 1902-3

Geology by J. B. Umpleby and Olaf Stromme Washington Geological Survey Surveyed in 1909

GEOLOGIC MAP OF OROVILLE-NIGHTHAWK DISTRICT

BY JOSEPH B UMPLEBY

ASSISTED IN THE FIELD BY OLAF STROMME

Scale

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 100 feet.

Datum is mean sea level.

SECTION ALONG *A-A'*

CHAPTER I.

PHYSIOGRAPHY.

GENERAL STATEMENTS.

The Oroville-Nighthawk district is situated in Okanogan county, and comprises the northeast part of the Chopaka and the northwest part of the Osoyoos quadrangles, as mapped by the United States Geological Survey. It is from six to thirteen miles in length by seven to fifteen miles in width, the international boundary forming its northern border.

The area mapped is embraced in that physiographic division of the state known as the Okanogan highlands and is characterized by deeply dissected land forms. Elevations range from 922 feet above sea level at Oroville, to 7,829 feet at the summit of Mt. Chopaka, although 3,500 to 4,000 is about the average altitude; with the larger inter-mountain valleys varying in depth from 2,000 to 2,800 feet. The sharpest transition from lowland to highland within the area is that from the floor of Similkameen valley to the south summit of Mt. Chopaka, where there is a rise of about 6,200 feet in a horizontal distance of two and one-third miles. Such slopes, however, are rare in the area, the rounded forms predominating. In general the district is a rolling upland rather deeply gashed by the valleys which drain it.

Prominent valleys divide the district into several distinct divisions chief of which are the Mt. Chopaka division, the Mt. Elemeham-Palmer Mountain division, and the Mt. Little Chopaka-Kruger Mountain division. The presence of these mountain areas in contrast to the intermontane valleys, seems to be due largely to stream courses which antedate the present topographic cycle rather than to differences in rock resistance or to structure. Roughly, the Okanogan valley forms the eastern boundary of the area, the Similkameen the northern boundary, the valley of Sinlahekin creek and of the Similkameen the west-

ern boundary, and Spectacle lake valley the southern boundary. The most interesting one of these is that along the western side of the area. This valley, although occupied in one part by a river, in another by a lake and in a third by a small creek flowing in a direction opposite to that of the river, is of almost constant width and about uniform depth. It continues south for many miles but within the area studied are two cross depressions of much less striking characteristics, which connect it with Okanogan valley to the east. One of these is at Loomis and the other along the course now occupied by the Similkameen river east of Nighthawk. The east-west depression joining the main valley at Loomis has a flat from one-fourth to one-half mile wide, giving way by gentle slopes and comparatively low cliffs to the higher country north and south. Spectacle lake, a narrow body of water two and one-half miles long, occupies the valley about half way betwen Loomis and the Okanogan river. The valley extending east from Nighthawk is steeper and more gorge-like in the east two-thirds of its extent than the one just described, but in the section near Nighthawk there is a narrow flat on each side of the river and the stream is sluggish.

Mr. Bailey Willis made a reconnaissance through the area in the later eighties and in the resulting publication* suggests that the Similkameen river formerly flowed south through the large valley first described, joining the Columbia at some point south of Conconully. In the Pleistocene period a great stream of ice occupied the valley, and deposited vast quantites of materal upon its floor. During the general ice recession there were several places where the waters from the glacier found lower outlets to the east than over the glacial debris to the south. Spectacle lake is thought to be one of these outlets and it is probable that it carried the waters from the ice front after it had retreated to a point above Loomis, and until it stood in the vicinity of the Canadian boundary, when it became possible for the stream to take its present course to the north. The

*Willis, Bailey, United States Geological Survey, Bulletin No. 40, 1887.

general topographic relations suggest that the present course of the river east of Nighthawk is due to piracy in post-glacial time by a stream working headward from near Oroville, but this is considered improbable as fine terraces of stratified drift occur at various places in the valley near the level of the river. Since the section of this valley near Nighthawk is broad and open, with a sluggish stream, while that part near Oroville is narrow and carries rapidly moving waters, the most feasible explanation of the relation seems to be that, in pre-glacial times, this valley was occupied in its eastern part by a tributary of the Okanogan and in its western by one of the Similkameen, the intervening divide being low. After the ice front had retreated to some point to the north, the waters escaped eastward over the divide due to the damming of the main valley to the south and the course has been held since that time.

Within the area mapped evidences of glaciations were seen at all altitudes visited. Striations, even when on the east and west slopes of the mountains* have a north south direction. This nullifies the possibility of local centers of radiation on the higher areas, and leaves no room for doubt that the ice which covered the area was the southward extension of the Cordilleran ice sheet which radiated from the highlands of British Columbia.

The soils of the valley floors are alluvial, while those of the terraces and benches bordering the valleys are glacial and in some cases partly alluvial. The valleys are all treeless in their natural condition, the vegetation consisting of sagebrush and greasewood, largely the former.

The area covered by this report is rather sparsely settled, and the inhabitants are engaged in agriculture, horticulture, stock raising and mining. The valleys require irrigation, as the rainfall is light, but when watered the soil will produce in great abundance any crop grown in the temperate zone; particularly apples, pears, small fruits and vegetables. Horticulture is in its infancy, however, and very little land is now under irriga-

*Mt. Elemeham, west slope at elevation of 4,600 feet shows small area of bedrock with striations running north 11 degrees west.

tion. There are a few places which are irrigated from creeks and in a few cases pumping plants have been installed, but no large irrigation canals have been attempted. On the uplands, up to an elevation of 3,000 feet or more, wheat, oats, and the hardier vegetables are successfully grown and yield abundantly, without irrigation. The bunch grass land of the higher altitudes is well adapted to grazing and there is still some open range, but owing to the altitude, the season is too short and the nights too cold for successful raising of crops.

The mining industry furnishes employment to a considerable number of men during much of the year, more in the carrying on of development and assessment work, than in the mining of ore.

Lack of adequate transportation facilities has been one of the chief drawbacks to the development of the area. Oroville, the principal town, is situated on a branch line of the Great Northern railway, as is Nighthawk, one of the smaller towns. Loomis, in the southwest part of the area, is reached by stage from Nighthawk or Conconully. The Oroville branch of the Great Northern railway follows the Similkameen valley from Oroville to Nighthawk, and then extends northerly up the valley into British Columbia. The area has a fair system of wagon roads, the principal ones following the valleys and having easy grades.

On the Similkameen river, about three miles northwest of Oroville there is a hydro-electric plant where approximately 600-horse-power is developed from a natural fall in the river, only a small portion of which is diverted. The current is transmitted to Oroville, and to the more important mines of the district. It is safe to say that less than ten per cent. of the power available on the Similkameen in Okanogan county has been developed, and it would seem that with an ample supply of water, such as exists in the Similkameen and Okanogan rivers and in Osoyoos and Palmer lakes, there ought to be an excellent opportunity for supplying cheap electric power for pumping water onto the bench lands.

It is probable that all the physiographic features of the area are post-Eocene and perhaps post-Miocene and had reached the stage of maturity which is characterized by approximately equal areas in upland and lowland flats, in other words, by a maximum of slope, before glacial times. The ridges were narrow, the slopes steep and the valleys deeply carved and "V-shaped." In the Pleistocene the cycle was interrupted by deposition of a mantle of drift on the uplands, the partial filling of the valleys with glacial material and resulant choking of the drainage system. Many closed basins were formed and in some of them lakes exist throughout the year. As would be expected in an area of heavily mineralized and heterogeneous rocks, these lakes being without outlet, and therefore subject to a constant concentration of impurities in the water by evaporation, contain a high percentage of mineral matter. The precipitates from some of them have been exploited recently but with what success is not known.

CORRELATION OF EROSION PERIODS.

The area herein described does not have that general accordance of summit levels which is very evident from a point of vantage in most parts of the Okanogan country. If its topographic cycle is to be defined, recourse must be made to records in adjoining regions. But there, as will be seen beyond, difficulties are encountered due to difference in age of the erosion surface known to the west and southwest and that occurring to the north and east.

G. M. Dawson* recognizes a peneplain in the interior plateau of Canada, remnants of which stand at elevations of from 4,000 to 6,000 feet above sea level, in the southern half of the interior plateau of today. The evidence for the Eocene age of this surface is the presence of Miocene beds in great valleys developed in it and the broad fact that extensive Eocene deposits are found in adjoining physiographic areas to the south while none are found here, which seems to imply that the area was land during the Eocene period.

*Dawson, G. M., Trans. Royal Society of Canada, 1890, p. 11.

In the Republic area (*a*) to the east an erosion surface was recognized and on the strength of fossiliferous beds so related as to be fairly conclusive, was assigned to the Eocene.

South of the area herein mapped, however, Bailey Willis (*b*) found that the oldest erosion surface recorded, the Methow stage, is cut on all rocks of the region including "the bedded basalt flows and the pumiceous clastics of the Ellensburg formation, which is known definitely to be of the Miocene age."

It appears therefore, that the old physiographic surface to the north is Eocene while that to the south is post-Miocene.

In a reconnaissance across the Cascade mountains along the forty-ninth parallel, Smith and Calkins (*c*), recognize this relation, for in referring to the physiographic differentiation of the Cascade mountains they write in part as follows:

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

Within the area represented by the present map the former erosion surface has been so destroyed that it is of little value for purposes of age determinations. All the older rocks, including the Similkameen batholith at least in its eastern part, have been beveled by it. Lake beds found west of Oroville and evidently occupying a post-peneplain depression, did not yield fossils, but in their lithologic characteristics and the association of andesite flows with them, they resemble very strongly the Miocene beds at Republic. These facts, together with the known occurrences of Miocene lake beds in British Columbia, suggests that this part of the area belongs to that physiographic unit known as the interior plateau of British Columbia;

(*a*) Umpleby, J. B., Washington Geological Survey, Bul. No. 1, pp. 19-20, 1910.

(*b*) Smith, G. O., and Willis, Bailey, U. S. Geol. Survey, PP. 19, pp. 17-71.

(*c*) Smith, G. O., and Calkins, F. C., U. S. Geol. Survey, Bul. 235, p. 90, 1904.

and if so, was peneplained in the Eocene period. Mt. Chopaka in point of elevation seems to correspond better with the post-Miocene surface to the west and may belong to the Cascade unit. If this relation is true the line of union of the Eocene and post-Miocene erosion surfaces will probably be found, within the present area, to approximately follow the Similkameen-Sinlahekin depression.

CHAPTER II.

GENERAL GEOLOGY.

BRIEF STATEMENT OF GEOLOGIC HISTORY.

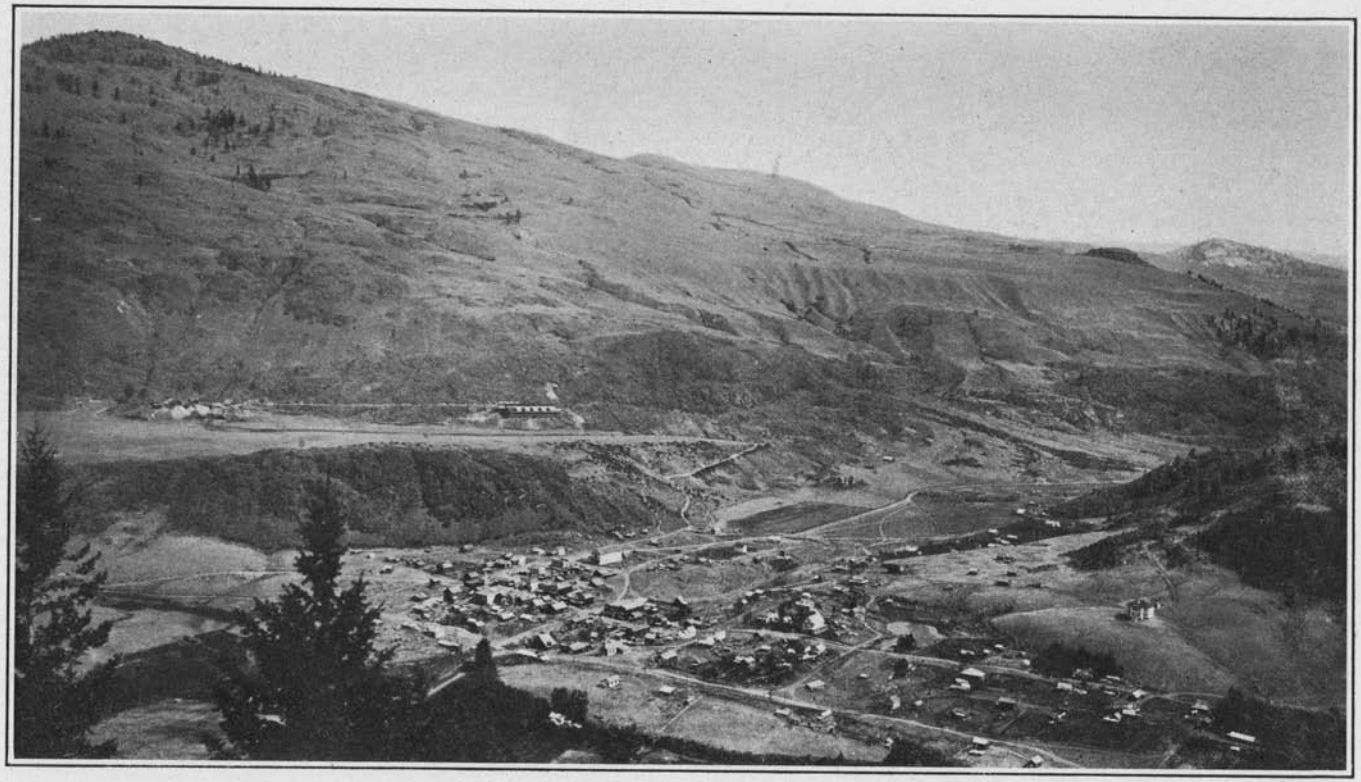
The broader features of the gologic history of the Oroville-Nighthawk area include sedimentation accompanied by igneous activity in the Paleozoic, with regional movements and resulting metamorphism about its close; erosion, and great batholithic intrusions, in the Mesozoic; planation in the early Tertiary, followed by elevation and erosion, the accumulation of lake beds and lava flows; and erosion and continental glaciation in the Quaternary.

The oldest rocks exposed in the area are the metamorphic equivalents of shales, sandstones, limestones and intrusive and extrusive basic igneous rocks, all of which appear to have been subjected to the same period of structural movements and regional metamorphism. On lithologic grounds this series is tentatively correlated with the Cache creek series of British Columbia which is Carboniferous. Intruded into these older rocks is a great granite batholith which, since it does not show evidences of diastrophic movements is thought to be of Mesozoic or early Tertiary age. Early in the Tertiary it is probable that the area was reduced to near base level, then elevated and extensively cut by erosion, lakebeds accumulating in some of the resulting valleys. Following the lakebeds and in part contemporaneous with them were local eruptions of andesite. In the Pleistocene a southward extension of the Cordilleran ice sheet covered the entire area, leaving a heavy mantle of glacial drift and profoundly influencing the drainage system.

PALEOZOIC SERIES.

Distribution.

A great series of rocks which has been assigned to the Paleozoic is widely distributed in the south and central part of the area and extends in a narrower belt west to Mt. Chopaka and



Loomis, from the southwest. Palmer Mountain in background and to left. Spectacle Lake and Valley extending to the right.

north to the international boundary, while west of Lake Osoyoos are three more or less isolated areas of the same formation.

Characteristics.

The series as a whole is notably but not intensely metamorphosed. Distinct bedding is seldom seen although foliated schists, quartzites presenting complete recrystallization, and even marble are rare and were not noted save in the vicinity of intrusive masses. On the other hand slaty cleavage and jointing are common. Intimately associated with this series are basic lavas, pyroclastics and intrusions.

The various types of rock present in the series were not differentiated on the map since to do so would have required far more time than could be given to the reconnaissance. The limestone areas are fairly conspicuous in the field and were sketched in order that the structural relations might the better be portrayed by the map.

Broadly speaking the series consists of three divisions, which beginning with the oldest are: (1) dark gray to greenish black thinly laminated clay slates and siliceous schists with occasional quartzite bands; (2) blue limestone with interstratified clay slates and siliceous beds; (3) siliceous and argillaceous beds with a great deal of interbedded igneous material.

The lower part of the series is exposed best in the central part of the area, Mt. Ellemeham being perhaps its type locality. The rocks as here found are dark gray, reddish brown and occasionally green siliceous schists and mica bearing clay slates. They are thinly bedded and very fine-grained. The beds are extensively jointed and in a few places slaty cleavage is more pronounced than the bedding. They strike north-south and dip 40 degrees to 50 degrees west. The thickness of this portion of the series is not known but it is by far the most important division and gives the impression that its thickness must be thought of in thousands rather than hundreds of feet.

The middle division of the series outcrops between Kruger

mountain and Osoyoos lake and from there the surface exposure swings southwest, having an extensive development a short distance west of Golden, whence it extends southeastward beyond the limits of the area mapped. The division consists of irregular lenses of blue limestones included in clay and siliceous beds which, save that they are more massive and in places finely conglomeratic, are not very different from those of the underlying division. The limestone weathers to a light gray which is in sharp contrast to the dark shades of the enclosing schists and slates, causing areas of it to stand as striking features in a general survey of the landscape. Closely examined, the rock is seen to be fine-grained, extensively crushed and locally partially converted into marble. In many places the bedding planes are still intact so that dip and strike can be measured easily. Usually the contact of the limestone with the enclosing schist is sharp but in places perfect gradation between the two occurs.

A remarkable characteristic in the limestone areas of this region is their irregularity in shape and the manner in which they pinch out along the strike. In general they are roughly lenticular but no general ratio exists between their areal extent and their thickness. There are two general horizons of these limestone lenses, separated by 200 feet to 400 feet of clay slate. In the upper horizon the lenses appear to be more numerous and it was here that the maximum thickness, 200 to 300 feet, was measured.

Time did not permit a careful study of the limestone beds but certain facts were noted which seem to have a bearing on their origin. There are apparently three ways in which they may have assumed their present peculiarities: (1) by the crushing together of more widely distributed beds; (2) by faulting; (3) by reason of special conditions of deposition. Considering the three alternatives in the order above named, it appears that the general preservation of bedding planes within the limestone refutes the first. Concerning the second, faults sufficient to account for the relations were not noted in the field

and indeed would not be expected since they would be out of harmony with the general structure of the region. By elimination therefore, it is suggested that the limestone areas may be due to special conditions of deposition such that the lenses now have essentially their original outline and geographic distribution.

The upper division of the Paleozoic series which contains large quantities of volcanic material is extensively developed on the south end of Palmer mountain, on the hill southwest of Palmer lake, and in the general area east of Loomis. Although the igneous material is far more conspicuous than the sedimentary in this part of the series, yet considerable beds of sediments are present, as can be seen in a traverse from Loomis up over the mountain to the vicinity of Ivanhoe mine. Along this course several areas of dark greenish black slate appear and are in contrast to the rusty black basaltic material. In places the two are scarcely distinguishable and close examination suggests that the rock is made up both of small angular pyroclastic fragments and sedimentary material.

The most striking exposures of these old volcanic beds is in the south wall of the valley which extends east from Loomis. Here, when seen from a distance, the beds have every appearance of basaltic flows, rough columnar jointing, and massive forms being very pronounced. Closer examination reveals a fine-grained rock, in places having scattered phenocrysts in a dull lustered ground mass; in others a decided brecciated appearance; and yet again being a mass of small angular volcanic fragments roughly intermingled with sedimentary detritus. Microscopic study of the specimens gathered is unsatisfactory in that alteration has universally progressed so far that the minerals essential in classification cannot be definitely determined. The few feldspar crystals which are sufficiently fresh for identification have about the composition of andesine. Outlines of some pyroxene mineral are usually present, as is also hornblende, magnetite, and a little quartz. From the few feldspars which were determinable together with the pyroxene and

magnetite, it seems that the rock is a basic andesite, although the general texture is that of basalt.

In part the brecciated character of the formation in many exposures may indicate pyroclastic origin but it might also be due to the sudden cooling of lava poured out beneath water and since the sedimentary part of the series was very clearly deposited in water, the latter view seems more probable.

Age.

Fossils were not found in the area but the general lithologic make-up of the series corresponds very closely to the Cache creek series which Dawson has described and which has yielded fossils of Carboniferous age. (*a*).

GABBRO OF PALMER MOUNTAIN.

An area of greenish black granular rock comprises the southwest slope of Palmer mountain and extends across Sinlahekin creek valley and a short distance up on the west wall. The boundaries of the area are difficult to trace since in many places the contact is with the basic lavas of the Paleozoic series, which are closely related in composition and general appearance. Indeed it has been suggested that this may be one of the centers from which the lavas poured. (*b*)

The rock has a marked ophitic structure and is made up essentially of feldspar and hornblende. The feldspar seems to correspond to a basic andesine in composition. A little quartz is usually present and frequently encloses minute needles of hornblende. Outlines and occasional remnants of some monoclinic pyroxene appear in specimens from near the summit of Palmer mountain. Olivine was not noted. Calcite, biotite, zoisite and green epidote as well as much of the hornblende, are secondary.

(*a*) Ann. Rept. Geol. Survey, Canada, new ser., vol. 7, 1894, pp. 37B-49B.

(*b*) Smith, G. O., and Calkins, F. C., A geological reconnaissance across the Cascade range near the forty-ninth parallel. Bull. U. S. Geol. Survey, No. 235, 1904, pp. 46-47.

SIMILKAMEEN GRANITE.

Distribution.

The Similkameen granite, so designated by Daly (*a*) occupies the northwest part of the area mapped. It is deeply trenched by Similkameen river from a point five miles below Nighthawk westward to the international boundary. South from Chopaka mountain the granite appears at intervals along the entire western limit of the area mapped. A noteworthy occurrence of the same or very similar rock is as small patches near Golden and between that place and the main granite area to the north.

Characteristics.

The Similkameen batholith (*b*) is composed of medium to coarse grained light gray granite. It varies in composition from place to place, biotite and hornblende being the chief variables, the former nearly always present but in different amounts, while the latter is frequently almost absent. Marginal variations are pronounced, quartz decreasing very markedly in amount while the ferromagnesian constituents become much more abundant. This marginal basification is so pronounced north of Loomis that specimens from near the contact would readily be classed as diorite save for the absolute gradation into the normal granite. Texturally the granite varies from equigranular to strongly inequigranular, while in places, as near Golden, the orthoclase has a strikingly phenocrystic development.

Microscopic examination shows that the average specimen consists of the following essential minerals decreasingly important in the order named: oligoclase, microperthite, quartz, orthoclase, biotite, microcline and hornblende. Magnetite, beautifully developed titanite, apatite, and occasionally zircon are accessory.

(*a*) Daly, Reginald A. The Okanogan Composite Batholith of the Cascade Mountain System, Bull. G. S. A., Vol. 17, 1906, p. 234.

(*b*) This granite is described by Daly, op. cit. pp. 452 to 454; and by Smith and Calkins, op. cit. pp. 32-33.

Age.

The age of this granite batholith is uncertain since there is no sedimentary record from the close of the Paleozoic until well on in the Tertiary. Daly (*a*) notes the lack of schistosity in the granite and takes this to mean that the intrusion post-dates the orogenic movements which Dawson recognizes throughout the Canadian Cordilleran and assigns to the close of the Laramie period. (*b*) Thus Daly believes the intrusion to be early Tertiary. In this connection it is perhaps significant that extensive faulting within the granite and which seems to be of the reverse type, occurs along the east face of Chopaka mountain while normal faulting appears in the area just west of Nighthawk.

On the other hand there is considerable reason for thinking that the area was peneplained in Eocene times, meaning thereby that comparatively static conditions then prevailed. Since, therefore, the granite was beveled by Eocene erosion, as discussed in the chapter on physiography, if it be assigned to the Tertiary it must be assumed that it was intruded during a period of diastrophic inactivity.

In view of these general considerations and since the faulting above referred to may be a local expression of the movements which closed the Laramie period it seems very possible that the granite is of pre-Tertiary age, preferably late Cretaceous.

TERTIARY ROCKS.

LAKE BEDS.

Extent.

Lake beds occupy an irregular area of about fifteen square miles lying north and west of Oroville. The general outline of the deposit is very irregular, due both to the encroachment of younger lavas and to the relation of the older metamorphics, a pronounced arm of which extends southward from east of Kruger mountain into the general area of lake deposits. From other known areas beyond the limits of the district mapped it is

(*a*) Op. cit. pp. 360-361.
(*b*) Bull. Geol., Soc. Am., Vol. 12, 1901, p. 87.

known that the formation is confined to a north-south zone, never over a few miles in width.

Description.

The Tertiary beds have suffered considerable deformation, in places presenting dips as high as 30 degrees. The strike is usually north-south in the northern part of the area and more nearly east-west in the southern, being directions of dip such as would correspond to an irregular anticline-syncline structure.

The beds are well exposed in the valley of Similkameen river where their unequal resistance to erosion gives steep bluffs along the valley sides and low falls and rapids in the river. In the bluffs sandstones and coarse and fine conglomerates are exposed, much of the latter being very angular and composed of fragments of metamorphic material and granite similar to the basement series of the region. The beds in the western extension of the area are largely composd of granite blocks with arkose filling the interstices, while the southern extension mostly presents detritus derived from the metamorphic series. In nearly all localities examined tuffaceous andesitic material was noted. This general composition suggests a very local derivation of the material, that in the west extension coming primarily from the adjacent granite, while to the south the metamorphic series was the chief source of supply. The andesite tuff was probably in part deposited directly in the lake and in part washed into it from the surrounding country.

The thickness of the formation could not be satisfactorily measured in any of the exposures visited but it will likely not be far amiss to think of it as 500 feet.

Age.

Fossils were not found in these beds but their lithologic character and topographic relations closely resemble the Tertiary deposits at Republic, (*a*) 45 or 50 miles farther east, which are placed as Miocene on the strength of fossil evidence. (*a*) The points of analogy are that both deposits contain much an-

(*a*) Umpleby, J. B., Geology and ore deposite of Republic District, Washington. Wash. Geol. Survey, Bull. 1, 1909, pp. 24-25.

desitic tuff and both are followed by andesite flows. Furthermore, beds of Miocene age have been reported from many of the larger valleys of British Columbia (*a*) while beds of Eocene age are absent and Pliocene lakes if reported are unknown to the present writer.

Since Miocene lake deposits are known at various places in the boundary country, while beds assigned to other divisions of the Tertiary are not common, if occurring at all, and since the analogy with the Republic deposits is so close, it would seem reasonable, even in the absence of fossils, to consider the lake beds at Oroville as Miocene.

ANDESITE.

Distribution.

Three areas of andesite occur in the Oroville-Nighthawk district. The largest comprises about one and one-half square miles and is plastered against the steep slope west of Oroville. The next in importance forms the capping of Kruger mountain, while the third appears in the valley wall west of Lake Osoyoos.

Characteristics.

The andesite is dark gray with phenocrysts of hornblende and feldspar rather closely spaced in a dense groundmass. The microscope shows the groundmass to be imperfectly crystalline and imbedded in it are crystals of andesine, hornblende, and a little oligoclase. Magnetite is accessory.

The flows rest unconformably on the lake beds but the amount of erosion which occurred between them is not important in comparison with post-andesite erosion. This probably means that the andesite eruption followed rather closely the formation of the lake beds.

QUATERNARY HISTORY.

Glacial drift appears at all altitudes within the area and in many places grooved and polished bedrock may be found. The striations in general indicate that the ice advanced from

(*a*) Dawson, G. M., Trans. Royal Soc. of Canada, 1890, p. 12 *et al.*

fault plane dipping west, granite on the east is in juxtaposition with metamorphosed sediments on the west. (*a*)

The great granite mass so prominent in the geologic history of the area does not seem to have had a pronounced influence on the structure of the rocks it entered. Faulting probably preceded it but those which are mapped affect the granite and hence are later. The lakebeds overlying all other formations, save the andesite, are folded to some extent but so far as noted are not faulted.

(*a*) Further notes on this fault appear in connection with the Little Chopaka group of mining claims.

about five degrees west of north. This direction of motion is clearly recorded on both the east and west slopes of Ellemeham mountain near its summit, thus obviating the possibility of local centers of radiation and leaving little room for doubt that the area was covered by a southward extension of the Cordilleran ice sheet. Further evidence of continental glaciation is the rounded and smoothed contour of the north-south valleys while the east-west ones are rough in outline and nearly always present a very heavy and hummocky accumulation on the north wall while that on the south is much less pronounced.

The influence which glaciation has had on the general drainage of the area is considered in the chapter on physiography.

The general structure of the Cascade mountains at the forty-ninth parallel has been described as a synclinorium (*a*) and the present area may well be considered a segment of this broad structural feature. The general strike of the formations are north-south, varying rather more to west of north than otherwise. An east-west section therefore, such as the one which accompanies the geologic map, gives in its broader features the structure of the area. Several small anticlines and synclines appear but they are seldom tightly compressed, dips of about 45 degrees being the rule.

Faulting is shown in the section but it is thought that it is far more prevalent than is suggested by the map. A pronounced fault follows the east face of Chopaka mountain and dips west at 45 degrees. It seems that the west side of the fault moved up relative to the east, both by reason of the steep scarp-like mountain face which lies immediately west of the fault and because the sedimentary cap still covers the granite in places on the east while it has long been removed from the area to the west. Another reverse fault was noted north of Oroville and is described in the notes on the Golden Chariot property. Normal faulting was noted on Little Chopaka mountain where, with a

(*a*) Smith and Calkins op. cit., p. 84.

CHAPTER III.

ECONOMIC GEOLOGY.

LOCATION AND CONDITIONS.

The Oroville-Nighthawk area includes six or seven mining districts situated in northern Okanogan county. As is generally true in this region, none of the districts are organized. The accompanying map includes a general area over which exploration has been more or less uniformly pursued and which is rather definitely separated from adjoining territory where mineral deposits have not been reported.

The district presents rough and mountainous features in the western part, while in the central and eastern portions bold, rounded hills and mountains, are the characteristic forms. The inter-montane valleys are deep and in much of their extent, steep-sided. Although the streams usually have very low gradients, yet in places, notably on the Similkameen river a few miles above Oroville, rapids and low falls afford abundant water-power to supply the entire district with electricity for all purposes which are at all likely to develop.

Scattered timber occurs on most of the area, while a few miles back in the mountains to the west, abundant supplies are available. Roads follow all the larger valleys and extend into some of the upland country, while the topography is such that others can be built at comparatively low cost to most points in the area if need for them exists. Communication with the outside is afforded by a branch line of the Great Northern railway which enters the district at Oroville and thence follows the course of the Similkameen river to a point in British Columbia.

HISTORY AND PRODUCTION.

The district is one of those which attracted the prospector during the period when placer excitement was waning in California and searchers for gold were reaching out into other parts of the west. As far back as 1859 placers were worked on Simil-

kameen river. Quartz lodes were recognized at that time but no known locations were made. Shortly thereafter the territory was set apart as an Indian reservation and the land withdrawn from mineral entry. Upon being reopened in the late nineties numerous locations were made and extensive promoting schemes inaugurated. Many of these early companies have had disastrous histories. Some were obviously born of ignorance and fostered by deceit, while others simply assumed the chances of legitimate prospecting and for one reason or another, lost. Many of the properties had excellent ore in the oxidized zone, which is very shallow throughout the area, but were unable to handle the lower grade pyritic material encountered below. Again, in many instances, the veins did not extend to the lower levels reached by long and expensive tunnels.

The actual total production of the district is not known, but it is probable that it does not exceed $1,000,000. This figure allows about $500,000 for the placers on Similkameen river, which cannot be verified. About $150,000 is ascribed to the Pinacle mine, while the remainder is from various properties, chief of which are the Black Bear, Triune and Golden Zone. The area has been primarily a gold district, although some silver and very minor amounts of the base metals are included in its production. It is possible that in the future this order will be reversed.

GEOLOGIC RELATIONS.

Broadly speaking the rocks of the area constitute a great series of metamorphosed shales, quartzites, basic lavas and tuffs, all of which have been cut in late Mesozoic or early Tertiary times, by a great batholith of soda-rich granite. Later, lake deposits accumulated and after them andesite flows spread over the eastern part of the district.

The ore deposits cut the granite but are presumably earlier than the lake beds, since in no place are they included in them.

ORE DEPOSITS.

The ore deposits fall into two general classes: (1) those in which the metallic mineral or minerals are rather evenly dis-

tributed through the rock formations, or disseminated deposits, and (2) vein deposits.

DISSEMINATED COPPER DEPOSITS.

Distribution.

Disseminated copper deposits are known a few miles west of Oroville. Development is not extensive, consisting of a few diamond drill bores and small open cuts. The principal property is known as the Kelsey group.

Characteristics.

Within the mineralized ground which comprises an ill-defined area of several hundred acres, copper stains appear on nearly every bluff and in some instances can be seen very clearly from a distance. The malachite and azurite, however, are very superficial so that within a few inches of the surface they give way to the chalcopyrite from which they are derived. This primary mineral occurs as fine grains scattered irregularly through the various rocks and as films along joints and fractures. Yet again, it is included in small quartz veinlets which cut the formations. In places rather strong quartz veins appear, as on the Golden Chariot claim, but these are not the rule.

The rocks impregnated are metamorphosed shales, quartzites and basic volcanic material. All are mineralized but perhaps the shales to a greater extent than the others.

An important feature in connection with the deposits is the occurrence of the primary minerals, chalcopyrite and pyrite, within a few inches of the surface, even where the surface alteration appears to be most intense. This relation clearly indicates that if the deposits are ever worked it will be for primary sulphide ore. A secondary zone of chalcocite enrichment, such as constitutes the ore body at Bingham, Ray and other camps of the southwest, cannot reasonably be expected here.

Just what the rock will assay on an average working basis is not known. A few diamond drill bores have been put down on the Kelsey group, but these are not in sufficient number to prove or disprove a workable body of ore.

Genesis.

The genesis of these disseminated deposits is obscure. The presence of occasional veinlets and stringers which cut the formations indicates that, in their present form at least, they are younger than the formations enclosing them, and since they disappear beneath the lake beds, they are pre-lacustrine. It appears therefore that they are to be assigned to some part of that great lapse of time to which the intrusion of the Similkameen batholith dates. Since such a deposit seems to necessitate very intense conditions whereby mineral-bearing solutions not only followed joints and fractures, but penetrated to the more impervious portions between them, a genetic relation between the great granite magma and the ore deposition strongly suggests itself. If such a relation is true it yet remains to determine whether the magma supplied the metals, or simply made possible their concentration (by heating the ground water and supplying it with solvents) from a more disseminated state in the older rocks. Evidence on this point was not sufficiently definite to be of value.

VEIN DEPOSITS.

Distribution.

Veins are widely distributed in the area but are specially developed around Nighthawk, Golden and on Palmer mountain. Those at Nighthawk strike predominantly north-south and dip west, while in the other locations no regularity in strike and dip was recognized. The strike of the several veins measured in the entire area have been plotted in a circular diagram (Fig. 3) which brings out a slight predominance of north-south directions, but were a half-dozen veins in the northwest corner of the area not considered the distribution would be remarkably regular throughout the 360 degrees.

Metals Represented.

Gold, silver and copper are the chief metals derived from the veins although lead and a little zinc are very commonly present. In the past gold has been the chief product but present develop-

first are usually more regular in outline than the second. The Triune mine illustrates the former class, while the Copper World Extension belongs to the second.

Again, the veins of the district might be classed according to whether or not they occur along a fault of considerable throw. Many of the north-south lodes near Nighthawk are along faults, some of which probably have throws of several hundred feet. The deposits near Golden and on Palmer mountain nearly all show slickensides and groovings but in these there is no evidence of appreciable displacements.

It would further be possible to class the veins according to the chief minerals for which they are worked if the percentage of different constituents from various parts of the area were known better.

In general the vein matter is coarse, crystalline quartz with metallic minerals distributed as small aggregates, which in places are zonally arranged and in others more or less completely isolated. Within the same vein the kind of minerals frequently varies from place to place. Pyrite is nearly always present where any mineralization has occurred. Chalcopyrite usually accompanies it, as does also galena and occasionally zinc blende. Gold occurs free, and also included in pyrite, chalcopyrite and galena (see description of Hiawatha mine). Silver is principally as argentiferous galena, proustite, pyrargyrite, stephanite, argentite, and cerargyrite.

Depth to Which Veins Extend.

Any attempt to suggest the depth to which the veins extend in an area so little known, must be very vague, but there have been so many disappointments in this district, where long tunnels have been driven to intersect a vein far below its outcrop, that those relations which have a bearing should be pointed out. The Similkameen and its tributary valleys exist as deep, opencuts through the area. Glaciation has so worn and polished them that in many places the sides are almost free from detritus and afford excellent sections of many of the veins.

ment strongly suggests that silver and copper may soon vie for first place.

Types of Veins.

Two distinct types of veins occur within the area, but since all gradations between them were noted, it does not seem wise

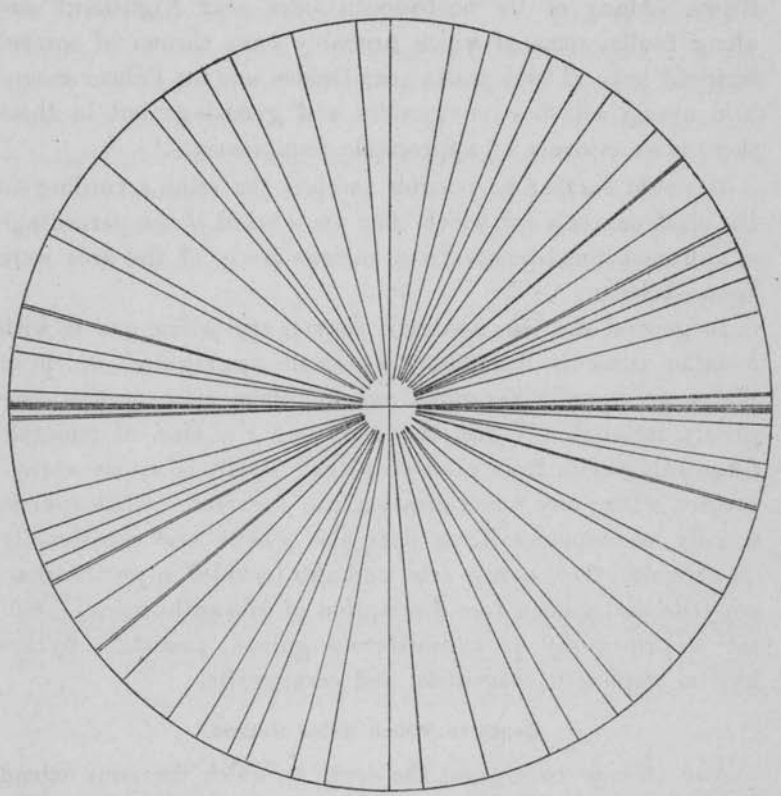


FIG. 3.—Graphic illustration of strike of the veins in the Oroville-Nighthawk District.

to treat them separately. The two types are tabular in form and both are properly to be classed as veins. In one the transition from vein matter to wall rock is sharp, while in the other it is so gradual that within the limits of perhaps a foot or more it would be difficult to locate the point of contact between vein and wall. In the former, mineralization is confined to the vein, while in the latter it extends out into the wall rock. The

The valley sides south of Nighthawk present many quartz veins near their rim, but few of them extend over a quarter of the way down the sides and only two were noted (southwest of Palmer lake) which reach the lower slopes. While it is not safe to generalize on the strength of these observations, yet they are considered sufficiently potent to emphasize the advisability of following the ore to lower levels rather than resorting to long tunnels. The history of the district amply bears out this suggestion.

Age and Genesis.

The ores are in part enclosed in the granite but nowhere are known to cut the lake beds. Hence they seem to be confined to that period between the intrusion of the granite magma and the lacustrine deposition. Since the granite is probably late Cretaceous or early Tertiary and the lake deposits are thought to be Miocene, the ores are probably early Tertiary.

Thus, dating the ores somewhere during that period when the great heat of the intruding granite magma was being slowly dissipated through the surrounding rocks, it seems very reasonable to suggest a relation between the two.

PLACERS.

The principal placers have been found along the Similkameen river about half way between Oroville and Nighthawk where somewhat more than a half million dollars is said to have been extracted within a short time after the discovery. Recently a river bed drying device has been installed, the object being to explore the present channel. Other placer operations are being undertaken on the river but with what success is unknown to the writer.

The gold which varies in size from coarse flakes to nuggets, occurs in the river bars and lower terraces. This part of the river valley is largely the product of post-glacial erosion, hence the placers are very young and quite possibly have been secondarily concentrated from vein material ground up by the ice sheet.

GROUND WATER LEVEL AND OXIDATION.

Perhaps the most striking feature in the ore deposits of the boundary country is the shallow zone of oxidation. In many instances this may be accounted for by the shallow depth of the water table. Usually, however, the water table is a considerable distance below the lower limit of oxidized ore. Thus in the Copper World Extension, primarily pyrite and chalcopyrite are encountered within a few feet of the surface, while water does not rise in the shaft above the 200-foot level. The Kelsey group also illustrates this point but here the water level is only 20 to 50 feet below the lower limits of predominant oxidation. Many other instances could be cited which illustrate the same general relation, namely, that the water level is lower than the present lower limit of oxidation.

This relation is probably to be explained by recourse to the influences of glaciation on the country. The ice not only cut off much of the oxidized zone in many places, but left a mantle of drift which serves to shed water that would otherwise enter the veins.

CONCLUSIONS.

Concisely stated, the conclusions deduced from the reconnaissance in the Oroville-Nighthawk area are as follows:

(1) Copper deposits occur both as veins and as disseminations. The former are definitely known, but the quantity of ore available is yet to be determined. The latter are in vast bodies but it is yet to be proven that the copper content is sufficient to justify working under present conditions.

(2) Gold production will probably be much lower, proportionately to silver and copper, in the future than in the past.

(3) The proportionate production of silver in the future will show a marked increase.

(4) The ores are probably genetically related to a great batholith of soda-rich granite.

(5) The deposits are thought to be of late Cretaceous or early Tertiary age.

(6) In few districts is the injunction to follow the ore more pertinent than here.

MINERALS OF THE DISTRICT.

The minerals recorded in a report of reconnaissance studies must in the nature of the case be incomplete, but for purposes of reference those that were noted are arranged in alphabetical order and their mode of occurrence briefly stated.

Argentite. Silver glance occurs in several of the silver-bearing deposits around Golden and Nighthawk but is never the chief ore of silver.

Arsenopyrite. This sulpharsenide of iron is not abundant in the area, being noted in but three places. It was intergrown in each case with vein quartz.

Auzurite. This copper carbonate is limited to the upper few feet of the copper deposits and even here is not conspicuous.

Bornite. Bornite occurs in many places as an alteration product intermixed with chalcopyrite and as thin films on adjacent material.

Calcite. The carbonate of lime frequently occurs as part of the gangue.

Cerargyrite. Hornsilver occurs near the surface in many of the silver-bearing veins but in no place constitutes a very appreciable part of the ore.

Chalcopyrite. This mineral is widely distributed in the area and is the chief ore of copper. It occurs in veins intimately intergrown with pyrite and as disseminations in the Paleozoic rocks.

Cuprite. Copper oxide is remarkably rare in the surface exposure of the copper deposits, the alteration having been almost completely to malachite.

Galena. Lead sulphide is widely distributed in the vein deposits. Silver is associated with it in several places and in one of the veins (Hiawatha) it is thought to carry much of the gold.

Gold. Gold is widely distributed in the area. It occurs free in placers and the upper portions of the quartz veins, and included in pyrite, chalcopyrite, galena, and sphalerite in the unaltered parts of the deposits.

Limonite. The hydrated oxide of iron occurs as a heavy stain on the gossans of the veins and on surface exposures of many of the rocks of the area, especially the basic lavas and tuffs.

Malachite. The green copper carbonate is always conspicuous in the outcrops of the copper-bearing deposits. It is generally confined to a few feet near the surface.

Molybdenite. Thin, graphite-like scales of the sulphide of molybdenum occur along many of the gouge seams accompanying the veins in the northeast part of the area.

Proustite. Light rubysilver is an important ore from the central and northwest part of the district. It usually occurs as stains and crusts but occasionally as small, hexagonal crystals in firm quartz.

Pyrargyrite. Dark rubysilver has a distribution similar to proustite and with it constitutes the chief ore of silver.

Pyrite. Pyrite occurs in all the deposits of the area.

Pyrolusite. This oxide of manganese was noted in several deposits both as druses and dendrites.

Pyrrhotite. Appears quite commonly in the quartzitic schists traversed by the Palmer mountain tunnel but was not noted in any of the veins.

Quartz. Quartz is the chief gangue mineral in the area.

Silver. Specimens of native silver have been encountered near the surface in several of the properties but does not constitute an ore of silver.

Sphalerite. Zinc blende is widely distributed in the veins. It occurs as fine-grained masses in the quartz but is never in commercial quantities.

Stephanite. Is one of the important silver ores especially in the Hornsilver mine. It is usually disseminated in irregular areas in the gangue but occasionally occurs as short prismatic crystals.

Stibnite. Antimony sulphide occurs in small lenses and bunches in the metamorphic rocks southeast of Loomis. Little of it was seen in place.

CHAPTER IV.

DETAILED DESCRIPTION OF MINES AND PRINCIPAL PROSPECTS.

In the descriptions which follow the properties will be divided into groups according to their location. Thus the claims situated near Oroville, Nighthawk, Wannacut Lake, and on Palmer mountain will be considered in turn. It is perhaps unnecessary to state that not all of the claims of the area were visited and it is likely true that some which were not visited are of more merit than some of those which were. It is thought, however, that the following descriptions in that they are to a large measure inclusive, will be of value in giving the report tangible form.

KELSEY GROUP.

The Kelsey group consists of fifteen claims which are situated about four miles north of Oroville and immediately west of Osoyoos lake. The property is owned by the Detroit-Oroville Exploration company with headquarters in Detroit, Michigan. Mr. N. B. Kelsey, of Oroville, Washington, is local agent for the company.

Development consists of several small open cuts and shafts in addition to six diamond drill holes, each of which reaches a depth of about 100 feet. No ore has been shipped from the property.

The country rock, as exposed on these claims, is predominantly greenstone, although large amounts of clay slate and quartzite are present. The greenstones seem to be interbedded with the sedimentary members, although it is possible that more careful study may show some of them to be intrusives. In the hand specimen they are usually green or greenish gray and present a granular to porphyritic texture with the grains rather ill-defined. Hornblende, feldspar, and quartz can be distinguished, and little veinlets of quartz usually less than a quarter

of an inch wide occupy joint and fracture cacks. Chalcopyrite, commonly altered on its surface to a blue, black or green sheen, and pyrite occur as disseminations both along the quartz stringers and out into the rock mass. The specimens studied were so extensively altered that accurate classification was not possible. From such determinations as were made, however, it appears that the rock is a basic andesite, consisting of oligoclase, andesine and a few labradorite feldspars, biotite, titanite, zircon, apatite and magnetite. Secondary epidote is nearly always present in conspicuous amounts, while chlorite, kaolin and a little sericite are variously found. Pyrite or chalcopyrite, and usually both, were present in all the slides studied.

Mineralization has affected all varieties of the country rock, copper in the form of chalcopyrite occurring as disseminations and as films along fracture lines and bedding- and joint-planes. In places, non-persistent quartz veins carrying chalcopyrite and pyrite occur but strong fissure veins are not found. A remarkable feature of the deposits is the very shallow depth of oxidation. Primary minerals usually appear by knocking small chips from the surface, even where copper stains are most extensive. This clearly indicates that secondary concentration on a large scale cannot be expected. The company have had a great many assays made on various parts of the property and an average of eighteen of these which were selected at random from a number of assays furnished by Mr. Kelsey gave 2.62 per cent. in copper, 0.6 in silver and 0.04 ounces in gold.

In conclusion it appears that this group of claims contains widely disseminated copper, but whether the percentage of copper on a large tonnage basis is high enough to constitute an ore, has not been proven.

The deposits, while similar to the great disseminated deposits of the southwest, must be distinguished from them by one very important difference. In the southwest oxidation is extensive and the workable ore lies below this zone and is due to concentration from it, while here no such general zone of enrichment is to

be expected. Chalcopyrite is the chief mineral of the deposit, even within a few feet of the surface.

OKANOGAN FREE GOLD MINE.

The Okanogan Free Gold mine lies on the north bank of the Similkameen river, about three miles above Oroville. Considerable work was done on the property several years ago and shipments of ore were made; but due to the high cost of mining which prevailed at that time, the mine was closed as soon as the richer oxidized ore had been worked out.

Development consists of several tunnels and open cuts. The lower tunnel was entered for a distance of 175 feet; otherwise observations are from the surface. This tunnel runs east through a finely laminated clay schist which is badly disintegrated and cut by numerous north-south stringers of quartz. At 175 feet from the portal the tunnel intersects a vein of milk-white quartz which is two to three feet wide. The vein, which strikes north 18 degrees west and dips steeply south of west, although apparently not mineralized at this level, has been stopped near the surface. Here it is from 6 feet to 25 feet wide and consists of blue and white quartz much fractured and including fragments of schist. Cubical iron pyrites are distributed through the gangue and out into the wall rock. Near the surface iron oxides are extensive and in places the quartz has a honeycomb texture due to the removal of pyrite.

GOLDEN CHARIOT.

The Golden Chariot claim is situated about five miles north of Oroville. Development consists of an incline 220 feet on the vein from which drifts extend out along the lode. Three cars of ore shipped from the property afforded an average return of about $26 per ton. Although the ore is mined for gold, yet some copper in the form of chalcopyrite is present.

The vein, which averages about two and one-half feet in width, strikes 15 degrees east of north and dips westward at angles varying from 40 degrees at the surface to eighteen or twenty

degrees at a depth of 50 feet. The fissure is of about constant width and within are essentially equal proportions of vein matter and gouge. The gouge shows excellent cleavage inclined about 45 degrees to the walls. In tracing the cleavage planes they are seen to incline toward the surface as the hanging wall is approached (Fig. 2), thus indicating that the hanging wall has moved up relative to the foot wall. The vein therefore occurs

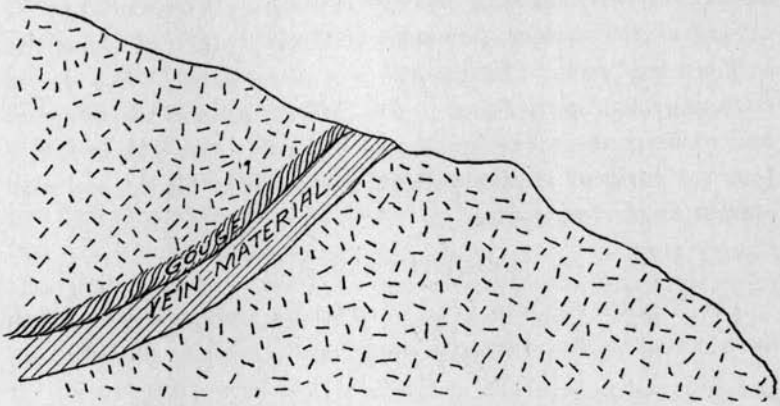


FIG. 2.—Golden Chariot vein which occurs along a thrust fault as shown by direction of cleavage in gouge near hanging-wall.

along the plane of a thrust fault which, however, is thought to have only a small throw.

The ore is a bluish white to milky quartz with chalcopyrite as the chief metallic mineral. Pyrite is also present and occasional black metallic ribbons occur. In places the mineralization is confined to one side or the other of the lode and in others it is evenly distributed throughout, while yet again the quartz is entirely barren. Where mineralization is present it is in blotches distributed more or less parallel to the margins of the vein. Films of molybdenite are found, especially along the contact with the walls.

OHIO CLAIM.

The Ohio claim lies immediately south of the international boundary and a short distance west of Osoyoos lake. It is held

for copper which occurs as disseminations in greenstone. The minerals noted were chalcopyrite, malachite, azurite, pyrite and chrysocolla. In no place is mineralization intense.

FORTY-NINTH PARALLEL MINING CO.'S PROPERTY.

This property consists of five claims situated near the Ohio claim. The vein, which is enclosed in the metamorphic rocks, strikes east-west and dips 36 degrees south. It does not appear strong at the surface, but below attains a width of about five and one-half feet. The gangue is a dense bluish white quartz enclosing chalcopyrite and pyrite, usually altered to carbonate and oxide forms. The ore is said to carry from $14 to $58 a ton, the ratio of copper to gold being about six to one with copper at thirteen cents.

NIGHTHAWK GROUP.

The Nighthawk Mine is situated on the east wall of Similkameen valley a few hundred yards south of the postoffice at

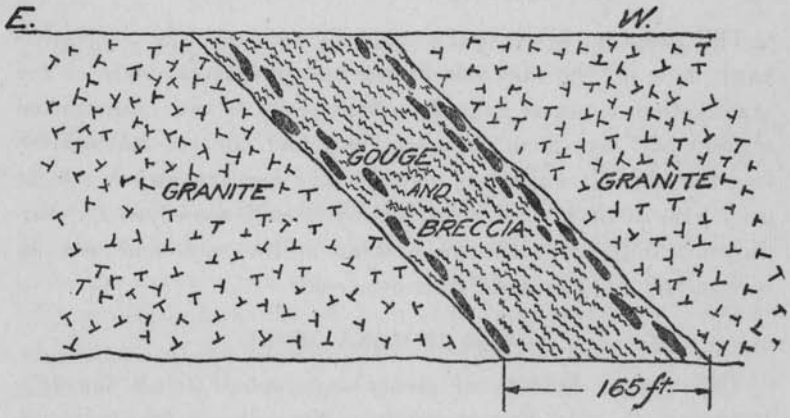


FIG. 5.—Showing the occurrence of ore along the margains of a brecciated zone in the Nighthawk Mine.

Nighthawk. The company have 65 unpatented claims located in section 13, township 40 north, range 25 east, and section 18, township 40 north, range 26 east. Development consists of a main tunnel 1,770 feet to the face, at the date of examination,

and several minor underground workings. A 20-stamp mill used for making concentrates is located near the portal of the main tunnel. Electric power for running the compressor and mill is furnished by the Similkameen Power Company.

The ore is enclosed in granite. That part being mined occurs as irregular bodies along the margins of a brecciated zone which is cut about 1,000 feet from the portal on the tunnel level and at this place is a little over 100 feet wide (Fig. 5). The hanging wall side of the zone is clearly defined while that opposite is more gradational. The principal ore has been taken from near the hanging wall and comes from small bodies of quartz which vary markedly in extent of mineral content from place to place. The quartz is friable and often minutely mixed with gouge material. In places it is distinctly fractured, thereby showing post-mineral movement. The mine is worked for lead and silver which are intimately associated with considerable amounts of iron pyrite.

FAVORITE MINING CO.'S PROPERTY.

This property is situated a short distance south of the Nighthawk mine on the east side of the valley. At the date of the examination, a tunnel running a little south of east had reached a point 850 feet from the portal but had not yet reached the vein for which it was being driven. The country rock is a light gray granite more or less mottled by hornblende crystals. Euhedral titanite crystals are present in the rock and may be recognized by their reddish brown color.

LITTLE CHOPAKA GROUP.

This group consists of eleven unpatented claims formerly known as the Six Eagles group. They lie on the west side of Similkameen valley about one mile south of Nighthawk. The principal development consists of a 200-foot shaft on the ledge and a tunnel 2,000 feet long on a level 500 feet below. The tunnel should have cut the vein at 1,500 to 1,600 feet, but instead a seam of gouge was encountered.

The vein is along a fault which runs north 2 degrees east and

dips 45 degrees northwest. The hanging wall is well defined and shows distinct vertical groovings while the foot wall is gradational. Along the foot wall and also within the vein there is considerable gouge. Where seen the vein is from one to three feet wide and varies in position from the middle of the gouge material to the hanging wall. The gangue is a milky colored quartz carrying pyrite, chalcopyrite, sphalerite, galena, rarely sericite and occasionally a black nonmetallic substance in the form of small specks, which is possibly gouge material. The property is held for gold, silver and lead, said to total about $5 per ton. The country rock is granite similar to that above described.

SUMMIT CLAIM.

Summit claim joins the Little Chopaka group on the south and is located on the same ledge. The vein, as exposed in an incline shaft some 70 feet deep, is about three and one-half feet wide and carries pyrite, galena, some chalcopyrite and a little sphalerite, occasionally molybdenite and rarely sericite irregularly scattered in a gangue of firm, milk colored quartz.

The enclosing rock, which is similar to that on the Little Chopaka property, is a light gray granite with conspicuous crystals of hornblende, frequently irregular in outline and in striking contrast to the light colored feldspars which are the chief constituents. Some of the feldspars are distinctly striated and lath-shaped with glassy luster. Quartz grains are present. Under the microscope the feldspars are seen to be microline and albite, while orthoclase is very subordinate in amount. Quartz represents about ten per cent. of the rock, and titanite about one per cent. Secondary epidote, sericite and calcite are extensively developed, together with some hornblende and chlorite. In passing it may be noted that the specimen from this property is much more basic than the average of the batholithic mass of which it is a part.

NUMBER ONE GROUP.

Number One group is situated on the south face of Little Chopaka mountain about one and one-half miles south of Night-

hawk and west of the Little Chopaka group. Development consists of a tunnel 200 feet long and several shafts, the deepest of which is 60 feet and connects with the tunnel level. The lode is from 3 feet to 12 feet wide and occurs along a fault plane which extends north-south and dips 31 degrees west. The vein can be followed on the surface for some 4,000 feet. Silver and lead, occurring in a friable quartz gangue, are the chief metals although a little gold and copper are usually present. Assays from the property show wide variations, but it is probable that the average will be found to be somewhat less than $10 per ton. The quartz is considerably fractured and in the tunnel level is so leached that galena is the only primary mineral remaining in conspicuous amounts. From the degree of weathering and the silver near the surface, it is thought probable that silver will be found to increase somewhat in amount down to the ground water level.

The hanging wall of the lode is a decomposed conglomerate in its lower part with slate above while the foot wall is a fresh granite face with texture and composition characteristic of the interior of the granite mass and showing none of the peculiarities expected along a marginal contact. This, together with the distribution of the two formations, clearly indicates a fault with downthrow on the west.

CALIFORNIA CLAIM.

This property is situated near the south base of Little Chopaka mountain. The vein, which is exposed in a tunnel 150 feet long, is from 6 to 12 feet wide and composed of coarse quartz with occasional vug-like cavities. The metallic content is distributed in patches through the gangue, the patches being arranged with a certain parallelism which gives the face a roughly banded appearance. Chalcopyrite, bornite, pyrite, sphalerite, and galena are the principal primary minerals, while secondary iron and copper stains are conspicuous locally. The wall rock is granite and a part of the same batholith which occurs to the north on the Little Chopaka and other properties.

PEERLESS GROUP.

The Peerless group consists of twenty claims situated in the Paleozoic area on the south face of Little Chopaka mountain. Several tunnels and shafts have been opened on the property, the principal one of which is a tunnel 400 feet long starting from near the level of Similkameen valley and extending north. Here the country rock is quartzitic slate and black metamorphosed shale together with some greenstone. No true ledge has been encountered but in places the rock passed through carries much magnetite, pyrite, and some chalcopyrite. Small garnet crystals were noted in two places.

CAABA LEAD.

In the north half of section 23, township 40 north, range 25 east, there are several prospects along a vein which strikes north 2 degrees west and dips 45 degrees southwest. The vein, which crosses the contact between the granite and metamorphic formations, is from 6 to 12 feet wide and shows a coarsely banded structure almost resembling bedding. The gangue is quartz, which is loose and friable and presents many crystal lined cavities irregularly distributed from wall to wall. Galena and pyrite occur along zones parallel to the banding of the quartz. Assays show silver chiefly, with usually about 50 cents in gold, the total being between $2 and $4 per ton.

PRIZE GROUP.

Prize group, consisting of twelve unpatented claims, is situated on the east side of the valley about three-fourths of the way from Nighthawk to Palmer lake. A small mill with a capacity of one ton per hour is used for making concentrates. The workings, consisting of two tunnels, are on the face of the mountain at an elevation of 3,200 feet. The vein is enclosed in greenstone and schist and strikes almost east-west, dipping south. The quartz is in large part intermixed with country rock, both enclosing fragments of it and extending into it as irregular stringers. Galena, pyrite and chalcopyrite, together with malachite, azurite, and iron oxides are irregularly scattered

through about fifteen inches of quartz. The metals sought are silver, lead and gold.

RUBY MINE.

Ruby mine is situated on the east face of Mount Chopaka near the level of Similkameen valley and about one and one-half miles north of the north end of Palmer lake. Some 6,000 feet of development work has been done on the property, 1,300 feet being in tunnels, which give a depth on the lode of 480 feet, and the remainder in drifts, raises and crosscuts. Two leads have been encountered, only one of which is of commercial 1,300 feet being in tunnels which give a depth on the lode of importance. This occurs along a fault plane which strikes north-south and dips 45 degrees west. Heavy black gouge, largely composed of powdered and secondary hornblende, occurs along the fault plane and is usually mixed with the ore. The ore shows a tendency to follow the hanging wall, but exceptions are numerous. Although the fissure is very irregular in width, varying from three or four to twenty feet, yet the ratio of vein material to gouge varies even more markedly from place to place. On the whole, gouge predominates. The vein matter occurs as lenses, stringers and as cement in brecciated material and varies from one-half inch to twelve or more feet in thickness, averaging about fifteen inches. It is frequently banded and includes much fragmental material.

The ore is milky white, friable quartz containing about five per cent. of lime, and carries pyrite, chalcopyrite, arsenopyrite, galena, sphalerite, proustite, pyrargyrite, some argentite and a little free gold, besides the alteration products—malachite, azurite and limonite. In detail, minerals are usually irregularly scattered through the quartz, although in broad outline they are zonally arranged. Supt. Monroe Harmon estimated that 35 to 40 thousand tons of ore of an average value of $10 per ton, is blocked out above the tunnel level and awaiting the installation of an electro-metal plant.

The enclosing rock is gabbro, varying in places to hornblende diorite, and in others less common, to dunite. It is

very rich in hornblende, often running as high as 73 per cent. in that mineral and seldom falling below 40 per cent. Apatite is conspicuous, sometimes representing 5 per cent. of the rock. A very little quartz is usually found and near the lode assays show traces of the vein metals. The exact relations of this basic rock to the granite which occurs on all sides of it, was not definitely determined, but it may be a differentation from that mass.

MOUNTAIN SHEEP PROPERTY.

This property is situated about three-quarters of a mile north of the Ruby and on the same fault. Extensive development work has been done in tunneling and otherwise exploring the vein. The deposit and its occurrence is similar to that at the Ruby mine. Some few cars of ore have been shipped.

GOLDEN ZONE MINE.

Golden Zone property, consisting of five patented claims, is situated at the base of Mount Chopaka about two miles south of the international boundary. The main lode, which strikes 20 degrees east of north and dips 40 degrees northwest, has been developed by some 5,000 feet of tunnel and drifts giving a depth on the vein of over 500 feet. A stamp mill for preparing concentrates is situated on the property and was in operation for about four years, when, due to litigation, it was closed. The property is held for gold, although some silver is present. In the upper levels free gold was found, but below the metal is intimately associated with iron sulphide, while the silver present seems to be as argentiferous galena. Chalcopyrite and occasionally sphalerite and arsenopyrite were noted on the dump. The country rock is granite, although the metamorphic rocks outcrop but a short distance to the south.

RICH BAR PROPERTY.

The Rich Bar Mining Company hold eleven claims on Similkameen river about five miles east of Nighthawk. The group receives its name from the placer which was worked as far back as 1859. Quartz lodes were recognized at that time but due to

withdrawal from mineral entry shortly thereafter, were not definitely located until 1901, when Mr. Charles T. Peterson staked out the several claims. Development consists of two shafts, the larger of which attains a depth of 150 feet, or 60 feet below the bed of the river, with drifts from the 50 and 150 foot levels. On the 50 foot level the vein tends to be in stringers, but below is better defined, and in the face exposed at the date of the examination was about 6 feet wide. At this place the vein strikes north 40 degrees west and dips 35 to 40 degrees northeast. The lode material, which is enclosed in a quartzitic slate of the Paleozoic series, is bluish white and varies greatly in mineral content from place to place. Where mineralized it carries chalcopyrite, sphalerite, pyrite, stephanite, galena and argentite, named in order of decreasing importance. Present developments suggest that the richer ore occurs in the central part of the vein. Assays differ greatly from place to place, varying between traces and $40 per ton.

SIMILKAMEEN PLACERS.

Placers were worked on Similkameen river as early as 1859, and in the few years following some $500,000 is said to have been shipped from the section of the river between Oroville and Nighthawk. During recent years placer mining has been pursued by a few individuals on this part of the river almost continually, but with only moderate success. During the season of 1909 a Gilman riverbed dryer was installed, the object being to work the bed of the river. At the time of investigation the installation was incomplete, and although operated since the results are unknown to the writer.

The gold occurs as flake gold, shot gold and nuggets, and is found in the river bars and lower terraces.

KIMBERLY MINE.

Kimberly mine is situated one-half mile south of the old postoffice at Golden. An incline shaft on the vein is 140 feet deep with drifts on the 60, 80 and 100 foot levels. The lode occurs along the contact (possibly a fault) between a highly

altered igneous rock of intermediate composition on the foot wall and clay slate on the hanging wall. It strikes north 46 degrees west and dips 52 degrees southwest. Within the deposit the ore occurs in lenses which vary in dimensions up to 40 or 50 feet in length by one to five feet in width, and always have a flatter dip than the vein. Thus the lower end of any

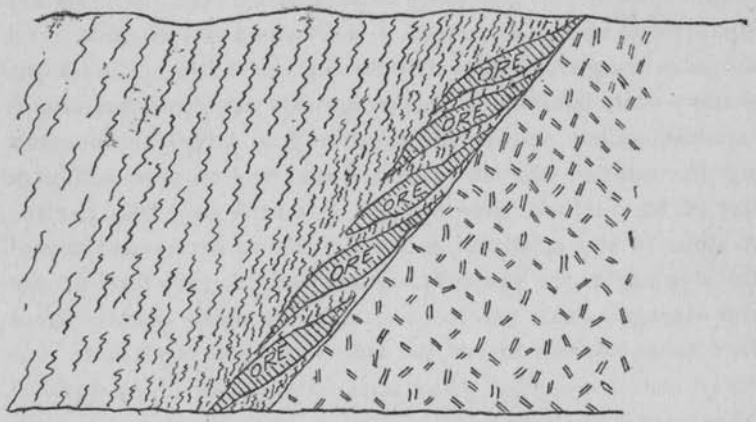


FIG. 4.—Section of Kimberly lode, showing distribution of ore in lenses.

lens overlaps the upper end of the next lower lens on the hanging wall side (Fig. 4). The gangue is massive bluish white quartz, rich in galena with some pyrite and chalcopyrite. The property is worked for lead, gold, and silver which according to Supt. S. A. DeMerchant, occur in the better ore in about the following amounts: lead 10 to 20 per cent; gold $6 to $15; silver 60 to 70 ounces.

TRIUNE MINE.

The Triune mine is situated one-half mile west of the old post-office at Golden and about the same distance northwest of the Kimberly. There are three claims in the group but most of the development has been done on one of them. There are several open cuts and small shafts but the principal development is a shaft 140 feet deep and a tunnel on a lower level, which, together with drifts from it, comprises somewhat over 2,000 linear feet.

All of the ore mined has been treated in a small stamp mill. The mine was formerly owned by Mr. Dell Hart of Wehesville, who operated it successfully for some years. Since its transfer to the Triune Power and Reduction Company of Boston, Mass., development has been carried on, but no ore milled.

The vein strikes north-south and dips 20 to 40 degrees east, the variation being from place to place along both the strike and dip. In harmony with this is a pronounced irregularity in width, varying from small stringers up to six feet. The gangue is milky white quartz carrying irregularly arranged, but usually bunched, galena and pyrite with the gold largely accompanying the galena. An average mill run, from stopes within 50 feet of the surface, gave returns of a little over $25 per ton. A stope of this grade of ore, and it represents essentially all the stoping on the property, is 365 feet long by 50 feet deep and averages about two feet in width. It opens to the surface. In a tunnel driven to cut the lode on a lower level four veins were encountered, all of which strike west of north and dip west. They vary greatly in width along the strike, averaging perhaps less than 18 inches and afford assays ranging from traces up to $15 in sections across the vein and up to $40 in roughly hand-picked samples.

The wall rock is clayey quartzite in the upper part and porphyritic granite below about 75 feet. The latter is coarse grained, consisting of quartz and pink orthoclase in almost equal proportions and together usually constituting about 90 per cent. of the rock. Hornblende varies in amount, and in places largely supplants quartz. Occasional feldspar crystals are two inches long and stand out boldly in a granitoid matrix, hence requiring the name porphyritic granite. The rock is highly altered, much epidote, sericite, kaolin and secondary pyrite being present. The ores are thought to be genetically related to porphyritic granite.

The Spokane claim is on the same general lode as the Triune and lies just south of it. Since the relations in it are very similar to those in the Triune it will not be described separately.

HIAWATHA LODE.

The Hiawatha vein lies north of the Triune and is very similar to it in general characteristics although in detail somewhat different. An incline 80 feet long follows down the dip which is about 10 degrees west at the surface and increases to 45 degrees at the bottom. The vein outcrops for a few hundred feet south from the shaft, but to the north it can be traced for over 2,500 feet by a well defined gossan of white quartz, which in places is heavily iron stained. It varies from one to twelve feet in width, averaging 3 to 4 feet. In places the lode breaks into stringers and in others is offset by small faults, but as a whole is strong and continuous. The ore is a friable white quartz carrying sphalerite, galena, pyrite, and chalcopyrited distributed in bunches through it. Mr. Dell Hart, who owns the property, has made careful assays of the various minerals separately, in order to determine the one with which the gold is associated, and found that galena carries by far the greatest quantities, while chalcopyrite and pyrite follow in the order named. Mr. T. F. Philbrook has sampled the property and reports $26 in gold with about an ounce in silver, as the average of 22 assays.

The wall rock is clayey quartzite in the parts now exposed, although it is very possible that the granite rock which underlies the Triune will be encountered at no very great depth.

TRINITY GROUP.

Trinity Gold and Silver Mining Company have four claims situated in the northeast quarter of section 28, township 40 north, range 26 east. Development is largely confined to the southeast claim, where there is a 40-foot shaft and a tunnel 200 feet long. Near the entrance the tunnel is in slate, while farther in a bed of black calcareous shale about fifty feet thick is encountered. Within the latter are occasionally very irregular lenses of quartz which are somewhat mineralized. Two or more quartz ledges which have not been developed outcrop on the north claims.

HORN SILVER GROUP.

The Horn Silver group consists of five claims situated in the south half of section 21, township 40 north, range 26 east. The property is developed by 750 feet of tunnel, an upraise of 100 feet and a shaft 100 feet deep. Three veins are recognized but most of the development has been on one of them, which strikes north 53 degrees east, and dips about 40 degrees northwest. The vein is very irregular in strike, dip and thickness, the latter varying from four inches to four feet, averaging about 18 inches. The country rock is in part a metamorphosed shale and in part a highly altered granite which shows the microcline, microperthite and titanite which characterize the great granite area to the north. It is probable that here is a small area where erosion has gone just far enough to partially uncover an underlying batholith which now appears at the surface in broad areas to the north.

The ore is white to bluish white quartz which as a rule is well mineralized, carrying stephanite, cerargyrite, a little proustite, galena, sphalerite, pyrite and chalcopyrite. The metallic minerals are distributed irregularly through the vein. In rare places they are along fracture lines, but more frequently are so intergrown with the quartz as to be unmistakably of contemporaneous origin.

Several carloads of ore have been shipped from the property, the two during the summer of 1909 averaging $62 per ton. The return was largely from silver with about $2.50 in copper and gold.

MAQUAE GROUP.

The Maquae group includes twelve claims, no one of which is sufficiently developed to afford satisfactory opportunity for observations. Three or four different veins are exposed on the property and in each the gangue is quartz with small amounts of calcite. The veins are held for gold and silver with which pyrite, galena, sphalerite and chalcopyrite are associated. A few stains of manganese were noted on the gossan at different places.

BELLEVUE GROUP.

This group consists of five claims situated in the northwest quarter of section 4, township 39 north, range 26 east. The principal lode, which strikes north 29 degrees east and dips 45 to 66 degrees southeast, is developed by a small shaft and several open cuts. The vein is enclosed in clay slates in the upper part and probably in limestone below, as indicated by the dip of a massive limestone member which outcrops about 600 feet east. The vein varies from ten inches to three feet in width and averages about 15 inches. It is made up of heavy, coarse textured quartz carrying arsenopyrite, pyrite, chalcopyrite, pyrargyrite, stephanite, a little native silver, free gold, and possibly a gold-silver telluride. A test shipment of 1,000 pounds gave returns of about $75 per ton in gold and silver with gold representing a little over one-half the total.

BULLFROG GROUP.

The Bullfrog group comprises 18 claims in the southwest part of section 33, township 40 north, range 26 east. There are two shafts, one 140 feet deep and the other 160 feet deep, in addition to a tunnel. The two shafts are connected by a crosscut, while other explorations have been made from each. The lower workings are said to crosscut three ledges, two of which show on the surface. The shafts were flooded at the date of the examination, but from the dump the wall rock is thought to be largely quartzite and sericitic schist. The ore is coarse textured quartz with pyrite and small black specks of some metallic sulphide rather sparsely scattered through it.

PALMER LAKE GROUP.

This group is situated well up on the valley side northeast of Palmer lake, and consists of five claims. The vein where seen is from two to three and one-half feet in thickness, strikes north 65 degrees west and dips 30 degrees northwest. The gangue is a massive, white quartz carrying small amounts of pyrite, chalcopyrite and bornite. The property is held for gold.

IVANHOE MINE.

In the early days of mining in the district considerable ore was shipped from the four claims which comprise the Ivanhoe group. The property is situated in the southwest quarter of section 16, township 39 north, range 26 east. The vein, which is enclosed in calcareous slate, is a fine-grained, greatly fractured quartz heavily iron-stained at the surface. Fresh ore as seen on the dump has a gangue of white quartz enclosing pyrite and some dark mineral or minerals which occur in streaks and ill-defined blotches. Silver is the chief precious metal, although some gold is present. The mine has been idle for about ten years, but during its period of operation ore was hauled to Wilbur and Coulee City and from there shipped to the smelter.

RAINBOW MINE.

The Rainbow mine, situated in the northeast quarter of section 22, township 39 north, range 26 east, was operated for some time during the early mining excitement and the ore treated in a mill located nearby. The vein, which is enclosed in metamorphosed limestone, schist and quartzite, is developed by three principal tunnels. It is very irregular in strike, dip and especially in thickness, occurring in lenses which thicken and pinch at short intervals. The quartz carries gold and silver accompanied by pyrite, arsenopyrite, chalcopyrite, and galena. Secondary iron and copper minerals are very limited.

BUCKEYE CLAIM.

This is one of eleven claims owned by Mr. A. M. Wehe, of Wehesville. A small vein averaging about one foot in width is opened on the property. Metallic minerals present include pyrite, chalcopyrite, galena and occasionally stephanite. Gold is said to predominate over silver. Present development is inadequate to determine the extent of the lode. The country rock is quartzite and siliceous schist.

COPPER WORLD EXTENSION.

Copper World Extension, also known as the Iron Mask property, is situated just west of the summit on the central part of

Palmer mountain. The claim joins the Copper World on the east and from that derives its name. The country rock is principally clay slate, although some schist and quartzite fragments appear on the dump. Development consists of a vertical shaft 300 feet deep, which is sunk in the foot wall of the vein and connected with it by crosscuts on various levels. Most of the drifting has been done on the 200 foot level. The ore body does not appear at the surface, but 100 feet below attains a width of four and one-half feet. Where crosscut at 200 feet, it is reported to be seventeen feet wide, while on the 300 foot level it is said to split into numerous small stringers. The deposit consists almost entirely of pyrite and chalcopyrite, so proportioned that the ore runs about four per cent. in copper. About one ounce of silver and from fifty cents to one dollar in gold are usually present.

The ore body strikes north 85 degrees west and dips 40 degrees southwest. Although tabular in general outline, it is not sharply defined. In places pockets of ore are found within the walls a few feet from the vein and isolated cubes of pyrite are rather generally distributed in the adjoining rock. Along the hanging wall the schist has been ground into gouge which is a few inches wide and probably indicates a line of pre-mineral movement followed by the ore solutions. Within the ore fragments of schists always heavily mineralized, are frequently met, further suggesting replacement along a zone of movement. Between the one hundred and three hundred foot levels a body of ore about two hundred feet long and of varying width has been blocked out.

Although considerable tonnage was extracted during several years, the property has not produced recently, due to lack of transportation facilities. The owners are now considering the feasibility of carrying the ore by areal tram from the mine down into the valley near the south end of Palmer lake, a distance of about two miles, from which point a haul of seven miles will place it aboard the cars at Nighthawk.

COPPER WORLD.

The Copper World property joins the Copper World Extension on the west, and is located on the same lode. The vein here has a surface exposure which, although not pronounced, can be traced for some distance. An incline shaft follows the dip of the ore body for 135 feet. At the time of the investigation the shaft contained water and only inferences from material found on the dump were possible. The country rock is schist and slate, much of which is found intimately mixed with the ore. Pyrite and chalcopyrite are the chief metallic minerals.

SECOND PRIZE GROUP.

The Second Prize group consists of nine unpatented claims owned by Mr. Charles Gerhart of Loomis, Washington. Development consists of small pits and tunnels located on various claims. The Second Prize claim is developed by two tunnels, one about seventy and the other one hundred and twenty-five feet deep. The latter or lower tunnel shows a small seam six inches to three feet across but averaging probably about fifteen inches, which follows a fault line. In the upper tunnel a quartz vein three to four feet wide strikes north 54 degrees east and dips 60 degrees northwest. An eighty foot winze extends from the tunnel and is said to contain very good ore in ten inches next to the foot wall. The enclosing rocks are schists, black slates, and quartzites.

On the Columbia claim a shaft thirty-five feet deep follows a body of quartz which, although very good at the surface, pinches out at the bottom. The ore consists of gold-bearing pyrite with an almost equal amount of arsenopyrite. The strike, although not clearly defined, seems to be about north 15 degrees east with dip 60 degrees northwest.

There are various other tunnels and small shafts on the property but those enumerated seem to present the most encouraging prospects.

LEADVILLE GROUP.

The Leadville group of claims lie on the west face of Palmer mountain at an elevation of 2,500 to 3,000 feet. They are

reached by wagon road, which extends from Loomis to the Copper World Extension and continues west to this group. Several minor openings have been made along various croppings on the property but the principal development consists of a tunnel about 300 feet long and a shaft some 70 feet deep. The vein, which strikes north 60 degrees east and stands almost vertical, is two to three feet wide and carries galena, iron pyrite and chalcopyrite in a massive, white quartz gangue. The property is held for gold. The outcrop of the vein is strong and can be traced for a considerable distance up over the mountain, but does not appear in the valley side to the west. The country rock consists of the various phases of the metamorphic series.

PINNACLE MINE.

This property was one of the claims early located in the district and perhaps has a greater production to its credit than any other. The amount of bullion taken from the mine varies greatly, according to the estimates of different individuals, but is considered by those now holding the property to be about $200,000. At present the tunnels are caved so that it is impossible to see the vein underground. In a bluff south of the main portal, however, is an old stope about five feet wide, from which the richest ore is said to have come. Another stope of high grade ore was found in the main tunnel at the junction of the Pinnacle vein with an east-west vein known as the Bunker Hill. At this point the quartz is from four to ten feet wide and average about $11 across the entire face, although extremely rich pockets and small seams are reported, the latter running parallel with the walls. The vein strikes north 60 degrees east and stands almost vertical.

The country rock is a highly altered igneous rock, probably diabase. In talus below the mine great quantities of black slates and some schists were noted. A gravity tram connects the mine with the base of the hill a short distance from a small stamp mill in which the ore was treated.

PALMER MOUNTAIN TUNNEL & POWER CO.'S PROPERTY.

This company holds an extensive group (about fifty) of unpatented claims. Extensive development consists chiefly of a double-track tunnel starting about a half mile north of Loomis and extending into the mountain a distance of about 4,800 feet. At various places in the tunnel drifts have been run to the east and west along quartz stringers or movement planes; in all totaling about 2,000 feet. In one place a quartz vein three feet wide is followed for a considerable distance, but is almost devoid of metallic content. Another stringer, ten inches wide, also developed to a considerable extent, gave an assay return from a sample taken by the writer of $1.80. These were the two best showings seen at the time of the investigation.

On the hill directly above, and about one-half mile northeast of the portal, is a shaft on the Black Bear claim. The shaft is down about 300 feet on a vein which strikes north 65 degrees west and dips 80 degrees northeast. At the surface, there is from fifteen inches to three feet of coarsely crystallized quartz, which in many places is stained by iron and manganese. It is said to have run about $24 per ton in gold, but pinched out on the 300-foot level. The main tunnel is well past the point where this vein should appear but it was not found. About a mile further up the hill from the Black Bear and in a general course with the main tunnel, is a quartz vein outcropping on the Grand Summit claim, which has produced some very good ore. At the time of the investigation, this outcrop was being explored by small tunnels in order to learn its characteristics, and hence the probability of finding it on the main tunnel level. Fourteen inches of quartz which appear in the floor of an upper prospect runs from $35 to $40 per ton in gold. The vein strikes north 55 degrees west and stands about vertical. Its position on the level of the main tunnel, if it should extend that deep, is several hundred feet beyond the present face.

There is one other claim in the group (Commanding) which affords some prospects. The vein here found strikes north 23

degrees west and dips to the east at a high angle. There is very little development work on this claim, but in one of the smaller pits extensively leached and copper stained material is exposed. It is from five or six feet wide, between poorly defined walls, although float can be traced for several thousand feet along the strike.

The company has extensive equipment. A power plant is situated in Toats Coulee, from which power for lighting and mining purposes is derived. A thoroughly equipped machine shop is situated near the portal and a one-hundred-stamp mill in which the stamps have not been installed, stands a short distance away.

ANTIMONY PROPERTY.

The Antimony property is situated in the northwest quarter of section 30, township 28 north, range 27 east, just beyond the southern limit of the map. Development consists of a tunnel 200 feet long. The country rock is slate and quartzitic shale. No true vein was seen in the tunnel, althought there are short, irregular drifts in two or three places from which ore has probably been removed. On the dump several pieces of beautiful stibnite were noted, but very little was seen in place.

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