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GEOLOGY AND MINERAL DEPOSITS

OF THE

COLVILLE INDIAN RESERVATION WASHINGTON

BY

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GEOLOGY AND MINERAL DEPOSITS OF THE COLVILLE INDIAN RESERVATION, WASHINGTON.

By J. T. PARDEE.

FIELD WORK AND ACKNOWLEDGMENTS.

A geologic reconnaissance of the Colville Reservation, together with an examination of the mining districts, was made by the writer during the periods July 1 to October 6, 1912, and July 15 to August 15, 1913. In the first season efficient assistance was rendered by T. H. Rosenkranz and F. H. Miller, and in the second by Mr. Rosenkranz. During a part of the second season A. R. Schultz, of the United States Geological Survey, shared also in the field work. The writer's best thanks are due to the mining men and prospectors of the area, who, without exception, gave generously of their time and information. Especially does he feel indebted to Messrs. H. G. Parmeter, B. E. Robinson, Jasper King, Alex. McMasters, and W. A. Starchman. For many courtesies acknowledgment is due to the local representatives of the United States Indian Office. To F. C. Calkins and E. S. Larsen, of the Geological Survey, the writer is indebted for the microscopic examination of rock sections, and to W. T. Schaller, also of the Survey, for the identification of several minerals.

SAMPLES AND ASSAYS.

Samples were taken by the writer or his assistants from several of the lodes to determine certain facts, as, for instance, the approximate average tenor of a particular layer or mineral, the results of the assays of which, of course, do not represent a thorough sampling of the deposits, a matter quite beyond the scope of the United States Geological Survey. Unless otherwise accredited, the assays inserted from place to place were made by E. E. Burlingame & Co., of Denver, Colo. To shed light on other problems, such as the relative distribution of the metals, numerous assays reported by the prospectors have been inserted, but as the writer has no knowledge of the circumstances under which the samples were taken these assays are quoted only for what they may be worth. On the other hand, sum-

maries from smelter certificates that are to be taken as trustworthy quantitative results are inserted, together with a few analyses made in the laboratory of the United States Geological Survey.

SCOPE AND ARRANGEMENT OF THE REPORT.

Although the present report notices practically all the prominent or promising mines and prospects known in the reservation up to 1913, the exigencies of the field work did not allow as complete an examination of many as they deserved, or an exhaustive search for outlying prospects. Therefore, brevity of notice or a failure even to mention any particular mine or prospect does not necessarily mean that it lacks merit. The several properties that were examined in some detail, however, constitute a sufficiently large proportion to warrant application to the whole of such generalizations as were permitted by the stage of the development work.

A broadly generalized description of the geography and geology of the reservation considered as a whole is followed by consideration of the four principal mining districts separately. For each of these a detailed description of the mineral deposits is prefaced by certain facts of geography and geology that appear to bear more or less directly upon the mining industry.

LITERATURE.

Aside from brief paragraphs appearing from time to time in statistical reports and in some of the mining journals, the reports heretofore published dealing specifically with the geology or mineral deposits of the diminished Colville Reservation are the following:

Collier, A. J., Gold-bearing river sands of northeastern Washington: U. S. Geol. Survey Bull. 315, pp. 56–70, 1907. Describes the geology and placer deposits of Colville Reservation adjacent to Columbia and Sanpoil rivers.

Weaver, C. E., Geology and ore deposits of the Covada mining district: Washington Geol. Survey Bull. 16, 1913. Gives detailed descriptions of most of the mines and prospects and discusses the geology of an area of about 40 square miles.

Bancroft, Howland, The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, 1914. Includes descriptions of a few of the mines in the Sanpoil, Covada, and Park City districts.

OUTLINE OF THE GEOGRAPHY.

AREA AND LOCATION.

The Colville Reservation covers an area a little larger than that of the State of Delaware. It is in northeastern Washington, occupying the southern portions of Ferry and Okanogan counties. Its form is roughly that of a quadrangle, about 65 miles from east to

west by 35 miles from north to south. It is bounded on the east and south by Columbia River, on the west by Okanogan River, and on the north by the line between tiers 34 and 35 of townships north of the Willamette base line. The city of Spokane is 50 miles to the southeast, and the mining camps of Rossland and Phoenix, British Columbia, and Republic, Wash., are respectively 45 miles northeast, 40 miles north, and 12 miles north. (See fig. 1.)

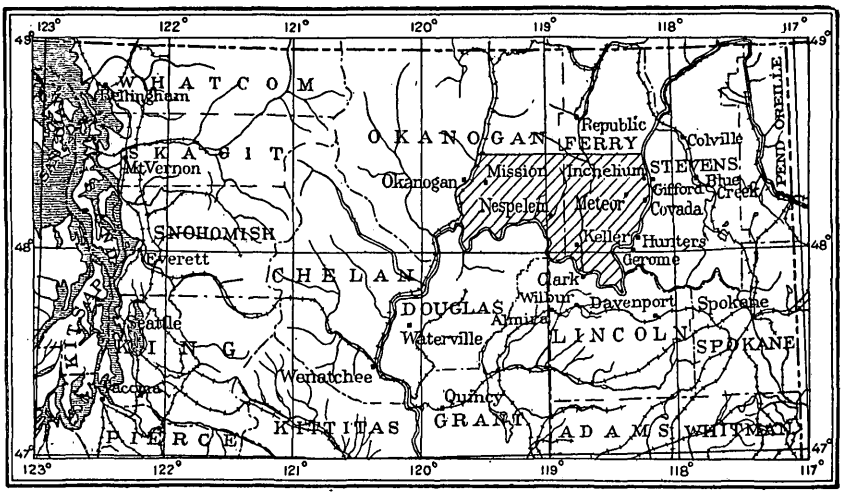


FIGURE 1.—Index map showing location of the Colville Indian Reservation, Wash. (diagonally shaded area).

TOPOGRAPHIC AND TOWNSHIP SURVEYS.

A map of upper Columbia River, by Capt. T. W. Symons, United States Army Engineer Corps, based on surveys made in 1891, gives the elevations and other details of that stream adjacent to the Colville Reservation. The barometric elevations determined for the eastern part of the reservation are based upon this map. The topographic map of the Okanogan quadrangle, surveyed by the United States Geological Survey in 1903, includes the extreme western portion of the reservation adjacent to Okanogan River and was used for datum levels for the adjacent areas. The township surveys of the General Land Office made in 1907 and 1908 were used as a base for the geologic map accompanying the present report.

SURFACE FEATURES.

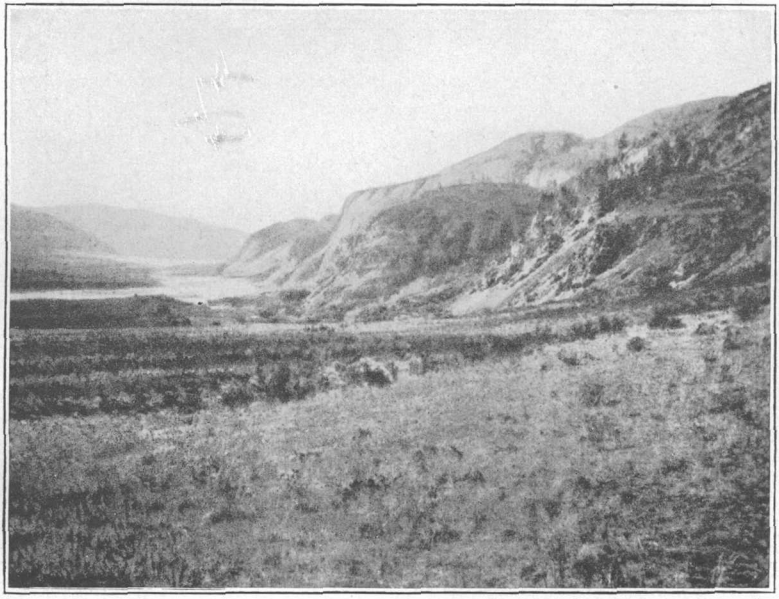
East of the Cascade Mountains the State of Washington is divided mainly between two provinces whose surface features contrast strongly. The southern and larger province, known as the Great Plains of Columbia River, or simply as the Columbia Plain, is a vast

stretch of treeless country that slopes very gently southwest, is deficient in surface water, and in distant views shows nothing to relieve its level monotony. In detail, however, the surface is modified by small dunelike hills and shallow valleys of the peculiar form known as coulees. The plain owes its topographic character to the fact that it was built by vast flows of basaltic lava. The surface of the Columbia Plain is regarded by Smith and Willis[1] as the result of erosion that reduced the region to a peneplain after the lava beds had been more or less deformed. In the Colville Reservation, however, the evidence is, in the writer's opinion, opposed to the idea of a postbasalt peneplain and strongly supports the view that the surface is dominantly a constructional form, as stated.

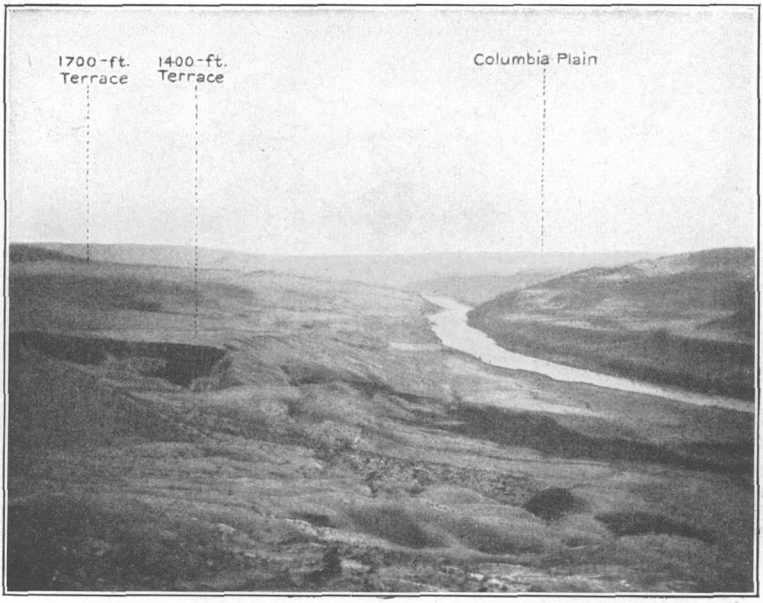
The northern province, known as the Okanogan Highlands, is a mountainous region of considerably greater average elevation, well timbered and watered, which presents a highly diversified and pleasing landscape. The two provinces meet without gradations between their unlike surfaces, the sharp line of demarkation being closely followed by Spokane and Columbia rivers. The Colville Reservation lies within the southwestern portion of the Okanogan Highlands, adjoining Columbia River, and to the north of that portion of the Columbia Plain locally known as the Big Bend country. The surface of the Colville Reservation exhibits great diversity in form and relief, including practically all gradations between rugged mountains and rolling plains, narrow canyons and wide valleys. The extreme relief is about 5,700 feet, the lowest point, at the mouth of Okanogan River, and the highest, at the summit of Moses Mountain, being, respectively, 773 and 6,500 feet above the sea. The average elevation of the surface rises gradually to the northeast. The shortest way of approach, from the south, involves the passage of a difficult barrier in the trenchlike valley of Columbia River, which separates the Colville Reservation from the Big Bend country. (See Pl. II.) Sunk 1,600 to 2,000 feet below the plain, this valley, with its somber colonnades, massive dull-gray terraces, and rugged, bleak promontories, together with the great volume of the swirling, rapid stream below, presents a scene that is fascinating and impressive in its barren grandeur.

In marked contrast, although by no means devoid of imposing effects, the valley of Columbia River above the mouth of the Spokane is characterized by wide cross sections, smooth contours, and moderate slopes. Except those occupied by Sanpoil River and Omak Lake, the other valleys of the reservation, including the Okanogan Valley, are of similar form. The deep valley which forms a short cut between

[1] Smith, G. O., and Willis, Bailey, Contributions to the geology of Washington: U. S. Geol. Survey Prof. Paper 19, pp. 20, 64, 70, pl. 16, 1903.

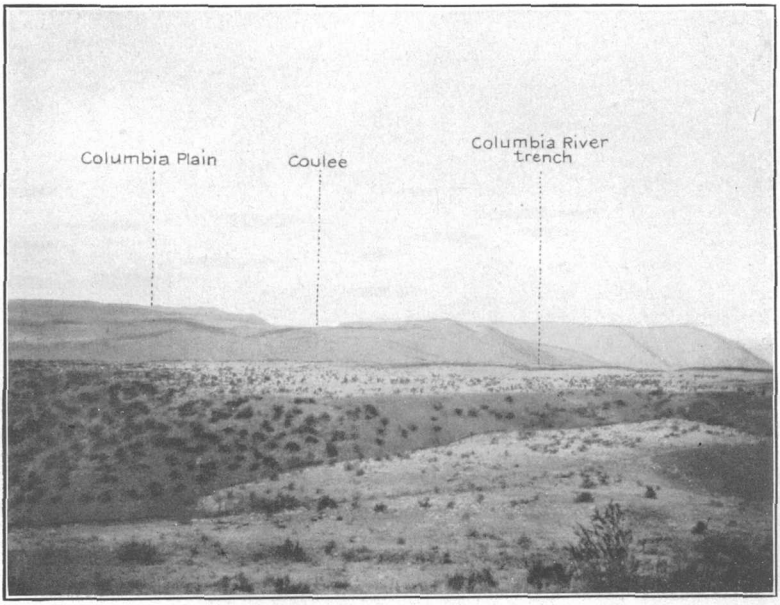


A. COLUMBIA VALLEY AT WHITESTONE CREEK.



B. COLUMBIA VALLEY BELOW SANPOIL RIVER.

A. NESPELEM VALLEY.



B. THE 1,700-FOOT TERRACE, NESPELEM VALLEY.

Columbia and Okanogan valleys by way of Omak Lake is comparable in form and dimensions to the Columbia trench. Sanpoil Valley also is relatively narrow and bordered by rugged, steep slopes and cliffs of considerable height.

Terraces are the one topographic feature common to practically all the valleys. The largest and most prominent ones are developed along Columbia River in broken chains that line both sides of its valley. As a rule they are arranged so that the gaps where portions of them are missing appear alternately on opposite sides of the stream. The highest prominent terrace stands between 1,700 and 1,800 feet above sea level, or 600 to 800 feet above the river. Its remnants, the larger of which are half a mile or more in width and several miles in length, are abundant from a point below Nespelem River upstream to the reservation boundary and beyond. (See Pl. III, *B*.) They are not prominently developed in Columbia Valley below Nespelem River or in Okanogan and Sanpoil valleys, although flats at about the same elevation occur near the mouths of tributaries to the Sanpoil. All the other valleys, however, contain terminal flats that pass without break into the 1,700-foot terrace of Columbia Valley and are evidently but extensions or embayments of that feature. In practically all the valleys sunk below that level another prominent terrace at an elevation of approximately 1,400 feet is abundantly represented by remnants as large as or even larger than those of the higher terrace. At intermediate and lower elevations lesser terraces occur, and in the upper part of Columbia Valley small terraces or shore lines were observed up to elevations estimated at 2,400 or 2,500 feet above the sea.

The principal mountains in the Colville Reservation are the divides to the east and west of Sanpoil River, known, respectively, as the Sanpoil and Nespelem ranges, together with Moses Mountain and its several extensive spurs. The Sanpoil and Nespelem ranges are massive ridges, practically unbroken by passes, that trend almost due north. Toward the south their crests descend gradually until cut off by the abrupt slope above Columbia River. The Sanpoil Range attains an elevation of nearly 6,000 feet at the north boundary of the reservation and is flanked by high and massive spurs that project almost to Columbia and Sanpoil rivers. The northernmost spurs are the largest and highest, but a very prominent and rugged one, known as Whitestone Mountain, occupies the extreme southeast corner of the reservation. The east slope of the Nespelem Range is likewise buttressed by heavy spurs, but its west slope has a comparatively even and gentle contour. Its highest point, at about 5,500 feet, is Old Glory Mountain, east of Park City. A short distance north of that point, near the valley of the West Fork of Sanpoil River, the range ends.

The mountains described occupy approximately the east half of the reservation, and three-fourths of the mountainous area is estimated to be composed of steeply sloping surfaces. The west half of the reservation is less rugged, not more than half of it perhaps being made up of steep slopes. In this portion of the reservation the dominating feature of the landscape is Moses Mountain, a large symmetrical dome at the head of Nespelem River, which attains an elevation of 6,500 feet. Prominent spurs radiate from it in all directions. One extending westward as far as Mission forms the rugged, picturesque divide between the valleys of Omak Lake and Omak Creek. Others extending northwest and northeast form, respectively, the divides north of Omak Valley and between Moses Meadows and Gold Creek. Still others projecting east, south, and southeast form the north and west rims of the Nespelem Basin and separate that river's numerous prongs.

A surface feature confined mostly to the western half of the reservation is a series of flat-topped table-lands or plateaus surrounded by steep walls. The most conspicuous example, which may be named the Okanogan Plateau (Pl. IV, *A*), occupies the greater part of the triangular area lying between the valleys of Omak Lake and Okanogan and Columbia rivers. Its surface, which coincides closely in elevation with that of the Big Bend country, to the south, covers an area of about 150 square miles. Its limiting scarplike walls drop in one or more steps from 50 to 500 or 600 feet, and, although broken in many places, are generally prominent and rest upon a massive sloping base. Smaller table-lands possessing the same elevation and other features similar to the Okanogan Plateau are common near Nespelem and occur at intervals near the Columbia as far east as the mouth of Spokane River.

All these plateaus or table-lands correspond almost absolutely in horizontal alinement with the surface of the Columbia plain or Big Bend country, across the river to the south. All, if a few small gravel flats clearly dependent upon them are excepted, are likewise underlain by horizontal beds of basalt. Their distribution and extent within the reservation are approximately equivalent to the areas mapped as basalt (Pl. I, in pocket). No basalt occurs at higher levels, and no other surfaces in the reservation can be correlated with these plateaus. They maintain their levelness to their extreme limits, meeting the adjoining slopes abruptly. Some of them, as, for example, those at Buffalo Lake and along Whitestone Creek, are merely level shelves that appear to be clinging to the mountain side.

Of the minor surface features, ravines are common on all the slopes, and deep, narrow gullies cut the terrace lands badly in places. Undrained hollows, irregular hillocks, and small flats or meadows,

of irregular distribution, are common generally, except in the unglaciated basins of Ninemile Creek, lower Sanpoil River, and some adjoining areas.

ACCESSIBILITY.

Although in close proximity to the Columbia plain, across which the main transcontinental railways are naturally located, the Colville Reservation is relatively difficult of access. It is sharply cut off from the Columbia plain by the intervening deep and rugged trench of Columbia River, and approach from the east or west is hindered by the north-south ranges prevalent in this general region. The only easy natural routes of approach, therefore, are from the north, down the Columbia, Okanogan, and Sanpoil valleys. From Spokane a branch of the Great Northern Railway follows a circuitous route that, encircling the reservation on the east and north, finally enters its western portion along Okanogan River, and, continuing down that stream and Columbia River, rejoins the main line at Wenatchee. This railway crosses the Columbia Valley about 12 miles north of the reservation and reaches the Sanpoil Valley at Republic by a spur. A branch of the Northern Pacific Railway extending west from Spokane passes from 10 to 20 miles south of the reservation. From Wilbur and Almira stations on this line stage roads, with ferries, extend into the Sanpoil and Nespelem valleys, respectively. From the mining camps of southern British Columbia the reservation may be approached via the Great Northern branch previously mentioned, together with a competing line that connects with the Canadian Pacific Railway and extends to Republic. Columbia River is a natural highway to the Colville Reservation but is little used, because of the difficulty and peril involved in navigating it. Boats, by lining over the worst rapids, make occasional trips from Wenatchee up as far as Nespelem, and at times a stretch of the upper Columbia east of the reservation is also navigated.

The reservation being divided by the north-south ranges into districts more or less isolated from one another, there is but little cross-country intercourse, each district communicating with the outside world independently of the others.

POPULATION AND SETTLEMENTS.

In 1912 the Colville Reservation contained an Indian population of nearly 2,500, most of whom may be classified as agriculturists, and between 100 and 200 white residents engaged in mining, prospecting, trade, and the administration of Government affairs. Nespelem, near which the Indian agency is located, Keller, Covada, and Meteor are the principal mining settlements. Nespelem is largely

inhabited by Indians, and Inchelium and Mission (St. Mary's Mission School) are two of the chief Indian settlements. All contain post offices and stores, and in most of them hotel and livery accommodations can be had.

DRAINAGE.

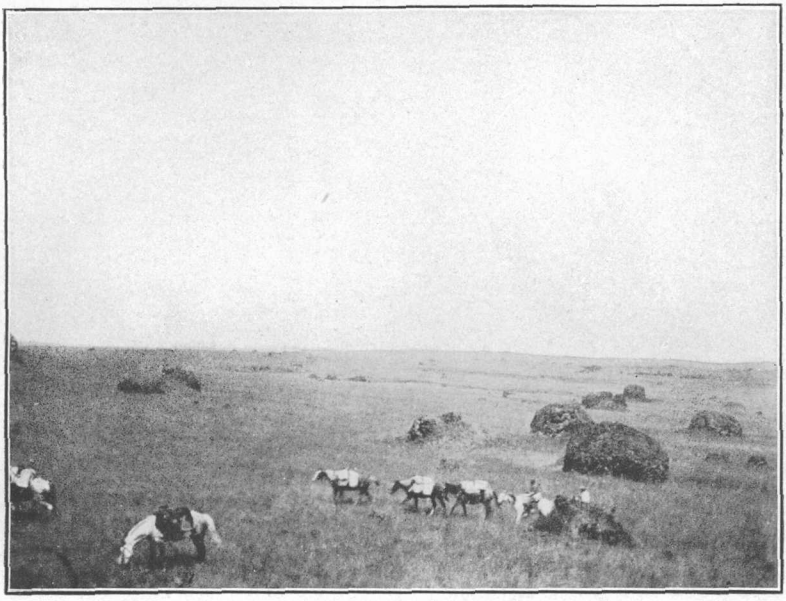
The eastern and northern portions of the Colville Reservation are plentifully supplied with running water. Over considerable areas in the southwestern part, however, notably in the plateau east of Okanogan River, the water supply is limited to widely scattered springs and ponds with no visible outlets. Sanpoil River, which rises outside the reservation and crosses it from north to south, has an average annual flow of about 180 second-feet and a descent of about 1,000 feet from Alkire or West Fork to its mouth, a distance of 40 miles as measured along the stream. Of the other principal streams, Nespelem River and Hall, Stranger, Nez Perce, Wilmont, Omak, and Ninemile creeks have average flows estimated to range from 40 second-feet for Hall Creek to 9 second-feet for Wilmont Creek.

Except Sanpoil River, which exhibits a fairly even grade in its course across the reservation, and Omak Creek, all the streams mentioned show at points 2 or 3 miles from their mouths marked abnormal changes from gentle grades above to steep grades below. The break occurs, as a rule, not far back from the front edge of the 1,700-foot terrace or terminal flat, as the case may be, and from this point onward each stream is characterized by cascades and waterfalls. The total descent of each stream in this part of its course ranges from 500 to 700 feet. Omak Creek, estimated to have about the same volume as Wilmont Creek, also has waterfalls about a quarter of a mile east of Mission aggregating several hundred feet, but, unlike those of the other streams, they are situated in the middle course of the creek. Above and below the falls the grade is comparatively gentle.

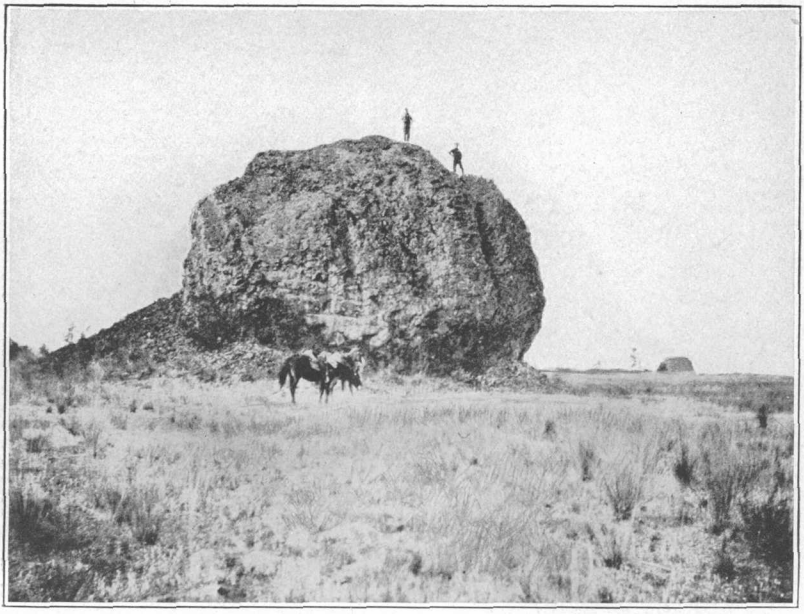
The peculiarities of grade mentioned afford unusual facilities for the development of water power, the available amount of which, however, is relatively small because of the small average flow of the streams. Along Sanpoil River conditions are also favorable to power development in places, one of which, near Keller, has been appropriated and improved by the erection of a hydroelectric power plant as an adjunct to the smelter, though neither plant has been in operation.

Columbia River,[1] in its course along the east and south boundaries of the Colville Reservation to the mouth of Okanogan River, a dis-

[1] Symons, T. W., Map of upper Columbia River, U. S. Army Eng. Corps, 1891.



A. SURFACE OF OKANOGAN PLATEAU.



B. ICE-TRANSPORTED BOULDER.

tance by water of 160 miles, descends from 1,160 to 773 feet above the sea. Its width ranges from a quarter of a mile to 1 mile or more, the depth in midchannel at low water is commonly from 30 to 50 feet, and the current is generally swift but variable, quiet pools and rapids alternating. In flood time the rise at constricted portions of the channel is as much as 60 feet. Okanogan River, in a course of about 40 miles along the west boundary of the reservation, descends about 100 feet. Unlike the Columbia, however, it descends with a regular grade, unmodified by alternating quiet pools and rapids. Its channel is almost free of rocks, and it is easily navigated.

All the streams are clear and of the relatively high purity common in the mountains of the Northwest. Most of the lakes contain fresh water also, but Omak Lake, a body of water 8 miles long and half a mile wide, with no visible outlet, and the numerous small ponds southwest of it are saline. The water of Omak Lake is clear and tastes of sodium carbonate. The ponds on Okanogan Plateau appear slightly turbid because of rank growths of small water plants. Their waters taste decidedly saline but are relished by stock, upon which they apparently produce no permanent ill effects.

CLIMATE.

From place to place the climate of the Colville Reservation shows considerable variations in moisture and temperature. The Columbia and Okanogan valleys are dry and hot in summer and are likely to be foggy during the rather short winter, but the snowfall in these valleys is light. The growing season is long and favorable to peaches, melons, and similar tender fruits. In the higher mountains the snow lies deep, and the winter is comparatively long but not unusually severe. In the summer the days are cool and the nights are likely to be frosty. The slopes and valleys at intermediate levels enjoy a mild, semiarid climate that is especially invigorating to mankind and favorable to the growing of grains and the more hardy fruits. Moderately dry summers are the rule in the lower valleys, and to attain the best results with agriculture irrigation is necessary. No records of precipitation are available for the reservation, but records of the United States Weather Bureau for near-by localities that correspond in relative situation with the intermediate valleys of the reservation show a general average annual rainfall of 16½ inches. The northern and eastern portions of the reservation apparently receive more and the southern and western portions less than the average. The dust storms that are a characteristic feature of the Columbia Plain in summer sometimes carry clouds of fine particles well across Columbia River, where they settle and add to the soil cover within the reservation.

VEGETATION.

Except the portions southwest of Omak Lake and immediately north of Columbia River, which are almost without trees, the Colville Reservation is rather generally timbered. The forest cover is most luxuriant in the highlands of the north and northeast, where the smaller conifers and underbrush form dense thickets, but it becomes gradually open and scrubby toward the south and finally disappears. Large groves of yellow pine occupy the lower foothills and upper portions of the valleys of Nespelem and Sanpoil rivers and Omak Creek. East of the Sanpoil Range similar groves cover the valley lands almost to the bank of Columbia River. The open lands are well grassed and bear scattering growths of sagebrush.

SOILS.

The soils of the Colville Reservation, fertile almost without exception, are predominantly sandy or gravelly. They are for the most part composed of transported material, such as glacial drift, and bear little relation to the rocks on which they lie. A good example of this is seen in the plateau east of Okanogan River, on no part of which is the soil a product of the disintegration of the underlying basalt. In the unglaciated area the deep soils are in part residual, those over the sedimentary rocks composing the Covada group being more or less clayey, and those over granite being sandy. Even in these localities, however, the soil is in large part a fine dust of extraneous origin transported by the wind, as suggested by the summer dust clouds, from Columbia Plain. Little mounds or dunes of the light-brown loesslike dust have accumulated in the "scab rock" areas of the plateau east of Okanogan River. The silt beds of the Nespelem formation, where free of the gravel cover, afford a fine light-gray dusty soil similar in many ways to the loess.

GENERAL GEOLOGY.

SEDIMENTARY ROCKS.

COVADA GROUP.

DISTRIBUTION AND LITHOLOGY.

The oldest known rocks exposed in the Colville Reservation consist of a series of sediments and lavas that have been more or less metamorphosed and include shale, slate, argillite, schist, quartzite, conglomerate, limestone, and greenstone. These rocks are most extensively developed in the northeastern part of the reservation, where, underlying most of the Covada mining district, they occupy a belt about 8 miles wide that extends from the head of Ninemile Creek east

to Columbia River and thence north to the reservation boundary. Because no well-marked stratigraphic break was seen in these rocks, because sufficient fossils upon which to base time divisions were not found in them, and because they are most conveniently mapped and described as a unit, the name Covada, which has been applied to that portion exposed in the vicinity of Covada settlement,[1] may be extended to the metamorphic series as a whole, which is here designated the Covada group.

A second area underlain by the Covada group has the form of an irregular broken belt about 3 miles in average width that enters the reservation north of Park City, extends south across the Park City district, and curves westward to the head of Nespelem Valley. Elsewhere the group is limited to a number of small patches, most of which are near Keller and Nespelem. The reconnaissance geologic map (Pl. I, in pocket) shows, in generalized fashion, only the principal areas and patches, the aggregate area of which is roughly estimated at 250 square miles. Within the reservation the marginal portions of the various masses of the Covada group rest, for the most part, upon the Colville batholith. In detail their boundaries are extremely irregular. Along some of the mountain ridges, notably to the north of Twin Lakes, capelike projections of schist, commonly penetrated by offshoots of granite, reach far out over the main mass of the granite. Evidently the Covada group was formerly more extensive than now, and the small island-like patches of it are merely remnants of the roof or cover it once formed over the Colville batholith. Most of the small masses referred to probably sank in the granite magma before it solidified, and this is certainly true of some that are penetrated by mine workings but not exposed at the surface. West of Nespelem River a veritable shower of these fragments became detached from the roof and sank various distances.

In the two principal areas underlain by it the Covada group consists largely of a somber-hued argillaceous rock that commonly has a moderate degree of slaty cleavage or else a plainly marked, closely spaced bedding-like shale but in places is devoid of either structure. Very common also are bluish-gray beds that resemble chert or quartzite, and others that are soft, thinly laminated, and glossy black with included carbon dust. As a rule the different beds described grade into one another, and in fact sharp or sudden changes from one distinct variety to another are practically unknown. The gradational beds are commonly made up of very thin alternate light and dark layers, in which the minor structural features, such as plications, crinkles, and brecciation, are plainly shown. The varieties that

[1] Weaver, C. E., Geology and ore deposits of the Covada mining district, Wash.: Washington Geol. Survey Bull. 16, pp. 21–23, 1913.

resemble chert and quartzite are commonly darkened with a little carbon dust and, so far as they have been examined, appear to be metamorphosed shale or mudstone rather than true chert or quartzite. Quartzites, however, are doubtless present and may be represented by certain light-gray to white beds that occur in the Hall Creek basin. Because of the difficulty of making distinctions in the field the cherty or quartzitic appearing rocks, whether derived from shale or sandstone, have been called quartzite, and the term argillite as used herein doubtless in many places includes rocks that might be more properly classified as slate and shale. Some of the argillite and quartzite beds are calcareous, and distinct masses of limestone, greenstone, and conglomerate are interbedded with them, all with apparent conformity.

The limestone occurs in irregular lenses or podlike masses, a few of which are several hundred feet thick in places and may be traced a mile or two along the strike. Most of them, however, are smaller, and the average thickness is probably not more than 100 feet. As to details of form and distribution these limestones may be best described as erratic. Some of them taper to nothing at one or both ends, but more commonly they are cut off abruptly or end in a number of irregular blocks partly or wholly detached from the main mass. Although they are most abundant at certain horizons and in certain areas, as in the dark-colored argillites in the basin of Ninemile Creek, isolated masses may be found in any part of the section and anywhere within the areas occupied by the Covada group; and an apparent hit or miss distribution, as if each mass were independent of the others, seems to be a general and characteristic feature. In color the limestone ranges from white through bluish gray to black, and in texture from finely to coarsely crystalline. Many of the masses are rather pure calcium carbonate, as, for instance, one at the east side of Rattlesnake Mountain, for which Bancroft[1] gave an analysis showing 50.3 per cent of calcium oxide, equivalent approximately to 85 per cent of calcium carbonate. Some of them, however, appear to be very impure, containing much silica, magnesia, or other foreign substances.

Included under the term "greenstone" are fine-textured massive to schistose rocks that show dull shades of green and are noticeably heavy. A mass of this description, several hundred feet thick, crops out prominently on the southeast shoulder of Reister Mountain, and another at the mouth of Covada Creek. Microscopic examination of the rock of the latter mass shows it to be an altered amygdaloidal lava, originally a basalt. Schistose greenstones were observed near the Gwin mine and at the head of Silver Creek and are doubtless present in many other localities.

[1] Bancroft, Howland, op. cit., p. 13.

Beds of conglomerate crop out on Reister Mountain southeast of the Meteor mine, near the mouth of Covada Creek, and probably in other localities also. The bed on Reister Mountain is about 200 feet thick and consists of small, smooth pebbles of the different varieties of argillite in a firmly cemented sandy matrix.

Except the limestone, all the rock varieties mentioned above are to some degree schistose and over wide areas pass into rocks that may be appropriately designated mica schist. The rocks of all the island-like masses, the contact belts, and other large portions as well are decidedly schistose. A large part of the belt that occupies the basins of Nez Perce and Wilmont creeks consists of a lustrous gray to brown mica schist. The details of its margin show it to be a relatively thin remnant of a batholithic cover that in places has been so intricately intruded by thin sheets of granite or its aplitic derivatives as to strongly resemble a gneiss. Brilliant mica schists are especially abundant on Mica Mountain, and a dull dark-gray schist occurs at the west edge of the Park City belt. Many of the rocks that are too fine textured to be determined by the unaided eye are shown by the microscope to be essentially quartz-mica schists. These are especially common in the Sanpoil and Enterprise (Covada) districts.

Natural exposures of the argillite series are prevailingly of dull, somber shades of gray or yellowish brown, and the siliceous or cherty varieties and the greenstone form bold, prominent outcrops. Outcrops of the normal and the highly carbonaceous argillites and the argillite schists are subdued or inconspicuous, and for this reason their relative bulk is likely to be underestimated.

Chiefly because of the difficulty of unraveling the structural details no measurement or even reliable estimate of the thickness of the Covada group was obtained. Considering the vertical and horizontal extent of the exposures, however, it is safe to say that its thickness is to be measured in thousands rather than hundreds of feet.

STRUCTURE.

Except some general features, little was learned of the evidently complex structure of the Covada group. The difficulties in the way of deciphering the structure are due chiefly to the indistinct bedding and gradational character of the parts that compose the whole. Such contrasting beds as are present—limestone, conglomerate, and some of the greenstones—are comparatively few and nonpersistent, and their erratic occurrence is no doubt an expression of the structural complexity. As a rule, in crossing an exposure of the Covada group the observer is impressed with the uniform steepness of the dips and their numerous variations from one side of the vertical plane to the

other. Evidently in most places, as, for example, the Covada locality, the beds are thrown into relatively small, tightly compressed folds. Exceptionally, however, as in the upper Ninemile Creek and Park City localities, larger, open folds and even gentle flexures are indicated. Minor structural features such as crinkles and plications are superimposed on the larger features, and a slaty cleavage or a wavy schistosity is developed over wide areas. The pebbles of the conglomerates are commonly elongated or stretched, and the matrix is schistose. The average strike of the folds is north, and the variations do not generally exceed 20° to either side of the meridian. In the Covada district the general strike is a few degrees west of north; in the Sanpoil and Nespelem basins it shows a comparable variation to the east of north, and in the basin at the head of Ninemile Creek the strike varies from one side of the meridian to the other within the limits given.

In localities that contain mine workings faults are shown to be numerous, and the erratic form and distribution of the limestones and of some of the other beds indicate the probability that faults are widespread. The more prominent of the faults observed parallel the folds—that is, they strike approximately north; others depart widely from the general direction. In none of the larger faults was the amount of displacement ascertained.

REGIONAL METAMORPHISM.

The rocks that have been designated argillite, schist, quartzite, greenstone, and marble have been derived from other rocks by chemical and physical changes. For the most part these changes are due to long-continued burial and severe compression within the earth's crust, the results of which are known as regional or dynamic metamorphism. Rocks that were originally shales or mudstones have been compacted by pressure or tightly cemented by the recrystallization of their quartz or the addition of new silica into argillite and modifications of it that resemble chert or quartzite. Chiefly because of the great shearing strains they underwent, wavy cleavage and abundant mica were developed in the argillite or other rocks, changing them to schists. The greenstones were, at least in part, derived from basalt, the change in color being caused by a transformation of the originally black ferromagnesian minerals to the green epidote and actinolite. The original character of other greenstones is uncertain except that all represent metamorphosed rocks of basic composition. Regional metamorphism has changed the limestones in part to marble and given a schistose structure to the conglomerates, the deformed pebbles of which are an impressive illustration of the force applied.

CONTACT METAMORPHISM.

Changes induced in the Covada group by the invasion of the Colville granite are superimposed upon the characteristics developed by regional metamorphism, and in many places it is difficult to decide to which cause the alteration is chiefly due. As a rule, however, the effects of the contact metamorphism are specifically characterized by certain minerals, among which are andalusite, magnetite, garnet, and other lime-iron silicates. The belts in contact with the granite are the most severely altered, and the distance to which the effects of contact metamorphism are noticeable ranges from 1,000 feet to several miles, being dependent upon whether the contact approaches the vertical or horizontal planes. In certain areas, as the basin of Wilmont Creek, in which the argillites form but a shallow cover above the granite, the belt of contact-metamorphosed rocks is broad and contains exceptionally abundant mica. The effect of contact metamorphism upon limestones is shown by their complete alteration to marble or variegated hornstones or the development of complex silicates, such as garnet and the introduction of magnetite, pyrrhotite, and chalcopyrite.

CORRELATION AND AGE.

North of the Colville Reservation, in British Columbia, as far as the headwaters of the Yukon, rocks thought to be equivalent to the Covada group are exposed here and there. Particularly close resemblance is shown by the Attwood series[1] at Boundary Creek, the Slocan series[2] at Kootenai Lake, and the lowest member of the Cache Creek series[3] of the Kamloops district. To the west and southwest, respectively, the Chilliwack series[4] along the Canadian boundary and the Peshastin and Hawkins formations[5] of the Mount Stuart quadrangle bear striking similarities to the Covada group. To the south the probably equivalent formations are an argillitic series in northeastern Oregon[6] and certain members of the "Bedrock series" of northern California, notably the McCloud limestone and Nosoni formation.[7]

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[1] Daly, R. A., Geology of the North American Cordillera at the forty-ninth parallel: Canada Geol. Survey Mem. 38, pt. 1, pp. 382–383, 1912.

[2] LeRoy, O. E., Slocan district, British Columbia: Canada Geol. Survey Summary Rept. for 1909, pp. 124–132, 1910.

[3] Dawson, G. M., Report on the area of the Kamloops map sheet, British Columbia: Canada Geol. Survey Ann. Rept., new ser., vol. 7, pp. 37B–49B, 1896.

[4] Daly, R. A., op. cit., pp. 508–516.

[5] Smith, G. O., U. S. Geol. Survey Geol. Atlas, Mount Stuart folio (No. 106), pp. 3–4, 1904.

[6] Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, pp. 577–579, 1901. Pardee, J. T., and Hewett, D. F., Geology and mineral resources of the Sumpter quadrangle, Oreg.: Min. Res. Oregon, vol. 1, No. 6, pp. 30–35, 1914.

[7] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Redding folio (No. 138), p. 3, 1906.

In its general lithology the argillite series of the Colville Reservation shows a striking similarity to the formations mentioned, especially those of British Columbia, Washington, and Oregon. Everywhere the association of black carbonaceous argillite, quartzite or cherty argillite, greenstones, and limestones of erratic form and distribution is repeated. Dawson[1] records their wide distribution and lithologic sameness as follows:

> The rocks referable to the Cache Creek series have in fact now been found to occur at intervals from the southern boundary of British Columbia northwestward to the upper waters of the Yukon, characterizing particularly a belt of country which lies to the east of the coast ranges and which corresponds more or less closely with the Interior Plateau of the southern part of the province. Their lithological composition throughout this length of over 800 miles parallel to the general structure of the Cordillera is everywhere much the same, massive limestones, cherty quartzites, and volcanic products being characteristic.

In most of the localities mentioned fossils, among them *Fusulina*, of undoubted Carboniferous age have been found. In the opinion of the geologists who described them the Attwood, Chilliwack, and Slocan series and the Peshastin formation are partly equivalent to the Cache Creek series between which and the Carboniferous rocks of the Taylorville region, Cal., a correlation is suggested by Dawson.[2] Fossils collected from limestones in the argillite series of northeastern Oregon are reported by G. H. Girty to "point to a relationship to the upper Carboniferous of California" and to suggest a correlation with the Nosoni formation of the Redding quadrangle. Thus a chain of Carboniferous rocks of generally similar lithology, extending from Alaska to California, seems fairly well established, and the position of the Colville Reservation strongly suggests that the Covada group is one of the links.

Fossils are extremely rare and poorly preserved in the Covada group, as, indeed, is to be expected in rocks that have been so extensively deformed and metamorphosed. The few that have been found lend their support, however weak, to the correlation proposed above. From limestone on the east side of Rattlesnake Mountain near Covada Bancroft[3] collected fossil remains of a plant provisionally described by David White as Carboniferous. Some coral fragments found by the writer in a small limestone reef on Lime Creek in sec. 25, T. 31 N., R. 32 E., 9 miles north of Keller, are reported by G. H. Girty to be "probably Paleozoic." The fossiliferous limestones are so closely associated with the other beds of the Covada group, as a rule, that all appear as if belonging to a single formation. The only indication of a stratigraphic break observed is given by the beds

[1] Dawson, G. M., op. cit., p. 47B.
[2] Idem, p. 48B.
[3] Bancroft, Howland, op. cit., pp. 14–15.

of conglomerate near Covada that contain waterworn pebbles of the other rocks in the series. These beds may possibly separate Mesozoic from Paleozoic argillites, as the former are reported[1] at a locality but a short distance to the north, namely, Sheep Creek, on the international boundary between Columbia and Kettle rivers. On the other hand, as suggested by its great apparent thickness and the fact that Devonian rocks in the Redding quadrangle, Cal.,[2] are somewhat similar lithologically, the Covada group may descend in the geologic time scale below the Carboniferous.

TERTIARY LAKE BEDS.

Shale and sandstone that crop out in a small area in the Park City district near Crounse's are correlated, as described on page 90, with the Oligocene or Miocene lake beds exposed at Republic, Wash. Although of very small area the occurrence is important because it fixes the age of the extensive lava beds associated with it.

GLACIAL DRIFT.

Within the area of Pleistocene glaciation drift is irregularly but rather generally distributed. The most extensive accumulations are in the upper valleys of Omak Creek and Nespelem River, the valley south of Omak Lake, and Twin Lakes basin. In these localities its depth ranges from 100 or perhaps as much as 200 feet down to the vanishing point, but probably averages less than the mean. Elsewhere the drift is in general of patchy occurrence and as a rule but a few feet thick. In the Colville Reservation the drift topography is characteristically irregular, but typical moraines are uncommon. Terraces, gravel flats, esker-like ridges, and combinations of these forms prevail, indicating the large part played in the deposition of the drift by running water, evidently as a result of the mountainous character of the region. Because the bulk of the ice lay in the valleys the bulk of the drift was deposited there and became thus most favorably situated for the concentration of floods upon it. Localities in which glaciofluviatile forms are especially well developed are the basin at the head of Omak Creek, the valleys of West Fork of Sanpoil River, Gold Creek, and Barnaby Creek, and the vicinity of Buffalo Lake.

In composition the drift ranges from a compact clayey till, which is uncommon, to loose water-assorted gravels, which form the bulk of the deposits. For the most part the gravels are subangular and indistinctly stratified, but all gradations from typical till to water-laid gravel, sand, and silt beds are seen. Boulders are plentiful and of characteristically irregular distribution. In any particular

[1] Daly, R. A., op. cit., pp. 322–323.
[2] Diller, J. S., op. cit., pp. 2–3.

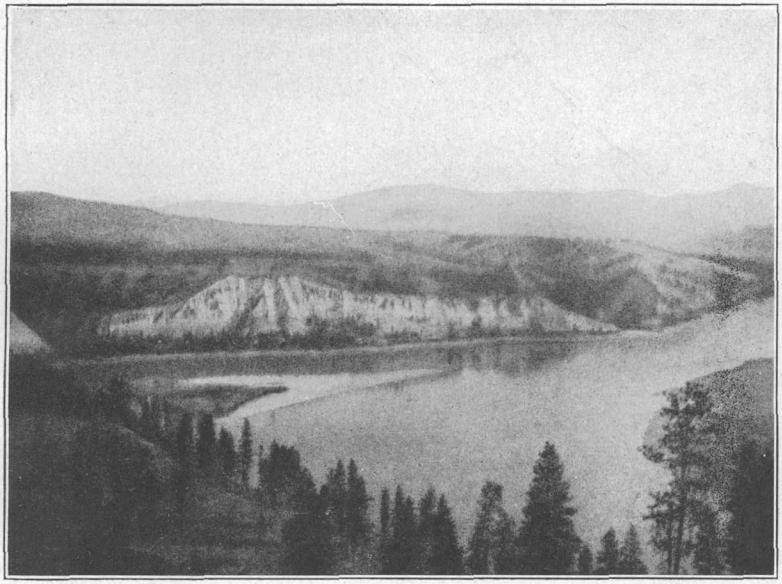
locality, as a rule, the largest proportion of the drift is derived from the rock formations that lie within a comparatively short distance to the north, and in addition a close examination will commonly discover fragments of rocks that crop out in more distant localities. The relative abundance of any particular rock variety is roughly a measure of the size of or distance to its outcrop. For instance, a large proportion of white quartz in the drift east of Twin Lakes directs attention to several large outcrops of that rock 3 or 4 miles to the north.

NESPELEM SILT.

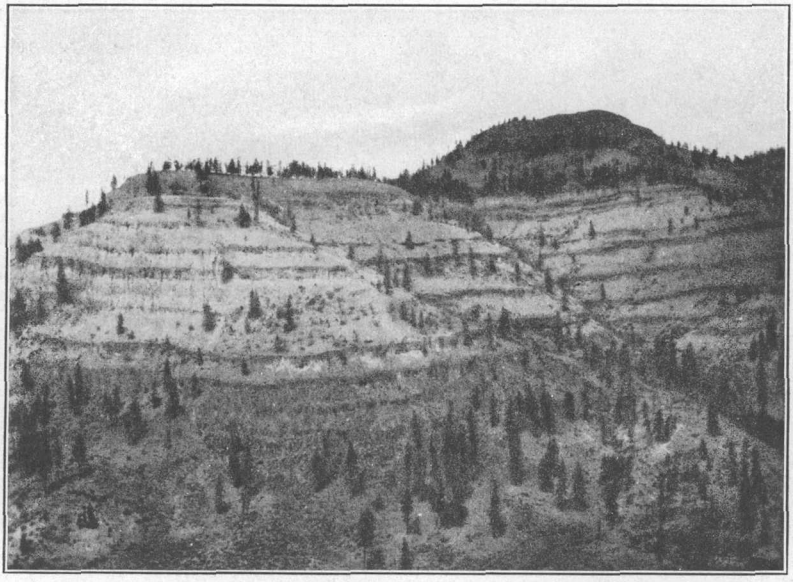
The terraces that line Columbia River valley and the correlated flats that fill the mouths of tributaries at elevations between 1,700 and 1,800 feet, including the exceptionally well-developed flat below Nespelem village, are composed of unconsolidated lake and stream sediments of glacial origin, for which the name Nespelem silt is proposed. The maximum thickness of the Nespelem silt, equivalent to the vertical distance between Columbia River and the Nespelem flat, is about 750 feet. Upstream the thickness gradually lessens to 500 or 600 feet near the north boundary of the reservation. Below Nespelem River the formation has not been identified with certainty, although similar material underlies some of the terraces in the Columbia and Okanogan valleys.

The bulk of the Nespelem formation is composed of very light colored silt, good exposures of which appear nearly white at a distance. In detail it shows various pale tints of gray, buff, and pink, and locally thin bands of dark gray and blue gray. In places thin beds and lenses of sand and fine-textured gravel are interbedded in the upper part of the formation and commonly form the top layer. The bedding of the silt is thin and fairly distinct, as a rule, and locally it exhibits a shaly parting that causes it to split into leaves as thin as paper. A poorly developed vertical jointing is expressed by a tendency to form vertical bluffs that resist weathering fairly well, considering the lack of induration in the beds. A very picturesque group of the bluffs is seen on the bank of Columbia River adjacent to the mouth of Nez Perce Creek. (See Pl. V, *A*.) The Nespelem silt yields readily to erosion and many of the terraces are badly channeled by rain gullies and steep-walled ravines. (See Pl. II, *B*.) Where present the gravel serves in a measure to protect the underlying silt, but at the same time it works down over the slopes, giving an exaggerated impression of its thickness.

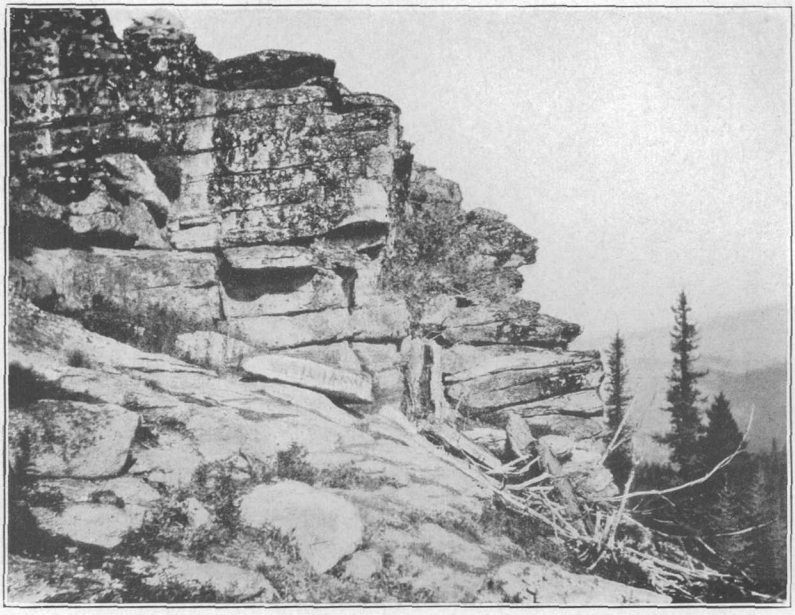
To the touch the silt is commonly smooth and even velvety, although the unctuous feel of clay is not very noticeable. It is composed of microscopic grains, many of which are irregular and sharp



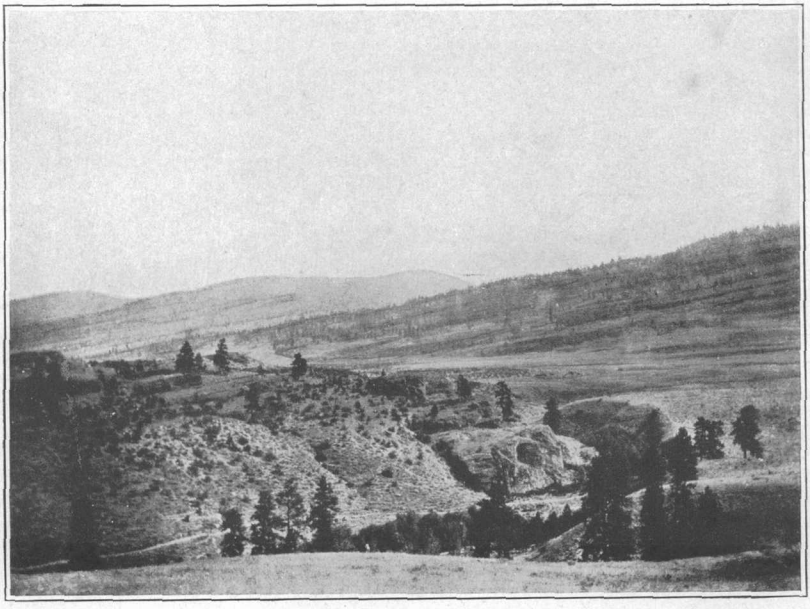
A. COLUMBIA VALLEY AT NEZ PERCE CREEK.



B. MOUNT KIKIYIS.



A. GRANITE AT SUMMIT OF WHITESTONE MOUNTAIN.



B. GRANITE IN OMAK VALLEY.

cornered and consist of quartz and undecomposed feldspar, mica, and other minerals; in short, the beds are composed largely of the glacial product termed rock flour.

Near the mouth of Nespelem River the Nespelem silt overlies glacial drift of the earlier epoch, and along Columbia River above the mouth of the Spokane it is deposited upon the latest drift. Its relative position, together with its indicated origin from the melting of glacial ice, therefore establishes its age fairly definitely as of the latest epoch of deglaciation in the Pleistocene. At its greatest development it filled that portion of the Columbia Valley between the north boundary of the reservation and Nespelem River to the 1,700-foot contour. Apparently it did not fill Okanogan Valley and Columbia Valley below Nespelem to an equal height, although knowledge of those localities is less definite.

From the agreement in their composition and occurrence there seems to be little doubt that the Nespelem silt and the White Silt formation in southern British Columbia described by Dawson[1] are equivalent.

IGNEOUS ROCKS.

SERPENTINE.

Serpentine dikes were observed in the vicinity of the Congress mine at Bridge Creek, along the lower course of Stepstone Creek north of Nespelem, and near the Controller and Red Bird mines, at the east edge of Nespelem Valley. The principal dike in the Bridge Creek locality is from 200 to 500 feet wide and is rather poorly exposed in the distance of a mile or more along the divide north of the Congress mine. Other dikes occur next to the Congress vein and in the claim of J. H. McJunkin. Their outcrops are weathered dark brown and exhibit surfaces that are rough and hackly in detail. The fresh rock is heavy, is dark green to light gray, and breaks into fragments bounded by characteristic curved slick surfaces. Under the microscope it shows mesh structure, suggesting a derivation from dunite. On Stepstone Creek the serpentine occupies most of a belt a mile long and one-fourth of a mile wide, but the exposures are poor. The rock is gray to green and otherwise characteristic of its species. The dikes near the Red Bird and Controller mines are small.

In each place the serpentine intrudes rocks of the Covada group, and in the Nespelem district it is itself cut by the Colville batholith. Its age is therefore between the two and most probably Mesozoic.

[1] Dawson, G. M., Report on the area of the Kamloops map sheet, British Columbia: Canada Geol. Survey Ann. Rept., new ser., vol. 7, pp. 283B–291B, 1896.

GABBRO.

A large dike at Park City, imperfectly exposed at the surface, is penetrated by underground workings on the Iron Dike claim. The weathered rock is a dark-brown earthy material, rich in iron oxides. Fresh specimens are heavy, dark green, and coarsely crystalline. The rock shows abundant secondary sulphide minerals and is traversed by veinlets of calcite. Its chief constituents are plagioclase and augite. The mass has been sheared and contains much secondary calcite, pyrrhotite, pyrite, sphalerite, and some epidote. The dike is intrusive in argillite of the Covada group, and its altered condition suggests that it is older than the Colville granite.

COLVILLE GRANITE BATHOLITH.

FORM AND EXTENT.

The principal rock of the Colville Reservation is an intrusive granite whose exposures occupy at least 1,000 square miles. Many parts of the reservation that show basalt and other rocks at the surface are evidently underlain by the granite, and the total horizontal extent of the batholith within the reservation is estimated at not less than 1,700 square miles. In addition the mass is known to extend for at least short distances beyond the reservation's northern and southern limits. At a distance of 10 miles to the south the granite is exposed between Creston and Fellows, stations on the Washington Central branch of the Northern Pacific Railway, and if the granite in the Grand Coulee[1] is to be correlated with the Colville mass the whole body may have a roughly circular plan as great as 60 or 70 miles in diameter. Within the reservation the actual horizontal limits of the mass are shown only in the Covada and Park City districts. In these localities the granite abuts against the rock of the Covada group, and is plainly shown by the outward pitch of the contact plane to be considerably enlarged in depth.

As a rule the boundary of the batholith is marked by apophysal dikes and other offshoots, the details of which are extremely irregular and intricate. Outlying masses appear here and there, the largest of which, near Covada, with an area of about 8 square miles, has been described under the name of Meteor granodiorite.[2]

The Colville batholith is but a few miles south of several large areas of intrusive granitic rocks that occupy most of southern British Columbia adjacent to the international boundary. As shown by the

[1] Russell, I. C., A geological reconnaissance in central Washington: U. S. Geol. Survey Bull. 108, p. 90, 1893.

[2] Weaver, C. E., Geology and ore deposits of the Covada mining district: Washington Geol. Survey Bull. 16, p. 23, 1913.

geologic map of North America,[1] these masses break through metamorphic Paleozoic rocks and are closely grouped about the southeast end of the huge Coast Range batholith of British Columbia. Southeast of the Colville Reservation is another huge intrusive granitic mass generally known as the great batholith of central Idaho. The distance between the two at the surface is about 120 miles, but if the superficial rocks were stripped away they would doubtless be seen to approach more closely.

In the northern Cascade Mountains are several granitic batholiths not far from the Colville Reservation. One of the best known of these is the Mount Stuart batholith,[2] about 50 miles southwest of the Colville body; the intervening space is partly occupied by similar rocks.

LITHOLOGIC CHARACTER.

Typical phase.—In its typical exposures the granite is a light-gray or pinkish-gray rock of medium texture, containing phenocrysts of feldspar that are commonly an inch or two long and project on weathered surfaces. The outcrops are light colored as a rule, are characteristically rounded, and on most of the higher mountains can be seen and recognized from long distances.

In composition the typical rock is a soda-rich granite that consists essentially of soda-lime and potash feldspars, quartz, and a comparatively small proportion of moderately fine brown mica. Named in order of their abundance the minerals of the groundmass are andesine or oligoclase (about $Ab_{70}An_{30}$), quartz, orthoclase or microcline, commonly both, or microperthite, and biotite. Some or all of the minerals, titanite, magnetite, apatite, and zircon, are present as accessories. Most of the phenocrysts are orthoclase, contain zonal inclusions, and are twinned according to the Carlsbad law. Specimens of the typical rock from widely separated localities show little or no variation.

Marginal variations.—Noticeable changes, however, are shown by the marginal portions of the batholith. In these the prevailing light-gray tint gives place to darker shades of gray and greenish gray produced by the accession of hornblende and larger proportions of biotite, which is itself of coarser crystal habit than common. Quartz is less abundant, the orthoclase phenocrysts are rare or absent, and the rock species ranges from granodiorite to quartz diorite. This marginal basification is well shown southeast of Twin Lakes and west of the Meteor mine. Specimens from these localities consist essentially of andesine, biotite, quartz, and hornblende, named in the order of their abundance, together with the common accessory min-

[1] U. S. Geol. Survey Prof. Paper 71, pl. 1, 1912.
[2] Smith, G. O., U. S. Geol. Survey Geol. Atlas, Mount Stuart folio (No. 106), p. 4, 1903.

erals. Elsewhere the marginal variation is perhaps best shown around the island-like masses of argillite on Boot Mountain and Cartar Hill and in Nespelem Valley.

Apophyses and outlying masses, notably that at Covada described by Weaver[1] as granodiorite, are also as a rule more basic than the main batholith. Their close relation to the main mass, however, is plainly shown by close agreement in texture and qualitative mineralogy, particularly the occurrence of sodic plagioclase.

Pegmatoid varieties.—Bodies of pegmatite or a pegmatoid variety of the granite are common but are not sharply separable from the main mass. They are moderately coarse textured, and the quartz and feldspar have crystallized in interlocking rectangular patterns that resemble graphic granite. This modification is shown over considerable areas at the head of Lynx Creek, to the southwest of Mica Mountain, and elsewhere. Dikes of a siliceous ilmenite pegmatite, described on page 151, occur near the head of Wilmont Creek, and small aplitic derivatives are abundant around the margins of the batholith.

Secondary alteration.—Changes in appearance and composition due to secondary hydrothermal alteration of the granite are conspicuous in most of the mining localities.

In the Sanpoil district, in a broad belt that extends from Keller to the north of Brush Creek, the outcrops are discolored with iron oxides and the fresh rock commonly shows pale shades of green. The dark mica is absent or decolorized, the feldspars are partly altered to sericite, and portions of the mass have been highly silicified. Specks and films of pyrite and locally of chalcopyrite are widely disseminated. Within the replacement vein belt of the Nespelem district a similar but less widespread alteration is well shown in the walls of the veins and in the exposures at the head of the Nespelem cascades. In the stream bed at the cascades the granite is pale green, has a waxy luster, and contains pyrite. Adjacent weathered exposures are reddish brown. In the Covada and Park City districts the alteration is not conspicuous to the unaided eye, but the microscope shows that sericitization has destroyed the feldspar in part and was locally accompanied by the formation of chlorite and calcite.

STRUCTURE.

The most common structural features of the Colville granite are three systems of widely spaced joints, two of which approach the vertical and the other the horizontal plane. As a rule one set of

[1] Weaver, C. E., Geology and ore deposits of the Covada mining district: Washington Geol. Survey Bull. 16, pp. 23–26, 1913.

joints is more prominent or more closely spaced than the others, good examples of which are the predominant flat joints at the summit of Whitestone Mountain (Pl. VI, *A*). Over considerable areas, however, other structural features are developed, among which may be included the fault and vein systems of the several mining districts.

In the Sanpoil district a large area coinciding with that of hydrothermally altered granite contains extensive groups of shear zones and closely spaced fractures that collectively cut the rock into small fragments. Fractures and shear zones are common also in the areas of altered granite in the other districts, in none of which, however, has the rock been so extensively broken as in the Keller locality. The strike of the most prominent of the faults and shear zones averages N. 45° W. in the Nespelem district and about N. 15° W. at Keller and Covada. Dips are steep as a rule. Fairly prominent cross faults and shear zones occur, and small fractures of various directions are numerous. Repeated faulting and grinding movements have taken place on most of the fractures, but the displacement, if any, effected at any particular locality is not known.

The most noticeable and extensive local structural feature in the Colville granite is a schistose or gneissic foliation that is characteristic of considerable areas along Omak Creek (Pl. VI, *B*) and the westerly tributaries of Hall Creek. In the Omak Creek area a schistose cleavage that dips 15°–20° W. is so plainly developed that outcrops seen at a distance suggest a thin-bedded sedimentary rock. A large proportion of the mica is concentrated in parallel bands that wrap or bend around the feldspar phenocrysts. As the rock almost invariably splits along the micaceous layers, which conceal the lighter minerals from view, it appears much darker in outcrops than the unmodified granite. The feldspar phenocrysts are slightly distorted, and the groundmass shows evidence of shearing strains. Except for the presence of a little muscovite mica the gneiss does not differ in mineralogy from the typical granite, of which it is evidently a dynamic modification. In the Hall Creek area the gneiss ranges in dip from 15° E. to 15° W. and its mica is for the most part white; otherwise it does not differ in composition from the typical granite.

AGE AND CORRELATION.

The Colville batholith was evidently intruded after the Covada group had been regionally metamorphosed, because tightly folded fragments of the Covada rocks have sunk in the granitic magma. As the great folding in this region involves sediments of probable Mesozoic age, the granite is probably not older than Jurassic. On the

other hand, the granite had been deeply trenched by erosion before andesite and lake beds which there is good reason to believe are Miocene, or at least Tertiary, were laid down upon it. No positive evidence fixing the age of the batholith within narrow limits was found, but as a great deformation is known to have taken place in this general region at the end of the Jurassic period, the Cretaceous is thought the most probable time of intrusion. The succeeding time would be ample for the very considerable erosion before the Tertiary formations were deposited.

So far as the meager knowledge of its petrologic details permits, the Colville batholith shows a general correspondence with the neighboring intrusive masses of British Columbia. It is very similar in mineralogy to the Similkameen and Cathedral batholiths,[1] exposed at the international boundary, about 50 miles northwest of the reservation, but differs from them considerably in structure and age. It also contains features in common with some of the other intrusive masses, notably the Rykert granite,[2] in southern British Columbia. On the other hand there is a general similarity in composition, structure, and age between the Colville granite and that of the great batholith of central Idaho,[3] which is less than 120 miles away. Their nearness, general similarity in composition, and agreement in age rather strongly suggest a close relationship between the Colville batholith and that of Mount Stuart, Wash. Whether the Colville mass is to be correlated with the batholiths of Idaho, Washington, or British Columbia or is a link between them are interesting questions that to answer definitely will require more extended petrographic study.

LAMPROPHYRE.

Lamprophyric dikes are not abundant in the Colville Reservation. A few small ones were seen in the vicinity of Covada. One of these in the NW. ¼ sec. 36, T. 32 N., R. 36 E., that cuts argillite is dark green to black, heavy, and coarsely crystalline. Its chief constituents are hornblende, augite, plagioclase, orthoclase, and quartz, named in the order of their abundance. Three or four similar dikes were seen in other parts of the township. All of them show hornblende conspicuously and intrude rocks of the Covada group not far from the granite contact.

[1] Daly, R. A., Geology of the North American Cordillera at the forty-ninth parallel: Canada Geol. Survey Mem. 38, pt. 1, pp. 455–464, 1912.

[2] Idem, pp. 284–287.

[3] Lindgren, Waldemar, A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: U. S. Geol. Survey Prof. Paper 27, pp. 17 et seq., 1904.

DIORITE, ANDESITE, AND RELATED PORPHYRIES.

GENERAL DISTRIBUTION.

Intrusive and extrusive andesitic rocks that occupy considerable areas in the Sanpoil drainage basin and elsewhere are so intimately associated and closely related that they are, for comparison, described together. The principal belt of these rocks crosses the reservation from Hellgate Rapids on Columbia River northward, passing out at the entrance of Sanpoil Valley. This belt, which is traversed for the most of its length by Sanpoil River, ranges from 3 to 10 miles in width and has an area of about 250 square miles. Another area of about 50 square miles extends as a broad belt from the vicinity of Nespelem northeastward, joining the Sanpoil area near Park City. Elsewhere these rocks were observed only in a small area on the divide north of Omak Valley and as a few patches here and there.

OCCURRENCE.

Diorite.—The western portion of the Sanpoil area, extending from Meadow Creek northward to the basin of Twentythree Mile Creek, is occupied by a granular intrusive rock that ranges from quartz diorite to basic granodiorite. This belt, which is about 4 or 5 miles across at its widest part, lies mostly west of Sanpoil River. Its extreme northern portion, however, crosses the river, which has excavated a narrow valley in the mass at the locality known as Devil's Elbow. In the Nespelem area similar rocks are confined to a few moderately large dikes southeast of Moses Mountain. The area north of Omak Valley is almost wholly of diorite, and isolated dikes of that rock were observed at the north end of Omak Lake, near Covada, and elsewhere.

Andesite.—Rocks mapped as andesite underlie nearly half of the Sanpoil area, occurring in two portions separated from each other by the diorite at Devil's Elbow. The smaller portion lies mainly east of Sanpoil River, extending as a belt 2 or 3 miles wide from the locality mentioned south to Keller; the other portion widens from 3 or 4 miles north of the diorite to 8 or 10 miles at the north boundary of the reservation and is bisected lengthwise by Sanpoil River. In the Nespelem area small patches of similar rocks occur in the upper valley east of the river.

Porphyry.—Rocks that range from quartz diorite porphyry to granodiorite porphyry or quartz monzonite porphyry form the remaining unit of the group under discussion. These rocks occupy the east side of the Sanpoil area in a practically continuous belt that extends from Hellgate Rapids to the reservation's north boundary. The Nespelem area is chiefly occupied by them, and dikes thought

to be correlated with them occur in many places elsewhere. The main bodies are themselves made up of great numbers of dikes, large and small, that cut the surrounding rocks in the most intricate manner and also cut one another. The boundaries as drawn on the reconnaissance geologic map (Pl. I, in pocket) omit details and separate in generalized fashion only belts that are chiefly porphyry and chiefly granite, argillite, or other rocks. Thus a great many patches of granite and other rocks not shown on the map lie within the mapped porphyry belts and almost innumerable tongues and dikes of the porphyry project beyond those belts. These modifications do not apply, to so great an extent, to the boundaries mapped between the porphyry and younger rocks, such as basalt, although they, too, are generalized. More or less isolated dikes of porphyry form an extensive fringe attached to the southwest end of the Nespelem body and are very numerous also west and northwest of Keller. The mapping of these dikes also gives but a combined generalization of occurrences that individually are numbered by hundreds. Elsewhere in the Colville Reservation correlative dikes are rather sparingly distributed.

LITHOLOGIC CHARACTER.

Diorite.—Good exposures of the diorite, locally known as Devil's Elbow granite, are made by the cliffs and steep slopes adjacent to Sanpoil River at Devil's Elbow. The fresh, clean surfaces of the cliffs and blocky fragments in the talus below show a moderately dark-gray rock of medium grain and fine texture. Small shiny scales of dark mica and grains of black hornblende are abundantly distributed through a groundmass that, so far as the unaided eye can detect, consists of milk-white feldspar. Back from the river the rock forms rounded, rather inconspicuous outcrops that weather brownish gray. The mass north of Omak Valley forms prominent outcrops along an east-west divide that attains an elevation of 5,700 feet. The exposures are severely glaciated and but slightly weathered and resemble the fresh surfaces of the diorite at Devil's Elbow. A few aplitic dikes less than a foot in width are present near its margin. Elsewhere dikes classified as diorite are similar in general appearance to the principal bodies described, although some of them are weathered to shades of brown.

Microscopic examination of a few specimens from the Sanpoil area of diorite show it to consist essentially of plagioclase (andesine-labradorite), hornblende, orthoclase, biotite, and quartz, named in the order of abundance, together with one or more of the accessory minerals titanite, magnetite, apatite, and zircon. The rock is therefore a quartz diorite verging on the border of granodiorite. No

orthoclase was observed in specimens from the mass north of Omak Valley, which is otherwise similar to that just described. A dike about 3 miles southeast of the summit of Moses Mountain shows augite and hypersthene instead of hornblende, and a dike a short distance west of the Silver Leaf mine, in the Covada district, contains hornblende and augite intergrown. Dikes at the north end of Omak Lake and at Duly Lake, on the Okanogan Plateau, both schistose in structure, contain secondary epidote and chlorite.

Andesite.—As is well illustrated on the south slope of Mount Kikiyis (Pl. V, *B*), the north shoulder at the entrance to Bridge Creek valley, the principal masses of andesite are built up of several layers that represent successive lava flows. The upper half of the slope is ascended by large steps or benches, each representing a separate flow, of which at least 10 that range from 30 to 100 feet in thickness can be counted. On Mount Chilimas, the opposite or south shoulder, a thickness of at least 1,800 feet of lava is measured by the difference in elevation between Sanpoil River and the summit. The general plan of the lava belt, together with its relation to the granite and older rocks, as exhibited in the vicinity of Keller, shows that it lies in an old valley eroded in the granite. Near Keller the floor of the old valley is 300 or 400 feet above Sanpoil River. Descending northward it passes beneath the bed of that stream near the mouth of Cache Creek and remains below, except where cut out by the diorite intrusion at Devil's Elbow, to the reservation boundary and beyond. In addition to those at the mouth of Bridge Creek, the andesite forms bold and prominent exposures all along the valley of Sanpoil River, particularly the cliffs 1,000 feet or more in height at the mouth of West Fork. In general the outcrops appear a dull brown or brownish gray. Freshly broken surfaces are light gray to greenish gray. Small laths of black or green hornblende and grains of white feldspar distributed through a fine-textured groundmass are commonly visible to the unaided eye. The rock ranges from dense to vesicular, and in the vesicular variety the cells are commonly filled with chalcedony or other secondary minerals. North of West Fork of Sanpoil River, at a point about a mile east of Crounse's, several beds that aggregate 100 feet or more in thickness of gray shale and sandstone are interbedded with the andesite. For the most part the beds consist of fine water-laid tuff, and in one or two places they contain very thin beds of coal.

At a point due north of Alkire, near the boundary of the reservation, a flow conglomerate is associated with the andesite. It contains both angular and smooth cobbles and boulders of greenish-gray porphyry and dark argillite embedded in a dark greenish-gray fine-textured matrix.

A specimen from the lower portion of a lava flow that crops out near the summit of Mount Chilimas contains phenocrysts of plagioclase, brown hornblende, hypersthene, and augite (named in the order of abundance) in a crystalline groundmass. Another from the spur south of Lime Creek is similar except that the hypersthene is replaced by a deep-green serpentinous substance. One from the small patch of andesitic lava in the upper part of Nespelem Valley contains quartz and biotite and may be classified as dacite.

Porphyry.—As a rule the porphyry forms prominent knobs and ridges that, where not smoothed by glaciation, are usually rough and rugged. Very picturesque outcrops form the immense walls and buttresses that rise above Columbia River at Hellgate Rapids and the large knob farther upstream known as Whitestone Rock. The general tint of the outcrops is a dull gray or brownish gray, although commonly they show very light shades and in some places a dash of green. Locally, as near the head of the Nespelem basin, and in small areas elsewhere, the outcrops are noticeably rusty, owing to the weathering of secondary pyrite. Fresh surfaces of the most common phase of the porphyry are medium gray to pale greenish gray. As a rule the fine-textured dark-gray groundmass is crowded with phenocrysts of milk-white feldspar less than one-eighth of an inch in diameter, together with a few small laths of black or green hornblende. One uncommon phase shows clusters of fine biotite, and another, called quartz porphyry in the field, contains quartz phenocrysts half an inch or less in diameter in a very light gray groundmass.

Specimens from the most abundant phase of the porphyry at points near the Golden Cord mine, on Silver Creek; on the slope north of Thirtymile Creek; and on the divide between Meadow and Jack creeks contain phenocrysts of plagioclase (andesine-labradorite), hornblende, biotite, and augite, the augite mostly replaced by actinolite or epidote. The groundmass is chiefly microgranular orthoclase and quartz with more or less micropegmatite. In specimens from the valley of John Tom Creek and the vicinity of Park City the ferromagnesian minerals are replaced by secondary calcite and chlorite. A dike that crops out on a spur about 3 miles west of Mission is a distinctly porphyritic light-gray rock with a pale-green cast, the phenocrysts in which are plagioclase, embayed quartz, and biotite. The microgranular groundmass consists of quartz and orthoclase; there is also considerable secondary calcite and epidote. In the Covada district and elsewhere are small dikes of fine-textured light-gray rocks that are too badly decomposed for identification and have been included in the porphyry group under discussion.

STRUCTURE.

Except for rather widely spaced joints, the diorite of the Sanpoil area in general is structureless. A small portion of it, however, lying between Empire and Lime creeks, plainly exhibits a schistose structure. As the evidence seems quite plain that this body has never been deeply buried, the schistosity must have been induced before the rock had completely solidified and while it was yet plastic. In the diorite north of Omak Valley no structure other than joints was observed, but the dikes at the north end of Omak Lake are decidedly schistose.

A common structure of the andesite is a closely spaced, slightly curved jointing that causes the rock to break down in small fragments having the shape of distorted cubes or rhombs. Platy structure and a columnar jointing similar to that of basalt are shown here and there. The beds exposed on Mount Kikiyis lie in the trough of a wide, gentle syncline whose axis trends north. North of Devil's Elbow some smaller folds appear and locally the beds dip as steeply as 40° from the horizontal.

The most common structural feature of the porphyries consists of closely spaced joints that meet at oblique angles and cause the rock to break into sharp-cornered fragments. Platiness is rare. As a rule the variety containing quartz phenocrysts has been crushed and sheared and shows the effects of hydrothermal alteration.

GENERAL RELATIONS.

The age relations between the diorite, andesite, and porphyries are well shown in the Sanpoil area. The less abundant dikes of quartz-bearing porphyry are evidently the oldest of the group. Not only are they cut by the other intrusive members, but they show deformative structure and hydrothermal alteration not displayed by the younger rocks. The bulk of the porphyry and the andesite are contemporaneous. Porphyry dikes pass up various distances into the andesite and apparently end in flows. Some dikes cut through the whole thickness of lava and also cut other dikes of the same composition. The diorite invaded the latest andesite flows now remaining but was itself cut by still later dikes of the porphyry.

Specimens from the contact belt of andesite and other rocks invaded by the diorite show some secondary epidote, but the evidences of contact metamorphism die out at a distance of a few feet. The metamorphism produced by the porphyry intrusions is even less noticeable. As the diorite body is almost batholithic in dimensions, the metamorphism it has caused appears remarkably slight. This is thought to signify, however, that the intrusion approached close to

the surface, so that its vapors or other metamorphosing emanations were able to escape freely.

CORRELATION AND AGE.

In the Nespelem Valley and on both sides of Columbia River near Whitestone Creek eroded surfaces of porphyries belonging to the rock group under consideration are overlain by the basalt of the Columbia Plain. A considerable time interval between the two is indicated by the extent to which the porphyry and associated rocks were worn away by the erosion referred to on page 42. The lesser age of the basalt is also shown by its relatively fresh appearance and lack of deformation compared to the beds of andesite that are contemporaneous with the porphyry as observed a few miles north of Whitestone Creek. In the south wall of the Columbia trench the thickness of basalt overlying the old erosion surface mentioned is in places more than 1,000 feet. Near Whitestone Creek, where the porphyry is strongly developed, the basalt is at least 500 feet thick. As the basalt of the Columbia Plain is known to be middle Miocene, the diorite, andesite, and porphyry group is thought from the foregoing considerations to be not younger than Oligocene.

Between the northern boundary of the reservation and Republic, Wash., the andesitic beds are apparently continuous. At Republic they are interbedded with fossiliferous sediments of similar composition to those exposed on West Fork near Crounse's, described on page 27. One lot of fish remains obtained from these sediments was assigned by C. R. Eastman[1] to the Oligocene or, possibly, lower Miocene. Another collection, composed of fossil leaves, is provisionally determined by F. H. Knowlton[2] to be Upper Miocene. In view, however, of the uncertainty expressed by Knowlton and the fact that the continuity of the andesite beds from the Colville Reservation to Republic seems unbroken, the assignment of an upper Miocene age to the andesite may be seriously questioned. It is difficult, if not impossible, in view of their relations, to conceive of the andesite and associated rocks as contemporaneous with or younger than the basalt.

BASALT.

Basalt underlies the Okanogan Plateau and the other similar tablelands adjacent to Columbia River. Its thickness ranges from 50 feet or less to 1,000 feet and is greatest near the river, where the mass includes several lava flows. Northward from the river the formation thins out, its higher beds successively overlapping the lower. The

[1] Umpleby, J. B., Geology and ore deposits of Republic mining district, Wash.: Washington Geol. Survey Bull. 1, p. 25, 1910.

[2] Bancroft, Howland, The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, pp. 141–142, 1914.

basalt in the Colville Reservation is similar in appearance to the basalt in general in eastern Washington. It is black, dense, and heavy, and the exposed edges of the lava sheets are commonly broken into colonnades, a result of the characteristic columnar parting. Another parting that is seen not infrequently causes the rock to break into small distorted cubes and rhombs. Cliff-like exposures are abundant and conspicuous around the margins of the table-lands and in the coulees that traverse them. The tops of the table-lands, however, are generally covered with soil or drift except in a few places where the black frost-cracked surfaces known as "scab rock" appear.

A specimen from the topmost flow in Okanogan Plateau west of Duly Lake shows abundant small cleavage faces of feldspar and, with the aid of a hand lens, crystals of olivine. Microscopic examination shows that the rock consists of laths of labradorite, grains of augite, and crystals of augite, magnetite, and apatite, named in the order of their abundance. The olivine is partly altered to iddingsite, and between the feldspar laths there is a small amount of brown clouded glass showing incipient crystallization.

The basalt appears everywhere to lie horizontal, but a slight southward dip, amounting to 500 feet in 12 miles, is shown on the Okanogan Plateau. As no lava vents were seen, particularly around the highest point, where the exposures are good, and as the basalt dies out to the north after the manner of overlapping beds, the flows could not have come from the north and the dip is interpreted as evidence of deformation.

The basalt of the Colville Reservation is evidently to be correlated layer by layer with that of the Big Bend country or Columbia Plain, on the opposite side of the river. The lowest exposed portions of the basalt lie on a surface eroded across the principal body of porphyry of the Sanpoil belt.

In the Yakima Valley,[1] 75 miles to the southwest, and in the John Day region[2] of Oregon, 200 miles south of the Colville Reservation, what is regarded as the same body of basalt is determined somewhat definitely to be of middle Miocene age.

The origin of the basalt is apparently somewhere outside of the Colville Reservation, probably to the south. Except one very small dike, no lava vents were seen within the reservation.

GEOLOGIC HISTORY.

During at least the later Paleozoic and perhaps early Mesozoic periods the present site of the Colville Reservation was submerged

[1] Smith, G. O., U. S. Geol. Survey Geol. Atlas, Ellensburg folio (No. 86), p. 3, 1902.

[2] Merriam, J. C., A contribution to the geology of the John Day basin: California Univ. Dept. Geology Bull., vol. 2, No. 9, p. 303, 1901.

by a shallow sea that probably extended continuously from Alaska to California. While this sea existed a great thickness of muds and fine sands settled on its bottom. At times lavas of basic composition were poured out and became interbedded with the accumulating sediments. At other times conditions became favorable to the growth of corals, and reefs of limestone were built.

In late Mesozoic time the sea disappeared and great mountain-building forces transformed its area into an elevated land. The fine sediments were compacted into shale and sandstone and bent into northward-trending folds. In places very basic igneous magmas were intruded, solidified as dikes of dunite or a related rock species, and later became changed to serpentine. During the processes of intrusion and the subsequent changes minerals of chromium, iron, and nickel were either segregated or concentrated in places along the margins of the dikes.

Repeated severe compression and shearing during long periods of time changed the shales and sandstones into argillite and quartzite and finally into schist, faulting them and pinching the folds together. At or shortly after the end of this great deformation a huge body of igneous magma invading the rocks from below solidified to become the Colville granite batholith. Vapors or other emanations given off by the magma metamorphosed the adjoining rocks and charged them in places with ores of iron and copper. As the batholith cooled cracks were formed in its shell and in the adjoining rocks, in which emanations from its still hot deeper portions deposited ores of silver, lead, zinc, and other metals.

Then followed a long period characterized chiefly by erosion, in which the surface was lowered and the granite exposed to view. In the succeeding Oligocene and Miocene epochs the degraded surface was warped, faulted, elevated, and further eroded. Igneous magmas again invading the rocks from below reached and overspread the surface and cooled to form bodies of diorite, porphyry dikes, and sheets of andesitic lava. A subsequent, comparatively brief erosion period, in which the land was sculptured to a semblance of its present form, was followed by the outpouring of great floods of basalt that submerged the then rugged surface of east-central Washington and diverted Columbia River north and west around the lava plain thus formed. After sufficient time had elapsed for the Columbia to sink its channel 1,600 feet or more below the northern edge of the lava plain, the present site of the Colville Reservation was largely overridden by the Cordilleran Pleistocene ice sheet. When the ice finally withdrew the land was so low that the present 1,700-foot contour and possibly, for a brief time, still higher ones coincided with the level of the sea.

The water body thus produced in the Columbia Valley became silted up, then gradually the land rose to its present altitude, the river reestablished its channel, and the surface assumed its present form.

PHYSIOGRAPHIC HISTORY.

A significant feature in the physiography of the Okanogan Highlands is the general northerly direction of the main divides and valleys. Furthermore, where the strongly deformed older bedded rocks (Covada group) appear at the surface, they are seen to strike in the same direction. Presumably, then, the ranges and valleys owe their inception and arrangement to the folding of the Covada group, a process thought to have begun soon after the disappearance of the sea from this general region in late Mesozoic time. Although the first mountains thus established on the new-made land were purely structural forms, erosion doubtless soon left its marks upon them and, indeed, may have reduced them completely. Certain elevated flats observed in many places in the Northwest, particularly in the Clearwater region of Idaho[1] and in the Republic mining district,[2] but a short distance north of the Colville Reservation, have been interpreted by the geologists who described them as the remnants of an extensive plain of erosion developed in early Tertiary time. No surfaces seen in the Colville Reservation, however, were determined as older than middle Tertiary. If the more ancient plain was developed in that area, it has been completely destroyed.

It is quite certain that subsequently in many other portions of the Northwest, and presumably in the Colville Reservation also, the peneplain or the surface contemporaneous with it was elevated, warped, and faulted, and new ranges and valleys that followed essentially the old structural trend were formed. This process was probably repeated, and thus through recurring cycles the early established direction has persisted and the main northerly valleys of to-day are viewed as the descendants of Mesozoic ancestors, although the argillites in which the ancient valleys were molded have in many places been worn completely away.

At an early stage of the physiographic development a deep, wide valley had its head near Keller and, coinciding approximately in position with the present Sanpoil Valley, extended northward beyond the reservation. What is presumably the same valley was recognized by Umpleby[3] at Republic, Wash. Little can be said as to the features

[1] Lindgren, Waldemar, A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: U. S. Geol. Survey Prof. Paper 27, pp. 14, 26, 1904.

[2] Umpleby, J. B., Geology and ore deposits of the Republic mining district: Washington Geol. Survey Bull. 1, p. 11, 1910.

[3] Idem, pp. 11–12.

of other parts of the reservation at that time except that a valley of unknown dimensions existed along the upper course of the present Nespelem River.

Subsequently these valleys were filled with lava of an andesitic type with which, notably at Republic, lake and stream sediments were interbedded. Fossil leaves and fish remains found in the lake beds serve to fix their age, and consequently the time of the volcanic eruptions, as either Miocene or Oligocene.

After this event the region was again deformed, as shown by gentle folds in the lava and lake beds. Then for a considerable time erosion held undisturbed sway, and the record of it is plainly preserved. In the Sanpoil drainage basin north of Keller the numerous long mountain spurs that project prominently from the main divide almost to the river are flat-topped at an elevation of approximately 3,500 feet. Many of the flats are half a mile or more wide and from good viewpoints appear as the remnants of the level floor of a wide valley. To the east and west this elevated valley is walled in by the comparatively narrow and low summit ridges of the Sanpoil and Nespelem ranges, extends northwestward around the end of the Nespelem Range, and becomes continuous with an undulating plateau that occupies the drainage basin of Gold Creek. In the Gold Creek area this erosion surface, which for convenience may be referred to as the Sanpoil surface, truncates granite and rocks of the argillite series, and in the Sanpoil basin it cuts across the gently tilted beds of andesite.

Elsewhere in the reservation evidences of corresponding surfaces are not so clear. East of the Sanpoil Range are some flat-topped spurs which, together with the surface in general underlying the basalt, are believed to be of about the same age as the Sanpoil surface. Before the basalt was extruded, however, the surface represented by the spurs was modified somewhat by deformation and erosion. That it was elevated locally at least is shown by the deep stream channels that are sunk below it, notably in the Gold Creek and Sanpoil drainage basins. Relative depression or downwarping of the surface is strongly suggested also. The Nespelem Valley, for instance, viewed broadly and without regard to the numerous stream channels that furrow its slopes, is a smooth, elongated dishlike basin. This form, which it is difficult to regard as produced by erosion alone, is similar to many others caused by Tertiary deformation in the northwestern region. The sharp unconformity between the slopes of this basin and the Sanpoil surface as exhibited directly south of Park City surely could not have been produced by other than deformative processes. Likewise a basin at the head of Ninemile Creek is thought to be a structural depression of similar age.

The angles at which tributaries join a main stream are, within certain limits, highly significant as showing whether or not the stream has always flowed in the same direction as at present. In drainage systems that have been undisturbed by deformation or other changes of the surface for a long time, the tributaries all tend to flow in the same direction as the main stream. Thus, in going down a stream of this character branches coming in from the right and left will be observed to approach it gradually and join at acute angles. An upstream direction of the tributaries relative to the main stream means, as a rule, that the trunk stream at no very distant geologic time flowed in the reverse of its present direction. After the lapse of a long period, however, the tributaries of a reversed stream will have shifted their channels toward the normal arrangement, and the record of the reversal may be partly or even wholly lost.

For Sanpoil River the evidence of reversal is fairly well preserved, but it is complex, as if several changes had occurred. However, a former northward flow beyond Devil's Elbow, about 18 miles north of Keller, is fairly well shown. Devil's Elbow is a crooked, gorge-like constriction in the valley of Sanpoil River where it traverses a belt of diorite. It is probable that this resistant rock was never entirely planed down to the level of the Sanpoil surface, and thus it formed in early times a divide between north and south drainage systems. Thirtymile Creek was then the head of Sanpoil River, which was therefore but a comparatively insignificant stream. Within the Gold Creek basin the evidence that drainage, at present northward, was formerly to the south is clear. The main forks of Gold Creek point south or southeast and from their present junction a fairly broad valley, sunk 200 or 300 feet below the Sanpoil surface, leads directly southward past Park City to the Nespelem basin. Evidently the Tertiary Gold Creek flowed to the south for a considerable time through this valley, now long abandoned.

The Sanpoil erosion surface is not to be confused with the surface represented by the Columbia Plain, the Okanogan Plateau, and the table-lands of the Nespelem Valley, described on page 16. Comparison of the two brings out the fact that the Sanpoil surface has suffered an incomparably greater erosion. If, as is believed, the slopes of the Nespelem basin are part of the Sanpoil surface, then that surface has also been considerably deformed. Both these considerations point to the much greater age of the Sanpoil surface. Moreover, from the facts given on page 16, it appears that the Columbia Plain is a constructional surface and the lavas that built it are observed to lie upon the surface represented by the generalized slopes of the Nespelem basin. In other words, the deformed and eroded Sanpoil surface passes beneath the Columbia Plain.

The erosion period that followed a gentle deformation of the Sanpoil surface was suddenly interrupted by the extrusion of vast quantities of basaltic lava over an area of thousands of square miles that includes the greater part of eastern Washington and touches the Colville Reservation on the south. Observations adjacent to the reservation and at other localities [1] show that the surface overspread by the molten mass is uneven. The cross section made by the trench of Columbia River at the south border of the reservation shows a moderately rough profile beneath the basalt.

In a distance of 50 or 60 miles this surface has an extreme relief of 1,600 feet or more, but in general it is characterized by rather low, rounded hills and wide valleys. Furthermore, the sections outlined on both sides of the river correspond, showing that the topographic features now covered by the lava of the Columbia Plain are the severed southward continuations of the valleys and divides of the Colville Reservation.

Before the lava was extruded, therefore, east-central Washington, instead of being a plain, must have been a region of moderately rugged topography and, like the Colville Reservation, characterized by a general northerly trend of its divides. A central lowland existed, no doubt, and toward this the Columbia, Nespelem, and other streams maintained their southward courses to points well beyond the present southern limit of the reservation. As successive flows of lava, some of them separated no doubt by considerable time intervals, gradually obliterated the topography many changes and readjustments of the drainage must have taken place. Of these little record is available except as the drilling of a well now and then brings to light a buried gravel channel, commonly a source of abundant water. When the final sheet of basalt had solidified Columbia River was forced to its present course along the northern border of the mass. Although in general it followed the sinuous edge of the plain, projecting mountain spurs caused it to cut across the tongues of lava that extended up the smaller valleys. Thus, as its channel was deepened to bedrock the small table-lands of basalt in the Nespelem Valley and elsewhere were cut off from the main mass. Into the Okanogan Valley or an embayment corresponding to it the lava extended as a broad tongue, along the northeast side of which the river first excavated a channel, now the Omak Lake trench. Later, for some unknown cause, the Columbia abandoned this channel for its present one, which leads westward across the lava tongue to the mouth of the Okanogan, thus cutting off the Okanogan Plateau.

[1] Smith, G. O., U. S. Geol. Survey Geol. Atlas, Mount Stuart folio (No. 106), p. 7, 1904; Geology and physiography of central Washington: U. S. Geol. Survey Prof. Paper 19, p. 28, 1903.

Although the Columbia Plain has been more or less extensively channeled, at least that portion of it in and adjacent to the Colville Reservation has suffered no general reduction in level by surface planation. The remnants existing within the reservation, as described on page 16, evidently still preserve the level at which the last basalt flow came to rest.

Between the time of the last basaltic flow and the beginning of the Pleistocene epoch Columbia River excavated its gorge, more than 100 miles in length, to the present depth of 1,600 feet or more. While the main stream accomplished this imposing work its tributaries deepened their valleys proportionately. Nespelem River made a new valley along the west edge of the lava tongue that filled its old one. Whitestone Creek cut in two a small lava patch that obstructed the mouth of its valley. In the Sanpoil Valley, however, no vestige of any lava tongue remains—a strange thing in view of the fact that on either hand much smaller valleys still contain basalt. Its absence here suggests that the Sanpoil Valley was much smaller and shallower then than now, as it would have been if the divide that limited its drainage basin at Devil's Elbow was at that time still in existence. However, with the deepening of Columbia River the Sanpoil, because of the increased grade thus afforded, no doubt enlarged its valley rapidly and soon worked headward, capturing streams north of its original basin, until its present drainage area beyond Devil's Elbow was appropriated.

In the Pleistocene epoch ice sheets descended from the north, glaciated most of the reservation, and even crossed the Columbia gorge at right angles, pushing far out over the Big Bend country. They rounded and smoothed prominent surfaces and dammed some of the valleys with drift, but did not modify the general surface greatly. Glacial and interglacial stream erosion probably enlarged some preexisting channels, notably the Omak Lake trench and the Sanpoil Valley. Goose Lake, in the Omak Lake trench, is the remnant of an abandoned large river channel so freshly preserved that it can not be thought of as older than Pleistocene. As suggested by other observers, the Sanpoil Valley probably contained a very large stream for a time, and its present dimensions are no doubt due in considerable measure to this erosion.

Adjacent to the Colville Reservation the highest large terraces of the Columbia Valley have been carved from sediments (Nespelem silt) composed chiefly of the residual silt of melting glaciers. This material, which evidently settled from still water, lies upon drift deposited directly by the ice and formerly filled the valley to the 1,700-foot level. Therefore the sediments were formed during the final deglaciation of the region, at a time when the ice had with-

drawn from the Colville Reservation but still remained along the upper Columbia. It follows that the river was ponded for a considerable time to the contour which is at present about 1,700 feet above the sea.

In southern British Columbia similar terraces, described by Dawson,[1] in the valleys of the Fraser River system and at Okanogan Lake, have a maximum development at 1,700 feet also, and their identity in composition with those of the Colville Reservation leaves little room to doubt their correlation. Other terraces that occur in British Columbia at different elevations up to 2,500 feet[2] may also correspond with terraces or shore lines seen in the Columbia Valley above the 1,700-foot level, but knowledge of the latter is too meager to warrant a positive correlation.

Terraces in the Columbia Canyon above Wenatchee, a town about 50 miles downstream from the Colville Reservation, are described by Russell[3] and mentioned by other observers. The most prominent, called the great terrace by Russell, is about 500 feet above the river, equivalent to about 1,200 feet above the sea. From a point a short distance below Chelan Falls this terrace may be traced up Columbia and Okanogan rivers to Pogue Flat, near the town of Omak, which is its northern end. Unlike the terraces described it is composed of gravel instead of silt, and is clearly glacial outwash deposited by a large stream that once discharged into the Okanogan Valley through the valley of Johnson Creek. Evidently at some time after the Nespelem silt had been deposited and eroded Okanogan and Columbia valleys from Omak to a point below Chelan Falls were filled with gravel to the 1,200-foot contour. This gravel can not, of course, be correlated with the Nespelem silt, but its deposition is thought to have been caused in a similar manner by ponding.

Along Snake River near Lewiston, Idaho, gravel terraces at elevations between 150 and 350 feet above the stream, or between 1,000 and 1,200 feet above the sea, are ascribed by Russell[4] to overloading or choking of the streams with sediment. Like the terraces of the Columbia, however, they may be explained also as a result of ponding. If the flats from which they were carved were simply the work of overloaded streams, their surfaces should rise more steeply upstream than the channels they smothered, a consideration which the meager observations available do not support. It is thought likely that the

[1] Dawson, G. M., Report on the area of the Kamloops map sheet, British Columbia: Canada Geol. Survey Ann. Rept., new ser., vol. 7, pp. 283B–291B, 1896.

[2] Idem, p. 289B.

[3] Russell, I. C., The great terrace of the Columbia and other topographic features in the neighborhood of Lake Chelan, Wash.: Am. Geologist, vol. 22, p. 365, 1898; A geological reconnaissance in central Washington: U. S. Geol. Survey Bull. 108, pp. 77–80, 1893.

[4] Russell, I. C., A reconnaissance in southeastern Washington: U. S. Geol. Survey Water-Supply Paper 4, p. 56, 1897; Geology and water resources of Nez Perce County, Idaho: U. S. Geol. Survey Water-Supply Paper 53, pp. 49–72 et seq., 1901.

terraces of both Snake and Columbia rivers are due to the same cause.

Dawson[1] interprets the ponding as the result of a regional depression, because of which the water bodies in the Fraser Valley were in direct communication with the sea and were governed in their level by the sea level at that time. If the correlation of the 1,700-foot terrace level between the Fraser and Columbia valleys is correct, it is certain that the cause was more than local in character.

When the ultimate drainage level stood at the several heights mentioned, considerable areas in eastern Washington must have been submerged. The existence of a Pleistocene water body in this region has been recognized by Symons[2] and Russell.[3] The latter concluded that the water body, which Symons had named Lake Lewis, stood for a brief time at the present 1,400-foot contour and expressed the opinion that it would adequately account for the great terrace of the Columbia. If, as is believed, Lake Lewis is to be correlated with one of the stages of the Pleistocene water body in which the Nespelem silt accumulated, the further idea suggested by Russell that a glacial dam obstructed Columbia River at The Dalles seems unlikely, because the lake persisted after the glaciers generally had dwindled away. However, as it has not yet been proved that the glaciers of the Cascade Range did not again advance after the Cordilleran ice finally withdrew, the idea of glacial damming can not be excluded.

That the water body was fresh rather than salt is suggested by the narrowness of the Columbia gorge through the Cascade Mountains, by which it was connected with the sea. The lake doubtless had a large outflow, whose volume may have been sufficient to occupy the gorge to the exclusion of the sea water.

Adjacent to the Colville Reservation the water body held by the Columbia Valley at the present 1,700-foot contour was long, narrow, and exceedingly irregular in the details of its shores. The river, swollen and silt laden from the melting glaciers above, began filling the lake or estuary with the fine light-colored sediments that form the Nespelem silt. Thus a flat or delta grew downstream, displacing the water not only of the main body but of the bays at the mouths of tributary valleys, until it reached a point at least below Nespelem. Then the region was reelevated, or some other event lowered the base-level to the present 1,400-foot contour, where it remained for a considerable time. As a result the river swept away

[1] Dawson, G. W., op. cit., p. 284B.

[2] Symons, T. W., Report of an examination of the upper Columbia River: 47th Cong., 1st sess., Senate Ex. Doc. 186, p. 109 and map following sheet 25, 1882.

[3] Russell, I. C., A geological reconnaissance in central Washington: U. S. Geol. Survey Bull. 108, pp. 26–27, 1893.

all but a few remnants of the silt above the newly established base level, which in turn was similarly lowered, another set of terraces carved, and this process continued until the stream reached its old channel in the bedrock.

While Columbia, Okanogan, and Sanpoil rivers thus reexcavated their valleys, none of the other streams of the Colville Reservation accomplished a like result. At the beginning of the down-cutting each stream had wandered to one side of the flat formed in its valley at the 1,700-foot level, and becoming intrenched on a high point of the bedrock it has been held in that elevated position to the present day. The most conspicuous example is afforded by Nespelem River, which, having turned west of its old course below the Indian agency, became intrenched on the buried prolongation of the mountain spur on which the Little Chief mine is situated. Over the resistant rock of this spur, in which it has not yet had time to wear a deep channel, the stream descends to Columbia River in waterfalls and cascades, at the same time being unable to destroy the level silt plain above the spur.

A peculiarity of the smaller eastward or westward flowing streams that demands special explanation is their persistent tendency to choose the south sides of their flats at the 1,700-foot level. It is most plainly shown by Ninemile and Hall creeks and the tributaries of Sanpoil River, which have become firmly intrenched in bedrock at the south edges of their flats. When newly formed the flats were level, and had they remained so the streams would not have chosen any one side, as a rule, in preference to the other. Therefore the conclusion is drawn that coincidently with its reelevation the area was tilted gently southward, or, in other words, that the elevation was greatest to the north. Hence the streams would naturally seek the lower south edges of their flats, and to this slight circumstance is chiefly due the preservation of valuable lands and the making of the falls over which the streams rush to join the main rivers.

GLACIAL HISTORY.

As indicated in the foregoing paragraphs, a large part of the Colville Reservation has been heavily glaciated. In fact the greater part of the area, having been overridden by two main lobes of the Cordilleran ice sheet, lies within the region of continental Pleistocene glaciation. The larger of the two lobes mentioned flowed down the Okanogan Valley, and covered all of the reservation west of the Nespelem Range. It not only filled the Columbia Valley from the Grand Coulee to Chelan Falls but pushed far out on the Big Bend plateau.[1] The other main lobe occupied the Columbia Valley down

[1] Salisbury, R. D., Glacial work in the western mountains in 1901; Jour. Geology, vol. 9, pp. 721–722, 1902.

almost to its west bend below the mouth of the Spokane. Above Nez Perce Creek it covered all the surfaces west to the main ridge of the Sanpoil Range, but below that point it was a relatively narrow tongue confined within the valley proper of Columbia River. In addition, a narrow ice tongue that branched from the Okanogan lobe north of the latitude of Lake Owhi extended down the Sanpoil Valley at least as far as Iron Creek.

The Okanogan lobe was so vast and had so much momentum that the valley or gorge of Columbia River, 2,000 feet deep, was unable to halt or even swerve it from a southward course. Within the reservation the mass must have been several thousand feet thick, all the surfaces west of the Nespelem Range, except possibly the summit of Moses Mountain (6,500 feet), having been submerged by it.

The erosive action of this glacier is abundantly shown by worn surfaces, particularly on prominences that lay in the path of the main current down the Okanogan Valley. At the entrance of the Omak Lake trench south of Mission, for example, two bold headlands exhibit extensive rounded and grooved rock surfaces that are especially impressive. In addition to the loose mantle rock considerable of the bedrock must have been removed from all exposed places, and it is evident that some of the valleys, such as the Omak Lake trench, were deepened and enlarged by the ice.

Over the scratched and worn surfaces the glacier left a mantle of drift that is patchy, as a rule, but here and there is thick and extensive. East of Mission the valley of Omak Creek is largely overspread with drift that in places attains depths of 100 feet or more. Moses Meadows, portions of the Nespelem Valley, and an area south of Omak Lake contain notably extensive deposits. Huge transported boulders (Pl. IV, p. 18), not inaptly named by the settlers "haystack rocks," are objects of striking interest within the glaciated area. In portions of the Nespelem Valley and the Okanogan Plateau these erratic masses are especially large and numerous. They may also be seen scattered as far as the eye can reach to the south in the Big Bend country, where they dwarf the farmers' houses by comparison. The larger boulders were plucked by the ice from the basalt cliffs at the edges of the Okanogan Plateau and similar table-lands and transported various distances southward. Among the smaller ones granite and gneiss are common, and other rocks foreign to the district occur.

In the undrained hollows of the drift that mantles the surface of the Okanogan Plateau are scores of ponds. Lakes Owhi and Buffalo occupy valleys dammed by drift, but Omak Lake fills a rock basin that was probably excavated by the ice. Goose Lake is merely a hole in the bed of what in Pleistocene time was a large river.

The lobe that descended the Columbia Valley reached an elevation of at least 5,000 feet at the north boundary of the reservation, and the ice was therefore about 4,000 feet deep over the bed of Columbia River. Toward the south its thickness decreased, as shown by the descent of its west margin to an elevation of 2,500 feet or less at the mouth of the Nez Perce Creek, and it ended at a point a few miles below the mouth of Spokane River. North of Nez Perce Creek the surface was scoured severely, but south of that point the ice apparently had little erosive power. It deposited a drift sheet that was comparable in general features to that left by the Okanogan lobe and was particularly extensive in the basin of Twin Lakes. Erratic boulders are likewise common but of much smaller average size than in the Okanogan area. Twin Lakes are held by drift dams and smaller lakes and ponds in undrained hollows are fairly plentiful in the northern part of the glaciated area.

In the Sanpoil drainage basin glaciation is general to the north of Bridge Creek. South of that point the plainer evidences of ice action are found only on the lower slopes adjacent to the river as far downstream as Iron Creek. On Mount Chilimas at the mouth of Bridge Creek, however, evidences of two summit levels of the ice are shown 600 feet and 1,800 feet above the river. The lower level was that of a tongue that left plain evidences of its advance as far as Iron Creek, where it apparently ended. The higher level was that of an ice stream of whose extent below Bridge Creek the records are poorly preserved. A few erratic boulders, however, distributed as far downstream as Keller, may mean that the ice reached that far.

Two levels of glaciation are also distinctly shown at Twin Lakes, the dam of which is the lateral moraine of the smaller glacier, deposited at an elevation of about 2,750 feet, or about 1,000 feet below the level of the greater lobe. A similar curtailed advance of the ice to the head of the Nespelem basin is shown by a moraine that in part forms the divide between that basin and the basin of Gold Creek. Whether or not a similar glacier occupied the Okanogan Valley was not definitely ascertained, but its probable existence is surmised from the fresh appearance of glaciated surfaces and of the drift north of Mission. The comparatively recent age of the lesser glaciation is indicated by the practically unmodified condition of its drift and the insignificant amount of weathering exhibited by its scoured rock surfaces. On the other hand, that considerable time has elapsed since the disappearance of the more extensive glacier is shown by the partial destruction and erosion of the glaciated surface. In the basin of Nespelem River on the spur west of Stepstone Creek, in sec. 17, T. 32 N., R. 31 E., an angular boulder of granite 8 feet in diameter is perched on a pedestal of monzonite porphyry 2 feet high. The under side of the boulder is planed flat and bears grooves

and ridges that fit into similar scorings that strike S. 40° E. on the surface of the underlying porphyry. Evidently the boulder remains on the striated surface of the formerly hard and solid porphyry in the precise position where it was left by the ice. Although the rock of the pedestal is now softened and partly decomposed, the boulder has protected it in a large degree from the weathering that has disrupted and decomposed the adjoining rock. Furthermore, the surface on which the boulder rests slopes not more than 15° SE., although the adjacent hill slope descends at an angle of 30° for 100 feet or more to the valley below. These facts show that an erosion period, long enough to deepen the valley perhaps as much as 50 feet, has elapsed since the ice withdrew.

HISTORY OF MINING.

Formerly the Colville Indian Reservation included all the land between Columbia and Okanogan rivers and the international boundary. On February 21, 1896, that portion north of the present boundary, locally designated the "north half," was restored to the public domain. The remaining portion, or "south half," was opened to mineral entry July 1, 1898. The name Colville attaches to a historic locality entirely outside the reservation as at present bounded. Originally the reservation lay wholly east of Columbia River and derived its name from Fort Colville or the Colville Valley, which were included within its limits. After a brief period, however, it was shifted without change of name to its present position west of the river.

Gold placers, of which the most productive are along Similkameen River, west of the Colville Reservation, were the first metalliferous deposits discovered and worked in this general region. Between 1870 and 1890 bars along Columbia River adjacent to the reservation were mined intermittently, mainly by Chinese. Although they are reported to have been rich in places, the pay gravel was thin and the total production was probably not great.

Prior to the opening of the present reservation to mineral entry, several valuable lodes in the adjacent areas, including those at Republic, had been developed. A rush of prospectors followed the opening, and it is said that within a short time 3,000 or more claims were located. Within the next 10 years the several mining districts were organized, a few stock companies were promoted, and a copper smelter, which has, however, never been in operation, was built at Keller at a reported cost of $300,000. After this period, in which no important discoveries were made, mining activity declined generally, many prospects were abandoned, and many others were worked only

enough to comply with the law. Relatively a few, however, were developed more extensively, and a very small number have become productive.

PRODUCTION.

The total metallic production, except placer gold, of the Colville Reservation up to 1912 probably did not exceed $25,000, all but a trifling proportion of which is to be accredited to silver. Authentic records show a production of about $12,000 from the Nespelem district and $3,500 from the Covada district. Somewhat indefinite reports place the production of the Park City district at $4,500 and claim a small additional output for Nespelem. In the Sanpoil district small shipments of unknown value are said to have been made prior to 1912. Since that date a production of about $2,500 in silver has been reported (April, 1915). The production of placer gold, obtained chiefly from the bars along Columbia River, is unknown but is thought to have been small.

CONDITION OF THE MINING INDUSTRY.

In August, 1913, in addition to a few that had been patented, between 200 and 300 claims were being maintained by annual assessment work, as required by law. On less than a dozen of these, from three or four of which ore was being shipped intermittently, additional development work was being prosecuted. Two additional mines have since been reported (April, 1915) as producing.

The principal causes of this comparatively inactive condition are the fact that the ores are not free milling and the lack, so far as known, of bodies large and rich enough to offset the high cost of transportation. No bonanza of sufficient size to attract general attention to the area, stimulate exploration, and invite the building of railroads has yet been found. At present the claim owners as a rule are able to do little more than mark time, awaiting the improvement in transportation facilities that will doubtless come eventually, either as a result of the gradual settlement of the country or the hoped-for "big strike." Whether or not bonanzas will be found can not be confidently predicted. In view, however, of the superficial character of the development work, together with the evidences of mineralization exhibited in the mining districts, the possibilities of finding bonanzas are by no means lacking. The developments made so far have shown, in addition to a few rich ore bodies, many comparatively small ones of medium to low grade that could be profitably worked if cheap transportation were available. The outlook at present, therefore, is good for increasing activity in the future.

GENERAL FEATURES AND DISTRIBUTION OF THE MINERAL DEPOSITS.

The mineral deposits in the Colville Reservation of predominant interest at the present time are metal-bearing lodes. Placers are of relatively little economic importance, and although the area is well supplied with limestone, building stone, and ordinary clay, these deposits are undeveloped and chiefly of future value.

Most of the lodes may be classified as simple and multiple veins, and these may be further subdivided into filled fissures and replacement veins. Some of them are large, but by far the greater number are comparatively small. Mineralized shear zones and disseminated deposits, some of which are extensive, are fairly common, and gradations between them and simple veins are to be seen. Silver is the principal valuable constituent in most of the veins and shear zones. As a rule lead is associated with the silver, and in some deposits it is of equal value. Zinc is almost as widely distributed and abundant as lead, but under present smelter practice it is commonly penalized instead of paid for. In a few deposits, however, zinc minerals predominate. Copper is present in many deposits, but except in some of the larger shear zones and disseminated deposits it is of little value. Gold occurs sparingly in most of the lodes, but in few does it add materially to the value of the ores. Antimony and molybdenum are possibly important in exceptional localities.

The remaining kinds of deposits in Colville Reservation may be grouped broadly as contact-metamorphic deposits. A very few show gradations between replacement deposits on the one hand and deposits formed by magmatic segregation on the other. Copper is the most valuable constituent in most of them, nickel in two, and although gold, silver, lead, and zinc are present in many, they occur in relatively small proportions.

Two periods of mineralization are shown, the earlier of which was associated with the intrusion of serpentine or the rocks from which serpentine is derived. So far as known the deposits of this date are limited to the nickel-bearing lodes. The later period of mineralization was associated with the intrusion of the Colville granite batholith and is separable into two epochs. In the earlier epoch the copper-bearing contact-metamorphic deposits are thought to have been formed at the time when the granite came to place, and the silver-lead-zinc lodes are believed to be later effects of that intrusion.

The contact-metamorphic deposits of the Nespelem district are similar in general features to those of southern British Columbia. The silver-lead-zinc lodes of the Ninemile Creek, Bridge Creek, and Iron Creek localities are similar to limestone replacement deposits generally in the Northwest, but the bulk of the lodes of the Keller

and Covada localities are of mixed rather than well-defined types and are not strictly comparable with lodes in other areas. All the lodes seen in the Colville Reservation are older than the principal deposits at Republic, 12 miles to the north.

Most of the known lodes of economic importance are confined within four more or less definite areas situated near Nespelem, Park City, Covada, and Keller. The Keller area contains several somewhat separate and distinct centers of mineralization—namely, the Keller, Manila, Silver Creek, Iron Creek, Bridge Creek, and Ninemile Creek localities. In each of the other areas most of the lodes are found within belts a mile or two in width and 3 or 4 miles in length, the remainder being more or less scattered but in the main clustered around centers.

With respect to rock formations, the lodes are about equally distributed between the Colville granite and the Covada group, and are seldom found very far from the contact plane between the two. In none of the formations later than the Colville granite, including diorite, porphyry, andesite, basalt, and the superficial sedimentary rocks, have any metal-bearing lodes been discovered.

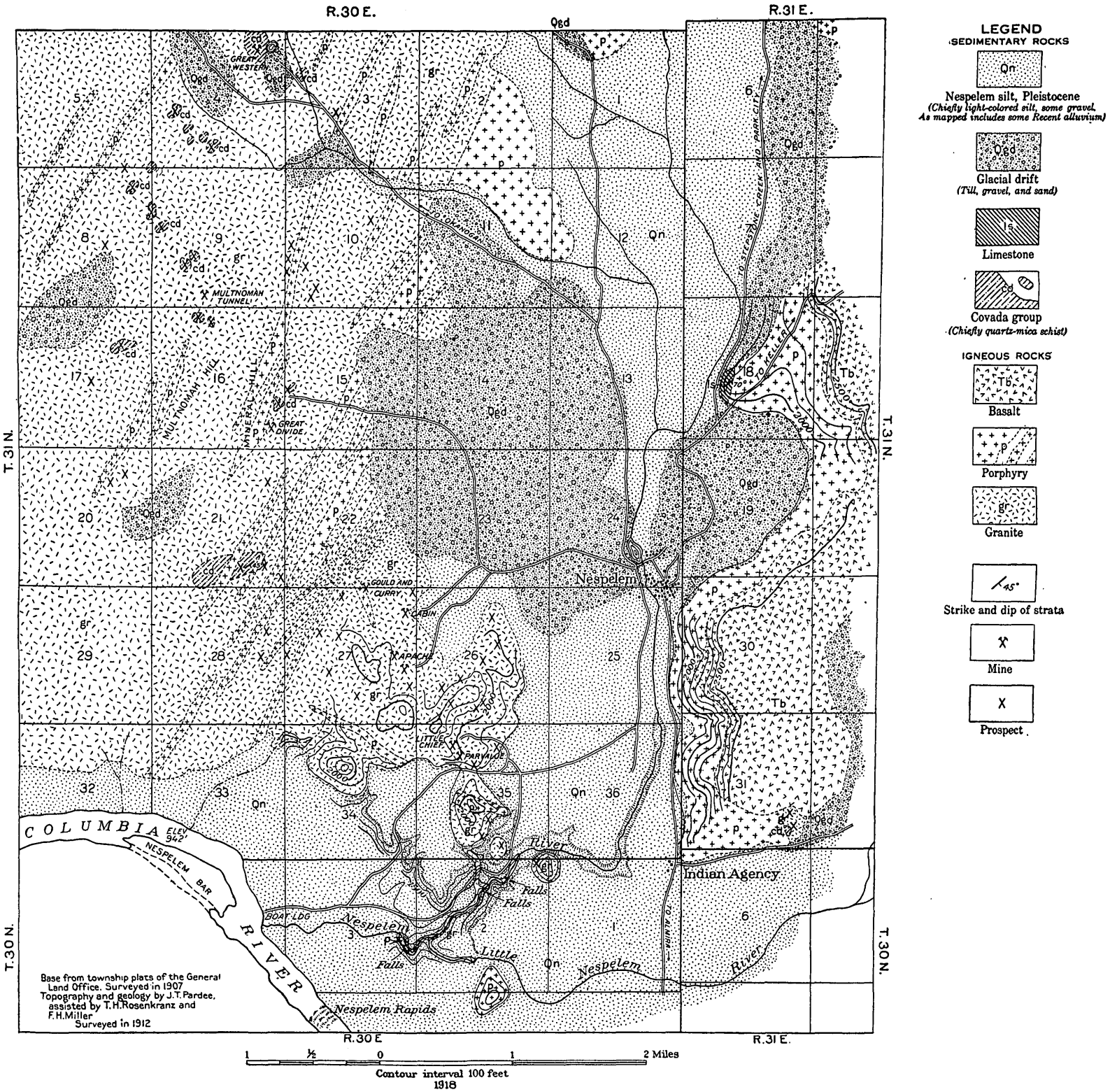
METALLIFEROUS DEPOSITS.

NESPELEM (MOSES) DISTRICT.

LOCATION AND PRINCIPAL SURFACE FEATURES.

The Nespelem or Moses mining district, in the southeastern portion of Okanogan County, occupies most of the western part of the Colville Reservation. Its legal boundaries are said to be, on the north an east-west line 12 miles north of Nespelem village; on the south, Columbia River; on the east, the Ferry County line; and on the west, Okanogan River. Mineral discoveries have been made in but a small part of this large area. Most of the known deposits occur in a belt that extends 4 or 5 miles west and northwest of Nespelem village, and practically all are situated in the drainage basin of Nespelem River and the Columbia slope south of it. This portion of the district is generally known as the Nespelem district, from its principal stream and settlement. It has an area of about 200 square miles, most of which is included in the basin of Nespelem River. (See Pl. VII.) The watershed that separates Nespelem and Sanpoil rivers coincides very nearly with the north-south Ferry County line. To the north and west the Nespelem basin is bounded by divides that lead east and south, respectively, from Moses Mountain. On the south it is open to the valley of Columbia River.

The area thus described as the Nespelem district is an elongated north-south basin that lies between Moses Mountain and Columbia River, and is inclosed on all sides but the south by a mountainous rim



LEGEND

SEDIMENTARY ROCKS

Qn — Nespelem silt, Pleistocene
(Chiefly light-colored silt, some gravel. As mapped includes some Recent alluvium)

Qgd — Glacial drift
(Till, gravel, and sand)

ls — Limestone

cd — Covada group
(Chiefly quartz-mica schist)

IGNEOUS ROCKS

Tb — Basalt

p — Porphyry

gr — Granite

45° — Strike and dip of strata

Mine

Prospect

GEOLOGIC MAP OF SOUTHWESTERN PART OF NESPELEM DISTRICT.

of various heights and undulating profile. On the east the rim ascends gradually northward from an elevation of 2,800 feet at the Columbia trench to 5,000 feet on Old Glory Mountain, and is broken by no low passes. Although containing some reverse slopes, the west rim rises gradually as a whole northward to Moses Mountain, and the north rim is a broad, undulating upland that joins Moses and Old Glory mountains. About 2 miles west of Old Glory Mountain the north rim contains a broad pass at an elevation of 3,100 feet, through which the trail to Park City goes. Near the north line of T. 31 N., R. 30 E., the west rim contains a pass at 2,800 feet, occupied by the Nespelem-Omak road. South of the pass the ridge expands to a broad elevated area that extends to the brink of the Columbia Valley and attains elevations of 3,200 and 3,400 feet, respectively, in Mineral Hill and Multnomah Hill.

Viewed broadly, the Nespelem basin is composed of a wide, central flat, from which gently sloping surfaces rise to the rims. In detail, however, the valley floor is seen to be composed of two flats at different levels. The higher, which has an elevation of about 2,600 feet, is a basalt table-land, a detached portion of the Columbia Plain. The lower is an embayment of the 1,700-foot terrace of the Columbia Valley. Above these flats the sloping surfaces are very uneven, those that rise toward the north in particular being deeply furrowed by stream channels. In the southern part of the basin a prominent spur extends from Mineral Hill southeastward, gradually descending to the level of the flat at the head of the cascades of Nespelem River.

ACCESSIBILITY AND SETTLEMENTS.

The Nespelem district is relatively difficult of access. Cut off on the south from the plains of eastern Washington by the deep, narrow valley of Columbia River and surrounded on other sides by mountains, it has no very easy natural avenue of approach, except that afforded by Columbia River itself. This waterway has been utilized to a small extent in shipping ore from the district, but because of its rocky channel and swift current its navigation is uncertain and hazardous. The nearest railroad points are Almira, 35 miles southeast, on the Washington Central branch of the Northern Pacific Railway, and Okanogan, 25 miles northwest, on the Wenatchee-Oroville branch of the Great Northern Railway. Until the completion of the Great Northern, the stage road from Almira to Nespelem was almost the only route over which supplies were taken to the district. The road to Okanogan is shorter, but needs considerable improvement to make it an important competitor of the Almira route. Within the district most of the mines and prospects are easily reached by good roads or trails.

Nespelem village has a considerable but fluctuating Indian population and a few permanent white residents who are engaged in mining or trading. Stores, a hotel, a post office, a Government sawmill, and an Indian school are located here. Two miles south of Nespelem is the Government Indian agency. Most of the Nespelem Valley is occupied by Indian allottees, many of whom cultivate the land.

CLIMATE, VEGETATION, AND DRAINAGE.

Records of precipitation and temperature are not available for this district, but the character of the natural vegetation, together with that of the crops produced by cultivation, indicates a mild, semiarid climate. In the valley and bench lands north of Nespelem village hay and grain are grown to some extent without irrigation. The more arid flats and bench lands between Nespelem village and Columbia River, however, require the application of water to insure good crops. With proper cultivation a variety of fruits, including melons and peaches, flourish in the lower parts of the district.

In the summer the air is pure, dry, and bracing. Occasionally, however, a dry, warm south wind brings clouds of dust across Columbia River from the arid plain of east-central Washington. Fogs are reported to prevail during a portion of the winter along Columbia River, and the snowfall is said to be light and of brief duration in the lower valley. In the highlands, especially on Moses Mountain, the snowfall is said to be heavy and to remain on the ground late in the season.

The southern part of the district is practically barren of timber. Sagebrush is moderately abundant, but the lands are well grassed also. From the latitude of Nespelem village northward the hills are covered with an open forest of yellow pine that persists up to an elevation of about 4,500 feet, above which it is succeeded by a dense growth of lodgepole pine, spruce, and related species. Heavy stands of large yellow pine trees cover the foothills around the head of the Nespelem Valley.

Except some small areas, adjacent to Columbia River, the Nespelem district is drained by Nespelem River, a perennial stream formed by the junction of several rapid creeks that rise on the southeast slope of Moses Mountain. The main stream flows sluggishly through the Nespelem Valley to the north wall of the Columbia Valley, over which, in the course of about a mile, it descends nearly 800 feet in waterfalls and rapids to the level of the Columbia River. The lower course of Little Nespelem River is likewise characterized by cascades, but the stream is small, and in places its course is dry, owing to underground seepage of the water.

The most productive portion of the Nespelem mining district—the area of Multnomah and Mineral hills, and the southeast spur from the latter—contains no perennial streams and but few springs. The water supply of the townships south of Little Nespelem River is also scant. Lakes Owhi and Buffalo are good-sized bodies of fresh water, which receive, however, but small inflows. Lake Buffalo has no surface outlet but probably discharges underground through a deposit of glacial gravel that forms its dam on the west.

PRODUCTION AND MINING CONDITIONS.

The gross production, reported from the Nespelem district up to February, 1913, was approximately $12,000, derived wholly from ores shipped within the two preceding years from two mines, the Apache and the Little Chief. Some earlier shipments, the amount of which is unknown, are said to have been made, and the Apache is reported (April, 1915) to have maintained intermittent shipments since the date previously given. Of the total approximately $500 is to be accredited to gold and $11,500 to silver.

Prospecting in the Nespelem district is hindered slightly by superficial deposits of glacial drift and, locally, by the lack of timber and water. In places, however, the surface contour is such that underground development work can be readily done by tunneling. Moderate to small flows of ground water are usually met at depths of 30 or 40 feet. The lack of cheap transportation imposes a considerable handicap on mining in this district. The most economical means for shipping ore is by steamboats which navigate Columbia River intermittently and with considerable difficulty. Freight charges per ton on ore shipped from the Apache mine in 1912 were as follows: Hauling from mine to boat landing, $2.50; boat transportation from Nespelem landing to Wenatchee, $8; railroad haul from Wenatchee to Tacoma, $9 for small lots or $6 for carload lots; total, $16.50 to $19.50 a ton. The smelter charges average about $7 a ton additional, so that after making due allowance for cost of mining it appears that ore of less value than $30 to $40 a ton can not be produced profitably. In the course of time transportation will no doubt be cheapened either by improvement of Columbia River or the extension of railroads to the district; both of these projects appear feasible.

ROCK FORMATIONS.

Covada group.—The oldest rocks in the Nespelem district are argillitic sediments, believed to be chiefly of Carboniferous age, confined for the most part to a belt 4 or 5 miles wide that enters the district

from the northeast and extends southwestward into T. 31 N., R. 30 E. Southwest of Nespelem, in Tps. 30 and 31 N., R. 31 E., there are a few small isolated patches of similar rocks. The rocks in the larger area consist chiefly of fine-grained argillite that ranges from gray to black and is commonly schistose or slaty. The darker layers are soft, argillaceous, and thin bedded or slaty, and their color is caused by disseminated carbon. The lighter-colored beds are siliceous, are inclined to be massive, and grade into fine-textured quartzite and quartz-mica schist. Locally these beds contain calcareous layers, lenses of limestone or marble, and an interbedded schistose greenstone that is probably an altered lava. Originally fine sandstone, shale, and limestone, the rocks have been changed to quartzite, argillite, schist, and marble, chiefly by regional metamorphism. However, in many places minerals characteristic of contact metamorphism are present, and it is difficult to ascertain what proportion of the alteration is due to each cause.

The general strike of the beds is approximately north-northeast, and the dip ranges from east to west but is steep, as a rule. The areas of argillitic rocks northwest and southeast of Nespelem village range in size from small fragments to masses covering 5 acres or more. All have been severely metamorphosed by the granite that surrounds them to quartz-mica schist and rocks that consists largely of coarsely crystalline aggregates of magnetite and epidote, vesuvianite, hornblende, and other silicates.

Serpentine.—Dikes of gray to green serpentine occur in a narrow belt that trends northeastward across the northwest corner of T. 32 N., R. 31 E., and adjacent lands. The best exposures seen are along the spur west of Stepstone Creek, a short distance north of the nickel prospects. The rock is intrusive in the Covada group and is in turn cut off by the granite.

Granite.—The chief rock formation of the Nespelem district is a medium-grained light-gray intrusive granite, characterized, as a rule, by large porphyritic crystals of pinkish-gray feldspar. The groundmass is granular and composed of white semitranslucent feldspars, clear quartz, and shining scales of dark mica. The rock occurs in the form of a batholith that underlies the larger part of the Colville Reservation. In composition it is a soda-rich granite that in places grades into granodiorite. The essential minerals are oligoclase, quartz, orthoclase or microcline, and biotite; the accessory minerals apatite, iron ore, zircon, and titanite. The phenocrysts commonly range in length from 1 to 2 inches, are mostly of orthoclase, and commonly show Carlsbad twins. In many places, particularly east and south of Buffalo Lake, the granite is coarse textured and the interlocking crystals of feldspar and quartz show

rectangular outlines, giving it the appearance of graphic granite. Pegmatitic and aplitic varieties are abundant. The granite is younger than the Covada group and the serpentine, both of which it displaces, but is in turn invaded by dikes of monzonite or granodiorite porphyry and overlain by Tertiary lavas and later sedimentary rocks. Rounded knobs such as are characteristic of granitic rocks in general form the outcrops of the Colville granite along the unglaciated portion of the Nespelem Range east of Buffalo Lake. Elsewhere in the district the naturally smooth contours of the granite area have been still further subdued by glaciation. As a rule the rock is cut by widely spaced joints only, but locally it is sheared or contains crushed zones. Within an area of 4 or 5 square miles, that includes Multnomah and Mineral hills and the spur that descends from Mineral Hill southeastward to the Nespelem cascades, the granite appears to be traversed in several directions by small, closely spaced joint and shear planes and, in addition, cut by a system of northwesterly fractures along which occur the principal ore deposits. At the surface in this locality rock weathers down to a mass of small fragments stained reddish brown with iron oxides. The fresh rock contains minute crystals of pyrite and chalcopyrite that have been introduced along seams, where also part of the feldspars have been altered to sericite.

Porphyry.—Intrusive dikes of porphyritic texture that range in species from granodiorite porphyry to quartz diorite are common in the Nespelem district, particularly north of Nespelem village. A belt 4 or 5 miles in width that extends from Nespelem Valley northeastward to the Sanpoil watershed and beyond is occupied almost exclusively by these rocks. Dikes that range from a foot to several hundred feet in width are numerous also in the mineralized area west and northwest of Nespelem village. With few exceptions the dikes trend approximately northeast, and cut the Covada group, the granite, and the metalliferous lodes. Locally the porphyry is traversed by closely spaced joints that do not coincide with those of the granite. As a rule it weathers to blocky or angular fragments and forms bold, rugged outcrops. In its most common phase the porphyry appears as a light-gray or pale greenish-gray rock crowded with moderately small phenocrysts of milk-white feldspar and with a smaller proportion of black or green hornblende prisms. Quartz phenocrysts are present in some varieties, hornblende is abundant in others, and some specimens contain rosette-like aggregates of black mica. As a rule the groundmass is microgranular, the feldspars are andesine or labradorite, and the accessory minerals apatite, magnetite, titanite, and zircon. For the most part the rock is fresh and unaltered. Locally, however, chlorite, sericite, and calcite have been developed, and in a considerable area in the southern part of T. 33

N., R. 31 E., thin films of pyrite have been introduced into the porphyry along seams. The outcrops in this area are noticeably rusty.

Dacite.—Lavas of an andesitic type, closely related to the porphyry, occupy large areas in the Sanpoil drainage area but are relatively scarce within the basin of Nespelem River. A few patches, not differentiated on the map, occur east of Nespelem River in T. 32 N., R. 31 E. A specimen from one of these exposures contains free quartz and is therefore dacite.

Basalt.—From Lake Owhi south to Columbia River a belt from 1 to 6 miles in width is underlain in part by basalt, the disconnected patches of which are the remnants of a lava tongue that projected from the basalt plain of east-central Washington into the ancient Nespelem Valley. In its most common phase the rock is dense, black, and heavy and with the aid of a hand lens shows the outlines of small lath-shaped feldspar crystals and in some specimens olivine. It is characterized by vertical columnar jointing and tends to weather out in cliffs and colonnades.

Glacial drift.—Over a large portion of the plain south of Lake Owhi and the foothills adjacent to the Nespelem Valley, the underlying bedrock is concealed by a thick, imperfectly assorted mass of gravel, sand, clay, and boulders deposited in the irregular forms typical of glacial drift. Elsewhere in the district the drift mantle is as a rule thin and patchy.

Nespelem silt.—Fine white to light-buff silt, sand, and gravel of Pleistocene age form the terraces adjacent to Columbia River and the floor of the Nespelem Valley up to an elevation of 1,700 or 1,800 feet. The silt that composes the bulk of the formation lies horizontal, is generally thin bedded, and was evidently deposited in tranquil water. The gravel contains abundant smooth-washed pebbles and small cobbles in a loose sandy matrix and is evidently of local fluviatile origin. The stratigraphic thickness of the whole is 700 feet or more. It overlies glacial drift and, except some insignificant deposits of recent alluvium, is the youngest formation in the district.

LODES.

CHARACTER AND DISTRIBUTION.

The metallic mineral wealth of the Nespelem district is practically confined to deposits of the form usually described as lodes. Their metals of greatest proved or prospective importance are silver, copper, lead, or nickel, though gold in small proportions is commonly present, and in a few deposits adds considerably to the value of the ore. Zinc blende occurs in most of the lodes but ordinarily not in sufficient proportions to be regarded as other than a detriment. Less common minerals, such as chromite, rhodonite, fluorite, and molyb-

denite, are present in some of the lodes but, so far as known, in too small quantities to be of commercial importance. Manganese oxides are sparingly distributed through the weathered parts of most of the lodes.

Most of the lodes fall readily into two main groups that contrast strongly in structure and composition. The more productive of the two, of which the Apache lode is typical, are associated with a northwest system of fractures and shear zones. Although the fracture planes show diversities in dip, there are no notable differences in the lodes that accompany them, and all are regarded as of essentially similar origin and history. The most productive lodes of this group lie within a belt not over a mile in width that extends from Multnomah Hill southeastward to the Nespelem Valley and has the form of an arc, broadly concave to the northeast. If, as seems probable, the Silver Cliff and adjacent lodes in sec. 17, T. 30 N., R. 31 E., belong to the same group, the system has an extreme length of about 8 miles, the outcrops of that portion between the western edge of the Nespelem Valley and the Silver Cliff claim being concealed by later formations.

The geologic associations of the lodes of the Apache group are simple. The lodes traverse the Colville granite and are cut by dikes of granodiorite porphyry. They are chiefly valuable for silver or silver and lead, and subordinately for gold.

A subgroup represented by a few prospects only, among which is the Sterling, occupy northeasterly fissures in granite. They are characterized by the presence of molybdenite, the sulphide of the metal molybdenum, but no ore of commercial importance has been found in them.

The lodes of the second main group, of which the Rebecca is typical, bear no apparent relation to fractures, although most of them are elongated in the direction of bedding planes or granitic contacts. They are most numerous in a belt a mile in width that extends from Multnomah and Mineral hills northeastward about 3 miles and are sparingly distributed through an area of 4 or 5 square miles that lies south and west of Buffalo Lake. A few are widely scattered elsewhere, and the nickel prospects of Stepstone Creek may be regarded also as a subdivision of this group.

The lodes of the Rebecca group are associated with small isolated masses of sedimentary rocks surrounded by granite, and as a rule are developed in calcareous beds at or near the contact. They are cut and interrupted by the lodes of the Apache group and by dikes of granodiorite porphyry. The most valuable metal occurring in them is copper. Silver, gold, lead, and zinc are present in most of them but are subordinate in value as a rule.

The lodes of the Stepstone Creek subgroup, although of similar form to those of the main division, are more closely associated with serpentine than with granite and contain nickel as the most valuable metal.

CLASSIFICATION.

Replacement veins.—The lodes of the Apache group are dominantly formed by replacement along fractures in the granite. They are tabular in form but lack sharp boundaries. As a rule each deposit is associated with a single main fracture, but in some places two or more closely spaced parallel fractures have served as channels for ore deposition, and a few deposits, as that of the Great Divide, occupy broad sheared or fractured zones.

To distances that range from a foot to 10 feet or more from the main fractures the granite is more or less completely altered to a pale-green waxy mass in which sericite is one of the chief constituents. Within this zone the lode minerals are irregularly distributed. They replace the granite and occur in greatest abundance near the main fracture or fractures. As a rule the width of material rich enough to constitute ore ranges from a few inches to a foot or two, but locally, as in the Little Chief, a width of 10 feet is said to be of milling grade—that is, worth about $20 to the ton. In the Great Divide deposit, so far as developments have shown, the commercial ore is confined to relatively small pockets.

Filled fissures.—Lodes of the Sterling subgroup have a northeastward strike, cut granite, and appear to be filled fissures. Development work on them is very meager and has not yet shown the presence of commercial ore.

Contact-metamorphic deposits.—The lodes of the Rebecca group are contact-metamorphic deposits confined to masses of sedimentary rock which are intruded and for the most part surrounded by granite and many of which have sunk in the granitic magma. These inclusions range in size from small fragments to masses that cover 5 or 10 acres, and in some of them the whole mass may be regarded as the lode. As a rule, however, mineralization is confined to certain beds and may extend for several hundred feet along the strike, with a variable thickness that may reach 20 feet or more. The meager information available indicates that although in detail these deposits are irregular in form, most of them have fairly sharp and definite boundaries. So far only low-grade ore has been found in them, and the dimensions of bodies that may be regarded as ore have not been determined.

The lodes of the Stepstone subgroup occur in argillitic and calcareous strata adjacent to dikes or sills of serpentinized intrusive rocks. Exploratory work has not been extensive enough to determine the

dimensions of these deposits, but unconnected workings indicate that the principal lode or zone may be a mile or more in length and several feet in width. For reasons already mentioned details of their form and structure and the dimensions of portions that may constitute ore are not known.

MINERALOGY.

Replacement veins.—So far as available evidence shows, the lode minerals of the Apache group may be grouped according to genesis as follows:

Primary minerals:
- Pyrite (iron disulphide).
- Chalcopyrite (iron-copper sulphide).
- Galena (lead sulphide).
- Zinc blende (zinc sulphide).
- Quartz.
- Rhodochrosite (manganese carbonate).
- Fluorite (calcium fluoride).
- Sericite (potassium mica).

Minerals of the oxidized zone:
- Limonite (hydrous iron oxide).
- Oxides of manganese.
- Oxides of antimony.

Minerals probably formed by downward enrichment:
- Native silver.
- Cerargyrite (silver chloride or horn silver).
- Argentite (silver sulphide).
- Chalcocite (copper sulphide).
- Pyrargyrite (antimonial sulphide of silver or ruby silver).

Pyrite is the most abundant and widely distributed of the sulphide minerals. For the most part it appears to have been deposited contemporaneously with quartz, rhodochrosite, galena, and zinc blende, but in one place, at least, it occurs as veinlets that cut across crystals of galena and zinc blende.

Chalcopyrite is nowhere an abundant constituent of the ore. It is sparingly present along seams in the wall rock and is most abundant in the crushed zone of the Great Divide mine, where it was apparently introduced prior to the other sulphides except pyrite.

Galena and zinc blende occur in all the lodes that have been opened below the oxidized zone. As a rule they are present in about equal proportions, but galena is the more abundant in the Gould & Curry and near-by prospects.

Rhodochrosite was identified in the Silver Cliff and Apache only but it is probably present in other lodes, as indicated by manganese oxides in their superficial portions. Fluorite was seen only in the Multnomah tunnel and prospects in that vicinity.

Argentite is the most valuable mineral of the Apache and Little Chief mines and occurs as films and veinlets in secondary fractures in the ore. In the Apache native silver and in the Little Chief pyrargyrite are associated with it.

A greenish-yellow stain of antimony oxide occurs in the outcrop of the Little Chief. Cerargyrite forms thin films on surfaces of specimens from the Par Value in close association with pyrargyrite. Sooty chalcocite coats small cavities in specimens of ore from the Great Divide.

Filled fissures.—In the lodes of the Sterling subgroup the most abundant mineral is massive quartz, which forms large, prominent outcrops. Molybdenite in small flakes is in places sparingly disseminated through the quartz and wall rock, and massive pyrite occurs here and there in bunches. Chalcopyrite, zinc blende, and fluorite are associated with the other minerals enumerated in the claim of Dr. F. O. Hudnut. A sample containing small proportions of zinc blende, pyrite, and fluorite yielded traces only of gold and silver by assay.

Contact-metamorphic deposits.—The minerals of the Rebecca group of lodes are characteristic of deposits formed by contact metamorphism. They may be grouped according to genesis as follows:

Primary minerals:
- Magnetite (magnetic oxide of iron).
- Specularite (platy iron oxide).
- Pyrite (iron disulphide).
- Pyrrhotite (magnetic iron sulphide).
- Zinc blende (zinc sulphide).
- Galena (lead sulphide).
- Chalcopyrite (iron-copper sulphide).
- Rhodonite (manganese silicate).
- Vesuvianite (a lime-iron-alumina silicate).
- Garnet (a complex silicate rich in lime and iron).
- Epidote (a lime-iron-alumina silicate).
- Hornblende (a complex silicate rich in lime, magnesia, and alumina).

Minerals of the weathered zone:
- Limonite (hydrous iron oxide).
- Manganese oxides.
- Malachite (basic copper carbonate).

The lime-iron silicates, vesuvianite, garnet, and epidote, together form a large proportion of nearly every deposit. Magnetite is present in all and in some places forms as much as 50 per cent of the mass. Pyrite and pyrrhotite are the most abundant sulphides; the latter occurs in considerable proportions in the Rebecca. Chalcopyrite is the chief valuable mineral present and occurs in practically all the deposits. Zinc blende is an excess of galena in most of the deposits, but rarely is either of the two of more value than the chalcopyrite. The sulphides enumerated are as a rule more

closely associated with magnetite than with the silicates. Weathered portions of the deposits contain masses of earthy limonite that are stained here and there with malachite.

In the Stepstone subgroup the following minerals were identified in the lodes or in their wall rocks:

Primary minerals:
- Chromite (oxide of chromium).
- Pyrite (iron disulphide).
- Pyrrhotite (magnetic iron sulphide, nickeliferous).
- Chalcopyrite (iron-copper sulphide).
- Dolomite (calcium-magnesium carbonate).
- Quartz.
- Fuchsite (chromium mica).
- Tremolite (silicate of lime and magnesia).

Minerals formed by secondary alteration, including oxidation:
- Limonite (hydrous iron oxide).
- Oxides of manganese.
- Calcite (calcium carbonate).
- Genthite (nickel silicate).
- Serpentine (hydrous silicate of magnesia and iron).

Dolomite occurs in massive layers a few feet thick and is the chief gangue mineral. Quartz is not abundant but in the serpentine forms veins and in the dolomite occurs as thin layers or lenses, some of which are fine textured and may be residual masses of quartzite. Chromite in small crystals is disseminated through the lode and wall rocks. Locally it is concentrated in bands a few inches thick. Pyrite, pyrrhotite, and rarely chalcopyrite occur in close association with the chromite. Fuchsite is widely distributed in the lode and wall rocks but occurs in greatest abundance in some of the argillitic layers.

Calcite and genthite form films in seams and efflorescence-like coatings on weathered surfaces. The fact that genthite was observed surrounding partly oxidized grains of pyrrhotite indicates that the pyrrhotite is nickeliferous. The serpentine is pale green to gray and was probably derived from peridotite or dunite.

ORE SHOOTS.

Except the Apache and Little Chief, none of the replacement veins are sufficiently developed to afford more than very meager data as to the probable form, richness, and extent of the ore bodies. Very rough sampling of some of them, however, notably the Gould & Curry, indicates that moderate-sized shoots of ore worth $30 or more to the ton are present. The Apache and Little Chief ore shoots are tabular or flat lenslike bodies that taper irregularly to their margins and are not over a foot in average thickness. The richest shoot so far discovered, that of the main adit level of the Apache, has a stope length of 40 feet and a pitch length of at least 70 feet.

A shoot of the same stope length occurs in the Little Chief, but its upper and lower limits had not been determined at the time of examination. These ore bodies lie on the footwall. They are separated from adjacent parts of the vein by slips lined with black gouge and locally are cut by similar slips into small lenses.

The average metallic content of ore extracted and shipped from the Apache shoot was approximately 560 ounces of silver and 0.8 ounce of gold to the ton, but as these figures apply to sorted ore only, the average content of the shoot as mined was lower. Shipments of ore produced by the Little Chief shoot averaged 124 ounces of silver and 0.2 ounce of gold to the ton. These figures also represent selected ore.

The available data as to the form and dimensions of ore bodies in the other groups of lodes in the district are not sufficient to form the basis for generalizations.

AGE AND GENESIS.

The ore deposits of the Nespelem district occur in sedimentary rocks that are presumably of Carboniferous age and in granite that is probably Cretaceous. They are clearly older than the diorite and granodiorite porphyries, which are believed to date from the early or middle Tertiary. The oldest deposits, those of Stepstone Creek, occur in Carboniferous argillite and are cut off by granite, and their origin, therefore, in point of time, lies between the two. The contact-metamorphic deposits of the Rebecca type are closely associated with the granite and are regarded as of practically the same age as that rock. The lodes of the Apache group are clearly younger than those of the Rebecca group but still are closely associated with the granite and are therefore thought to be of Cretaceous or possibly very early Tertiary age.

The relative age of the lodes of which the Sterling is an example is not definitely shown. The deposits are younger than the granite, however, and the fact that their minerals are characteristic of a somewhat deeper-seated origin than those of the Apache group, although the latter occur at about the same horizon, tends to the belief that a time interval, with lowering of the surface by erosion, elapsed after the Sterling group and before the Apache group were formed.

The genesis of the lodes is indicated by their geologic association and mineralogy. The nickel-bearing lodes of Stepstone Creek are closely associated with serpentine and are characterized by chromite, nickeliferous pyrrhotite, and chalcopyrite. This association of minerals is characteristic of nickel deposits elsewhere that are formed by segregation or emanation from peridotite or a related igneous rock, which, as a rule, has been changed to serpentine.

The chief features of the Rebecca group of lodes are typical of deposits found at the contact of intrusive magmas of moderately siliceous composition, and these deposits were, without doubt, derived from the granite. Lodes of which the Sterling is a type contain molybdenite, a mineral characteristic of deposits formed at high temperature. The abundant, coarsely crystalline quartz of these lodes is not unlike that of extremely siliceous pegmatites, of which they may be an end product. They are thus indicated to have been derived from the granite immediately after the consolidation of its outer portion.

The geologic and mineralogic features of the lodes of the Apache group may be briefly reviewed. All are associated with a group of related fractures in the Colville granite and are distinctly older than dikes of granodiorite porphyry. Adjacent to the fractures the granite is altered to a material in which sericite is abundant and replaced by minerals among which are galena, zinc blende, pyrite, chalcopyrite, rhodochrosite, and fluorite. These conditions are similar to those of lodes believed by most geologists to be formed at intermediate depths by ascending solutions that emanated from granitic magmas. In the Nespelem district the source of the material is probably the deeper-seated portions of the granite or a later intruded mass of similar rock not yet exposed.

OXIDATION AND ENRICHMENT.

In the Nespelem district the oxidized zone extends to depths of 15 to 40 feet only, at which permanent ground water is met. In many places the oxidation of this shallow zone is imperfect, and sulphide minerals occur almost at the surface. This condition is notably true of the contact-metamorphic deposits of the Rebecca type and is a result of the close-textured, impervious physical condition of the lodes. On the other hand, the lodes of the Apache group contain abundant fractures along which meteoric water can descend, and in these lodes oxidation is more nearly complete to water level.

In Pleistocene time whatever oxidized zone existed was no doubt in large part removed by glaciation, and the present zone may be regarded as a rough measure of the weathering since the ice disappeared. No evidence is at hand that deposits enriched by oxidation have been formed; on the contrary, the available data indicates that the oxidized zone is impoverished.

Enrichment by sulphide minerals is shown in two lodes, the Apache and Little Chief. Portions of the lodes that begin near water level and extend downward are notably enriched by argentite and other silver-bearing sulphides of distinctly later age than the body of the

lode. A proportionate increase of gold has taken place also. Although there is no conclusive evidence that these minerals were not at least in part introduced from below, available facts indicate them to be the result of downward enrichment. The textural evidence of minerals filling cracks later than the body of the lode allows the possibility of downward migration, and the secondary minerals, notably ruby silver, are characteristic of that form of lode enrichment. This view is further supported by the fact that the oxidized zone is impoverished. The presence of manganese in these lodes also is a chemical factor favorable to the solution and downward migration of gold.

No evidence of enrichment of the contact-metamorphic or other types of deposits was observed.

SUMMARY AND CONCLUSIONS.

The lodes of the Apache group occur in a narrow belt along a system of moderately extensive, closely related fractures. Silver, lead, and, subordinately, gold are the valuable metals of their primary ores, and some of them contain high-grade shoots formed by downward enrichment with gold and silver. In one place and perhaps in others primary ore of commercial grade is close to the surface, but most of the lodes are oxidized to depths of 15 to 40 feet or more, and the oxidized portions are of low grade. In the Apache mine rich ore occurs in greatest abundance where the lode has been broken by cross fractures, and in general oxidation is most nearly complete in the lodes that have been broken by later movements. Because downward enrichment of lodes is preceded by oxidation and leaching of their upper portions, the lodes of this group that have oxidized zones are the most favorable in which to search for rich ore. But it does not follow that every lode with an oxidized zone has a rich shoot below, for it may never have contained any primary ore. The fact that enriched ore bodies occur in some lodes, however, gives a reasonable warrant to search other lodes in the same vicinity. It is believed, then, that there is a reasonable "mining chance" of finding shoots similar to those in the Apache and Little Chief in the lodes near by that have outcrops of comparable size, composition, and structure. No good basis exists upon which to predict the depth to which the downward-enriched shoots extend. As a general principle, however, they are confined to a relatively shallow zone, but many of them give place to smaller pipes or shoots of good ore that continue to great depths.

Because the fractures are of fair size and persistence and the ore minerals are thought to have come from below, the primary ore is believed to extend to considerable depths. The ore in the Gould & Curry mine is of this class, and its relative amount and richness support the view that primary lead-silver ore exists in some of the lodes.

There is no ground for believing, however, that the primary ore bodies increase in size and richness with depth. Search for them should be made by drifting on the lodes rather than by sinking. The lodes with oxidized zones should be explored by first sinking to the sulphide zone and then drifting. Deep shafts and long crosscut tunnels may yield no more information about a lode than shallow workings along the outcrop. The lodes of the Apache group are relatively small and therefore the ore, because of the relatively high cost of mining small bodies, will probably be limited to bodies of medium or high grade.

The most valuable metal in most of the lodes of the Rebecca group is copper. Zinc and lead are present in nearly every lode, and on the Great Western and Evening claims they appear to predominate. The ore contains a gangue of tough, heavy silicate minerals and is therefore not well suited to concentration. On the other hand, because of its high lime and iron content, the crude ore would seem to be well adapted for smelting. Data as to the extent of any portion of these deposits that may be of value are not at hand. Samples that represent certain portions only of some of them range in assay value from 1 to 5 per cent of copper and an ounce or two of silver to the ton.

Under favorable conditions large bodies of ore, containing 2 per cent or less of copper and small amounts of gold and silver, are profitably mined and smelted. The Granby Co., at Phoenix, British Columbia, reported mining and smelting at a profit ore that is similar in composition to the ores under discussion and that contains not over 2 per cent of copper and $1 to the ton in gold and silver. No deposits that approach the Granby in size, however, are indicated by the outcrops in the Nespelem district. Nevertheless, the mineralization in some of the larger sedimentary inclusions looks encouraging enough to warrant a reasonable search for ore bodies of fair size. The association of deposits of this type with limy beds should be utilized as a guide in prospecting.

No evidence of downward enrichment of these deposits was observed. Numerous crosscuts at or just below water level would explore them more thoroughly than a single deep shaft. As a rule, small inclusions of sedimentary rock can not be expected to contain ore bodies of sufficient size to be valuable.

The principal metal in the lodes of the Stepstone subgroup is nickel. Development work has not gone far enough to determine the form, size, or richness of any portions of the lodes that may be considered ore. The outcrops are extensive and rather generally stained with a nickel silicate; samples representing a very small portion of one lode yielded appreciable percentages of nickel. One sample that yielded more than 2 per cent of nickel showed the sulphide to be richer than the oxidized ore. With due allowance for

the meagerness of the data at hand, it is a reasonable inference that fair-sized bodies of 2 per cent nickel ore may be found by exploration, but it is doubtful if such bodies would be of commercial importance at present. A new nickel producer would have to compete with the deposits at Sudbury, Ontario, which are much larger and considerably richer than the Stepstone deposits are indicated to be.

The lodes of the Sterling subgroup show no very encouraging evidences of ore. They are thought to be very deep-seated portions of lodes whose upper and most valuable portions have been carried away by erosion.

PLACERS.

Placer claims have been located on the lower terraces that border Columbia River near the mouth of Nespelem River. No production was reported from them, and they were not being worked, and were not examined. A description of the gold-bearing gravels along this course of the Columbia River is given by Collier.[1] Elsewhere in the Nespelem district no placer gravels are known, and the late physiographic and glacial history of the region is unfavorable to their existence. It is an interesting speculation, however, whether or not placer gravels, now deeply buried under basalt, exist in the earlier and later Tertiary valleys of Nespelem River. The erosion that produced the earlier valley in particular is thought to have extended over a long time and was not rapid, conditions which favor the concentration of gold in gravels. If such deposits occur, however, they are deeply buried beneath basalt or silt, except, perhaps, where the ancient channels are crossed by Columbia River.

MINES AND PROSPECTS.

REPLACEMENT VEINS.

APACHE.

The Apache mine, the property of the Apache Mining Co., is the most productive mine in the Nespelem district. It lies on the northeast slope of the southeast spur of Mineral Hill, in the east-central part of sec. 27, T. 31 N., R. 30 E., about 2 miles west-southwest of Nespelem village.

During 1911 and 1912 the mine was operated under lease by Hoyt, Beggs & Miller, who reported approximately 29 tons of ore shipped to the Tacoma Smelting Co., at Tacoma, Wash., the smelter certifi-

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

cates for which showed a gross value of about $10,170 and a net yield of $9,865.85. The mine is said to have been opened but a few years before 1911 and to have produced, in addition to that mentioned above, some shipping ore, the amount and value of which, however, are not known.

As it comes from the mine the ore is washed and hand sorted, high-grade material only being sacked for shipment, the remainder going to the stock dump, in which a considerable tonnage has accumulated. The assay value of the different lots shipped by the lessees ranges from 0.67 ounce of gold and 455.05 ounces of silver to 3.34 ounces of gold and 2,443.8 ounces of silver to the ton.

The principal underground workings consist of an adit level 365 feet long at an elevation of about 2,100 feet, from which winzes, upraises, stopes, and short crosscuts are made. About 500 feet northwest of the portal of the adit is a shaft not now in use, from which a shipment of high-grade ore is said to have been extracted. Winzes are sunk 40 feet below the adit level, which at the face is not more than 100 feet beneath the surface.

The lode is a replacement deposit along a N. 45° W. fracture that dips 45°–60° NE., cuts Colville granite, has smooth walls lined with black gouge, and in several places is interrupted and displaced a foot or more by cross fractures. The outcrop is very inconspicuous but may be traced for about 1,000 feet northwest of the adit by means of fragments of quartz stained with the oxides of iron and manganese.

The oxidized zone is not more than 20 feet deep, as a rule, and is reported to contain little ore of commercial value. It consists chiefly of decomposed altered granite and quartz fragments stained with limonite and manganese oxides.

Except the high-grade ore shoots, the unoxidized vein filling consists of sericitized granite partly replaced by quartz, rhodochrosite, pyrite, galena, and sphalerite. The alteration and mineralization extended into the hanging wall and to a slight degree into the footwall of the fracture, with intensity diminishing outward, affecting an indefinitely bounded zone 8 or 10 feet in width.

The principal shoot of high-grade ore is a tabular mass that ranges from 12 to 18 inches in thickness in its central portions and thins to an edge at its margins. It has a stope length of 40 feet and a pitch length of 70 feet or more, is separated by gouge-lined partings into irregular lenslike masses, and lies on or near the footwall.

The high-grade shoots were formed by enrichment of portions of the lode with argentite and native silver deposited along secondary fractures. Argentite is most abundant opposite the cross fractures that displace the footwall. As a rule the native silver is closely associated with the argentite, but it occurs also as flakes and films in

seams in the adjacent sericitized granite. In some places pyrite also was observed to form veinlets that cut across grains of quartz and galena.

Outside of the high-grade shoots the material of the lode to a width of 4 or 5 feet is said to assay $20 or more to the ton, chiefly in silver, with a dollar or two in gold. The lower limits of the high-grade shoots have not yet been reached by the workings, and further exploration may be reasonably expected to reveal additional rich shoots.

LITTLE CHIEF.

The Little Chief mine, owned by the Double Header Mining Co., is in the NW. ¼ sec. 35, T. 31 N., R. 30 E., about 2 miles southwest of Nespelem village, from which its shaft house and dump are visible. It lies at an elevation of 2,050 feet on the opposite or southeastern slope of the same spur as the Apache, from which it is three-quarters of a mile distant.

In 1911 and 1912 the Little Chief was operated under lease by H. L. Mayberry, who shipped about 33 tons of ore to the Tacoma Smelting Co. The smelter certificates show a gross value of about $1,895 and a net value of $1,682.07, and the assay value of the different lots ranged from 0.09 ounce of gold and 77.7 ounces of silver to 0.31 ounce of gold and 590.59 ounces of silver to the ton.

The principal working is a shaft 80 feet deep, equipped with a horse whim and bucket hoist, from which levels are run northwest and southeast 100 feet and 50 feet, respectively, and short crosscuts have been made.

The lode, which is very similar to the Apache, is a replacement deposit along a N. 60° W. fracture plane that dips 45° NE. and cuts the Colville granite. The outcrop and oxidized zone are also similar to those of the Apache, but the outcrop is locally somewhat more siliceous and bears a greenish-yellow stain that is apparently an oxide of antimony. The lode ranges from a few feet to 20 feet or more in width and consists of sericitized granite largely replaced by quartz and to a small degree by pyrite. Locally the quartz is banded with very fine specks of dark minerals that appear to be sulphides. To a moderate degree the lode is sheared and fractured by post-mineral movement. Northwest of the shaft an ore shoot 40 feet in stope length and 4 inches to 4 feet thick is exposed. It is a portion of the primary lode enriched by argentite and pyrargyrite (ruby silver) deposited in secondary fractures and was the source of the ore shipped. Stoping on this shoot was in progress at the time the mine was visited. Outside of the shoot described the lode is said to assay from $7 to $40 to the ton in silver and gold, which, however, does not, under present conditions, constitute profitable shipping ore.

PAR VALUE.

The Par Value mine adjoins the Little Chief on the southeast and evidently includes the extension of the same lode. It is developed by a shaft 300 feet southeast of that on the Little Chief, which is said to be 68 feet deep but which was not entered because of water that stood within 15 feet of the surface. The dump contains ore similar to that of the Little Chief but apparently not so well mineralized. Pyrite, argentite, pyrargyrite (ruby silver), and cerargyrite (horn silver) were identified in it.

MONTANA AND SURPRISE CLAIMS AND OTHER PROSPECTS NEAR THE LITTLE CHIEF.

The Montana and Surprise claims, a quarter and three-quarters of a mile, respectively, southeast of the Little Chief, are developed by shafts which were flooded at the time of examination. The dump at the Montana shaft consists of sericitized granite and iron-stained vein quartz in which a few specks of ruby silver and pyrite were detected. The Surprise dump contained similar quartzose material, in which, however, no ruby silver was seen. A sample from a selected portion of the Surprise dump yielded by assay at the rate of 0.03 ounce of gold and 31.6 ounces of silver to the ton.

A number of prospect pits and tunnels have been made on a subsidiary spur that extends northward from the vicinity of the Little Chief into sec. 26. Most of them expose northwestward-trending lodes a few feet in width, composed of sericitized granite and vein quartz stained with iron oxides. None of the openings had penetrated to the unoxidized zone. In some of them manganese stains were observed, and in general the superficial portions of the lodes bear a resemblance to the Little Chief and Apache lodes. It does not necessarily follow, however, that they contain similar ore bodies, but they offer sufficient promise to warrant some exploratory work. In addition to manganese stains, which are, however, too widespread to be very significant, the presence of the greenish to brownish-yellow stains of antimony ocher should be looked for as indications of ore below.

SILVER CLIFF AND NEWPORT.

The Silver Cliff and Newport mines are in sec. 17, T. 30 N., R. 31 E., in the hilly country south of Little Nespelem River, about 5 miles south-southeast of Nespelem village. The country rock is the Colville granite, which at short distances to the south and west is overlain by basalt. Here and there in the granite are small included masses of quartzite, marble, and metamorphosed argillite, some of which contain sparingly disseminated grains of copper, iron, and lead sulphides. In addition, the granite and included

sedimentary masses have been cut by fracture planes along which lodes have been formed. The principal underground workings on the Silver Cliff are a tunnel (No. 1), driven southward 110 feet from a point near the north line of sec. 17; a parallel tunnel (No. 2), 75 feet long, a short distance to the east; and a tunnel (No. 3), about 200 feet long, with crosscuts, about 1,000 feet south of the No. 1. In addition, there are some shafts and open cuts. Tunnels 1 and 2 crosscut a lode that strikes N. 70° W., dips 60° SW., and ranges from 2 inches to 3 feet in width. The vein filling is quartz, which has replaced granite and is sparingly mineralized with pyrite and galena. A winze sunk from tunnel 1 on the lode was not entered. A carload of ore is said to have been extracted from the winze and shipped to a smelter. Pyrite and sericite accompany quartz veinlets that branch from the main lode and penetrate the walls in various directions.

A short distance to the south open cuts expose a lode or zone of altered mineralized granite not reached by the tunnels. To a width of 20 or 30 feet the granite is sericitized and partly replaced by quartz and contains sparingly disseminated grains of pyrite, galena, and chalcopyrite.

Tunnel 3 is a drift on a lode that strikes N. 60° W., dips 60° S., and ranges from 4 to 18 inches in width. It consists of sericitized granite largely replaced by quartz, with which small percentages of galena and pyrite are associated. In places rhodochrosite is present. The shafts on this property were not entered.

About 1,200 feet south of the Silver Cliff a shaft and an adit level 175 feet long on the claim of Mr. Newport explore a lode in the Colville granite that strikes N. 75° E., dips 60° S., and ranges in width from that of a seam to 2½ feet. This lode is similar in composition to those of the Silver Cliff except that no sulphide other than pyrite was observed in it.

GOULD & CURRY.

The Gould & Curry mine is on the southeast spur of Mineral Hill, about 2½ miles due west of Nespelem village, near the quarter corner on the north line of sec. 27, T. 31 N., R. 30 E. The country rock is the Colville granite, slightly sheared and altered and cut by numerous dikes of granodiorite porphyry, most of which trend northeast. The underground developments aggregate about 200 feet, distributed between two adit levels one of which is 40 feet long and the other, 60 feet lower, 130 feet long, with short crosscuts. The two levels are connected by a winze near the face of the upper one. Except a few feet in which the lower one crosscuts the granite, both levels follow a lode that strikes N. 50° W. and dips 50° SW. The outcrop is inconspicuous, consisting merely of a loose mass of

decomposed granite with which fragments of vein quartz are mingled. To a more noticeable extent than common, however, this material is coated with the oxides of iron and manganese. As exposed by the workings the lode has a clean-cut footwall and ranges in width from 3 to 15 inches, with an average of perhaps 1 foot, but the hanging wall is not well defined. The vein filling consists of quartz, pyrite, galena, and zinc blende in coarse interlocking grains that appear to have replaced the granite. The wall rock is pretty thoroughly sericitized for a distance of a foot or more from the walls and contains a small percentage of the sulphides mentioned, introduced along seams. In the lower adit the lode is cut and displaced a few feet to the northeast by a transverse porphyry dike.

In places the sulphide minerals, of which galena is most abundant, form 50 per cent or more of the vein filling, and as a rule are plentifully distributed throughout the portions of the vein so far developed. The zone of oxidation extends about 10 feet below the surface and contains limonite and manganese oxides, although no manganese minerals were seen below. A sample somewhat richer in galena than the average, from a 50-ton ore pile on the dump, gave an assay value of 40 cents to the ton in gold, 30.18 ounces to the ton in silver, and 20 per cent of lead—a total value of approximately $38.50 to the ton.

Because of the high cost of transportation to and from this district, it is doubtful whether ore of this grade can be made to pay at present; with a slight improvement in conditions, however, it should be mined profitably.

PITTSBURG.

The Pittsburg prospect is in the SE. ¼ sec. 21, about half a mile west of the Gould & Curry, 1 mile northwest of the Apache, and within the zone of Colville granite affected by the Apache group of northwesterly fractures. At the time this prospect was visited (July, 1913) the workings were limited to some open pits and shafts, nowhere over 10 feet in depth. The granite exposed in these workings was highly altered and silicified and stained with iron oxide. No unoxidized mineral except pyrite was visible. Since that date, however, a good-sized body of silver lead ore is reported (April, 1915) to have been struck.

CABIN.

The Cabin mine, near the northeast corner of sec. 27, is developed by a 100-foot shaft. At the 85-foot level a 15-foot crosscut penetrates a zone of altered granite cut by several N. 60° W. fractures that dip steeply northeast. The fractures bear quartz veinlets that range from less than an inch to 4 inches in width and contain appreciable proportions of galena, pyrite, and zinc blende.

The intervening granite is altered and impregnated sparingly with these sulphides.

OVERSIGHT.

The Oversight prospect is near the north line of sec. 27, T. 31 N., R. 30 E., about half a mile east of the Gould & Curry claims. A 40-foot shaft that was inaccessible at the time of the writer's visit is said to develop a vein similar to that of the Gould & Curry. Very similar ore was present in the dump.

GREAT DIVIDE.

The Great Divide mine is on the summit and east slope of Mineral Hill, in the southeastern part of sec. 16, T. 31 N., R. 30 E., about 3 miles west-northwest of Nespelem village. The country rock is sheared and altered Colville granite. The principal underground working is a tunnel driven 300 feet on a northwesterly course from a point on the east slope of Mineral Hill about 200 feet below the summit. Crosscuts that aggregate 100 feet or more have been made at several points along the course of the tunnel. In addition, there are several small shafts and pits near by. These workings disclose the presence of a zone 50 feet or more in width, in which the granite is cut by numerous fractures and seams of an average N. 60° W. strike and a steep southwest dip. In places the mass is sheared and crushed. The granite of the zone is more or less altered to a waxy mass in which sericite is one of the principal constituents. Pyrite and chalcopyrite are widely but sparingly distributed along the seams. Locally the granite is silicified and traversed by small non-persistent veinlets of quartz banded with pyrite. In addition, pyrite, chalcopyrite, and galena together form scattered bunches that range from fractional dimensions to 2 feet in diameter. Small cavities here and there are dusted with sooty chalcocite. Bunches in which galena is preponderant are said to assay as high as 100 ounces of silver to the ton. Pyrite is, however, the most abundant and widely distributed sulphide, and the zone, considered as a whole, is very sparingly mineralized.

The zone is cut and its continuity interrupted by several large dikes of granodiorite porphyry, one of which, 56 feet in width, is pierced by the tunnel. The dikes are not themselves altered or mineralized and evidently bear no genetic relation to the ore.

MULTNOMAH.

The Multnomah tunnel is at an elevation of 3,000 feet in the southern part of sec. 9, T. 31 N., R. 30 E., near the foot of the north slope of Multnomah Hill. It is straight and well constructed, is driven south 1,220 feet, at its face is about 400 feet vertically below

the summit of Multnomah Hill, and affords a good section of the Colville granite within the mineralized belt. Thin films and small grains of pyrite are sparingly but widely disseminated along small irregular fractures and slips, and the feldspars are partly sericitized. Here and there small masses of sedimentary rocks are exposed that have sunk in the granitic magma and been severely metamorphosed and sparingly mineralized with chalcopyrite. At a point about 1,000 feet from the portal a N. 60° W. vein that dips steeply northeast and ranges from an inch to a foot in width is penetrated and a drift run on it for 40 feet. The vein filling is quartz irregularly banded with pyrite, fluorite, and a small proportion of a very fine black sulphide that was not identified. These minerals occur in interlocking grains and are evidently of the same generation. At the face a smooth vertical wall that strikes N. 75° W. and carries a few inches of gouge and breccia and bunches of quartz and sulphides similar to that of the first vein is exposed. The vein filling is somewhat sheared and crushed because of postmineral fault movements. Presumably the tunnel was driven to develop some limonitic quartz lodes that crop out on the summit of Multnomah Hill. No raises had been made on the veins cut by the tunnel, but the projected planes of the veins would intersect the surface near the outcrops mentioned.

FILLED FISSURES.

STERLING.

A small shaft and open cuts on the Sterling claim, near the center of sec. 8, T. 31 N., R. 30 E., expose a 15-foot vein of white quartz that strikes N. 30° E. in granite. The quartz, which contains sparingly disseminated flakes of molybdenite, is sheared, and the seams are coated with limonite. At wide intervals bunches of massive pyrite 1 foot or less in diameter occur. This interesting vein seems to be remotely related to a pegmatite. So far as developed it appears barren of copper, lead, and zinc minerals, but whether or not it carries gold was not ascertained. Prominent outcrops of similar quartz 10 to 50 feet in width and 500 feet or more in length occur in the SW. ¼ sec. 4 and the SE. ¼ sec. 8, but no minerals other than films of limonite are to be seen in them at the surface.

HUDNUT.

A claim of F. O. Hudnut, near the center of sec. 17, T. 31 N., R. 30 E., on the west shoulder of Multnomah Hill, is developed by some open cuts and pits. The formation is sheared Colville granite, partly sericitized and very rusty on the weathered surface. One of the pits exposes a lode about 18 inches wide that consists of a dark-gray

fine-textured quartz through which rather coarse crystals of pyrite, sphalerite, and fluorite are scattered. Small proportions of pyrite, chalcopyrite, sphalerite, fluorite, and molybdenite are disseminated in the wall rock as grains and films along seams.

CONTACT-METAMORPHIC DEPOSITS.

REBECCA MINE AND ADJACENT PROSPECTS.

The Rebecca mine is situated along the south line of T. 30 N., R. 3 E., near the southeast corner of sec. 32, 2 miles southwest of Buffalo Lake and about 3 miles east-northeast of the ferry across Columbia River at Barry, with which the mine is connected by a wagon road. The property was idle and its principal workings locked up at the time of examination. To judge by the volumes of the dumps at three shafts and two adits, the underground workings must aggregate several hundred feet.

The rock formations are interbedded argillite and impure limestone that strike N. 10° E., dip 80° E., and together form an inclusion half a mile long by 500 feet or more wide in the Colville granite. To the east basalt overlies the granite and the argillite in part. Glacial drift conceals the bedrock over considerable areas to the north and northeast.

Open cuts along a course of about 400 feet expose a bed of impure limestone 20 feet or more in width in contact with the granite to the west. A large proportion of limonite is associated with the limestone, and the green stain of malachite is present. The deeper workings mentioned are situated within this belt, and the material of their dumps consists largely of aggregates of lime-iron silicates, chiefly epidote and vesuvianite, together with magnetite, which may form 50 per cent of the mass. The sulphides, pyrrhotite, chalcopyrite, and sphalerite, are intergrown with the minerals mentioned and locally form as much as 20 per cent of the whole. All the dumps show chalcopyrite and sphalerite in variable but appreciable percentages, and the mineralized zone is evidently of good size. A fairly representative sample from the surface of one of the richest-looking dumps yielded by assay at the rate of 2.68 ounces of silver to the ton, a trace of gold, and 5.15 per cent of copper. No test was made for zinc, which is commonly present but in less quantity than the copper.

Within a radius of 2 miles of the Rebecca are several prospect pits and short tunnels on outcrops of sedimentary rocks surrounded by granite. These rocks range from quartz-mica schist to hornstone and magnetite-silicate rock similar to that at the Rebecca. All the masses are smaller, however, and none show as large proportions of copper and zinc minerals.

CONTROLLER AND RED BIRD MINES AND NEIGHBORING PROSPECTS.

The Controller and Red Bird mines are near the southeast corner of T. 31 N., R. 31 E., about 7 miles south-southwest of Nespelem village. The properties were idle at the time of examination, and the workings were inaccessible because of water. The principal workings are two shafts that have been sunk in a small area of limy argillite and impure limestone surrounded and metamorphosed by granite. A certain layer a few feet in width is weathered to a highly limonitic material that resembles the gossan of a pyritiferous lode but is probably derived in the main from magnetite and iron-bearing silicates. Unoxidized material in the dumps of the shafts consists largely of magnetite, vesuvianite, and green and red garnet. Small percentages of pyrite, chalcopyrite, and sphalerite are closely associated with the other minerals and were evidently introduced into the rock at the same time. A fairly representative sample of material of this kind taken from one of the dumps yielded by assay at the rate of 1.2 ounces of silver to the ton and 1.9 per cent of copper.

Prospects pits a mile north of the Controller and Red Bird expose comparatively small inclusions of a similarly metamorphosed sediment, one of which is cut by a small dike of serpentine. Certain layers contain disseminated crystals of galena, which in this particular locality is the principal valuable mineral to be seen.

GREAT WESTERN.

The Great Western mine lies in the NE. ¼ sec. 4, T. 31 N., R. 30 E., about 5 miles northwest of Nespelem village and a short distance north of the Nespelem-Omak road.

The development work consists of a timbered shaft more than 40 feet deep, from which levels are said to have been run. This property was idle when visited in August, 1913, and the shaft was inaccessible because of water that filled it within 40 feet of the surface. The shaft is equipped with a "baby" hoist, and the size of the dump would indicate that perhaps 200 linear feet of underground work had been done. In addition, a short distance to the west two other shafts had been sunk, each 40 feet or more to water level. The workings penetrate a small body of sedimentary rock that is entirely surrounded by granite. Considerable glacial drift is strewn over the surface, so that it is difficult to determine the exact areal extent of the sedimentary mass, which, however, does not exceed a few acres.

The outcrops range from a rusty quartz-mica schist containing veinlets of aplite, pegmatite, and quartz to a banded hornstone, por-

tions of which have disintegrated to gossan-like masses of limonite showing the stain of manganese oxides. Unoxidized rock in the dumps at the shafts shows that the sediments, which were originally sandstone and limy shale, have been metamorphosed in large part to crystalline masses of vesuvianite, garnet, epidote, and magnetite. Considerable rhodonite, a pink silicate of manganese, is disseminated through the mass, and crystals and small bunches of galena and zinc blende occur sparingly. For the most part the sulphides and magnetite are intergrown with the silicates and appear to have been introduced when the rocks were metamorphosed. A 40-ton pile of ore that had apparently been selected as the development work progressed was roughly estimated to contain 6 per cent of zinc blende and galena together.

RAMSEY AND HIDDEN TREASURE.

The Ramsey and Hidden Treasure mines, about three-quarters of a mile north of the Great Western, were not being worked at the time of examination. They are in a small area of argillite and schist surrounded by granite and metamorphosed in a similar manner to that at the Great Western. The workings consist of several shafts sunk to depths of at least 40 feet, below which they were filled with water. The material of the dumps is chiefly vesuvianite, hornblende, magnetite, and specularite, through which small proportions of chalcopyrite and pyrite are irregularly distributed but most closely associated with the specularite and magnetite. A sample selected from one of the dumps yielded by assay at the rate of 2.16 ounces of silver to the ton, a trace of gold, and 5.05 per cent of copper.

HOME RUN, MODOC, GOODENUF, AND ADJACENT PROSPECTS.

The Home Run, Modoc, and Goodenuf prospects are in secs. 8 and 9, T. 31 N., R. 30 E., about 1½ miles southwest of the Great Western claim and a short distance north of Multnomah Hill.

The Home Run is developed by a shaft 30 feet deep, sunk in a small area of banded silicified argillite and quartzite that strikes north, dips 65° W., and is surrounded by granite. The original constituents of the sedimentary rock have been largely supplanted by epidote, hornblende, magnetite, and specularite. Joints and seams are stained with malachite, limonite, and oxides of manganese, and on fresh fracture the rock shows specks of chalcopyrite and pyrite intimately associated with magnetite and the silicate minerals mentioned. A sample of this material, representative of a small portion of the lode, gave an assay value of 2.32 ounces of silver to the ton, 0.51 per cent of copper, and a trace of gold.

The Modoc and Goodenuf are developed by shafts 40 feet and 25 feet deep, respectively, sunk in sedimentary inclusions that are metamorphosed and mineralized in a similar manner and degree to that at the Home Run.

In the western part of sec. 9 and the SW. ¼ sec. 4 a number of prospect pits expose contact-metamorphosed masses of sedimentary rock that range from a few square yards to an acre or two in areal extent. None of these masses are developed except by shallow pits, but the superficial portions of each show alteration and mineralization similar to those described above.

On the Iron Cap claim, near the west line of sec. 9, is a deposit of massive to earthy limonite 20 feet or more in width at the surface. As indicated by fragments present in it this gossan is probably in the main a decomposition product of magnetite rather than one resulting from the oxidation of chalcopyrite.

Several prospect shafts and pits in the central and southwestern parts of sec. 10 and near the west line of sec. 15, on the east slope of Mineral Hill, expose small sedimentary inclusions, metamorphosed and mineralized to a degree similar to that of the Modoc and Goodenuf. In addition, the granite exposed by the pits in sec. 15 is sheared, contains sparingly disseminated grains of pyrite and chalcopyrite, and is stained on the weathered surface with the oxides of iron and manganese. This mineralization, however, was later than that of the inclusions and is to be correlated with that of the Apache group.

An inclined shaft on the Iron Crown claim, near the center of sec. 10, is sunk along a north-south wall formed by a dike of granodiorite porphyry. The porphyry is later than the mineralization, however, and therefore does not form a true wall of the deposit.

EVENING.

The Evening prospect is in the southern part of sec. 21, T. 31 N., R. 30 E., about a mile south of the Great Divide group, and is developed by a few small pits only. The surface being tolerably free from glacial drift, there are good exposures of a mass of metamorphosed sediments about 10 acres in areal extent, surrounded by granite. For the most part the rock is quartz-mica schist interbedded with a gray banded dense argillite that strikes N. 50° E. and dips 45° SE. Certain limy layers interbedded with the schist have changed to massive aggregates of epidote and vesuvianite. Chalcopyrite, galena, and sphalerite are sparingly associated with these layers but absent from the others.

From a pit on the Evening claim a picked sample that consisted of a soft gray mass containing coarse crystals of galena yielded by

assay at the rate of 20.2 ounces of silver to the ton and a trace of gold. Compared with ore of similar composition from other inclusions, the silver content is exceptionally high and suggests that the mineralization of the Apache type has been superimposed on that of metamorphic origin.

STEPSTONE.

The Stepstone (Cabin) prospect is in the NW. ¼ sec. 5, T. 32 N., R. 31 E., on the east bank of Stepstone Creek and the west slope of a long spur that descends from Moses Mountain southeastward to the Nespelem Valley. The upper end of the Nespelem Valley and Nespelem village lie, respectively, 1½ miles and 10 miles to the south. The formations are interbedded carbonaceous and calcareous shale, argillite, quartzite, dolomitic limestone, and quartz-mica schist. The strike is north or northeast as a rule and the dip steep east or west. The beds have been intruded by dikes of serpentine and later by masses of granite, and on the south they are cut off by the still later granodiorite porphyry.

At the time of examination the Stepstone prospect was idle. It had been developed by a shaft and an incline, neither of which was accessible. Some open cuts, however, expose the superficial portion of the deposit. The section consists of 6 feet or more of slightly brecciated gray dolomitic limestone that on weathered surfaces is brown and gritty to the touch and 15 feet of green serpentine, succeeded by quartzite and carbonaceous argillite. Layers in the limestone that range from 1 inch to 1 foot in width consist of fine-grained quartz or quartzite with which chromite, fuchsite (green chromium mica), limonite, and a little pyrite and pyrrhotite are associated. Seams and surfaces bear thin efflorescence-like coatings of genthite, an apple-green silicate of nickel and magnesium. A sample from one of the bands, analyzed in the laboratory of the Geological Survey, yielded 1.56 per cent of metallic nickel. The shaft and incline are sunk on the limestone-serpentine contacts, and the material of their dumps contain noticeable proportions of chromite, pyrite, and pyrrhotite in disseminated fine grains, together with the apple-green stain of genthite, which in some places was observed surrounding partly oxidized grains of pyrrhotite. A specimen of practically unoxidized ore from the dump yielded 2.65 per cent of metallic nickel.

In the space intervening between the Stepstone claim and the Jumbo prospect, which lies half a mile or more to the north, the rocks of the limestone serpentine belt crops out here and there as small knobs that project through the glacial drift. Several of the outcrops were observed to contain abundant fuchsite and stains of genthite.

JUMBO.

The Jumbo (Greenback) prospect lies about half a mile north of the Stepstone on the limestone-serpentine belt, which continues 1,500 feet or more to the north, where it is cut off by the Colville granite. The total length of the belt from the porphyry at the south to the granite at the north is approximately a mile. Developments on the Jumbo consist of a crosscut tunnel 25 feet under cover and some open pits. The tunnel is driven eastward and crosscuts argillite and serpentine that strike about north and dip 35° E. In places along the course of the tunnel the rocks are cut by quartz veinlets that contain chalcopyrite, pyrite, and genthite. An open pit east of the tunnel exposes the following section:

Section in open pit east of Jumbo tunnel.

	Ft.	In.
6. Brecciated gray dolomite, weathered brown, seams coated with genthite	4+	
5. Chiefly chromite with varying percentages of pyrite and fuchsite. On seams a canary-yellow coating (iron sulphate?)		3
4. Dolomite like No. 6	6	0
3. Sheared quartz; contains a considerable percentage of chromite and a little fuchsite and genthite	1	0
2. Porous vein quartz; vugs filled with limonite	3	0
1. Dolomite like No. 6	2+	

IDELL AND NEIGHBORING PROSPECTS.

West of the Stepstone and Jumbo several prospect pits are distributed over an area about a mile wide that extends from sec. 12, T. 32 N., R. 30 E., northeastward across sec. 6, T. 32 N., R. 31 E., into sec. 31, T. 33 N., R. 31 E. The country rock is siliceous and calcareous argillite parallel in structure to that of the Stepstone-Jumbo belt and similarly intruded by serpentine. In the NE. ¼ sec. 12, T. 32 N., R. 30 E., a small pit exposes a 4-foot lode that strikes N. 30° W., dips 85° NE., and cuts serpentine. The vein filling is slightly crushed quartz, the seams in which are coated with genthite and calcite. The wall crop also is nickel stained and contains manganese and iron oxides and aggregates of fibrous radiated tremolite.

Several open pits on the Idell No. 1, Idell No. 2, and Idell No. 3 claims, in the NE. ¼ sec. 6, T. 32 N., R. 31 E., expose small ramifying quartz veinlets that cut argillite and serpentine. Both vein and wall rocks are slightly nickel stained. A similar nickeliferous mineralization of the argillite and serpentine is shown by some pits in sec. 31, T. 33 N., R. 31 E.

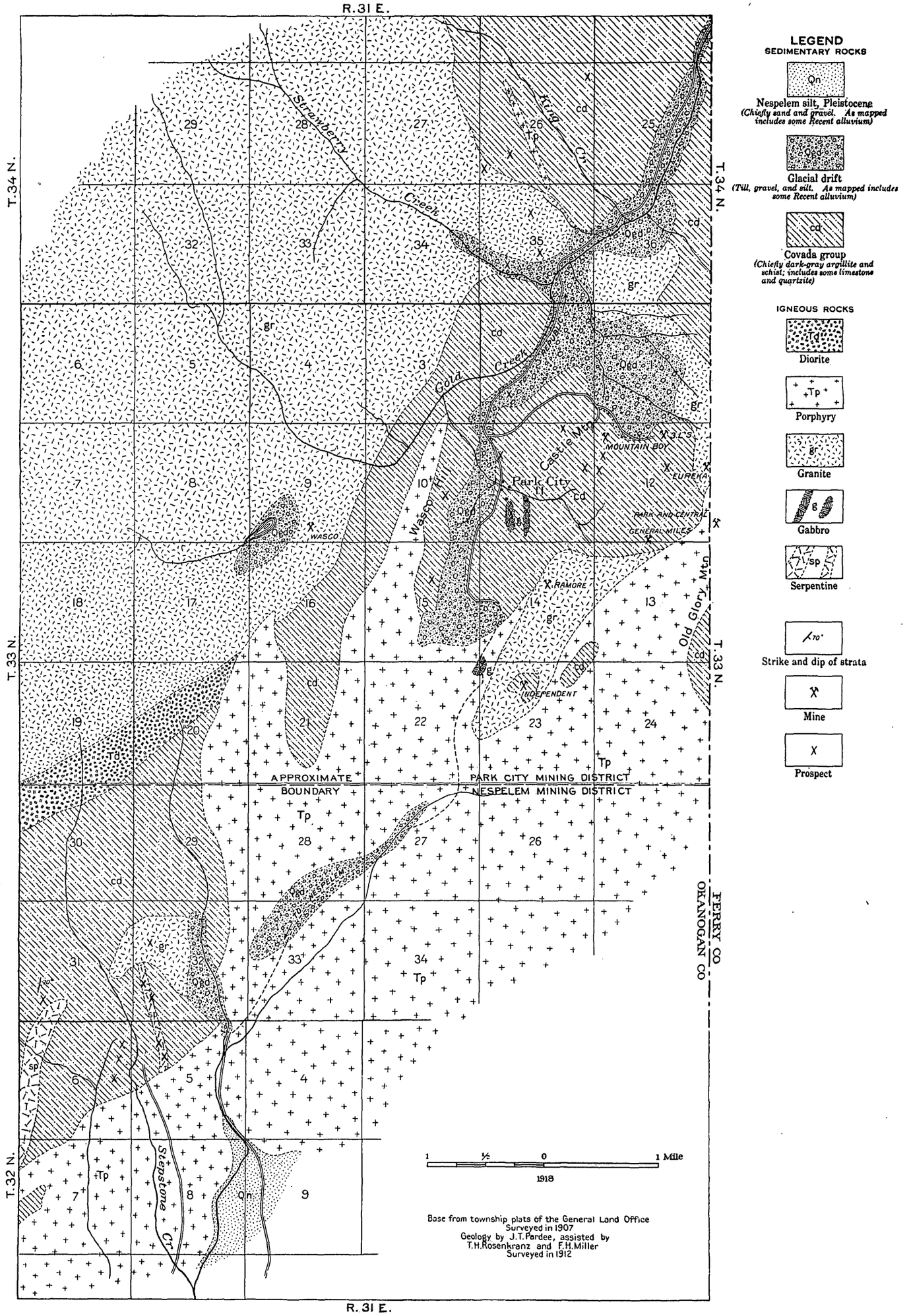
PARK CITY DISTRICT.

LOCATION AND PRINCIPAL SURFACE FEATURES.

The area commonly designated the Park City district (Pl. VIII) lies chiefly in the eastern part of Okanogan County, between the Nespelem (Moses) district and the north boundary of the Colville Reservation, and occupies most of the drainage basin of Gold Creek. In addition, the designation applies to an indefinite portion of Ferry County adjoining on the east, including the valley of the West Fork of Sanpoil River. This portion of Ferry County is included in a district organized and recorded as the Nespelem district, but for the purposes of reference the name Nespelem is by common consent now applied only to the district near the village of the same name. Practically all the important mines and prospects in the Park City district are within Okanogan County and in the Gold Creek drainage basin. Most of them are confined to the northeast quarter of T. 33 N., R. 31 E., but scattered prospects are found from that locality north to the reservation boundary.

The drainage basin of Gold Creek is a mountainous area of about 100 square miles that is overlooked from the northwest and southeast by moderately rugged divides. The divide to the northwest, which is the higher, is marked by low sags and high peaks but as a whole descends gradually from Moses Mountain (elevation 6,500 feet) northeastward to the top of a steep slope south of West Fork of Sanpoil River. The southeast divide is a northward extension of the Nespelem Range. It reaches an elevation of 5,000 feet in Old Glory Mountain, a prominent ridge east of Park City, gradually lessens in height from that point northward, and is lost in a plateau-like surface at an elevation of 3,500 feet. The southern rim of the basin is a broad undulating upland of moderate elevation that swings from Moses Mountain southeast and east to Old Glory Mountain. On the northeast the basin is open to the broad but steep-walled valley of West Fork of Sanpoil River.

About 2 miles west of Old Glory Mountain is a chain of small flats or "parks" at an elevation of 3,100 feet that extend from the northward bend of Gold Creek southward across T. 33 N., R. 31 E., to a broad pass at the same elevation in the southern rim of the basin. Spurs, of which the most prominent is Castle Mountain, project west 2 miles from Old Glory Mountain, and Wasco Hill, a low flat-topped ridge, is immediately west of the parks. From the parks west and north to the limit of the basin the surface is an undulating plateau about 3,500 feet in elevation, dissected by valleys that range from 500 to 1,500 feet in depth. Most of the valleys are steep walled and lack any notable width of bottom land. The valley of



R. 31 E.

GEOLOGIC MAP OF PARK CITY DISTRICT.

Gold Creek below the mouth of Strawberry Creek contains flats a few hundred feet wide and descends from an elevation of 2,400 feet to about 2,000 feet at its mouth.

ACCESSIBILITY AND SETTLEMENTS.

The principal mining section of the Park City district is about 21 miles south-southwest of Republic, Wash., the nearest railroad point, but the distance by wagon road between the two is about 25 miles. Except trails, this road is the only route into the district. From Republic it goes down Sanpoil River 15 miles to West Fork, thence up West Fork and its tributary Gold Creek to the mouth of Strawberry Creek, where, continuing southward, it leaves the stream and climbs a steep slope to the mines. The road is a fairly good one and, except for the last stretch, of easy grade. From the mines trails extend southward to the Nespelem Valley and eastward to Sanpoil River, and a dim trail not much used leads northwestward to Moses Meadows.

Alkire, more commonly known as West Fork, or LeRoi's, is a small settlement at the mouth of West Fork of Sanpoil River that contains a hotel and is a convenient way station between Park City and Republic or Keller. A few prospectors' cabins grouped in the western part of sec. 11, T. 33 N., R. 31 E., east of a small woodland park, are known as Park City. About a mile northeast, in a small basin north of Castle Mountain, generally referred to as the "Bungalow," are several log buildings of the Castle Creek Mining Co. A few cabins are scattered elsewhere, but few of them are occupied more than a brief portion of each year.

CLIMATE, VEGETATION, AND DRAINAGE.

The winter snowfall is said to be deep, showers are frequent in summer, and the density of the vegetation, together with the volume of the drainage, indicates an abundant annual rainfall. The summers are cool and the winters are said to be moderately cold but not severe.

The district is thickly timbered with lodgepole pine, fir, spruce, and related species. Along Gold Creek and West Fork are groves of yellow pine. Underbrush is abundant, and as a rule forage is scanty.

Practically all the drainage goes through Gold Creek northeastward to West Fork of Sanpoil River. The streams that cross the principal mining area east of Park City drain a relatively small area and are small in volume. Those tributary to Gold Creek from the west drain a larger area that contains high mountains and therefore maintain flows of good volume all the year. They have steep grades and could be made to generate a moderate amount of power.

PRODUCTION AND MINING CONDITIONS.

Ore to the amount of four or five carloads that averaged $60 to the ton is said to have been shipped from the Mountain Boy mine, but no more definite information was obtained regarding the shipments, nor was production from any other mine reported. Four carloads of 20 tons each at $60 a ton would amount to $4,800. In addition, an output of $100 in placer gold is reported from the Crounse mine on Strawberry Creek.

In 1912 a little ore was being extracted at the Mountain Boy mine, but not much more than annual assessment work was being done on about 20 other claims.

The widespread mantle of glacial drift and the generally prevalent undergrowth make the search for lode outcrops difficult. The surface contour is, however, favorable to development by tunneling, and wood and water are abundant. The greatest handicap of mining at present is the high cost of transportation due to the wagon haul of 25 miles to Republic. If a railroad, as projected, is built down the Sanpoil Valley, the wagon haul will be reduced one-half.

ROCK FORMATIONS.

Covada group.—Very fine grained argillite and siliceous rocks, believed to be of Carboniferous age, underlie most of the northeast quarter of T. 33 N., R. 31 E., and the east half of the adjoining township on the north. They form a north-south belt about 3 miles wide that abuts against the Colville granite on the west and is either displaced by granodiorite porphyry or overlain by Tertiary lavas on the east. Although separated from it by intrusive rocks, the Park City belt is evidently the northward continuation of the argillite area of Stepstone Creek, in the Nespelem district.

In the northern part of the Park City belt the prevailing kinds of rock are blue siliceous argillite and a soft gray argillite with which layers of quartz-mica schist and chlorite schist are interbedded. Toward the granite contact on the west the whole mass becomes decidedly micaceous and schistose. In the vicinity of Park City the rocks are chiefly fine-grained quartz-mica schist and light-gray to black argillite. Some of the argillitic layers are calcareous, and there are a few small detached masses of limestone. The average strike of the rocks in the Park City belt is about N. 10° W., and with few exceptions the dip is east. In the vicinity of Park City there are some local variations in strike, and the beds approach horizontality in many places. Elsewhere their dips range from 40° to 90°, the vertical attitude appearing near the granite contact south of West Fork of Sanpoil River.

Faults are commonly exposed by the mine workings, but none of structural importance was traced on the surface.

Gabbro.—Underground workings on the Iron Dike claim at Park City expose a dark greenish-gray crystalline rock that intrudes argillite. Imperfect surface exposures indicate the mass to be a dike 100 feet or more in width and a mile long. A short distance east are some similar outcrops that probably represent a parallel dike. The rock is decomposed at the surface to a dark-brown earthy material rich in iron oxides. The chief constituents of the fresh rock are coarsely crystalline plagioclase, feldspar, and augite. Secondary silicates and sulphides mask some of the original characteristics of the rock, but it appears to be a gabbro.

Granite.—The western two-thirds of the Gold Creek basin is underlain by granite that is areally continuous with that of Moses Mountain and the Nespelem district. A large offshoot from the main mass projects southeastward along the north slope of Castle Mountain, well across the argillite belt, and a large dike of the same rock crops out southeast of Park City.

In its general appearance and composition the granite is identical with that ocurring in the Nespelem district. In the vicinity of Park City it is cut by fractures of various trends, along which ore bodies have been developed. Elsewhere no structural features other than the jointing common generally to granitic rocks were observed in it.

Porphyry.—The broad belt of porphyritic intrusive rocks that occupies much of the Nespelem district continues northeastward to the middle of T. 33 N., R. 31 E., where it splits into several branches that penetrate still farther into the argillite and granite. The summit of Old Glory Mountain is formed of this rock. In general the rock that occurs in the Park City district shows no differences in appearance and composition from that of the Nespelem and Sanpoil districts. In places, however, as on the slope south of the Nespelem-Gold Creek divide, the outcrops are noticeably rusty. The discoloration is due to the oxidation of secondary pyrite deposited in seams. In a specimen from Old Glory Mountain the ferromagnesian minerals have been replaced by calcite and chlorite.

Andesite.—The large mass of andesitic lava of the upper Sanpoil Valley extends into the northeastern part of the Park City district, forming the prominent cliff-like slopes of the valley of West Fork below Crounse's. The weathered surfaces are brownish gray, and the outcrops are generally somber in appearance. The fresh rock is a medium gray with lighter feldspars and dark-green or black crystals of hornblende. The andesite and the porphyry are closely related in origin and composition, and in neither has any evidence of valuable mineralization been found in the Park City district.

Tertiary lake beds.—On the slope north of West Fork in sec. 8, T. 34 N., R. 32 E., about 450 feet above the stream, are some small outcrops of shale interbedded with andesitic lava. The thickness of shale exposed, together with that of some included layers of lava, is estimated at 300 feet. Several beds 10 feet or more thick consist for the most part of fine gray water-laid tuff. Thin layers of silt and sandstone interbedded with these contain locally a little coal. The rocks strike N. 20° E. and dip 20° W. Because of a marked similarity in composition and occurrence, they are thought to be of the same age as the Oligocene or Miocene lake beds exposed at Republic a few miles to the north.

Glacial drift.—At least 75 per cent of the basin of Gold Creek is overspread by a mantle of glacial drift that is mainly thin and patchy but in places forms extensive deposits 100 feet or more thick. The deepest accumulations are in the valleys, and as a rule the material bears evidence of a partial arrangement by running water at the time it was deposited. It is composed principally of subangular, indistinctly stratified gravel with boulders of various sizes and abundant sand in the matrix. Beds of fine sand and silt are not uncommon, and boulders of rock foreign to the district are widely distributed.

LODES.

CHARACTER AND DISTRIBUTION.

The most productive known mineral deposits in Park City district are quartz lodes, in which silver and lead are the predominant metals of value. Zinc is commonly present, but except in one mine, the Iron Dike, is subordinate in amount. Gold and copper occur in most of the lodes but as a rule are practically negligible.

The most promising lodes so far discovered occur in an area of about 4 square miles in the northwest quarter of T. 33 N., R. 31 E., in the vicinity of Park City. North of this area prospects are scattered here and there as far as the reservation boundary, but all lie within a north-south belt from 1 to 3 miles wide and 9 miles long.

CLASSIFICATION.

Most of the lodes are lenticular quartz veins in fissures that cut the Colville granite and rocks of the argillite series in a general north-northwesterly direction. Some of them may be classified, however, as shear zones in which silicification and replacement have occurred. In either class variations of as much as 70° from the general strike are shown here and there. The dips cover a wide range, and many of the lodes in the argillitic rocks coincide in slope and direction

with bedding planes. The Iron Dike lode, however, is notably different from the others. It is essentially a mineralized shear zone in gabbro, with no silicification.

MINERALOGY.

The minerals that have been identified in the lodes are tentatively grouped according to genesis as follows:

Primary minerals:
- Pyrite (iron disulphide).
- Pyrrhotite (magnetic iron sulphide).
- Chalcopyrite (iron-copper sulphide).
- Galena (lead sulphide).
- Zinc blende (zinc sulphide).
- Tetrahedrite (antimonial copper sulphide).
- Quartz.
- Calcite (calcium carbonate).
- Fluorite (calcium fluoride).

Minerals of the oxidized zone:
- Limonite (hydrous iron oxide).
- Oxides of manganese.
- Malachite (green carbonate of copper).
- Azurite (blue carbonate of copper).

Pyrite is abundant and widely distributed in most of the lodes. It occurs as disseminated crystals and as grains interlocked with other sulphides. In the Old Glory and Independent mines it forms massive bunches of coarsely granular texture that contain a little silver but a trace only of gold.

Pyrrhotite is abundant in the Iron Dike lode, in which it is closely associated with zinc blende. It was identified in but one or two other deposits.

Chalcopyrite is present in many of the lodes, but as a rule in relatively small proportions. In some of the scantily mineralized lodes, however, it is the principal valuable mineral to be seen.

Silver-bearing galena is economically the most important mineral in the district. It occurs in greatest abundance in the lenticular veins in both argillite and granite adjacent to Park City and is sparingly present in most of the other prospects. In many of the lodes it is coarsely crystalline and associated with zinc blende.

Zinc blende in subordinate proportions has about the same range in distribution as galena. It is the most abundant mineral, however, in the Iron Dike lode.

Tetrahedrite was not identified by the writer but was observed in the Mountain Boy and in lodes of the Ramore Mining Co. by Bancroft.[1]

[1] Bancroft, Howland, The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, pp. 207–208, 1914.

Quartz is by far the most abundant and in most places the only gangue mineral but is notably absent in the Iron Dike. Calcite and fluorite are present in a few of the lodes.

ORE SHOOTS.

Ore has so far been developed only in some of the lodes east of Park City. In the upper workings of the Mountain Boy several disconnected lenses of ore have been stoped. For the most part they are not more than a foot in average width and range in diameter from a few feet to 30 or 40 feet. The ore extracted from them is said to have averaged $60 to the ton. A lens exposed in the Eureka lode is 18 inches thick in the middle, tapers to a feather edge, and is 8 or 10 feet in longest dimension. A selected sample of this body contained more than 40 per cent of lead and 150 ounces of silver to the ton. In few other lodes has ore so far been found in commercial quantities, and in none examined had the dimensions of actual or prospective ore bodies been determined. The lodes cut by the Ramore adit tunnel, as described by Bancroft, and that exposed in the workings of the Independent group contain bodies of what may be regarded as low-grade ore, which are from 5 to 10 feet in width but of unknown vertical and horizontal dimensions.

AGE AND GENESIS.

The lodes of the Park City district are clearly of later date than the intrusion of the granite and earlier than that of the granodiorite porphyry. They are thought to be genetically connected with the granite, which is probably of Cretaceous age, and therefore they probably date from the Cretaceous.

The lode minerals are characteristic of deposits believed by geologists generally to have been formed at shallow to intermediate depths by ascending solutions given off by cooling granitic magmas, and the relations of the lodes to the granite suggest that they are an after-effect of that intrusion. The lodes containing much zinc blende and pyrrhotite were probably formed under greater cover than those in which galena is most prominent.

OXIDATION AND ENRICHMENT.

As a rule the oxidized zone is very shallow, and in many places it is absent, owing in part, no doubt, to the comparatively recent wearing away of the surface by glaciation. Data concerning the relative leaching or enrichment of the oxidized zone are lacking. No minerals characteristic of downward enrichment or other evidences indicative of that process were observed, and it is thought to have been of little or no importance in the lodes of the Park City district.

CONCLUSIONS.

Because the ore bodies are composed essentially of primary minerals of presumably deep-seated origin, they need not be expected to improve with depth, but, on the other hand, they should not decrease notably in grade. Most of the ore bodies are relatively small and nonpersistent, do not encourage mining operations on a large scale, and can not, under present conditions, be expected with certainty to pay even in a small way. Some of the larger ones, however, as, for instance, the Independent and the body opened by the Ramore tunnel, may prove to contain fair amounts of low-grade ore. The Iron Dike lode is a large deposit of very low grade zinc ore. Whether portions of it are rich enough to be mined and reduced at a profit remains to be determined. It is certainly worth further exploration. The most richly mineralized area lies in the northeast quarter of T. 33 N., R. 31 E., adjacent to Park City. West and north of that locality the conditions are less encouraging.

PLACERS.

Gravels adjacent to Strawberry Creek, in the southwest quarter of T. 34 N., R. 31 E., are locally gold bearing and are said to have produced $100. The deposit is not of great extent and has been mined only in a very small way. It lies in a valley transverse to the general direction of glaciation and may in part be preglacial material that was not disturbed by the ice. Panning tests at one point showed the presence of gravel rich enough to pay, under favorable conditions of mining.

Placer claims have been located on West Fork of Sanpoil River and Gold Creek below the mouth of Strawberry Creek, but have not been developed except by pits and open cuts sufficient to comply with the law. Panning tests here and there failed to reveal anything of value. As a rule, pay dirt is not to be expected in deposits such as these, which consist of practically unmodified glacial drift.

MINES AND PROSPECTS.

LODES.

MOUNTAIN BOY, SUMMIT, AND SNOWSHOE.

The Mountain Boy and Summit mines are on Castle Mountain, about a mile northeast of Park City, and the Snowshoe claim lies half a mile farther east, on the northwest slope of Old Glory Mountain. These claims, together with some others near by, are the property of the Castle Creek Mining Co. and are collectively known as the Mountain Boy group.

The three claims named above were examined in 1910 by Bancroft, from whose report[1] the following descriptions are quoted:

Summit.—Workings on the Summit claim consist of numerous surface cuts and one adit tunnel which was 350 feet long in July, 1910. These workings are located near the top of Castle Mountain and are the highest workings of note on the ground of the Castle Creek Mining Co. The portal of the adit tunnel is a little less than a mile south of west of camp, at an elevation of 4,360 feet.

A sedimentary series of argillite, limestone, quartz-mica schist, and lime shale intruded by dikes of granite of varying dimensions constitute the geologic section in this locality. In general the sedimentary rocks appear to dip at flat angles, and only minor folding was seen. It was impossible to ascertain the general dip and strike of the formations because of the disturbances caused by the many intrusions of granite. This rock prevails throughout the adit tunnel. Along a fault plane in the granite much shearing has taken place, and in a 50-foot drift on this shear zone, which is 150 feet from the portal of the adit tunnel, the rock greatly resembles shale. In this shear zone, which contains much gouge and is about 18 inches wide, are lenticular masses of quartz containing scattered patches of galena, pyrite, chalcopyrite, sphalerite, and tetrahedrite. The ore from a small stope in this short drift is said to contain 0.06 to 0.12 ounce of gold and 35 to 90 ounces of silver to the ton and 30 to 40 per cent of lead. The ore and gangue minerals occur in pockets that do not appear to be very extensive.

The surface cuts expose quartz veins in the limestone and shale series, and these appear to be more numerous in the vicinity of the intrusive granite dikes than elsewhere. The veins are all more or less lenticular and are broken up by postmineral faulting. Some were seen which had a very flat dip, and in general they appear to have the same attitude as the sedimentary formations. Galena, sphalerite, chalcopyrite, pyrite, and gray copper are sparingly distributed through the quartz, and near the surface the oxidized products limonite, malachite, azurite, and anglesite were seen.

Snowshoe.—The workings on the Snowshoe claim are about four-fifths of a mile southeast of the camp, a little less than a claim's length southwest of the portal of the adit tunnel on the Summit. The original discovery hole and an abandoned adit are located at an elevation of 4,225 feet, and an adit tunnel 35 feet above these workings has been driven southeastward for a distance of 180 feet. This adit tunnel exposes a shale and limestone series which strikes about east and dips 25° S. No mineralized veins had been cut when the adit was examined in July, 1910. The discovery hole or open cut exposes a quartz vein 2 to 3 feet wide between a footwall of granite and a hanging wall of lime shale or limestone. The vein has a dip of 5°–10° S. and strikes with the strata—that is, east. As only a small portion of the vein was exposed in this discovery hole, it is impossible to give much information as to the size and continuity of the ore body. Galena and some sphalerite seem to be fairly well distributed through the outcrop of the vein. Limonite, resulting from the alteration of pyrite, is prominent and stains the outcrop a dull reddish-yellow color.

Mountain Boy.—Three adit tunnels with short drifts, inclines, and other workings are located near one another on the Mountain Boy claim, about half a mile southwest of the camp. Another adit tunnel, which is about 950 feet long, has been driven through the Copper King claim southeastward into the Mountain Boy claim. The portal of this adit tunnel (No. 4) is about 200 feet

[1] Bancroft, Howland, The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, pp. 205, 207, 1914.

lower than the highest working on the Mountain Boy. The rocks explored in all these workings are a part of the limestone and shale series which prevail over a large portion of Castle Mountain and the ridges projecting from it. The rocks have a general northeast strike in the vicinity of the Mountain Boy workings and dip 30°–60° NW., although many local variations from these directions were seen.

Only two of the four tunnels represent development on ore bodies, Nos. 3 and 4 having been driven to open ground under the ore shoots above. The No. 1 and No. 2 workings are within 75 or 100 feet of one another and on practically the same level.

No. 1 tunnel is located at an elevation of 3,920 feet. A crosscut adit extends 30 feet, beyond which point a gentle incline 75 feet long and a steep pitch of 50 feet lead to a level known as No. 3, which is connected with the No. 2 and No. 3 workings. Short drifts of various sizes have been run off from the main level in all directions, having resulted from gutting the small irregular ore-bearing quartz lenses that occur along the planes of schistosity of the sedimentary rocks. Underground developments show that these quartz lenses vary in width from half an inch to 18 inches and in length along the dip and strike from 2 inches to 30 feet, and some of them may have greater dimensions. They contain irregularly scattered patches of galena, sphalerite, chalcopyrite, pyrite, and tetrahedrite. The ores show some banding and are brecciated by post-mineral movement. Both the ore bodies and the sediments are traversed by innumerable veinlets of calcite.

The sedimentary rocks are less disturbed in the No. 2 workings, where a quartz vein about 18 inches wide has been explored for a short distance. This vein strikes N. 47° E. and dips 60° NW. and contains the same association of minerals as the quartz lenses explored in the No. 1 workings.

In 1912 a few men were at work on the Mountain Boy, and a small lot of ore had been extracted. The total production of this mine is reported to be four or five carloads of an average value of $60 to the ton, presumably in silver and lead. One ton is said to have yielded $600. But little new work had been done on the Summit and Snowshoe and no additional facts of importance were learned concerning them.

EUREKA.

The Eureka mine, also included in the Mountain Boy group, lies on the north slope of Old Glory Mountain, about a quarter of a mile east of the Snowshoe. The principal underground working is a tunnel driven southeastward 200 feet in the Colville granite. Here and there are veinlets and bunches of quartz through which a little galena is disseminated. At 65 feet from the portal the tunnel pierces a northeasterly fault fissure that dips 45° SE., has smooth walls, and contains a foot or two of crushed granite, talc, and vein quartz. At the tunnel intersection there is a lens of ore 18 inches thick in its central portion and 10 feet or more in diameter, composed of quartz, galena, pyrite, and chalcopyrite. Galena is in excess of the other sulphides and a selected sample as nearly pure galena as could be found yielded by assay 41.4 per cent of lead and 150.6 ounces of silver to the ton.

THREE L'S.

The Three L's prospect of the Mountain Boy group is near the north line of sec. 12, T. 33 N., R. 31 E., on the lower north slope of Old Glory Mountain. A tunnel 200 feet long, with several crosscuts, exposes blue and white crystalline limestone and gray fine-grained quartzite that strike north and dip 45° E. These rocks are cut by several fissures, most of which strike east, dip steeply south, and show evidences of fault movement, but no ore worthy of attention was seen in them. About 100 feet east of the portal of the tunnel is a small knob of the Colville granite in which open pits expose two nearly vertical east-west walls about 6 feet apart. The prism between them is sheared and traversed by veinlets of quartz and galena that range from a fraction of an inch to 2 inches in width. Although the tunnel runs directly beneath this outcrop, it had cut neither the granite nor the mineralized shear zone, both of which have probably been shifted by a fault.

HANFORD.

The prospect of Judge Hanford is about a quarter of a mile southwest of the Mountain Boy, on the southwest slope of Castle Mountain. At the time it was visited the claim was idle and its principal underground working, an inclined shaft, was nearly filled with water. At the surface the vein is 2 or 3 feet wide, is inclosed in argillite, and consists of porous iron-stained quartz similar to the croppings of the Mountain Boy. The dump contained partly oxidized material in which galena and pyrite were present. A sample that showed 30 per cent or more of galena yielded by assay 25.9 per cent of lead, a trace of gold, and 20.48 ounces of silver to the ton.

PARK AND CENTRAL AND GENERAL MILES GROUPS.

Several patented claims are included in the Park and Central and the General Miles groups, situated on Old Glory Mountain near the SE. ¼ sec. 12 and in the N. ½ sec. 13, respectively. When visited in 1912 they were closed and had apparently been idle for a considerable time. Little was learned concerning them except that the geologic relations of their veins are similar to those of the Mountain Boy group and their most valuable mineral is silver-bearing galena.

POORMAN AND CLIFF.

The Poorman and Cliff prospects are three-quarters of a mile northeast of Park City, on a south spur of Castle Mountain. Some short adit tunnels and pits on the Cliff expose a crushed zone of

indefinite boundaries in argillite. The breccia is cemented with calcite and sparsely mineralized with pyrite and zinc blende. On the Poorman a 100-foot adit level follows a N. 15° E. vein, 6 to 18 inches in width, of banded quartz, sparingly mineralized with pyrite, galena, and zinc blende. The wall rock is argillite.

SHARP & BALTHUS.

The prospect of Sharp & Balthus lies half a mile north of Park City, along the road to Gold Creek. The formations are interbedded black and greenish-gray argillite that strike N. 80° E. and dip 45° W. and are locally crushed and recemented with films of calcite and pyrite. The development workings are two tunnels driven eastward, one above and one below the road. The upper tunnel, 40 feet in length, follows a bedded vein that pinches and swells and averages about 2 feet in width. The vein filling consists of banded quartz that carries small percentages of pyrite, galena, and zinc blende and is separated from the walls by a soft black gouge. At the north wall of the tunnel the vein is cut off by a smooth fault plane that strikes N. 55° E. and dips 45° SE.

The lower tunnel had not intersected the vein, although run on the downward projection of its dip. The fault exposed in the upper tunnel shifted the vein, so that its continuation should be looked for to the north.

IRON DIKE.

The Iron Dike prospect of John Redmond, in sec. 4, T. 33 N., R. 31 E., adjoins the site of Park City on the southeast. Development work is limited to two short crosscut tunnels and a few pits. The lode is an altered mineralized dike of a composition similar to gabbro, and the inclosing rock is argillite. Because of the abundant glacial drift the boundaries of the dike could not be closely determined. The visible outcrops indicate, however, that the mass trends about north and is at least 100 feet wide and several hundred feet long. If a similar outcrop on the line of strike near the southwest corner of sec. 14 is part of the same mass, the dike is a mile or more in length. About 400 feet to the east of the dike some small pits expose a similar rock that appears to be a parallel dike separated from this one by a belt of argillite.

The weathered rock is dark brown, soft and crumbly, and rich in iron oxides. The unweathered rock, as exposed in the upper tunnel, is dark greenish gray, massive, tough, and of moderately coarse granular texture and in mining splits into blocks along vertical northerly and easterly joints. Its chief constituents are plagioclase

and augite, the former considerably altered. Secondary calcite and epidote are present, and the whole is impregnated with grains of zinc blende, pyrite, pyrrhotite, and chalcopyrite. In part the sulphides are aggregated as flakes and thin films in minute fractures that traverse the rock in various directions. Locally they are concentrated in bands as much as a quarter of an inch in width. Some bands are formed almost exclusively of zinc blende. Others contain chiefly the iron sulphides and chalcopyrite. Calcite forms veinlets of various directions and also lines joints in the rock. The main crosscut tunnel penetrates 20 feet of weathered material and 55 feet of unoxidized rock containing sulphide. In this width of 55 feet there is but little variation in the percentage of sulphide present. A fairly representative sample of the width mentioned yielded by assay 3.2 per cent of zinc, 0.3 per cent of copper, and traces of gold and silver. At a level about 50 feet lower a crosscut tunnel 20 feet under cover ends in unoxidized rock like that of the upper tunnel except that it is serpentinous in places and is slightly richer in zinc blende and pyrite. A selected sample from the face yielded by assay 6 per cent of zinc, 0.05 per cent of copper, a trace of gold, and no silver. So far as exposed by two pits, the eastern dike is similarly mineralized. Without doubt, large bodies of very low grade zinc ore exist here, and the chances seem favorable that portions rich enough to be profitably mined will be found.

RAMORE MINING CO.

The Ramore Mining Co.'s property, in the NE. ¼ sec. 14, T. 33 N., R. 31 E., was idle and the principal workings were closed when it was visited in 1912. They were examined in 1910, however, by Bancroft, from whose report [1] the following is quoted:

> Four patented claims belonging to the Ramore Mining Co. are located about 3 miles south of the Castle Creek Mining Co.'s camp. The developments consist of two main levels, one on the Hercules claim and another on the Ramore. The portal of the adit tunnel on the Ramore claim is about 1,600 feet northeast of and 350 feet higher than the level on the Hercules claim. No large shipments of ore are reported from either of these claims.
>
> Limestone, lime shale, argillite, and quartz-mica schist intruded by granite are the prevailing rocks in this locality. The sedimentary series has a general north-south strike, although variations from this direction were seen in many places. The dip ranges from east to west and is not constant over great distances. Faulting is a prominent feature of the geology in this vicinity, especially along the intrusive contacts of the granite and the sedimentary rocks.
>
> The adit tunnel on the Hercules claim, at an elevation of 3,600 feet, has been driven due east for a distance of 430 feet, and this part of the level is almost entirely granite. A contact between the metamorphic sedimentary series and granite is encountered 120 feet from the portal of the adit. On this contact,

[1] Bancroft, Howland, op. cit., pp. 207–209.

which runs northeastward, a drift has been run for a distance of 180 feet. Near the end of the drift is a 100-foot crosscut. Along the contact between the two kinds of rock is a zone of intense movement which has an average width of about 5 feet and a dip from 45° NW. to vertical. Galena, sphalerite, chalcopyrite, pyrite, pyrrhotite, and tetrahedrite are more or less disseminated through the sedimentary rocks in the vicinity of the intrusive granite, and some limestone strata are replaced by these minerals. In the crosscut from the drift is a small vein in granite. This vein strikes N. 65° W., dips 65° SW., and is only a few inches wide. It contains a similar association of ore minerals, together with quartz and fluorite. As exposed by the workings on this level the major part of the mineralization is scattered through the metamorphic sedimentary series near igneous contacts in small veinlets containing also some quartz, calcite, and fluorite and as irregular partial replacements in the limestone and lime shale. The extent of the mineralization has not been determined, but as exposed in the drift along the main contact it appears to have been pockety and irregular.

The Ramore adit tunnel has been driven N. 4½° E. for a distance of 440 feet. About 40 feet from the breast a branch crosscut extends northeastward for 600 feet, and from this branch several short crosscuts have been run. On a good-sized vein cut 220 feet from the portal a short drift has been run and a winze sunk for 45 feet on the footwall. This vein is the only ore body of note exposed in these workings. It strikes N. 20° W., dips 30° NE., and is about 10 feet wide. It has been explored along the strike for about 70 feet. The hanging wall of the vein is granite, and the footwall is a part of the metamorphic series. The vein filling is chiefly quartz, with which are associated some fluorite and calcite. Sphalerite, galena, pyrite, chalcopyrite, pyrrhotite, and tetrahedrite are irregularly scattered through the quartz and disseminated through the sedimentary series, locally replacing the limestone, and these minerals are also found is small fractures in the granite. The ores are reported to contain appreciable amounts of lead, silver, and copper, with some gold and zinc. Four analyses by H. J. Armstrong, of the Republic Gold Mining & Milling Co., show the presence of 2.7 to 9.6 per cent of lead and 13 to 59 ounces of silver and 0.05 to 0.07 ounce of gold to the ton. The intrusion of the granite which has so promiscuously invaded the sedimentary series was accompanied by severe dislocations. The fractures thus caused and the contiguous limestone strata have been more or less mineralized by ore-bearing solutions, which followed the intrusion. The limits of the ore bodies have not been ascertained, and much work has been done on this level that has not tended to develop the main ore body exposed 220 feet from the portal. In fact, the developments have been carried away from rather than along the course of the ore deposit. If the ore body is as persistent as its general appearance where exposed seems to indicate, it does not seem unreasonable to suppose that the deposit could be profitably exploited by concentration on the ground.

INDEPENDENT.

The Independent mine is 1½ miles south of Park City, in the N. ½ sec. 23, T. 33 N., R. 31 E. The principal workings are a large open pit or glory hole and an adit level to the east of it 60 feet in length. Both penetrate contact-metamorphosed bluish and greenish gray argillite through which pyrite films are disseminated. At short distances to the east and west the Colville granite displaces the argillite.

The glory hole exposes an east-west sheared zone 5 feet in width that is silicified and partly replaced by pyrite, galena, and zinc blende. Of the sulphides mentioned, pyrite is in considerable excess and occurs both as disseminated grains and massive granular bunches as much as 2 feet in diameter. A representative sample of one of the larger bunches yielded by assay a trace of gold and 1.32 ounces of silver to the ton. The galena and zinc blende are sparingly and irregularly scattered through the zone. No samples containing them were assayed, but galena in other portions of the district is silver bearing.

A 4½-foot zone mineralized similarly to that shown in the glory hole is cut by the tunnel 40 feet from its portal.

WASCO.

The Wasco group of claims covers the western slopes of Wasco Hill in sec. 9, T. 33 N., R. 31 E., about a mile west of Park City. The workings were examined in 1910 by Bancroft,[1] who describes them as follows:

> Several claims about 3 miles a little south of west of the camp of the Castle Creek Mining Co., on top of the first ridge west of the main course of Gold Creek, constitute the Wasco group. On these claims a shallow shaft, several small surface cuts, and a short adit tunnel represent the development work. No shipments are reported to have been made from this group.
>
> Medium to fine grained quartz-mica schists intruded by granite form the ridge in which the Wasco workings are located. The general strike of the sedimentary rocks is north, and the dip is about 60° E. The intrusive dikes of granite follow the general direction of the strike of the schists and range in width from a few feet to several hundred feet or more. Molybdenite and the oxidized product molybdic ocher, together with large crystals of muscovite, occur in many of the granite dikes in this locality.
>
> As no connected development exists on the ore deposits in this group the ore bodies exposed in the different workings will be described separately. A shaft at an elevation of 3,900 feet and said to be 40 feet deep, but practically full of water when seen, exposes a quartz vein about 12 inches wide which strikes N. 30°–40° W. and dips 15°–40° NE. The vein is in granite and is sparsely mineralized by galena, sphalerite, chalcopyrite, and pyrite.
>
> An open cut 300 to 400 feet north of the shaft and about 50 feet higher exposes a contact of the granite and schist along which occurs a quartz vein about 3 feet wide, sparsely mineralized by chalcopyrite, pyrite, and sphalerite and the oxidized products malachite, azurite, and limonite. These ore minerals occur in pockets. The vein strikes northwest and dips 65° NE. An opening on the same vein 50 feet northwest of this open cut and 25 feet lower shows the vein between walls of granite. No ore minerals are visible in the main vein, but three small cross fissures which strike northeast and dip 40° SE. are filled with quartz carrying some chalcopyrite and sphalerite. Other small workings show the same general scattered mineralization in quartz veins in granite and schist or between the two kinds of rock.

[1] Bancroft, Howland, op. cit., pp. 209, 210.

An adit tunnel, from which there are several short drifts and crosscuts, has been driven for a distance of 350 feet at an elevation of about 3,900 feet. In this working a vein has been exposed for short distances in two places. Where seen the vein appeared to strike N. 60°–70° W. and to dip 45°–55° NE. The vein is 24 inches wide and is composed mainly of quartz with the ore minerals "steel" galena, chalcopyrite, pyrite, sphalerite, and tetrahedrite sparsely distributed through it. The ores are said to contain appreciable quantities of silver and copper and some gold.

The Wasco group was idle in 1912, and apparently no work other than that required for annual assessment had been done since 1910. The 350-foot adit tunnel mentioned by Bancroft had been extended 50 feet or more and a winze sunk a few feet on the vein. In addition to most of the minerals enumerated by Bancroft fluorite was identified at this point.

OLD GLORY.

Several prospects are located on the southern extension of Wasco Hill in sec. 15, T. 33 N., R. 31 E., of which the Old Glory has been the most extensively developed. On this claim a tunnel 140 feet long exposes quartz-mica schist and gray argillite that are cut here and there by quartz veinlets and contain sparingly disseminated grains of pyrite and chalcopyrite. In addition, lenslike bunches of massive granular pyrite 1 foot or less in thickness are exposed in places, but no well-defined vein is shown. The adjacent portions of sec. 15 and the E. ½ sec. 16 contain several prospects on quartz-limonite outcrops, some of which are of fair size, but none have been explored below the oxidized zone.

MONEYMAKER AND GOVE.

The Moneymaker prospect is on the slope north of Strawberry Creek, half a mile above the stream, near the southwest corner of sec. 26, T. 34 N., R. 31 E. The rock formation is the Colville granite, which abuts against quartz-mica schist on the east. The principal working is a large open pit sunk 15 feet in a north-south zone of sheared, silicified granite. Within the zone are two or more irregular streaks of vesicular iron-stained quartz that range from a foot to 3 or 4 feet in width. A sample from one of the streaks yielded by assay a trace of gold and 2.72 ounces of silver to the ton. Seams in the quartz and granite are heavily coated with manganese oxides.

On the Gove prospect, about a claim's length northeast of the Moneymaker, a sheared zone 10 feet wide that strikes N. 20° W. and dips 20° E. is conformable with the bedding of the inclosing quartz-mica schist. The material of the zone is silicified and contains a little disseminated pyrite.

ATKINS.

An inclined shaft on the prospect of W. A. Atkins is sunk near the southwest corner of sec. 12, T. 34 N., R. 31 E., about 1½ miles southwest of and 1,500 feet higher than Crounse's cabin on West Fork of Sanpoil River. At the time of examination the shaft, which is said to be 40 feet deep, was filled with water within a few feet of the surface. It exposes a 3-foot vein bedded between gray mica schist and blue argillite that strike north and dip 50° E. Near the shaft the vein is cut by a northeastward-trending dike of granodiorite porphyry. At the surface the vein filling is chiefly massive quartz, but a layer about 1 foot in thickness is irregularly banded with pyrite, galena, and zinc blende. A picked sample from this layer yielded by assay a trace of gold and 2 ounces of silver to the ton. The sample was not assayed for lead or zinc but contained by estimate 20 per cent of galena and zinc blende together. The oxidized zone is not over 4 or 5 feet deep and in addition to limonite contains a little copper stain. The outcrop of the vein is traced 200 feet or more to the north by means of small pits.

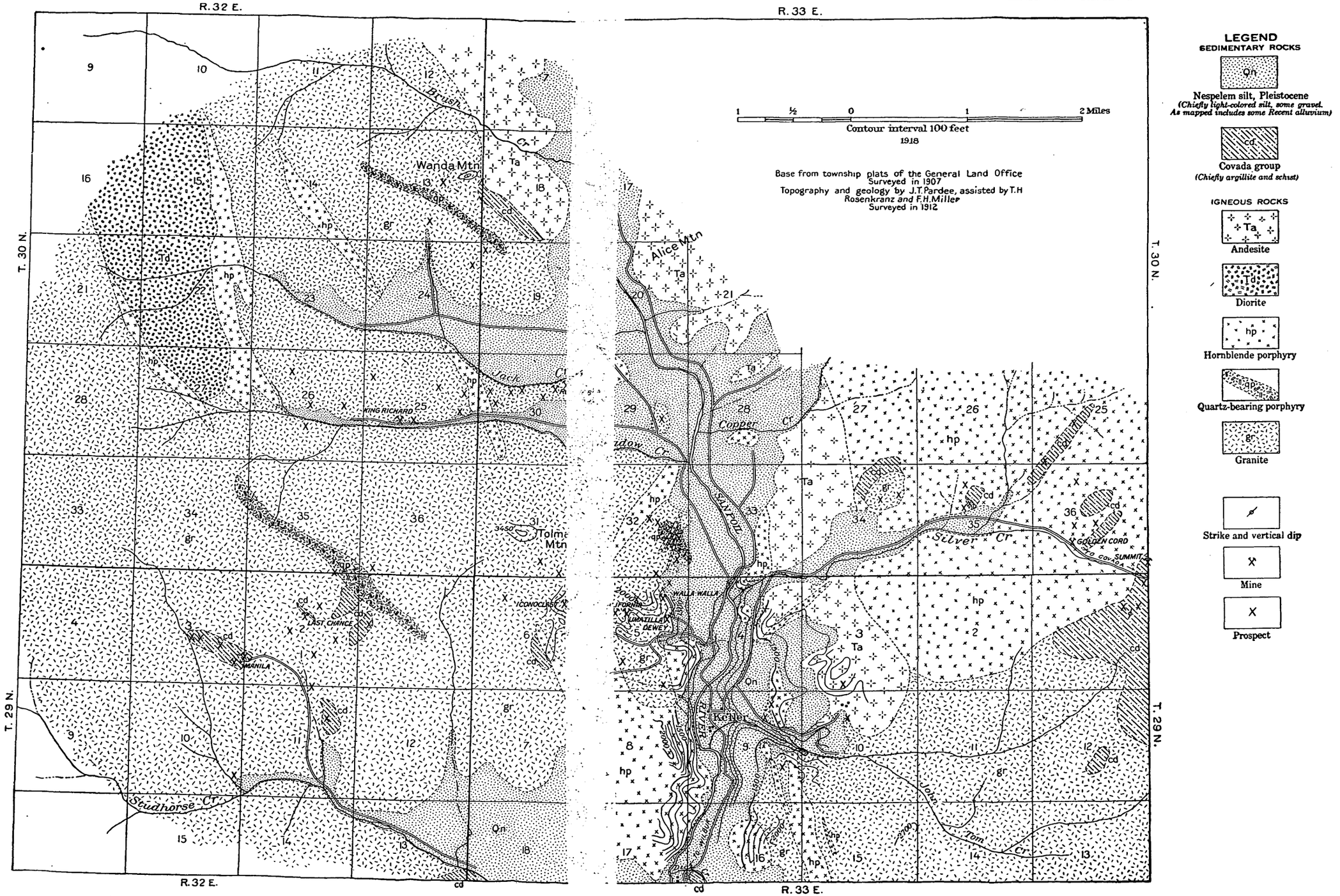
BONANZA AND MAID OF ERIN.

The Bonanza and Maid of Erin prospects of Harry Crounse are in sec. 1, T. 34 N., R. 31 E., on the slope north of West Fork of Sanpoil River, 2½ miles above the mouth of Gold Creek. The formations are siliceous blue-gray argillite and green, thinly laminated mica schist that strike N. 30° W. and dip steeply southwest. In broad zones that trend in a general N. 15° W. direction the argillite and schist have been largely replaced by silica and are traversed by irregular veins of white quartz. On the Bonanza claim is a bold outcrop of quartz 20 feet wide, lenticular in plan, and cut by vertical N. 40° W. shear planes. The quartz is white and pure, except that here and there it shows a grain of pyrite or chalcopyrite or a vug that contains limonite or earthy manganese oxides. The seams are iron stained and in places washed with the green stain of copper carbonate. On the Maid of Erin claim an open cut exposes two parallel lenticular veins of massive white quartz 3 feet in maximum width bedded in green mica schist that strikes N. 10° W. and dips 40° E. Here and there in the quartz are small lenslike bunches of pyrite and chalcopyrite.

PLACERS.

CROUNSE.

The placer claims of Harry Crounse lie along the lower course of Strawberry Creek in the S. ½ sec. 35, T. 34 N., R. 31 E., and adjacent



GEOLOGIC MAP OF SOUTHWEST[illegible]RT OF SANPOIL DISTRICT.

lands. On each side of the stream are flats that range from 20 to 200 feet in width and are underlain by a shallow deposit of gravel that is chiefly of glacial origin. It is loose textured, as a rule, and contains abundant cobbles and large boulders. Some small pits dug in the creek bank are said to have yielded collectively $100 worth of gold. Two pans of gravel from the layer next to bedrock tested by the writer yielded 1 cent in gold and an ounce or more of black sand. The particles of gold are small and rough or but slightly waterworn, and some of them are attached to fragments of clear white quartz. The black sand consists chiefly of magnetite and ilmenite, together with some small pink and red garnets.

PLACER CLAIMS ON GOLD CREEK AND WEST FORK OF SANPOIL RIVER.

A chain of placer claims extends from the mouth of Strawberry Creek down Gold Creek to West Fork of Sanpoil River, and on down that stream to its mouth. No mining has been done on them, and they are developed by prospect pits only. The flats and terraces they cover are underlain, for the most part, by unmodified glacial drift. Here and there, however, lenses of stratified sand and gravel occur that yield a "color" or two of gold to the pan. Panning tests were made at several pits along West Fork and Gold Creek, and the greatest amount of gold obtained from a single pan of dirt was estimated to be 0.005 cent. Similar placer claims in the vicinity of Alkire, at the mouth of West Fork, are described by Collier.[1]

SANPOIL (KELLER) DISTRICT.

LOCATION AND PRINCIPAL SURFACE FEATURES.

The Sanpoil district (see Pls. IX, X) occupies a large area in the southwestern portion of Ferry County, Wash. It lies in the southeastern portion of the Colville Indian Reservation between the Nespelem and Covada districts, its recorded boundaries being Columbia River and Okanogan County on the south and west, respectively, and lines 25 miles distant from these on the north and east. This approximate square includes the lower course of Sanpoil River and the basins of Ninemile Creek, Wilmont Creek, and several smaller tributaries of Columbia River. The basin of Wilmont Creek, however, is also included in part within the boundaries of the Covada district and is more conveniently described as a part of that subdivision.

The Sanpoil district is mountainous and rugged throughout. Picturesque cliffs and canyons are abundant; the relief is commonly 2,000 or 3,000 feet and reaches an extreme of about 4,000 feet. Steep

[1] Collier, A. J., Gold-bearing river sands of northeastern Washington: U. S. Geol. Survey Bull. 315, p. 68, 1907.

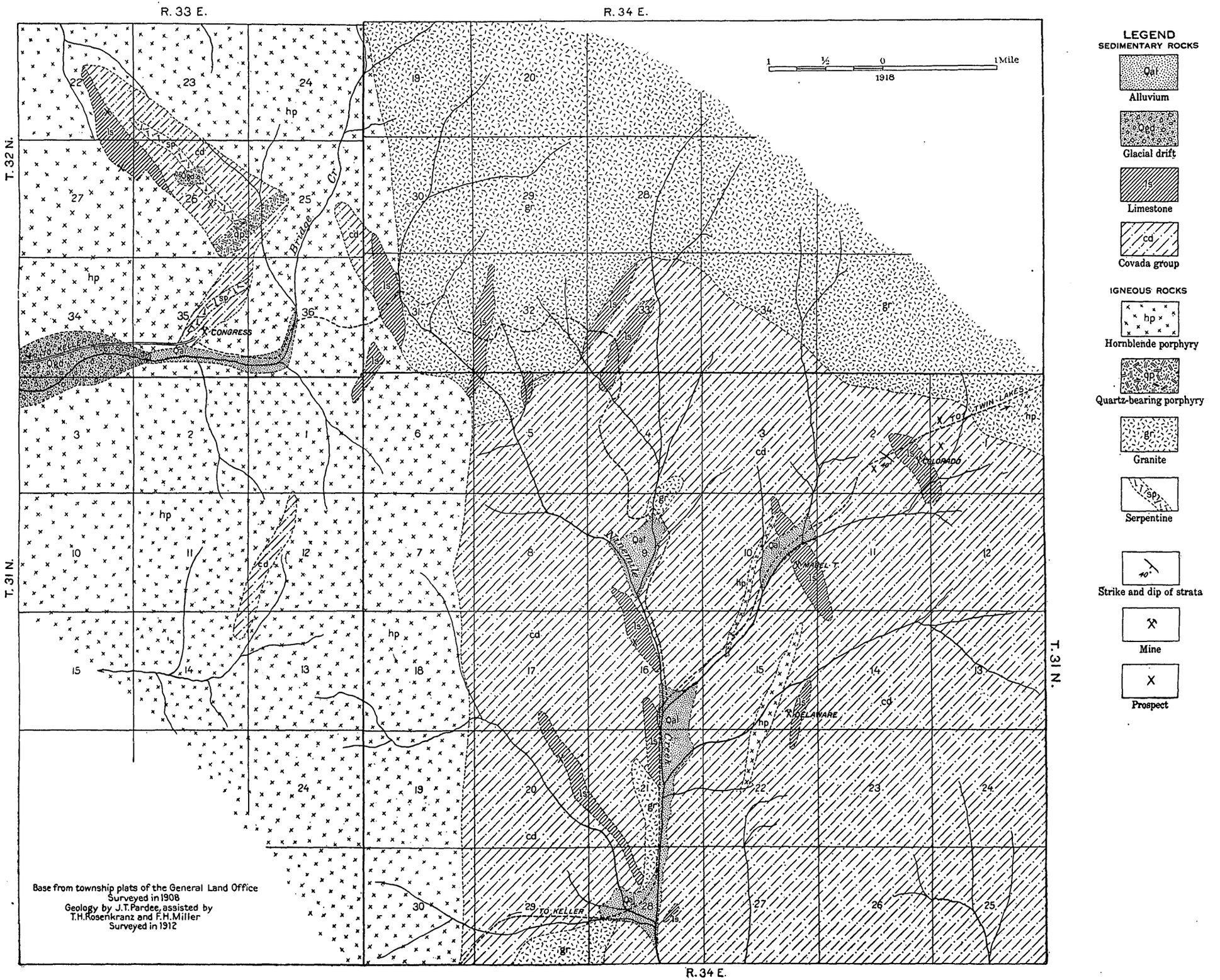
slopes prevail, level land forming but a very small proportion of the whole. Sanpoil River, which traverses the district from north to south, is bordered by flats from 500 to 1,500 feet in width, beyond which are level terraces well developed along its lower course at various elevations up to 600 feet above the stream, or 1,700 feet above sea level. Valleys of tributary streams are narrow and deep and extend back well toward the main divides. Most of them have flats near their mouths that coincide in level with the higher terraces of the main stream. The valley slopes are steep as a rule and in many places cliff-like. Most of the spurs that separate the side tributaries of the Sanpoil have flat tops at elevations of about 3,500 feet, and the main divides, from which they project at right angles, rise 500 to 1,500 feet higher.

The upper drainage basin of Ninemile Creek is somewhat less rugged than the Sanpoil area, but the stream lies about 1,000 feet higher. The southeastern portion of the Sanpoil district is a very rugged area that culminates in Whitestone Mountain, at an elevation of 4,700 feet.

ACCESSIBILITY AND SETTLEMENTS.

In common with the other districts in the Colville Reservation, the Sanpoil district is somewhat isolated from the adjoining regions by natural barriers. Approach from the south meets an obstacle in the deep valley of Columbia River and from the east and west is hindered by transverse mountain ranges. The valley of Sanpoil River forms part of an easy but comparatively long and circuitous natural avenue of approach that enters the district on the north. An excellent wagon road goes the length of the valley from Republic past Keller to Clark Ferry, on the Columbia. From the ferry a well-constructed road ascends the south wall of the Columbia Valley 1,600 feet to the level of the Big Bend country at Wilbur. East-west roads that are not so good cross through passes at the heads of Silver and Cache creeks and connect Keller with Covada and Nespelem. The distance from Keller to the nearest railroad points—Wilbur, on the Washington Central branch of the Northern Pacific Railway, and Republic, on the Great Northern and Spokane & British Columbia railways—is 25 and 50 miles, respectively. Most of the mines and prospects are connected with Keller by wagon roads. Upper Ninemile Creek, however, the most distant mining locality, is reached by trails only.

Keller, the only settlement in the district, is on Sanpoil River and contains a small population, chiefly white, for the most part engaged in prospecting. A 100-ton copper smelter was built here by the Keller & Indiana Consolidated Smelting Co. but was never in opera-



GEOLOGIC MAP OF NORTH-CENTRAL PART OF SANPOIL DISTRICT.

tion, and is said to belong to the Walla Walla Mining Co. at present. In addition, the town contains a store, post office, hotel, and livery barn and has a daily stage connection with Wilbur.

CLIMATE, VEGETATION, AND DRAINAGE.

The climate is similar to that of the Nespelem district at the same altitudes, though as the district is in general more mountainous it probably has a somewhat lower average temperature.

Most of the lower slopes south of Keller are barren of timber or support scattered trees only. North of Keller the valleys contain open forests of yellow pine, and smaller conifers cover the mountains. Grass is abundant on the open lands, and hay, grain, and fruits are produced to a minor extent by Indian allottees on the valley and bench lands.

The drainage of the western half of the Sanpoil district escapes through Sanpoil River, a large stream that heads near Republic and flows south to Columbia River at Clark Ferry. In its course across the reservation Sanpoil River descends from an elevation of about 2,000 feet to 1,050 feet at its junction with the Columbia, having thus an average grade of about 22.5 feet to the mile. Unlike most of the other streams of the Colville Reservation, however, it is devoid of waterfalls in its lower course, although in this portion it is somewhat more rapid than above. The average annual flow is about 180 second-feet. Most of the tributaries of the Sanpoil north of Keller are perennial streams of fair size, and some of them have cascades near their mouths. The principal stream in the eastern part of the district is Ninemile Creek, which heads about 18 miles northeast of Keller and flows south and southeast to the Columbia. It is a perennial stream of moderate flow that near its mouth descends about 500 feet within 1¼ miles. A large number of small streams, only a few of which contain water all the year, drain the slopes adjacent to Columbia River.

PRODUCTION AND MINING CONDITIONS.

No records of production for the Sanpoil district were seen. Small shipments of rich silver ore are reported to have been made from the Golden Cord mine prior to 1912, but their value is unknown. Since that date the Iron Creek Mining & Milling Co. is said (January, 1915) to have shipped 50 tons of ore, worth about $50 to the ton, principally in silver, from a mine on Iron Creek.

Little more than annual assessment work was being done in the Sanpoil district in 1912. Most of the claim owners were marking time, awaiting the coming of railroads, of which one or more have

been projected down the Sanpoil Valley. Under present conditions transportation is too expensive to permit the profitable working of the lodes except to a very small extent. In most parts of the district the topography is favorable to underground development by tunneling, and timber and water are abundant.

ROCK FORMATIONS.

Covada group and serpentine.—Fine-grained rocks of sedimentary origin that have been altered to argillite, schist, and marble occupy the upper part of the basin of Ninemile Creek and form isolated patches scattered along the divide from Bridge Creek south to Columbia River, on Mica Mountain, and west of Sanpoil River. In the vicinity of the prospects in the Ninemile basin and on Bridge Creek and Iron Creek these rocks range from a black carbonaceous argillite to quartz-mica schist and contain interbedded lenslike layers of marble. Elsewhere, particularly on Mica Mountain, they are prevailingly schistose. In the Bridge Creek locality relatively small bodies of green to gray serpentine intrude the argillite and schist along the bedding planes.

Granite.—The Colville granite batholith underlies at least half of the district. It cuts and intrudes the Covada group and is probably everywhere present beneath it at no great depth. The principal exposures of the granite occupy the Nespelem Range, Whitestone Mountain, and large areas in the vicinity of Keller and north of the Ninemile basin. Over most of the district it is a normal-appearing light-gray granite containing conspicuous feldspar crystals and exhibiting the joints and rounded weathered forms typical of granites generally. Near the quartz lodes, however, the appearance of the granite varies considerably, according to the degree of alteration it has undergone, as described in the paragraphs relating to the different mining localities.

Quartz-bearing porphyry.—A light-gray porphyry that contains abundant good-sized phenocrysts of quartz occurs in the form of dikes that cut granite in the Keller and Manila localities and invade argillite north of the Congress mine, on Bridge Creek.

Diorite, porphyry, and andesite.—A quartz-bearing diorite, a hornblende porphyry, and an andesitic lava that are closely related in age together form a north-south belt from 5 to 10 miles in width that occupies most of the Sanpoil drainage basin east and north of Keller. The porphyry extends in a broad strip from Hellgate Rapids northward along the Sanpoil Range. The diorite forms the western strip of the belt, and the lava occupies the middle portion adjacent to Sanpoil River. Outside of the main belt the porphyry

occurs in many places as relatively small dikes. Fine exposures of the lava in horizontal beds are seen on Mount Kikiyis and Mount Chilimas, at the mouth of Bridge Creek. At the Devil's Elbow, on Sanpoil River, the diorite forms prominent cliffs and blocky talus slopes. The porphyry is abundantly exposed in the Sanpoil Range and elsewhere.

Glacial drift.—Small terraces along Sanpoil River near Iron Creek are composed of partly assorted gravel that includes many very large boulders and is evidently of glaciofluviatile origin. Farther upstream boulders transported directly by the ice and flats underlain by glacial silt appear from place to place.

Nespelem silt.—The terraces and, for the most part, the flats adjacent to the lower course of Sanpoil River are underlain by a fine white silt together with some interbedded gravel. The beds are younger than the glacial drift and are described elsewhere as the Nespelem silt.

GLACIATION.

The Sanpoil district is distinguished from the other portions of the Colville Reservation in the fact that it is almost unglaciated. The large ice mass that descended on the reservation from the north separated into two main lobes, which submerged the districts on the east and west but failed to override the greater part of Sanpoil district. However, a comparatively feeble branch lobe pushed down the Sanpoil Valley at least as far as Iron Creek. Below Bridge Creek the ice was but a few hundred feet thick and occupied only the narrow valley along the river. Above Bridge Creek the ice was considerably more extensive, but, except possibly a part of the area north of the Congress mine, none of the localities containing mines or prospects show evidence of having been overridden by the ice.

LODES.

CHARACTER AND DISTRIBUTION.

The metals of greatest proved or prospective value in the lodes of the Sanpoil district are silver, lead, zinc, copper, and nickel. Gold is present in nearly all the lodes, but in only a few is it sufficiently abundant to be worth taking into account.

The most common metal associations are silver and lead; silver, lead, and zinc; and silver and copper. A few of the lodes contain both copper and lead or zinc minerals in comparable proportions. Gold appears to be most abundant in the copper-bearing lodes, and a little copper and silver are associated with nickel.

Of the rarer minerals molybdenite is commonly disseminated through the walls of the lodes inclosed in granite and is reported to occur in commercial quantity in the claim of E. Schminski, north of Hellgate Rapids. A vein of fluorite on the property of Charles Fogarty, north of Jack Creek, is of interest and possible value.

Most of the known lodes of the Sanpoil district are in a belt about 6 miles wide and 18 miles long that extends from the vicinity of Keller northeastward into the basins of Bridge and Ninemile creeks. Within this belt the lodes are for the most part grouped around six principal localities separated by comparatively barren areas.

The largest group occupies a belt a mile or two in width extending from the vicinity of Keller northward into the basin of Jack Creek and may conveniently be referred to as the Keller group. About 4 miles west of Keller is a small cluster of prospects that includes the Manila and may be called the Manila group. A third group is situated along the upper course of Silver Creek, and three others in the drainage basins of Iron, Bridge, and Ninemile creeks, respectively.

Scattered prospects in which no noteworthy developments have been made are distributed over the area between the Keller and Manila groups and the area extending from the Keller group southeastward to Whitestone Creek.

CLASSIFICATION.

With the exception of two contact-metamorphic deposits—those at the Belcher and Dave Campbell prospects—all the lodes seen in the Sanpoil district may be broadly classified as replacement veins, although many show in part the characteristics of filled fissures. Modifications of type occur with changes in the kind of country rock or other local factors, and as most of the lodes in a single locality are similar they are conveniently described by groups or localities, as already outlined.

GENERAL FEATURES.

IRON CREEK, BRIDGE CREEK, AND NINEMILE CREEK LOCALITIES.

Except the Congress, the lodes examined in the Iron Creek, Bridge Creek, and Ninemile Creek localities were dominantly formed by replacement along fracture or bedding planes in limestone, although some of them cross into argillite and merge into filled fissures. So far as the development work shows, they are for the most part lenses or pockets that range in width from an inch or two to 5 feet or more.

The outcrops are not conspicuous but are fairly well marked by porous quartz and gossans of limonite, some of them extensive. Nearly all the deposits have at least one well-defined wall, which is the fracture or bedding plane along which the deposit was formed.

As a rule, the lodes show but moderate effects of faults or other postmineral movements. An exception is the lode of J. H. McJunkin on Bridge Creek, which has been severely sheared and crushed. The most abundant ore minerals are galena and zinc blende; galena predominates in the Ninemile group and zinc blende appears to be common in the Bridge Creek and Iron Creek localities. Pyrite is present in all the lodes, arsenopyrite in some, and the chief gangue mineral is quartz. Assays indicate that the galena and zinc blende are silver bearing and that the ore contains little or no gold.

On the Colorado claim an ore pocket about 20 feet in length and breadth and 5 feet in maximum thickness was uncovered near the surface. In the other prospects ore bodies 2 inches to 1 foot in width are shown. A width of 3 feet is reported in a lode of the Iron Creek Mining & Milling Co., and 4 feet or more of McJunkin's lode may possibly be regarded as low-grade or concentrating ore.

The tenor of two carloads of ore reported to have been shipped by the Iron Creek Mining & Milling Co. is said to have been 100 ounces of silver and $2 or more in gold to the ton. An assay of massive galena from the U. S. claim showed 45 per cent of lead and about 60 ounces in silver and 80 cents in gold to the ton, and a sample from McJunkin's claim that yielded 7 per cent of lead and 23 ounces of silver to the ton evidently contained a large percentage of zinc in addition.

The zone of oxidation is very shallow, as a rule, but appears to have reached a considerable depth in the Delaware lode. Its depth has been controlled, no doubt, by the relatively open or close structure of the lodes. A noteworthy exception, however, is the lode of J. H. McJunkin, which is open and easily permeable to surface waters but shows a partial oxidation only to a depth of 20 feet. This condition is paralleled at several places in the Keller area, where the lack of oxidation is thought to be explained by the recent date of the fault movements that opened the lodes. Limonite is abundant in the oxidized zone, and in one or two places cerusite was identified. Whether or not any part of the material in this zone may be regarded as ore is not known, and no evidences of downward enrichment were observed.

The Congress lode is a composite quartz vein or silicified shear zone in schistose rocks adjacent to a serpentine dike. It is large and persistent and not broken by faults so far as the workings show. The most valuable mineral is nickeliferous pyrite,[1] which is accom-

[1] Identified by Howland Bancroft.

panied by a little chalcopyrite. Assays show a maximum of 5 per cent of nickel, a few ounces of silver to the ton, and but traces of gold. Partial oxidation has reached a depth of 100 feet or more, and the oxidized zone appears to have been partly impoverished.

MANILA LOCALITY.

The lodes of the Manila group are disseminated replacement deposits along northwesterly shear zones in granite and schistose argillite. They are fairly persistent along the strike and range from 3 feet to 14 feet or more in width, but their lateral boundaries are indefinite. Most of them have been broken by postmineral movement. Except for the presence of a little more iron stain than is common and a thin wash of malachite here and there, the outcrops are indistinguishable from the adjacent country rock. The schistose rocks in the Manila locality occur as relatively small masses that are surrounded by granite. Both rocks have been sheared and show considerable iron stain on weathered outcrops, and fresh specimens indicate that the granite is altered similarly to that of the Keller locality. The most valuable ore mineral in the Manila group is chalcopyrite, which occurs as disseminated grains and small masses that replace the country rock along seams. Pyrite and, here and there, a little zinc blende accompany it, together with the gangue minerals quartz and calcite. A few assays of the best-looking ore yielded about 2 per cent of copper and 2 or 3 ounces of silver and $1 in gold to the ton. Positive evidence as to the form and dimensions of bodies that may be regarded as ore is lacking, but some of the mineralized schist masses which may prove to be low-grade ore are 60 feet or more in width.

Partial oxidation extends to a depth of 100 feet or more, but the zone of complete oxidation is very shallow. In addition to limonite and malachite, oxides of manganese are present in small amounts, but the minerals from which they were derived in the zone below were not identified.

KELLER LOCALITY.

The lodes of the Keller locality are single or multiple quartz veins formed by both filling and replacement along fissures in granite. Most of the larger single veins range from 6 inches to 3 feet in width, but a maximum of 8 feet is reached in the King Richard. Commonly several parallel veins occur within short distances, as shown by the King Richard and Rover-Bonanza tunnels. South of Meadow Creek the veins are smaller and more numerous, and in some places, as at the Addie B. prospect, they form lodes composed of several closely

spaced parallel veinlets. Over wide areas the number of veinlets or "knife-blade seams" of quartz that permeate the granite is legion. In the Iconoclast ground and adjacent areas the veinlets are so closely spaced that they may be considered to form large stockworks or stringer lodes of indefinite boundaries.

Most of the larger single veins strike northwest, but a few, including the King Richard, strike northeast; the majority of them dip steeply northward. Considerable variety in strike and dip is shown by the smaller veins, but the stringer lodes in general strike northwest. Whether the northwest or the northeast lodes are the older was not ascertained. So far as their composition and structure are concerned, they appear to be of similar origin and history.

The outcrops are not prominent. In some places quartz is exposed at the surface, but as a rule the superficial portions of the lodes are broken down to a loose material distinguished from that over the adjoining rock only by an excess of limonite and quartz fragments stained green here and there with copper carbonate.

Some of the lode outcrops can be traced several hundred feet, and so far as underground workings show, most of the larger veins are fairly persistent along the strike and fairly regular in width. Practically all the lodes of the Keller area have been affected by postmineral movements that in places, particularly in the area south of Meadow Creek, have been widespread and extremely severe. As exposed by the Surprise tunnel on the Walla Walla claim, for instance, wall rocks and veins are broken and shifted to so great an extent that it is impossible to follow any particular vein more than a few feet. A great many of the fracture planes fall into closely spaced systems that strike about N. 15° W., as shown in the Iconoclast and California workings. Faults and slips of other directions are numerous, and repeated movements appear to have taken place on all of them. North of Meadow Creek faults are much less numerous, and though most of the veins show the effects of postmineral shearing, as far as they have been explored few are seriously faulted.

In the Keller locality the granite and quartz porphyry adjoining the veins have been bleached and altered to a material in which sericite is an abundant constituent and pyrite occurs as thin films along seams. Weathered outcrops of the rocks thus altered are broken down to small fragments that are very rusty with iron oxides. The alteration, which was undoubtedly caused by the solutions that deposited the vein minerals, is most extensive in the areas of closely spaced quartz veinlets south of Meadow Creek but is very noticeable elsewhere. No comparable alteration, however, was observed in the dikes of hornblende-bearing granodiorite porphyry, which appear to have been modified only by shearing and faulting and the introduction of a little secondary pyrite.

Except for variations in the relative proportions of the different minerals present, practically all the lodes of the Keller group are of similar composition. In the unoxidized zone galena, zinc blende, and chalcopyrite are the most abundant valuable minerals, pyrite is present in all, and the predominant gangue mineral is quartz. The relative proportions of the valuable minerals differ, however, from place to place. Broadly speaking, chalcopyrite is the most abundant constituent of the lodes south of Meadow Creek, galena of those between Meadow and Jack creeks, and zinc blende of those north of Jack Creek. Combinations and modifications of these types, however, are plentiful. In the Walla Walla, King Richard, and near-by lodes all three minerals appear to be equally abundant. Galena and zinc blende appear to be absent from the Iconoclast and other lodes in that vicinity, and in general chalcopyrite appears to be the chief or only valuable mineral of most of the very small veins and of the lodes composed of a network or series of veinlets.

Of the presumably secondary minerals, chalcocite and chrysocolla are abundant in the Blue Bird near the surface and occur sparingly in the upper portions of the Dewey and Iconoclast lodes. Malachite occurs in the oxidized zones but not in commercial quantities. A few flakes of native copper were seen in the Dewey. Molybdenite is widespread in the Keller locality but occurs in seams in the wall rocks rather than in the lodes themselves. Arsenopyrite was detected in one of the veins of the Rover Bonanza group. Calcite occurs in a few of the lodes, and rhodochrosite in the Humboldt. Fluorite was not observed in association with other minerals but occurs alone as a vein in granite on a claim of Charles Fogarty, north of Jack Creek.

Molybdenite and part of the chalcopyrite, pyrite, and quartz appear to have been first introduced, followed by a second generation of the same minerals except molybdenite, together with galena and zinc blende. Where calcite has been observed it is later than the quartz. The chalcocite and chrysocolla are, so far as observed, secondary alteration products occurring in the upper portions of the lodes.

Except the width, the dimensions of the ore shoots are not known. Assays of a few samples show that of the single veins, like those of the Rover Bonanza group, portions 3 inches to 1 foot wide are of present or prospective commercial grade, and of the smaller stringer lodes, such as the Mono and Addie B., 3 feet or more is possible ore. In the larger stringer lodes, if they may be termed such, portions that range from 10 to 150 feet or more in width show some mineralization, but whether or not it is sufficient to pay for working under any conditions is not known.

As a rule the zone of oxidation does not exceed 20 feet in depth, and in many lodes it is much less. In the Dewey a little chrysocolla and native copper and in the Iconoclast trifling amounts of chalcocite have accumulated below it. Oxidation and leaching are active at present, producing coatings of copper sulphate in the mine workings, as shown, for instance, on the walls of the Dewey tunnel.

In view of the open structure of most of the lodes and their considerable elevation above the local drainage level, the shallowness of the oxidized zone seems remarkable. Under the conditions given one would expect lodes such as the Iconoclast and Walla Walla to be completely oxidized to much greater depths than they are. So far as the Sanpoil district is concerned, the shallowness of the oxidized zone can not be ascribed to the removal of the superficial layer by glaciation, and although a study of the physiographic history shows that the present surface forms are due to a comparatively late and rapid erosion (see pp. 45, 47), with which weathering may not have kept pace, that explanation is far from satisfactory. The most probable explanation that can be suggested is that the fault movements that crushed and opened the lodes and admitted the surface waters to them are, geologically speaking, of very recent date, but no positive geologic evidence for or against this hypothesis was obtained.

The Bodie-Zip and Tedie lode is exceptional in that it has walls of andesite, a formation believed to be younger than the mineralization in the Sanpoil district. The relation, however, is purely accidental. It is due to faulting that has dragged fragments from a vein in the granite into a fissure in the overlying andesite. The lode of Dave Campbell is a contact-metamorphic deposit that has been sheared in a northwesterly direction. Its valuable minerals are chalcopyrite and chrysocolla, but commercial ore has not yet been developed in it.

SILVER CREEK LOCALITY.

Except the Belcher and Vesuvius, the lodes of the Silver Creek area are quartz veins in schist formed in part by replacement of the wall rock. The general strike is northwest, the dip is southwest, and the veins range from 1 to 3 feet in width and are moderately persistent. The Golden Cord, however, is wider and more irregular in form than the others and appears to be principally a replacement deposit along bedding planes of schist that strike northeast. The outcrops are not prominent but commonly show abundant limonite and porous quartz that in some places are rich in silver.

The principal valuable minerals of the Silver Creek lodes are chalcopyrite, zinc blende, and galena. In the Summit and neighboring lodes zinc blende predominates. Chalcopyrite, however, is relatively the most valuable mineral in the lower levels of the Golden Cord and the lodes in that vicinity. The oxidized zone is less than

100 feet deep in the Golden Cord and appears to be very shallow as a rule elsewhere, and its most abundant ore mineral is limonite, said to be commonly rich in silver. Except that a little calcite occurs in the Summit, the gangue is exclusively quartz, so far as observed.

A stope below level No. 1 of the Golden Cord is said to be 60 feet in length and 3 feet in average width and to have yielded ore worth $14 to the ton. In the upper portions of the lode rich oxidized ore appears to have been confined to small pockets. In some of the other lodes, notably the Summit, portions at least 1 foot wide are evidently ore of good grade, but other dimensions of the ore bodies are not known.

The Belcher is a typical contact-metamorphic deposit in which the valuable minerals are chalcopyrite and its decomposition products accompanied by magnetite, epidote, and vesuvianite. This deposit occurs in a mass of limy argillite of small area, of which beds that aggregate 10 feet or more in thickness may be said to constitute the lode. Commercial ore had not been found at the time of visit.

The Vesuvius appears to be dominantly a replacement deposit in granite, with coarsely crystalline pyrite as the only ore mineral.

MINERALOGY.

For convenience in reference and comparison, the following list of minerals occurring in the lodes of the Sanpoil district is inserted:

Primary minerals:
- Magnetite (magnetic iron oxide).
- Specularite (platy iron oxide).
- Pyrite (iron disulphide).
- Chalcopyrite (iron-copper sulphide).
- Galena (lead sulphide).
- Zinc blende (zinc sulphide).
- Arsenopyrite (arsenical iron sulphide).
- Quartz.
- Calcite (calcium carbonate).
- Rhodochrosite (manganese carbonate).
- Barite[1] (barium carbonate).
- Fluorite (calcium fluoride).
- Vesuvianite (a lime-iron-alumina silicate).
- Garnet (a complex silicate rich in lime and iron).
- Hornblende (a complex silicate rich in lime, magnesia, and alumina).
- Epidote (a lime-iron-alumina silicate).

Minerals closely associated with the lodes but observed only in the adjacent wall rocks:
- Molybdenite (molybdenum sulphide).
- Sericite (a potassium mica).

[1] Identified by Howland Bancroft.

Minerals of the oxidized zone:
- Limonite (hydrous iron oxide).
- Oxides of manganese.
- Molybdic ocher.
- Malachite (green carbonate of copper).
- Azurite (blue carbonate of copper).
- Cerusite (lead carbonate).
- Carbonate of nickel.[1]
- Chrysocolla (copper silicate).

Probably formed by downward enrichment:
- Chalcocite (copper sulphide).

AGE AND GENESIS.

The lodes of the Sanpoil district, like those of other localities in the Colville Reservation, occur in argillitic rocks of probable Carboniferous age (Covada group) and granite that is thought to be Mesozoic. The mineralization appears to antedate the intrusion of the great bulk of the porphyries, particularly those related to diorite and andesite that, for reasons discussed in the pages relating to geology, are thought to be Oligocene.

No positive evidence as to the relative age of the Congress lode was obtained. Like the nickel-bearing lodes of the Nespelem district and many nickel deposits elsewhere, however, it is closely associated with serpentine and is therefore believed to be genetically related to that rock and older than the granite. The contact-metamorphic deposits are thought to be next in order of age, and the replacement veins are clearly the latest.

Of the contact-metamorphic deposits, Dave Campbell's lode is clearly related to the granite. The Belcher, on the other hand, is surrounded by granodiorite porphyry, but an examination of other similarly metamorphosed and surrounded masses near by reveals the presence in some of granite and pegmatite. In other localities the porphyry is observed to cut argillitic rocks without causing noticeable contact metamorphism. Therefore the conclusion is drawn that the granite and not the porphyry was the direct cause of the contact metamorphism, not only of the Belcher mass but of the other sedimentary inclusions in the district, and that it was later displaced by the porphyry.

The assemblage of minerals in the replacement deposits is characteristic of lodes believed by many geologists to have been formed at intermediate depths by the emanations from granitic magmas. The Colville batholith is most probably to be regarded as the source of the vein minerals, although a later magma, of which the quartz porphyry dikes are offshoots, may have been the source. The quartz porphyry dikes have undergone almost as great deformation and alteration as the granite, and in one place, at least, they show a like

[1] Identified by Howland Bancroft.

mineralization. It is apparent that the outer portion of the magma had solidified and had been extensively fractured before the formation of the lodes.

CONCLUSIONS.

Of the single veins, as distinguished from the stringer lodes or mineralized zones like the Iconoclast, many appear promising. Not a few contain ore that would be rated as of good grade if cheap transportation were available. As a rule, however, ore shoots of other than small dimensions can hardly be expected, as most of the veins are narrow. In particular, the lodes north of Meadow Creek and in the basins of Iron, Bridge, and Ninemile creeks encourage further exploration. In some lodes of the Silver Creek area the mineralization warrants the expectation of finding relatively small shoots of silver-lead or silver-zinc ore, and this observation is true also of the Mono claim, north of Jack Creek. The Blue Bird is an exceptionally promising prospect, and comparatively little development work would serve to show whether the rich ore in the outcrop is merely a pocket or the top of a fair-sized shoot.

Developments so far made show that the rich oxidized ore in the Silver Creek area is confined to small pockets, succeeded below by lean sulphide ore. In the claims between Meadow Creek and Keller, particularly the Walla Walla, Iconoclast, and intervening prospects, fairly extensive underground workings show that the formation and the veins are broken and faulted to an extraordinary degree. The veins individually are small, from a fraction of an inch to 6 inches wide, as a rule, but in many places are very numerous and closely spaced. Not very persistent originally, perhaps, but evidently well mineralized in places, they have been dislocated to so great an extent that no considerable portion of any ore shoot remains intact. Certain zones of considerable width of this brecciated material, however, may prove to be a very low-grade ore under more favorable conditions than exist at present. The volume of mineralized rock is so great that a very small profit to the ton would render the deposits extremely valuable. The Manila group likewise offers the problems peculiar to the working of large bodies of very low grade. Under present conditions the building of smelters offers no solution, for even if the ore were rich enough to mine, it is not self-fluxing and transportation becomes the controlling factor in the end. Some process of leaching may possibly be found adapted to the low-grade ore bodies mentioned.

The Congress is thought by Bancroft[1] to offer encouragement for deeper development workings, but, like the nickel prospects in the

[1] Bancroft, Howland, The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, p. 185, 1914.

Nespelem district, this property at present faces a market controlled by large and comparatively rich deposits elsewhere.

As the vein minerals, except very near the surface, are primary and of deep-seated origin, they will probably be found to continue in depth without radical change, except that zinc blende may be expected to supplant galena more and more. Considering the showings so far made, it is not unreasonable to predict that with fairly cheap transportation the district will become a moderate but steady producer for a considerable time.

MINES AND PROSPECTS.

LODES.

Keller locality.

WALLA WALLA GROUP.

Location and geology.—Several adjoining claims, among which are the Walla Walla, Handspike, Jumper, and Umatilla, collectively known as the Walla Walla group, have been located in the N. ½ sec. 5, T. 29 N., R. 33 E., on the slope west of Sanpoil River, 1 mile northwest of Keller. Except for the presence of a few porphyry dikes, the claims are underlain by Colville granite that has been extensively sheared, crushed, and altered. Closely spaced shear and fracture planes form broad zones that trend about N. 10° W. In addition, slips and faults traverse the rock in all directions. Weathered outcrops are reduced to masses of small subangular fragments coated with the oxides of iron. The unoxidized rock has been bleached, and the feldspars are partly altered to sericite and chlorite. Some silicification has occurred, and specks of pyrite and chalcopyrite are widely disseminated. To the east the granite is overlain by andesite lava and gravel and silt of the Nespelem formation.

Walla Walla.—The Walla Walla mine is developed by a crosscut known as the Surprise tunnel, situated a mile N. 20° W. of Keller, on the slope west of Sanpoil River, at an elevation of 1,700 feet above the sea, or about 600 feet above the stream. The average course of the Surprise tunnel is about due west. Beginning with a course of N. 46° W., at the end of 160 feet it turns sharply southward and maintains an average course of S. 60° W. for 475 feet to the face. Near the face a crosscut is run 75 feet to the north. Throughout the length of the tunnel the granite is sheared, sericitized, and as a whole sparsely mineralized with disseminated pyrite and chalcopyrite.

At 320 feet from the portal a zone 40 feet or more across is entered in which quartz veinlets less than 1 inch in width are very numerous and closely spaced. In most of them the quartz is dark gray, appar-

ently because of the presence of finely divided sulphide minerals. Within a width of 3 feet near the farther side of the zone are several veinlets, one of which, 6 inches wide, is filled with quartz and pyrite in about equal proportions. The whole zone is so severely crushed and faulted, however, that a single veinlet can rarely be followed more than a foot or two. Most of the fault and shear planes trend N. 10°–20° W., and the remainder in various directions. The zone is bounded on the northeast by a smooth fault plane that strikes N. 70° W. and dips 65° S., but the opposite boundary is indefinite.

At the face the tunnel has entered another crushed zone in which one or more of the veins are at least 1 foot in width. Postmineral crushing and grinding have progressed to such a degree, however, that only fragments of the maximum dimension given remain. Some of the larger fragments or bunches contain generous proportions of pyrite, chalcopyrite, zinc blende, and galena. Molybdenite films occur on many of the slip planes. In addition, similar but much smaller zones, one of which is cut near the portal of the tunnel, occur here and there.

The crosscut north from the end of the tunnel penetrates a porphyry dike which shows small phenocrysts of feldspar and hornblende and specks of pyrite in a fine-grained pink groundmass. It interrupts the zone of crushed granite and is not itself noticeably mineralized.

Handspike.—At a point about 1,000 feet southwest of the Surprise tunnel a tunnel on the Handspike prospect at an elevation of 1,800 feet is driven 150 feet northward in similarly sheared and altered granite. Near the face it crosscuts a 3-foot lode that strikes N. 60° W., dips 45° SW., and consists of sheared altered granite partly replaced by quartz, pyrite, and chalcopyrite, the latter two disseminated in fine grains. Seams in the lode and wall rocks are plastered with molybdenite, and the whole is sheared and broken by postmineral movements.

Jumper.—An open cut at an elevation of 2,000 feet about 700 feet northwest of the Handspike tunnel exposes a 3-foot lode on the Jumper prospect. The outcrop shows stains of malachite and iron oxides, and the walls of the cut bear thin blue crusts of copper sulphate, due to recent oxidation and leaching of chalcopyrite. Undecomposed pyrite, chalcopyrite, and zinc blende occur within a few feet of the surface, although the lode is broken by many postmineral fractures. For the most part the lode filling is altered granite, but quartz veinlets that contain finely divided sulphides are numerous and closely spaced. Next to the footwall is a lenticular mass 6 inches in width composed of quartz, pyrite, chalcopyrite, and zinc blende, a sample of which yielded by assay 7.5 per cent of copper and 11.4

ounces of silver to the ton. A test sample of 1 ton of ore from this opening is reported to have yielded silver and copper to a total value of $39. Films of molybdenite occur on seams in both the lode and the wall rock.

Umatilla.—The principal working in the Umatilla mine is a tunnel at an elevation of 1,750 feet about 800 feet west of the Handspike tunnel. This working is driven westward 350 feet. It cuts Colville granite that has been severely sheared in an average N. 15° W. direction, is partly sericitized, and contains innumerable minute quartz veinlets sparingly mineralized with pyrite and chalcopyrite. The tunnel exposes a 50-foot porphyry dike that cuts the granite, strikes northwest and dips steeply northeast, and is slightly sheared but not perceptibly mineralized. On the slope above is an incline, which, however, does not connect with the tunnel and was filled with water at the time of examination. According to Jasper King, a sample from a crosscut at the bottom of the incline that represented a width of 14 feet was reported by a sampling works to contain $2 in gold and $3 in silver to the ton and 2.75 per cent of copper. Fragments of quartz on the dump at the incline contain bands of pyrite crossed by seams of pyrite and chalcopyrite of a later generation.

DEWEY.

The Dewey mine includes four patented claims that adjoin the Walla Walla group on the east and are situated on the terraces and lower slopes adjacent to Sanpoil River about 1 mile north of Keller. The extreme western portions of the Dewey and the adjoining claim on the north are underlain by the Colville granite; elsewhere only gravel and silt of the Nespelem formation are exposed. The principal workings consist of a tunnel and shaft near the west end of the Dewey claim at an elevation of 1,600 feet. The tunnel is driven 125 feet west across a zone of severely sheared and crushed granite. The principal shear planes strike about N. 20° W. and dip steeply northeastward, but numerous fractures of various directions are present also.

The granite is sericitized and traversed by innumerable quartz veinlets that contain small proportions of pyrite and chalcopyrite and here and there a crystal of galena. In zones several feet in width the whole mass is reduced to a fine breccia as the result of postmineral movements.

The zone of complete oxidation is not over 15 feet in depth, but a partial oxidation extends 30 or 40 feet deeper. Oxidation and leaching are active at present in this zone, as shown by bluestone (copper sulphate) that is being deposited in crusts on the roof and walls of the tunnel. Limonite, chrysocolla, and a few flakes of native copper

were identified in the tunnel, at the lower limit of oxidation. What portion, if any, of the rock mass penetrated by the tunnel is of present or prospective commercial value is not known. The whole undoubtedly contains a very small percentage of copper, and portions of it appear richer than the average. It is certainly worth systematic sampling.

The shaft is sunk near the edge of a gravel terrace a short distance below the tunnel but was flooded at the time of examination. According to Jasper King, it is 60 feet deep, and a 40-foot crosscut to the west at the bottom penetrates similar material to that exposed in he tunnel. It is interesting to note that the shaft, which starts in gravel, penetrates next, according to Mr. King, several feet of granite, then a few feet of gravel, and ends in granite, showing, presumably, a cliff-like slope of granite with an overhanging ledge that is buried by the Nespelem formation.

CALIFORNIA GROUP.

The California group consists of several unpatented claims that lie about 1½ miles northwest of Keller and adjoin the Walla Walla group on the west. The sheared and altered Colville granite that underlies the Walla Walla group extends into the California group but in the western portions of the claims is largely displaced by granodiorite porphyry. The principal occurrence of the porphyry is a dike several hundred feet in width that trends N. 15° W.

To the east of this dike a 40-foot tunnel at an elevation of about 1,900 feet, on the Caledonia claim, exposes granite that contains very numerous quartz veinlets sparingly mineralized with pyrite and chalcopyrite. Molybdenite occurs in seams in the wall rock. For the most part the zone penetrated by this tunnel has been severely crushed by postmineral movements, and partial oxidation is shown by the presence of iron oxides, the green stain of copper carbonate, and a yellow molybdic ocher. A little sooty chalcocite is deposited here and there in cavities. A sample representative of several feet of the material exposed in the tunnel yielded by assay 2.2 ounces of silver to the ton and 1 per cent of copper. Along a line 1,000 feet or more in length that extends north and south of the Caledonia tunnel several open cuts and short tunnels expose material similar to that in the Caledonia.

ICONOCLAST GROUP.

The Iconoclast group, consisting of several unpatented claims, is about 1¾ miles northwest of Keller. It adjoins the California group on the west and occupies the upper south slope of an easterly spur from Tolman Mountain. The prevailing formation is the Colville

granite, outcrops of which are weathered to small fragments stained dark brown with iron oxides. The unweathered rock is severely sheared, crushed, bleached, and sericitized. Through large, indefinitely bounded zones the rock contains a network of minute quartz veinlets that carry specks of pyrite and chalcopyrite. Large dikes of granodiorite porphyry that cut the granite are moderately sheared and faulted but not noticeably altered or mineralized.

The outcrop of the Iconoclast lode or zone shows limonite and a little copper stain here and there. Its limits are not sharply defined, but a zone 150 feet in width and at least a quarter of a mile in length from south to north shows the superficial evidences of mineralization mentioned.

The principal underground working is a tunnel at an elevation of 2,450 feet. It is driven northward 250 feet and has a crosscut extending 50 feet to the west at a point 150 feet from the portal and a drift 125 feet long at the face. The drift follows a smooth gouge-lined wall that strikes N. 51° E., dips 60° NW., and is displaced at the end of the drift by a fault that strikes N. 10° W., dips 55° W., and separates porphyry on the east from granite on the west. With the exception noted, sheared, crushed, partly altered and silicified granite is exposed throughout the workings. As a whole the mass is scantily mineralized with pyrite and chalcopyrite, and small amounts of molybdenite are widely distributed along seams. Quartz veinlets that are most commonly an inch or less in width and attain a maximum of 6 inches are relatively more numerous in small, indefinitely bounded zones than elsewhere. All contain pyrite, much of which is coarsely crystalline; some show bands of molybdenite, and many are cut by pyrite-chalcopyrite veinlets of a later generation.

Partial oxidation to a depth of 50 feet or more is indicated by stains of malachite and limonite on fracture planes, but the depth to which oxidation is complete is very slight. A little sooty chalcocite was observed in cavities in the partly oxidized zone. Whether or not any considerable portion of this general zone is rich enough to constitute ore is not known, but as a whole it is evidently of extremely low grade. Along the course of the tunnel and its branches portions of the rock 2 or 3 feet wide here and there are estimated to contain as much as 5 per cent of pyrite and chalcopyrite together. Where the mineralized zone crosses the ridge a quarter of a mile north of the tunnel, a sample taken across the outcrop for a distance of 60 feet yielded by assay a trace of gold and 0.4 ounce of silver to the ton. The sample showed a slight stain of copper.

ILLINOIS COPPER & SILVER MINING & MILLING CO.

Several claims belonging to the Illinois Copper & Silver Mining & Milling Co. are in the SW. ¼ sec. 5, T. 29 N., R. 33 E., about half a

mile south of the California group. The formation is the Colville granite, which contains a few small inclusions of schist and is cut by large dikes of granodiorite porphyry. The principal development working is a tunnel at an elevation of 2,100 feet, driven west about 500 feet. It is equipped with an air compressor and ventilating fan driven by a gas engine, but no work was being done at the time of examination.

For a distance of 250 feet from the portal granodiorite porphyry is exposed, then granite for 150 feet, succeeded by a greenish-gray mica schist in which the tunnel ends. The porphyry is moderately sheared and faulted but shows little or no evidence of alteration or mineralization. The granite and schist are sheared and crushed and contain sparsely disseminated grains of pyrite and chalcopyrite, but the deformation and alteration are less severe than in the California and adjacent claims on the north. Films of molybdenite occur in seams. A few small irregular veins and bunches of quartz in the granite and schist are cut by the tunnel. All contain considerable percentages of pyrite and most of them chalcopyrite also. The largest bunch or lens seen is about 1 foot wide at its widest part and contains fair percentages of galena and zinc blende. Secondary quartz and calcite form veinlets in the ore.

HUMBOLDT.

The Humboldt prospect includes several claims that adjoin the Walla Walla and Dewey on the north and occupy portions of the terrace and adjacent slopes west of Sanpoil River, 1½ miles above Keller. The formation is the Colville granite, intruded by porphyry dikes of two generations. On the east these rocks are overlain by gravel and silt of the Nespelem formation. The discovery cuts are sunk in a large dike of light-gray porphyry that contains abundant quartz phenocrysts. The rock is moderately sheared in a northerly direction and shows the effects of hydrothermal alteration. Prominent fracture planes strike N. 50° E., dip 20°–40° SE., and are coated with oxides of manganese and iron and the green carbonate of copper. In addition, here and there are detached lenticular bunches of ore that range from less than 1 inch to 6 inches in thickness and contain zinc blende, galena, pyrite, chalcopyrite, and rhodochrosite in a matrix of decomposed porphyry. So far as shown by the workings, the minerals are distributed among several fractures but are confined to a north-south belt about 15 feet in width. About 200 feet to the north and at a level about 100 feet below the discovery cut is a tunnel driven westward about 360 feet. This working begins in quartz porphyry similar to that exposed above, at 75 feet pierces an 80-foot dike of dark-gray hornblende porphyry, again traverses

quartz porphyry, and ends in a dike similar to the first one. Neither of the hornblende-bearing dikes is sheared or perceptibly altered. The quartz porphyry is moderately sheared but contains no visible mineralization other than a few specks of pyrite. The minerals exposed in the discovery cut probably ascended along the fracture planes and should therefore be looked for southeast of the outcrop rather than north of it.

ADDIE B.

The Addie B. prospect adjoins the Humboldt on the north and is underlain by similar rocks. The development workings consist of four tunnels of which the longest is 60 feet under cover, an inclined shaft that contained water at the time of examination, and some open pits. These openings are distributed along a course that begins near the west edge of the terrace at an elevation of 1,600 feet and extends in a N. 30° W. direction about 600 feet up the slope. The lowest working is a tunnel driven 20 feet westward in a quartz porphyry dike cut by faults that strike N. 15° W. and dip 60° E., but it shows no mineralization other than veinlets of calcite and stains of iron and manganese. About 250 feet up the slope a 10-foot tunnel exposes a contact plane, stained green with malachite, that separates quartz porphyry from a small dike of hornblende porphyry. Beyond the dike is a belt of Colville granite 150 feet or more in width, bounded on the west also by a dike of hornblende porphyry. As exposed by a 20-foot and a 60-foot tunnel and an inclined shaft sunk along its western margin, the belt of granite is sheared, sericitized, and mineralized in a similar way to that of the Walla Walla and adjacent claims. Numerous quartz veinlets that contain specks of pyrite and chalcopyrite traverse the rock. Most of them are "knife-blade" seams, but a few of them are as much as 3 inches in width; these show an average strike of N. 50° W. and contain appreciable percentages of zinc blende, galena, pyrite, and chalcopyrite. All are broken by postmineral fractures, and in the shallow oxidized zone limonite, malachite, and azurite appear. Molybdenite was observed on seams in the wall rock. In places, as shown by the upper workings, the veinlets are closely spaced within zones 2 or 3 feet wide that may be regarded as stringer lodes.

ROVER BONANZA GROUP.

Several adjacent claims that extend from the east line of sec. 30, T. 30 N., R. 33 E., half a mile westward along a narrow ridge that separates Jack and Meadow creeks, are known as the Rover Bonanza group. Near the east and west lines of the section the granite is displaced by massive dikes of granodiorite porphyry, and to the north and south it is overlain by gravel and silt of the Nespelem

formation. Although the granite has been sheared and sericitized to a considerable degree, it has, as a rule, undergone less deformation and alteration than in the locality of the Walla Walla and other claims adjacent to Keller.

On the Rover Bonanza group several tunnels are driven southeastward from the north slope of the ridge, near the level of Jack Creek. The easternmost, 150 feet long, crosscuts the Colville granite for a distance of 40 feet, beyond which it is a drift on a vein. Where first exposed the vein strikes S. 75° E. and dips 30° NE., and in the succeeding course of 40 feet its average width is 3 inches, its strike S. 75° E., and its dip from nearly flat through northeast slopes to the vertical. Postmineral fractures that strike northwest and small transverse slips are common. Between points 80 and 90 feet from the portal the vein is completely cut out by faults. At 90 feet the vein comes in again and continues to the face with a strike of S. 50° E. and dip of 63° NE. In this course the width ranges from 3 to 18 inches, averaging about 7 inches, and the vein is not seriously displaced by postmineral faults. The vein material ranges from a moderately sheared quartz containing disseminated fine crystals of zinc blende, galena, pyrite, and arsenopyrite to a breccia of granite and quartz associated with a dark-colored gouge rich in finely comminuted sulphides. A sample representing a cross section of the vein at one point near the face of the tunnel yielded by assay 0.09 ounce of gold and 52.9 ounces of silver to the ton. In addition, considerable percentages of lead and zinc were evidently present.

About 700 feet southwest of the working described is a tunnel driven southward 120 feet in granite. At the face a lens or vein of quartz 2 feet wide that appears in the floor of the tunnel is cut off above by a flat fault. Appreciable percentages of galena and pyrite are associated with the quartz, and the whole has been moderately crushed. The strike and dip of this body are not definitely shown.

About 200 feet farther west a third tunnel is driven southeast 400 feet, and short crosscuts have been made at four points along its course. Three of the crosscuts expose sparingly mineralized quartz veinlets of variable strike. From a point near the face the fourth crosscut pierces two parallel veins about 10 feet apart that strike N. 70° E., dip 60° S., and average 12 inches and 6 inches in width. The vein filling consists of quartz with considerable percentages of pyrite, galena, and zinc blende.

About 500 feet west of the last-described working a fourth tunnel penetrates the Colville granite for 200 feet in a S. 70° E. direction. From the portal to a point 65 feet beyond are irregular discontinuous exposures of vein quartz, confined to the floor of the tunnel. In places they are 2 feet or more in width and contain coarse grains

and bunches of galena and pyrite. Near the face the tunnel penetrates an east-west vein that ranges from 2 to 12 inches in width and consists of quartz, galena, and pyrite, the latter two distributed through the quartz in finely divided particles.

Several open cuts expose the oxidized portions of some of the lodes described, or other similar lodes which consist chiefly of porous quartz and limonite, with here and there stains of manganese and unoxidized grains of pyrite or galena.

NORTH STAR.

The North Star prospect adjoins the Rover Bonanza group on the west and is developed by a shaft that was inaccessible at the time of examination. In the dump, however, are fragments of quartz that must have come from a vein at least 10 inches in width. The quartz is sparingly mineralized with fine crystals of galena, zinc blende, and pyrite distributed in bands.

GOLDEN CHARIOT.

Near the west line of sec. 30 a pit on the Golden Chariot prospect exposes the oxidized portion of a 5-foot vein that strikes N. 40° W. and consists of porous quartz and limonite.

GOLDEN RULE.

On the Golden Rule prospect south of the Golden Chariot, an open cut exposes a 12-inch vein that strikes N. 60° E. and consists of quartz banded with finely divided pyrite and an unidentified sulphide mineral.

KING RICHARD.

The King Richard mine is on the south slope of the divide between Meadow and Jack creeks, in sec. 25, T. 30 N., R. 32 E., about 4 miles northwest of Keller. The claims of the Rover Bonanza group are from 1 to 2 miles to the east. The principal rock formation is the Colville granite, which is sheared and sericitized to a moderate degree and cut by dikes of granodiorite porphyry.

The main working is a tunnel at an elevation of 1,900 feet, near the level of Meadow Creek, driven north 200 feet. Throughout this working the granite is moderately sheared, crushed, and cut by numerous fractures, the most prominent of which strike northeast and dip steeply northwest. Quartz veins, most of which are less than a foot in width, accompany all the prominent fractures, and films of pyrite are distributed through the granite along minor slips. In an exposure near the surface a short distance east of the tunnel the granite contains closely spaced wavy veinlets of molybdenite a

quarter of an inch or less in thickness, closely associated with a N. 20° W. fault plane. The principal vein, exposed 130 feet from the portal of the tunnel, is 8 feet wide and bounded by smooth walls that strike N. 50° E. and dip 75° NW. to 90°. A drift follows it 40 feet to the northeast and shows it to be regular and persistent. The vein filling is quartz through which interlocking grains of chalcopyrite, pyrite, zinc blende, and galena are distributed in bands parallel to the walls. The sulphides are most abundant in a foot or two of the vein next to the footwall, and a sample of this portion yielded by assay 5 per cent of lead, 4.05 per cent of copper, and 27.12 ounces of silver to the ton. In addition, a small percentage of zinc was evidently present. So far as exposed, the vein shows but moderate effects of postmineral movements. A winze is sunk a few feet below the drift, but no upraises or stopes have been made, and the dimensions of any portion of the lode that may be regarded as ore are not determined.

A small pit on the Josie claim, east of the King Richard, exposes a N. 80° W. shear zone in the Colville granite that is silicified and mineralized with pyrite, chalcopyrite, and specularite.

ABE LINCOLN.

A 40-foot adit level a short distance up the slope north of Meadow Creek and about half a mile west of the King Richard tunnel explores a 6-inch vein on the Abe Lincoln prospect. The strike is northwest, and the vein filling is quartz through which pyrite, chalcopyrite, galena, and zinc blende are distributed in bands. Seams in the wall rock are coated with films of molybdenite and pyrite.

BLUE BIRD.

An open cut on the Blue Bird prospect, a short distance north of the Abe Lincoln and at a level about 500 feet above Meadow Creek, imperfectly exposes the top of a vein that strikes N. 80° W., dips 60° S., and is about 2 feet in width. The walls are soft, decomposed granite, and the work done is insufficient to show positively that the vein is in place. As exposed along a distance of 8 or 10 feet the outcrop consists of brilliantly green chrysocolla that surrounds nodules of chalcocite. The gangue is sheared quartz but does not form more than 20 per cent of the mass, which evidently contains a high percentage of copper. This outcrop offers exceptional encouragement for development work, and although the ore minerals exposed may be products of secondary alteration and confined to a shallow zone, they may reasonably be expected to cap a primary ore shoot of fair grade and dimensions.

GREAT NORTHERN.

The Great Northern is one of several prospects on Wanda Mountain and the spurs projecting south and west in secs. 13 and 24, T. 30 N., R. 32 E. The formation is moderately sheared and sericitized Colville granite cut by dikes of quartz porphyry and hornblende or granodiorite porphyry. On the divide leading west from Wanda Mountain open cuts expose a well-defined vein that strikes nearly east, is 1 foot in width, and consists of quartz liberally sprinkled with small crystals of galena and zinc blende. According to Charles Fogarty, samples from this vein assay from 55 to 170 ounces of silver to the ton.

MONO.

About half a mile south of the Great Northern a 30-foot tunnel on the Mono prospect penetrates a sheared zone in Colville granite 6 feet or more in width, the average course and dip of which are N. 40° W. and 30° NE., respectively. The outcrop is a heavy gossan of limonite, beneath which bunches of coarsely crystalline pyrite as large as 3 feet in diameter have been formed by the replacement of the granite. In addition, the zone contains veinlets that range from a fraction of an inch to 2 inches in width and consist of solid aggregates of zinc blende, galena, and pyrite. Several of these veinlets appear in the face of the tunnel, and a sample from one of them yielded by assay 23.7 per cent of zinc, 1.4 per cent of lead, and 5.44 ounces of silver to the ton.

MINERAL HILL.

In the NE. ¼ sec. 24, half a mile southeast of the Mono tunnel, open pits expose the outcrop of a 1-foot northwesterly vein on the Mineral Hill prospect. The vein filling is iron-stained porous quartz that contains dark spots, apparently due to the presence of finely divided unoxidized sulphides.

A number of similar veins crop out between the Mineral Hill claim and Wanda Mountain, on the southeast slope of which a dike of quartz porphyry has cut the granite. Seams in both the granite and porphyry contain small crystals of galena.

FLUORITE VEIN.

Near the northeast corner of sec. 24 pits expose a vein of pure fluorite 16 inches in width that strikes N. 65° W. and stands vertically between walls of the Colville granite. Margins of the deposit show the outlines of cubical crystals, and the mass may be readily cleaved to large transparent octahedrons that show pale shades of green with zonal bands of violet.

BODIE.

The Bodie prospect is about a mile east of Keller, north of John Tom Creek, in the N. ½ sec. 10, T. 29 N., R. 33 E. The formation is hornblende andesite lava that overlies the Colville granite. The principal development is an adit level driven 150 feet southeastward, with a short crosscut and a winze 25 feet deep. These workings explore an irregular but well-defined fault that has an average strike of N. 30° W. and dip of 60° SW. Some 10 feet or more of breccia that accompanies the fault consists largely of a blue gouge in which are fragments of andesite, granite, and vein quartz. The quartz is banded with finely divided pyrite, and open spaces are dusted with sooty chalcocite. Breccia that has lain on the dump exposed to the weather shows the green stain of copper carbonate.

ZIP AND TEDIE.

A quarter of a mile northwestward from the Bodie adit are a shaft and tunnel, situated near the line between the patented Zip and Tedie claims. A portion only of the tunnel was accessible at the time of examination. The lode is a fault breccia of trend, structure, and composition similar to that of the Bodie, and is probably developed on the continuation of the same fracture.

CAMPBELL.

The prospect of Dave Campbell is about a mile west of Sanpoil River, on an easterly spur from Mica Mountain, near the center of sec. 30, T. 29 N., R. 33 E. At this locality the formation is a schist that contains large proportions of epidote, garnet, and hornblende and is injected by numerous small pegmatite dikes. Surface workings expose an indefinitely bounded sheared zone that strikes northwest and is silicified and slightly copper stained. A crosscut tunnel 140 feet long shows the formation to be sparsely mineralized here and there with chalcopyrite and pyrite. In addition, small masses of chrysocolla occur along seams in the sheared zone.

Manila locality.

MANILA.

The Manila workings were examined by Howland Bancroft[1] in 1910, and from his report the following extract is quoted:

> The Manila mine is 4 miles in an air line S. 87½° W. of Keller, the distance by wagon road being about 7 miles. A smelter consisting of two 100-ton blast furnaces has been constructed at Keller by the Keller & Indiana Consolidated

[1] Op. cit., pp. 185–186.

Smelting Co. to treat the ores from this mine. A small sampling mill is connected with the smelter. Power is to be generated by electricity from hydroelectric installation. Up to the time of the writer's visit (July, 1910) the smelter had not been blown in. Timber is plentiful at no great distance from the mine, and enough water for domestic purposes is available near by. The claims are held by annual assessment work, and none of them are patented.

Lee Farr is said to be the principal owner of this mine, and although it has several times been under lease and bond he still holds the title. The production consists of 1,500 tons of ore, which is reported to have been mined and hauled to the smelter at Keller, where it has remained unsmelted.

Two levels, separated from each other by a vertical distance of 150 feet, constitute the principal developments on the property. The lower level, at an elevation of 2,675 feet, is 1,415 feet above Keller. This is a crosscut between 250 and 300 feet long with a 100-foot drift from the end of it, from which another crosscut has been driven about 75 feet. The upper level consists of a 50-foot crosscut and a stope about 45 by 25 by 14 feet, which is connected with the surface by an air shaft 20 or 30 feet long. Three 10 to 20 foot crosscuts have been run from the stope. The workings are located on a narrow ridge which has a general northeast-southwest trend and rises several hundred feet above the gulches on each side. The levels have been run from the east side of the ridge in a direction transverse to its trend—that is, westerly.

The rocks in this vicinity are medium to coarse grained quartz-mica schists with intercalated amphibolite and quartzite, and the whole series is intruded by coarse-grained granite, which now occupies the major part of the ridge. The schists appear to strike northeast and to dip northwest at a steep angle. In this immediate vicinity they are not over 500 feet thick and are cut off on the southwest and northeast by granite, so that their linear extent along the strike is not over 500 or 600 feet. Doubtless the continuation of the schists could be found beyond the intrusive granite.

The quartz-mica schists are in the main hard, compact, generally dark-colored rocks, but some varieties are softer and contain less quartz and more mica. The amphibolite is a medium to fine grained light to dark green rock which is composed essentially of hornblende and may have resulted by the metamorphism of limestone strata or may be an altered diabase. The quartzite is a medium to coarse grained rock which shows some schistose structure. The granite is composed essentially of orthoclase and quartz with subordinate biotite. Fresh specimens of this rock are pinkish blue, but the altered rock shows a dirty brownish-white color. Contact-metamorphic minerals were not seen in the strata through which the granite has cut.

Chalcopyrite and pyrite are sparingly disseminated through the schists and still more sparsely through parts of the granitic intrusive. Mineralization seems to be a little more extensive in the stope above the upper workings than in the workings below. The whole ore body, as exposed by these workings, probably contains less than 1.5 per cent of copper. A trace of gold and from 0.5 to 4 ounces of silver to the ton are reported to be shown by assays of this ore. The extent of the mineralized zone has not been definitely determined. The maximum boundaries for this one ore body are the limits of the schist in the locality, and the actual width is probably considerably less than the distance between these boundaries.

At the time of the writer's visit, in 1912, the upper adit level and stopes were caved, the lower level was still accessible, but no additional work beyond that required for annual assessment appeared

to have been done. The lower edges and corners of an ore bin were coated with crusts of bluestone and flakes of copper produced by partial oxidation and leaching of the ore above by rain water. The smelter at Keller was still inactive. Examination of the lands surrounding the Manila revealed the fact that the granite is the chief formation of the general locality and that the schistose rocks are limited to several patches of a few acres maximum extent that are, in fact, simply inclusions in the Colville batholith. Prospect cuts a short distance northwest of the Manila expose a mineralization similar in kind but more scanty than that of the Manila lode.

LAST CHANCE.

The Last Chance mine, in the N. ½ sec. 2, T. 29 N., R. 32 E., about two-thirds of a mile northeast of the Manila, is developed by two tunnels on the west slope of a narrow north-south ridge. The upper tunnel, at an elevation of 3,000 feet, is driven northeast 100 feet through the Colville granite and an included mass of schist 65 feet in thickness. The bedding or schistosity of the schist strikes N. 55° W. and dips 80° SW. Certain layers of the rock are rich in hornblende; others are composed chiefly of quartz and mica, and thin sheets of granite and aplite have been forced between the leaves. The whole has been moderately sheared and crushed and recemented with calcite, rhodochrosite, pyrite, and chalcopyrite. Crystals and irregular grains of chalcopyrite are widely distributed but are estimated not to exceed 2.5 per cent of the whole through any considerable portion of the exposure.

Partial oxidation only is shown to a depth of 50 feet, and postmineral fractures are heavily coated with manganese oxides.

At the time of examination the lower tunnel had not reached the lode.

COUGAR.

An adit level 200 feet long, at an elevation of 3,100 feet, on the Cougar prospect is about a quarter of a mile northeast of the Last Chance tunnel, on the opposite or east side of the hill. In this locality the formation is almost exclusively Colville granite but a few dikes of quartz-bearing porphyry occur in the vicinity of the adit and along the ridge to the north. The adit follows a northwestward-trending sheared zone 3 feet or more in width, in which both granite and porphyry are partly replaced by quartz, calcite, pyrite, chalcopyrite, and zinc blende. The calcite and zinc blende, together with some of the pyrite, occur as a second generation. Postmineral fractures coated with manganese oxides are common. A sample of the zone taken at one point in the level yielded by assay 0.02 ounce of gold and 3.46 ounces of silver to the ton and 1.8 per cent of copper.

Within a radius of a mile of the Cougar are several other prospect pits that expose small schist inclusions or sheared zones in granite. All show a scanty mineralization similar in kind to that of the Cougar and Last Chance, but no commercial ore has yet been found in them.

Silver Creek locality.

SUMMIT.

The Summit mine is about 5 miles east of Keller, near the southwest corner of T. 30 N., R. 34 E., on the divide at the head of Silver Creek. At this locality a mass of schistose argillite and quartzite cut by small dikes of pegmatite forms a triangle about 2 square miles in area, with the apex to the north. On the south these rocks are cut off by the Colville granite and on other sides by porphyry. The main workings consist of two shafts, both of which were nearly filled with water at the time of examination. The outcrop is concealed by débris, but the course of the lode, presumably shown by the line joining the shafts, is N. 40° W. Fragments of ore 1 foot in diameter that lie in the dumps indicate locally, at least, the minimum width of the lode. At the lower shaft an ore pile of 10 tons or more (estimated) contains fair proportions of zinc blende together with some galena, pyrite, and chalcopyrite in a quartz gangue. From this pile a sample of material somewhat richer than the average yielded by assay 14.2 per cent of zinc, 5.4 per cent of copper, a trace of gold, and 17.7 ounces of silver to the ton. The upper shaft, situated on the divide 400 feet N. 40° W. of the lower one, has a dump of perhaps 100 tons which shows pyrite, chalcopyrite, zinc blende, and galena in a gangue that is chiefly quartz but contains noticeable proportions of epidote and specularite. A small pile of selected ore contained, by estimate, about 20 per cent in the aggregate of the sulphides mentioned. The waste dump, presumably of material from the walls, consists chiefly of pegmatite with some hornblende, epidote, schist, and vein quartz.

POOR MAN'S HOPE.

The Poor Man's Hope prospect is in a patented claim lying a quarter of a mile southwest of the Summit mine and within the same area of metamorphosed sediments. The principal working is a shaft, said to be 35 feet deep, sunk on a N. 20° W. vein 20 inches in width that cuts quartzite, quartz-mica schist, and sheared argillite. The outcrop is inconspicuous but can be traced to a point about 100 feet to the northwest, where the vein is cut off by a porphyry dike. The vein filling is quartz sparingly mineralized with galena, zinc blende, pyrite, and chalcopyrite. The lode is slightly sheared by postmineral pressure, and veinlets of secondary calcite have formed here and

there. The shaft was not descended because of water, but ore said to have come from the bottom is of considerably better grade than that in the superficial portion of the lode.

HANDY ANDY.

The Handy Andy prospect, half a mile southwest of the Summit mine, is in an area underlain in part by a green mica schist that is interbedded with the sedimentary rocks previously described. The workings consist of some open pits, an inclined shaft said to be 85 feet deep, and a crosscut tunnel 200 feet long. The pits expose a lode that ranges from 6 to 18 inches in width, strikes N. 20° W., dips 60° SW., and consists of closely spaced veinlets of iron-stained quartz separated by schist. The shaft, which was not examined because of water, had, as shown by the composition of its dump, penetrated a portion of the lode, sparingly mineralized with pyrite and chalcopyrite. Green schist only was exposed in the crosscut tunnel, which had not yet intersected the lode.

GOLDEN CORD.

The Golden Cord mine includes three patented claims that lie along the upper course of Silver Creek 4 miles east-northeast of Keller. The property is connected with Keller by a wagon road 6 miles long that follows the stream. The Golden Cord was one of the first prospects located after the extension of the mineral-land laws to the diminished Colville Reservation in 1898. Very rich silver ore is said to have been found in the outcrop and upper portions of the lode, and some ore shipments are reported to have been made, the value of which, however, is not known. A stock company was formed, and considerable money was spent in development work, but rich ore was not found below a comparatively shallow depth. The property was idle in 1912. The principal rocks at the Golden Cord and adjacent lands are intrusive porphyries of two or more generations, which are closely related, however, in age and composition. Small masses of schistose rocks of sedimentary origin, intimately intruded by irregular bodies of pegmatite and Colville granite, occur here and there as the remnants of an older series that has been almost entirely displaced by the porphyries. A narrow belt that trends northeastward across the Golden Cord and Silver Gulch claims contains a number of these fragmentary remnants, the bedding planes of which, as a rule, strike northeast and dip steeply northwest. The principal development workings are within this belt on the slope north of Silver Creek. The discovery pit (elevation, about 2,800 feet) on the Golden Cord claim exposes quartz-mica schist in which

a zone 6 feet wide that has been sheared and silicified parallel to bedding planes strikes N. 50° E. and dips 65° NW. Within this zone porous quartz heavily coated with a greenish-yellow ocher occurs in pockets as much as 2 feet in diameter, from which ore said to contain 800 ounces of silver to the ton was taken.

Tunnel No. 1, at a level 100 feet below the discovery pit, is driven eastward 125 feet—the first 60 feet through porphyry and the remainder through metamorphosed sediments cut by aplite and pegmatite. Near the face is exposed a layer about 6 feet in width that is sparingly mineralized with bands and scattered grains of chalcopyrite, zinc blende, and galena. Postmineral fractures are stained green with copper carbonate.

Tunnel No. 2, near the creek level and 150 feet below No. 1, is driven eastward more than 400 feet through porphyry. At a point 350 feet from its portal a crosscut extends 100 feet north and near the face penetrates some small bodies of metamorphosed sediments. The largest body is about 15 feet in width, strikes northeast, dips 75° NW., and is cut sharply by the porphyry. This mass is a gray hornstone that has been intimately intruded by pegmatite, largely replaced by quartz, and scantily mineralized with pyrite, chalcopyrite, and zinc blende. Here and there are small quartz lenses that contain relatively larger percentages of the sulphide minerals named and, in addition, a little galena. In places the rock is largely an aggregate of epidote and garnet, with bands of hornblende. The whole has been sheared and the fractures cemented with epidote and pyrite.

At a point 400 feet from the portal is a raise, said to connect with a winze from tunnel No. 1, sunk in the mineralized zone. This working was not accessible, but the schist evidently does not extend to the lower level at this point. A quantity of ore, reported to be worth $14 a ton, is said to have been extracted from the winze and upraise. Tunnel No. 2 is said to extend 150 feet beyond the upraise, but entrance beyond that point was barred by a cave.

MALACHITE, VESUVIUS, AND BELCHER.

Several prospects that were idle and for the most part inaccessible to examination in September, 1912, lie on the slope north of Silver Creek within a 2-mile radius of the Golden Cord. All are on deposits whose general features and geologic relations are similar to those of the Golden Cord. Considerable money has evidently been spent on the Malachite, a mile west of the Golden Cord and likewise one of the earlier locations in the district. A shaft is sunk in a small mass of schistose argillite that is stained green with copper carbonates at the surface. Pockets of oxidized ore rich in silver are said

to have been found to a depth of 30 feet. Two tunnels begun in porphyry at lower levels and run beneath the outcrop did not develop commercial ore.

The Vesuvius prospect of Lew Wilmont, half a mile west of the Malachite, is developed by an inclined shaft 60 feet deep and an adit level 140 feet long that connects with it. The workings expose a lode about 4 feet in width that strikes N. 50° E. and dips steeply northwest. The wall rock is the Colville granite, and the lode is composed of altered granite and vein quartz in which coarsely crystalline pyrite occurs in good-sized bunches.

The Belcher prospect, half a mile north of the Golden Cord, is on a small body of limy argillite that is slightly copper stained and largely replaced by aggregates of crystalline epidote, vesuvianite, and magnetite. Replaced and mineralized layers to an aggregate thickness of 10 feet or more are exposed by an open cut and shaft. Portions of the unoxidized mass a few feet below the surface show sparingly disseminated grains of chalcopyrite, but the material as a whole appears to be of very low grade. Other similar outcrops appear in the vicinity of the Belcher. In some of them a little rich silver ore is reported to occur near the surface.

Bridge Creek locality.

CONGRESS.

The Congress mine was examined by Howland Bancroft[1] in 1910, and from his report the following description is quoted:

Location and development.—Nickel ore has been exposed by the workings on the Congress prospect, on the north side of Bridge Creek, 3½ miles east of Sanpoil River. The camp is at an elevation of 2,500 feet, and a rough wagon road has been built from the main Sanpoil road to the deposit. Republic and Wilbur are each about 30 to 35 miles from the camp, the former being a little west of north of it and the latter a little west of due south. The building of a railroad down the Sanpoil would of course make the deposits much more accessible. Timber and water are plentiful in the immediate vicinity of the camp.

The developments on the prospects consists of five adit tunnels with drifts and crosscuts and a shallow discovery hole, aggregating about 1,500 feet of underground workings. The levels are separated by vertical distances of 50 to 100 feet, and the deposit has been explored through a vertical range of approximately 300 feet. The work has been done by hand, no machinery having been installed. No shipments are reported from the prospect.

* * * The workings are located on a northeast-southwest offshoot of a ridge which projects southeastward from the principal mountain mass and slopes rather precipitously down to Bridge Creek, about 1,000 feet below the crest of the ridge.

Geology.—Schistose rocks of both sedimentary and igneous origin, showing considerable dynamometamorphism, constitute the principal part of the geologic

[1] Op. cit., pp. 182–185.

section exposed in this locality. These rocks are believed to be of Paleozoic age and have been intruded by a large dike of quartz monzonite porphyry, which is exposed on the southern slope of the main ridge at an elevation of 2,900 feet and which is thought to be of Mesozoic age. Lava flows, probably of Tertiary age, cap some of the ridges and in places extend down to the level of the valleys in the vicinity of Bridge Creek.

The schistose rocks have a general northeast strike and dip at angles varying from 45° NW. to 90°. They are composed of apparently conformable strata of amphibolitic schists with interlaminated lime shale, quartz-mica schist, and a rock which resembles sheared granite. Beds of limestone and quartzite are also included in the series.

As the soil covering and underbrush conceal part of the geologic section, it is impossible to give the thickness of the several formations, which as a whole are probably several thousand feet in width. Faulting is pronounced in the schistose series, and shear zones of considerable size were seen in the Congress workings. The principal faults appear to trend in a northeast-southwest direction, parallel to the foliation in the schists.

The amphibolite has probably resulted from the dynamometamorphism of a basic rock having the composition of a gabbro or related rock magma, intruded into the sedimentary limestone, shale, and quartzite prior to the metamorphism. The lime shale and limestone are fine grained and of a dark-gray color, and the former represents a more or less impure platy limestone. Veinlets of siderite are present in the limestone. The quartzite is a fine-grained grayish-white rock showing distinct schistose structure. The rock which now resembles sheared granite is of a yellowish-brown color and is in places distinctly schistose, especially where it forms the footwall of the deposit in the Congress workings. This rock contains phenocrysts of white mica with some biotite and much talc. Magnetite, barite, and epidote are present in the rock near its contact with the schists. * * * The intrusive quartz monzonite porphyry * * * has a typical porphyritic texture, is of a general gray color, and contains phenocrysts of andesine and orthoclase feldspar, with some biotite and quartz, in a cryptocrystalline groundmass. * * * The limestones contain large quantities of epidote, with which are associated magnetite and tremolite. The tremolite in places along shear zones is asbestiform.

Ore deposit.—The deposit occupies a shear zone or fault plane in the schistose series and consists of a quartz vein from 6 to 32 feet in width, which has an average strike of N. 50°–70° E. and a dip of 45° NW. to 90°. The strike and dip of the vein conform to the planes of schistosity of the inclosing walls. The quartz filling the vein is of a bluish-white color, is fine grained and compact, and is cut by joints into cubical and rectangular blocks measuring from a fraction of an inch to a foot or more. The portion of the vein explored by the Congress workings is somewhat cellular, the small vugs present being filled with quartz crystals and some malachite. Talc and barite form a small part of the vein filling. Sparsely scattered through the quartz are small veinlets and aggregates of pyrite associated with some chalcopyrite. These veinlets of pyrite range from a fraction of an inch to an inch or more in width, and the quartz with scattered aggregates of pyrite may extend over a larger portion of the vein. The pyrite is nickeliferous, and where oxidation has been active the sulphides have been altered and their oxidation products have been deposited as thin films along the joint planes and fractures and in fact along all the openings in the quartz veins. Limonite, malachite, and a carbonate of nickel are present in thin films, with the result that the whole vein is discolored, the predominant color being reddish brown with scattered patches of light and dark

green. Samples were taken by the writer to determine the approximate average tenor of parts of the vein, and the results of assays of this material should not be taken as indicative of a thorough sampling of the deposit, a matter which is quite beyond the scope of the work of the United States Geological Survey. A sample from a crosscut of the vein in the lowest or No. 1 level, 390 feet from the portal of the adit tunnel and 90 feet beyond the intersection of the adit with the vein (at this place 23 feet wide), contained 0.17 per cent of nickel and 0.013 per cent of cobalt. On the No. 2 level, where the vein is cut 40 feet from the portal of the adit and then followed by a drift for 160 feet or more, a sample of 14 feet of the vein was taken along the drift. This sample contained 0.246 per cent of nickel and 0.034 per cent of cobalt. A crosscut at the end of this drift shows the vein to be approximately 32 feet wide at that place. A third sample was taken in No. 3 level in a crosscut on the vein 90 feet from the portal, where the vein is encountered. This sample extended across 20 feet of the vein from the hanging wall toward the footwall and contained 0.12 per cent of nickel and 0.016 per cent of cobalt. The silver and gold contents were determined from a composite of the three samples. The results of this assay show 5.5 ounces of silver to the ton and a trace of gold. A picked specimen of sulphide ore containing chiefly pyrite was analyzed for nickel and cobalt by Mr. Fairchild and found to contain 5.71 per cent of nickel and 0.35 per cent of cobalt.

In the oxidized ores the nickel content is low, but as the picked specimen of sulphide ore showed over 5 per cent of nickel it seems possible that this deposit might be profitably worked below water level, where oxidized material would be practically absent and where sulphides should predominate. Because of the scanty distribution of the nickel-bearing sulphide ores in the quartz vein the ore would have to be concentrated.

When visited by the writer in 1912 little or no additional development work had been done, but the main workings were open and in good repair. It may be added that more extended inspection revealed the presence of a serpentine dike that parallels the hanging wall close to the vein. The schistose rocks are surrounded by porphyry and practically confined to a belt not more than half a mile in width that extends from the Bridge Creek northeastward about a mile.

M'JUNKIN.

The prospect of J. H. McJunkin is about 1½ miles northwest of the Congress, on the divide between Bridge Creek and Thirtymile Creek, at an elevation of about 3,500 feet. It lies within a belt of schistose argillite, quartzite, and limestone that begins a mile northeast of the Congress and extends northwestward 2 miles or more. These rocks are intruded by dikes of serpentine and a quartz-bearing porphyry similar to that of the Keller area, and the whole is cut off and surrounded by granodiorite porphyry.

The principal working is a 45-foot adit level driven along a N. 80° E. fault plane that dips 75° S. and separates porphyry from limestone and serpentine. A 4-foot layer of breccia above the wall contains bunches 1 foot or less in diameter of limestone largely replaced

by bands of fine-grained zinc blende, galena, and pyrite. A crosscut driven 15 feet into the hanging wall reveals a parallel fault accompanied by a similar breccia. The intervening rock contains many seams and veinlets of quartz, calcite, and the sulphide minerals named. At the adit level a slight oxidation is apparent along the seams, which are coated with limonite and show in some places apple-green stains of a silicate or carbonate of nickel. A sample of one of the larger ore bunches yielded by assay 23.36 ounces of silver to the ton and 7.7 per cent of lead. In addition, a considerable percentage of zinc was evidently present. About 50 feet to the north a short tunnel exposes soft, earthy limonite, in which bunches of massive pyrite are inclosed.

HINES.

On the prospect of Frank Hines, half a mile north of the McJunkin workings, an inclined shaft is sunk 30 feet on a 3-foot vein inclosed by black argillite. The vein strikes N. 65° W., dips 40° SW., and is filled with pyrite-bearing quartz that is said by Mr. Hines to assay a few dollars to the ton in gold. The wall rock contains small bunches and irregular veinlets of galena.

Ninemile Creek locality.

LOCATION AND GEOLOGY.

There are a number of prospects in the drainage basin of the north fork of Ninemile Creek, in the central and northern portions of T. 31 N., R. 34 E. This locality is 10 miles northeast of Keller, with which it is connected by a road and trail 15 miles long by way of Copper Creek. Other trails lead to the Sanpoil and Columbia valleys by way of Bridge Creek and Twin Lakes, respectively.

The principal formations of this area are schistose argillite and limestone of the Covada group that range in strike from N. 20° E. to N. 20° W. and dip east or west at moderate angles. These rocks extend eastward to Columbia River and beyond but are cut off on the north and south by the Colville granite and on the west by still younger porphyry. Dikes of the two intrusive rocks mentioned appear within the sedimentary area, and in places thin sheets of granite and pegmatite have been injected between the foliated leaves of the schist.

U. S.

A crosscut tunnel 50 feet long with a 30-foot drift on the U. S. prospect, below the Twin Lakes trail, in the W. ½ sec. 1, explores a vein that strikes N. 30° W., dips 40° SW., and is from 6 to 10 inches

wide. The vein lies between quartz-mica schist and limestone and is filled with quartz, arsenopyrite, pyrite, and galena. On the footwall is a layer 2 inches thick of almost pure galena, a sample of which yielded by assay 49.5 per cent of lead and 59.96 ounces of silver and 0.04 ounce of gold to the ton. Open cuts above the tunnel along a course of 100 feet or more show the outcrop to be persistent at least that far and to contain a large proportion of unoxidized arsenopyrite.

COLORADO.

On the Colorado mine, about 1,000 feet west of the U. S., a lens-shaped ore pocket about 5 feet thick and 20 feet in diameter was mined out by an open cut. About 30 tons, by estimate, of ore piled on the dump consists of galena and limonite in a quartz gangue. The lens was inclosed in limestone in which pale-green hornblende and other silicates are developed. A tunnel 100 feet to the south, driven beneath the pocket, crosscuts for a distance of 80 feet gray slaty argillite and limestone that strike N. 65° W. and dip 40° SW. At 50 feet from the portal is a bed of limestone 1 foot thick that contains scattered grains of galena, and the tunnel ends in limestone sparingly mineralized with pyrite and arsenopyrite.

MABEL T.

A tunnel south of the trail, in the E. $\frac{1}{2}$ sec. 10, that was inaccessible at the time of examination, is the principal working on the Mabel T. group of three patented claims. According to Thomas Wells, the tunnel is 300 feet long and explores a lode that strikes N. 30° W., dips 45° SW., and contains an ore body 1 foot wide and 20 feet long. The ore piled on the dump consists of galena in a gangue of quartz and calcite. The wall rock is limestone interbedded with black carbonaceous argillite.

DELAWARE.

The main adit level on the Delaware mine, also inaccessible, was said by Mr. Wells to be 270 feet in length. This working is in the SE. $\frac{1}{4}$ sec. 15, about 1 mile east of Ninemile Creek. The dump contains a large proportion of earthy limonite with which are mingled fragments of porous quartz. The quartz contains cerusite, a little unoxidized pyrite, and galena.

On the slope above (south of) the adit open cuts along a course of half a mile expose a persistent outcrop of limonite and porous quartz 5 feet or more in width that strikes N. 30° E. and lies between black argillite and limestone.

SALNAVE.

In the N. ½ sec. 16, west of the main fork of the creek, a tunnel on the claim of George Salnave is driven 120 feet along a plane that strikes N. 10° E., dips 75° W., and separates gray micaceous argillite from white crystalline limestone. To a width of 10 inches the limestone is appreciably mineralized with pyrite and galena. In places it is brecciated as a result of postmineral movements.

Outcrops of limonite that may be the cappings of lodes similar to those described above are imperfectly exposed by open pits in the NW. ¼ sec. 1 and the NE. ¼ sec. 20. The formation at both localities is limestone, and the outcrop at the former is 40 feet or more in diameter and at the latter 40 feet in width and of considerably greater length.

Iron Creek locality.

Several prospects along Iron Creek in sec. 35, T. 31 N., R. 33 E., 12 miles by wagon road from Keller, were not examined in detail. In this general locality several detached areas of quartz-mica schist and impure limestone of the Covada group are surrounded by granodiorite porphyry. In general the outcrops appear rusty and show that the rock has been sheared and silicified, and some of them contain vein quartz heavily coated with limonite. It is noteworthy, as shedding some light on the origin of their alteration, that some of the sedimentary masses contain small apophyses of the Colville granite and pegmatite. The porphyry is but slightly sheared in places and not visibly altered or mineralized. In the prospects of Tom Henneway brecciated limestone has been silicified and sparingly mineralized with zinc blende, galena, and pyrite. Work has been done recently on claims of the Iron Creek Mining & Milling Co., from which 50 tons of ore that contained an average of about 100 ounces of silver and a few dollars' worth of gold to the ton is reported to have been shipped in 1914.

Outlying prospects.

SCHMINSKI.

A prospect belonging to E. Schminski, said to contain large percentages of molybdenum together with some silver and gold, was not seen by the writer. Its reported location is about 3 miles north of Hellgate Rapids of Columbia River, on the upper west slope of a rugged mountain that occupies parts of secs. 1 and 2, T. 28 N., R. 33 E.

PROSPECTS AT HEAD OF DICK CREEK.

Several prospects along the divide at the head of Dick Creek, about 5 miles southeast of Keller, and beyond on the slope west of Whitestone Creek contain northeasterly veins of fair size, inclosed

by argillite schist. Most of them are composed mainly of barren quartz, although some show considerable limonite and scattered grains of pyrite. Except a little copper stain, no valuable minerals were seen in them.

PROSPECTS ON DIVIDE BETWEEN NINEMILE AND WILMONT CREEKS.

On the divide between Ninemile and Wilmont creeks, in the southern part of T. 30 N., R. 35 E., several prospect pits expose small veins of iron-stained quartz that are said to assay a few dollars in gold.

STOTESBURY.

On the claim of Robert Stotesbury, in the NW. ¼ sec. 28, a northerly vein 2½ feet wide in an intrusive dike rich in hornblende is developed by a 50-foot adit level. The vein filling is cellular, iron-stained quartz that carries small percentages of pyrite and zinc blende.

PLACERS.

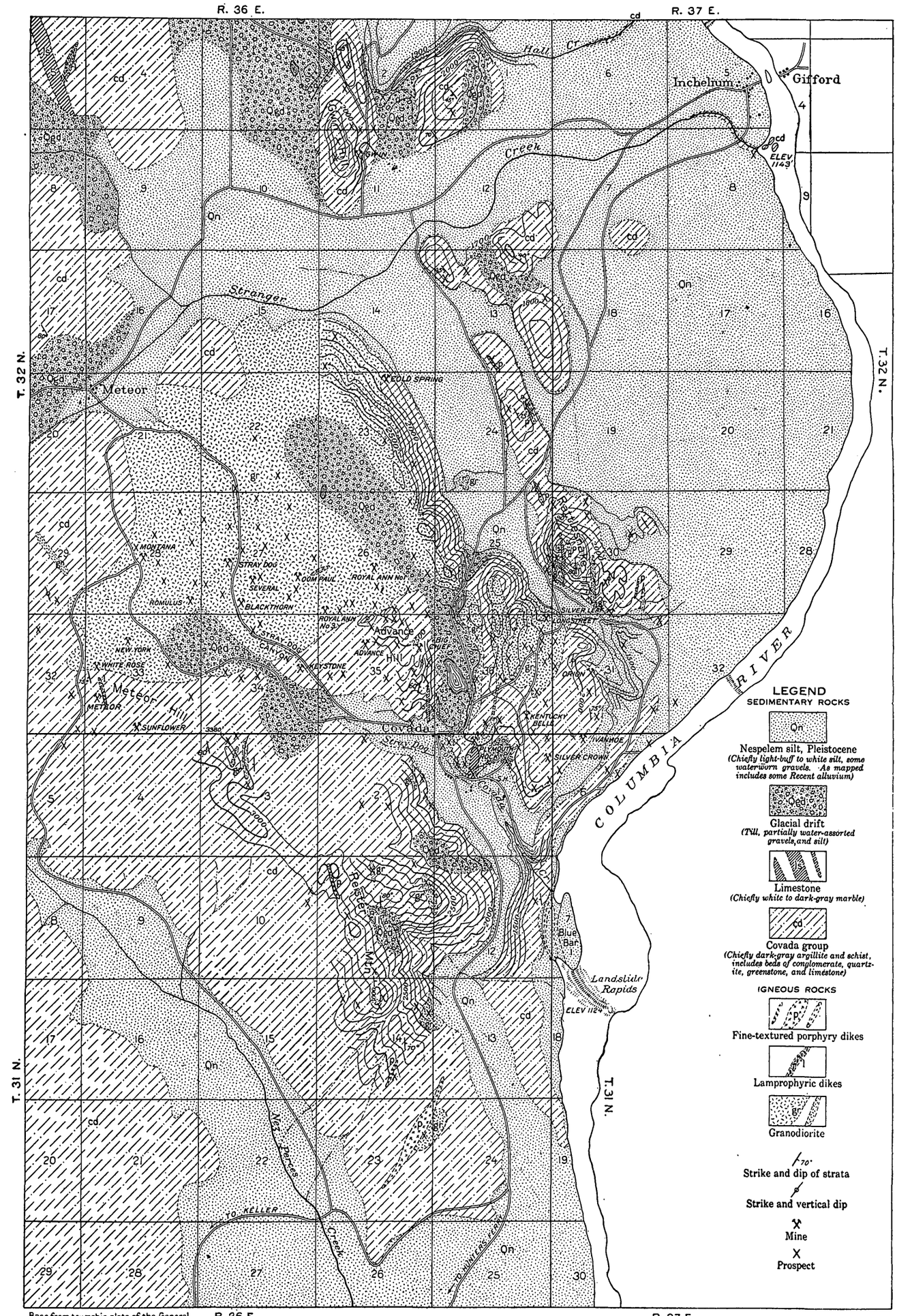
Bars here and there along Columbia River between the mouths of Sanpoil River and Wilmont Creek have been mined for placer gold but were not examined by the writer. The claims had been idle for some time, and the reader is referred to a report by Collier[1] for descriptions of them. Placer claims along Sanpoil River near Keller had not been worked up to the time of the present examination. Panning tests of them, made by the writer, yielded but an inconsiderable quantity of gold.

COVADA (ENTERPRISE) DISTRICT.

LOCATION AND PRINCIPAL SURFACE FEATURES.

A mining locality surrounding the settlement of Covada and commonly known by the same name lies within the boundaries of an area organized as the Enterprise mining district. The Enterprise district, situated in the east-central part of Ferry County, in the northeastern part of the Colville Indian Reservation, occupies an area of about 250 square miles bounded on the east and south by Columbia River and on the west and north by Wilmont Creek, the Sanpoil watershed, and the north line of the reservation. It includes the drainage basins of Barnaby, Hall, Stranger, Nez Perce, and in part Wilmont creeks, together with the slopes adjacent to Columbia River. The Covada locality, which is the most valuable mineral-

[1] Collier, A. J., Gold-bearing river sands of northeastern Washington: U. S. Geol. Survey Bull. 315, pp. 62–65, 1907.



Base from township plats of the General Land Office. Surveyed in 1907
Topography and geology by J.T. Pardee, assisted by T. H. Rosenkranz and F. H. Miller.
Surveyed in 1912

1 ½ 0 1 2 Miles

Contour interval 100 feet
1916

GEOLOGIC MAP OF COVADA DISTRICT.

bearing area known within the Enterprise district, covers portions of two townships north and south of the settlement of Covada. (See Pl. XI.)

The area between Covada and Meteor is a rolling upland few of whose summits exceed 3,000 feet in elevation above the sea. Its south-central portion is dissected by a narrow, steep-walled trench from 500 to 1,000 feet deep, known as Stray Dog Canyon. To the north and east it is bordered by a plain at elevations of 1,700 to 1,800 feet, across which Stranger Creek flows in a shallow channel. A short distance east of the main upland a chain of low rounded hills projects above the plain. The northernmost part of the chain, north of Stranger Creek, is known as Gwin Hill, from the mine near its summit, and the southern and most rugged point is known as Rattlesnake Mountain. From the upland area south of Stray Dog Canyon a prominent spur known as Reister Mountain projects about 5 miles southeastward. A mile or more east of Covada the surfaces descend rapidly to Columbia River at an elevation of 1,170 feet.

Elsewhere the Enterprise district is diversified by broad valleys and fairly rugged mountains. The divide along its western border reaches an elevation of 5,000 feet or more, and the long spurs between the forks of Hall Creek are but little lower. As the valleys approach Columbia River they open funnel-like to a common plain at an elevation of about 1,700 feet that descends in steplike terraces to the river.

The surfaces in general and of the lower hills in particular are smoothed and rounded, the result of glaciation. Cliffs and talus or slide rock are uncommon but are found on certain hillsides that sloped away from the advancing ice, notably the south slopes of Rattlesnake Mountain and Stray Dog Canyon.

ACCESSIBILITY AND SETTLEMENTS.

The Covada locality is somewhat less difficult of access than the other districts in the Colville Reservation, although the topography peculiar to this general region causes the easiest natural route of approach, namely, by way of Colville and Columbia valleys, to be relatively long and circuitous. From Meyers Falls station on the Great Northern Railway, near the junction of Colville and Columbia rivers, a good wagon road goes down the east bank of Columbia River a distance of 30 miles to Gifford. Gifford is also reached from Addy or Blue Creek stations on the Great Northern Railway by a road about 18 miles long, but this route necessitates a considerable climb over the Huckleberry Range. A ferry connects Gifford with Inchelium, on the opposite bank, from which roads extend up the valleys of Hall and Stranger creeks, the latter reaching the Gwin

mine and Meteor settlement, and a road runs southeastward past Covada, Hunters Ferry, and Gerome Ferry, and continues to Keller by way of Ninemile and Silver creeks. The distances from Gifford to the Gwin mine and to Covada or Meteor are about 5 and 7 miles, respectively.

Practically all the active mines and prospects are near Covada or Meteor and can be reached by wagon or saddle horse. In general the outlying parts of the district can be readily traversed on horseback.

Covada is about 2 miles above the mouth of Stray Dog or Covada Creek, near the southeast corner of sec. 35, T. 32 N., R. 36 E. It contains a store, a post office, and, scattered over a considerable area, the dwellings of a number of miners and prospectors. Meteor, about 5 miles to the northwest, on Stranger Creek, is a small trading settlement. Inchelium, at the mouth of Stranger Creek, the headquarters of the local Indian subagent or farmer, contains stores, post office, hotel, and livery and a considerable but fluctuating population, mostly Indians.

CLIMATE, VEGETATION, AND DRAINAGE.

The climate of the principal valleys is favorable to the production of fruits and grain, and although it may be classified as semiarid, the general abundance of vegetation indicates a slightly greater annual rainfall than is had in corresponding portions of the Nespelem and Keller districts.

Except on some of the lower slopes and the terraces adjacent to Columbia River, which, however, bear abundant bunch grass and other forage plants, the Enterprise district is well timbered. As a rule the forest is open and free of underbrush, but in the highlands of the northwestern portion, the growth of smaller conifers and shrubs is very dense. Groves of yellow pine occupy large areas around Twin Lakes and in the valleys of Nez Perce, Stranger, and Hall creeks. Most of the Covada locality is covered with an open forest of conifers.

The Enterprise district contains several good-sized perennial streams, of which Hall and Stranger creeks are the largest. All flow directly into Columbia River and, like most of its other tributaries from the Colville Reservation, exhibit cascades or waterfalls near their mouths. Most of them descend about 500 feet within 2 or 3 miles, a condition very favorable to the development of water power. Both Hall and Stranger creeks are used to a considerable extent for irrigation by the Indian allottees, and Twin Lakes, at the head of Stranger Creek, may be readily converted into a storage reservoir. The comparatively small mineralized area near Covada has no permanent streams but for the most part lies beneath the level of Twin

Lakes, from which water could be conveyed in case of need. A small lake half a mile north of Covada is reported to overflow intermittently, and a small stream occupies Stray Dog Canyon part of the year. Springs are moderately abundant, but the great flow of Columbia River, although near by, is sunk so far below the general level as to be practically out of reach.

HISTORY, PRODUCTION, AND MINING CONDITIONS.

The surface of the Enterprise district was pretty thoroughly examined by prospectors within the decade following the opening of the diminished Colville Reservation or "south half" to mineral entry in 1898. The Meteor was one of the first lodes to be explored, and for a short time considerable activity prevailed, mainly in the digging of crosscut tunnels along Stray Dog Canyon. During an early period work was prosecuted on several tunnels on the Stray Dog and other claims. Occasionally a small lot of ore was shipped, but as no very extensive bodies of rich ore were found, mining activity soon dwindled and little else than annual representation work was done.

Four mines, the Meteor, Stray Dog, Longstreet, and Silver Leaf, have reported ore shipments aggregating 70 tons that yielded approximately $3,500, or $50 to the ton. Exclusive of the Stray Dog shipments, some of which were evidently unprofitable, the average value of the ore produced was a little more than $70 a ton.

In 1912 systematic development work was in progress at the Gwin mine and preparations were being made for the erection of a concentrating mill, which is reported (April, 1915) to have since been built and to be in successful operation. Elsewhere but little more than annual representation work was being done on a hundred or more prospects.

Over a considerable part of the Covada area the topography is favorable to underground development by tunneling, and timber for mining purposes can be readily procured. Ground water is usually found at a depth of 30 feet or less, but as a rule is not of sufficient flow to interfere seriously with sinking. Under present conditions, however, transportation costs are too high for the economical marketing of ore. Freight charges on a recent shipment from the Silver Leaf mine to Grand Forks, British Columbia, were $16.80 ton, and the combined freight smelter charges on shipments made from other mines have ranged from $23 to $30 a ton. This condition tends to induce the claim owner to search for the richest ore only and to neglect the development of low-grade bodies that may have a value at some future date.

ROCK FORMATIONS.

Covada group.—Considerably more than half of the Enterprise district is underlain by rocks included in the Covada group. Adjacent to Columbia River, from the reservation line south to Ninemile Creek, they occupy a strip 6 to 18 miles wide that is in reality but the marginal portion of a larger area of similar rocks exposed east of the Colville Reservation. On the west and south the Covada group abuts against the Colville granite, and its areal boundary is a sinuous and ragged line. From the north line of the reservation the boundary follows a general southward course past Twin Lakes to upper Nez Perce Creek, from which it makes a long loop westward that includes the basins of Wilmont and upper Ninemile creeks, the latter within the Sanpoil district. Beyond the main boundary small outliers of the Covada rocks are common, and, on the other hand, small areas within it, notably that between Covada and Meteor, are occupied by granite.

The rocks of the Covada group range from shale, slate, and argillite to conglomerate, including limestone, greenstone, quartzite, and schist. In the Covada area a large proportion of the beds are blue-gray or black carbonaceous shale or slate, but their softness renders outcrops low and inconspicuous and likely to be concealed by surface mantle. This rock is commonly made up of thin foliated, alternately gray and black leaves that split most readily on the black, showing lustrous surfaces. Locally the leaves are crinkled, crenulated, or plicated, and commonly the freshly cleaved surfaces shimmer in the sunlight because of abundant scales of fine mica. These rocks grade into fine-grained gray quartzite and dark siliceous argillite. West of the Meteor mine the rocks are largely mica schists that near the granite contact resemble gneiss. Beds of fine-textured conglomerate crop out along the summit of Reister Mountain and near the mouth of Covada Creek. Its pebbles are distorted or stretched, and the matrix is micaceous. Near by are prominent outcrops of greenstone, which is shown by microscopic examination to be an altered amygdaloidal lava that was originally a basalt. The chain of hills from Rattlesnake Mountain to Gwin Hill is underlain largely by rusty-weathering quartzite or quartzitic argillite that grades into quartz-mica schist and is associated with argillite and greenstone schist. Thin nonpersistent beds of impure limestone and marble crop out on Rattlesnake Mountain and a short distance southeast of Covada, and many of the shale beds elsewhere are more or less limy. In the basins of Hall and Barnaby creeks beds of siliceous blue argillite and fine-grained gray quartzite, both commonly cut by threadlike networks of white quartz, crop out prominently. Limestone, greenstone, and schists occur in these localities also. The belt extending from Nez

Perce Creek to Ninemile Creek is underlain largely by mica schist that grades into an injection gneiss over wide areas.

The characteristics now exhibited by the various kinds of rock included under the term Covada group are for the most part the result of regional or dynamic metamorphism—that is, of physical and chemical changes induced in the original forms by the pressure and heat incident to deep burial or movements in the earth's crust. Rocks that were originally mudstone and sandstone became argillite and quartzite and, under a severe application of the metamorphosing agents, were finally changed to schists. Likewise the greenstones and greenstone schists are derived from basic lavas or intrusive rocks, and marble from limestone.

Adjoining the contact of granitic intrusive rocks the beds have undergone additional changes known as contact metamorphism.

Near Covada a narrow belt next to the granodiorite contains andalusite, garnet, epidote, and aggregates of fine biotite in proportions characteristic of a moderate degree of contact metamorphism, and the presence of certain of these minerals in a small area near the Gwin mine indicates that although it is not exposed, a granitic intrusive rock approaches the present surface. A broader belt of rocks is altered adjacent to the main Colville batholith and it is difficult to determine to which kind of metamorphism the schistose character of the rocks is chiefly due.

The Covada group appears everywhere to have undergone severe deformation, the most conspicuous evidence of which is the steeply tilted attitude of the beds. As a rule the dips range from 45° to 90°, but the average is nearer the vertical, and the layers, which were originally horizontal, appear to have been compressed into a series of relatively small closed folds that strike on the average N. 15° W. As shown by the mine workings, faults of the same and of a northeast direction also are numerous, but the displacements they cause, although doubtless large in the aggregate, appear to be small individually. Because of the structural complexity of the group and the fact that contrasting beds are few and ill defined, it is exceedingly difficult to work out the details necessary to a correct measurement of its thickness. Considering the horizontal and vertical extent of the exposures, however, it seems unlikely that the beds aggregate less than several thousand feet.

Granite and granodiorite.—The Colville batholith underlies a large area in the northwestern portion of the Enterprise district, in which, for the most part, it shows no great differences in appearance or composition from its exposures as described in the section relating to the Nespelem district. A similar abundance of twinned orthoclase phenocrysts and a tendency toward graphic texture may commonly

be observed here. Variations, however, are shown in some of the marginal portions, particularly in the neck or tongue that projects southeastward to a point within 2 miles of the Meteor mine. In these portions the phenocrysts are generally absent and the rock exhibits darker shades of gray than is common, owing to the accession of hornblende and larger proportions of black mica. Quartz is less abundant, and the rock species range from granodiorite to quartz diorite.

A large part of the Covada locality is occupied by the exposure of an intrusive granodiorite that is regarded as an offshoot of the Colville batholith. It is areally separated from the batholith by a strip of severely metamorphosed argillites, less than 2 miles in width, beneath which the two are thought to be continuous. The rock of the Covada exposure is similar to the marginal portion of the main mass, and its relation to that mass is suggested in particular by the presence here and there of orthoclase phenocrysts.

East of Covada post office granodiorite occupies some small irregular areas and on Reister Mountain breaks through the Covada group in the form of dikes. For the most part the main granite mass is traversed by widely spaced joints only and weathers to the rounded forms characteristic of that rock. In a large area north of Lynx Creek, however, a gneissic or schistose structure is well developed, and the outcrops appear more angular than common. In portions of Stray Dog Canyon the granodiorite forms cliff-like slopes below which a blocky angular talus has accumulated; elsewhere its outcrops are not prominent. Except the system of fractures and shear zones in which mineralization has developed the granodiorite shows no marked structural feature other than joints.

Porphyry, lamprophyre, and aplite.—Dikes of light-gray fine-textured siliceous porphyries, most of which are too far decomposed to permit the identification of their rock species, are sparingly distributed through the Covada area. They are thought to be most probably correlative with the granodiorite porphyries of Sanpoil and Nespelem districts. Most of them are small, are considerably decomposed, and cut rocks of the Covada group. A few lamprophyric dikes consisting of dark-green to black rocks rich in hornblende cut both the argillite and granodiorite of the contact belt.

A few aplitic dikes occur also within the contact belt, and over wide areas the rocks lying next to the main batholith have been changed to injection gneiss by dikelets and thin sheets of aplitic rock forced in along cleavage and bedding planes.

Glacial drift.—In the Enterprise district glacial drift is very irregularly but widely distributed, and in the vicinity of Covada, although nowhere very deep, it is sufficiently abundant to be a consid-

erable hindrance to the prospector. As a rule the deepest accumulations are found in the mountain valleys, the most extensive deposit occupying the basin of Twin Lakes. In composition the drift ranges from compact clayey till to loose water-assorted gravels, the latter being the most common. Subangular erratic boulders are fairly plentiful, and some of them consist of rocks foreign to this general area. The knowledge that the ice moved from north to south and that as a rule more than 50 per cent of the drift fragments originated within a few miles of their resting places may be utilized in prospecting. Thus the very abundant fragments of white quartz around the shore of North Twin Lake can be traced directly north about 3 miles to the ledges whence they came.

Nespelem silt.—In the Enterprise district, as elsewhere in the Colville Reservation adjacent to Columbia River, lands below an elevation of 1,700 feet are for the most part underlain by the silts and gravels described elsewhere as the Nespelem silt. They form the small flat at Covada settlement, fill the small valley between Rattlesnake Mountain and the Covada upland, and form the extensive floors of Stranger and Hall creek valleys and the terraces adjacent to the river. The steep slopes of the terraces afford good exposures of the fine light-colored, horizontally bedded silt of which the formation is chiefly composed.

LODES.

CHARACTER AND DISTRIBUTION.

The metals of greatest proved or prospective value in the Covada district are silver and lead. Zinc is commonly present and may in some localities be of economic importance, but under present smelter practice it must as a rule be regarded as a detriment. Copper occurs in a few of the lodes, but in only one, the Gwin, is the percentage large enough to be worth taking account of. Nearly all the ores contain gold in proportions that range from a few cents to a dollar or two to the ton. Larger amounts have been reported exceptionally.

Of the less common metals antimony is of possible economic importance in the Longstreet-R. E. Lee zone but is practically absent elsewhere. Arsenic and molybdenum occur only locally and in small amounts.

Practically all the known lodes of the Covada locality may be included in a diamond-shaped area the longer diagonal of which extends from the Gwin mine southward about 9 miles to the southern part of Reister Mountain. Its east-west diagonal is about 5 miles in length from Rattlesnake Mountain to the Meteor mine, and its

center is on Advance Hill, a short distance northwest of Covada post office. Within this area, however, the lodes are by no means uniformly distributed. Of a total of more than 140 lodes, at least 60 per cent are grouped in a belt about 2 miles wide that extends from a point near the mouth of Covada Creek in a north-northwesterly direction. The remainder form smaller clusters, of which the one that includes the Gwin mine is economically the most important.

Outside of the Covada locality the Enterprise district contains many quartz outcrops in widely separated localities, but few of them appear promising or have been developed to any extent. West of the Nez Perce Creek, in the west-central part of T. 31 N., R. 36 E., is a small group of prospects of some promise, and scattered over the northeastern part of T. 30 N., R. 36 E., west of Monahan's ranch, are many lode outcrops, on some of which prospect holes have been dug.

From the vicinity of Meteor settlement northward to the reservation line outcrops of barren-appearing white quartz, some of them very large, are plentiful.

CLASSIFICATION.

Most of the lodes of the Covada area are simple quartz veins that have filled open fissures, and practically all the remainder appear more or less closely related to the same type. Replacement of the wall rocks by quartz has occurred in some, notably the Silver Leaf and Longstreet lodes, which may be classified as silicified crushed or sheared zones. In some mines, as, for example, the Romulus and others near Stray Dog Canyon, the lode is made up of several closely spaced parallel veinlets. Commonly the veins are accompanied by zones of crushed or sheared country rock.

The directions of the lodes range through all points of the compass. Nevertheless, most of the larger and more persistent ones are confined in strike between the limits of N. 5° W. and N. 30° W., averaging about N. 16° W., and a smaller group shows an average N. 50° E. course. Considering all the lodes, 36 per cent of the strikes fall within the angle from north to N. 30° W., 20 per cent fall within the angle from N. 80° E. to S. 80° E., and all but 10 per cent of the remainder are distributed through the angle from north to N. 80° E. The relative age of the north-northwest and northeast systems was not definitely made out. A few lodes of northeasterly trend were observed to be faulted by fractures of the other general direction, but the evidence is too meager to establish a rule. So far as the composition and structure of the lodes are concerned, all may be of the same age and appear to be of similar origin.

In width the lodes, exclusive of numerous very small stringers and some large outcrops of barren white quartz, range from 3 inches to 8 feet, or, if the Longstreet silicified zone is considered a lode, to an extreme width of more than 40 feet. Lodes more than 3 feet in width, however, are not common. The average width of the largest lodes of north-northwest strike (exclusive of the Longstreet) is about 5 feet, and that of the six largest lodes of northeast trend is about 4 feet. The remainder average about 1 foot, and a general average of all the lodes in the district is less than 2 feet. In making these comparisons the widths of lodes as given include not only the quartz filling but the accompanying gouge or breccia if any is present. The larger lodes, particularly those of northwestward strike, fill fractures that are persistent along the strike, and so far as their development workings show persist in depth also. The small veins are fairly persistent, considering their size, but they commonly show variations in direction and dip. All are inclined to pinch and swell to a moderate degree. As a rule the veins in granodiorite tend to be more simple in form than those in the Covada group, owing, no doubt, to the fact that in portions of the Covada rocks the bedding planes are or were open, affording spaces for the growth of branch veins and stringers, a condition not found in the massive rocks.

As a rule the lode outcrops do not project noticeably above those of the inclosing rocks; neither do they form depressions. Exceptions to this rule are the outcrop of the Longstreet zone, which forms a prominent knob, and the large veins of white quartz in the outlying portions of the district, most of which project slightly above the general surface. Apparently both lodes and rock formations offer about the same degree of resistance to weathering; or if differences exist there has not been sufficient time for them to be manifested since the ice planed all to a common contour. Most of the lode outcrops are stained with iron oxides, a reddish-brown color that contrasts more or less noticeably with the weathering shades of the adjacent rock, particularly if the rock is granodiorite. In many of the lodes, also, white quartz is abundant enough to attract attention. Most of the small veins are aggregates of quartz together with a few other minerals, all of a single generation, that have completely filled open spaces. A banded structure is common in the larger veins, however, as if they had been built up in successive layers. Since the deposition of minerals ceased shearing and crushing movements have modified almost all the larger veins and lodes, particularly those of north-northwesterly strike, in some of which the effects are severe. Transverse faults are moderately plentiful, but in only a few places were they observed to have shifted the vein greatly.

MINERALOGY.

The lode minerals occurring within the Enterprise district are tentatively grouped according to genesis, as follows:

Primary minerals:
- Pyrite (iron disulphide).
- Pyrrhotite (magnetic iron sulphide).
- Chalcopyrite (iron-copper sulphide).
- Arsenopyrite (arsenical iron sulphide).
- Galena (lead sulphide).
- Zinc blende (zinc sulphide).
- Stibnite (antimony sulphide).
- Molybdenite (molybdenum sulphide).
- Tennantite (arsenical copper sulphide).
- Tetrahedrite[1] (antimonial copper sulphide).
- Quartz.
- Calcite (calcium carbonate).
- Rhodochrosite (manganese carbonate).
- Siderite (iron carbonate).
- Ilmenite (iron-titanium oxide).

Minerals of the oxidized zone:
- Limonite (hydrous iron oxide).
- Oxides of manganese.
- Oxides of antimony.
- Oxides of arsenic.
- Malachite (green copper carbonate).
- Azurite (blue copper carbonate).

Minerals probably formed by downward enrichment:
- Native silver.
- Cerargyrite (silver chloride, horn silver).
- Argentite (silver sulphide).
- Pyrargyrite (antimonial silver sulphide, ruby silver).

Silver-bearing galena occurs in all the lodes that have been opened below the zone of complete oxidation. It is subordinate or even negligible (as in the Gwin) in some of the larger lodes, but it is the chief valuable substance in the smaller ones, almost without exception. Results of a few assays of primary ore indicate that silver is associated with the galena in the ratio of one-third of an ounce or less to 1 per cent of lead. In the Silver Leaf lode, however, the galena appears to be exceptionally rich in silver.

Zinc blende is of practically as widespread occurrence as galena and in many lodes appears to equal galena in abundance. It was almost nowhere, however, observed to be in excess of galena.

Silver-bearing tennantite is the chief valuable mineral in the Gwin mine. It was identified in only one other lode as a very subordinate constituent. In the Gwin mine it occurs in small grains intergrown with primary quartz and is practically unassociated with other metallic minerals.

[1] Reported by Bancroft.

Stibnite fills small veins and veinlets in the Longstreet silicified zone and is closely associated with silver ore. It does not appear to be silver bearing of itself, however, and is rare in other parts of the district.

Chalcopyrite is of rather exceptional occurrence and commercially of negligible importance.

Pyrrhotite occurs in the New York mine curiously intergrown with galena. Assays indicate that both minerals are silver bearing. Elsewhere in the district pyrrhotite is rare.

Tetrahedrite was identified in a few places by Bancroft, and arsenopyrite and molybdenite occur sparingly in a few of the lodes.

Pyrite is present in all and is the only sulphide seen in some of the undeveloped lodes. As a rule it constitutes a minor part of the vein filling.

Native silver, cerargyrite, argentite, and pyrargyrite were identified in the upper portions of a few lodes and may be present in others from which assays high in silver have been obtained. They occur in films and grains on secondary fractures.

All the outcrops contain limonite, but no very extensive "gossans" of that mineral were seen.

Oxides of manganese, arsenic, and antimony and the copper carbonates malachite and azurite are of rather uncommon occurrence.

Quartz is almost the exclusive gangue mineral and is generally of primary deposition. In a few places, however, quartz together with calcite fills secondary fractures. In the sulphide-bearing lodes it shows a moderately fine texture, but in most of the large outcrops in outlying portions of the district it is of coarsely crystalline texture like a pegmatite.

Siderite was observed in a few places only in the white quartz outcrops north of Meteor. It forms irregular bunches and grains of contemporaneous deposition with the quartz.

Ilmenite (oxide of iron and titanium) occurs in large tabular crystals, primarily intergrown with quartz of a pegmatitic texture. The only occurrence seen is a large dike or vein in the Colville granite in sec. 6, T. 31 N., R. 35 E., near the head of Wilmont Creek and a short distance above the trail between upper Ninemile Creek and Twin Lakes. Although probably not worth mining as ore, the dike yields abundant specimens valuable to a collector of minerals.

ORE SHOOTS.

In but few of the lodes do the development workings show the dimensions other than width of the bodies that may be regarded as commercial ore. In the Meteor, of two lenticular shoots that were stoped above the tunnel level the larger had a maximum thickness of

1½ feet, a stope length of 15 feet, and a pitch length of 30 feet. In the Longstreet and Silver Leaf the shipping ore was taken from irregular, ill-defined, pocket-like bodies a few feet in dimensions. The form of the ore body stoped in the Stray Dog is not known, but its dimensions were evidently small. In the Gwin bodies having a width of 6 feet and stope lengths of 50 feet or more are considered milling ore, but their vertical extent is not known. In some of the other lodes ore worth $20 to $40 a ton occurs in bodies that range from a few inches to 3 feet in width. The other dimensions are not shown, but some of the bodies, no doubt, will prove to be of workable size. However, as ore of this grade can hardly be mined and shipped profitably under present conditions, it is chiefly of future value. Of two shipments from the Meteor, one that probably represented the run of mine contained about 66 ounces of silver and 0.06 ounce of gold to the ton and a fractional percentage of lead. Shipments reported from the Stray Dog[1] "assayed, respectively, 0.03 and 0.06 ounce of gold and 5 and 66 ounces of silver to the ton." The Longstreet and Silver Leaf shipments contained 144 ounces and 180 ounces of silver to the ton, respectively, but as they consisted of sorted ore the average content of the bodies mined was lower. In addition to the silver, the ore from the Silver Leaf contained small percentages of lead and zinc. For the Gwin vein as exposed in the drift and winze an average content of 3 per cent copper and about 28 ounces silver and $1 in gold to the ton is shown by the company's assay records.

In but few other lodes has ore been developed. A dozen or more high assays have been reported, but the samples were evidently selected and were not representative of an ore body. Assays of a few samples representing some particular points only indicate that ore in some of the smaller veins contains 4 to 25 ounces of silver and 20 cents to $1 in gold to the ton and 8 to 20 per cent or more of lead. A large number of assays are reported, including those returned by the smelters and various assayers, from shipments and samples made by the miners, those given by Weaver,[2] and some obtained by the writer. Collectively they cover the Covada locality in a fairly uniform manner, and a comparison of them reveals an interesting variation in the distribution of silver. If the lodes within the central area of granodiorite are compared with those in the adjacent belt of moderately metamorphosed sedimentary rocks, the average silver content is greater in the sedimentary area in the ratio of about 3 to 1. A somewhat erratic distribution of the gold appears, but there is a noticeable relative concentration of gold in the lodes adjacent to

[1] Bancroft, Howland, op. cit., p. 193.

[2] Weaver, C. E., Geology and ore deposits of the Covada mining district: Washington Geol. Survey Bull. 16, pp. 44–83, 1913.

Stray Dog Canyon or near the central part of the granodiorite area.

Few assays or analyses showing the relative distribution of lead and zinc are available. So far as an inspection of the lodes shows, there is little or no difference in the relative percentage of these metals as between the granodiorite and adjacent areas.

AGE AND GENESIS.

In common with the lodes in other districts in the Colville Reservation the lodes of the Enterprise district occur in sedimentary rocks believed to be of Carboniferous age (Covada group) and an intrusive granitic rock of later date. Lodes are observed to cross from one formation to the other; all are apparently of the same age and therefore later than the granodiorite. The Tertiary porphyries that form the younger age limit for the lodes in the Nespelem and Sanpoil districts are too sparingly represented in the Covada area to be of chronometric value. However, there is no reason to doubt that the lodes closely followed the granodiorite intrusion and are contemporaneous with those in the districts mentioned—that is, of late Mesozoic age.

In the Covada locality the lodes are grouped about comparatively small areas of granodiorite occurring both within that rock and in a belt of moderately contact-metamorphosed argillites adjoining it. Beyond the distance of a mile or so from the granodiorite body or bodies no valuable lodes have been found. Because it is farther away than common from an areal exposure of granodiorite, the Gwin mine appears as an exception to the rule, but contact metamorphism in the rocks near by shows that a granitic intrusive rock, although unexposed, is present at no great depth.

The geologic associations of the lodes as above set forth strongly suggest that they are genetically related to the granodiorite, and this view is supported by their mineralogy. The minerals arsenopyrite, pyrrhotite, chalcopyrite, tennantite, stibnite, and molybdenite, together with the more commonly occurring zinc blende and galena, are typical of lodes generally believed by geologists to have been formed at moderate depths by emanations ascending from granitic magmas.

OXIDATION AND ENRICHMENT.

In most of the lodes oxidation has been more or less complete to depths that range from 10 to 30 feet, at which water level is usually reached. Exceptionally, in some of the more open-structured lodes, traces of oxidation were observed as deep as 200 feet. Many of the smaller close-textured lodes, on the other hand, contain sulphide minerals at or very near the surface. This is not surprising in view

of the fact that the severe glaciation to which the district was subjected in geologically recent time probably removed at least the weathered portion of country rock and lodes. The shallowness of the oxidation in most of the lodes of open structure also is probably due in part to the fact that commonly the ground-water level is high.

Little or no rich oxidized ore was reported in the district, and the shallow oxidized zone appears to have been to some degree impoverished. An exception to this may be some of the moderately rich ore said to contain native silver, extracted from the Stray Dog.

Enriched ore has been yielded by the Meteor and Stray Dog and probably by the Longstreet also, and the exceptionally high assay values in both gold and silver that have been reported from the upper portion of a dozen or more lodes are probably minor examples of the same process.

Absolute proof that the enrichment was effected by downward migration is not available, but certain minerals in the Meteor and Stray Dog—cerargyrite (horn silver), pyrargyrite (ruby silver), and argentite (silver glance)—strongly suggest that process.

SUMMARY AND CONCLUSIONS.

The largest and most persistent lodes in the Covada district do not depart far from a strike of N. 16° W. A few lodes of less prominence but still of noteworthy size show an average strike of between N. 50° E. and N. 60° E. The two groups are accompanied by a great number of small lodes that show a considerable range in direction. Some of the more prominent lodes contain shoots of downward enriched ore of good grade but of comparatively small dimensions.

So far as developments show, the primary ore is very lean in many lodes, but in some, as in the Gwin, it is of milling grade. The high-grade ore of the Silver Leaf may be primary also.

In but few of the smaller lodes (1 foot or less in width) is commercial ore yet exposed, although most of them show appreciable percentages of valuable minerals. At least half of them are too small to be profitably worked even if rich. However, as they have been but slightly explored as a whole and some of them show tendencies to swell in places or to approach and form composite lodes, they are probably worth further exploration. The well-marked linear persistence of the larger lodes argues for a considerable extent in depth, and there is no reason for thinking that those in which workable primary ore is found, as the Gwin, will become impoverished within a considerable distance below the surface.

So far as the present comparatively meager explorations show, a zone composed of the thin outer layer of granodiorite and the moderately to slightly contact-metamorphosed sedimentary rocks next

to it is the most richly mineralized. The four most valuable ore bodies yet discovered are in this zone, and the assay evidence available shows it to be relatively three times as rich in silver as the next deeper zone in granodiorite. However, no marked difference in the abundance of lead or zinc was observed in either zone; and gold, although of relatively slight importance, appears most abundantly in the deeper zone.

MINES AND PROSPECTS.

LODES.

METEOR.

The Meteor mine, described by both Bancroft[1] and Weaver,[2] is near the summit of Meteor Mountain, in the SW. ¼ sec. 33, T. 32 N., R. 36 E., about 3 miles west of Covada. The shipment to the Tacoma Smelting Co. of two lots aggregating 20 tons of ore, of a total gross value of about $1,000, is shown by smelter certificates. The bulk of the formation in the vicinity of the Meteor is a schistose lead-gray to black carbonaceous shale interbedded with gray quartzite and quartz-mica schist. The average strike of the beds is N. 10° W., they dip 75° W., and to the north they are cut off by granodiorite.

At an elevation of about 3,100 feet is an inclined shaft that was not accessible to examination, said to be sunk 160 feet on the vein. About 200 feet lower is a crosscut level 700 feet to the vein, which strikes N. 45° E., dips 80° NW., and is followed by a drift 125 feet to the northeast. At the face of the drift the vein is cut off by a N. 20° W. fault, beyond which is a mass of hornblende-rich rock, apparently a lamprophyric dike.

The footwall is a well-defined plane above which lies 1 to 3 feet of gouge and quartz. The quartz forms a lenticular vein that exhibits comb structure and ranges from 1 inch to 1½ feet in width. For the most part the only ore minerals visible are small crystals of pyrite and galena intergrown with the quartz. Stopes have been made on two ore shoots, however, that show, in addition to the minerals named, zinc blende and rhodochrosite, and a little cerargyrite and pyrargyrite as films on secondary fractures. The ore shoots are near together, are about 15 feet each in length, and have been stoped 30 feet above the level. The maximum width of ore is 1½ feet. To judge by the ore on the dump of the shaft, a shoot of similar composition was found in that working.

Smelter certificates for ore shipped show an average content of 3.4 per cent of lead, 0.09 ounce of gold, and 178.81 ounces of silver in one lot of 3 tons, and 0.6 per cent lead, 0.06 ounce of gold, and 65.84

[1] Bancroft, Howland, op. cit., pp. 191–192.
[2] Weaver, C. E., op. cit., p. 84.

ounces of silver in the other lot of 17 tons, the former probably representing sorted ore and the latter mine run.

The hanging wall is not well defined and contains quartz veinlets that branch from the main lode.

DIXIE QUEEN, RUBY, NEGLECTED, RESERVE, AND SANTA CLAUS.

The Dixie Queen, Ruby, Neglected, Reserve, and Santa Claus prospects, all situated near the Meteor, are briefly described by Weaver.[1] The lodes in nearly all of them strike northeastward, range from 1 to 3 feet in width, and consist of iron-stained or pyrite-bearing quartz that shows considerable evidence of post-mineral movements. None are extensively developed.

WHITE ROSE.

The White Rose mine, mentioned also by Weaver,[2] is in the extreme western part of sec. 33, T. 32 N., R. 36 E., a short distance north of the Meteor and just within the main area of granodiorite. Shafts not now accessible for examination are sunk on two parallel veins about 75 feet apart that strike N. 25° E. As shown by an open cut the west vein is 30 inches wide and consists of crumbly iron-stained quartz. The shaft dump contains similar quartz in which unoxidized pyrite occurs. At the collar of the shaft the east vein is about 3 feet wide and consists of decomposed granite and iron-stained quartz. The dump, however, contains a considerable proportion of unoxidized ore that consists of quartz carrying pyrite, galena, zinc blende, and fragments of granodiorite cut by thin veinlets of the sulphides mentioned. A sample from a small ore pile on the dump of this shaft yielded by assay 4.4 per cent of lead and 3.12 ounces of silver to the ton.

SUNFLOWER (JAVA).

The Sunflower mine is in the southern part of sec. 33, T. 32 N., R. 36 E., half a mile southeast of the Meteor and 2½ miles west of Covada. The formation is a greenish-gray mica schist interbedded with quartzites and argillites of about N. 10° W. strike and vertical dip. An adit level is driven 450 feet northward along a vein that strikes N. 15° W., dips 45° W., and averages 3½ feet in width. To a point 75 feet from the portal of the adit the vein is filled with barren white quartz. Beyond this there is only gouge and brecciated country rock to a point within a short distance of the face, where quartz, scantily mineralized with pyrite and chalcopyrite and severely crushed by postmineral movements, again comes in.

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[1] Weaver, C. E., op. cit., pp. 75–76.
[2] Idem, p. 75.

NEW YORK.

The New York mine, mentioned by Weaver,[1] is in the north-central part of sec. 33, T. 32 N., R. 36 E., about half a mile north of the Meteor, within the main area of granodiorite. Two shafts, one of which is equipped with a small steam hoist, were filled with water within 10 feet of the surface. Near the collar of one shaft a quartz-limonite vein 16 inches in width that strikes N. 70° E. is exposed. The dump, however, contains considerable unoxidized ore that consists of pyrrhotite, pyrite, zinc blende, galena, and arsenopyrite in a quartz gangue. The galena and pyrrhotite occur in coarse crystals intergrown somewhat after the manner of pegmatite or graphic granite. Assays of selected samples show that ore in which pyrrhotite predominates contains 0.02 ounce of gold and 4 ounces of silver to the ton, and that ore in which galena is the most abundant sulphide contains the same proportion of gold but only half as much silver.

MONTANA.

The Montana mine is near the center of sec. 28, T. 32 N., R. 36 E., near the western limit of the main granodiorite area, and about 3 miles northwest of Covada. It is briefly mentioned by Weaver.[2] Three shafts said to range from 20 to 90 feet in depth were not accessible for examination because of water that filled them within 10 feet of the surface.

Quartz fragments 1 foot in diameter in one of the dumps indicate the vein to be of at least that width. A ton or more of sacked ore contains by estimate 10 per cent each of galena and zinc blende in a quartz-calcite gangue. A little pyrite is present also. Samples from the Montana vein are said to show assay values of as much as 0.16 ounce of gold and 224.8 ounces of silver to the ton and 47.6 per cent of lead.

SNOWSTORM, ADMIRAL, AJAX, CAPTAIN, IMPERIAL, DEAD SHOT, JULIET, ST. PATRICK, KING FRACTION, SEVERAL FRACTION, AND ETTA.

Adjacent to Stray Dog Canyon in the granodiorite of secs. 27 and 28, T. 32 N., R. 36 E., veins and prospects, in addition to the Montana, Stray Dog, and other mines described, are very numerous. Among them mention is made by Weaver[3] of the Snowstorm, Admiral, Ajax, Captain (Gold Cup), Imperial, Dead Shot, Juliet, St. Patrick, King Fraction, Several Fraction, and Etta prospects. Except on one or two the development workings are very shallow. The veins or lodes range from 3 inches to 5 feet in width, but half of them are 8 inches

[1] Weaver, C. E., op. cit., p. 78.
[2] Idem, p. 76.
[3] Idem, pp. 68–78.

or less. The Captain and Snowstorm are composite veins, or stringer lodes, in which the closely spaced component veinlets are separated by altered county rock. Almost all the veins strike east or northeast and show small percentages of pyrite and galena. The gangue is quartz, as a rule, but in the Captain calcite predominates. Nearly all the veins show moderate effects of postmineral movements.

KEYSTONE.

The Keystone mine, described by both Bancroft[1] and Weaver,[2] is on the west side of Stray Dog Canyon about 1½ miles from Covada. The formation is made up of quartz-mica schist and carbonaceous shale that contains disseminated crystals of pyrite and numerous veinlets of quartz and is displaced by granodiorite a short distance to the north. The development working is an adit level driven 550 feet along a S. 60° W. fault plane. Three feet or more of gouge and breccia mineralized with pyrite accompany the fault. Veinlets that range from less than 1 inch to 4 inches in width branch from the main fracture. Some of them contain quartz banded with galena, zinc blende, and pyrite and are said to carry as much as 4 ounces of gold and 190 ounces of silver to the ton. Much postmineral faulting has occurred, and secondary quartz and calcite are present.

SYNDICATE.

The Syndicate prospect, mentioned also by Weaver,[3] is in the northern part of sec. 34, T. 32 N., R. 36 E., on the north side of Stray Dog Canyon, within the main area of granodiorite. It is developed by a crosscut tunnel more than 800 feet long, which is driven on a northeast course but has not cut a quartz vein said to crop out above. Along the course of the tunnel several small quartz veinlets that show a little galena were cut and a N. 45° W. fault, accompanied by 1 foot of gouge, is exposed.

GOOD ORE.

The Good Ore prospect, which is briefly described by Weaver,[4] is 2½ miles northwest of Covada, in the SE. ¼ sec. 22, T. 32 N., R. 36 E., within the central part of the main granodiorite area. Several open cuts expose a 6 to 10 inch quartz vein that strikes N. 60° E., dips steeply southeast, and is inclosed in a narrow zone of sheared country rock. The quartz is irregularly banded with small percentages of galena and pyrite. Assay certificates of samples said to be from the

[1] Bancroft, Howland, op. cit., p. 195.
[2] Weaver, C. E., op. cit., p. 70.
[3] Idem, p. 71.
[4] Idem, p. 69.

Good Ore vein show metallic contents that range from 0.6 to 4.06 ounces of gold and 9 to 89 ounces of silver to the ton. The vein and zone persist at least 100 feet along the strike. A crosscut tunnel, begun at a point 200 feet to the northwest, has not reached the main vein but has cut a few parallel quartz and calcite stringers.

GOLDSMITH.

A few prospects are situated within the granodiorite area northwest of the Good Ore. Of these the Goldsmith, developed by a 30-foot shaft and a short tunnel, contains a vein from 1 to 4 inches in width, of pyrite, zinc blende, and galena in a quartz-calcite gangue.

SILVER SPAR.

The Silver Spar prospect, mentioned by Weaver,[1] is in the northeast corner of sec. 27, T. 32 N., R. 36 E., 2¼ miles northeastward of Covada, within the main area of granodiorite. A vein that averages about 1 foot in width, strikes N. 45° E., and dips vertically is exposed by a shaft 15 feet deep and several pits distributed along a course of about 200 feet. The vein filling is almost wholly coarsely crystalline calcite in which pyrite is sparingly disseminated and a finely divided unidentified sulphide occurs in seams.

STRAY DOG.

The Stray Dog mine was examined by Bancroft[1] in 1910, and from his report the following description is quoted:

> The Stray Dog is located about midway between Meteor and Covada on the west side of the road. No work was being done on it when visited. Two shipments of 20 tons each are reported, and these are said to have assayed, respectively, 0.3 and 0.6 ounce of gold and 5 and 66 ounces of silver to the ton. The wide range in the silver content indicates that one shipment was probably assorted ore and the other run of mine.
>
> The developments consist of a main level at an elevation of 2,250 feet, on which there is a 260-foot crosscut, a 300-foot drift, a 75-foot winze, and a 108-foot upraise; an intermediate level, at an elevation of 2,300 feet, on which 100 feet of work is reported to have been done; an upper level, at an elevation of 2,360 feet, on which some 50 feet of work has been done; and a shaft, said to be 100 feet deep, on top of the ridge.
>
> A small quartz vein, having a general northeast strike and a dip of 75°–90° NW. and occupying a shear zone or fault plane in quartz monzonite porphyry, shows some scattered mineralization by pyrite, chalcopyrite, sphalerite, galena, tetrahedrite, and lesser quantities of pyrargyrite, argentite, and arsenopyrite. Native silver is reported from this deposit and calcite forms part of the vein filling. The shear zone ranges from 18 inches to 4 feet in width and contains

[1] Weaver, C. E., op. cit., p. 69.
[2] Bancroft, Howland, op. cit., p. 193.

talc, gouge, and brecciated country rock, besides the quartz vein, which is in some places 2 feet wide and in others pinches out. The deposit is lenticular and only sparingly mineralized. Postmineral faulting is indicated by the attrition marks on the ore minerals and the brecciated condition of the vein.

The Stray Dog is described also by Weaver.[1]

But little additional work had been done on this property between the date of Bancroft's examination (1910) and 1912. Both cerargyrite and native silver were identified in the ore by the writer.

BLACK THORN.

The Black Thorn mine, briefly described by Weaver,[2] is 2 miles northwest of Covada, on the east side of Stray Dog Canyon, within the main area of granodiorite. The principal working is a tunnel driven northward 210 feet through a heavy talus to the solid rock, and thence 55 feet on a vein that strikes N. 75° E. and dips 80° N. The vein ranges from 3 inches to 1 foot in width and consists of quartz irregularly banded with galena and pyrite that together form small percentages of the whole. Postmineral fractures filled with calcite displace the vein slightly.

ROMULUS.

The Romulus mine is near the southeast corner of sec. 28, T. 32 N., R. 36 E., about half a mile southeast of the Montana, and within the main area of granodiorite. The principal working is an inclined shaft which at the time of examination was filled with water to a point 70 feet below the collar. The lode is about 5 feet in width, strikes N. 75° E., dips steeply north, and is composed of several closely spaced parallel quartz veinlets, separated by sericitized granodiorite. As far as it was seen, namely, to water level, the lode is decomposed and considerable limonite is present. Here and there, however, the quartz shows a little unoxidized galena and pyrite.

SEVERAL.

The Several mine, briefly described by Weaver,[2] is in the central part of sec. 27, T. 32 N., R. 36 E., east of Stray Dog Canyon, within the main area of granodiorite. The workings consist of a tunnel driven N. 75° E. 200 feet, with drifts aggregating 150 feet, a shallow discovery shaft, and some open cuts. Along a course of 100 feet a vein of porous iron-stained quartz exposed by the surface workings ranges in strike from N. 25° E. to N. 75° E., dips 70° S., and averages 10 inches in width. At points 120 feet and 200 feet from the

[1] Weaver, C. E., op cit., p. 74.
[2] Idem, p. 70.

portal the tunnel cuts two veins, each of which averages N. 10° W. in strike, ranges from 2 to 4 inches in width, and is filled with quartz banded with zinc blende, galena, pyrite, and chalcopyrite. Along the drifts the veins are broken and cut out in several places by strike faults.

RED CHIEF.

The Red Chief prospect, briefly described by Weaver,[1] is in the west-central part of sec. 34, T. 32 N., R. 36 E., 2 miles west-northwest of Covada. An incline 20 feet deep to water level is sunk on a 4-foot vein that strikes N. 50° E. and dips 70° SE. At this point the vein lies between granodiorite and schist, but a short distance farther east it is wholly within granodiorite. The walls are smooth and well defined, and the vein filling is quartz and brecciated country rock. To a depth of 15 feet oxidation is complete and considerable limonite is present. Below 15 feet a little unoxidized galena and pyrite appear.

DILL, PRESCOTT, AND VERNIE.

Two prospects near the Red Chief are the Dill and Prescott, about one-third mile to the southwest and west, respectively, and a third, the Vernie, which is briefly described by Weaver,[1] lies a short distance to the east. The veins in all range from 3 to 4 feet in width and are sparingly mineralized with pyrite, galena, and zinc blende. That in the Vernie strikes northeastward.

OOM PAUL.

The Oom Paul mine, briefly described by Weaver,[2] is a short distance east of the Several, within the main granodiorite area. The developments consist of a shaft, open cut, and tunnel. These workings expose a vein that ranges from 4 to 12 inches in width, strikes nearly east, dips steeply north, and is filled with quartz, galena, and pyrite. The best-looking ore occurs in the discovery cut. Here the vein is from 4 to 6 inches in width and contains about 50 per cent of the sulphides mentioned. A selected sample yielded by assay 69½ per cent of lead and 25.14 ounces of silver to the ton, or a ratio of a trifle more than one-third ounce of silver to each 1 per cent of lead.

ROYAL ANN.

Three contiguous claims known as the Royal Ann No. 1, Royal Ann No. 2, and Royal Ann No. 3, of which the second contains no developments of interest, form a group in the south-central part of sec. 26,

[1] Weaver, C. E., op. cit., p. 78.
[2] Idem, p. 67.

T. 32 N., R. 36 E., about 1⅓ miles north-northwest of Covada, within the main area of granodiorite. The group was examined by Weaver[1] in July, 1912, and from his report the following extracts are quoted:

Royal Ann No. 1.—* * * At a point 800 feet from the east end line a crosscut tunnel extends southward 75 feet into the hill toward the vein. * * * At the face * * * there are two parallel veins running approximately in an east-west direction and consisting of quartz rich in galena and pyrite. The veins together average about 1 foot in thickness, with a dip to the south and southwest. An assay of an average sample taken here showed 0.04 ounces of gold and 12.50 ounces of silver to the ton. Another tunnel, extending S. 40° W., has been driven 110 feet. Fifty feet from the mouth a drift has been run along a vein to the left. To the right another extends 72 feet in the direction S. 85° W. At the face of the crosscut a drift extends to the right and left for 25 feet in the direction S. 40° E. The discovery shaft is an open cut 25 feet long, 15 feet deep, and 4 feet wide. The vein is 8 inches wide, with small stringers along the side. The gangue is quartz containing considerable amounts of galena, sphalerite, cerusite and pyrite. * * *

Royal Ann No. 3.—* * * The discovery shaft, 735 feet east from the west end line, has been sunk 10 feet in granodiorite. The vein, which is 6 inches wide, consists of well-mineralized quartz. An average sample from here yields upon assaying 0.02 ounces of gold and 3.20 ounces of silver to the ton. One hundred and fifty feet east of the discovery a shaft has been sunk on the vein to a depth of 40 feet. * * * The vein ranges from 10 to 16 inches in width, strikes N. 70° E., and dips 75° N., * * * and contains considerable galena.

OHIO, DRUMMOND, JOKER, LITTLE JAY, AND DISCOVERY.

The Ohio, Drummond, Joker, Little Jay, and Discovery prospects, situated in the granodiorite area in the vicinity of the Royal Ann group, are all briefly described by Weaver.[2] Except the Ohio, on which there is a tunnel 150 feet under cover, none has extensive development workings. The veins show a general easterly strike, range from 4 inches to 2 feet in width, and are composed of quartz that is more or less porous and iron-stained at the surface and commonly shows pyrite and galena at a few feet in depth.

SILVER QUEEN.

The Silver Queen prospect is 1¾ miles due west of Covada post office, near the summit of the spur that divides Stray Dog Canyon from the valley of Nez Perce Creek. Near by are the Grand View and Laura S. prospects, described by Weaver.[3] Two shafts about 400 feet apart have been sunk on a vein 1½ feet wide that strikes N. 50° E. The formation is schistose argillite which near the shafts is cut by a dike of granodiorite. The shafts were not accessible for examination, but an open cut shows the vein to be well defined and

[1] Weaver, C. E., op. cit., pp. 60–61.
[2] Idem, pp. 59–65.
[3] Idem, p. 79.

filled with earthy limonite and quartz. Fragments of vein quartz in the dumps of the shafts contain appreciable quantities of pyrite, zinc blende, and galena.

ADVANCE.

The Advance mine was examined by Bancroft[1] in 1910, and from his report the following description is quoted:

The Advance property is located 1 mile northwest of Covada, on the northeast side of the gulch. It was idle when visited, and no shipments of ore are reported.

The developments consist of two main levels connected by an upraise. The lower level, at an elevation of 2,390 feet, comprises an 849-foot crosscut, a 350-foot drift, and a 37-foot winze. The upraise between the two levels extends 180 feet on the vein, the vertical difference in elevation being about 170 feet. The workings on the upper level consist of a 200-foot drift, a 40-foot upraise, a 35-foot winze, and a 350-foot crosscut.

Quartz-mica schists showing ill-defined schistose structure are the rocks in which the ore deposits occur. These appear to strike northeast and dip 15°–60° NW.

Dikes of a fine-grained grayish rock showing phenocrysts of biotite and very much altered by metamorphic processes, yet evidently of igneous origin, intrude the sedimentary series. This rock was seen in the upraise from the lower level and in the drift on the upper level, and in places it occurs in the ore body. The microscope shows that the feldspar constituents are entirely altered to or replaced by calcite. Phenocrysts of quartz can be seen in places in the rock. Its general appearance is that of a dike accompanying the eruption of lavas, although it may be a phase of monzonitic intrusion. Because of the alteration which the rock has undergone identification is impossible.

The main developed ore deposit consists of lenticular masses of quartz from 1 inch to 16 inches in width, contained in a shear zone in the schists. This zone has an average width of 2 or 3 feet, strikes northwest, and dips 60°–70° N. 15° E. It is filled mainly with gouge and brecciated country rock, together with the quartz lenses or veins and some calcite. The mineralization was more or less scattered, and the association of pyrite, chalcopyrite, galena, and sphalerite so common in the deposits of this district is also found here. Some pyrrhotite, associated with pyrite, was seen, and native silver and pyrargarite are reported to have been found in the veins.

A smaller vein was cut 150 feet from the portal of the lower tunnel and followed by drifts for 10 feet on each side of the crosscut. This vein is 9 to 12 inches wide, strikes where exposed N. 55° W., and dips 45° NE. The vein filling is quartz, gouge, and brecciated country rock, sparingly mineralized by the usual association of ore minerals found in the camp.

Weaver[2] gives a detailed description of the mine workings as they were in July, 1912, from which it appears that they had been extended but slightly since the date of Bancroft's visit. It is noted by Weaver that the vein in its descent from the upper to the lower level crosses from the sedimentary rocks into the granodiorite. As the areal boundary of the granodiorite is about 1,200 feet north of the

[1] Bancroft, Howland, op. cit., pp. 193–195.
[2] Weaver, C. E., op. cit., pp. 44–47.

portal of the lower tunnel, through which it is reached at 800 feet or thereabouts, a decided outward inclination of the contact plane is shown.

In August, 1912, at the time of the writer's examination, the face of the right-hand drift from the lower level exposed a vein about 3 feet in width that contained moderate quantities of zinc blende and galena. A representative sample from this point yielded by assay 8 per cent of lead and 4.48 ounces of silver to the ton. Assays from various parts of the vein, reported by the owners, range from 0.05 ounce to 333 ounces of silver and from a trace to 0.93 ounce of gold to the ton.

LONE PINE, CHANCE, SILVER SPAR, SILVER PLUME, AND RELIANCE.

In addition to those in the Advance and Big Chief properties described above, there are several prospects on quartz veins on the south and east slopes of Advance Hill. Among them the Lone Pine, Chance, Silver Spar, Silver Plume, and Reliance are briefly described by Weaver.[1] Most of them are developed by shallow shafts or open cuts only. The formation is largely black carbonaceous shale interbedded with quartzite and limestone. These rocks are displaced by granodiorite near the west edge of Covada Lake and north of the Advance mine and show moderate effects of contact metamorphism. The general strike is a little east of north, and the presence of small close folds is indicated by changes in dip from 50° E. through the vertical to 45° W.

The veins range from 8 inches to 4 feet in width and consist of iron-stained quartz or of quartz and altered country rock. Most of them show unoxidized pyrite within a few feet of the surface, and many contain galena and zinc blende. Three-fourths of them strike east or northeast, and the remainder north or northwest. The latter invariably show the effects of severe postmineral movements. The Colorado vein, situated north of the Advance and near the granodiorite contact, shows a width of 2 feet and contains antimonial minerals and galena.

BIG CHIEF MINING CO.

Several mines and prospects, among which are the Apex, Legal Tender, Carbonate Chief, Jennie C, and Little Pet, the property of the Big Chief Mining Co., briefly mentioned by Weaver,[2] lie on the east slope of Advance Hill within a mile north of Covada post office. The country rock is the Covada group, of which about 50 per cent

[1] Weaver, C. E., op. cit., pp. 61–62.
[2] Idem, p. 83.

in this locality is black carbonaceous shale and the remainder chiefly schistose quartzite and siliceous argillite, and all the beds show moderate effects of contact metamorphism. The general strike is north-northeast, and the dip ranges from the vertical to 45° E. or 45° W. These rocks are cut by a few small aplite dikes and a great many small quartz veins, most of which contain, in addition to pyrite, varying proportions of galena or zinc blende or both.

On the Little Pet claim a 40-foot incline is sunk on a 3-foot vein which follows a bedding plane in black shale that strikes N. 60° E. and dips 70° NW. To a depth of 10 feet the vein filling is quartz and limonite; below that depth arsenopyrite, pyrite, galena, and zinc blende appear. Here and there quartz veinlets branch off into the wall rock, which also contains sheets of aplite and pegmatite between its layers.

Near the north end of the Little Pet claim and on the Legal Tender claim surface workings expose other veins, mostly smaller but of similar appearance, in one of which molybdenite was identified. Other veins exposed by shallow workings on the Apex, Carbonate Chief, and Jennie C claims are small and of similar composition to those described. On August, 1912, the Big Chief Co. was driving a crosscut tunnel westward in the lower east slope of Advance Hill for the purpose of exploring the veins in depth.

PLYMOUTH ROCK.

The Plymouth Rock mine, described also by Weaver,[1] is about a third of a mile east of Covada post office, in an area underlain by rocks of the argillite series that have been intimately intruded by granodiorite. The principal working is a crosscut tunnel driven southeastward 150 feet that penetrates metamorphosed argillite, limestone, and granodiorite in the order named. A drift is run 125 feet along the contact between granodiorite and limestone, which trends northeast and is occupied for part of the distance by an irregular vein that ranges in width between 2½ feet and the vanishing point. The vein filling is quartz appreciably mineralized in places with galena, zinc blende, and pyrite. The outcrop as exposed by shallow workings on the hill above consists of rusty porous quartz.

KENTUCKY BELLE.

The Kentucky Belle mine, described by Weaver,[1] is in the SW. ¼ sec. 36, T. 32 N., R. 36 E., three-quarters of a mile east of Covada, in an area of schistose quartzite and limy shale that are succeeded

[1] Weaver, C. E., op. cit., p. 48.
[2] Idem, p. 55.

short distances to the west and north by intrusive granodiorite. The workings consist of a crosscut tunnel driven eastward nearly 500 feet, a shallow shaft, and open pits. The shaft is sunk on a north-south vein about 5 feet wide of quartz and silicified argillite brecciated by postmineral movements and coated with iron oxides. A parallel vein 3 feet in width exposed a short distance to the west is of similar composition. Where cut by the tunnel the smaller vein shows a scant mineralization with pyrite, arsenopyrite, zinc blende, and galena, and the larger one appears practically barren.

SILVER CROWN.

The Silver Crown mine, described also by Weaver,[1] is near the northeast corner of sec. 1, T. 31 N., R. 36 E., about 1 mile east of Covada, within the same area of schistose quartzite and limy shale as the Kentucky Belle. The principal workings consist of a shaft 112 feet deep with crosscuts and drifts at the 50 and 100 foot levels. Additional workings are a crosscut tunnel a short distance east of the shaft, driven 125 feet in a northwest direction, and some open cuts and pits. Several veins are exposed, of which the principal one strikes N. 12° W., dips 60° W., and is developed by the shaft. At the surface this vein is 18 inches in width and consists of iron-stained quartz. On the 50-foot level short drifts show a width of 3 feet of moderately sheared quartz banded with finely divided pyrite and other unidentified sulphides. A sample across the vein at this level yielded by assay 0.06 ounce of gold and 14.94 ounces of silver to the ton. At the 100-foot level the vein is of similar general appearance and somewhat wider.

IVANHOE (SOUTHERN CROSS).

The Ivanhoe mine is on the slope west of Columbia River, in the NW. ¼ sec. 6, T. 31 N., R. 37 E., 1¼ miles east of Covada. A tunnel at an elevation of 1,900 feet, driven westward 650 feet, crosscuts limy shale and penetrates three veins, each of which has an average width of 10 inches, strikes about N. 30° W., and dips steeply southwest. In each vein the filling consists of rather massive quartz in which partly silicified fragments of shale are included and pyrite occurs as films on seams and disseminated specks. Although these veins are barren in appearance, samples from them are said to assay fairly well in silver.

ORION.

The Orion mine is in the west-central part of sec. 31, T. 32 N., R. 37 E., on the slope west of Columbia River. Two tunnels driven 1,200 and 500 feet westward crosscut limy shale and argillite of an

[1] Weaver, C. E., op. cit., p. 57.

average northerly strike and vertical dip. The tunnels cut several veins that range from 1 inch to 3 feet in width and consist of pyrite-bearing quartz said to carry a little silver and gold.

JOHNNY BOY AND NORTHERN LIGHT.

The argillitic rocks of the slope between the Orion mine and Columbia River contain many outcrops of small quartz veins, some of which have been explored to moderate depths. The vein in the Johnny Boy prospect, half a mile south of the Orion, shows a little pyrite and chalcopyrite. In the Northern Light prospect, half a mile east of the Orion, silicified argillite traversed by many veinlets of iron-stained quartz is exposed by a short tunnel.

GREASY RUN, LAKEVIEW FRACTION, MAYFLOWER, KING SOLOMON, QUANDARY, BLUE BIRD, PILGRIM, SUNSET, IXL, IDORA, SILVER DOLLAR, SUNSHINE, AND BUTTERFLY.

The area extending from the vicinity of Covada post office east and southeast to Columbia River contains, in addition to those described, a large number of prospects. The Greasy Run, Lakeview Fraction, Mayflower, King Solomon, Quandary, Blue Bird, Pilgrim, Sunset, IXL, Idora, Silver Dollar, Sunshine, and Butterfly situated in this locality have been described in more or less detail by Weaver,[1] upon whose report the following summary is in part based.

The formations are siliceous argillite, quartzite, and limestone, which near Covada are cut by irregular apophyses of granodiorite. With few exceptions the veins strike north or northwest; half of them are but a few inches in width and the remainder range from 1 to 3 feet. The workings are shallow as a rule, and the exposed portions of the veins consist of quartz that is commonly iron stained at the surface and in most of the veins shows a little pyrite and galena at a depth of a few feet. Zinc blende and chalcopyrite are present in a few places. The larger veins show well-marked effects of postmineral shearing and crushing movements.

LONGSTREET.

The Longstreet mine, described by both Bancroft[2] and Weaver,[3] is 1½ miles northeast of Covada, in a small outlying mass of granodiorite. The workings consist of a crosscut tunnel 200 feet long at an elevation of 2,100 feet, a large irregular open cut about 70 feet higher, and, a short distance south of the open cut, an 80-foot tunnel at the same elevation. The mine was idle when visited by the writer,

[1] Weaver, C. E., op. cit., pp. 47–59.
[2] Bancroft, Howland, op. cit., p. 195.
[3] Weaver, C. E., op. cit., p. 67.

but some small shipments are reported from it, one of which consisted of 2,880 pounds of ore that yielded 207 ounces of silver, or at the rate of 144 ounces to the ton. The outcrop is a prominent reef of silicified breccia that is 40 or 50 feet wide, several hundred feet long, and trends about north. Underground workings show that a zone 200 feet or more in width is cut by closely spaced northerly faults and shear planes. South of the Longstreet the zone of sheared and crushed rocks extends with diminishing width for a mile or more. The northward prolongation is probably represented by a small fault zone on the lower west slope of Rattlesnake Mountain, half a mile north of the Longstreet. In the vicinity of the Longstreet workings seams and fractures in the outcrop are commonly stained deep shades of yellowish-green and reddish-brown with the oxides of antimony.

In the open cut shipping ore occurs at depths of 5 to 20 feet as irregular, indefinitely bounded bunches along seams. The main tunnel exposes brecciated silicified granodiorite. Through a width of 30 feet or more, beginning near the portal of the tunnel, grains of pyrite, stibnite, argentite, and galena are irregularly distributed. Postmineral fault movements parallel to the strike have reopened the zone and produced large bodies of gouge and breccia. A fault plane that strikes N. 15° W., dips 75° W., and is exposed about 75 feet from the portal of the tunnel is accompanied by 20 feet of finely comminuted rock fragments and blue-black gouge. Beyond this fault are a number of seams and veinlets that show pyrite and stibnite. Several assays, reported by the owners and said to represent selected portions of the zone at the tunnel level, show an average of 83 ounces of silver and a few cents in gold to the ton. The 80-foot tunnel exposes several veinlets of stibnite that range from a fraction of an inch to 3 inches in width.

ROBERT E. LEE.

The Robert E. Lee prospect, adjoining the Longstreet on the south, was not examined by the writer. The following description is quoted from the report by Bancroft,[1] who visited the property in 1910:

> The R. E. Lee prospect is located 1¼ miles northeast of Covada, about a quarter of a mile south of the Longstreet. It is interesting mainly because of the occurrence of small veins of stibnite or berthierite, which are exposed in the workings. This prospect also was idle when visited, and no shipments are reported. The developments consist of a 76-foot crosscut, at an elevation of 2,160 feet, in which there is a 5-foot winze 30 feet from the portal.
>
> Quartz monzonite porphyry is the country rock. In the winze are exposed small veins or fractures containing stibnite or berthierite. One stringer 3

[1] Bancroft, Howland, op. cit., p. 196.

inches wide completely filled with this mineral is the widest; others range from half an inch to an inch in width and are separated from one another by barren country rock, the whole mineralized zone being about 2 feet wide. This zone has been exposed for only a few feet along the strike and dip, and its extent in these directions is uncertain. The strike of the ore body is N. 30° E., and the dip 40°–50° NW. An analysis of this ore by R. C. Wells, of the United States Geological Survey, showed it to be composed almost wholly of antimony sulphide with a little iron and a trace of arsenic. Copper and zinc are reported to be absent, and Mr. Wells suggests that the mineral conforms more nearly in composition to berthierite than to stibnite. An assay of a picked sample of this mineral by Burlingame & Co., of Denver, Colo., showed it to contain traces of gold and silver.

A description of this prospect is also given by Weaver,[1] who visited it in July, 1912.

SHOOFLY, PERRY, BIG JOKER, WHITETAIL, POLARIS, THREE PINES, OLD NELL, AND BLACKTAIL.

There are a large number of prospects in the area of granodiorite and the irregular strips of metamorphosed sedimentary rocks south and west of the Robert E. Lee prospect. Among them the Shoofly, Perry, Big Joker, Whitetail, Polaris, Three Pines, Old Nell, and Blacktail have been described by Weaver,[2] upon whose report the following summary is in part based:

The workings on all are shallow. The lodes are about equally divided as to strike between average N. 20° W. and N. 70° E. directions. Those of northwestward strike range from 2 to 5 feet or more in width and are commonly in the form of composite veins or sheared zones. The others for the most part are single veinlets or veins from 1 inch to 18 inches in width. Practically all show a sparse mineralization with pyrite and galena, which in some places are accompanied by zinc blende and stibnite. Moderate effects of postmineral movement may be observed in most of the lodes.

ROSARIO.

The Rosario prospect, briefly mentioned by Weaver,[3] is in the NW. ¼ sec. 31, T. 32 N., R. 37 E., a short distance east of the R. E. Lee. A tunnel driven westward 300 feet or more through silicified granodiorite cuts some small quartz veins that contain bands of pyrite and films of molybdenite on seams. A short tunnel and some open pits farther north expose quartz veinlets that contain scattered grains of tennantite or tetrahedrite and pyrite.

[1] Weaver, C. E., op. cit., p. 66.
[2] Idem, pp. 51 et seq.
[3] Idem, p. 81.

BLUE JAY, RATTLESNAKE, AND YELLOWSTONE.

Several prospects on the west slope of Rattlesnake Mountain lie at an average distance of 1¾ miles northeast of Covada and half a mile or more north of the Longstreet. The formation is chiefly quartz-mica schist and siliceous blue argillite, with which some thin lenslike layers of limestone are interbedded. The general strike is N. 15° W., and dips range from 70° W. to the vertical. Small dikes of fine-textured gray porphyry occur here and there, and at the southwest foot of the mountain the sedimentary rocks are cut and metamorphosed by granodiorite.

As exposed by a shallow pit, the vein on the Blue Jay prospect is 3 inches wide, strikes N. 15° W., and shows fairly abundant galena and pyrite in quartz.

Workings on the Rattlesnake prospect comprise some open cuts and a tunnel 200 feet in length at the foot of the slope. For 100 feet the tunnel penetrates loose slide rock or talus, from which a strong current of cold air flows out during warm weather. Dripping water forms ice in the tunnel during even the warmest days. This interesting phenomenon is no doubt a result of the well-known principle that heat is absorbed by the evaporation of liquids. The water from a small spring trickling downward through the loose talus above the tunnel moistens the rock fragments and is thus favorably exposed to evaporation. In the summer the air is dry in this region; evaporation is therefore rapid, and the tunnel, by drawing off the cooled air from the interstices of the slide rock, increases the circulation and consequently the speed of evaporation and loss of heat until a freezing temperature is reached. Beyond the talus the tunnel enters gray argillite and banded hornstone and cuts a quartz vein 2 inches wide that contains moderate proportions of pyrite, galena, and zinc blende. The discovery pit, a few hundred feet north of the tunnel, exposes a north-south sheared zone in metamorphosed argillite that contains several veinlets of quartz, pyrite, and galena.

A short distance south of the Rattlesnake a 160-foot tunnel on the Yellowstone prospect follows a N. 75° E. quartz vein that cuts granodiorite and ranges from 6 inches to 1 foot in width. The vein filling is quartz carrying fair proportions of pyrite, galena, and zinc blende.

Other small veins of a similar character are exposed by open cuts in this vicinity. In some of them manganese oxides and chalcopyrite were identified in addition to the minerals named.

SILVER LEAF.

The Silver Leaf mine is near the quarter corner on the south line of sec. 30, T. 32 N., R. 37 E., 1¾ miles west-northwest of Covada, at the foot of a southeast spur from Rattlesnake Mountain. Brief

descriptions of this property are given by both Bancroft[1] and Weaver.[2] Development work was in progress in August, 1912, and shipments that aggregated 11 tons of ore of an average content of 3.6 per cent of lead, 2.2 per cent of zinc, and 180 ounces of silver to the ton are reported.

The formation at this locality is siliceous argillite and quartzite, with thin interbedded layers of limestone that have an average northerly strike and nearly vertical dip. Small dikes of siliceous intrusive rock cut the sedimentary beds here and there, and a few hundred feet west of the Silver Leaf shaft is a large northerly dike of quartz diorite. Below an elevation of 1,800 feet these rocks are generally overlain by the Nespelem silt, which fills a narrow valley between Rattlesnake Mountain and the hills east of Covada.

The principal workings are a tunnel at the valley level (1,800 feet), driven northward about 200 feet, and a pit and shaft 40 feet deep begun on the slope about 40 feet higher than the tunnel. The lode is irregular, about 8 feet in greatest width, strikes N. 30° W., dips steeply northeastward, and has rather indefinite boundaries. It is filled with argillite breccia cemented and partly replaced by quartz. The ore minerals are zinc blende, pyrite, and silver-bearing galena. Numerous drusy cavities are lined with quartz needles and crystals of the sulphide minerals, which are also intergrown with the quartz. The ore minerals are distributed irregularly through the lode, considerable portions of which appear barren. The ore shipped was sorted by hand from the material taken from the shaft and open cut. No well-defined ore shoot appears, but the best ore occurs in very irregular bunches. Some slip and fault planes cut the lode, and the zone of oxidation is very shallow. The tunnel does not connect with the shaft or penetrate the lode. Whether or not the lode is persistent along the strike is not shown by the underground workings or the outcrop, which has not been traced very far.

ZEARN.

The Zearn prospect is a quarter of a mile south of the Silver Leaf, on a small exposure of argillitic rocks that is surrounded by the Nespelem silt. A small pit is sunk on a northerly lode about 1½ feet wide that consists of brecciated quartzite and hornstone, with a considerable percentage of limonite and irregular grains and bunches of pyrite and galena.

SILVER BELL.

The Silver Bell prospect is at the end of the southeast spur from Rattlesnake Mountain, about half a mile east of the Silver Leaf. A short tunnel, shaft, and crosscut expose a gray vitreous hornstone

[1] Bancroft, Howland, op. cit., p. 197.
[2] Weaver, C. E., op. cit., p. 80.

that weathers rusty and is irregularly mineralized with galena, pyrite, and zinc blende. The dimensions and course of the lode are not definitely shown, but a width of at least 1 foot contains a fair proportion of galena.

ST. PAUL, LAUREL, RATTLER, AND JAY BIRD.

About three-quarters of a mile north of the Silver Bell and Silver Leaf are a few prospects near the northeast foot of Rattlesnake Mountain, of which the St. Paul, Laurel, Rattler, and Jay Bird are briefly described by Weaver.[1] The veins are, as a rule, less than 8 inches in width, strike north or northeast, and are but slightly developed, and that in the St. Paul shows small percentages of galena and pyrite in quartz.

J. H. E.

Specimens said to have come from the J. H. E. prospect, north of the St. Paul, show fairly abundant zinc blende and galena.

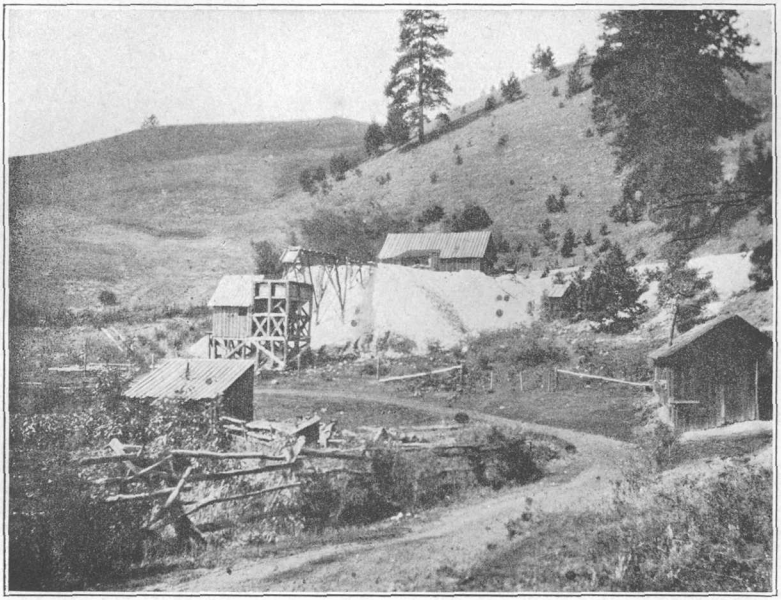
COLD SPRING GROUP.

Seven patented claims 3 miles a little west of north of Covada, on a northeast slope adjacent to the valley of Stranger Creek, constitute the Cold Spring group. The formation is schistose argillite that has been intruded and metamorphosed by granodiorite, the contact of which crosses the middle portion of the group in a northerly direction. The principal working is an adit level at an elevation of 1,000 feet, driven 300 feet or more southwestward along a narrow, crooked vein that follows the granodiorite contact part way. The vein filling is quartz scantily mineralized with galena and pyrite. Near the face of the drift the vein is intersected by a N. 15° W. shear zone 5 feet wide, on which a drift is run southward 100 feet. Within this zone the schist is silicified and irregularly mineralized with pyrite, chalcopyrite, zinc blende, and galena.

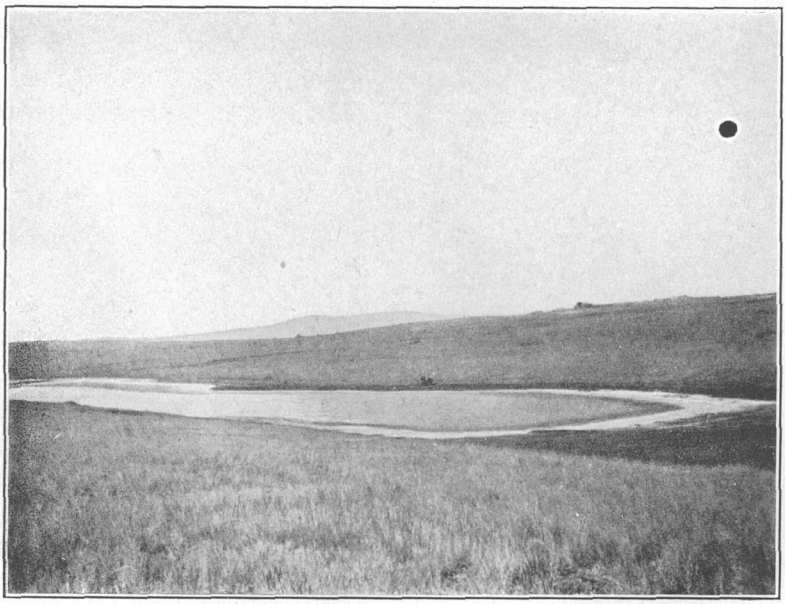
MONARCH, ROULETTE, AND GREAT EASTERN.

Several prospects are located in the granodiorite area to distances a mile southeast and half a mile northeast of the Cold Spring. The Monarch prospect, in the SW. ¼ sec. 14, T. 32 N., R. 36 E., shows a vein about 3 feet in width that strikes northward and contains a little galena in a quartz gangue. The Roulette and Great Eastern prospects, in the southeastern part of sec. 23, are reported to show a similar mineralization.

[1] Weaver, C. E., op. cit., pp. 71–73.



A. GWIN MINE.



B. SALT-RIMMED POND, OKANOGAN PLATEAU.

GWIN AND ADJACENT PROSPECTS.

The Gwin mine (Pl. XII, *A*) and several adjacent prospects, the property of the Hall Creek Mining Co., briefly mentioned by Weaver,[1] are on a low hill between Stranger and Hall creeks, about 3½ miles west of Inchelium. The mine is approached over good roads that lead from Inchelium, Meteor, and the valley of Hall Creek. Underground development work was in progress when the property was visited in 1912, and a concentrating mill is reported (April, 1915) to have since been built and to be in successful operation.

Gwin Hill is one of several gently rounded knobs of older rocks that are elongated in a N. 20° W. direction and project like islands above the summit level (1,700–1,800 feet) of the lands underlain by the Nespelem silt. Together with a knob half a mile to the east it forms an exposure about 1 square mile in area of fine-grained sediments of the Covada group. The average strike and dip are N. 20° W. and 45° SW., respectively. From east to west, outcrops of fine-textured rusty-weathering quartzite and sandstone are succeeded by gray mica schist and greenish-gray argillite. In a small area half a mile north of the Gwin tunnel limy shales have been metamorphosed to gray-green and purple banded hornstones characteristic of contact effects, although no intrusive granite or similar rock is exposed at the surface.

The principal workings consist of an inclined shaft at an elevation of 2,300 feet in the NW. ¼ sec. 11, T. 32 N., R. 36 E., near the summit of Gwin Hill, and a crosscut tunnel on the east slope, 260 feet lower, from which drifts and winzes are made. The shaft was not accessible for examination but is said to be sunk 150 feet on the vein, which dips 45°–60° NE. No connection has been made between the shaft and the tunnel. The tunnel is driven westward 644 feet and cuts the vein 356 feet from the portal. A drift follows the vein 175 feet northwestward, and at 60 feet from the crosscut there is a winze sunk 100 feet, with short drifts from the bottom. The workings are equipped with a compressor plant, hoist, pump, and drill. As exposed by the drifts, the vein strikes N. 30° W., dips 45° NE., is persistent and fairly regular, has well-defined walls, and ranges from 6 to 8 feet in width. It shows banded structure and is but moderately sheared and broken by postmineral movements. Going down the winze, several small strike faults are seen, each of which steps the vein up a foot or two. At the bottom a nearly vertical strike fault, accompanied by 2 or 3 feet of gouge and brecciated quartz and wall rock, cuts off the vein. The amount or direction of the displacement is not shown. The vein filling is quartz, sprinkled with small grains

[1] Weaver, C. E., op. cit., pp. 81–83.

of a silver-bearing arsenical sulphide of copper, either tennantite or enargite. In places a little galena and pyrite are present, the pyrite occurring chiefly as films on secondary fractures. At a depth of 200 feet but a trifling degree of oxidation is shown by faint stains of malachite and azurite on seams. Ore from the shaft, however, is brightly colored with the two minerals named. Practically the full width of the vein, as exposed in the lower workings, may be regarded as ore. The company's assay records show an average content of 3 per cent of copper and 27.7 ounces of silver and 0.049 ounce of gold to the ton.

Several prospects belonging to the Hall Creek Mining Co. lie within a mile north of the Gwin. None of the lodes are developed extensively and, for the most part, their oxidized portions only are exposed. A quarter of a mile north of the Gwin tunnel, an open cut on the Wizard claim exposes 8 feet of sheared iron-stained quartz, in which a little unoxidized pyrite and arsenopyrite remain. On the Missing Link claim, east of the Wizard, banded hornstones are cut by a 2-foot vein of cellular iron-stained quartz, and on the B. C. fraction, a short distance west, is a 1-foot vein of similar material. The wall rocks contain disseminated grains of pyrite and arsenopyrite. Quartz-pyrite veinlets in hornstone are exposed on the Missing Link and Iron Cap claims, one-fourth to one-third mile north of the Wizard. The dump of a shaft on the Galena claim, 1 mile north of the Gwin, shows considerable galena associated with quartz and pyrite.

ALGONKIAN, VICTOR, ST. PAUL, GREAT SCOTT, DAN PATCH, AND REN RICE.

Several prospects are situated on a chain of low hills that partly fill the space between Rattlesnake Mountain and Gwin Hill. These hills form a small range, all but the summits of which are buried beneath the silts and gravels of the Nespelem formation. Their rocks are chiefly fine-grained rusty-weathering quartzite, gray argillite, and green schist. A few dikes of fine-grained gray porphyritic rock are present. The general strike is N. 20° W. and dips range from 40° E. to 45° W. In order from south to north are the Algonkian, Victor, St. Paul, Great Scott, Dan Patch, and Ren Rice prospects, briefly described by Weaver.[1] None of them are extensively developed. The Algonkian vein is about 6 inches in width, strikes east, and shows dark bands in quartz, apparently due to finely divided sulphides. A sample from the vein at a depth of 10 feet yielded by assay 0.03 ounce of gold and 6.25 ounces of silver to the ton. The Victor-St. Paul lode is a sheared zone 5 or 6 feet in width and strikes N. 25° W. and is partly silicified and mineralized with

[1] Weaver, C. E., op cit., pp. 71–73.

pyrite. A greenish-yellow stain that suggests an oxide of arsenic is present in the outcrop. On the Great Scott, Dan Patch, and Ren Rice are several small veins that range from N. 10° W. to N. 68° E. in strike, some of which show small proportions of galena and zinc blende. Weaver reports an assay of 0.04 cunce of gold and 10.15 ounces of silver to the ton in a sample from the main vein on the Dan Patch.

GOLD TWENTY AND PROSPECTS IN THE BASIN OF HALL CREEK.

Outcrops of white quartz characterize a broad belt that extends from the vicinity of Meteor northward to the reservation boundary. In general, the quartz occurs as small irregular veinlets that form closely spaced networks over considerable areas in which the vein quartz may constitute as much as 50 per cent of the formation. Locally the veinlets swell to bodies several feet in width. For the most part the quartz is white, barren, and coarsely crystalline, and its general appearance suggests a rock intermediate between ordinary vein quartz and pegmatite. In many places prospect pits and tunnels have been dug on these bodies, but except in a few places, three of which are noted below, the quartz appears wholly barren of valuable minerals. On the Gold Twenty claim, in the NW. ¼ sec. 5, T. 32 N., R. 36 E., 3 miles north of Meteor, a 175-foot crosscut exposes black argillite crisscrossed by white quartz veinlets, some of which carry small percentages of galena, zinc blende, pyrite, and calcite.

A prospect in sec. 5, T. 33 N., R. 36 E., east of Hall Creek, is on a large composite vein that strikes a little west of north and consists chiefly of barren white quartz. In places, however, along the courses of a 40-foot open cut and a 40-foot tunnel, the quartz shows a little green discoloration, due in part to copper minerals and in part to chlorite. Grains of siderite occur here and there, and its oxidation has produced a little iron stain that coats seams in the quartz.

A mile north of the prospect above described, near the summit of a steep slope east of Hall Creek at Albert Hall's house, a tunnel and open cuts have been made on another white quartz outcrop. In one place the vein is 4 feet in width and contains considerable calcite, some siderite, and a slight wash of copper carbonate.

SILVER PLUME.

The Silver Plume prospect, of which Weaver[1] gives a brief description, is in the NE. ¼ sec. 2, T. 31 N., R. 36 E., near the foot of the slope west of Stray Dog Creek and about a quarter of a mile southwest of Covada post office. The formation is black siliceous

[1] Weaver, C. E., op. cit., p. 50.

argillite, cut by a northerly dike of granodiorite. The workings consist of a crosscut tunnel at an elevation of 1,900 feet, driven 160 feet southward, and some shallow openings on the hill above. At the face of the tunnel there is a 20-inch vein that strikes northeastward and is composed of quartz that carries appreciable percentages of pyrite, zinc blende, and galena. At 100 feet from the portal a 4-inch vein of similar composition is pierced. The outcrop is porous iron-stained quartz. In the vicinity of the Silver Plume are several prospects, but the workings are shallow, and the veins are small and, so far as they have been explored, consist only of iron-stained quartz.

TWIN PINES, FIVE HUNDRED, AND PRINCE HENRY.

From the vicinity of the Silver Plume southeastward 3 miles along the summit and northeast slope of Reister Mountain are a dozen or more prospects on which but shallow workings have been made. The formation consists of schistose argillite and greenstone that have an average N. 10° W. strike and a steep eastward dip. Several good-sized dikes of granodiorite and fine-textured porphyry cut the sedimentary series.

On the Twin Pines prospect, in the SW. ¼ sec. 13, T. 31 N., R. 36 E., the vein is 5 feet wide, strikes N. 35° E., and consists of alternate layers of crushed argillite and vein quartz that contains a little pyrite and galena. On the Five Hundred prospect, in the NW. ¼ sec. 14 of the same township, the vein strikes east, is 4½ feet wide, and is filled with a breccia of quartz and argillite that shows a little gold and silver by assay. The vein on the Prince Henry, in the NW. ¼ sec. 14, near the foot of the east slope of Reister Mountain, strikes north, is inclosed by granodiorite, and contains 4 feet of crushed, iron-stained quartz. Other quartz veins exposed range from 1 to 30 feet in width. Most of the smaller ones contain iron stain and a few grains of pyrite and galena, but the larger outcrops, as a rule, consist only of barren-appearing white quartz.

PROSPECTS WEST OF NEZ PERCE CREEK.

The slope west of Nez Perce Creek, in secs. 20 and 21, T. 31 N., R. 36 E., is underlain by moderately schistose rocks of the Covada group, in which are numerous quartz outcrops. Several prospects belonging to P. A. Paulsen lie north of the tracts mentioned. The veins are reported to strike northward, to range from 4 to 8 feet in width, and to contain pyrite, zinc blende, and galena in a quartz gangue. Of other prospects in the same locality a pit in the SE. ¼ sec. 20 exposes a vein that strikes N. 45° W., is 5 feet in width, and contains pyrite and chalcopyrite, sparsely distributed through the quartz.

A short adit level in the SW. ¼ sec. 21 follows a vein that strikes N. 30° W., is 6 inches wide, and contains liberal percentages of galena, zinc blende, and pyrite in a quartz-calcite gangue. The vein is accompanied by 4½ feet of brecciated altered argillite.

PLACERS.

Gravel bars, described by Collier,[1] adjacent to Columbia River, between the mouths of Wilmont and Barnaby creeks, have been mined here and there for gold. As a rule the gold is confined to very thin pay streaks which are none too rich and the most readily available of which have been worked out and abandoned.

A short distance below the mouth of Stray Dog Creek a thin layer of rusty gravel is exposed in the bank of a high-water channel of Columbia River. Panning tests yielded, to each pan of gravel, an average of 100 particles of finely divided or "flour" gold, estimated collectively to be worth between one-eighth and one-fourth cent. Blue Bar Island is a low gravel bar in Columbia River, near the mouth of Stray Dog Creek, that is overflowed at high tide. Flour gold in the superficial layer of gravel is said to be renewed by the annual freshets. Panning tests indicate that, in places, a miner using a sluice or rocker, with blanket riffles, might wash out 50 cents' worth of gold a day.

On the claim of James Thompson, on the river bank almost due east of Covada, a little work had been done recently. A small supply of water, available in the spring only, is conducted to the pit through a ditch from Stray Dog Creek and used for sluicing. The pay streak is 6 inches thick, of the same average tenor as the gravel of Blue Bar Island, and for the most part covered by a thick overburden. Its washing is said to have yielded but "small wages."

The placer mine of W. Johnson is on the bank of Columbia River in the NE. ¼ sec. 8, T. 32 N., R. 37 E., just below the mouth of Stranger Creek. For this mine an abundant supply of water from Stranger Creek is available, and a little mining, done recently, is said to have been profitable. A production of about $100 is reported from a pit approximately 2,000 cubic yards in size, equivalent to a yield of about 5 cents a yard. Evidently this deposit is the one referred to by Collier,[2] who says:

> Mining by hydraulicking was in progress on a bench at the mouth of Stranger Creek. * * * The pay streak was tested by panning at several places and is estimated to contain from 40 cents per cubic yard at the richest spot to 5½ cents at the poorest.

[1] Collier, A. J., Gold-bearing river sands of northeastern Washington: U. S. Geol. Survey Bull. 315, pp. 65–68, 1907.

[2] Idem, p. 67.

The pay streak consists of 1 to 3 feet of medium to fine textured gravel, beneath 4 to 8 feet of sand, and is evidently limited on the west by a terrace a few hundred feet from the river. Its extent south from Stranger Creek was not ascertained.

NONMETALLIFEROUS DEPOSITS.

LIMESTONE.

Detached masses of limestone of irregular blocky or lenslike form are fairly well distributed in the areas occupied by the Covada group. They are therefore comparatively plentiful in the basin of Ninemile Creek and in the Covada and Park City districts and rare elsewhere. These masses range from a few feet to 200 feet or more in thickness, most are crystalline gray or white marble, and many appear in part to be nearly pure calcium carbonate. Lime was burned from a small mass that crops out on Lime Creek, 9 miles north of Keller, and was used in the construction of the Keller smelter. On the slope east of Okanogan River in sec. 16, T. 33 N., R. 26 E., two small quarries are made in a bed of marble. Some of the layers contain pyrite and are colored green with chlorite; others are white and apparently consist of little else than calcium carbonate. A small amount of lime has been burned here. As exposed in the quarry, however, the marble is too badly crushed to be valuable as building stone. The total thickness of the deposit is about 200 feet. Two miles north of Nespelem village, on a low hill east of the road, is an undeveloped outcrop that yields specimens of handsome white and gray marble.

BUILDING STONE.

Stone suitable for ordinary building purposes is abundant almost everywhere in the reservation. In addition to marble, the most valuable variety apparently is the diorite, or "Devil's Elbow granite," as it is locally known, exposed along Sanpoil River about 18 miles north of Keller. The rock is medium textured and of a pleasing gray color, and is said to take a high polish. The rock is dense and could doubtless be quarried in large blocks free of flaws, and the supply is inexhaustible.

CLAY.

Fine sediments, including most of the Nespelem silt, that may be classified as common brick clay, are widely distributed in this area but have not yet been utilized. As this material is chiefly of glacial origin, containing a high percentage of minute undecomposed rock fragments, or rock flour, it is doubtless too high in fluxing materials

to yield a high-grade brick. A deposit believed to be essentially similar to those in the reservation has been opened along Columbia River at Kettle Falls. The analysis[1] of this clay shows relatively high percentages of iron, lime, and magnesia.

SALINES.

The numerous ponds scattered over the surface of the Okanogan Plateau (see Pl. XII, *B*, p. 172) deposit around their margins thin salt crusts that are fairly rich in potash. Although probably of too small volume to be commercially important, these deposits are nevertheless of some interest. A sample of a saline crust taken from a pond in sec. 14, T. 31 N., R. 26 E., 2½ miles northwest of Duly Lake, was analyzed by W. B. Hicks in the laboratory of the United States Geological Survey. The total salts (ignited residue), which formed 72.16 per cent of the original sample, contained 6.28 per cent of potassium (K), which is equivalent to 7.57 per cent of potassium oxide (K_2O), or 11.98 per cent of potassium chloride (KCl). A qualitative examination of the sample showed the presence of considerable quantities of chlorides, sulphates, and carbonates, and the potassium therefore probably occurs as chloride or as both chloride and sulphate.

Omak Lake, which is about 8 miles long and rather deep but narrow, is the largest of the notably saline water bodies. Though the salines in it are not sufficiently concentrated to be deposited, the water has a smooth, soapy feeling, froths along the shore, and tastes of sodium carbonate. A sample of the water from the east bay at the north end of the lake was analyzed in the laboratory of the United States Geological Survey with the following result:

Analysis of water from Omak Lake, Wash.

[George Steiger, analyst. Parts per million except as otherwise stated.]

Calcium (Ca)	13
Magnesium (Mg)	103
Sodium (Na)	1,831
Potassium (K)	254
Sulphate radicle (SO_4)	1,185
Chloride radicle (Cl)	116
Carbonate radicle (CO_3)	1,979
Bicarbonate radicle (HCO_3)	173
Boron (B)	None.
Total solids (calculated)	5,566
Specific gravity at 25° C., 1.004.	

[1] Shedd, Solon, The clays of the State of Washington, p. 219: Washington State College, 1910.

Thus, by calculating all the potassium as potassium sulphate, the remaining sulphate radicle as sodium sulphate, and the excess of sodium as sodium carbonate, the principal salts in this water may be assumed to have approximately the following proportions, although it is recognized that the ions determined by analysis may not actually be combined in this way:

	Percentage of dried salts.
Potassium sulphate (K_2SO_4)	9.93
Sodium sulphate (Na_2SO_4)	22.62
Sodium carbonate (Na_2CO_3)	57.20
Other salts not calculated	10.25
	100.00
Total salts	.57

The analysis shows a salinity of 0.57 per cent, or 40 to 100 times that of ordinary fresh lake or river water, and this percentage is thought to be a minimum, because the bay from which the sample was taken receives a small but perennial stream of fresh water and is therefore probably less saline than the body of the lake. Compared with the water of other saline lakes on the Columbian plain[1] and in central and southern Oregon, the water of Omak Lake shows about double the salinity of that of Moses Lake but only one-fifth that of Soap Lake. It is about one-third as saline as Harney and Summer lakes and one-sixth as saline as Abert Lake.

The level of Omak Lake rises a few feet in winter and falls a few feet in summer, but as the shores are steep the changes in the area of the water surface, unlike those in the surface of the lakes of southern Oregon, are slight. The area of Omak Lake is a little more than 3,500 acres, and on the assumption that the average depth is 50 feet the total amount of salts in solution would therefore be somewhat more than 1,300,000 tons. Of this amount more than 100,000 tons may be calculated, in the same way as was done above, as potassium sulphate and 700,000 tons as sodium carbonate. Although the saline residue of Omak Lake is less in amount than that of Abert and other lakes that have been considered as possibly profitable sources of salts, it is richer in sodium carbonate, and it contains about three times as much potash, but very much less of the chlorides. It is, however, much higher in sodium sulphate.

Whether or not salines can be profitably extracted from Omak Lake depends largely on the facilities available for evaporating the water, as to which few or no data are at hand. However, a bay that covers 100 acres on the east side of the lake and that is connected with the main water body by a strait only 400 feet wide at one place might perhaps be utilized as an evaporating basin.

[1] Clarke, F. W., The data of geochemistry, 3d ed.: U. S. Geol. Survey Bull. 616, pp. 161–162, 1916.

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