

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT
ON A PORTION OF THE
WEST KOOTANIE DISTRICT,
BRITISH COLUMBIA,
1889,

BY

GEORGE M. DAWSON, D.S., F.G.S.

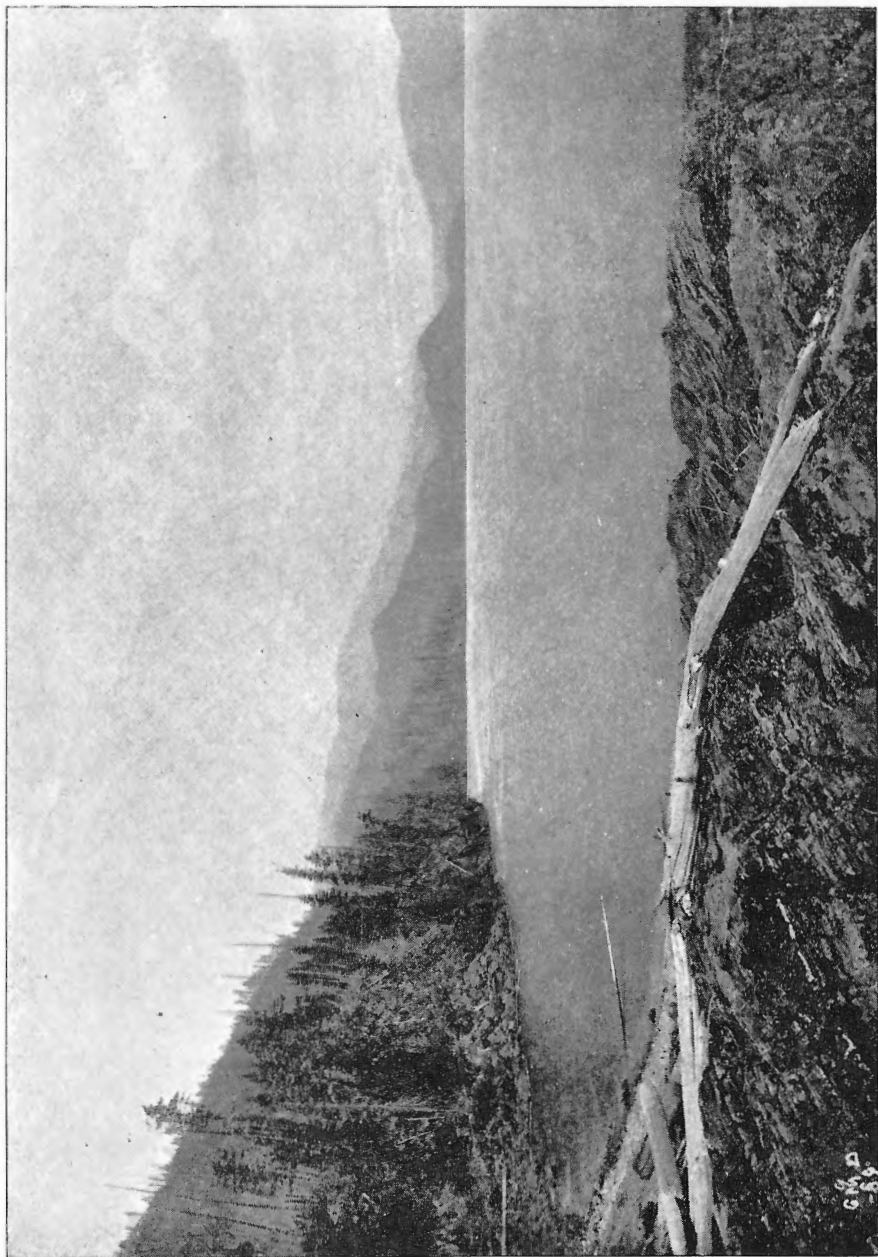


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G. M. DAWSON, PHOTO., JUNE 22, 1889.

HOT SPRINGS, KOOTANIE LAKE, FROM THE SOUTH.
Showing mica-schists of Shuswap series in the foreground.

"THE DOMINION ILLUSTRATED," ENG. & PR., MONTREAL.

TO ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to present herewith a report of a geological reconnaissance in the southern part of the West Kootanie District, British Columbia. The field-work, of which this report gives the main results, occupied about a month in the early part of the summer of 1889.

I have the honour to be,

Sir,

Your obedient servant,

GEORGE M. DAWSON.

OTTAWA, March 18, 1890.

NOTE.—The bearings given in the first part of this report refer to the true meridian, unless otherwise specially noted. In the detailed description of mining regions forming the concluding part of the report (p. 45'B *et seq.*) the bearings refer to the magnetic meridian. See foot-note, p. 46 B.

REPORT
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INTRODUCTORY.

Within the past three years, numerous discoveries of valuable ores ^{Discoveries in West Kootanie.} have occurred in the West Kootanie district,* and this district appears likely to be the first in which metalliferous mining on an extensive scale will be initiated in the province of British Columbia. As nothing was known of the geological structure of the southern part of the West Kootanie district, where a number of the more important discoveries of ores have been made, it was considered desirable that the writer should undertake a geological reconnaissance of that part of the district, with the special purpose of ascertaining the character and mode of occurrence and association of the ore-deposits, and of estimating their prospective importance. The present report embodies the results obtained with reference to these points. The field-work upon which it ^{Object of present report.} is based, occupied little more than a month, extending from June 10th to July 12th, 1889; and while this time proved to be sufficient for the purpose of visiting the several mining camps, as well as for some general examinations along the routes followed, it did not admit of

*The name here written Kootanie, has been and is rendered in a variety of ways. Without exhausting the subject, the following versions may be quoted:—Arrowsmith's general map of British North America, 1811, *Coo-too-nay*. Arrowsmith's maps of 1850 and 1854, Palliser's official map printed in 1865, and on earlier preliminary maps published in connection with Palliser's expedition, also on the map accompanying Alex. Ross's book on the first settlers on the Columbia River (1849), and many others—*Kootanie*. On the joint maps of the Boundary Commission between British Columbia and the United States, on Trutch's map of B. C., and in recent maps published by the Government of B. C.—*Kootenay*. As applied to a station on the Northern Pacific Railway—*Kootenai*. There is perhaps little to choose between these various renderings, no one of which represents the true pronunciation of the Indian word, but I can see no reason to alter the older spelling, which has been used in former reports of the Geological Survey and is here adopted.

detailed or close work, which, when the district shall have been further developed and rendered more easily accessible throughout, will become necessary.

Area traversed. Starting from the line of the Canadian Pacific Railway at Revelstoke, it was necessary in order to reach the more important localities on and near Kootanie Lake, to follow the Columbia River and Arrow Lakes to the mouth of the Kootanie River, and to travel thence overland to Kootanie Lake. The West Arm, together with the shores of the entire northern half of Kootanie Lake, were also examined. This region thus passed through, though to a certain extent overrun during the placer gold mining excitement about twenty-three years ago, has remained comparatively little known till the late discoveries have drawn the attention of numerous 'prospectors' and mining men to it. Mr. Amos Bowman, in the interest of the Geological Survey, had made a somewhat hurried traverse of the Columbia River and Arrow Lakes, in the autumn of 1884, while leaving his field of work to the west. His sketch of the river and lakes had, however, remained unpublished, and even the principal geographical features of the region are laid down on the published maps in an extremely imperfect and sketchy manner.

Surveys made. Advantage was therefore taken of the journey here reported on, to carry out running surveys along the line of route. The lakes were measured by patent boat-log, while distances on the rivers and trails were estimated, and the whole checked by a number of astronomical observations for latitude and longitude. The work done by the Dominion Lands Branch has been utilized for the country in the vicinity of the railway, while the surveys of the Boundary Commission are employed for a belt along the forty-ninth parallel. Certain parts of Mr. Bowman's traverse have also been adopted, as stated 'on the face of the map, and the through distance from the Columbia to Kootanie Lake depends on a line surveyed some years ago for railway purposes by the 'Ainsworth Co.' With these exceptions, however, the geographical features here published depend on surveys made by myself. No geological description of the district has previously been given.

GENERAL FEATURES.

Mountain systems.

The West Kootanie district as a whole, is rugged and mountainous in character. It comprises the southern portions of the Selkirk and Columbia or Gold ranges, but these mountain systems are not here so definite or regular in trend as to admit of precise separation. As a matter of convenience the mountains to the west of the Arrow Lakes may be described as belonging to the Columbia or Gold Range,* those

* Here used in a limited sense. The name Gold Ranges is often applied as a general one to the second great mountain system of the Cordillera, counting from the east.

between the Arrow Lakes and Kootanie Lake may be referred to as representing the Selkirk Range proper, while those to the east of Kootanie Lake are regarded as forming the Purcell division of the Selkirk system.

The general trend of the constituent mountain-ridges or subordinate ranges is here, as usual, about north-north-west by south-south-east; but few of these are so continuous or so straight as are most of the minor ranges composing the Rocky Mountains proper in their corresponding part. In the Rocky Mountains this regularity depends largely upon the lines of outcrop of the great thickness of well bedded Palæozoic rocks of which they are composed, while in the southern part of the West Kootanie district, great areas consist of massive granitic rocks, which do not, as a rule, give rise to parallel ranges of mountains. Thus, when viewed from a considerable elevation, the appearance of this region is that of a rough, irregular mountainous country, in which the highest points are grouped toward the centres of blocks of mountains which are circumscribed and divided from each other by the valleys of the larger streams and lakes. Wherever straight, escarpment-like mountain-ridges appear, there is reason to suspect the existence of the stratified rocks which overlies the granites, and which are elsewhere described in this report. The height of a great number of the higher summits, reaches or exceeds 8000 feet, while some probably attain an altitude of 9000 feet or more. Considerable fields of snow remain throughout the summer on some of the mountains over 8000 feet in height. While the general altitude of the timber-line may be stated as about 7000 feet, the woods are always open and park-like above 5000 feet, and rocky or exposed slopes above this level, as well as many broad mountain tops, are almost entirely destitute of trees. Elsewhere the country is generally wooded, and in the lower and more sheltered valleys much good timber is to be found. Of timber suitable for mining purposes, an ample supply may be obtained almost anywhere.

The most remarkable physical feature of the district is found in the two long and deep valleys which traverse it with north-and-south bearings, one of which is occupied by the Columbia River and Arrow Lakes, the other by Kootanie Lake. These valleys do not strictly conform to the general trend of the mountain systems, and while some portions of them are due to excavation occurring along the line of outcrop of certain parts of the stratified rock series (as subsequently noted), their origin as a whole is a question of considerable difficulty. These two main longitudinal valleys are connected by the equally remarkable transverse valley which holds the West Arm of Kootanie Lake, together with the short length of the Kootanie River, by which the lake discharges into the Columbia.

Drainage
system.

A glance at a general map of the south-eastern part of British Columbia, will show that the whole drainage system there, tributary sooner or later to the Columbia, is of an extraordinary character. The Columbia itself, rising between the Rocky and Selkirk mountains, in latitude $50^{\circ} 12'$, flows northward to the Great Bend, and then, turning sharply round, flows nearly due south to the point at which it crosses the forty-ninth parallel. The Kootanie, on the other hand, rising in the heart of the Rocky Mountains, in lat. $51^{\circ} 15'$, flows southwardly, passing within a couple of miles of the lake in which the Columbia heads, and subsequently turning to a north-westward direction, empties into Kootanie Lake, from which it issues to the west, and after a short further course joins the Columbia at Sproat's Landing. It is probable that at different times during the Tertiary period streams have flowed along, and helped to erode these great valleys, draining in different directions, in accordance with the relative elevation and depression of various parts of this and contiguous regions. Till all the circumstances have been fully studied, the present drainage system can, however, only be characterized as perplexing.

Columbia River.

River south of
Revelstoke.

The Columbia River, from Revelstoke, where it is crossed by the Canadian Pacific Railway, runs in a south-south-eastward bearing to the head of the Upper Arrow Lake. The general course of the river is direct, and the distance from the bridge at Revelstoke to the head of the lake in a straight line, twenty-seven miles. Following the sinuosities of the river in detail, the actual distance is nearly thirty miles. The height of the river at Revelstoke above sea-level is, according to the railway levels,* 1437 feet; that of the lake, determined barometrically by the writer within small limits of error, is 1390 feet. The difference, 47 feet, divided by the length of the river, gives a descent of 1.56 feet to the mile; but this is not uniformly distributed, as in addition to local irregularities in strength of current, the lower portion of the river, with a length of about nine miles, is relatively slack. This lower reach of the river was estimated to have an average flow at the rate of about three miles an hour, while the whole upper part averages probably about four miles an hour or rather more, and is characterized by numerous islands and side channels or "sloughs."

Bordering
mountains

The valley is continuously bordered on both sides by parallel ranges of mountains, the summits of which are pretty uniform in height, averaging nearly 6000 feet above the river; and though several streams

* Revised according to the best available information.

join the river in this part of its course, there are no large or important lateral gaps south of those of the Illecillewaet and Eagle Pass. Several of the summits in these bordering ranges, however, considerably exceed the general altitude above given, notably Mount Begbie, situated about nine miles south-east of Revelstoke and six miles back from the river, with a height of 8834 feet above the sea. The higher points of the inner ranges of the Selkirks are not seen from the river valley, in consequence of the height of the bordering range on its east side, which, moreover, is closer to the river and slopes more steeply down to it than the range on the west. The latter spreads out toward the base into rocky ridges and hills. With the exception of Mount Begbie, none of the mountains in sight from the river are remarkably rugged in outline.

The flat bottom of the valley, through which the river winds, has a general width of a mile to a mile and a half. Most of the flat land, for eleven miles below Revelstoke, lies on the east side of the river, but is rather low, and, though wooded, is said to be in great part liable to overflow at high stages of the water. Further down, the flats are alternately on the east and west sides of the valley till within about six miles of the mouth, when both sides of the river become bordered by a certain width of flat land. Altogether, the valley should afford a not inconsiderable area of land susceptible of cultivation when cleared.

Character of valley
Indigenous?
W.S.P.

The valley, as well as the slopes of the mountains generally, is well wooded, and so far but a small proportion of the timber has been destroyed by fire. The trees most abundant are spruce, cedar and cottonwood, with some white pine, hemlock and birch, while alder fringes the borders of the river and the sloughs. The cedar is here the most valuable timber, and many of the trees are of considerable size. In a number of places along the east side of the valley, the tracks of snow-slides are apparent, but these are confined to the higher part of the mountains and do not come down to the flat land of the bottom of the valley.

Upper Arrow Lake.

The Upper Arrow Lake extends nearly due south from the point at which the Columbia enters it, with a length of thirty-six miles and a half and an average width, nearly uniformly maintained, of about two miles. Adding to the above measurement the length of the North-east Arm, which runs off in the direction indicated by its name beyond the mouth of the Columbia, the total length of the lake may be given at about forty-six miles.

The North-east Arm of the lake has a length of about ten miles, with an average width of about a mile. The angle between the Arm

Dimensions.

North-east Arm.

Streams enter-
ing the Arm.

and the Columbia is occupied by steep and rough mountains, which rise abruptly from the shore of the Arm, and toward its head reach heights of 6000 feet or more above the lake. The slopes on the opposite, or south-east side of the Arm, are more gradual, and its lower part is separated by a promontory, of a few hundred feet in height only, from Thumb Bay. Two streams enter at the head of the Arm. One, known as Fish Creek, coming from the north-eastward, and according to report running nearly parallel to the Illecillewaet toward its head. This is said to be comparable to the Illecillewaet in size. The second stream comes from the south-east, and is smaller, but is of importance as being that up which a railway heading for the north end of Kootanie Lake would probably run. Neither the valleys of these streams nor the mountainous country which they drain has been explored, though traversed here and there by prospectors, and it is consequently impossible to do more than indicate on the map their probable courses. Being anxious to reach the principal mining camps without undue delay, I did not go to the very head of the Arm, which is therefore merely sketched on the map as it appeared from the furthest point reached. Some mining claims have been taken up in the mountains to the north of the Arm as well as on Fish Creek, and good looking specimens of argentiferous galena have been brought from these.

Thumb Bay.

Thumb Bay, just alluded to, is an indentation in the east shore of the lake, immediately south of the North-east Arm. The country about it is rather low and may afford some fair timber and possibly even some arable land. A projection corresponding to this bay occurs on the opposite side of the lake, and is known as Bannock Point.

Character of
main lake.

With the exception of these irregularities in outline about its north end, the lake as a whole is so direct in its course and so uniform in character as scarcely to require any detailed description. For about twenty-two miles from its upper end, the view to the westward is bounded by a rather massive range of mountains, the summits of which are shattered and rugged and carry some snow throughout the summer. The highest points are from five to eight miles distant from the lake and reach elevations of about 8000 feet. The intervening country is occupied by wooded mountains and ridges of lesser altitude quite down to the lake shore.

Entering
streams.

At about twenty-two miles from the head of the lake, on the west side, Fosthall Creek comes in, and is probably the most important feeder from that direction. It rises in the southern termination of the mountain range just described, to the south of which, for some miles, no high mountains are in sight from the lake, but a hilly country, gradually rising to the west, extends to the valley of Mosquito Creek or possibly further. To the south of this, and opposite the south end

of the lake, is another rather conspicuous and isolated group of mountains, of which Saddle Mountain is the culminating point.

The east side of the lake is in general rather closely bordered by mountains, which do not show any striking peculiarities, and if at a greater distance inland they rise to peaks like some of those of the opposite side, these were concealed by the lower ranges fronting on the lake. One considerable brook enters the lake on the south side of Thumb Bay, and at six miles from the lower end of the lake a small river named the Koos-ka-nax flows in. This name, meaning 'long point,' is descriptive of the delta-flat which has been formed by the stream. The flat, in the form of a low terrace, has considerable dimensions between the shore and the bases of the mountains. It appears to bear some fairly good timber, and though the soil where seen, was rather sandy, may afford room eventually for a few farms. Another stream of comparatively small size, flowing in a mile and a half south of the last, is known as the Na-kusp. It comes from a low and rather wide valley which is reported to be used by the Indians as a pass to Slocan Lake.

Streams on
East side.

The southern end of the Upper Arrow Lake is narrowed in toward its outlet by the actual encroachment of the bordering mountains on the hollow which it occupies, and not merely by the accumulation of detrital materials. The homogeneous structural valley occupied by the lake to the north, here appears to become subdivided and is continued or replaced by several less regular and relatively unimportant valleys, of which that of the Na-kusp is one. These run off among mountains of some height, and, at no great distance from the end of the lake, must begin to drain toward Slocan Lake; the discharge of the Upper Arrow Lake taking place to the westward, at right angles to the general trend of the lake.

Southern end
of lake.

The beaches along the Upper Arrow Lake are in general narrow and rocky, and its shores are frequently for some miles continuously formed of solid rock. Some fine sandy and gravelly beaches are, however, to be found, and one need seldom be at a loss for a convenient and attractive camping place. The depth of the lake is evidently great, but the time at my disposal did not warrant much enquiry on this point. Of two soundings made at selected localities, one, twelve miles from the lower end of the lake and rather over half a mile off the east shore, showed 490 feet; in the other, one mile south of Thumb Bay and half a mile distant from the same shore, no bottom was found at 720 feet. At the north end of the lake a rather extensive shoal has been formed at the mouth of the Columbia River. The dimensions of this shoal are indicated by the presence of numerous snags, consisting of trees which have been under-

Character of
shores and
depth.

mined by the river and brought down it in times of flood, but which, owing to the quantity of rocky matter attached to their roots, have become anchored on this submerged delta. This shoal reaches nearly across the mouth of the North-east Arm, and will doubtless in the course of time separate this Arm from the main lake. Another shoal area, also marked by snags, occupies the narrow funnel-shaped southern end of the lake where the river flows out, extending for perhaps half a mile.

Seasonal rise
and fall.

The season of high water in the lake, depending upon the rise of the Columbia, is that in which the melting of the snows upon the more lofty mountains is proceeding most rapidly, which occurs generally in the early summer. Owing to the relatively inconsiderable snow-fall of the preceding winter, the high-water of 1889 was not as well marked as usual. In June the water stood six feet below a distinct high-water mark which had frequently been attained in previous years, while persons familiar with the lake stated that the winter low-water stage was at least twelve feet below the same datum. The ordinary seasonal rise and fall may therefore be stated as about twelve feet.

Hot spring.

Eleven miles from the head of the Upper Arrow Lake, on the east side, is a somewhat remarkable hot spring. It is situated about a third of a mile back from the lake, on a rather steep wooded mountain-slope and at a height of about 400 feet, but may readily be found in coasting the lake by means of a conspicuous vertical cliff which forms the shore of the lake just a mile to the north of it. The water flows from two principal sources within a few yards of each other, and there are said to be several other smaller springs in the vicinity, which were not seen. The water from the two sources just mentioned forms a small brook, which runs down the mountain side to the lake. I had no means of accurately ascertaining the volume of the discharge, but estimated it to be about 300 gallons a minute. One of the springs issues among partly cemented, stony drift material, the other from a crevice in the solid rock. The temperature of both, carefully taken on June 13th, proved to be 123.5° F. The water emits a rather strong smell of sulphuretted hydrogen, and a scanty deposit, apparently siliceous, occurs on stones over which it flows. The taste is not disagreeable, and the quantity of saline matter held in solution is evidently small. In the stream of hot water flowing from these springs a copious growth of green, yellow, red and white confervoid matter is found.

Orifice of
spring.

Little solid rock is seen near the springs, but that forming the orifice of one of them is a fine-grained grey gneissic material containing a good deal of black mica. This, at the lips of the orifice, has been decomposed by the long continued action of the hot water to a depth of half an inch or rather more, the rock being bleached and its felspar completely

kaolinized. The rocks seen on the shore of the lake opposite the spring, are all much shattered and jointed, and it is probably in consequence of this shattering of the rocks that the springs have found issue at this place.

The Connecting River.

The river connecting the Upper and Lower Arrow Lakes is eighteen miles in length. As already noted, it turns, immediately on leaving the upper lake, to a westerly direction, crossing the axis of a high and well marked range of granitic mountains. After flowing in this direction for about nine miles, it meets another wide valley parallel to that of the upper lake. It then bends at a right angle to the southward, and follows this valley for the second half of its length, turning again to the westward for a distance of about two miles to join the head of the lower lake. The wide valley just referred to, is, to the north, occupied by Mosquito Creek, a tributary stream of some size which is reported to rise in a couple of lakes, though its upper part is not known. In a southward direction from the connecting river, the same valley is continued in a direct line, for some miles, by that of Trout Creek, but at no great distance splits up into several smaller and narrower valleys, which run out among the high ridges and crests of the Valhalla Mountains. The valley of the river between the Upper and Lower Arrow lakes, is rather more than a mile in width throughout, with flat bottom-lands or low terraces, twenty feet or more in height, between the banks of the river and the mountains on both sides. Its width is not notably increased where it corresponds with a portion of the longitudinal valley just described. The river touches a point of solid rock at one place only, two miles from its mouth, and evidently represents an old deep hollow now filled with glacial drift or other still later deposits. The flat land bordering the river, with that running up the Mosquito Creek valley, should afford in all a not inconsiderable area susceptible of agricultural occupation.

Character of valley.

Indicated


The connecting river itself is, generally speaking, a wide, tranquil stream, easily navigable by steamers. There are, however, two little rapids, one of which, eight miles from the upper lake, appears only at low water. The second, two miles from the lower lake, is swifter, and the channel is said to be somewhat crooked at low water.

The river

Lower Arrow Lake

The Lower Arrow Lake has nearly the shape of a bow, lightly bent and with the convex side to the west, the two ends lying almost exactly in a north-and-south line. The lake is fifty-one miles in length, and

Form and dimensions.

Lake-shores
and surround-
ing country.

much narrower than the upper lake, averaging about a mile in width, seldom exceeding a mile and a half, and tapering gradually toward both ends. The head of the lake lies between high and rugged mountains, and no wide stretches of low land border it anywhere, but the mountains about it generally are considerably lower than those seen from the upper lake and along the connecting river. They are also more rounded and flowing in outline, though often rough and rocky in the details of their slopes. The mountains, however, again become higher and rise more steeply from the lake toward its southern end. The entering streams have very often formed low, sandy, delta-points, and here and there narrow flat borders or lower hills appear capable of affording some farming land if cleared. Bluff, rocky shores are, however, frequent along this as well as the upper lake. The shores of the lake, together with the surrounding country and mountains, are almost everywhere wooded where not too steep and rocky to afford a foothold for trees, but the forest is generally more open in character than that met with in the vicinity of Revelstoke. Fine groves of cottonwood occupy some parts of the shores and low sandy points along the lake, but as a rule, the timber seen was not of very great size or of superior quality. Where the lake turns eastward near its southern end, its northern banks show a good deal of open grassy country. The most attractive and park-like portion of this country is commonly named the 'Deer Park,' and is frequented by great numbers of deer, when in winter their higher pastures in the mountains become covered with snow. At the 'Painted Rocks,' a few miles below Deer Park and on the same side, there is a considerable number of Indian pictographs, roughly done in red paint on precipitous or overhanging surfaces.

Entering
streams

No large streams enter the Lower Arrow Lake from the east side, which was that more particularly examined by me, and it is evident that the country in that direction, must, at no great distance from the lake, drain toward the Slocan or to Pass Creek. On the opposite side, however, are several streams, some of which might be called small rivers, and occupy notable valleys. Of these, Whatshan River, ten miles and a half from the north end of the lake, drains, by one of its branches, a lake reported to be eighteen miles in length. Eight miles further south is Sanderson Creek, the valley of which is said to contain some good land. Either this stream or a western branch of the Whatshan heads close to the upper part of the Kettle River, and as the country between the Lower Arrow Lake and the Kettle River is not roughly mountainous, their valleys might afford good routes toward Cherry Creek. The upper part of Mosquito Creek seems also worthy of

Low valleys to
west.

examination in this connection. South of Sanderson Creek, three or four streams of minor importance fall in, after which comes Bowman Creek, with a considerable valley which appears to lead westward toward Kettle River. South of this, Dog Creek and two or three other insignificant streams complete the list.

The depth of the Lower Arrow Lake, though considerable, is evidently not so great as that of the upper lake, the deepest water found in three soundings at selected localities being 460 feet. This was obtained midway up the lake and near the middle between its shores. At twelve miles from the head, and again in the centre of the lake, the depth was 125 feet only. At ten miles from the lower end and nearer to the north (which is here the steeper) shore, the depth was 170 feet.

The barometer readings taken on the Arrow Lakes, checked by station-readings at Kamloops and Spokane Falls (the latter obtained through the kindness of General Greely, United States Chief Signal Officer), though sufficient to give a good approximate value for the general elevation of the lakes, were not sufficiently numerous nor exact to determine accurately the difference of level between the two lakes. The observations taken on both lakes have, therefore, been combined in a common mean, and a difference of ten feet allowed as between the upper and lower lakes. This is probably very near the fact, the level for the lower lake thus arrived at being 1380 feet. The seasonal fluctuations of the lower lake are much greater than those of the upper, and evidence was found of a rise of twelve to fourteen feet above the actual level in June last. In consequence of the narrowness of the ends of this lake, its smaller sectional area as compared to the upper lake, and the considerable volume of water passing through it, a distinctly perceptible current exists in several places round the ends of the more prominent points.

From the southern end of the Lower Arrow Lake, the Columbia flows due east ten miles, in an almost perfectly direct course, to Sproat's Landing, where it turns to the south, and in less than a mile is joined by the Kootanie River. This part of the valley is somewhat narrow, and is uniformly bordered on both sides by rather steep mountains of moderate height and rounded form. The current of the river to Sproat's Landing is also nearly uniform, its rate being probably about four miles an hour. Just below Sproat's Landing, between that place and the mouth of the Kootanie, is a pretty strong rapid, which is said to have a crooked channel, somewhat difficult of ascent by steamers at low water. The elevation of the Columbia River at Sproat's Landing is approximately 1375 feet. The water of the river where it issues from the lower lake, though much clearer than where

it enters the head of the upper lake, does not even then exhibit the blue transparent lucidity of the Kootanie.*

Below Sproat's Landing the river was not examined by me, but according to Mr. Bowman's traverse (which is employed for this portion of the map and has been previously referred to), after making one large and wide bend to the westward, it returns in an easterly direction and crosses the forty-ninth parallel into Washington, nearly due south of the Landing. The distance by river from Sproat's Landing to the international boundary is about thirty miles. Thence to the Little Dalles is a further distance of about fifteen miles, and the river is continuously navigable by steamers of good power to this point.

General Remarks.

Length of water
route.

In reviewing what has been said of the Columbia River and Arrow Lakes in the preceding pages, it will be found that the total distance by water from Revelstoke to Sproat's Landing, is one hundred and forty-five miles and a half, of which eighty-seven miles and a half is lake and the remaining fifty-eight miles river. Respecting the character of this water-way as a means of communication, I may state that it is likely to prove of much greater importance and utility than I had supposed before examining it. A steamer was put upon it and was used by miners at the time of the Big Bend excitement as long ago as 1866, and again, during the construction of the Canadian Pacific Railway, a second steamer was built, by which men and supplies were taken north. During the past summer it was continuously navigated by two small steamers, running between Revelstoke and Sproat's Landing, named the 'Dispatch' and 'Marion' respectively. Neither of these possess more than very moderate engine power, yet little difficulty has been experienced in ascending any part of the river. These steamers, together with those before alluded to, are stern-wheel boats, which are better suited than any others for the navigation of rivers like that part of the Columbia between Revelstoke and the upper lake.

Steamers.

* It has not been considered necessary to include mention of the various astronomical determinations of position made during this reconnaissance, which have been employed in the construction of the map. Sproat's Landing has been employed as a principal point. My observation spot here was situated a mile above the 'town,' and about 300 yards above Mr. Sproat's house, on the bank of the river. The position depends on the following observations:—

By meridian altitude of sun, Lat. = 49° 19' 46''

By observations on Polaris, " = 49° 19' 54''

Mean Lat. adopted 49° 19' 50''

By chronometer and observations June 9th and July 8th, 1889—Long. 33° 52' 5'' east of observation point at Revelstoke, on bank of river in garden of Government building.

This is, I believe, the second year during which the 'Dispatch' has been on the route, and her captain, Mr. Robert Sanderson, is very familiar with the lakes and adjacent country. In travelling from Revelstoke to the Landing I employed an ordinary row-boat, this being more suitable for the purposes of examination and survey; but on returning took passage on the steamer, and obtained a number of useful notes from Mr. Sanderson.

The river from Revelstoke to the head of the upper lake is generally run down by the 'Dispatch' in two hours and a half. Several places on this length of river are generally found pretty shoal in the first trips made in early spring, when the water is lowest; and there are also a number of places where the removal of snags and 'sweepers' would be an advantage, particularly at low water, when it is necessary to follow the deepest channel throughout. The shoal already referred to as existing at the mouth of this part of the river, is sometimes troublesome after a sudden fall in the level of the water. At such times Mr. Sanderson has occasionally found no channel deeper than twenty-two inches across it, but in the course of a few days a channel always scours out to a depth of about five feet. The river connecting the two lakes affords a channel of not less than three feet throughout, even at the lowest observed stages of water, but there are several bars across which at such stages it is necessary to select a course with care. In the river between the lower lake and the Landing there is always an ample depth of water, and though some bouldery reefs appear at low stages, there is sufficient room to pass these in the channel. It would thus appear that a steamer for this route should be a stern-wheeler with good power, built to draw not more than four feet, and not loaded down over three feet when the water is low.

Character of
navigation.

No statistics are available respecting the total annual precepitation of rain and snow at Revelstoke, but the appearance and character of the forest and vegetation generally, indicates that it is very considerable. In travelling southward by the river and lakes evidence of the same kind proves a constantly decreasing rainfall and humidity of the atmosphere, and the climate of the southern end of the lower lake with that of Sproat's Landing and its vicinity, may be characterized as rather dry.

The trees forming the forest near Revelstoke have already been noted (p. 9 B). The Douglas fir (*Pseudotsuga Douglasii*) was first observed near the shore about the head of the Upper Arrow Lake, but may occur on the slopes of the mountains near Revelstoke. The western larch (*Larix occidentalis*) was first seen about midway down the upper lake, and thereafter was noted as generally abundant. Juniper (*Juniperus Virginiana*), assuming an arboreal form, is found on

Trees.

rocky beaches on both lakes, but less abundantly toward the head of the upper lake. The yellow pine (*Pinus ponderosa*) appears for the first time near the head of the Lower Arrow Lake, and is increasingly abundant thereafter, becoming the characteristic tree of the southward-facing slopes near the Deer Park. *Syringa* bushes (*Philadelphus Lewisii*) appeared, about half way down the lower lake, growing in quantity on rocky slopes and in full bloom on the 16th of June.

Kootanie River.

The valley.

The lower reach of the Kootanie River, and the West Arm of Kootanie Lake, from which it flows, occupy an important and continuous valley which runs off from that of the Columbia at Sproat's Landing in an east-north-easterly direction. This valley lies almost directly transverse to the main direction of the mountains and to that of the wider valleys occupied by the Arrow lakes and Kootanie Lake. The distance from the mouth of the Kootanie at Sproat's Landing to the main, or north-and-south portion of the Kootanie Lake, by this valley, is thirty-nine miles, the river occupying about twenty miles, while the West Arm of the lake takes up the remaining nineteen miles. The recently laid out town of Nelson, is situated about two miles from the outlet of the West Arm and on the south side of the Arm. It is at present reached by a fairly good pack-trail from Sproat's Landing, the distance between these points by trail being about twenty-one miles.

Sproat's Landing to Slocan River.

On leaving Sproat's Landing, the bank of the Kootanie is reached in about half a mile, and the trail follows the north side of the valley for some distance. The river near its mouth is often bordered by rock on both sides and is very rough and rapid, and the trail for some miles runs along a rocky broken side-hill, but as the valley widens it leaves the immediate bank of the river and traverses terrace-flats, some of which reach a height of about 300 feet above the water. At about eight miles and a half from Sproat's Landing the Slocan River is reached and crossed by a good ferry. A large accumulation of heavy boulders occurs in the valley just below the mouth of the Slocan.

Ward's Ferry.

After leaving the Slocan, the trail runs for rather more than a mile across a level and wide wooded flat, when the Kootanie River is crossed by a second ferry in a wide and slack part of its course. From this point (Ward's Ferry) the trail continues on the south side of the river, at a variable distance from it. The valley retains the same uniform trough-like character, and, as in its lower part, is uniformly bordered by rather steep wooded or rocky mountain-slopes.

Falls and rapids.

Below Ward's Ferry, the river is almost everywhere swift and there are numerous rough, wild rapids, but the lowest fall occurs at about a

mile above Ward's. The river is here divided into two channels, the water on one side falling vertically a distance of about thirty feet, on the other coming down a steep chute with great velocity. These are known as St. Agnes Falls, and they limit the ascent of the salmon on the Kootanie. The falls were formerly a noted salmon-fishing place for the Salish Indians and the limit of these people to the east, the country beyond belonging to the Kootanie tribes. The fall on the north side is a very picturesque and striking feature, its beauty being enhanced by the clear, blue colour of the water. Fine trout may be taken in the basin below it, in almost unlimited quantity at certain seasons. Within a couple of miles above the falls, two other notable falls occur, named the Pillar and Geyser Falls respectively, and between the highest of those and the end of the West Arm the river forms several strong rapids.

Eastern limit
of Salish
Indians.

Between Ward's Ferry and Nelson several streams enter the Kootanie from the Toad Mountain range on the south. These are known as Rover, Forty-nine, Eagle and Sandy creeks, and just before reaching Nelson Cottonwood-Smith Creek is crossed. This is larger than any of those first mentioned, and flows from a deep valley which bounds Toad Mountain on the east and runs through to the head waters of Salmon River. Several small streams enter the Kootanie from the north in this part of its course, the most important, with a valley about nine miles in length, coming in just at the head of the river.*

Tributary
streams.

Whatever may have been the origin of the transverse valley which now serves as the outlet of Kootanie Lake to the Columbia, it is evident, speaking of that portion of it now occupied by the river, that its rocky bed is little if at all below the present level of erosion. This is particularly apparent on the lower part of the river, about the falls, and again near the outflow of the river from the lake, where the banks of the river are frequently formed of solid rock. Had the valley been much deeper than it now is and filled only with drift deposits due to the glacial period, the difference of level between the Columbia and Kootanie Lakes (amounting to 356 feet†) would long since have enabled the river to cut down its bed to such an extent as to drain much of the Kootanie Lake.

Valley not
deeply filled
with drift.

Though entirely unsuited for navigation by reason of its rapids and falls, this part of the Kootanie is capable of affording, at the falls, an almost unlimited amount of water-power for milling or other purposes. The quantity of arable land contained in the valley is inconsiderable,

Water-power.

* By meridian altitude of sun, the latitude of observation point on lake-shore in front of Nelson is $49^{\circ} 29' 54''$.

† According to levelling by C.P.R. Survey, kindly communicated by Mr. H. Abbott.

as even the greater part of the terrace-flats is either sandy or stony. There are, however, some wooded flats with silty soil which will no doubt eventually be cleared and cultivated. There has been in the aggregate a considerable quantity of fair to good timber in this part of the valley, but the greater portion has unfortunately been destroyed by fire.

Vegetation.

For a few miles above the mouth of the river, the north-west bank is open and its vegetation is indicative of a dry climate, like that of the Lower Arrow Lake. Here *Clarkia pulchella*, a plant seldom elsewhere found in British Columbia, was collected. *Balsamorhiza sagittata* was also noted. Further up the valley the rain-fall is evidently greater. The forests consist chiefly of Douglas fir, hemlock, cedar and larch, with occasional specimens of yellow pine and other trees. The western yew (*Taxus brevifolia*) was also occasionally seen in damp spots, as a small tree with trunk a foot in diameter. On the river-flats and terraces in the immediate vicinity of Ward's Ferry, there occurs a greater number of species of coniferous trees than I remember to have seen together elsewhere in the Province. The list includes cedar (*Thuja gigantea*), yellow, black and white pine (*P. ponderosa*, *P. Murrayana* and *P. monticola*), larch (*Larix occidentalis*), Arboreal juniper (*Juniperus Virginiana*), Douglas fir (*Pseudotsuga Douglasii*), hemlock (*Tsuga Mertensiana*) and Engelmann's spruce (*Picea Engelmanni*).

The handsome malvaceous plant, *Sphaeralcea rivularis*, was noted in abundance near Ward's Ferry, though rarely seen elsewhere in British Columbia. As denoting the progress of the season it may be added that the service-berry, flowering-raspberry and large blueberry (*Amalanchier alnifolia*, *Rubus Nuthanus* and *Vaccinium myrtilloides*), were found with ripe fruit on June 20th.

Slocan River.

As already mentioned, the most considerable tributary received by the Kootanie, between the lake and the Columbia, is the Slocan. This stream, where crossed by the ferry near its mouth, is very rapid and strong, with a width of one hundred and eighty feet. From Mr. Archie McDonald, who had been engaged in prospecting on the Slocan, the following notes were obtained. It will be found that the distances as given by him do not correspond with those of the map, as his estimates doubtless include the various sinuosities of the route necessarily followed. An attempt has been made to indicate the portion of the river and lake on the map in relation to the other known features. The length of the river from its mouth to the lake in which it rises, Mr. McDonald estimates at forty miles. At eighteen miles up, a branch comes in from the west, by the valley of which the Indians cross over to Deer Park on Lower Arrow Lake—distance, say, twenty miles.

The greater part of the length of the river is swift, and can be ascended only by poling, but one reach of eight miles occurs, and another of four miles, just below the lake, where the current is quite moderate. Two extensive log-jams exist which necessitate portages. The lake is said to be twenty miles in length, with steep, bluff banks on the west side and flat land on the east, for the first half of its length. On the upper part of the lake, flat land occurs on the west and steep slopes on east. From the head of the lake a pass leads to the lower end of the Upper Arrow Lake, the distance across being stated at about eighteen miles. There is also said to be a pass used by Indians from the vicinity of Slocan Lake to the West Arm of Kootanie Lake. High mountains carrying some snow in summer were seen about the head of Slocan Lake, but no glaciers were observed on them.

The steep and generally uniform slopes of the lower mountains, which border the deep valley of the Kootanie River, prevent any general view of the higher and more distant summits from being obtained; but from one of the eastern points of Toad Mountain a somewhat extensive outlook was gained, though the atmosphere was unfortunately at the time somewhat obscured by smoke. From this point, with an altitude of 6990 feet, it was estimated that the general height of the summits of mountains in view on all bearings except to the south-westward (where the distant view was cut off by other summits of Toad Mountain) was about 6000 feet above sea-level. This height is maintained with considerable uniformity, and at or about it rather extensive rocky or partially wooded plateau-like areas occur in some places. Above this general level, however, higher and rougher peaks rise, usually about the central parts of the blocks of mountainous country which lie between the several larger valleys occupied by rivers and lakes. One of the most important of these culminating ranges, with wild ragged outlines and carrying much snow, was seen on a north-west bearing at a distance of about thirty-five miles. This was evidently the southern aspect of the Valhalla Mountains, previously noted as lying to the east of the head of Lower Arrow Lake, between that lake and the Slocan valley. It is probable that several peaks in these mountains reach a height of 8500 feet. The mountains between the Slocan valley and that of Kootanie Lake, culminate in a second central alpine region of about 8000 feet in height, in addition to which there is another partially isolated group of mountains near the headwaters of Coffee Creek, some points in which may attain a height of 9000 feet. The Ymir Mountains, to the south of the West Arm of Kootanie Lake, after their first abrupt rise from the lake-shore, continue rising gradually in wooded slopes, till, on a bearing about due east from Toad Mountain, they attain heights of about 8000 feet, and

General aspect
of surrounding
country.

form together a considerable area of rather rough, rocky ridges and summits, among which more or less snow remains during the summer.

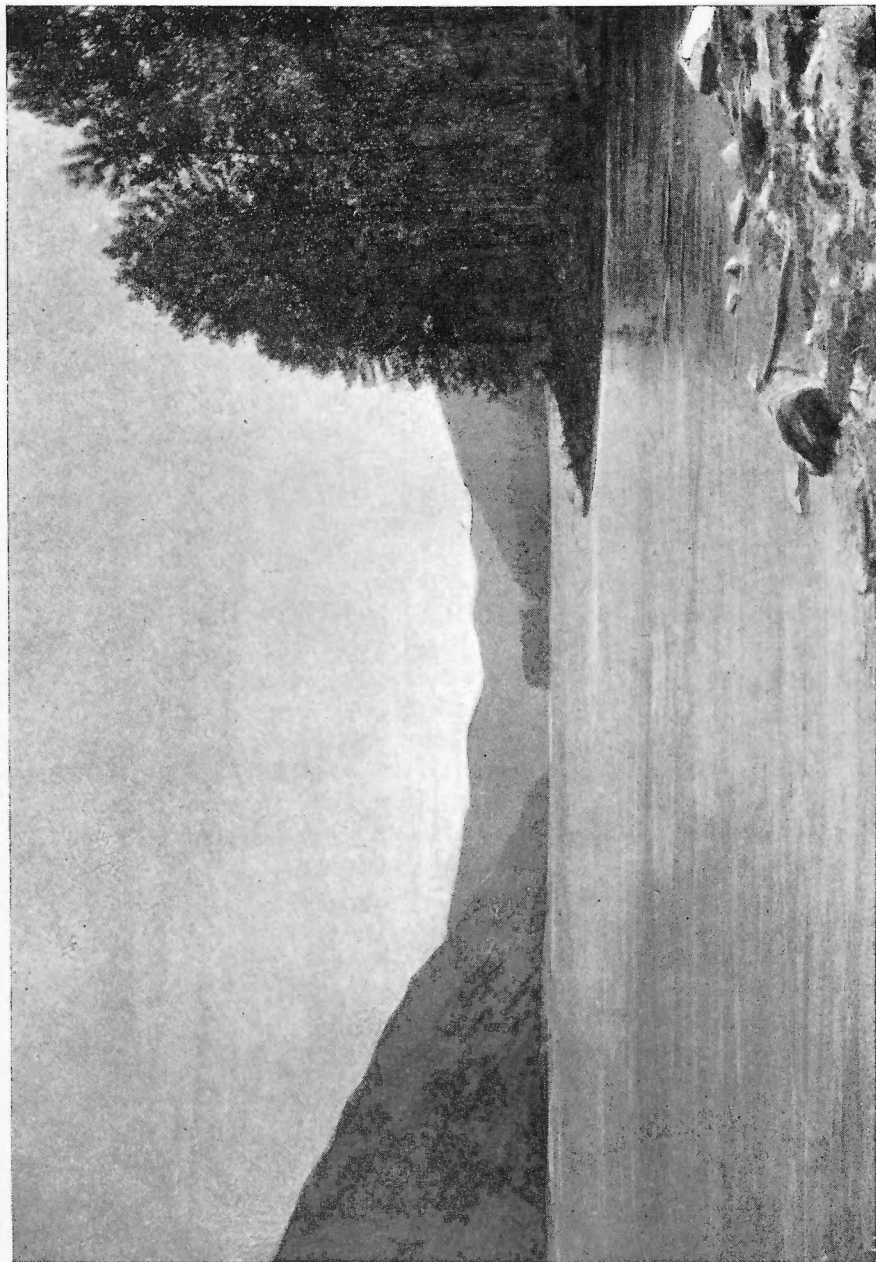
Southward from Toad Mountain, several mountains on different bearings reach heights of about 8000 feet, but there is no conspicuous range of high mountains. Through this mountainous region the deep valley of Salmon River may be seen running nearly due south for many miles. As before mentioned, the head-waters of this river and that of Cottonwood-Smith Creek nearly inosculate to the east of Toad Mountain. The exact height of the watershed in this valley was not ascertained, but it is probably about 1200 feet above the lake, or 2930 feet above sea-level.

Toad Mountain Toad Mountain is a name of very recent origin, dating only from the discovery of the Hall Brothers' silver mine. The mountain so called, forms the eastern end of a high region which lies to the south-east of the Kootanie River, and of which several points surpass 8000 feet in elevation. It is drained on the south by tributaries of the Salmon River, on the north by Cottonwood-Smith Creek and other streams previously mentioned which fall toward the Kootanie. The trail by which the Hall Brothers' and other claims, situated at heights of 5700 to 6300 feet above sea-level on the mountain, are reached from Nelson, follows Cottonwood-Smith Creek and a branch of that stream known as Give-out Creek. A second trail, running westward from this, falls into the Kootanie River trail near Forty-nine Creek. The various mining claims visited on this mountain, together with the character of its rocks, are noted subsequently.

Timber line. The slopes of the mountain are in general densely wooded and some good timber occurs in the valleys. Above 5000 feet the forest becomes more open and of smaller growth, and though trees are still found at a height of about 7500 feet, they are here stunted and this height may be assumed as approximately that of the timber-line. *Pinus albicaulis* is abundant on the higher points of the mountain, where also *Xerophyllum tenax* was observed, with a number of alpine flowers, common to most mountains of the Province.

Kootanie Lake.

West Arm. The West Arm of the Kootanie Lake, from its outlet, extends about nine miles and a half north-eastward, beyond which it turns to an east-north-east direction for a similar distance, when it opens, at Queen's Bay, on the main lake. The average width of the first half of the Arm slightly exceeds half a mile. The second half is somewhat wider, but more irregular in width. A number of small streams enter the Arm on both sides. All these streams have formed sandy delta-flats of



G. M. DAWSON, PHOTO., JULY 2, 1882.

WEST ARM OF KOOTANIE LAKE, FROM NELSON.
Granitic mountain to the left.

"THE DOMINION ILLUSTRATED," ENG. & PR., MONTREAL.

greater or less size at their mouths. In this way the area of the waterway is diminished to such an extent as in some places to produce rather strong river-like currents. The Arm is evidently nowhere very deep, but even in the various narrows affords at all stages of water a sufficient depth for any steamers likely to be employed upon the lake.

The valley occupied by this arm of the lake is identical in character with that of the Kootanie River below, but is here flooded. In the first half of its length, its width between the slopes of the opposite mountains is less than a mile, but it becomes wider on approaching the main lake. The bordering mountains rise with steep slopes in the first instance to heights of 1500 to 3000 feet above the lake, beyond which the slopes generally become more gradual and much higher points are seen up some of the valleys of the entering streams. Along the eastern half of the Arm, there appears to be some arable land, though the soil is usually sandy. Certain areas here and there might also be reclaimed by dyking swampy land. Much of the timber, which in places is of very fair quality, has already been destroyed by fire.

Valley of the
West Arm.

The immediate cause of the flooding of the valley now occupied by the West Arm, is the blocking of the valley at the western extremity of the Arm, by a mass of rough bouldery wash which has been brought down by the large stream previously alluded to as entering from the north at that point. This causes a little rapid, which is the beginning of the lower part of the Kootanie River, and has a width of from 300 to 400 feet, according to the height of the water. Its south border is formed by rocky bluffs, against which the wash from the stream just mentioned has been projected. It has been proposed to lower the general level of the Kootanie Lake by removing the obstruction here described, and this is no doubt possible. Should, however, such reduction exceed a few feet in amount, several of the narrows in the West Arm would be converted into shallow rapids, thus rendering the Arm unfit for navigation; while to achieve any important lowering of the level of the lake, each of these obstructions would in turn have to be removed. The remarks made on a previous page, together with the known great depth of the Kootanie Lake, show that if even the whole of the loose material now found in the valley of the West Arm and Kootanie River were removed it would not result in the draining of Kootanie Lake.

Character of
outlet.

Having thus described the West Arm of Kootanie Lake, a few notes may now be given on the main lake, which occupies one of the longitudinal valleys of the mountain ranges, and is comparable in this respect to the Upper and Lower Arrow lakes, though more important than either of these. Its total length is about sixty-four miles. In form it is nearly simple and straight, lying on a bearing which departs a few degrees to the west of north. Its height above the sea is

The main lake.

approximately 1730 feet, and its average width, which is preserved with considerable uniformity, about two miles. The West Arm joins the lake a little to the south of its centre, the distance from the mouth of this arm to the north end of the lake being thirty-eight miles. This part of the lake is shown upon the accompanying map according to the results of my survey. The southern portion of the lake, which has never been surveyed in detail, is represented in broken lines, according to the Map of the Eastern Part of British Columbia, compiled by direction of the Hon. F. G. Vernon, Chief Commissioner of Lands and Works, 1888. With the exception of the West Arm, the most important interruption to the general outline of the lake is Crawford Bay, which occurs on the east side, opposite the entrance of the arm, and is separated from the main lake by a low hilly point or peninsula.

Hot Springs
camp.

The Hot Springs, or 'Warm Springs,' mining camp, is situated on the west side of the lake, eight miles north of the West Arm. Here, chiefly comprised within a tract about six miles in length, between Coffee and Woodberry creeks, a large number of mining claims have been taken up. These are noticed in detail on a subsequent page. Several stores and houses have been established on the shore of the lake, and a town-site, which has been named 'Ainsworth,' has been laid out. Three miles north-east of Hot Springs, on a small peninsula on the opposite or east side of the lake, is situated the Hendryx mining camp, and elsewhere in the vicinity of the lake isolated mining claims have been recorded.

The distance by water from Nelson, near the extremity of the West Arm, to Hot Springs, is twenty-six miles.

Character of
lake-shores
and surround-
ing country.

The whole northern part of Kootanie Lake, and, so far as could be observed from distant views, the southern part as well, may be described as closely bordered by mountains, which, as a rule, slope up more or less steeply from the lake-shore without any intervening flat land, to heights often of 6000 feet above it. On closer inspection, however, it is observed that the axial lines of the dominant and higher ranges tend to cross the line of the lake obliquely in its northern part, in consequence of their more westerly trend. Many of the mountains are somewhat rugged in outline and show much bare rock, and very abrupt rocky hills and bluffs often front directly on the shores. Cliffs of some height occur in several places along the margin of the lake, the most conspicuous being situated on the east shore about sixteen miles north of Hot Springs. Many fine sandy or gravelly beaches are, however, also found, particularly at the mouths of entering streams. The general aspect of the lake is in fact not unlike that of the Upper Arrow Lake, save that the mountains are here crowded more closely upon the shores. The depth of the lake is evidently very

great, and though no soundings were made by me upon it, statements reported lead to the belief that it considerably exceeds the Upper Arrow Lake in this respect.

The principal feeder of the Kootanie Lake, is of course the river of ^{Kootanie River} the same name, which, after a long southward course between the Rocky Mountains and the Purcell Range, passes between the south end of this range and the Cabinet Mountains in Montana and Idaho, and turning to a northerly direction adopts the continuation of the Kootanie Lake valley, and falls eventually into the south end of the lake. A few miles beyond the north end of the lake, the valley becomes more or less interrupted by hills, and bifurcates, the branch valley to the west bringing in the Lardo* River, that to the east the Duncan River. ^{Lardo and Duncan rivers.} The first-mentioned valley trends toward the head of the North-east Arm of Upper Arrow Lake, and is reported to afford a good pass. The second, so far as known, trends nearly due north, and is more nearly in the line of that of the lake. It holds a second lake, reported to be of considerable size, known as Upper Kootanie Lake, and unwaters the western slopes of the axial range of the Selkirk Mountains. The united streams of the Lardo and Duncan, where they enter Kootanie Lake, form a fair sized river, but not one such as to be navigable for steamers of any kind.

The flat land at the north end of the lake, runs on for about five ^{North end of lake.} miles with about the same width as the lake itself, before the previously described bifurcation of the valley occurs. The border of this land on the lake, consists of wide grassy marshes, on which a considerable quantity of swamp-hay might be cut. Further back, groves of cottonwood and willows occur, and rising above these, at a distance of about a mile or so, coniferous trees appear, and it is probable that beyond this point the land is not subject to flood. The action of the waves in the shallow water at the head of the lake, has produced a rather remarkable ridge or bar of sand which runs almost completely across it, at a short distance out from the edge of the meadows. This, at the date of my visit, was bare, with a channel running continuously behind it.

Fry River, seven miles and a half from the north end of the lake, on ^{Other streams.} its east side, and Caslo River, eighteen miles from the same point on the opposite side, are the only other important affluents in the northern half of the lake. One or both of the streams flowing into Crawford Bay may be of importance, but were not seen. There are, in addition, many smaller streams with short courses among the neighbouring mountains, but these do not require special mention.

* Also written Lardeaux.

Seasonal rise
and fall.

Notwithstanding the considerable area of Kootanie Lake (about 135 square miles), it is subject to great changes in level. In the latter part of June, 1889, the water had fallen a few feet from its highest stage of that year, in which the annual rise had been exceptionally small. Evidences were, however, found of extreme high-water stages, occasionally reached, about fourteen feet above the actual water-level. In consequence doubtless of the great depth of the lake, it seldom freezes over any considerable part of its area, the interruption to navigation from ice upon it being much less than that on the Arrow lakes.

Hot Springs.

The hot springs from which the mining camp previously referred to takes its name, constitute a remarkable feature. They are situated on the immediate shore of the lake and within the town-site of 'Ainsworth.' Unlike the hot springs on Upper Arrow Lake, these give rise to a copious calcareous deposit, which extends for about 300 feet along the edge of the lake, and forms a little terrace with a height at the front of about twenty feet, and sloping gradually up toward the foot of the hill. At the southern end, a lower floor of the deposit, nearly on the level of the lake-shore, presents a number of basin-like pools with well marked rims, into which the water trickles. The principal visible flow occurs on the summit of the little terrace, where there is one main orifice with several surrounding smaller ones. There are as well, however, several outflows along the edge of the water, where the terrace has been cut into a rough low cliff, and there are very probably others also beneath the surface of the water of the lake. It is thus impossible even to guess the volume of water rising from these springs, but that afforded by the principal orifice on the terrace was roughly estimated at about sixty gallons per minute. The temperature of the water on June 25th, was found to be 101.5° F. It has a slightly saline and rather pleasant taste. The calcareous deposit is a porous travertin of a cream colour, which forms more or less parallel or concentric layers.

Vegetation.

The vegetation characterizing the vicinity of Kootanie Lake resembles that of the Lower Arrow Lake and the lower part of the Kootanie River. The yellow pine and larch were found quite to the north end of the lake, and may extend some little distance beyond it. The yew was observed forming a small tree in several places. In the lower valleys, and also probably in many high though sheltered valleys among the mountains, considerable quantities of good timber, particularly cedar and white pine, exist.

Climate.

In regard to the rainfall and general humidity of the atmosphere in the region to which this report relates, it is evident that in conse-

quence of the variety and prominence of its physical features, nothing certain can be affirmed till continuous observations at a number of stations have been made. Meanwhile, the character of the natural vegetation, and especially that of the forest growth, is sufficient to indicate these climatic features in a general way. No part of the region which was traversed seems to possess a humidity equal to that of the vicinity of Revelstoke and the valley of the Illecillewaet. This district of humid atmosphere and great precipitation, as we travel southward, appears to fall back to the eastward, associating itself with the higher ranges of the Selkirk and Purcell mountains, so that a line drawn from the head of Upper Arrow Lake to the north end of Kootanie Lake, and thence in a south-south-easterly direction, would separate the more humid from the drier parts of the region. It is evident, however, that each of the more important and higher mountain masses becomes to some extent a separate centre of precipitation and moisture, while the lower and wider valleys are relatively dry.

Rainfall and
degree of
humidity.

Routes and Means of Access.

The immediate need of a means of transport for the rich ores of the vicinity of Kootanie Lake, may render appropriate a few words on the question of prospective railway routes, as affected by the physical features of the district. The navigation of the lakes and rivers has previously been referred to. (p. 17 B.)

No special difficulties present themselves in the way of a railway line to connect Sproat's Landing on the Columbia with the West Arm of Kootanie Lake. The distance measured along the river-valley, as already stated, is about twenty miles. The greater part of this route may, in fact, be described as easy work, though in the first three or four miles from the mouth of the Kootanie some moderately heavy work along the rocky side-hill would be necessary. The river might also require to be crossed once or twice in order to allow the best line to be followed. As I believe a survey of this line is now actually in progress, it is unnecessary to refer to it in further detail.

Railway routes.

The most advantageous permanent railway connection for the Kootanie Lake country would, however, undoubtedly be one from Revelstoke, on the Canadian Pacific Railway, direct to the lake. Such a line would follow the Columbia valley for twenty-seven miles, the North-East Arm of Upper Arrow Lake for about ten miles, and thence the Lardo River pass for about forty-eight miles to the north end of Kootanie Lake, making a total length of about eighty-five miles. From Revelstoke to the head of the Upper Arrow Lake, such a line would be easily constructed along the continuous flats on the

east side of the river, with the exception of one portion less than two miles in length, where rocky bluffs come out to the river. Thence, following the north-west side of the North-east Arm, no great difficulty would be encountered except in one length of about a mile, where most of the road-bed would require to be cut out along a cliff and one short tunnel would probably be necessary. It is possible, that by taking advantage of the shallow delta of the Columbia, the Arm might be crossed at its mouth, and a better line obtained on its opposite side, but the depth, as well as the width of the deep part of the channel which exists between the delta edge and the south shore is unknown. I am unable to supply any notes on the character of the route from the head of the North-east Arm to Kootanie Lake, but the summit in this pass is reported as not of great height and to be situated near the Arm, while the Lardo valley is described as being favourable. The flat land at the mouth of a small stream two miles from the head of Kootanie Lake, on the west side, would afford a suitable terminal point for such a railway, with bold water and good shelter from southerly winds. Should it be contemplated, at a later date, to extend the line along the shore of the lake to Hot Springs, a good deal of rocky side-hill and numerous bluffs fronting on the lake would have to be passed, the character of the work much resembling that on the east side of the Salmon Arm of Shuswap Lake. A further extension to Nelson would entail rough work of the same character as far as Queen's Bay, beyond which either shore of the West Arm would afford an excellent route.

GENERAL GEOLOGICAL FEATURES OF THE WEST KOOTANIE DISTRICT.

Nature of observations made.

The geological structure of the region covered by the reconnaissance here reported on, is extremely complicated, and the information obtained is not sufficient to admit of a systematic or satisfactory description of the rocks occurring in it. The Gold, Selkirk and Purcell mountains have not yet been studied in detail in any part of their extent, and the formations entering into their composition differ widely, if not in age, at least in lithological character and degree of alteration from those found in the Rocky Mountains proper, on one side, and in the Interior Plateau region of British Columbia on the other. As it is probable that more consecutive and detailed observations on the structure of the ranges above named will shortly be made, including as a first step a section across them on the line of the Canadian Pacific Railway, I shall here refer merely to the more salient features, and in particular to those which have been noted in connection with the occurrence of the ore-deposits. These appear to possess some immediate practical im-

portance in affording clues to the origin and habitus of the ore-deposits, and are thus likely to prove of service in connection with the prospecting and development of the region.

While in the Rocky Mountains proper, in corresponding latitudes, Shuswap series neither granites nor crystalline schists are brought to the surface, in the region here reported on both occur in abundance. The oldest stratified rocks found here, consist of mica-schists and gneisses, the former often coarsely crystalline and frequently garnetiferous, the latter usually characterized, so far as observed, by a preponderance of orthoclase felspar, and generally grey in colour and not very coarse in grain. With these are associated hornblende-schists, hornblende mica-schists and hornblende-gneisses, as well as coarsely crystalline marbles, which are often spangled with mica- and occasionally with graphite-crystals. These marbles, with calcareous gneisses, are particularly abundant toward the observed base of the series, and constitute an important feature of the rocks on Kootanie Lake. The mica-schists and gneisses are also often siliceous, and pass in some places into nearly pure quartzites, which were found in greatest development in the vicinity of the marbles.

From their highly crystalline character, and from analogy with other not far remote sections, such, especially, as those of the Shuswap Lakes, these rocks are regarded as Archæan.

Overlying these rocks, at Hot Springs, is a great thickness of grey and green schists, which are seldom coarsely crystalline. No detailed lithological examination has yet been made of these rocks, but of the green schists a great part is believed to consist of diabase-schist, while felspathic chloritic, hornblende and micaceous schists are included in the series. Some grey quartzite-schists, with micaceous division planes, are also found, with numerous other varieties of rocks intermediate in composition between those above noted. Micaceous schists are particularly abundant in the vicinity of granitic intrusions, and in such cases rocks are occasionally met with, which can not be clearly separated from those of the preceding series. As a rule, however, the general appearance even of the highly altered representatives of this series is somewhat different, and their crystallization is less perfect and finer in grain. While there is reason to believe that this series is unconformable on the last, no distinct evidence of unconformity has been discovered, and it is not known whether this circumstance is due to original pseudo-conformity in deposition, or to the intensity of the forces which have acted in folding the two series, and thus forcing them into an appearance of parallelism.

The rocks just described, are overlain by beds, which consist Series No. 5. largely of massive limestones of grey or blue-grey colour, as a rule, but

locally converted into white, or nearly white, fine-grained marble. These are interbedded to some extent toward the base with grey schistose rocks like those of the last series, and are found to be underlain, at Hot Springs, by a fine-grained conglomerate, which has been rendered schistose by pressure, and shows mica on its division-planes. With the limestones are associated black schistose argillites, with lustrous surfaces, on which more or less mica is often found to have been developed. These argillites constitute an important part of this group, but with respect to the relative volume of the argillites and limestones no certain data were obtained.

Constitution of
Adams Lake
series.

The grey and greenish schistose rocks constituting the second group may, with confidence, be affirmed to be essentially composed of altered volcanic materials, and their present schistose character may probably be regarded as in the main due to the enormous pressure to which they have been subjected during the movements of the earth's crust, which resulted in the uplift of the mountains of the region and the extrusion of the great masses of granite here everywhere found. The original character of the material of the schists might not have been ascertained from the somewhat cursory examination of the district to which this report relates, though transitional stages in the passage of distinctly volcanic products into these schists occur on Toad Mountain, where the direct effect of pressure has been less and the alteration due to the heat of the later granitic masses has been greater. As stated below, however, the same schistose series occurs on Shuswap and Adams lakes; and in the vicinity of the last named lake and in the country between it and the North and South Thompson rivers, the actual passage of the schists, on their line of strike, into massive volcanic materials, chiefly consisting of diabase-agglomerates and amygdaloides has been studied.

Section at Hot
Springs.

The most instructive general section met with, of the stratified rocks of the West Kootanie district, is that afforded by the shores of Kootanie Lake, near and to the north of Hot Springs, taken in conjunction with that on the trail which ascends the mountains behind Hot Springs. Some details of this are referred to in connection with the metalliferous deposits of that locality. It is sufficient to indicate the general order of superposition of the three sets of beds just described and to show that the total thickness of stratified rocks is very great, but owing to local complications the actual volumes of the respective members could not be ascertained, except in the case of the first or lowest. This was found to have an approximate thickness of 5000 feet. Taking as a standard of comparison the section met with and measured in 1888, on the lower part of Adams Lake, and adding to it the above thickness of series 1 on Kootanie Lake, the following outline of the arrangement and

respective thickness of the rocks of this part of the Gold and Selkirk ranges may be given, the order being descending.—

		FEET.	General section
	6. Greenish and grey schists, with many beds of limestone, (generally altered to marble) in the lower part..	2,000	
	5. Limestone or marble, often banded with siliceous layers, and associated with considerable volumes of black glossy argillites and some grey schists.....	2,500	
Adams Lake Series.	4. Chiefly greenish schists, varying considerably in texture, and with some grey-green and grey schists.....	4,050	
	3. Chiefly grey schists, varying in texture like the last, and including some green-grey and greenish schists...	8,650	
Nisconlith Series.	2. Black, shaly or schistose argillites, with much dark-coloured limestone in thin beds, both argillite and limestone often more or less micaceous. Thickness not definitely known, say.....	1,000	
Shuswap Series.	1. Mica-schists, gneisses and marbles, completely crystalline and often highly siliceous.....	5,000	

The following remarks may be made in explanation of the above Explanation of section. general section. No. 6 includes the highest beds seen on Adams Lake, and was not recognized in West Kootanie, where No. 5 is found on the mountain-slopes to the west of Hot Springs forming the highest member of the local section. Nos. 4 and 3 are so similar in general character, and blend so completely in the Adams Lake section, that it is proposed to unite them under the general provisional name of the Adams Lake series. Both grey and green schists referable to this series occur in the Hot Springs section, but the total thickness is there either smaller than on Adams Lake, or is only shown in part. No. 2 is not found in the Hot Springs section, but is believed to be represented by the argillites of the south-east shore of Upper Arrow Lake and elsewhere in West Kootanie. This is provisionally designated as the Nisconlith series, from a locality on the South Thompson. No. 1 is not well shown on Adams Lake, but is found in its vicinity extensively developed about Little Shuswap Lake. As above stated, however, the thickness assigned to this member of the section is derived from observations on Kootanie Lake. No distinct evidence of uncomformity has been found throughout the entire section, but this lowest series may be provisionally referred to the Archæan under the name of the Shuswap series.

The total thickness of beds represented in the general section is Total thickness. very great, aggregating at least 23,200 feet. In 1877 the same rocks were examined by me on Great Shuswap Lake, and the general section

constructed as a result of this examination, corresponds pretty closely with that here given, though the dividing lines between the several component members were not always drawn in precisely the same places. The total thickness met with on the Great Shuswap Lake was estimated at about 32,200 feet.*

Probable age
of rocks.

The stratified rocks of the Gold and Selkirk ranges, above referred to, have not yet been closely studied from a lithological point of view, and no attempt is therefore made in this report to do more than broadly characterize them by their more evident features. Neither is it possible, as yet, to speak with any certainty as to the geological periods to which these rocks should be referred, as no fossils have been obtained from them. It is believed, however, that the whole of these rocks above those of the Shuswap series (No. 1), are in all probability Palaeozoic in age, and analogy with what is known elsewhere in British Columbia, suggests that they may eventually be referred to various systems, including the Carboniferous and extending downward to the Lower Cambrian.

Granites.

A large part of the West Kootanie district is occupied by granites and granitoid rocks, the main area of which (so far as observed) includes the whole basin of the Lower Arrow Lake, and extends thence eastward nearly to Queen's Bay on Kootanie Lake. Besides this great granitic area, there are several others of smaller dimensions, as indicated on the map, as well as numerous dykes and eruptions too small to be separately shown. It is in fact probable, that about one-half of the entire region here reported upon is occupied by granites and granitoid rocks. The granites differ considerably in appearance and composition, and appear to be referable to at least two and probably to three distinct periods, though it is as yet impossible to define the respective areas of these. The granites which are supposed to be of the greatest age, were found in some places underlying the lowest beds of the gneissic and mica-schist or Shuswap series. They appear to be closely attached to this stratified series, if not connected with it in origin; and in texture and composition, as seen in hand specimens, can often scarcely be distinguished from some of its homogeneous gneisses. They are generally rather fine-grained, and are believed to consist for the most part of muscovite-biotite-granite, though much further investigation would be required before it can be asserted that this is their characteristic composition.†

Oldest granites.

* Report of Progress Geol. Surv. Can. 1877-78, p. 96 B.

† Thin sections of these, and of some other rocks here mentioned, have been subjected to a preliminary microscopic examination by Dr. A. C. Lawson, with the object of ascertaining by what names they may be appropriately designated.

Granites of this character form an extensive area south of Thumb Bay on Upper Arrow Lake, and were again seen on the north side of Queen's Bay in small exposures in contact with gneiss.

The granites which, however, occupy by far the largest area, are of ^{Hornblende-}granites. coarser texture, generally grey, passing to black in colour, and are characterized by black mica, with frequently much black hornblende. They may be described, as a whole, as hornblende-granites, but occasionally pass into mica-syenite. In some localities they are not infrequently coarsely porphyritic with large twinned orthoclase felspar crystals, while sphene is often present as an accessory mineral.

These granites are evidently intrusive and of later date than the stratified rocks, which are altered by them at contacts. They appear to have a rather intimate connection with the occurrence of metalliferous deposits in adjacent areas of the stratified rocks, and the conditions which have resulted in the formation of the metalliferous veins probably occurred for the most part at the time of their intrusion.

Granites of the third and most recent class are largely displayed along the east shore of the lower part of Lower Arrow Lake, where ^{Red granites.} they continuously characterize a considerable area, but are also found in spurs and dykes cutting through the coarse grey granites. They are pink or reddish in colour and consist largely of orthoclase felspar, with black mica and hornblende. The proportion of quartz contained varies widely, as does also the coarseness of texture, in the various specimens.

With the foregoing description of the general geological character of the district as a basis, a few words may now be added on the relations ^{Occurrence of ore-deposits.} of the ore-deposits to the various rocks. Some further details bearing on the same important question will be found in the sequel, in connection with the descriptions of Toad Mountain, Hot Springs and Hendryx. With the exception of the "Poorman" mine and other adjacent claims on Eagle Creek, near the west end of Toad Mountain, all the metalliferous deposits so far found occur in the stratified rocks. These exceptional veins traverse a hard dark-grey mica-syenite, and differ in character from the other ores, consisting of auriferous iron-pyrites in a quartz gangue. They are of particular interest in showing that the granitoid as well as the stratified rocks of the district may merit the attention of the prospector.

The ore-deposits found in the lowest stratified deposits, or gneissic ^{Ore-deposits at Hot Springs.} and mica-schist rocks included in the Shuswap series (No. 1), so far as yet determined, consist principally of galena, with some blende, pyrites and other accessory minerals, and are rather low-grade ores in respect to silver. These deposits include those of Hendryx, and the lower tier of veins at Hot Springs, extending from the shores of the lake back to

the line of the "Spokane" claim. All the richer argentiferous ores of Hot Springs are included in the zones characterized by the green and grey schists, and that of limestones and argillite schists, embraced in series Nos. 3, 4 and 5. This difference in richness in the veins is, I believe, to be attributed to the influence of the country-rock upon them; though possibly also in part due to the greater proximity of the veins in the higher rocks, to the edge of a granite mass which is found near the summits of the mountains behind Hot Springs. While, therefore, the north-western extension of the limestones and black schists from the Hot Springs localities, constitutes the most promising region for further prospecting in that vicinity, it is not probable that all parts of the outcrop of these and of the underlying green and greyschist series will prove equally rich in metalliferous deposits, but rather that such places will be found localized here and there upon this belt of rocks, where other conditions necessary to the formation of veins have coöperated.

Ore-deposits at
Toad Mountain

The area of stratified rocks in which nearly all the metalliferous deposits of Toad Mountain have been found, appears to be surrounded on all sides by granite. The rocks represented are believed to be those of the Adams Lake series, (Nos. 3 and 4,) but they are here seldom so schistose in character as at Adams Lake and Hot Springs, and frequently occur as little-altered diabases or diabase-porphyrates, while in immediate contact with the granite they are occasionally converted into pyroxenites, containing more or less hornblende and mica. In some places the amygdoidal structure which has originally characterized some of the diabases is still clearly apparent. The alteration of the stratified rocks of this vicinity appears, in fact, to be due chiefly to the heat of the adjacent granitic rocks at the time of the extrusion of these, and they have been subjected to less alteration by pressure. Concurrently with this difference, it is found that the contained ores also differ in character from those afforded by the veins traversing the rocks of the same age at Hot Springs. At Toad Mountain, copper ores are more, and galena is less abundant, while the percentage of silver is frequently very high.

The somewhat peculiar auriferous deposit of the Cottonwood mine, on the east end of Toad Mountain, is separately described in the sequel.

Metalliferous
diabase series.

In the Summary Report of the operations of the Geological Survey for 1888, the following remarks were made in connection with the description of the metalliferous deposits of the vicinity of Stump Lake, south of Kamloops:—"The country-rock consists of altered volcanic materials, probably of Palæozoic age, and may be generally characterized as a diabase-porphyrite, the most characteristic material in this place being a rock of green and green-grey colour with coarse porphyritic crystals of plagioclase and pyroxene. * * * The occurrence

of these ores in the green, altered volcanic rocks, which, under slightly varying forms, occupy so large an area of the southern interior of British Columbia, is a feature of peculiar interest, inasmuch as it leads to the belief that these wide-spread rocks become a metalliferous series when the other conditions are favourable. What these precise conditions are, beyond the existence of fissures in which the segregation of metallic minerals has occurred, we are yet unprepared to say. Massive granite rocks occur a few miles to the west of the mineral belt of Stump Lake, and while a similar rock may underlie the surface at no great depth in the mineral belt, there is nothing to indicate that the ores partake of the nature of contact deposits."

Series 3 and 4 of the West Kootanie section, as previously explained, evidently represent rocks originally of volcanic origin, very similar to, if not actually of the same age with, those of the vicinity of Stump Lake. Like them they are referable to the great, green predominantly-diabase portion of the Palæozoic strata of British Columbia, and the fact now ascertained, that these rocks are also among those which hold rich ores in West Kootanie, adds further confirmation of their economic importance. The resemblance is closer as between the rocks of Toad Mountain and those of Stump Lake, under similar conditions of metamorphism, than between the Stump Lake rocks (which are seldom schistose) and those of Hot Springs. On Toad Mountain, some diabase-porphyrates practically identical in character with those of Stump Lake occur.

Ore-bearing
rocks of Stump
Lake and
Kootanie.

A few notes on the distribution of the various rocks spoken of in the foregoing pages, so far as this was investigated on the route followed, may here be added.

The rocks seen in a few places in descending that part of the Columbia between Revelstoke and the Upper Arrow Lake, are chiefly light-coloured mica-schists and gneisses, which are generally highly quartzose. No massive granitic rocks were seen, and the appearance of the mountains on both sides of the valley favoured the belief that they also were composed of similar strata. As rocks of the same kind appear along the line of railway at least as far east as Albert Cañon Station, and as the general strike of the rocks met with along the river crosses the line of the Columbia valley obliquely, with north-west by south-east bearings, it is probable that these rocks spread over a rather wide area on both sides of the river in this part of its length. The dips observed on the river are generally northerly, but some are in the opposite direction. All these rocks are referable to the Shuswap series or No. 1. of the general section.

Rocks along
river below
Revelstoke.

In Sproat Mountain, in the angle between the river and north end of the lake, similar rocks occur with northerly dips and form a bold

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Rocks on
North-east
Arm.

southward-facing escarpment. The strike runs nearly due east, parallel to the direction of the lower part of the North-east Arm, but at about four miles up the Arm, on the north shore, darker and finer grained calcareous mica-schists appear. These were also seen on the opposite side of the Arm at this place, and though the Arm was not followed to its head, it is probable that it has been principally excavated along the strike of these softer rocks, which are supposed to represent the Nisconlith series (No. 2) in a rather highly altered state. Some of the mountains on the north side of the Arm, show evidence of a compressed anticlinal, overthrown in a southward direction, and it is quite possible that the crest of this anticlinal is coincident with a line of reversed fault, such as those which have been described by Mr. McConnell in the Bow Pass.*

Veins containing argentiferous galena have been found in the mountains on the north side of the Arm, but these were not visited.

Thumb Bay to
Creek to Half-way
Creek.

The south side of the lower part of the Arm is composed of the fine grained granites, of what is supposed to be the oldest series. This rock also forms both sides of Thumb Bay, and extends along the east shore of the lake to a point seven miles south from the mouth of the river. At this point, to the south of the granite, rocks of the same character with those seen on the river recur, and continue along the east shore of the lake to a point about five miles south of Half-way Creek. They consist as before of fine grained gneisses, with mica- and hornblende-schists, the last-named rock being, however, rather infrequent. The strikes and dips are very irregular along this part of the lake, and some of the mountains to the eastward, near Half-way Creek, appear to be composed of granite.

Half-way
Creek to south
end of lake.

Following the rocks last described to the southward and striking along the lake-shore, are thin-bedded fine-grained micaceous and hornblende schists, often calcareous. The dips are generally eastward in direction, and at the high rocky bluff, known as 'Cape Horn,' a mass of grey granite interrupts these stratified rocks for a short distance. Immediately to the south of this granite cliff, the stratified rocks, however, reappear, consisting of argillite-schists with some thin layers of dark-coloured limestone. They are here only occasionally distinctly micaceous. From this point to the south end of the lake, the rocks observed along the east shore consisted of similar argillites, more or less micaceous in places. Though somewhat irregular, the strikes show a distinct tendency to turn to a south-eastward bearing, running off toward the high mountains of the Valhalla group. Quartz veins were observed in several places cutting these rocks, but specimens

* Annual Report Geol. Surv. Can., 1886, p. 31 D.

VALHALLA
AND THE NORTH-EAST ARM

collected from one of the largest and most promising looking of these proved on assay to contain neither gold nor silver.

All the rocks described to the south of those of the gneissic and mica-schist series (No. 1) may with probability be referred to series No. 2 of the general section; while the mountains through which the river breaks after leaving the lake appear for some miles to be again composed of the rocks of series No. 1, with easterly dips. Though the west shore of the Upper Arrow Lake was not examined, it is probable that at least the entire lower portion of the lake-basin has been excavated along the outcrop of the softer strata of series No. 2. Reference of rocks

At about six miles west of the lower end of the Upper Arrow Lake, the river which connects this with the Lower Arrow Lake enters a great granitic area, which, with small exceptions, includes the whole of the Lower Arrow Lake, the lower part of the Kootanie River and nearly all the West Arm of Kootanie Lake. A line joining the eastern edges of the granite rocks on the connecting river between the Arrow Lakes and on the West Arm of Kootanie Lake, will be found to run in a south-east direction and to cut Slocan Lake, as approximately placed on the map. This agrees with the description received of the rocks of Slocan Lake, and it is probable that such a line as that indicated will be found to outline the extent of the granite on this side, approximately. Its extent to the southward and westward is as yet unknown. Rocks of connecting river

The granite met with on the lower part of the river connecting the Arrow lakes, and near the head of the lower lake, is a coarse grey hornblendic granite with crystals of sphene. Grey granites continue along the east shore of the lake to a point nearly opposite Sanderson Creek, beyond which, for eight miles southward, are pink and reddish granites, believed to be referable to the latest period of eruption. The lithological character of these granites has already been referred to (p. 33 B). Further south, the granitic rocks are for the most part again of grey or greenish-grey colour, but for a distance of about four miles to the north of Deer Park, considerable masses of pinkish granite recur. Lower Arrow Lake

The west shore of this lake, as of the Upper Arrow Lake, was not closely examined; but the width of the lake being small, it was often possible from the east shore to recognize its granitic character. It is probable that this shore also is chiefly, if not entirely, formed by granitic rocks, and the mountains on both sides of the lake appeared to be of the same character. Pink granite occurs on the west as well as on the east side of the lake, and characterizes considerable areas opposite the previously-noted principal occurrences of the same rock on the east shore.

Grey hornblendic or micaceous granitic rocks continue along the river between Lower Arrow Lake and Sproat's Landing. These were The Columbia to Sproat's Landing

in several places observed to possess more or less gneissic structure, but as they are similar in composition to the adjacent granites and not clearly separable from these, it is quite probable that this appearance is due to the foliation of the granite itself. These obscurely foliated rocks are quite different in appearance from those of the Shuswap series (No. 1) of the general section.

It is possible that some of the granitic rocks met with on this part of the route, particularly on the lower part of the Lower Arrow Lake and along the river, may include areas of the older granites, though none such were distinctly observed.

Sproat's
Landing to
Kootanie Lake

As already noted, the rocks met with between Sproat's Landing and Nelson are all granitic, with the exception of certain schistose rocks having a width of about two miles, which are crossed by the trail near Ward's Ferry. These constitute the eastern extremity of the stratified rocks with which the ore-deposits of Toad Mountain are associated, and are described in connection with these. The granites are grey, and usually more or less markedly hornblendic in composition. These, together with those on the West Arm of Kootanie Lake, appear to be all referable to what has been spoken of as the granite of the second period. The exposures along the West Arm show, however, a greater degree of variety in composition and texture than usual, including some coarse-grained hornblendic granites, with large porphyritic crystals of orthoclase feldspar, some varieties characterized by abundant black mica, and others unusually fine in grain. Granitic dykes or veins are also found cutting the main masses in some places. The mountains on both sides of the Arm, as shown by their appearance and the material brought down from them by small lateral streams, are probably all granitic.

West Arm to
Hot Springs

The position of the eastern edge of the great granite area on the West Arm was not exactly determined, in consequence of the absence of exposures near the shore toward the eastern extremity of the Arm, but is approximately shown on the accompanying map.

At the north point of Queen's Bay of Kootanie Lake, fine-grained granites, passing into granitoid gneisses of similar character and scarcely separable from these, are met with. Thence northward to Hot Springs similar gneissic rocks, not generally very distinctly bedded, are associated with a larger volume of mica-schists, which are often garnetiferous, and with some hornblende-schists. The shore follows the strike of these rocks, which dip regularly westward at low angles and are referable to the Shuswap Series. The overlying members of the section, as seen in the vicinity of Hot Springs, are described on p. 47 B, in connection with the ore-deposits of that place.

Generally speaking, and with trifling exceptions, the main strike of

the rocks for twenty-seven miles northward from Queen's Bay is parallel to the direction of the lake, or nearly due north-and-south, with prevailing westerly dips. There can be little doubt that this part of the basin of the lake has been excavated principally along the outcrop of the lower calcareous, and therefore less resistant portion of the Shuswap series.

The north end of the lake, with a length of eight miles, takes a more westerly bearing. The rocks are here considerably disturbed and irregular, with some evidence of faulting, to the influence of which the changed trend of this part of the lake may perhaps be attributed.

On crossing the lake from Hot Springs to Hendryx, the rocks of the peninsula there are found to consist of coarse mica-schists, marble and quartzite, with westward dips at angles of 20° to 60° . The mountains to the east were not examined, but are, I was informed, composed of granite, with which information their appearance accords. The granite gradually approaches the shore of the lake as this is followed northward, and appears in dykes and considerable masses, breaking through the schists on the shore for half a mile or more before the main area of granite reaches the water's edge. This occurs at about six miles from Hendryx, where a coarse grey micaceous granite appears. Thence northward, granitic rocks form the shore for four or five miles, to a conspicuous high cliffy point, where their edge again retires from the shore, but continues to run northward nearly parallel to it and not far inland for nine miles, or to Fry River. Thence it turns off in a north-eastward direction among high mountains, and is not again seen.

The bluff or cliffy point just referred to, itself consists largely of granite; but it includes as well, and in great quantity, large and small masses of the stratified rocks, which have been caught up by and embraced in the edge of the granitic intrusion. The narrow strip of stratified rocks which to the northward separates the granite from the shore, is broken and traversed in all directions by granite dykes from the main mass. These dykes are well shown in the face of some of the cliffs which here occur along the lake. The stratified rocks consist of mica-schists, quartzites and marbles, resembling those of Hendryx. Much of the granite brought down by Fry River, differs in character from that elsewhere seen in the region in containing numerous aggregations of small black tourmaline crystals. From the quality and size of fragments of this kind the parent rock must cover a considerable area, and its position can not be far back from the shore.

Beyond Fry River, the strike of the schistose rocks takes a decided turn inland, in conformity with the direction of the edge of the granite mass. Beyond this point, and to the head of the lake, (still following the east shore,) the rocks are considerably disturbed, and exposures

were found near the head of the lake of black argillites, which are probably referable to series No. 2, though it is impossible to say in exactly what way they are brought in here. These are the only rocks met with on either side of the part of the lake examined, which do not appear to belong to No. 1, of the general section, the Shuswap series.

Head of lake to
Hot Springs.

On crossing to the opposite or west shore of the lake, at its head, high cliffs are found, composed of practically horizontal beds of mica-schist, quartzite and white or grey marbles of medium grain; but in the wash brought down by the first brook to the south, there is much grey, greenish and black schist, rendering it probable that Nos. 2 and 3 of the general section occur here, at no great distance inland among the mountains. The rocks seen along the whole west shore from this point southward to Hot Springs are referable to the Shuswap series. They consist of the usual association of coarsely crystalline, glittering mica-schists, with hornblende-schists, quartzites and marbles. For about ten miles from the head of the lake, the direction of dip is rather irregular and the angles are quite low, but beyond this there is little divergence from a general westerly direction in the dip. From about eight miles north of Caslo River, to that river, the strike of the rocks shows a somewhat more westerly bearing than usual, cutting the shore obliquely, and it is probable that along this part of the shore most of the strata concealed by the lake between Hot Springs and Hendryx are represented. Among these rocks beds of marble of various texture are abundant, and their existence throws additional light on the connection between the rock-series and the position of the lake-basin, which has already been alluded to.

Glaciation and Superficial Deposits.

In the course of the reconnaissance here reported upon, some observations on the evidences of glaciation and on the superficial or drift deposits of the country traversed were made. These were necessarily confined to localities visited in connection with other work, and are therefore somewhat fragmentary. As being the first for the district, however, and inasmuch as they include some facts of special interest, they are here put on record.

High
glaciation.

The only locality in which glaciation of rock surfaces was observed at great heights, was the summit of Toad Mountain. Here, on the outlook point not far from the eastern end of the mountain (see p. 21 B), at a height of 6990 feet above the sea, distinct though light glacial striation was found on projecting points of rock, in bearings between S. 6° and S. 33° E. The mountain from this point slopes away on

northerly bearings toward the great Kootanie valley and on the south to the basin of Salmon River. The glaciation was situated within a few feet of the very summit of the isolated point, and some of it near the edge of a precipitous descent of several hundred feet, where the crest of the mountain breaks down toward the north to a cirque in which is the head of Give-out Creek. Several isolated points of Toad Mountain, with elevations a few hundred feet greater than that here described, occur within two to four miles to the south-westward, but the nearest extensive mass of higher mountains in that direction is situated about ten miles off. In a northerly direction, the nearest important groups of higher summits was estimated to be about twenty miles distant, and at a greater distance somewhat higher mountains occur in various bearings. None of these are, however, so much superior in altitude (as the description on p. 21 b will show) as to suggest or even to admit of a proximately local origin for the glaciation on this point.

Local
circumstances.

On hard rock-surfaces situated about 800 feet lower, and nearly a mile east of the summit just referred to, similar distinct, though not very heavy glacial striation, was again found, running S. 36° E. This place is also situated on the watershed ridge between the Kootanie River and Salmon River. It would appear that the somewhat more easterly bearing here found may be explained by a deflection to the eastward of the ice which has produced the striation as it passed southward round the base of the higher point.

The whole tendency of the evidence as examined into on the spot and here briefly described, leads to the belief that this glaciation is due to the action of what I have elsewhere named the great Cordilleran Glacier, at about the maximum stage of the glacial conditions in this part of the continent. Though glaciation evidently due to this Cordilleran Glacier has been found by me in one place at a height greater than that now recorded, at some distance to the north and west in the interior of British Columbia, * the importance of these observations, lies in the circumstance of their southern position taken in conjunction with their great height. The latitude of this part of Toad Mountain is about 49° 25'. In almost exactly the same latitude, but about one hundred and seventy miles further west, on Loadstone Peak, south of the Tulameen River, glaciation again obviously referable to the Cordilleran Glacier was found at a height of 6370 feet in 1888.

The Cordilleran
Glacier.

Superficial deposits are scanty on the higher parts of Toad Mountain and most, if not all, of the material observed might have had a local origin. This was noted not only in the vicinity of the watershed

Scanty drift
deposits.

* Compare Geological Magazine. Decade III., Vol. V. (1888), p. 347 and Vol. VI. (1889), p. 350.

ridge, but also on the higher parts of the western slopes, and again near the extreme east end of the mountain, in the vicinity of the "Cottonwood" mine. Here, doubtless in consequence of the pyritous and schistose character of the rocks, decomposition has often affected them to a depth of ten feet or more, and in such places the soft rusty rock forms the actual surface on which the vegetation is rooted.

Glaciation at
lower levels.

In the lower parts of the region examined, glacial striation and grooving were frequently observed, and in all cases appeared to follow the direction of the main valleys in a southerly sense. Evidence of this kind, clearly the result of the movement of glacier-ice, was found on the Columbia between Revelstoke and Upper Arrow Lake, going south-south-east with the valley, on the North-east Arm going south-west, or down the Arm, and along the main lake, in a number of places, going south down the valley. Similar glaciation occurs in many places along Lower Arrow Lake, but more particularly in the north-and-south part of the lake. Below this lake, along the river to Sproat's Landing, no glacial striation was seen on such rock-surfaces as were examined; nor was such striation observed along the Kootanie River or on the West Arm of Kootanie Lake, though it is quite possible that a more complete examination might lead to its discovery in these places. Heavy glaciation is frequently apparent along the shores of the north part of Kootanie Lake, for about fifteen miles southward from its head, the direction, as in the cases already cited, being straight down the lake, or southward. Farther south on the lake, as far as the mouth of the West Arm, the rocks near the water were not observed to be striated, but at Hot Springs, surfaces showed well marked striation on the slope of the hill at about 400 feet above the lake, the direction being, as before, southward. As already stated, the southern half of Kootanie Lake was not seen by me, and no observations can therefore be quoted from it. Further inspection of the higher parts of the mountains about this and the Arrow lakes would doubtless yield many additional facts of interest.

Boulder-clay.

Well characterized boulder-clay can not be said to have been recognized in the entire region covered by this report, though the stony clays found covering the lower slopes of Toad Mountain near Fortynine Creek probably represent this deposit. Most of the superficial deposits cut into by the rivers or seen near the lakes are stratified sands and gravels, which often include boulders, but can seldom if ever be called true boulder-clay. Speaking generally, no great accumulations of superficial deposits occur along any of the lakes here reported on, the immediate valleys of which are in fact rather remarkable for the absence of such materials, though not more so than those of the Shuswap Lakes, Adams Lake and other lakes similarly situated

with these in relation to the Selkirk and Gold ranges. Well-defined terraces, though here and there recognisable, are therefore seldom seen along these lakes. Thus near Sproat's Landing a very distinct terrace Terraces. occurs at about 250 feet above the river, and terraces at the same or nearly the same level, recur at intervals on the lower part of Lower Arrow Lake, in the valley of the river between this and the Upper Arrow Lake and on that lake.

In the valley of the Kootanie, between Sproat's Landing and Nelson, superficial deposits are, however, much more important, and often take the form of terraces more or less well marked. A wide terrace at Ward's Ferry has an elevation estimated at 400 feet above the river. On the West Arm of Kootanie Lake, more or less irregular, small terraces occur at the mouths of entering streams, with levels about 100 feet above that of the lake. These may possibly represent the same level with that of the terrace at Ward's Ferry.

Without here entering into any general discussion of the complex Condition during glacial period. question of the glaciation of the Cordilleran region, it may be stated that the glacial striation of the summit of Toad Mountain appears to be referable to the period of maximum accumulation of ice, during which almost the entire country was covered by the great Cordilleran Glacier, moving slowly southward. Even at this time, the lower parts of the ice probably flowed more or less perfectly in accordance with the directions of the leading valleys, but the glaciation now actually seen in the lower parts of these valleys, is probably due to a later stage, during which the glacier-mass, being much reduced, became broken into tongues which occupied the various main valleys. In conformity with observations elsewhere made in the province, * it may be supposed that a second advance of the ice, of minor importance, broke the continuity of its retreat, and in this case the southern extremities of the present basins of the Lower Arrow and Kootanie lakes may approximately represent the limit of that advance, after which a comparatively rapid dissolution of the ice occurred, so rapid as not to allow sufficient time for the obliteration of these hollows by the accumulation of detritus after the ice had left them. † It is thus quite possible that at a time when tongues of glacier-ice still extended as far as the southern ends of the Lower Arrow and Kootanie lakes, the transverse valley by which the river now flows between these lakes, was comparatively, if not altogether, free from glacier-ice, and that at this time the deposits now forming the terraces by which it is characterized were laid down. In the same way, at a still later stage, it may be

* See Quart. Journ. Geol. Soc. 1878, p. 39 *et seq.*

† Compare Report of Progress, Geol. Surv. Can., 1877-78, p. 153 B.

supposed that glacier-ice filled the hollow of the Upper Arrow Lake, and descending also by the Mosquito Creek valley extended some way down the basin of the Lower Arrow Lake, while the crooked and in part transverse valley now occupied by the connecting river, remained open, and was occupied by a lake in which the drift materials through which the river has since cut were deposited. In this case, it is likely that if these lake deposits were removed, it would be found that a deep continuous erosion connects the basins of the upper and lower lakes.

Lake basins.

Though the southern end of Kootanie Lake was not visited, it appears probable, from the low, flat land here flooring the part of the valley which extends beyond the lake, that this end of the lake has since the glacial period been to a considerable extent curtailed by deposits brought down by the Kootanie River. The southern end of the Lower Arrow Lake, however, from the small width of the valley at this place and the occurrence of solid rock here and there in the flat between the bounding mountains, appears to be a true rock basin. While it cannot be affirmed that this basin was not excavated by the action of the glacier-ice by which the whole valley of the Arrow Lakes was at one time filled, it appears to me more probable that it, as well as the basin occupied by Kootanie Lake, is chiefly due to subaërial and river erosion which occurred previous to the glacial period; such erosion having taken place at different times, and under varying differential conditions of elevation of the land surface. The same explanation seems to be the most tenable one with respect to the basins of many other lakes in British Columbia, as well as in the case of the numerous fiords of the coast, with which the long lakes occurring in the mountainous regions of the interior appear to be strictly analogous in character.

Transport of material.

From an economic point of view, the principal importance of a study of the conditions of the region in the glacial period, depends upon the light which such study throws upon the probable origin of loose masses of ore which may be found. Such masses may have been carried by the ice during this period for considerable distances, and a knowledge of the direction of the ice-movement may thus become at any time of interest. The subsequent transporting action of rivers and streams must, however, also be taken into account, as well as that of the general tendency of detached fragments of rock to move down hill from their points of origin, under the influence of gravitation or that of occasional floods due to exceptional storms or other causes, which may in the course of time remove such fragments to long distances.

DETAILS OF MINING DISTRICTS AND MINING CLAIMS.

*Hot Springs Mining Camp.**

The first mining claims were taken up at this place in 1883 by Thomas Hammill, afterwards murdered at Hendryx. These claims were situated near the shore of the lake and were named the "Lu-lu" and "Spring." Later in the same year claims known as the "Surprise," "Morning Star" and "Evening Star" were staked, further back from the lake and nearly on the line of what is now known as the Spokane vein. The ores discovered at this time were, however, rather low in content of silver,† and it was not till the find of rich ores in Toad Mountain became generally known, in the spring of 1887, that an impetus was again given to prospecting and high-grade ores were discovered in this vicinity.

Nearly all the principal deposits since found here, some of which have been developed to a considerable extent, are included in an area extending, from south to north, between Coffee Creek to Woodberry Creek, a length of about six miles; from east to west, from the lake shore to the vicinity of the "Sky Line" claim, a width of little over two miles. The number of actual discoveries of considerable bodies of good ore already made in this comparatively limited area is remarkable, and new finds are still occurring from time to time.

From the edge of the lake, the country rises to the west in a long irregular slope, which, as seen from a distance, presents a series of step-like ascents, produced doubtless by the irregular denudation of a series of beds of unequal hardness. This step-like appearance, though also observed to the northward, along the same side of the lake, is here much more marked than elsewhere. The region has originally been densely wooded, and in some of the hollows excellent cedar and white pine timber is still to be found, but since the occupation of the 'camp' most of the original forest has been burnt off, either accidentally or with the object of facilitating prospecting. A fairly good trail has been made from the lake shore to the "Number One" mine, a distance of about two miles in a straight line, in a west-north-west bearing, the height above the lake attained at this point being about 2520 feet. The course of the trail is, however, exceedingly sinuous, and besides the numerous sharp zig-zags necessary to overcome the steeper parts of the ascent, it makes a long sweep to the southward and another to

* The expression "Mining Camp" is here used in its Western sense as a convenient and generally recognized term for a mining district of limited area, more or less definitely separated from others.

† See Annual Report Geol. Surv. Can., 1885, p. 26 M.

the northward before reaching the "Number One." Smaller trails and tracks branch off in various directions to other claims, and by one of these the ascent of the main slope may be continued in a south-westerly direction from the "Number One" mine to the "Sky Line" at an approximate height above the lake of 3460 feet. No attempt has yet been made toward the construction of a waggon road, and such ore as has been sent out has been carried down to the lake shore on horses or mules.

General
relations of
rocks.

The best general section of the rocks of the vicinity was obtained along the main trail, measurements being made by pacing, but as there are considerable intervals in which no rock-exposures occur, this still leaves much to be desired. The general strike of the rocks, which is preserved with considerable regularity, is nearly due north-and-south, but about half-a-mile below the "Number One" mine it turns gradually to a nearly north-west bearing, a change which, however, is probably local in character. The dip of the rocks is, almost without exception, to the westward, at an average angle of perhaps 45° . The inclination is, however, considerably less near the shore of the lake and probably also in the vicinity of the "Number One" mine, while further up, near the "Sky Line," and in the vicinity of the edge of a granite mass to the west, the beds are much disturbed and crumpled, and often nearly vertical.

Section at Hot
Springs, lowest
rocks.

On the shores of the lake, the rocks are coarsely crystalline, glittering mica-schists, often garnetiferous and in thin flaggy beds, dipping $S. 77^{\circ} W. < 20^{\circ} *$. Rocks of the same character and referable to the Shuswap series of the general section, are seen in a few places and appear to be continuous, for a distance of a little more than a quarter of a mile back from the lake, measured at right angles to the strike. A belt of green schists is then crossed, with a width of about 700 feet, and with westward dips at angles of 45° to 50° . A trail going southward toward the "Little Donald" claim, branches off a short distance before the west edge of the green schists is reached, and between this trail and the west edge of these schists, the beds have irregular and sometimes very high dips. To the west of this belt of green schists, the rocks appear for the most part again to consist of rather coarse mica-schists, to the vicinity of the "Spokane" mine, a further distance of 1300 feet measured as before directly across the strike. The "Spokane" mine is situated near the brow of a steep, step-like ascent of about 200 feet, at the foot of which runs a strong body of 'barren quartz' and silicified rock, together with a wide dyke of augite-

*The bearings given in this and following pages are magnetic, it being supposed that such compass bearings may prove more serviceable to the miners and prospectors than true bearings. The magnetic declination here is about $24^{\circ} E$.

andesite, with large porphyritic crystals of black pyroxene and glassy felspar. It appears probable that some faulting may occur near this line, and that the strata so far described in ascending from the lake may form a single synclinal fold, overthrown to the eastward, of which the belt of green schists marks the axis.

Beyond the "Spokane" mine, considerable intervals occur in which no rock-exposures are seen near the trail, but the rocks appear to consist almost entirely, for a width of 2800 feet across the strike, of greenish schists, which though fine-grained, are often distinctly hornblendic in character. The angles of dip observed are nearly uniform, and it is probable that the thickness of these schistose beds is here about 2350 feet. One bed of hard grey, somewhat schistose and slightly micaceous quartzite, of forty or fifty feet in thickness, was noticed in this schist series not far west of the "Spokane" mine. Another rock of peculiar character was found near the upper part of this series of schists, possibly forming its upward termination and immediately underlying the limestones next above. This is a grey, rather fine-grained schistose conglomerate, of which the schistose surfaces are often highly micaceous, and in which numerous small garnets occur. This entire series of schists, though not distinctly separable into greenish and greyish members, and though more highly altered and much less in thickness than those of the Adams Lake series in its typical locality, is supposed to represent that series. Green and grey schists.

Overlying these generally-green schists, is an important bed of Limestones limestone, the upper and western line of which is found on the trail at Cooper's cabin. It occupies a width, measured across the strike, of 600 feet, and has a possible thickness of 530 feet, though from its massive character and the crumpled appearance in some small exposures where bedding can be seen, this is very uncertain. It is chiefly grey and fine-grained, though occasionally marble-like. This limestone, together with the rocks overlying it and forming the whole upper part of the Hot Springs' section, are supposed to represent series No. 5 of the Adams Lake section, though the considerable volume of greyish schists found between the limestone and that at the "Number One" mine is not precisely parallel on Adams Lake.

The section between Cooper's cabin and the "Number One" mine is very imperfectly exposed, but the rocks met with are chiefly greyish schists, often rather micaceous (though quite different in appearance from the mica-schists of the lake-shore), with one or more rather important belts of black glossy argillites. Micaceous quartzite-schist occurs among the grey schists in places. The width occupied by these rocks, measured across the strike from the line of Cooper's cabin to

that of the "Number One" mine, is about 2900 feet, and the thickness of rocks represented may be about 2600 feet.

Probable syn-
clinal.

In the vicinity of the "Number One" mine, limestone is again found, and is supposed to represent a second and higher zone of this rock. It is conjectured that this may occupy the centre of a synclinal fold, the eastern side of which is regular and rather wide. The disturbed and often vertical black argillite-schists near the "Sky Line" in the vicinity of the edge of the bordering granite to the west, may represent the return on the west side of the synclinal of the similar rocks alluded to in the foregoing paragraph. It would, however, require much detailed examination to fully work out the structure of this section.

Connection of
ore-deposits
with rocks.

That a considerable amount of importance attaches to the arrangement of the various rocks comprised in the section at Hot Springs, is evident from the observed dependence in character of the ore-deposits on that of the country-rock. The general direction of the veins is nearly north-and-south, being nearly or in some cases exactly parallel with the strike of the rocks. Some of these, like the "Spokane," appear to dip also at the same angle with the enclosing beds, but in other cases, to the west of this, the metalliferous veins cut across the bedding of the rocks to a greater or less extent, and may be expected to change in character when followed in depth into country-rock of another kind. The number of well defined veins which occur has not yet been ascertained. Some of the lodes are said to have been followed for several miles, but while it is evident that belts producing similar ore and exhibiting veins of like character and appearance have thus been traced out, it is not yet certain that any single vein runs continuously for such distance. This can not, in fact, be certainly ascertained till much further work has been done. The lowest tier of deposits, included in the mica-schists of the Shuswap series, may be stated to yield ore averaging from 20 to 40 ounces of silver to the ton, while further up selected ore, in lots of several tons, has yielded from 85 to 300 ounces to the ton, the richest deposits being those associated with the limestones and black argillites.

Character of
ore-deposits.

The ore is principally argentiferous galena, which, in the lower veins contained in the harder rocks, has usually become decomposed to a very limited depth only from the surface; but in the limestones the decomposition has often extended to a considerable depth, and has resulted in the production of soft rusty 'carbonate ores,' filiform native silver or 'wire silver,' together with tetrahedrite are also found in some of these richer deposits. The veins which, like the "Spokane," follow the bedding of the mica-schists, are the most regular, while, as might be anticipated, those contained in the limestones are not

nearly so uniform in size and tend apparently to assume the character of mineral-impregnated belts of rock in which occasional large masses or 'chimneys' occur. This is apparent in claims such as the "Sunshine" and "Number One." In the latter, where most work has been done, there is comparatively little true gangue associated with the ore, but zones of the limestone itself have become shattered and more or less highly charged with ore throughout. The ore even penetrates the limestone itself in the vicinity of the main deposit, and thin plates of native silver are found in joints, particularly in those parts of the rock which immediately overlie the larger masses of rich ore.

The importance of the Hot Springs vicinity as a producer of silver and lead may, I believe, be stated to be assured by the number of deposits already known, and by the richness in silver of the ores from many of these which have been partially developed. Should only a small proportion of the numerous claims prove eventually to be as valuable as many of them now appear to be, the output of ore can not fail to become very considerable within a few years.

The following notes relate to such of the claims as I was able to inspect personally last June. While those include several of the best known and most promising properties, numerous others are not mentioned, as it was impossible to visit all in the time at my disposal. The notes here given may, however, serve to afford some information as to the general mode of occurrence of the ores. The claims first described are those met with on or near the main trail, in order of ascent from the lake, and ending with the "Sky Line." After these, some claims to the south of the main trail are noted. A considerable group of claims situated some distance to the north of the main trail, including the Gallagher and others, was not visited by me.

Jeff. Davis Claim.—Height above lake 690 feet.* Very little work has been done upon this deposit, which, at the surface, appears to consist of an irregular shattered belt of rock, silicified and charged with ore, rather than a well defined vein. Veins running through this, contain galena in considerable quantity, in some places with a width of six inches of nearly pure ore. The ore is considerably decomposed at the surface, but is occasionally found to include a little copper-pyrites. This claim was first taken up in 1883 and has since been relocated several times. Several other claims supposed to cover extensions of the same deposit, have been staked to the north and to the south.

Spokane Mine.—Height above lake 1120 feet. This is situated on a very well defined vein, which runs between the beds of a medium

* The heights, assigned to this and other claims were barometrically determined with approximate accuracy.

Mining claims
at Hot Springs
continued.

grained, grey, silvery mica-schist. The course of the vein is the same as the strike of the beds, or N. 43° W. It dips to the south-westward at an angle of about 60°. The vein, as seen on the surface, is from one to two feet in thickness and is largely composed of galena, associated with a little iron-pyrites and quartzose gangue. A shaft has been sunk to a limited depth on the vein, following its dip, and a good deal of exploratory work has been carried on. The shipments during 1889 amounted to forty-four tons, which yielded at the rate of 35 ounces of silver to the ton. The following claims are supposed to be upon the continuation of the "Spokane" lode, and there is little doubt in this case, from the remarkable regularity of the deposit, that most of them are actually situated on the same lode. Claims to the southward: "Mæstro," "Little Phil," "Black Diamond," "Little Donald," "Paymaster," and one or more in addition of which the names were not ascertained. Claims to the northward: "Trinket," "Maple Leaf," and others beyond Cedar Creek, which, owing to the amount of cover in the valley of the creek, can not be certainly traced into connection with the "Spokane."

Sunrise Claim.—Height above lake 1920 feet. The country-rock is here limestone, forming the lower part of the important limestone belt already described. The ore-deposit, so far as it has been exposed by surface-work, appears to be rather irregular in character, the ore reticulating through the limestone for a width of twenty feet or more, where best exposed. The direction of the general run of the ore at this place appears to be from N. 20° W. to N. 30° W., or nearly transverse to the strike of the rocks, which, however, turns more to the westward a short distance further north. A considerable body of ore is seen on the "Sunrise," most of it rusty and decomposed, forming the so-called 'carbonate ore.' This, however, contains numerous irregular masses of unaltered coarse-grained galena, which holds also a little iron-pyrites. To the southward, along the strike of the rocks, the "Coronation" and "Black Chief" claims, with several others, have been taken up. To the north are the "Ohio," "Sweden," and a number of other claims.

Sweden Claim.—This is situated about 1200 feet northward from the last-described, the "Ohio" claim intervening. A shaft has been sunk here to a depth of forty feet, in which the width of the vein is stated to average three feet. The upper part of the deposit is completely decomposed, forming a soft rusty mass of 'carbonate ore.' From the shaft, unaltered ore consists of galena, with zinc-blende and some iron-pyrites. The gangue is calcite, with a little quartz.

Tiger Claim.—Height above lake 1790 feet. This lies still further to the northward, on the edge of the wide valley of Cedar Creek. It is

spoken of as being on the continuation of the last deposit, but the con- Mining claims
nection is not definitely traced. The vein here follows the bedding of at Hot Springs
the rock, running N. 65° W., with a southerly dip of about 60°. The continued.
vein is overlain by rather fine-grained, grey, micaceous schist, and underlain by limestone, and appears to be about three feet wide. The ore is considerably decomposed and resembles that of the "Sweden," consisting of coarse, crystalline galena, with some iron- and copper-pyrites.

Number One Mine.—Height above lake (at shaft) 2510 feet. More development work has been carried out on this claim than on any other at Hot Springs. During the past year (1889) it is stated that 130 tons of selected ore has been shipped, the return in silver being at the rate of 85 ounces to the ton. Several substantial houses have been erected and other improvements made. A shaft had been sunk on the ore to a certain depth, at the time of my visit, and an adit run in for the purpose of intersecting the shaft, but I am unable to state what progress has been made in these workings up to date. The ore occurs in grey limestone, which is often rather shaly, and just above the shaft glossy black argillites are seen in the hill. The deposit appears to be somewhat irregular and 'pockety' in character, as is usually the case in limestone country-rock. Its general run is supposed to be about N. 15° W., and ore presumably representing a continuation of the same deposit, has been uncovered at several places, extending for a length of about 400 feet. At the surface, the ore is completely decomposed, forming a soft rusty mass, which is excavated by pick and shovel. In depth it is found to consist of galena and blende, with a little iron- and copper-pyrites. Native (wire) silver is not infrequent, and it is probable that some tetrahedrite or ruby-silver ore also occurs, minutely disseminated. The metalliferous constituents of the ore are usually disseminated in small crystalline aggregations, the gangue consisting of more or less altered and silicified limestone and sometimes of quartz. Many little cavities lined with quartz crystals are found in the mass, and in some instances the metalliferous minerals penetrate the limestone irregularly for considerable distances. The mode of occurrence of the ore at this place and elsewhere in the limestone country, is such as to suggest that systematic exploration with the diamond drill will in future prove to be of essential service in tracing out and exploring for the more important deposits. Claims upon which ore has been found, and which are supposed to cover portions of the northern continuation of the "Number One" deposit are, the "Columbia," "G. B. Wright," "Black Bear," "Della" and "Kate."

Della Claim.—This is the only one of the claims just enumerated

Mining claims
at Hot Springs
continued.

which was visited. It is situated at a distance of nearly a mile in a north-westward direction from the "Number One," at an elevation of 2490 feet above the lake. From the "Della," sixteen tons of ore is stated to have been shipped during the past season, yielding about 105 ounces of silver to the ton. An opening about fourteen feet in depth had been made on the outcrop at the time of my visit, but the vicinity is so much covered by soil and undergrowth that little could be seen of the relations of the ore. Black glossy argillites, however, outcrop on the up-hill side of the ore, which is evidently in considerable body, though its width could not be ascertained. Where excavated it is almost completely decomposed and resembles the upper part of the "Number One" deposit, but contains more galena in proportion. Some iron-pyrites was also seen.

Sky Line.—This claim is situated nearly a mile from the "Number One;" in a direction about S. 30° W., and at a considerably greater elevation, being approximately 3460 feet above the lake. It was discovered just about the time at which I reached Hot Springs, and it so happened that I was unable to find the point at which it had been uncovered. Specimens of the ore obtained at the surface, consisted of rather fine-grained, grey, siliceous rock which had become porous from the weathering out of its metalliferous constituents, but had no rusty appearance. In an unaltered state the ore might probably resemble some of the more siliceous portions of the "Number One." Under date January 24, 1890, Mr. J. Anderson informs me that a shaft has been sunk on this deposit to a depth of one hundred feet, where the ore appears to be unaffected by surface action and shows more galena. It also occasionally holds native silver and some copper-pyrites with sulphuret of silver or tetrahedrite. This claim is situated close to the eastern edge of the granite, which bounds the mining field to the west. An experimental shipment of twelve tons of ore has yielded about 300 ounces of silver to the ton. The ore is said to occur at the junction of argillite and limestone, the argillite forming the hanging wall.

The following claims situated to the south of the main trail were visited.—

Little Donald.—Height above lake 1120 feet. This has already been alluded to as being on the southern extension of the "Spokane" vein, it is distant about a mile from the "Spokane" mine. The country-rock is mica-schist, dipping S. 70° W. < 45°. The vein here dips at an angle of about 40° and an incline had been run down on it for about fifty feet, with a drift to the north of about forty feet at the date of my visit. The shaft was full of water at the time, but was afterwards

cleared and carried down to seventy-five or one hundred feet when the quantity of water coming in led to the temporary suspension of operations. The vein is reputed to average from six to nine feet in thickness. The ore consists chiefly of galena in coarsely crystallized form, and is not decomposed far from the surface. The gangue is chiefly calcite and dolomite and the fact that very high assays are occasionally obtained, indicates that some of the richer silver ores, such as tetrahedrite or argentite are present in places. During the summer of 1889, sixty-six tons was shipped, yielding 95 ounces of silver to the ton.

Krao Claim.—Height above lake 1390 feet. Some shipments were here first made of ore obtained from cavities in limestone, which constitutes the country-rock. These were said to run high in silver. After going down about forty feet, at this place, a second opening was begun at about one hundred and fifty feet from the first, where the vein was better defined. A shaft was begun near the vein and was down about twenty feet last June. It has since, I believe, been carried to a depth of seventy-five feet. The vein appeared near the surface to be from six to eight feet wide, but with rather irregular walls. The limestone has the appearance here of a greyish or bluish marble and dips S. 60° W. < 80°, which the vein also appears to follow. The ore consists chiefly of rather massive, coarsely crystalline galena, more or less decomposed, but occasional finds of native silver are reported. During the season eleven tons of ore was shipped, yielding at the rate of 90 ounces to the ton. Several claims supposed to cover the southern continuation of the same lode as far as Coffee Creek, or for a distance estimated at 7500 feet, are said to show well in ore. These are the "Crow Fledgling," "Now Then," "Crescent" and "Eden."

United Claim.—Height above lake, 1500 feet. Situated about 1500 feet to the north-west of the "Krao." This was a new discovery at the time of my visit, and had been uncovered for about fifty feet only. The foot-wall, which was exposed, consists of greenish schist, dipping south-westward at an angle of about 40°, and the vein appeared to be parallel to its bedding. Its thickness, as uncovered, was from three to five feet. Part of the ore consists of coarsely crystallized galena, part of very fine-grained galena.

Arkansas Claim.—An opening known by this name has been made in this vicinity on what appears to be a considerable deposit. There is a good showing of galena and rusty vein-matter.

Black Chief.—Height above lake, 1690 feet. Small prospect-holes only had been opened upon this deposit, showing galena and rusty

Mining claims
at Hot Springs
continued.

vein-matter with much quartz. The dip of the vein is about S. 78° W < 20°. Pure galena is said to assay 46 ounces of silver to the ton.

As previously stated, a great many claims upon which more or less ore has actually been found were not visited by me. Of these, one of the most important is that known as the "Gallagher," to the north of Cedar Creek, from which, during the past summer, thirteen tons of ore was shipped, which is reported as yielding 126 ounces of silver to the ton. This is one of a considerable group of claims in the same vicinity. The notes given above, while incomplete, may serve to give some idea of the present appearance of this new district. The various claims in the present incipient stages of work, change more or less in relative importance and appearance every month, as the work of development goes on, and thus render very minute description or enumeration of little practical importance.

Hendryx Mining Camp.

The peninsula on the east side of Kootanie Lake, nearly opposite Hot Springs, has become known as Hendryx, from the name of the very energetic manager of the Kootanie Milling and Smelting Co., by which company most of the work so far done here has been carried out. The rocks here met with have already been described as belonging to the lower part of the mica-schist series, or Shuswap group of the general section (p. 92 B). The ore is comparatively low-grade as regards silver, and will probably require the erection of smelting works on the spot before it can be profitably utilized. Its profitable shipment under the present conditions is quite out of the question.

Discovery of
ore.

The deposits of galena at this place are said to have been discovered by the botanist Douglas as long ago as 1825. In later years they have been taken up and abandoned several times, the country being too remote for their utilization or development.

Character of
deposit.

The ore-deposit, though as above stated low in content of silver, assays giving from 15 to 40 ounces to the ton only, is very large and striking in appearance. It seems to run in a general north-and-south direction through the entire length of the little peninsula, and is covered by three claims, known, from south to north, as the "Kootanie Chief," "Blue-bell," and "Comfort." The lode is shown at intervals, partly in natural exposures and in part in strippings, through all three claims, or for a total length of about 4000 feet. Though varying much in appearance from place to place, and also in the upper and lower parts of the deposit as seen in single exposures, its general character is very similar in all. The ore consists of a mixture of iron- and copper-pyrites, galena and blende, contained in a quartzose

gangue, which is often more or less cavernous and crystalline. Portions of considerable thickness occur throughout, which are almost pure galena, while in others iron-pyrites preponderates, and these two minerals are usually associated in a finely or coarsely granular mass.

Though generally speaking very constant in its direction, the thickness of the lode appears to vary considerably. Thus on the southern point of the peninsula ("Kootanie Chief" claim) the main ore-mass has an average thickness, so far as can be seen, of about twelve feet. In a cross-cut made on the "Bluebell" claim, the ore is reported to be about eighty-six feet thick, and from the material on the dump, must here consist chiefly of galena. In a general way, the lode closely follows the strike of the containing rocks, which consist of mica-schists, marbles and quartzites. That the lode is not, however, always in strict parallelism to the bedding, is shown by the fact that the bed above it is in some places marble, in others mica-schist. Also by the circumstance that parallel zones of ore occur at some distance from the main mass. It should be added, that while the general run of the ore appears to be persistent and continuous, as above stated, there are evidences of small displacements by faulting, while masses of marble or limestone also occur in it, and irregular spurs of ore were observed to run off, as though at times the ore had replaced parts of the adjacent marble.

At the south point of the peninsula, the ore and containing rocks dip S. 80° W. < 60°; at the "Blue-bell" openings, S. 73° W. < 45°, and near the north end of the "Comfort" claim, S. 80° W. < 20°.

A considerable amount of prospecting and development work has been done on the "Blue-bell" claim, and an adit is now being run in from the vicinity of the lake-shore with the object of tapping the vein at a considerable depth and affording a satisfactory beginning for regular work. This, at latest advices, had reached a length of over 300 feet. The work done on the "Kootanie Chief" and "Comfort" claims has been confined to stripping and surface trenching.

Toad Mountain and Vicinity.

The greater number of the discoveries of metalliferous deposits made on Toad Mountain and in its vicinity, are included within the limits of an apparently isolated area of stratified rocks. This area runs nearly east-and-west, extending, from the head of Cottonwood-Smith Creek, westward to the vicinity of the lower fall of the Kootanie River at Ward's Ferry. Its length, in the direction above indicated, is about eleven miles, while its average breadth may be about two

Width and
peculiarities of
ore-deposit.

Insular Area
of bedded
rocks

miles. While, however, its northern boundary may be considered as being shown with approximate accuracy by the line on the map, its southern edge was not examined by me, but depends on statements received from others. The rocks surrounding this area are everywhere, so far as observed, grey granites:

Lithological
character.

The stratified rocks here met with differ considerably in appearance from those found in the vicinity of Hot Springs, but, as already mentioned (p. 34 B) it is supposed that they represent, for the most part, the greenish and grey schists of the Adams Lake series. The differences found between these rocks and their supposed representatives at Hot Springs is paralleled elsewhere in the Province, and appear to depend chiefly on the greater amount of pressure and consequent crushing to which the rocks of the last-named locality have been subjected. It is principally to action of this kind that the markedly schistose character of the rocks of Hot Springs is attributed. The outlier constituting the stratified area of Toad Mountain, has apparently been more affected by heat and hydrothermal action consequent on the extrusion of the granite, and while schists resembling those of the grey and green series at Hot Springs are not wanting here, they are subordinate in importance. Connected with this difference in the mode of alteration of the rocks, rather than with any original diversity in the mineralogical composition of the country-rock, is no doubt the well-marked difference in the ores of the two places.

The rocks characteristic of this outlier, though presenting many varieties which will eventually be found worthy of more minute investigation, may be described as consisting for the most part of stratified volcanic materials of Palæozoic age. These are generally of greenish or grey colour, and appear, for the most part, to be diabase in lithological composition. Diabase-porphyrite is not uncommon, and notwithstanding the considerable degree of metamorphism which the strata have suffered, some distinctly amygdaloidal diabases are still to be found. Hornblende-schists and rather massive pyroxenite-like rocks with some hornblende, also occur, especially in the immediate vicinity of the granite. When the rocks assume a distinctly schistose character, as in certain belts near the "Cottonwood" and "Silver King" mines, it is sometimes clearly apparent that the schistose structure does not entirely correspond with the original bedding, but crosses it at an angle. Near the western extremity of the stratified area, where the rocks are more closely surrounded by the granite than elsewhere, they are found to have suffered more than the usual amount of change. They consist of fine-grained gneissic, hornblende and micaceous schists, often greenish in colour, owing to the development of epidote. Here also a thin bed of limestone converted to

a coarsely crystalline marble was observed. In addition to the rocks of volcanic origin, beds of blackish argillite, more or less pure, were found in some places, but these hold a subordinate position in the series.

The general direction of the strike of the rocks in this area is nearly parallel to the longer axis of the area itself, while the majority of the dips are in a southward direction, usually at high angles or nearly vertical, though toward the west end decreasing to 40° or even to 20° . Strike and dip.

Much-altered fragments of the stratified rocks are frequently found enclosed in the mass of the granite near the line of junction. The granite near this line is also generally much jointed and often greenish from the development of epidote, which is specially abundant along the jointage-planes. Junction with granite.

The occurrence of this isolated area of stratified rocks, together with that of the smaller but similar mass on the east side of Cottonwood-Smith Creek, renders it probable that additional similar areas yet remain to be found elsewhere in the great granite region. Should such be discovered they may prove to afford further deposits of ores like those of Toad Mountain. Other stratified areas.

The following notes refer to the claims visited by me on Toad Mountain and in its vicinity, last June. These comprise the principal properties upon which more or less work has been done.— Mining claims, Toad Mt.

Silver King Mine.—Height above lake (at houses) 4310 feet. This property, sometimes known as the "Hall Brothers' mine," is the most important so far known, and its discovery led directly to the recent interest and developments in this region. It was accidentally found late in the autumn of 1886, but nothing was done toward opening it up till the next spring. Toad Mountain, previously one among many undesigned summits, received its somewhat peculiar name at the same time. The mine is now reached by a fairly good, though often steep trail, the distance from Nelson being about five miles in a straight line. The property consists of three claims, each 1500 feet in length. Of these two, named the "Silver King" and "Kootanie Bonanza," are laid out along the run of the principal vein, the third, known as the "American Flag," lies alongside, to the north, and is supposed to cover a second parallel vein.

In ascending the mountain by the trail, granite continues for some distance from Nelson, but is replaced by the stratified rocks previously described, probably near the point at which Give-out Creek is crossed by a bridge. Greenish diabases, both massive and schistose are characteristic, but about quarter of a mile southward from the houses

Mining claims
Toad Mt.
continued.

at the mine, these are followed by a grey decomposed quartz-porphry, which, from its appearance and mode of fracture along jointage-planes, simulates granite when seen from a distance.* The rocks in the immediate neighbourhood of the openings made on the ore, are generally massive, though also in places schistose. They are here frequently more or less completely silicified and blotched by little seggregations of quartz. On the slopes of the summit situated about a mile to the westward from the houses at the mine, some blackish argillite-like beds occur, and on this summit one of the distinctly amygdaloidal rocks previously alluded to was found. Lithologically this rock is a diabase-porphryite.

The rocks are generally highly inclined or vertical and their strike is nearly parallel to that of the schistose lamination, so that it is difficult to determine whether the schistose zones have differed originally in composition, or whether they merely represent lines along which the rocks have yielded to crushing. The general run of the metalliferous veins is also here nearly, though probably not exactly, parallel to the strike of the rocks.

The greater part of the work accomplished, has been carried out on the "Silver King" claim, for an opportunity to examine the openings on which and other facilities I was indebted to Mr. J. Macdonald and Mr. Hall.

The lode or ore-body, has been traced more or less continuously through the "Silver King" and "Kootanie Bonanza" claims, with a general direction nearly east-and-west magnetic. While, however, the general continuity of the ore-bearing zone has thus been proved, it appeared to me probable, on comparing the positions of the various openings, that its run is not throughout perfectly straight. On the "Silver King" claim, houses have been built and two drifts have been run in at different levels on the lode. From the end of the upper drift, the ore had been followed down by a winze to a depth of thirty feet at the time of my visit. This is stated since to have been continued to fifty feet, at which depth it is reported to be in a large body of rich ore.

The best opportunity of examining into the character of the deposit occurs in these workings. The lode is found to possess no distinct walls, but to occur as a zone of variable, and sometimes apparently of indefinite width, of shattered and mineralized rock, throughout which veins of pure and richly argentiferous ore occur in a

* According to Dr. A. C. Lawson, this rock consists of a ground-mass of feldspar and quartz, throughout which is scattered secondary muscovite, calcite and chlorite and an opaque indeterminate mineral, and in which are imbedded numerous idiomorphic, porphyritic crystals of much decomposed orthoclase feldspar.

somewhat irregular manner. Where gangue appears it is principally quartz, but there is on the whole a rather notable absence of gangue or crystallized vein-material, the ore apparently filling irregular crevices and running in shoots and spurs into the rock so as to form here and there considerable masses. The metalliferous minerals comprise bornite and tetrahedrite, with some iron- and copper-pyrites but only occasional traces of galena. The two first-mentioned minerals, when nearly pure, contain the largest percentage of silver, while the pyrites is comparatively poor. In surface exposures the material of the lode is almost completely oxidised, producing a brown or blackish gossany material with some green and blue carbonates of copper.

Mining claims
Toad Mt.
continued.

The excavations so far made are of a very irregular character, the ore having been followed wherever it appeared, and in some cases a considerable quantity of barren rock has been dealt with in pursuing this method of work, which can be justified only because of the great richness of the ore and the want of sufficient capital for more systematic operations. All the circumstances appeared to me to warrant the expenditure of a large sum of money, if necessary, in order to define and open out this remarkable deposit in a proper manner, and till work of this kind has been done it will be impossible to ensure any large or continuous out-put of ore. The richer portions of the ore are at present selected by cobbing and hand-picking, and packed in sacks for shipment; but a considerable proportion of the whole is thrown to one side, pending the erection of machinery for fine concentration. According to the Report of the Minister of Mines of British Columbia for 1889, the cost of conveying the rich ore on pack-mules from the mine to Nelson, was \$10 per ton, and from Nelson to Butte, Montana (a distance of 700 miles), including the charge for smelting, cost a further sum of about \$47.

The character of the ore obtained is shown by the following analyses by Messrs. Johnson and Matthy, London, for which I am indebted to Mr. R. D. Atkins, who collected the three specimens referred to.—

	1.	2.	3.
Copper.....	47·000	24·900	40·100
Silver.....	2·360	·232	1·292
Iron.....	7·300	12·200	1·800
Zinc.....	1·300	2·400	5·700
Manganese.....	1·200	5·100	·400
Antimony.....	1·400	3·400	15·600
Cobalt and Nickel.....	traces.	traces.	traces.
Lead.....	·100	traces.	1·700
Arsenic.....	3·100	2·100	4·500
Carbonic Acid.....	nil.	6·000	nil.
Lime.....	nil.	5·200	' nil.

	1.	2.	3.
Mining claims Toad Mt. continued.			
Magnesia.....	.700	traces.	nil.
Alumina.....	nil.	.200	nil.
Sulphur.....	22.900	22.000	27.200
Phosphorous.....	nil.	traces.	nil.
Siliceous insoluble matter.....	9.200	8.800	1.000
Traces of gold, oxygen, water and loss.....	3.440	7.468	.708

To the ton of 2240 lbs., specimen No. 1 contains 771 ounces of silver. No. 2, 75 ounces 16 dwt. No. 3, 422 ounces. Traces of gold were found in all, and in two shipments made to smelter, of which details have been obtained, the value of the gold recovered per ton of 2000 lbs., amounted to \$2.16 and \$1.44 respectively.

The ore where exposed on the "Kootanie Bonanza," to the east of the "Silver King," and at a height of about 200 feet above the level of the lower drift on that claim, is similar in appearance to that of the "Silver King," but more or less superficially decomposed. What is known as the "Gwizzly" claim, lies parallel to the "Kootanie Bonanza," adjoining it to the north. This is not a part of the Hall Brothers' property. An opening made to a small depth in one place, again shows similar ore in a shattered zone of country-rock. The "American Flag" claim was not visited.

A small opening made at the side of the main trail a short distance below the houses on the "Silver King" and at the west end of that claim, deserves some notice. This, according to Mr. Macdonald, is precisely on the line of the main lode, and is considered to represent its continuation at a lower level. The lode is here much more regular in character than where it has been worked, being enclosed by schistose rocks, the strike of which it follows. It is from three to four feet in width, and contains a considerable proportion of galena, approaching in character and appearance the deposits found on the "Iroquois" and "Dandy" claims, subsequently noticed. On the assumption that this actually represents the continuation of the "Silver King" lode, it is evident that that deposit must change in its character to the westward or in depth, and it seems probable that such change occurs together with that in the nature of the country-rock, the hard, massive, irregularly shattered rocks found in the drifts appearing to yield the richest ore. The shipments from the "Silver King" during the past season are reported to have aggregated sixty tons, averaging about 300 ounces of silver to the ton.

Dandy Claim.—Height above lake (at entrance to drift) 3980 feet, or about 300 feet below the houses at the "Silver King." This claim lies to the west of the "Silver King" claim, adjoining it, and there can be little doubt that it is located on the continuation of the same lode,

which has been exposed at various places throughout the length of the Mining claims claim. Comparatively little work beyond this tracing of the lode, had Toad Mt. continued. been done at the time of my visit. The lode runs nearly east-and-west magnetic, showing, where a drift had been begun, a dip at an angle of about 80° to the southward and a width of three feet. The ore consists principally of galena, with copper-pyrites, and occasionally some blende. It shows besides occasional stringers of tetrahedrite, which are reported to yield very high assays. The gangue consists of quartz, which is present in larger quantities than in the "Silver King" ore. The wall-rocks are composed of green slates or schistose diabases, the strike of which the vein follows exactly. It holds its width well where exposed and appears to be fairly regular in direction and character. No ore rich enough to ship under present circumstances has yet been obtained from this property, which nevertheless promises well, and appears capable of yielding, with fine concentration, a large proportion of rich ore.

Iroquois Claim.—Height above lake (at entrance to drift) 4190 feet. This claim lies to the south of the run of the "Silver King" lode, and is supposed to cover a distinct deposit. The vein here runs about S. 80° E. and has been traced by trenching at intervals through the whole length of the claim, or for a distance of about 1500 feet. The country-rock is a grey, rusty or green-grey schist, probably a diabase-schist, but so much decomposed in some places that it is difficult to characterize it. A drift about sixty feet in length had been run in along the lode at the time of my visit. The lode is practically vertical, with a width in some places of twelve feet of ore or mineralized rock. It is stated to be not less than six feet in width in any place where it has been exposed. The ore somewhat resembles that of the "Silver King," but contains more galena, and is more diffused through the gangue and the country-rock where exposed in the working. It also contains copper- and iron-pyrites, together with some tetrahedrite, the last-mentioned mineral being the richest in silver. Crystalline quartz, which often occurs in nearly pure masses of some size, is much more abundant than in the "Silver King" workings. This is another very promising deposit, but like the "Dandy," yields no ore rich enough for present shipment.

The group of claims to which the above description refers, including those of the Hall Brothers, are contiguous, and are comprised in a comparatively small area on and near the sources of Give-out Creek. Here, the discoveries and work already accomplished are such as to ensure a large output of rich, or rich and medium grade, silver ores, and the combination of the interests thus included within a length of less than a mile from east to west, would appear to justify the imme-

Mining Claims
Toad Mt.
continued.

diate initiation of some more efficient system of transport to the shore of the lake than that afforded by the present trail. While a waggon road with moderate grades might, I believe, be constructed from Nelson, the cost would be great, and the late date at which snow lies at the considerable altitude of these claims, as compared with that at which it entirely disappears from the lower levels, would be a drawback. The transport of ore down the steep grades of the upper part of the mountain might be arranged for, however, by a tramway to a point lower in the valley of Give-out Creek, or an aerial wire-tramway might without difficulty be constructed. Some such means of conveying the ores, together with the capital necessary for the systematic opening up of the deposits and the introduction of machinery for the fine concentration of the second quality of ore, are the most pressing needs of this locality. No very important further developments need be expected till some such facilities are available, except indeed, in the case of the richer portions of the "Silver King" lode, which may continue for some time to yield sufficient high-grade ore to pay for its working on the present comparatively ineffective system.

Cottonwood Mine.—Height above lake 2835 feet. This is situated at the extreme east end of Toad Mountain, on the summit of a spur which lies between the source of Cottonwood-Smith Creek and a small western feeder of that stream. A good trail has been constructed from Nelson to this property, which consists of three claims placed end to end on the length of the deposit, and a fourth claim lying alongside. The deposit consists essentially of a belt of pyritized schists holding gold. The rocks of the stratified series seen a short distance to the north of the deposit, and near their junction with the granite, are diabases and diabase-schists of the usual kind, and include diabase-porphyrite precisely like that previously described. In the immediate vicinity of the metalliferous belt, the rocks are chiefly schistose diabase, and the belt itself consists of similar rocks, which here and there include lenticular areas of massive diabase, together with some almost nacreous pale-grey and whitish schists. In what I have spoken of as the metalliferous belt, all these rocks are more or less completely, though irregularly, silicified, and charged with granular iron-pyrites, with here and there a little copper-pyrites and specks of galena. These pyritized schists are further, seamed in all directions by little veins and stringers of quartz, holding the same minerals but chiefly iron-pyrites. The entire superficial portion of this metalliferous belt of rock has been more or less completely oxidized to a depth varying from a couple of feet to ten, twenty, or more feet. The decomposition of the rock is usually so complete that it may be removed easily with

the pick and shovel. Some portions of the little quartz veins traversing the rocks, present in the decomposed mass an almost scoriaceous appearance, due to the removal of the iron-pyrites, and occasionally the whole of the iron-oxide produced in this process, has subsequently been leached out, leaving porous masses of white quartz. The iron-oxide thus removed has elsewhere been deposited in fissures and hollows in the form of bog-iron ore.

Mining claims,
Toad Mt.
continued.

The metalliferous belt is said to be continuously traceable throughout the length of the three claims above alluded to, and in the vicinity of the present workings must have a width of at least 300 feet. The average dip of the schists at this place is about S. 12° E. $< 80^{\circ}$, and this is probably followed by the metalliferous zone.

The assay value of the metalliferous material appears to vary considerably, and I am not in possession of such information as to be able to state what might be taken as a fair average. For the purpose of working the superficially decomposed portions of the deposit, two Huntington mills with a capacity of $12\frac{1}{2}$ tons, have been erected, and the necessary houses, ore-shoots, etc., constructed. But a small quantity of the material has, however, as yet been milled. Should the results prove satisfactory, the quantity of pyritized material which may eventually be treated by concentration and chlorination appears to be practically unlimited, and in consequence of the facility with which it may be handled and worked, a comparatively small average yield in gold would be sufficient to justify work on a large scale.

Umatilla and Uncle Sam Claims.—Height above lake (at cabin) 1280 feet. These claims are situated on the east side of Cottonwood-Smith Creek, about two miles and a half from Nelson. Together with a third claim called the "Apex," these are generally known as the "Labeau Mines." They occur in an outlier of the diabase series, the extent of which to the eastward was not ascertained. The vein opened on the two first-mentioned claims, is stated to be continuously traceable for a considerable distance and to average about two feet in width. Where I saw this vein, at a point at which a small shaft has been sunk on it, it runs N. 20° W., and is nearly vertical or dipping at an angle of about 80° to the eastward. The eastern or hanging-wall is here formed by a dyke of grey granite, five or more feet in width. The foot-wall is not well defined, the ore blending irregularly with the diabase rock on that side. The vein covered by the "Apex" claim is stated to run nearly east-and-west.

Labeau Mines.

The character of the ore obtained from this group of claims differs considerably from that elsewhere seen in the district. The quartz gangue is hard and vitreous, and more or less charged with green chloritic minerals. The metalliferous constituents are fine-grained,

and consist chiefly of galena, and an intimate mixture of galena and blende. Tetrahedrite, or some such richly argentiferous mineral probably also occurs in small quantity, irregularly disseminated.

Mining claims,
Toad Mt.,
continued.

Tough Nut Mine.—This is situated on the northern slope of Toad Mountain, at the head of Sandy Creek, and about two miles in a north-westward direction from the "Silver King." The vein here opened appears well defined. It runs S. 70° E., and is nearly vertical; the width of the ore-bearing part of the vein being, where seen, about four feet and a half. The vein has been exposed at intervals throughout the length of the claim of 1500 feet, and is seen on the summit of the ridge to the eastward on an adjoining claim known as the "Evening Tide." The ore contains galena with iron- and copper-pyrites, zinc-blende and tetrahedrite, the last named mineral being as usual the richest in silver. Crystalline quartz is moderately abundant, but a considerable part of the gangue is made up of dolomite and shattered and mineralized rock-matter. The adjacent country-rock consists of green schists of the usual character. The vein is well situated for working by means of drifts, as the hillside up which it runs is very steep, and over 900 feet in height. The work done at the time of my visit, besides surface stripping, included a drift about one hundred feet in length on the vein, and a shaft thirty feet deep at a distance of 440 feet from the mouth of the drift, and about 160 feet higher on the hill.

Several other claims have been taken up in this vicinity, but with the exception of the "Tough Nut," little or nothing has been done toward their development.

Eagle Creek.

Poorman Mine.—This is one of several claims belonging to the Eagle Creek Gold Mining Company, but on this only has any considerable work of development been accomplished. These claims, with several others in different hands, are situated about four miles west of Nelson, and the point at which most work has been done is about half a mile south of the main trail from Nelson to Sproat's Landing, on the east side of Eagle Creek. The deposits of this locality differ from all those previously described in being situated beyond the area of the stratified rocks, the country-rock here being a dark grey, mica-syenite of granitic appearance, and referable to the granites of the second period of irruption, as already noted. This, as already mentioned, is an interesting point, as showing that the granitoid rocks may under certain circumstances also prove to be metalliferous.

The lode opened up on the "Poorman" claim, runs about S. 60° E., with a northerly dip at an angle of 50° to 60°. It averages about eighteen inches in width, and seems regular and fairly constant in this respect. The gangue consists of glassy or milky quartz, and contains

copper- and iron-pyrites distributed throughout in stringers and small bunches. The gold is contained in these sulphurets, and the average value in gold per ton of the ore is stated at \$30. At the date of my visit an adit had been run in to the vein, intersecting it at a depth of about ninety-five feet from the outcrop, and since that time further work has been done, and a ten-stamp mill, with concentrators and other machinery, has been placed on the ground ready for erection in the spring.

Other Metalliferous Deposits.

Though scarcely recognized as belonging to the Toad Mountain region proper, the deposits on Eagle Creek are really on the northern slope of the mountain-mass thus named. A few outlying localities in this vicinity and elsewhere in the district, in which minerals of economic value are known to occur, may now be alluded to.

Copper Queen.—This name is applied to a discovery situated on the ^{Copper ore} north side of the Kootanie River, about a mile above the mouth of Forty-nine Creek. I was unable to visit this claim, which is described as an irregular deposit of great size. Specimens received from it, however, show the ore to consist chiefly of massive copper-pyrites. Though reported to contain a considerable proportion of silver, specimens of this ore subjected to examination in the laboratory of the Survey proved to contain only 1.4 ounce of silver to the ton, with traces of gold.

Iron Ore near the Lower Fall.—About half a mile below the lower ^{Iron ore} fall of the Kootanie River, on the north bank, and near the water's edge, is a remarkable occurrence of magnetic iron-ore. The ore is found in large loose masses weighing several tons, but owing to the want of good exposures its actual relations to the rocks adjacent could not be ascertained. The place of its occurrence is near, if not on, the line of junction of the granites with the, here, highly altered rocks of the stratified series. It appears to be associated with a dyke about forty feet in width of green-grey augite-porphyrite of somewhat peculiar appearance, which crumbles down easily under the action of the weather.* It seems probable that the iron-ore when *in situ* may form large irregular masses along the borders of this dyke.

* In this intrusive mass, according to Dr. A. C. Lawson, the predominant mineral is pyroxene, in idiomorphic porphyritic crystals, or occasionally in polysynthetic masses. The pyroxene is partially altered to hornblende and there are besides some hornblende crystals which may not have been so derived. Felspar is present, but in subordinate amount. Biotite, magnetite and chlorite are sparingly found as accessory minerals, and there is a little quartz which is probably secondary in origin.

The ore is finely granular in texture and generally free from rock-matter or other impurities, but in some places contains siliceous kernels, with epidote and brown garnet. A fragment of the ore comprising one of these kernels and rusty in appearance, was examined for gold and silver, but proved to contain neither.

North-east Arm On the north-east arm of Upper Arrow Lake, referred to on page 36 B, ten mining claims have been taken up, according to the Report of the Minister of Mines for British Columbia. Good specimens of argentiferous galena ores have been brought from these claims, which, however, were not visited by me, and on which little work has yet been done.

Quartz Veins Specimens from a quartz vein traversing the argillite-schists a short distance north of the mouth of Koos-ka-nax Creek, on Upper Arrow Lake, proved, on assay in the laboratory of the Survey, to contain neither gold nor silver.

Some specimens of a peculiar vitreous quartz traversing the gneissic and mica-schist series at the north-west corner of Kootanie Lake, though showing a little galena, also proved to contain neither gold nor silver on assay.

The occurrence of tourmaline with some peculiarities in the appearance of the granites, already referred to (p. 39 B) as being characteristic in the vicinity of Fry River on Kootanie Lake, led me to collect some of the heavier materials by washing the gravel of the river in a gold-pan, for the purpose of ascertaining whether any trace of tin could be found, but this also proved to be quite barren on analysis.