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HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY
W. H. COLLINS, DIRECTOR

Summary Report, 1928, Part A

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OTTAWA
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TOPLEY MAP-AREA, BRITISH COLUMBIA

By George Hanson and T. C. Phemister

CONTENTS

INTRODUCTION

The village of Topley is on the Canadian National railway, 285 miles west of Prince George and midway between Prince George and Prince Rupert. The area with which this report is immediately concerned stretches from Topley on the south, northwards about 12 miles; the width of the map-area is also 12 miles. The area was mapped geologically during the summer of 1928 with the aid of the topographic survey made during the previous year by Mr. MacDonald. During the work valuable assistance was rendered by Mr. A. E. Goranson and Mr. N. Freshwater.

The district has been the scene of considerable prospecting for some time past. Since the discovery of the Topley Richfield property by Mr. Taylor, in June 1926, this activity has grown until at the present time there is little unstaked ground in the neighbourhood. The only other prospect comparable in size and development with Topley Richfield group is the one about one mile to the southwest known as the Golden Eagle group. These two prospects are about 8 miles north of Topley and can easily be reached by road from that village.

The area is easy of access, the Canadian National railway and the highway from Hazelton to Prince George running along its southern boundary. From Topley a wagon road runs northwards through the area and continues to Babine lake. The northern section is in very poor condition, but the southerly part as far north as the branch road to the Topley-Richfield mine has been widened and greatly improved. The country is well provided with trails over most of which pack horses can be taken.

The only previous geological studies carried out in this district are those by Mr. D. Lay, published in the Annual Reports of the Minister of Mines, British Columbia. His detailed descriptions were of great assistance to the writers in the field. A careful study of the rocks met at the Topley Richfield mine was made also by Professor J. Turnbull of the University of British Columbia.

The writers' thanks are due to Mr. F. H. Taylor, general manager of the Topley Richfield Mining Company, for many courtesies, and to the prospectors in the field during the season, for the unselfish manner in which they gave of their experience and assistance.

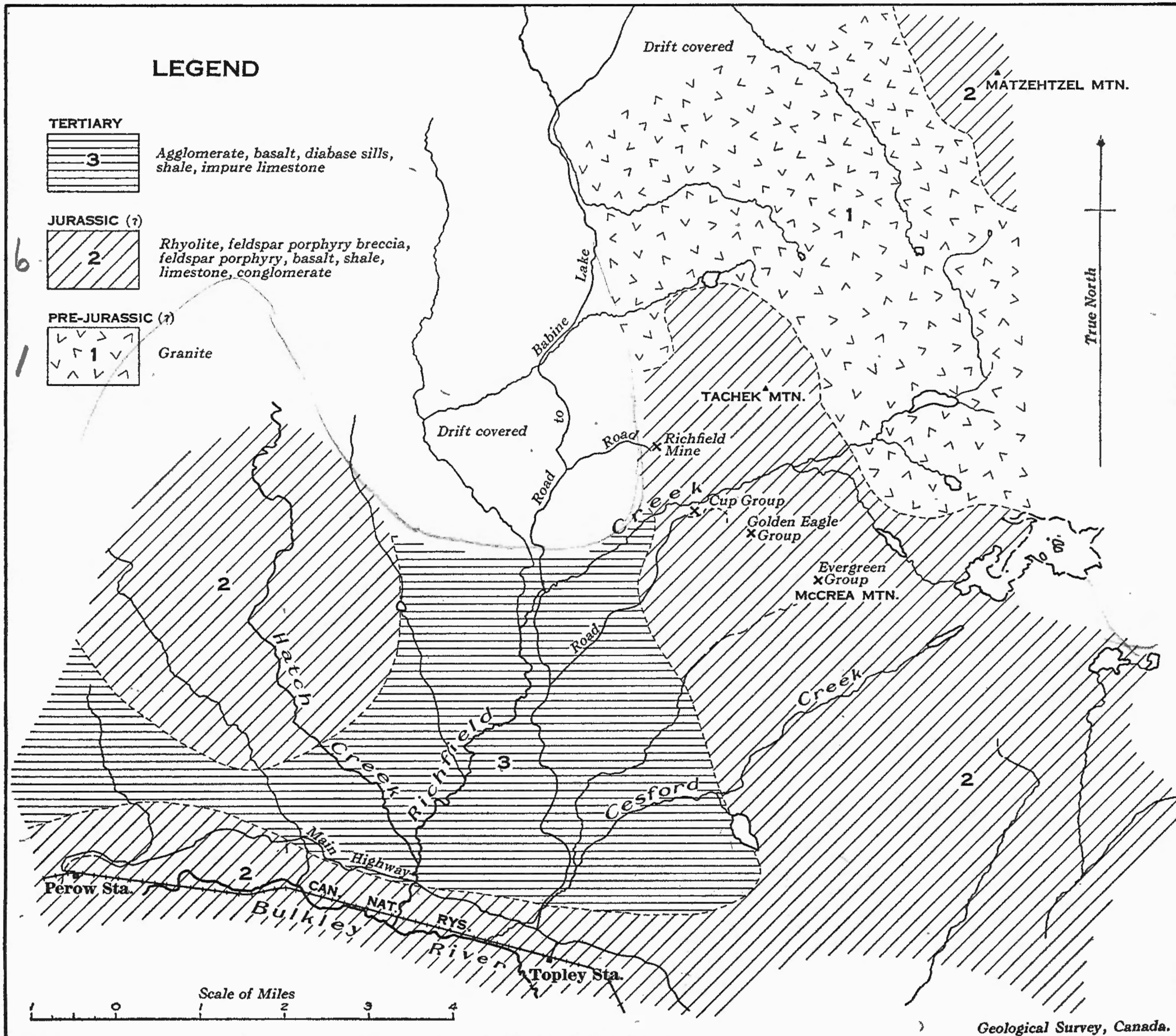

Figure 4. Topley area, Coast district, B.C.

PHYSICAL FEATURES

Topley area lies just to the west of Nechako plateau. The map-area may be divided into three topographic divisions: (1) Bulkley valley; (2) a broad valley running northwards towards Babine lake; and (3) the mountainous country to the east. Of these three divisions the first is the least conspicuous. Bulkley river here is not far from its source and, therefore, has not developed a valley at all comparable in width with that farther northwest. Prior to the location of the river in its present course there was formed a considerable thickness of sand, gravel, clay, and silt in a valley bounded by the high ground just to the south of Topley and by Tachick[1] and McCrea mountains to the northeast. In the drift sections exposed, boulder clay occurs with sands, gravels, and silts. The gravels above the boulder clay were, in many cases, derived from the latter. The boulder clay beds occur at various horizons in any one section and throughout the valley irregular patches of boulder clay pass into gravel and sand beds. Small glaciers, therefore, must have been present in the valley and before their final disappearance they probably advanced and retreated locally more than once, leaving behind them the beds of boulder clay now found at different horizons in the drift. The glacial agency, however, though important, has not been the most important factor in the formation of these drift deposits which, on the whole, consist dominantly of coarse gravels and sands. In places these show distinct bedding, but the bedded materials in many cases grade into very coarse, bouldery material lacking any signs of bedding, occurring in lens-shaped patches which pass into finer gravel and into sand beds. Examples of such relations can be seen in the cuttings in the main road, both east and west of Topley. It appears, therefore, that these deposits were formed, on the whole, by rapid, perhaps torrential streams coming from the high ground and depositing their sediment in a series of fans spread over the floor of the valley. If this were the case, there probably would be local quieter pools in which the finer sediment would settle, giving silt and clay beds. Such quiet waters would likely be only temporary and in the lowest part of the valley. This was probably a little north of the present river and there are found the largest developments of silt and clay beds. The best examples are: (1) about half a mile southeast of Topley, where an arm of the Bulkley has cut through banded silts and clays which form a steep bank about 50 feet high; and (2) on the main road about a quarter of a mile east of the bridge over Johnny David creek, where the road runs through banded, whitish silts which in dry weather give rise to a very fine white dust. Some silts and clays occur elsewhere, but nowhere occupy areas as large as those mentioned.

After the filling of this valley, the streams from the hills ran in shallow troughs in the drift and these troughs are still to be seen along most of the present creeks. The best examples are along Byman and Ailport creeks at the western and eastern edges of the area respectively. There, stretching on either side of the gorges of the present creeks, are broad, shallow valleys cut below a terrace-level that seems to mark the old top of the sediments. This terrace-level is about 2,800 feet, rising a little towards the hills. The same phenomenon can be seen along Richfield creek, although there it is not so well marked. Looking down the canyon

[1]Tachek on Figure 4.

of Richfield creek one can distinguish at the top of the canyon proper a gentle slope up to the general level of the terrace-level. If the profile of this slope be completed, one realizes that here also a broad, shallow valley existed prior to the formation of the present stream bed. We can, therefore, picture Bulkley valley at this stage as a broad valley filled with sediments, with a flat surface sloping gradually up towards the high lands to the northeast. Shallowly scooped into this surface were creeks probably sluggish and probably draining westwards along the axis of the valley. Following this stage, the streams were given great erosive power which resulted in their cutting down into the mantle of drift and, on the sides of the old valley, through that mantle into the solid rocks beneath. Owing to their greatly enhanced erosive power they were able to cut deeply into the solid rock, making narrow, steep-sided gorges of which Richfield Creek canyon is the best example. The increased westerly drainage gave the present Bulkley River valley. The river runs close to the southern side of the old valley and has formed its trough between the high ground southwards and the main mass of sediment to the north, so that some rock is exposed on its southern bank. The depth to which it cut into the sediment of the old valley is indicated by the high bluff on its southern bank just east of Perow station. Here a section of 80 to 90 feet of sand, gravel, and clay rises very steeply from the river. This thickness seems to be nearly the total thickness of the sediments at this point, for both to the west and east there are small exposures of rock in the stream bed.

In the case of Richfield creek, a tributary flowing from the north, the stream has cut a canyon through Tertiary volcanic rocks and has done so by pot-hole erosion. In the deepest part of the canyon there are some splendid examples of this process, the walls of the gorge in many cases sloping upwards and inwards from some large pot-holes now broken through. At the falls the water rushes down from one pot-hole to another. Higher up the stream where it has cut into the well-jointed Jurassic rocks, pot-hole action has been less and erosion has been determined more by joints, the steep walls of the creek in some cases being simply joint-planes from which the rock has slipped off in great blocks now lying in the bed of the creek. In the case of Ailport creek, another tributary from the north, no pot-holes developed. The creek runs along the eastern contact of a dyke. The rock on the eastern side of the dyke has been greatly shattered and it is in this material that the stream has cut its course.

The broad valley running northwards to Babine lake is one of the most important physiographic features of the area, but unfortunately little data can be acquired as to the character of the deposits forming its floor, since practically all of the valley is covered with vegetation. The only exposures found were in the banks of Hatch creek about 2 miles from the source of that stream, and if any conclusion may be drawn from this occurrence it would be that the floor of the valley consists of rock covered only by a thin layer of sediment. No sections of drift were found, but the occurrence of ridges of gravel and boulders was noted.

In the mountainous eastern country of the map-area there are two mountain ridges. These have the forms of roughly parallel arcs, convex towards the southwest. The more northerly and higher of the ridges contains Matzehtzel mountain (5,700 feet). Only part of this ridge comes into the map-area. Except for the peak of Matzehtzel mountain, the contours of this ridge are smooth. Only at the summit are there rocky eminences and these are neither high nor steep. The more southerly and westerly ridge contains as its highest point Tachick mountain (5,400 feet) with McCrea mountain (4,800 feet) to the south. The ridge becomes lower where it swings round to the east, the elevation there being 4,500 feet. Tachick mountain stands up as a squarish block with steep, rocky faces on all four sides. Towards the base the slope becomes much gentler as a rule. The mode of retreat of the face of the mountain has been mainly by the breaking off of blocks isolated by the intersection of joint-planes. Some of these joint-planes are practically vertical and some are inclined at small angles. Joint-planes with similar directions appear to prevail throughout the rocks of the mountain. Near the base, the breaking up of the rock by formation of joint-blocks and their removal will not be the dominant process, but it is higher on the mountain. Hence, the sharp change from the more gradual lower slopes to the precipitous, blocky contours of the main part of the mountain as found on the east, south, and west faces. The northern side, however, rises in a remarkably steep face with only a very short, gentler, lower slope. The reason for this departure from the normal is that beneath the main, jointed formation of the mountain, are sedimentary beds which at the contact have tended to weather away rapidly, thus undermining the formation above.

McCrea mountain presents characters similar to those of Tachick mountain, but differs in having a greater area at the top and in the character of its peaks. The latter stand out much more sharply than do the highest points on Tachick mountain. This difference is due to a difference in the character of the rock. The broad area of the top of McCrea mountain is much dissected by small valleys. The lower peak, to the southeast, presents a much more even surface than do those of Tachick and McCrea mountains. It is considerably lower than both of these and the rock of which it is composed also differs.

Between these two curved ridges of Tachick mountain and Matzehtzel mountain lies a stretch of low ground which drops to the west and northwest to the valley that strikes towards Babine lake. In the middle of this low ground, in its northern section, there is a low ridge that also sweeps round to the northwest. The contours of this ridge are very smooth and suggest a maturer topography than found elsewhere in the area.

Parts of two drainage systems occur within the map-area. All the creeks in the extreme northern part flow towards Babine lake and thence by Babine river to the Skeena. All the creeks south of this northerly section flow southwards to Bulkley river which flows westwards along the southern edge of the map-area. No well-defined watershed separates the two drainage systems, but only low, flat, swampy ground from which the dip of the surface to either north or south is scarcely appreciable. The high ground where one would expect to find watersheds did not exercise much control over the distribution of the drainage system. Thus, one section of Richfield creek, the largest creek in the area, has its sources in small lakes in the low ground between Matzehtzel mountain and Tachick mountain and cuts across the Tachick Mountain-McCrea Mountain range. The creek just to the north of Tachick mountain also comes from the same low ground. The effect of Tachick mountain is simply to deflect the stream a little to the north before it joins the main, southerly drainage into the Bulkley. In a similar way McCrea mountain has deflected the drainage from Nez lake northwards to where it joins with Richfield creek to flow south. As will be shown later, it is believed that underlying the area is a great mass of granitic rock, the surface of which seems to dip to the south in the main part of this area. Tachick Mountain and Matzehtzel Mountain ranges are residual masses of a later formation that has elsewhere been removed, revealing this older surface. It is on this resuscitated, older surface that the sources of the present creeks are mostly found.

GENERAL GEOLOGY

There are two great drawbacks to a complete understanding of the geology of this district. In the first place, the exposures are few, practically only one-tenth of the total area of the map-area showing rock outcrops. Of course, even in the drift-covered areas, there are small, isolated exposures, but since the rocks are dominantly igneous and show marked and rapid variations, the value of these small outcrops is not so great as it would be if the formations were of more uniform character. In any case, these small, isolated exposures are of very little value so far as elucidation of structure is concerned. It is in this matter of structure that the second difficulty arises, for, the formations being practically all igneous, there are no sedimentary horizons that can be followed and the degree of folding thereby determined. The main igneous formation over practically the whole of its extent shows absolutely no trace of bedding. The dominantly igneous character of the rocks presents the further difficulty of a lack of fossil evidence as to the age of these rocks, although elsewhere, igneous rocks probably of the same age as the presumably Jurassic rocks of the map-area do contain fossils.

The age classification of the rocks of Topley area is based on a comparison of the rocks met there with the formations of known age in nearby areas and on the general distribution of these formations in this part of British Columbia. Dawson at an early date carried out reconnaissance studies in the vicinity of François lake about 35 miles south of Topley. He distinguished a great series of porphyritic rocks with breccias and agglomerates, the Porphyrite group, overlain by vesicular, basaltic lavas of Tertiary age. A little to the southwest these Porphyrite rocks have later been shown to be Jurassic. About 50 miles east of Topley map-area, reconnaissance mapping has been carried out by Camsell in the stretch between Stuart and Takla lakes. There the oldest rocks are Carboniferous and are dominantly sediments. The younger formation may be Cretaceous and consists of an upper sedimentary and a lower volcanic series. The volcanic series consists of andesites, tuffs, breccias, and some rhyolites. It is overlain by Tertiary volcanic rocks. Intruding the Carboniferous, but antedating the other formations, there is a granite whose age could only be stated as "Triassic or Jurassic." No rocks of the Porphyrite group occur there. Thirty miles to the northwest of Topley more detailed geological mapping has been carried out by Hanson in Driftwood Creek district, Babine mountains. The most widespread formation is the Hazelton group which is considered to be the equivalent of the Porphyrite group of Dawson and is of Jurassic age. It is divided into three subdivisions, a lower volcanic division, a middle sedimentary division, and an upper volcanic division. The latest phase of these Hazelton rocks is a set of rhyolite and quartz-porphyry intrusions. These were followed by a series of diorite and quartz-diorite stocks and dykes which are the only other pre-Pleistocene rocks of the district, though Cretaceous sediments are found in immediately adjacent areas.

About 45 miles due west of Topley, mapping of the Telkwa River area has been carried out by Leach. In this area Lower Cretaceous sediments overlie rocks of the Porphyrite group and in the extreme west the crystalline rocks of the Coast Range occur. The rocks of the Porphyrite group are here all of igneous character.

Within Topley area the oldest formation observed lies in the low land between Tachick and Matzehtzel mountains. The rock belongs to the granite family. It forms the surface on which the rocks of the two mountains rest as great blocks and this surface dips south and perhaps also west. Although the exposed extent of the surface within the area studied is not large, its presence suggests that prior to the formation of the Jurassic rocks there must have been a considerable interval during which the land was planed down and the batholithic rocks unroofed. On this surface the first deposits formed in Topley area were a series of tuffs, shales, and limestones with some conglomeratic beds. These are exposed in only two places: (1) at the northern end of Tachick mountain, the better outcrop; and (2) a thin, poorly exposed layer of breccia-conglomerate at the southeastern end of the same mountain. Their deposition was followed by that of a great volcanic series, the sequence and character of which varied from place to place. The variation is so great that it is difficult to express it in a summary fashion, but this much may be said: to the northeast only a thin layer of feldspar porphyry breccia was formed. Southwards the first of the volcanic rocks over the greater part of the area consists of very fine-grained, reddish and purplish andesitic material much of which is porphyritic with white plagioclase and, in some cases, pink orthoclase crystals. Overlying this in Tachick mountain is a great thickness of massive feldspar-porphyry breccia which continues southwards to McCrea mountain. South from the latter mountain the rocks change to amygdaloidal basalts and to the southeast to fine-grained, purplish, porphyritic rocks which in places approach rhyolites in composition. The latest phase of the volcanism was an irregular injection of rhyolite dykes and the formation of irregular bodies of banded rhyolite and rhyolite breccias. These bodies reach their greatest development on Matzehtzel mountain where they make up practically the whole mass of the mountain. They also form the southeastern side of McCrea mountain and are the rocks of its southern peaks. After the formation of these volcanic rocks Topley area was subjected to erosional processes which carved its surface into configurations not much different from those of the present day. The highlands of the present Matzehtzel-Tachick-McCrea Mountain area were formed and a large basin developed to the south. In this basin there was formed first a series of Tertiary shales and sandstones whose distribution indicates that the deepest part of this basin was somewhat to the north of the present Bulkley river. On top of these sediments was ejected Tertiary basalt flows and agglomeratic rocks, all of which are extremely vesicular. These rocks lap up around the bases of Tachick and McCrea mountains and in Richfield Creek canyon have a slight dip towards the mountains.

Table of Formations

Age	Character of rocks, etc.	Greatest thickness
		Feet
Recent	Sands, gravels, boulder clays, silts, and clays	200
Tertiary	Vesicular, basaltic rocks with diabase sills and dykes probably of same age	400
	Shales and sandstones	50
Jurassic (?)	Dykes and flows of rhyolite and rhyolite breccia	1,000
	Feldspar-porphyry breccia, etc	1,200
	Shales, limestones, conglomerates, and breccias, with some volcanic material	300
Pre-Jurassic (?)	Granitic rocks	

DESCRIPTION OF FORMATIONS

Pre-Jurassic Granitic Rocks

These rocks occur in the low ground between Tachick and Matzehtzel mountains and outcrops were also noted north of Nez lake. They form, therefore, an arcuate outcrop bounded on the north, south, and southwest by overlying Jurassic volcanic rocks. Within this area of outcrop, however, there are, locally, small exposures of the Jurassic porphyritic rocks. It is noteworthy that such rocks in many cases occur on small knolls at about the same elevation as the base of the volcanic rocks of the mountains. Since none of the exposures has any depth it was impossible to be sure, however, that faulting had not been operative in determining their presence.

In hand specimen the granitic rocks vary considerably. Three varieties can be distinguished: (1) pink and white granite, (2) white granite, (3) grey granite. The most prevalent type, the pink granite, is a coarse, porphyritic, gneissose rock consisting of white feldspar, pink feldspar, quartz, biotite, and hornblende. The pink feldspar characteristically forms large euhedral crystals which have crystallized prior to the development of the gneissose structure, for they show all degrees of attempted alinement with the grain of the rock. Carlsbad twinning is frequently present in them and in this respect they are quite distinct from the white feldspar crystals which with quartz form the base of the rock. Although the pink feldspar crystals have been turned in the direction of the gneissosity of the rock they do not show any signs of fracturing or crushing, so that we must conceive that they were so oriented while the rest of the mass was liquid. The best exposures of this type are on the small hill about 2 miles north of the northern end of Tachick mountain. There the gneissosity strikes 35 degrees west of north, but the dip could not be determined. At this locality the pink feldspar crystals attain dimensions of 2½ and 1½ inches and many show a peripheral zone of somewhat different appearance. Cutting across the gneissose structure in this locality are quartz and pink feldspar, pegmatite veins, the largest vein observed being 9 inches wide. In the pegmatite veins the largest piece of pure, pink feldspar seen was about 3 by 2 inches. Similar pink and grey granite occurs also at the southeastern end of Tachick mountain underlying the formation of the mountain. There the gneissosity strikes 80 degrees east of north. Quartz and quartz-pink feldspar veins are present, but reach only 2 inches in width. Throughout the area underlain by the granitic rocks this coarse type is dominant, but with the exception of the two localities mentioned the gneissic structure is either absent or is irregularly developed.

The white granite is a departure from the prevailing rock type due to the absence of the porphyritic character, the rock becoming even and usually also finer grained. All gradations from the normal variety are found. In these non-porphyritic rocks very little pink feldspar is present. Such rocks show no trace of gneissose structure.

The third variety into which the second grades, is the grey granite. It is much duller than the two varieties mentioned above, the quartz content is smaller, and all the feldspar is a dirty white, greenish shade. In grain it is similar to the white granite and no porphyritic modifications were found. The third variety grades into the second, but nowhere was seen to directly grade into the first variety.

Within the granitic rocks there are many inclusions of rocks of various types. In size they vary from small fragments about 6 by 3 inches to masses certainly greater than 12 by 12 feet. From a study of hand specimens it would appear that the original material of these inclusions has been volcanic. They are now completely recrystallized and in some cases have received material from the granitic rocks. Some are hornblende and mica schists, whereas others have no alinement of prismatic or flaky minerals and are hornfelsic in character. These hornfelses, in hand specimen, appear to consist of abundant, heterogeneously arranged hornblende prisms and pinkish feldspar crystals. In practically every case thin, irregular stringers of granitic matter traverse the rock.

In many of the exposures, especially those of the coarse, pink and white granite, thin, irregular stringers of epidote are present. Spots of epidote are also scattered irregularly throughout the rock mass.

Evidence of Age. There can be no doubt that these granitic rocks are the oldest present. The evidence on which this conclusion is based is as follows.

Granite boulders occur in conglomerate, and pink feldspar similar to that in the granite occurs in a breccia overlying the granite at the base of the volcanic rocks.

Fragments of the granitic rocks also occur in the overlying volcanics which are probably of Jurassic age. The best exposures of this relationship are at the base of Matzehtzel mountain. There, in the low ground, amongst the timber and in the creek beds, are many exposures of pink and white granite and these exposures continue to the base of the mountain.

The first sign of the presence of a new formation is an abundance of large boulders of porphyrite breccia, all of which contain subangular fragments, of varying size, of the granite on which the boulders now rest. The porphyrite breccia is then met in place and the distance between the last exposure of granite and the first of porphyrite breccia is not more than 40 yards. In the last exposure of granite the rock shows no variation from the normal, coarse, pink and white type of this part of the area and no xenoliths occur. The fragments of granitic rock in the porphyrite breccia are identical with the granitic rock beneath and vary from very small up to boulders about 9 by 6 inches. The porphyrite breccia forms only a thin, irregular strip in this part of the area and the dominant formation is rhyolitic. In the lower exposures of the rhyolitic member, fragments of pink and white granite are also abundant.

Although specially searched for, no veins or dykes of granite were found traversing the Jurassic rocks. Since the presence of such minor intrusions is considered by prospectors to indicate favourable conditions for ore deposition, search for them has not been confined to geologists, but so far as the writers are aware no prospector has yet found a stringer from the granitic rocks penetrating the Jurassic rocks. It may, therefore, be taken as proved that such intrusions are absent. It seems that the most logical conclusion is that the granite is the older formation.

The granitic rocks show, in places, well-developed primary gneissose structures. Considering the origin of such structures one would expect that their strike would parallel the contact with the rocks into which the granite has been injected. The only place where this test could be applied was at the southeastern end of Tachick mountain. There, at the base of the mountain, gneissose pink and white granite occurs and its contact with the overlying formation can be located within a range of about 100 feet and runs approximately north and south. The direction of the gneissosity, however, strikes 80 degrees east of north, so that there is a marked obliquity between it and the contact. In the locality where the gneissic structure is best seen and most regularly developed, i.e., about 2 miles north of Tachick mountain, the strike of the structure is 35 degrees west of north. There is no conformity between this direction and any contact between the two formations.

Within the granitic rocks large inclusions occur and these inclusions have in all cases been greatly metamorphosed. It is to be expected, therefore, that the roof of the granite would also show considerable metamorphism. Nowhere was rock seen immediately on top of the granite, but at the north end of Tachick mountain the sediments, amongst which are limestones, are exposed down to an elevation about 200 feet above the granitic rock surface, and show no trace of thermal metamorphism.

The granitic intrusion probably took place under conditions of some lateral stress in the earth's crust. The Jurassic rocks, however, show no evidence of folding, but appear to be relatively undisturbed, so that it is improbable that they were the country rock into which the batholith was injected. The position of the outcrop of the granitic rocks with respect to the topography shows that the Jurassic rocks have been stripped off the surface of the granite and it is considered to be probable that this granitic surface underlies the whole area. The boundaries of the granitic and Jurassic formations are not determined by faults, since signs of faulting are absent.

In the general area between Hazelton and Dawson's type area of the Porphyrite group wherever the Porphyrite rocks are intruded by granitic bodies, the granitic masses stand up, usually as peaks overlooking the Porphyrite rocks. Nowhere do they occur in low ground with the Porphyrite rocks forming mountains above them. The reversal of this relation in Topley area indicates some different relationship between the granite and the Porphyrite formations and suggests that the most satisfactory explanation is that the granite is older than the Jurassic rocks of the area and that the latter formed on its surface, from which, in places, they have since been stripped.

Jurassic Rocks

In the group of rocks classed as Jurassic, three divisions are distinguished: (1) a basal series consisting of sediments; (2) overlying this conformably, so far as can be judged, a great thickness of volcanic fragmental rocks referred to in the present report as the porphyrite breccia series; and (3) rhyolitic rocks cutting the porphyrite breccia.

Basal Sediments. All the exposures of the basal sediments are on Tachick mountain on the northern and southeastern ends. The better exposure is at the northern end, but even there the outcrops are few. This end of the mountain is precipitous down to an elevation of about 4,500 feet. At this elevation, timber begins and here also are the first outcrops of the sedimentary beds. The upper beds of the sediments have weathered more rapidly than the overlying rocks, so that some undercutting of the cliffs occurs. The upper contact of the sediments can be traced along the face of the mountain, but falls eastwards, so that it is ultimately lost in the timbered land. All the sedimentary beds are covered by timber and the only exposures are on ledges within the forest. By stripping the moss in likely places other outcrops are obtained.

The exposures at the southeastern end of Tachick mountain are few and it is evident that the sedimentary layer must have thinned considerably within the length of the mountain, because here the distance between the porphyrite breccia of the mountain and the granitic rocks is not over 50 feet at the most.

The sedimentary rocks are tuffs, shales, conglomerates, and limestones. The tuffs are dense rocks, breaking in many cases with a conchoidal fracture. Their hardness is about 5 and in some cases this is the only indication that they are not limestones. They are pale grey to bluish grey and on the surface in many places they are bleached white through a depth of about 1 mm. Extremely delicate banding is present in some of the outcrops, but the banding is not continuous. The bands vary in thickness from 2 millimetres to leaf-like laminæ. Specks of pyrite are present, but are by no means abundant. The shales are bluish to purplish and probably contain a considerable amount of volcanic material. Pyrite is present and the rock weathers to a rusty mass that may readily be mistaken for gossan. Only small, isolated exposures of the conglomerates were found. In a band near the top of the series, the average grain size is about 2 millimetres. Farther down are exposures of a bed with pebbles of granitic rock similar to that to the north and about 4 inches in greatest dimension.

The component fragments of the conglomerates are subangular, rarely rounded. Quartz is the most abundant constituent. Calcite is present in the matrix. Breccias of similar characters were met in two places: (1) at the southeastern end of Tachick mountain where all the exposures are of this material; and (2) about 300 yards south of the small creek at the northern end of the mountain about ¾ mile from where it leaves the lake. The base of this breccia is light coloured. The larger and most conspicuous fragments are of a dark green rock that effervesces slightly with acid, and holds pseudomorphs after feldspar; it is probable that the fragments are altered volcanic rocks. The other quantitatively important components of the breccia are quartz and feldspar. The feldspar is of both the pink and the greenish white varieties and it is probable that along with the quartz they have been directly derived from the granitic rocks beneath. Much calcite is present, disseminated throughout the matrix. The situations of the exposures of this rock make it seem probable that the rock is very close to, if not actually at, the base of the sedimentary series. The limestone is impure and fine-grained. The only good exposure is below a peculiar trachytic, feldspar-porphyry on the lower slopes of the northwestern end of Tachick mountain. There the rock is cut by many irregularly distributed calcite veins, varying in width from mere leaves up to 4 inches. Crystals of pyrite abound; these are probably not due to hydrothermal agencies.

Porphyrite Breccia Series. This series consists of a great variety of rocks which for convenience of description may be placed into four groups. These are: (1) porphyrite breccias; (2) epidotized porphyrite breccias; (3) purplish volcanic rocks; and (4) greenish basalts and diabases.

The porphyrite breccias are the most abundant rocks of the series. They form, practically, the whole of Tachick mountain and all but the southwestern end of McCrea mountain. They occur also at the eastern end of a mountain to the southeast where they are cut through by Ailport creek. The fragments in these breccias vary greatly in size. The largest seen were 3 feet square in section and from these there are all variations down to fragments about half an inch square. The rocks vary from dark grey to purple, green, and white. In places there is a difference in colour between the fragments and the matrix, but no regular relationship was found. On weathered surfaces the breccias are much lighter in colour and, indeed, from a distance look somewhat like granitic rocks. The breccia character is beautifully exhibited on the weathered surfaces and can be more easily studied there than on a freshly broken surface. There is not, in every case, a sharp boundary between the fragments and the matrix, but instead, in many instances, the fragments are accretions of the crystalline material of the matrix into which there is a continuous gradation. In other cases, a part of the boundary of a fragment is sharp, whereas the rest of the boundary is of the transitional type. Between these two types of fragments and fragments whose whole boundary is sharply defined, there are all gradations and the materials of the matrix and of the fragments are essentially the same. These relations indicate that the breccia character was due to the aggregation of crystalline material in parts of the cooling magma. In the matrix, flow lines around the fragments occur in many cases and, throughout the mass, well-banded, somewhat rhyolitic-looking material forms short bands that fade out into more normal rock. The directions of these bands appear to be unrelated. The flow lines and the irregular distribution of bands of the rhyolite-like material indicate that the magma was viscous at the time of its crystallization and was subjected to movements. These movements and the viscous condition gave rise to the brecciated appearance.

In the typical porphyrite breccia there is no sign of vesicularity. The rock is characteristically dense and compact, with the base of the fragments and of the matrix fine to medium-grained. The rock types met in fragments and matrix are diorites, porphyritic rocks in which the dominant phenocrysts are soda-lime feldspar. The diorites hold remarkably few dark minerals. In the porphyrite varieties, which are the most abundant, the dark minerals, hornblende and augite, are also present as phenocrysts. No quartz is to be seen in hand specimen.

Porphyrite is not limited to the breccias, but occurs also as an unbrecciated rock. Such material is found on the northeastern side of the mountain west of Ailport lake and also northwards towards Nez and Ailport lakes. It occurs also in some exposures in the lower ground of the area, but its areal distribution there cannot be determined on account of the drift, although from its distribution it would appear as if it were below the porphyrite breccia. At the northern end of Tachick mountain a variety of the porphyrite occurs beneath the main formation of the mountain. It consists of remarkably white plagioclase crystals about a quarter of an inch in length, in many cases in radiating intergrowths, set in a very fine-grained, purple matrix in which a few small crystals of hornblende also occur. At higher elevations fragments of this rock occur in the porphyrite breccia. Normally only one kind of feldspar is to be observed in the porphyrites, but about half-way up Hatch creek, a little to the east of that stream, in addition to the whitish plagioclase, there are also large crystals of pink orthoclase. These orthoclase crystals attain dimensions of as much as 1 inch by ½ inch and seem to be of a different generation from the much smaller, plagioclase crystals, for whereas the latter show perfectly sharp boundaries against the matrix, the orthoclase crystals have been much corroded and in some cases are mere ghosts of their former selves. The plagioclase crystals in one or two cases appear to have replaced orthoclase crystals. Quartz and mica are also present in this rock and probably it approaches a type intermediate between the latites and the dacites.

Much of the porphyrite breccia has undergone alteration to epidote. This alteration is displayed practically throughout the whole of the formation, but is especially pronounced on the western exposures of these rocks on Tachick mountain and southwards to McCrea mountain. The epidote occurs in various ways. It is present frequently as numerous, thin veins of irregular distribution. The boundaries of the veins are, in some cases, sharp, but in just as many instances the epidote has spread outwards into the porphyrite so that there is no distinct boundary between vein and rock. The thickest vein seen was 9 inches wide and occurred just west of the Cup group on Richfield creek. In the middle of the veins there are many open spaces lined with quartz and calcite, but not sulphides so far as was observed. The formation of the veins must have taken place after the rock in which they are now found had become sufficiently rigid to yield by fracture, but the epidotization process may have been effective before complete solidification of the porphyrites as a whole, for the peripheries of many of the fragments of the breccia are completely altered to epidote, whereas the matrix in which they lie shows no sign of the alteration in hand specimen. This relation may indicate that these fragments were acted upon by the altering agent prior to their final cementing in the breccia. The process of alteration of the fragments has been carried to completion in many cases and all gradations occur from fragments altered only along a narrow peripheral zone to others completely changed to epidote—at least so far as can be ascertained from examination of hand specimens. Within such completely altered fragments there are, in many cases, vugs, and some of these vugs are lined with crystals of epidote, quartz, and calcite.

At the top and at the bottom of the porphyrite series occur volcanic rocks of considerable variety, but all are reddish purple and of very fine grain. At the northern end of Tachick mountain, underlying the main formation of the mountain and immediately overlying the sediments, there are rocks of this class. The lowest member has patchy texture due to some parts showing many small phenocrysts and other parts none. There are no sharp boundaries between these patches. Upwards this material gives place to the already described more porphyritic rock with phenocrysts up to about one millimetre in length. Above this occurs the porphyrite with very white plagioclase crystals and purple base.

The purple volcanic rocks which occur at the top of the series, above the porphyrite breccia, are different from those at the bottom and probably represent more rapidly chilled varieties of the porphyrite breccia. The upper development shows rhyolitic tendencies and many of the rocks are banded and have their feldspar crystals arranged with their longer dimensions roughly parallel to the direction of the banding. In the field, in places, they appear like flagstones, showing dip and strike like sedimentary rocks. The dips observed seem to indicate that the inclination of the flows varies irregularly from place to place. Since, however, none dips at very high angles it is probable that the formation as a whole is comparatively flat.

An important variety of these purple volcanic rocks is a markedly amygdaloidal and vesicular rock. It is in considerable abundance in the gorge of Ailport creek where it passes in places into a breccia, with a very irregular concentration of phenocrysts relative to base in different parts of the rock. As in the porphyrite breccia of Tachick mountain, some fragments have sharp boundaries and others have poorly defined boundaries or lack them. Similar amygdaloidal and vesicular basalts occur on the eastern part of the mountain between Cesford and Ailport creeks.

On the southwestern and middle parts of the mountain between Cesford and Ailport creeks there occurs a series of greenish rocks, some of which have the texture of basalts and some that of diabases. Their relations to the other rocks of the mountain could not be accurately determined, but they appear to be of the same general age as the purplish volcanic rocks described above, for the latter pass into them without any marked unconformity such as is found elsewhere between the Jurassic and Tertiary volcanics and, furthermore, on the southwestern side of the mountain, rhyolite cuts these rocks. These greenish rocks, moreover, are much more altered than any of the Tertiary and the majority of the basalts are amygdaloidal, whereas the basalts of Richfield creek, etc., are typically vesicular. The filling of the amygdules consists of quartz and calcite and in the majority of cases calcite is widespread throughout the rock, due to alteration of the primary minerals. Thin veins of calcite are also present. At the southwestern side of the mountain between Cesford and Ailport creeks the best examples of the developments of the diabasic texture are found. There, on the lower slopes of the hill, the rock becomes very coarse and in places is best described as a gabbro-diabase. Within it are segregations of extremely coarse material, one of the best examples seen being a roughly triangular segregation about 8 inches by 9 inches by 12 inches. Within it the plagioclase crystals are, on an average, about 1 inch by $\frac{1}{4}$ inch, and are arranged in a criss-cross manner. The rock at this point is much veined by epidote and also by thin, white veins of saussurite substance.

Rhyolite Series. These rocks make up practically the whole of the part of Matzehtzel mountain that is included in the map-area, and stretch eastwards from this point. They occur also on the southwestern corner of McCrea mountain, and dykes and irregular intrusions of rocks of this group are found throughout other parts of both McCrea and the mountain between Cesford and Ailport creeks. It is difficult to determine exactly how these rocks occur, whether they are flows, dykes, sills, or more irregular intrusions. At some places on the southwestern part of McCrea mountain distinct dykes of rhyolite occur, but in most exposures the rhyolite appears to be a flow breccia of irregular thickness and distribution. On Matzehtzel mountain some of the banding of the rhyolite is almost vertical, suggesting dyke-like bodies.

Amongst these rhyolite rocks there is great variety. The types met are: (1) light-coloured rhyolites with practically no phenocrysts; (2) very well-banded, pink rhyolite; (3) dense, black, structureless rhyolite; (4) porphyritic rhyolite, the phenocrysts being practically all feldspar with occasionally some hornblende; (5) flow breccias with angular fragments of rhyolite in a rhyolite matrix that flows around the fragments, the rhyolite of matrix and fragments is in some cases porphyritic; (6) undirected rhyolite breccias with angular fragments of pink and black rhyolite in rhyolite matrix. In all these types epidote occurs as small cavity-fillings, or as irregular stringers, or as alteration products of feldspar. The latter mineral is practically always altered and appears white, pink, or green. In the rhyolite porphyrites the matrix is coarser than in the non-porphyritic variety and in some extreme cases is almost identical with some of the finer phases of the porphyrites of the area.

Correlation and Age. No fossils were found in these rocks. They agree in characters with the Jurassic, Hazelton, or Porphyrite rocks. A comparison with those of proved Jurassic age in Driftwood Creek area emphasizes the probable correctness of the view that the Topley rocks also are Jurassic. In Driftwood Creek area Hanson distinguishes four divisions of these Jurassic rocks; a lower volcanic, a sedimentary, an upper volcanic, and a rhyolite division. In the upper volcanic division the base consists of amygdaloidal lavas or tuffs and tuffaceous sediments. Breccias occur and in the eastern part of the area there are crystalline, feldspathic porphyries several hundred feet thick, which are interpreted as sills. These rocks agree in general characters with the Topley porphyrite series. Rhyolite flows occur in Driftwood Creek area and in Topley area the close of this phase of the igneous activity was also marked by the injection of rhyolite material. It thus seems that the Topley rocks were contemporaneous with the upper volcanic and rhyolitic divisions of Driftwood Creek district.

Tertiary Rocks

Practically all these rocks occur in the lower areas in a basin that coincides in general with the present Bulkley valley. On Matzehtzel mountain, however, at an elevation of 5,000 feet, a small patch of volcanic rock was found overlying and enclosing fragments of the porphyrite breccia, so that we must consider that though the accumulation of the Tertiary volcanic rocks was in the depressions, their source was, in some cases at least, at greater elevations.

At the base of the Tertiary rocks are sediments which are nowhere well exposed and are best developed on Byman creek. There, about three-fourths of a mile north of the road crossing, the creek passes into a gorge which has been the locus of faulting that strikes roughly north-south. There has been considerable dragging of the beds into the fault-plane, so that no reliable estimate of their thickness can be made. The rock consists of impure limestones, black shales, and intercalated volcanic rocks which are now almost completely altered to dark green chloritic products. In these beds there has been evidently considerable disturbance, part of which may possibly be due to the accumulation above them of the great thickness of volcanic material. There has, also, been a great deal of alteration of solution and of reprecipitation. These processes have been facilitated by the fracturing of the beds, but they have probably been due mainly to the movement of ground water along this plane of unconformity. One of the effects of these processes has been the formation of many calcite veins in both the impure limestones and shales. These veins, since some contain pyrite, are apt to be mistaken for valuable mineral veins, but their mode of origin makes it improbable that they will contain any values. A much veined rock of this series is found also on Richfield creek, about one-fourth of a mile north of the road-crossing. Here practically the whole of the originally calcareous rock has been broken across by veins and cavities filled by crusts of calcite. It is improbable that these basal Tertiary sediments are anywhere thicker than about 50 feet.

The volcanic rocks, which make up by far the greater thickness of the Tertiary material, are exposed in a splendid section in the canyon of Richfield creek. The rock types are feldspar-porphyry flows with very coarse crystals of labradorite, agglomerates, columnar basalts, and vesicular basalts. These rocks, on the whole, dip gently northeast and this dip is probably due to their formation on the sloping sides of the basin. They are cut by dykes and sills of fresh diabase. All the material of the agglomerates and basalt flows is vesicular. The degree of vesicularity varies considerably and the more vesicular varieties weather more rapidly than the less vesicular types. In some cases the fragments of the agglomerates are spherical masses up to 20 feet in diameter. These are practically glassy on their periphery, with vesicles elongated circumferentially. Inwards the mass becomes somewhat more vesicular, but is always markedly less so than the matrix. The latter in most cases is almost a pumice and, therefore, weathers very rapidly. In the weathered rock faces in the canyon of Richfield creek, south and north of the falls, the large, spherical masses stand out like great carbuncles in a mass that below shows signs of stratification. Some of the apparent stratification is due to alternation of flows of different vesicularity.

The greatest thickness of these volcanic rocks is about 400 feet.

Age and Correlation. There are three principal reasons for placing these rocks in the Tertiary: (1) They overlie unconformably the Jurassic rocks; (2) they are lithologically similar to the Tertiary rocks to the south; and, (3) they occupy a structural position similar to the Tertiary rocks to the south, i.e., they fill valleys not much different in location and extent from those of the present day and are overlain by drift of glacial origin.

STRUCTURE

Lack of exposures makes an accurate determination of the structure of the area impossible. Enough data have been acquired, however, to establish the more important facts concerning the structure. (1) The granitic rocks in the low ground between Tachick and Matzehtzel mountains underlie the Jurassic rocks of these mountains. (2) The Jurassic rocks dip gently northwards on Tachick mountain. (3) The porphyrite breccia is cut and overlain by the rocks of the rhyolitic series. (4) The Tertiary sediments and lavas lie in basins in the Jurassic rocks, these basins not being very much different in location and in outline from those of the present day. (5) Faulting has occurred along the western base of Tachick mountain in lines running about magnetic north.

The precise contours of the granite surface beneath the Jurassic rocks are unknown and it is not known to what extent, if any, folding or faulting has affected the Jurassic and pre-Jurassic rocks. However, since the granitic rocks occur at both the northern and southeastern ends of Tachick mountain and do not reappear to the south, it seems reasonable to assume that the granite surface dips gently southwards and that, moreover, folding and faulting have not much influenced the distribution of the rocks. The degree of faulting on the western base of Tachick mountain could not be ascertained, but it may be in part responsible for the presence of the granitic rocks at the lower part of the northwestern corner of the mountain. This faulting appears to continue southwards, for, on Richfield creek, the most westerly exposure of the porphyrite breccia shows evidence of considerable shearing. Evidence of faulting is also to be found in the rocks on Ailport, Hatch, and Byman creeks. The faulting in these creeks does not, however, appear to be of any great displacement and certainly has not exerted any marked influence on the distribution of the formations.

The area is regarded as being close to the eastern limit of the Jurassic rocks. The low ground between Tachick and Matzehtzel mountains is a "window" in which we see the rocks of the basement which here consists of granitic material. This surface dips gently southwards. All reports dealing with the Jurassic rocks immediately to the east of the Coast range speak of them as being of great thickness and as nowhere having their base exposed. Dawson estimated their thickness at 10,000 feet in the country south of François lake and Marshall has recently given even a greater thickness to the group in the area immediately adjacent to the Coast range. Next to the Coast range these Porphyrite rocks have been subjected to considerable folding. Topley area was apparently too remote from the focus of these movements to suffer any marked distortion, and its Jurassic rocks probably dip uniformly westwards and southwards. Denudation in pre-Tertiary time produced a basin in the southern section of the area and here first some sediments and then a great thickness of volcanic rocks were formed in Tertiary time. In late Tertiary, or post-Tertiary, minor faulting occurred.

ECONOMIC GEOLOGY

GENERAL STATEMENT

All the mineral deposits are veins and replacement deposits and, so far as present prospecting has shown, are confined entirely to Jurassic rocks. In considering this statement, however, it must be kept in mind that practically all the best outcrops of the district consist of these Jurassic rocks, these being the formation of the mountains. Although there are abundant smaller outcrops of the granite, yet the exposures occur in heavily timbered land in which prospecting is difficult. In the granite outside of the map-area two cases of cupriferous staining were reported to the writers, but no primary copper sulphide was seen. In the Tertiary volcanic rocks, in their best exposures in Richfield Creek canyon, no signs of mineralization were observed and since it is probable that practically the whole thickness of the formation is visible in this gorge, the suggestion is that the ore-bodies were formed in pre-Tertiary time. In the sediments at the base of the Tertiary, especially in the impure limestones, pyrite occurs, in some cases quite abundantly, as for example in the lower parts of Byman creek. Such occurrences, however, are probably to be referred to reduction of iron sulphates by carbonaceous matter under atmospheric conditions and not to hydrothermal agencies. No values in precious metals are to be expected in such cases.

So far, mining activity in the district has not gone beyond the prospecting stage. One of the great difficulties with the ore-bodies so far found has been the determinations of their extent in a horizontal direction. The ore-bodies occur near the base of the mountains and are covered by a mantle of drift the thickness of which varies rapidly and irregularly. At the Topley Richfield mine the drift is locally as much as 50 feet thick. From investigation of the surface it is practically impossible to come to any reliable conclusion as to the detailed structure in the vicinity of the prospects and perhaps the cheapest method of obtaining reliable information is by the use of the diamond drill. Up to the present, this method of attack has been employed only at the Topley Richfield group.

MINERALOGY

Classified according to mineral content, three types of deposits can be distinguished. These are: (1) Replacement deposits and veins containing pyrite, chalcopyrite, sphalerite, galena, and tetrahedrite, with a quartz and calcite gangue. Gold and silver values occur with these deposits. (2) Veins containing specularite, with quartz and epidote gangue and in some cases with some pyrite and chalcopyrite. These contain little or no values in gold or silver, so far as work up to the present has shown. (3) Veins containing galena and chalcopyrite with barite and carbonate gangue. There is not yet sufficient reliable data to hand to make possible a generalization on the precious metals content of this type of vein.

None of the minerals presents characters meriting special mention, except perhaps the sphalerite. This mineral shows a variety of shades from almost colourless through green to greenish brown and brown. A crystal from the Golden Eagle group shows a peripheral zone of emerald green and a core of the colour of amber. The form of the crystal is determined mainly by dodecahedral cleavage planes, but a tetrahedral face is present. The lustre on the cleavage surfaces is adamantine, whereas the tetrahedral face is much duller.

The country rock of the first of these types is always the porphyrite breccia and the deposits appear to occur only in the areas where the rocks of this series show pronounced epidotization. Thus the Topley Richfield mine, and the workings of the Cup and Golden Eagle groups, are located in porphyrite breccia which shows epidotization in a marked degree. Indeed the belt of porphyrite breccia stretching between these three properties shows the greatest development of epidote found in the area mapped. It should be noted, however, that there is no direct relation between the degree of epidotization at any point and the abundance of mineral, i.e., although the veins occur in the area of greatest epidotization yet within that area the greatest mineralization and the greatest development of epidote do not go hand in hand. Furthermore, there is no evidence of epidote having been formed with the minerals in the veins, so that there does not appear to be any reason for assuming any direct genetic relationship between the phenomena of epidotization and of mineralization. The veins of this type have usually sharp walls and vary in width from a fraction of an inch to about 8 feet. Information as to their length and depth is as yet scanty, but one vein in the Topley Richfield mine is known to be as much as 300 feet long. The larger veins are usually banded. The bands are due to: (a) presence of different minerals in the various bands, and (b) remnants of altered wall-rock, these remnants being parallel to the walls of the vein. The irregular characters of the boundaries of these included fragments of the walls indicate that replacement has been operative in determining their isolation within the vein. Fissure filling has also been a mode of mineral formation, for we find an abundance of crystal-lined cavities within the veins and some of the banding also is obviously due to the formation of a coating of one mineral, the crystals of which have projected into the open space, and then the deposition of a layer of another mineral on top of this crust. The formation of these larger veins appears, therefore, to have taken place along a fracture zone within which there were many small fissures between the individual fractures. These fissures were filled wholly or in part by crusts of minerals and the rock between fracture planes was replaced in varying degree.

The replacement deposits are tabular and vein-like, but although they are the more important mineral deposits at the Topley Richfield mine and have consequently been explored by underground workings, very little is known yet about their age or mode of origin. It is not known whether the loci of the replacing solutions were fractures, beds, or shear zones. Individual replacement deposits are known to be as much as 50 feet long and 6 feet thick, but as they have been developed on only one level their depth is not known. From the evidence so far collected it seems possible that though an individual replacement deposit may not persist for any great distance along the strike, yet its place may be taken by another adjacent one, so that an *en échellon* arrangement is suggested.

The veins of type (2), specularite with or without pyrite and chalcopyrite, in a gangue of quartz and epidote, occur either within the rhyolite or in the sheared and altered porphyrite breccia immediately adjacent to it. In some cases, as on the northwestern end of the mountain between Cesford and Ailport creeks, blocks of porphyrite breccia have been isolated by the intrusion of the rhyolite and within these blocks, hematite-quartz-epidote veins, with in some cases, chalcopyrite, occur. So far the only prospects in this type of vein have been located on McCrea mountain. Matzehtzel mountain, where the rhyolite series is best developed, either shows no such mineralization or prospecting has not been sufficiently intensive to bring it to light. This type of mineralization is present in small, irregular veins, usually of very small width, and in some occurrences they form knots from which veinlets stretch into the surrounding rock.

The only veins with barite gangue (type 3) so far located have been in the porphyrite breccia, one about the middle of McCrea mountain and the other at the eastern end of the mountain between Cesford and Ailport creeks. In the latter case the porphyrite breccia is of a much more open type than that of Tachick mountain, but it is doubtful if this fact has any relation to the special type of gangue here found.

Metasomatic Processes

Attention has been drawn by previous observers to the alteration of the rock associated with the main mineralization in this area and a laboratory study of the altered material has been made by Mr. V. Dolmage of the Geological Survey. The results of this study have been written up in the Annual Report of the Minister of Mines, British Columbia, 1926, pages 139, 140. The following partial chemical analyses of three samples of altered rock at the Topley Richfield mine, by the Bureau of Mines, British Columbia, are taken from page 140 of the above-mentioned report.

—	Per cent	Per cent	Per cent
Gold	trace	....	trace
Silver	trace	....	0·4
SiO_2	44·4	63·2	50·8
Al_2O_3	2·3	2·0	1·0
Fe_2O_3	7·1	9·7	8·0
$CaCO_3$	20·4	11·8	17·0
$MgCO_3$	17·5	5·1	15·3

The minerals in the altered rock are chiefly quartz, calcite, and dolomite. Since the characters of the unaltered rock had not been fully determined at the time of these studies it was not possible to trace the course of the alteration. Although no further chemical analyses are yet to hand, a little fuller explanation of the phenomenon is possible and is attempted below.

In general it may be said that mineralization in the porphyrite breccia occurs only in areas exhibiting this particular, yet to be described, type of rock alteration. Thus all the veins of Topley Richfield group occur in a section of the porphyrite breccia that is intersected by zones of alteration, and the same holds true for the veins at the Golden Eagle group and elsewhere. The alteration in these areas appears to have taken place laterally from small cracks which are now in some cases filled with calcite. These cracks may or may not contain sulphides, for though mineralization occurs only in areas that show rock alteration, yet within these areas the mineralization does not follow the alteration in detail. This point has been mentioned by Mr. Lay and by Professor Turnbull in the case of the mineralization at Topley Richfield mine and the same feature can be observed at other prospects. The relation, therefore, between the mineralization and the alteration is of somewhat the same type as that between the former and the epidotization of the porphyrite breccia mentioned above. There is this difference, however, that the areas of this type of alteration are more local than those of epidotization which is on a much larger scale. The mineralization, therefore, bears a closer general relation to the rock alteration than to epidotization.

The boundaries between altered and unaltered porphyrite breccia are remarkably sharp. This relation is well shown in specimens from the Topley Richfield area. In them typical porphyrite breccia, to all outward appearance quite unaltered, is separated, in many cases, by a knife-like boundary, from material so completely transformed that no trace of even the original texture remains. A similar relation is to be observed in the case of the wall-rock of some of the veins, as, for example, the east vein at Topley Richfield mine which in the exposure is about 3 feet in width. The zone of alteration bordering the vein cannot exceed about 6 inches and the rock beyond is apparently normal porphyrite breccia.

In the least altered phase, the base of the rock consists of a greenish chlorite, white mica, calcite, and quartz. All the crystals are minute. The feldspar phenocrysts have undergone practically complete alteration to white mica, calcite, and quartz, which occur as exceedingly fine-grained aggregates with boundaries representing those of the original feldspar crystals. The ferromagnesian phenocrysts are completely altered to chlorite pseudomorphs. There is no evidence that the alteration has proceeded from small cracks. The agents affecting the alteration, perhaps mainly water and carbon dioxide, must have permeated the rock, but, on the other hand, the products of the reactions remained in the place where the reaction took place. The original texture of the rock has, therefore, not been destroyed and in hand specimens the shapes of the original individual crystals have been preserved and the breccia character of the rock is still apparent. The rock as a whole, however, has become much softer due to the formation of softer minerals and the extremely fine-grained character of the alteration product.

In another phase the alteration, even more intense, is to white mica, and there is a partial loss of the original textural characters. The ferromagnesian minerals are completely altered to chlorite and serpentine pseudomorphs. In the groundmass, along with the white mica, are long prisms of colourless amphibole arranged in criss-cross fashion. Some calcite, serpentine, and quartz are present. Narrow veins of calcite and of quartz are visible, though they are scarcely to be perceived in hand specimens. The rock is usually whitish to greenish, and, on cursory examination, shows no signs of its original characters. A closer inspection, however, reveals small, rectangular areas which differ slightly in colour from the rest of the rock. These are the now wholly altered feldspar phenocrysts. The rock also presents a blotched appearance and this is all that remains of the original breccia character. That any trace of this primary structure remains at all is due to the fact that some of the original fragments were very high in feldspar phenocrysts, so that, in the alteration, they have given a patch somewhat lighter in colour than the rest of the rock. In still more highly altered material even this feature has disappeared and the rock is entirely without sign of its original character. It is an aggregate of white mica, calcite, serpentine, chlorite, colourless amphibole, and quartz. Under the microscope the serpentine and chlorite can be seen aggregated here and there, such aggregations probably representing former ferromagnesian minerals, but, on the whole, no trace of the original crystals remains. Microscopic veins of calcite and of quartz are numerous. Many similar veins are also visible in hand specimens and due to these veins, many of which are open in the centre, the rock is much more open textured than in any of the other phases of the alteration. There has been considerable introduction of new material, principally calcite with some quartz and a little sulphide.

In the less altered material, the dominant process seems to have been one of alteration of the material already present. In the more advanced stages of the alteration of the rock there has been an ever increasing addition of material. The materials introduced, carbonate and silica, become more and more the important components of the system, until finally there results a replacement of the rock by carbonate and silica. This is a dense, whitish to light brown, rock with a somewhat conchoidal fracture and with, in some cases, the lustre and appearance of flint. It is, however, easily scratched with the knife and effervesces with acid. Cubes of pyrite are present and thin veins of compact calcite traverse it.

Though, for purposes of description, these phases of the alteration have been described as though they were quite distinct, it must be remembered that in the field all variations, from completely altered to fresh porphyrite, occur and, in some cases, in most confusing relationships. In the Topley Richfield mine the rock alteration has been further complicated by later shearing which broke up and brought together in perplexing relationships, completely altered rock, black sheared porphyrite, and fragments of quartz veins.

Origin of the Mineral Deposits

The origin of the mineral deposits has not been established. It has been stated that the chief mineral deposits occur in porphyrite breccia in an area that shows considerable epidotization. If, however, the epidotization is related to a late stage in the consolidation of the porphyrite breccia its relation to much later mineral deposits must be remote, in which case the association of mineral deposit and epidotized areas is fortuitous.

It is probable that a strong fracture fault or shear zone existed at the Topley Richfield deposit prior to its deposition and if so this suggests that the area as a whole was consolidated prior to the fracturing. The parallelism of several veins, e.g., those on the Golden Eagle and Box groups, suggests for their pre-ore fractures a common regional origin which also suggests that the area as a whole was consolidated prior to mineral deposition.

It seems, therefore, that the source of the ore is intrusive rock younger than the porphyrite breccia. This intrusive may be represented by the rhyolite, which occurs in the area, or it may be still younger and if so does not outcrop in the area.

The veins of type 2 show such a close relation to the rhyolite that there seems little doubt that they have been derived from that magma. In some cases their form suggests that they are segregations from the rhyolite, since they form small, irregular masses completely enclosed by that rock.

Oxidation, Etc.

In the deposits examined the oxidized zone is of very small depth, and in some cases is practically absent. The minerals found are iron hydroxide, malachite, azurite, and, in one case, a few small crystals of chalcanthite. The evidence so far available indicates that very little if any secondary enrichment is to be expected. Below the shallow oxidized zone, the minerals of the veins appear quite unaltered and of primary generation.

DESCRIPTION OF PROPERTIES

TOPLEY RICHFIELD MINE[1]

The Richfield group of mineral claims is north of Richfield creek at the base of Tachick mountain 8 miles from Topley. A good automobile road connects the property with the Canadian National railway and the Hazelton-Vancouver highway at Topley.

The claims were staked in June, 1920, by F. H. Taylor and Wesley Banta and were known then as the Red Top group. The property was taken under option by the Standard Silver Lead Mining Company who did some 700 feet of underground work before relinquishing the option in July, 1927. In the autumn of 1927 Mr. Taylor organized the Topley Richfield Mining Company, Limited, to develop the property, which then became known as the Richfield group of claims or the Topley Richfield mine. Mr. Taylor is the general manager at the mine and since commencing operations late in 1927 has maintained continuous underground development.

The country rock at the mine consists of fragmental volcanic rocks referred to in this report as porphyrite breccia. Because glacial drift is thick and plentiful, bedrock can be seen practically only in the mine workings. The rock is strongly sheared locally and near the mineral

[1] Ann. Rept., Minister of Mines, B.C., 1927, pp. 140–147; 1926, pp. 121, 122, 138–143.

deposits is intensely altered to a soft rock consisting chiefly of magnesium and calcium carbonates. This alteration product is known locally as "topleyite" and has been discussed in preceding pages.

One zone of post-ore shearing is so far known. It is exposed by the mine workings and lies chiefly west of the mineral deposits, but also includes them in some places. The sheared zone has not been completely crosscut, but it is more than 75 feet wide. The sheared rock is a fissile, soft, chlorite schist. Some shearing probably took place prior to mineral deposition and some, if not all, certainly took place later. Fragments of altered wall-rock and of ore in the shear zone adjacent to the ore-body show clearly that some of the shearing took place after the ore was deposited.

Two mineral deposits occur on the Richfield group and are known locally as the "North vein" and the "East vein". All of the underground work except diamond drilling has been done on the "North vein."

The "East vein" is about 370 feet east of the most northerly known point on the "North vein". It strikes north and dips 65 degrees west. Open-cuts prove a length of 100 feet and a width of 3 feet. This is a clear-cut vein occupying a single fissure. It is roughly banded in that one of the constituents, tetrahedrite, is commonly present in narrow bands a quarter of an inch or more wide. The vein consists of quartz and the sulphides, pyrite, chalcopyrite, sphalerite, galena, and tetrahedrite. The pyrite is disseminated through the quartz. Sphalerite is fairly abundant and is in most places of a normal resin colour, but is in some places yellowish green. Chalcopyrite is not so plentiful as sphalerite. Galena is fairly abundant and has been rendered gneissic by post-ore earth movements. Tetrahedrite is fairly abundant and commonly occurs in fine bands. Two diamond drill holes drilled to intersect the "East vein" showed narrow mineral deposits slightly below commercial grade from 100 to 200 feet below the surface. These, although not commercial, contain 0·6 to 0·2 ounce of gold and from 1 to 4 ounces of silver per ton. It is not known whether these deposits are to be correlated with the vein sought. A crosscut has been driven east 400 feet from the workings on the "North vein" to intersect the "East vein". This crosscut about 150 feet below the outcrop of the "East vein" exposes some half a dozen clear-cut quartz sulphide stringers up to 6 inches wide, but although it had gone beyond the point where the "East vein" was expected, it had not encountered any larger veins that could be correlated with the "East vein" at the time of the writer's visit in early September, 1928. Further development will be necessary to prove the value of this vein.

The "North vein" has been developed by two shafts, by some 2,000 feet of drifts and crosscuts, and by several diamond drill holes below the level of the drifts. A shaft sunk on the discovery outcrop of the deposit follows it downward about 70 feet on a dip of about 50 degrees. Drifts were driven north and south from the shaft, and later the second shaft was sunk for purposes of ventilation. The drifts about 50 feet below the collar of the discovery shaft extend south 100 feet and north 750 feet. Crosscuts have been driven east at distances of 60, 220, and 570 feet north of the shaft, the one at 570 feet being the one driven to cut the "East vein". Crosscuts to the west are at the shaft, and at distances of 100, 140, and 400 feet north of the shaft. The ground rises to the north, so that at the beginning of the "East vein crosscut" the drift is 100 feet below the surface.

The development has shown that the "North vein" is not a single mineral deposit, but consists of veins and replacement deposits. The northern part of the workings expose a definite quartz sulphide vein striking north 30 degrees east and dipping 45 degrees west. The vein is 280 feet long and 3 to 12 feet wide. It consists essentially of quartz and pyrite and where exposed in the workings is below commercial grade. About 220 feet north of the shaft, near the south end of the quartz-pyrite vein first mentioned, a horizontal quartz sulphide vein has been followed east for 100 feet. South of the shaft a drift driven south for 100 feet encounters two vein-like replacement deposits each several feet wide and about 5 feet apart. They strike north 30 degrees east and dip 45 degrees to 10 degrees west. They may be faulted portions of a single deposit. In any case the deposits appear to enter the east wall of the drift and the northward continuation should pass east of the shaft. Another definite vein is exposed in the crosscut to the east, 60 feet north of the shaft. The strike of this vein is about north 30 degrees east and the dip is vertical. Between the shaft and the flat vein 220 feet farther north are at least three tabular replacement deposits, each several feet thick and 2 to 6 feet apart. They strike roughly north 30 degrees east and dip at varying angles west. The southward continuation of these deposits should pass west of the shaft. These deposits are folded and broken. Diamond drill holes drilled from the surface to explore the "North vein" at depths ranging from 100 feet to 400 feet had at the time of the writer's visit failed to locate any ore-body that can be definitely correlated with deposits in the mine workings, although they did penetrate several mineral bodies. This condition is not to be wondered at, as the deposits are very irregular and until they are followed downward for some distance along the dip very little can be known of their probable location at greater depth. According to a report by J. M. Turnbull, consulting engineer for the company, issued in January, 1929, further diamond drilling has been done from underground stations with the result that commercial ore has been found in several places below the drift level.

The deposits, particularly the replacement deposits, appear to be rather short. Faults are numerous and it is quite possible that a solution of all the fault problems would indicate one or more fairly regular deposits. Shearing has also broken the deposits. It is likely, however, that several replacement deposits occur which are perhaps lenticular in shape.

The replacement deposits are dark in colour, in general darker than the enclosing rock. The material of the deposits is hard and consists of quartz and calcite or dolomite and the sulphides pyrite, arsenopyrite, sphalerite, chalcopyrite, galena, and tetrahedrite. The sulphides are fairly uniformly distributed through the gangue. From microscopic study of polished specimens of replacement ore it can be seen that pyrite, arsenopyrite, and quartz were deposited first. These early minerals were crushed and fractured and at this time and later came sphalerite and chalcopyrite. Clearly later than the narrow crushed zones in the early minerals are galena and tetrahedrite. Still later earth movements are indicated by gneissic galena. Later still the whole deposit was fractured and the fractures filled with a carbonate which is chiefly dolomite.

As development work in the area is so far not extensive and as surface rock exposures are infrequent the extent and nature of the locus of the ore solutions causing the ore deposits at the Topley Richfield are not known. It is possible that prior to ore deposition a shear or fracture zone of considerable extent existed striking north 30 degrees east and that the deposits of the Topley Richfield mine were formed in this zone.

GOLDEN EAGLE GROUP[1]

The Golden Eagle group of claims is on Richfield creek 7½ miles from Topley. The property is controlled by a company known as Topley Silver, Limited.

The mineral deposit is in fragmental volcanic rocks and consists of a narrow, quartz-sulphide vein. It is a few inches to 2 feet wide and has been traced for 300 feet along the strike by open-cuts and three shafts. It strikes northwest and dips 35 degrees northeast. Two of the shafts were full of water at the time of the writer's visit and the vein in them could not be examined. In the deepest shaft, 90 feet deep, the wall-rock has been altered to a light-coloured rock for a distance of 2 feet from the vein. The alteration has been effected by the introduction of sericite, calcite, chlorite, and pyrite. The vein consists of quartz mineralized with pyrite, sphalerite, chalcopyrite, galena, tetrahedrite, and probably polyargyrite. It contains for the whole depth of the shaft a band of sulphide 4 inches or more thick on its hanging-wall side. The vein is drusy and holds well-formed crystals of quartz and sphalerite. A peculiarity of the mineralization is the colour of the sphalerite which is a pale or yellowish green. The vein contains rather high-grade silver ore and for this reason, even though it is narrow, is worthy of considerable development.

CUP GROUP[2]

The Cup group of three mineral claims is on Richfield creek about 7 miles from Topley.

Some development was done on the property in 1924 by Frank Chettleburgh of Telkwa, B.C., who in that year held an option on the claims. In 1927 further work was done by the Topley Consolidated Mining and Development Company, Limited. In 1927 this company went into liquidation and the property reverted to the original owner.

The mineral deposit consists of one or more quartz-sulphide veins lying in fragmental volcanic rocks. The veins are practically horizontal and outcrop in the canyon of Richfield creek. The outcrops have been broken into by open-cuts and by five short tunnels and in this way vein outcrops have been traced for a quarter of a mile. The veins exposed in the various tunnels are similar in general appearance and may be parts of a single vein.

The veins vary in width from a few inches to 4 feet and consist of quartz mineralized with pyrite, sphalerite, chalcopyrite, and galena. Assays show that the vein matter contains half an ounce or less of silver per unit of lead.[3] Sulphide mineralization is in general rather sparse, but small local shoots of sulphide occur where the vein consists chiefly of galena.

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[1] Ann. Rept., Minister of Mines, B.C., 1927, p. 148.
[2] Ann. Rept., Minister of Mines, B.C., 1927, pp. 147, 148; 1924, p. 98.
[3] Ann. Rept., Minister of Mines, B.C., 1927, p. 148; 1924, p. 98.

BOX GROUP[1]

The Box group of four mineral claims adjoins the Golden Eagle group and is on Richfield creek about 7½ miles from Topley.

The mineral deposits are veins in a country rock of feldspar porphyry-breccia. The wall-rocks are whiter close to the veins than farther away, the colour being due, probably, to sericite and calcite. Two veins are known. They strike northwest and dip steeply northeast. The veins are 1 to 4 feet wide and one of them has been traced by open-cuts for a distance of 300 feet. They contain pyrite, chalcopyrite, sphalerite, galena, and tetrahedrite, in a quartz gangue. The galena and tetrahedrite are silver bearing. Mr. Lay cites one assay which shows that locally at least the vein matter contains 2 ounces of silver per unit of lead.[2] An attempt should be made to trace the veins farther along the surface.

EVERGREEN GROUP

The Evergreen group of mineral claims are on McCrea mountain about 6½ miles from Topley.

Two veins are known on the property. They occur in volcanic rocks; are about 500 feet apart, are roughly parallel, and strike north. Each vein has been traced by open-cuts, trenches, and shallow shafts for 300 feet. The veins are a few inches to 3 feet wide and consist of quartz, barite, calcite, and specularite, and a little pyrite, sphalerite, and chalcopyrite. No ore of commercial importance has yet been found.

MCCREA AND KYLLING CLAIMS[3]

Several mineral claims staked by Messrs. Kylling and McCrea of Topley are on the south side of Cesford creek about 4½ miles from Topley.

The country rock is of rhyolite and rhyolite breccia. An oblong body of diabase 150 feet wide also occurs in the vicinity, but its relationship to the rhyolite is not clear. Open-cuts have been made in the rhyolite which in some places contains disseminated pyrite, chalcopyrite, specularite, and chlorite. The material is too low grade to be ore. The diabase is commonly amygdaloidal, contains a great deal of epidote, and in several places contains narrow veins of quartz and specularite.

HAVEN'S CLAIMS

Mr. Haven has explored the contact between the feldspar-porphyry breccia and the underlying sedimentary material at the northern end of Tachick mountain. A cut about 5 feet wide and exposing a face of rock about 6 feet high has been made, but so far no reliable signs of any mineralization have been discovered. The reddish weathering of the formation at this point is due to the presence of a shaly bed which crumbles easily under the action of the water seeping down from the mountain.

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[1] Ann. Rept., Minister of Mines, B.C., 1927, pp. 148, 149.
[2] Ann. Rept., Minister of Mines, B.C., 1927, p. 148.
[3] Ann. Rept., Minister of Mines, B.C., 1926, p. 144.

CLAIMS AT THE NORTHWEST CORNER OF TACHICK MOUNTAIN

On the lower slopes, at the northwest corner of Tachick mountain, the granite is exposed on a small knoll. Between it and the feldspar-porphyry breccia there are irregular patches of limestone, which contain pyrite. Claims have been staked here, but it is probable that the pyrite is not to be referred to ore-forming agencies, but rather to the action of hydrogen sulphide generated locally in the adjacent material at the time of its formation. Considerable prospecting has also been carried out on the granite which contains some irregular quartz veins. The latter are segregations from the granite and if similar to those met elsewhere in the area will probably not carry any mineral values.

WATSON'S PROSPECTS

These are about the middle of the mountain between Cesford and Ailport creeks, one at the top of the mountain and one at the base. The former consists of a very narrow zone of sheared feldspar-porphyry impregnated with pyrite. The strike of the mineralization runs about north-south. Some copper staining is present and specularite occurs which would seem to relate the mineralization to that found at the western end of the mountain on the McCrea and Kylling claims. Rhyolite intrudes the feldspar-porphyry a little to the north. The mineralization at the base of the mountain also occurs in feldspar-porphyry. The rock is greyish green and contains many veinlets of epidote. There is a considerable zone of oxidized rock, and the main zone of the rock, which may contain ore, runs about 5 degrees south of west. The mineralization observed consists of quartz, pyrite, and chalcopyrite.

The operations at both of these prospects consist of shallow pits.

AILPORT'S PROSPECT

The claims staked by Mr. Ailport are on the eastern side of the gorge of Ailport creek. The rock is of the feldspar porphyry-breccia type, but has been greatly broken by faulting. This zone of faulting has determined the course of Ailport creek and can be followed southwards towards Six-mile creek which is just to the south of the map-area. Within the faulted zone are many calcite veins of varying width. The veins cross one another and all dip steeply either to the west or east. Green cupriferous staining occurs in many of them. The vein opened up by Mr. Ailport strikes 10 degrees east of north and dips about 80 degrees east. It is about 12 inches wide and there are thinner parallel veins in the wall-rock. The gangue minerals are barite and calcite. Though cupriferous staining occurs, sulphides are rare; only a little chalcopyrite and one or two specks of galena were observed. At the time of the writer's visit, however, very little development had been carried out, and it was practically only the outcrop that could be seen.

JOHNNY DAVID'S PROPERTY

Johnny David's property is situated about 3 miles north of the main road, in a small gully about a quarter of a mile east of the eastern fork of Johnny David creek. Although practically all the surrounding country is drift covered, rock is exposed in the sides of this gully and at the time of the visit a continuous exposure of the rock was being made by a stripping about 180 feet in length running along the side of the gully which runs about 60 degrees east of north. This stripping shows a zone of sheared and altered feldspar-porphyry. The zone is traversed by bands of completely altered and mineralized rock, these bands run about 55 degrees or so west of north and dip about 60 degrees to the west. The best bands are at the western end of the stripping and there vary in thickness from mere stringers to about 6 inches. In the middle of the stripping there is a band of comparatively unaltered rock containing only a little sulphide, towards the eastern end the alteration again becomes complete though the amount of sulphide is very small. The sulphide present is chalcopyrite. The gangue is mostly carbonate with a little quartz.

East of the workings the rock is much less altered and is feldspar-porphyry breccia. The same rock is met in the small gorge of the east fork of Johnny David creek and also farther west in the gorge of Johnny David creek. In many of the exposures there are zones where alteration to carbonate material has been complete and where pyrite occurs. No signs of a heavy mineralization were, however, encountered.

CLAIMS ON BYMAN CREEK

On Byman creek about a mile north of the main road, openings have been made in the rock-walls of the gorge. This gorge is along a zone of faulting which has involved sandstones, shales, and volcanic rocks believed to be at the base of the Tertiary series. The rocks are thoroughly broken and have been extensively veined by calcite probably derived from the calcareous rocks. The veins here and there contain some pyrite. Prospecting has been done on them, but it is most improbable that veins so formed will carry any values in gold and silver.

LUCKY SUNDAY GROUP [1]

About 500 yards east of Perow station on the southern bank of Bulkley river a small rock exposure 100 feet or so in length emerges from the drift which covers practically all of this area. On the eastern part of the exposure the rock is feldspar porphyry breccia. The rest of the exposure consists of streaked white and black material, the white being quartz and calcite, the black altered rock. The quartz and calcite bands are very thin and all strike about 10 degrees west of north and dip about 70 degrees west. A little pyrite and a few grains of chalcopyrite were identified in some of the bands, but no signs of a heavier mineralization were seen.

[1] Ann. Rept., Minister of Mines, B.C., 1927, p. 149.

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The annual Summary Report of the Geological Survey is issued in parts, referring to particular subjects or districts. This year there are three parts, A, B, and C. A review of the work of the Geological Survey for the year forms part of the Annual Report of the Department of Mines.