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GEOLOGICAL SURVEY

MEMOIR 246

LOWER STIKINE AND WESTERN ISKUT RIVER AREAS, BRITISH COLUMBIA

BY

F. A. Kerr

(Compiled by H. C. Cooke)

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OTTAWA
EDMOND CLOUTIER, C.M.G., B.A., L.Ph.,
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View southwesterly over junction of Stikine and Iskut Rivers past outlet of Great Glacier in Stikine Valley. Photo by United States Army, 1941. (Page 16.)

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PREFACE

The late Forrest A. Kerr examined the Stikine River area in the years 1926 to 1929 inclusive. His explorations covered altogether some 2,500 square miles of extremely mountainous and difficult country, for much of which he found it necessary to map the topography as well as the geology. The three geological maps covering this area were published in 1935, but the voluminous account prepared by Mr. Kerr to accompany the maps was never put into shape for publication, and after his death, in 1938, war conditions compelled further postponement of the project. Immediately after the war, however, the manuscript material was turned over to H. C. Cooke of the Geological Survey, and the present report has been prepared by him. Although Dr. Cooke believes that he has correctly stated Dr. Kerr's facts and conclusions, it is of course impossible now to verify this, and the report is, therefore, issued, frankly, as a posthumous compilation from Dr. Kerr's manuscript. At all points in the report where statements occur such as "the writer believes," "it is the writer's view," etc., the "writer" is Dr. Kerr.

The report itself deals with a large, potentially metalliferous region about which little factual geological information has yet been published. It contributes substantially to the age, character, and relationships of the various sedimentary and volcanic formations; deals at some length with the composite structure of the Coast Range batholithic complex and the individual characteristics of its several components; and includes some particularly instructive data on the physiographic history and glaciation of the region, and on the products of late Tertiary and Recent vulcanism. The report is also a valuable guide to conditions and means of travel within the area mapped, and contains pertinent information on the known mineral occurrences and on areas favourable for prospecting.

GEORGE HANSON,
Chief Geologist, Geological Survey

OTTAWA, April 15, 1947

Lower Stikine and Western Iskut River Areas, British Columbia

CHAPTER I

INTRODUCTION

GENERAL STATEMENT

Stikine River has been a highway of travel to the placer gold fields of Cassiar district for more than 70 years. During the boom days there were probably few bars along the main river or its tributaries that were not carefully prospected for placer deposits, but the yield was relatively small. In the late sixties and early seventies, before the main Cassiar rush, some bars south of Telegraph Creek yielded good returns for short periods; and in recent years limited amounts have been revealed by drilling.

Until recently, lode mining attracted little attention in Stikine River district. After the slight success of early efforts to discover placer deposits, it was largely ignored, although desultory prospecting resulted in discoveries of some copper, gold, and silver-lead-zinc deposits, particularly along Iskut River. The Stikine-Iskut area, however, lies within the eastern contact zone of the Coast batholith, which has long been known to be favourable for the occurrence of mineral deposits. Some prospecting was done in the district in 1929, and more in 1930. Although no important discoveries were made, mineralization proved to be widespread, holding out the hope that valuable deposits may be found with more intensive search.

Geological work leading to the present report was begun in 1926 along Stikine River, and continued in 1927-8 as far as Telegraph Creek, ascending the tributaries to the limits of easy accessibility. In 1929 the western part of Iskut River was traversed, thus completing the survey of the readily accessible parts of the drainage basin. Unfortunately, the only available maps of the district were the topographical maps of the International Boundary, and Dawson's sketch map of the river. The International Boundary maps were published on a scale of 1 inch to 4 miles, and for present purposes had to be enlarged to twice this scale, with corresponding loss in accuracy. For the rest of the area it was necessary to construct a topographic base, an effort that consumed much of the first 3 years work; and as the more distant parts were commonly sketched by long-range observation, their accuracy is not considered particularly good.

LOCATION AND ACCESS

The Coast Mountains, in northern British Columbia and Alaska, occupy a strip of country 60 to 75 miles wide along the Pacific seaboard. The boundary between Canada and Alaska follows the axis of this range, and crosses Stikine River about 26 miles above its mouth. The area mapped extends from the International Boundary about 120 miles north-northeast to Telegraph Creek, and thus lies largely within the eastern part of the Coast Mountains.

Stikine River, the main stream, drains a large part of northern British Columbia. Its upper part flows westerly to a point near Telegraph Creek, where it bends southwest and then south to cross the Coast Mountains at an acute angle. Tributaries in the northeastern part of its basin rise in the Cassiar Mountains, from which they derive an abundant supply of water. To the west, the river drains a plateau region that is relatively dry, but still farther west, much water comes from the eastern side of the Coast Mountains where precipitation is heavy. About 35 miles from its mouth the Stikine is joined by its largest tributary, the Iskut, which rises mainly on the east side of the Coast Mountains and flows almost directly across it.

Access to the area mapped is almost entirely by means of Stikine River and its tributaries. The river is navigable for most of the summer as far as Telegraph Creek. The season for larger boats begins when the ice goes out late in April or early in May, and ends between the middle of October and some time in November, when low water makes it impossible to navigate the upper parts of the stream. For small boats the season is usually longer, and on rare occasions the river has remained open all winter. During the period of field work boats of the Barrington Transportation Company made regular weekly trips from Wrangell, Alaska, near the mouth of the Stikine, to Telegraph Creek (Plate II A). No regular service has been maintained on the Iskut, but the smaller boats of this company have frequently travelled it as far as Bronson Creek, and under normal conditions can reach Snippaker Creek without great difficulty. The navigation period is about a month shorter than on the Stikine.

Three boats, of different sizes, are used by the Barrington Transportation Company of Wrangell, according to the stage of the water and the load to be carried. The largest has twenty staterooms. The boats have gasoline motors and propellers that operate in tunnels in the bottoms and can be raised to avoid shallow water or obstructions. The trip between Wrangell and Telegraph Creek usually requires 2 or 3 days going up stream, and 1 day coming down.

Wrangell is the port for the entire drainage basin of the Stikine, and goods in transit from Vancouver or Prince Rupert go through in bond. During the summer a regular steamer service of several boats a week operates from Seattle and Vancouver; in the winter there are fewer boats. The trip from Vancouver requires 2½ days.

Telegraph Creek is linked to Hazelton, on the Canadian National Railway, and to Atlin, on Atlin Lake, by government telegraph, and well-maintained pack trails follow the telegraph lines. An automobile road connects Glenora and Telegraph Creek with Dease Lake. In winter, traffic to Telegraph Creek, including the regular mail service, is mainly by dog-team from Atlin.

Aeroplanes can be used to advantage in many parts of the area, and there are landing fields near Telegraph Creek. Innumerable sand bars, valley flats, and glaciers also afford possible landing fields within the area mapped. Seaplanes can land on Alkali, Sawmill, or Yehiniko Lakes in the northern part of the area, or on quieter stretches of the Stikine and Iskut. During the winter, planes equipped with skis could land in many places.

It should not be too difficult to build a railway up Stikine Valley, did traffic possibilities warrant it. The wide, gravel-filled valley affords an ideal base, and the average gradient, from the mouth to Telegraph Creek, is less than 4 feet to the mile.

Stikine River. This stream is swift and dangerous, and, except for men skilled in navigating such waters, the regular passenger and freight boats afford the only sensible means of travel. A type of craft in general use is flat bottomed and shovel nosed, with considerable beam. The length varies with the need,

though 24 feet is usual. It should be equipped with a motor that under normal load will give a speed of 10 miles an hour. Outboard motors are used on such boats.

The regular passenger and freight boats will stop at almost any point along the main river channel, but the river has many distributaries (sloughs) so that it is not always possible to reach the shore from the nearest landing point. As a rule, the mouths of tributaries are the best landing points. When approaching the river to take passage on one of the boats it is best to choose a spot where the main channel is close to the valley wall in order to avoid intervening waterways and the dense matted jungle that covers the valley flats.

The mouth of Stikine River is best entered at or near high tide, to avoid the bars and snags that at low water are difficult to detect in the slow current there. The first stretch of swift water is opposite the Great Glacier. During high water the riffle there is troublesome for low-powered boats, and low water exposes several treacherous bars. Between this point and Little Canyon the current averages 5 to 6 miles an hour, and snags are numerous. At Little Canyon the river is confined, for some 6,000 feet, between rock walls about 75 feet apart, but it is deep, and only during high water, especially when there is much driftwood, is it difficult or impassable. Above the canyon to Telegraph Creek the river is increasingly swifter, in places exceeding 8 miles an hour. Conditions vary from year to year, and difficulties come and go. Grand Rapids is one of the most serious obstructions. Boats do not use the main channel because of its numerous boulders, but follow a small slough that at low water is very shallow. At this point, and others higher up, it is often necessary to use a line to pull up the larger boats, and when the water is unusually low such craft do not go above Glenora, because of the numerous bad riffles.

In winter the Stikine generally freezes to a point near salt water, though occasionally it remains open. Normally, freezing has progressed far enough by the first of January to permit of travel on the ice, and this condition prevails for about 3 months. The ice usually goes out between the middle of April and the middle of May. The river is then at a very low stage and, particularly if cold weather continues, the regular boats may take several days longer than usual for their trips. As summer approaches the river rises and generally reaches its maximum in the latter half of June, continuing high through July and August. In September the level falls fairly rapidly, and is very low by the middle of the month or soon after. This period is usually short, for late September rains raise the level and navigation is fair until mid-October when snow begins to fall and the river level is lowered. For 1 or 2 months after this, sometimes more, the river is navigable by small boats.

The main river is not subject to rapid changes in level, though in the autumn after a heavy rain a rise of as much as 6 feet in narrow sections has been known. On rare occasions, in late summer, the lake on Flood Glacier breaks loose, and the tremendous amount of water suddenly released carries everything before it. The outbreaks cannot be predicted, nor is there much warning, but they have been so rare in recent years that they are disregarded by the ordinary river services.

High water in the spring loads the river with trees and other drift, but with care a boat can usually avoid them. In Little Canyon at such times the water drives through with tremendous force and develops powerful boils and eddies. The condition has seldom lasted long enough of late years to cause important delays.

In autumn, winter, and spring, tributaries bring in very little silt, and the river becomes clear and is able to pick up material from its channel and trans-

port it downstream. The river is then confined to definite channels from which most of the sand bars are removed, though gravel bars remain. With high water, so much material is carried by the swift tributaries into the slower flowing Stikine that it is unable to carry the load and aggrades its channel. Bars are built wherever the water is slack; the river becomes constricted opposite stream mouths; and the channel changes considerably, particularly in the lower reaches where the material is finer and easily moved.

Iskut River. The Iskut is navigable for 40 miles. For about 7 miles from its mouth, to Johnson bar, it is somewhat like the lower Stikine, but is swifter and contains more snags. From Johnson bar to the canyon the valley bottom is a gravel flat 1 to 2 miles wide, over which the river is continually shifting. Nothing is stable; with the lodgement of an obstruction the entire river may in a short time change its course. The stream is much split, in places into hundreds of channels, but as a rule one channel carries enough water for the larger boats, though in places even small boats have to be manhandled over obstacles.

About 40 miles from its mouth the Iskut issues from a canyon reported to be about 12 miles long. The lower 5 miles of the canyon twists abruptly every few hundred feet, and the width in general varies from 100 to 200 feet. The walls average somewhat less than 100 feet in height. The south wall is vertical for the most part, and consists almost entirely of horizontal lava flows, with some intrusive rocks. The north wall, which is not as consistently vertical, displays mainly intrusive rocks with smaller amounts of the lava.

In September 1929, during low water, the canyon was ascended for about 5 miles with a small, powered boat, and could have been ascended by hand power. Except, however, at low water the trip would be dangerous, and no one is known to have gone farther up the canyon.

Iskut River differs from the Stikine mainly in drawing all its water from one mountain belt rather than from three different regions. During the winter it shrinks appreciably, and is subject to fluctuations due to rainfall, particularly in late autumn and early spring. During May and June it tends to rise, but with great and sometimes very rapid fluctuations. High water is believed to come late in June or early July, probably somewhat later than on the Stikine.

Chutine River. This stream has some bad rapids and much swift water, but small boats equipped with high-powered motors and lifting devices can ascend as far as Chutine Lake, beyond the western limit of the area mapped. However, there is a road for motor trucks from Chutine Landing on the Stikine to Barrington River, which enters the Chutine some 8 miles above its mouth. A good bridge crosses Barrington River, and trails continue from this point in several directions, making a large area readily accessible.

Scud River. The Scud was navigated, with some lining and considerable difficulty and danger, for about 17 miles. It spreads into many channels over a wide gravel bottom, and loaded boats could probably ascend at least 25 miles, perhaps farther.

Porcupine River. This stream is like the Scud, but smaller. A power boat can ascend about 7 miles, and can then, with difficulty, be tracked upstream to the glacier. It is probably easier to travel the stream on foot, over the barren gravel bars. The south side should be followed, to avoid the large tributaries entering from the north.

Craig River. This river, a tributary of the Iskut, was navigated in September 1929 without serious difficulty as far as Dick Creek, using a 24-foot power boat. The stream was very swift, however, even at that time of low water, and might be impassable in high water. Above Dick Creek the stream

is greatly split for about a mile; then, opposite Simma Creek, it is constricted into a gorge through which no boat is known to have been taken. Above the gorge are several miles of navigable water.

Jekill River, a tributary of the Craig, does not appear to be navigable with power, but at low water a boat might be tracked up for several miles, though with difficulty.

Other Methods of Travel. Between Telegraph Creek and Shakes Creek horses can be used to some extent, as there are a few trails on the lower wooded slopes, and above timber-line much of the surface is not too rugged. As far south as Little Canyon, pack dogs were used to advantage by the writer. There a good dog can go almost anywhere, though in the lowlands it may be necessary to follow trappers' trails. It is not necessary to carry dog feed, as game is abundant. Elsewhere in the area overland transport is by back-packing, either along the wide valley bottoms or the game trails that commonly follow the base of the valley walls, or in the open spaces above timber-line.

SETTLEMENT

The one village in the area mapped, Telegraph Creek (*See* Plate III), is situated on Stikine River at the head of navigation. It has a large Hudson's Bay Company post and two other stores, two hotels, government offices, a telegraph office, a school, and a church. It is the distributing centre for the greater part of northern British Columbia, and, as already mentioned, has a regular mail, freight, and passenger service by boat in the summer, and mail service by dog-team for most of the winter.

Glenora (*See* Plate II B), about 12 miles to the southwest, was formerly the head of navigation and a thriving village, but is now used only during exceptionally bad water stages and is deserted. Its chief periods of activity were during the Cassiar rush, 1874-6, and the Klondike rush, 1897-1900.

About 2 miles east of Glenora there is a large farm where hay and potatoes are grown, and horses kept. Small farms are maintained at the mouths of various streams, such as Hyland, Ware, Kunishma, Shakes, Chutine, Kirk, and Dokdaon; at a few other points cabins are occupied intermittently. South of Jacksons Landing there is only one permanent habitation, at Great Glacier. The Customs House on the Stikine is open during navigation, and the officer in charge is a sub-mining recorder and represents both the provincial and federal governments in other capacities. There are about five habitable trapper's cabins on the lower Stikine, and six on Iskut River.

The most stable source of income for the district is trapping. Big game hunting in the autumn usually attracts some wealthy hunters, and every year sees the arrival of a few tourists. The movement of supplies for placer operations in Dease Lake area affords a fairly continuous but fluctuating return. Small farms along the river supply some of the local needs for vegetables and small fruits, and hay for horses. Timber resources are limited, but a little lumber is cut near Telegraph Creek when needed.

Good agricultural land is found only above Grand Rapids, where the valley flats, especially when irrigated, yield splendid crops of the more hardy vegetables and small fruits. Wheat, barley, potatoes, carrots, parsnips, strawberries, raspberries, gooseberries, etc., can mature every year and are of fine quality. Some benches above the valley bottoms are good for agricultural purposes, but are drier and more difficult to irrigate. Potatoes have been grown over 2,500 feet above tide, but their maturing is always in doubt. Below Grand Rapids, the valley flats can be used for gardens, but the wetter climate of the Coast Range is less favourable for successful farming.

CLIMATE

The area mapped extends from the heart of the Coast Range, a wet belt, to the Stikine Plateau, a dry belt, so that all gradations in climate are encountered. Moisture-laden winds sweeping in from the Pacific precipitate their moisture on striking the coastal mountains both on the main range and throughout a distance of 10 to 20 miles east of its main axis. In this section the annual precipitation is between 75 and 150 inches. Except during July, August, and September, precipitation on the mountains is mainly snow. In the winters the accumulations of snow are heavy, attaining a thickness of 8 to 10 feet or even more on the river flats. Temperatures, however, are not extreme; there is little sub-zero weather, and much that is mild. Temperature observations taken on the coast show that the average minimum temperatures during December, January, and February range from 23 to 27 degrees above zero, and average maximum temperatures from 30 to 39 degrees. For the summer months, June, July, and August, mean minimum temperatures are 44 to 50 degrees, mean maximums 61 to 69 degrees. Prospecting in this wet belt can commence in May on favoured southern slopes, but not until August are large areas of snow-free ground available for inspection above timber-line, and little work can be done after the middle of October.

The wet belt is bounded, roughly, by a line drawn from Little Canyon on the Stikine to the canyon of the Iskut. Northeast of this line is the intermediate or gradational belt that extends, roughly, to the border of the dry belt at about Mess and Winter Creeks. Above Little Canyon it is common to find the sun shining, although rain may be falling below the canyon. There is also a fairly well-marked change in vegetation at this line. Throughout this belt precipitation decreases gradually from one side to the other. There is little rain in the summer, and snowfall in winter is much lighter than in the wet belt. Prospecting can be begun early in May and continued until the middle of October.

In the dry belt of the Stikine Plateau precipitation is very light. Around Telegraph Creek it probably averages about 10 inches, and accumulations of snow in the winter rarely exceed 18 inches. Temperatures range from 50 degrees below zero in winter to 90 degrees above in summer.

On Stikine and Iskut Rivers, as in all the valleys of northern British Columbia that cut through the Coast Range, the winds in summer invariably blow upstream, and downstream in winter, and are entirely independent of those that blow across the mountains above the valleys. Such valley winds usually commence about noon, attaining their greatest velocity in the afternoon, and may die completely after sunset. Their velocity may not be high in the lower section of the river, but increases in the upper reaches, particularly above Scud River. Apparently the greater heat of the interior, particularly in the valley bottoms, causes the air in them to rise rapidly, while cooler air from the axis of the Coast Range rushes upriver to take its place. In winter, when the Stikine Plateau is colder than the coastal section, the conditions are reversed, and the winds may blow down the valleys with such force as to interrupt the normal passage of coastal traffic. Between seasons the direction of the wind varies with the temperature.

VEGETATION

In the wet belt, river flats above high-water level are a veritable jungle, in which large cottonwood trees and a few evergreens tower above a tangled mass of willows, cranberry bushes, devil's club, and other shrubs. Lower slopes, where conditions are favourable, are heavily clothed with a mature forest of

spruce, hemlock, and fir, through which travel is easy. Where trees are sparse, however, as on slopes that are steep and subject to snow slides, there is generally a thick undergrowth of alders, huckleberry bushes, and devil's club. Still steeper slopes may expose much bare rock and have little vegetation. Gullies and protected spots where the snow lingers are generally fairly free of vegetation.

Timber-line throughout the wet belt is low, about 3,500 feet above tide, though in localities favourable to growth it extends to 4,500 feet.

The belt of timber along the principal valleys is 2 to 5 miles wide. Many spruce trees attain diameters of 5 to 6 feet, and hemlocks of 2 to 3 feet. Western hemlock constitutes 50 to 75 per cent of the trees in many places, though Sitka spruce in places is nearly as abundant. Engelmann spruce is found in the higher reaches, but sometimes as low as 1,000 feet above sea-level. Alpine fir was noted, but is relatively rare. Very spindly cedars were seen in a few places.

Above Little Canyon, in the intermediate climatic belt, there is less vegetation on the valley flats than farther down stream. On northerly slopes, protected from the sun, the vegetation differs only slightly from that in the wet belt. Elsewhere, however, there are fewer trees, and lodgepole pines, birches, poplars, and maples are present, in places abundantly. Underbrush is less abundant, and in general the virgin forests are open and park-like. Unfortunately, most sections on the Stikine have been burned within the last 50 years, giving rise to much fallen timber and second growth. Timber-line averages about 4,500 feet above tide, but may extend to 5,000 feet.

On the Stikine Plateau vegetation is still less abundant, and many slopes and hill tops carry little but grass. Sparsely timbered areas are extensive, and the trees are much smaller than in the wet belt. Pines, poplars, birches, and maples are the most abundant types, though spruce, hemlock, fir, and balsam are found in the damper sections. Many areas have been burned.

Among the smaller shrubs, commercial cranberries are said to be abundant in the swamps southeast of the junction of the Iskut and Stikine, and were formerly picked for market by the Indians. Other edible wild fruits include salmonberry, service-berry, thimble-berry, strawberry, raspberry, black cap, soapallali, red and black currant, high-bush cranberry, elderberry, gooseberry, and several kinds of huckleberry.

Above timber-line and in the higher parts of the timber white and purple heather are abundant, and there is an amazing growth of flowering alpine plants and shrubs that in spring give the mountain slopes the aspect of multicoloured carpets.

GAME AND FISH

No sheep are found in the wet belt, but goats are to be seen on practically all mountains, though they are rare west of the Stikine between Patmore Creek and the International Boundary. Moose frequent all the main river valleys, but are not numerous except on the Iskut toward the eastern limit of the mapped area. Coast deer have penetrated up the Stikine as far as the Iskut, but are rare. Black, brown, and grizzly bears are fairly abundant everywhere. Porcupines are well distributed but scarce. Marmots were noted only in isolated localities. Wolves are rare. Geese and ducks nest in fair numbers in the sloughs along the rivers, and late in summer are augmented by others, so that in September they are fairly abundant. Grouse and ptarmigan are sparsely scattered through all sections.

North of Little Canyon and Scud River goats are abundant above timber-line. Moose are plentiful north of Chutine River, and sheep are found in the northeastern part of the area. Bears are everywhere in about the same numbers

as in the wet belt. Caribou have occasionally been seen, and marmots are fairly abundant on the mountains. True wolves are scarce, but coyotes are fairly numerous and appear to be increasing.

Fur-bearing animals appear to be fairly abundant, especially beaver, which in unmolested sections have dammed most of the suitable streams and sloughs. Mink, muskrat, fox, marten, weasel, fisher, lynx, marmot, wolverine, wolf, and coyote are trapped in considerable numbers.

Salmon are abundant in the main rivers and many tributary streams in late summer and autumn. Cut-throat and Dolly Varden trout can be caught in the river, and are abundant in some of the clear streams and small lakes in the valley flats. In some small lakes northeast of Yehiniko River, very small trout, locally called mountain trout, are very numerous.

WATER POWER

Much waterpower could be developed in the area. Many large streams enter the main river through short canyons with a rapid fall, and afford favourable dam sites with considerable heads. Many of the wide glaciated valleys would afford storage facilities, and in some places are already partly dammed by moraines. Tertiary lava flows on upper Stikine and Iskut Rivers beyond the area mapped have provided natural dams that might afford sites for large power developments. The principal difficulty to be encountered will be found in the large seasonal fluctuations in the volume of the streams.

PICTOGRAPHS

On the west side of Stikine River about a mile below the mouth of Anook River, a prominent rock point is called Painted Point because of pictographs on it. They are a few feet above medium water level, and are covered at high water. When exposed, the rocks are, therefore, partly coated with mud, and as the paint is also partly worn away the pictographs are not readily visible. Two designs, painted in red, were noted. One is a circle of 6 inches diameter, the other the base of three U's with the near arms linked together as in a long-hand W. The right-hand U is about a third as deep and half as wide as the centre U, which is a little narrower than that on the left. The total width is about 18 inches, the depth about 6 inches.

Legend states that they were placed on the point shortly before prospectors came into the country, or about the middle of the nineteenth century; and that they commemorate a massacre of the Stikine or Wrangell Indians by the Nass Indians, and the capture of a canoe load of slaves.

PREHISTORIC CAIRNS

Along both sides of Stikine River, from the International Boundary to Chutine River, prehistoric cairns are evidence of fairly early human life in this district. The monuments are most abundant near Scud River, and become fewer both to the north and south. Both on Geology Ridge and Pereleshin Mountain more than twenty were observed, and the mountains immediately north of these were also popular sites. None was noted either along the Iskut or the Chutine.

All the observed cairns were on bare rock knolls either in scrub timber or above it. All were probably near or above an elevation of 3,000 feet. None was much less than half a day's hard travel, without load, from the river. They

were generally placed on some prominence and overlook the river, but are not necessarily on the highest or most prominent peak. They were noted to be more abundant on granite mountains than on others, possibly because these are as a rule more rounded and support less vegetation. In places the cairns occur in groups, fairly often three in a line. On Pereleshin Mountain such lines point toward the mouth of Flood River. Elsewhere their directions vary, but tend towards north and south.

Some of the cairns are well constructed, whereas others were thrown together more carelessly, particularly those toward the north and south sides of the cairn area. Many have been partly destroyed by erosive forces. In some, the blocks are carefully fitted and have flat faces arranged to give a fairly smooth outer surface to the cairn. The larger contain some rocks that would more than tax the strength of one man, but usually all the rocks could be carried without much difficulty. Some of the larger and well built cairns would require the labour of a man for the better part of a day.

There are two main forms, the beehive and the slender cone. The former is the more common, though usually the tops are not completely rounded, but are roughly flat. The common size is 3 to 4 feet in diameter with the same height, though specimens up to 6 feet were found. The slender cone type was found mainly on Pereleshin Mountain, though some of the beehive type were also noted. The cone has a base of about 2 feet in diameter and is 4 or 5 feet high. Great care and precision was commonly used in building these, as the sides are nearly vertical. A few cairns of other types were observed, among which was one of poor construction, about 12 feet long, 4 feet wide, and 3 feet high.

Nothing was found in any of the cairns to suggest their purpose, though many were examined with care. Most contain some fine sand blown in by the wind. All show a mature growth on the outside of the hard, brown lichen common to other exposed rocks in the area. In some, the outer sides of the rocks are considerably weathered to a rough crumbly surface, whereas the inner sides are still hard and smooth, as if polished by ice or water. These features indicate a considerable age for the cairns.

Careful inquiry by an intelligent halfbreed who was born and has lived more than 50 years in the vicinity elicited no information about the cairns from even the oldest natives. Apparently they know nothing about them, nor are there any legends that offer a clue. They are not burial cairns such as are known in other parts of British Columbia; nor have they any connection with hunting, as they are placed on mountains little frequented by game, and were not seen on some mountains where hunting is excellent.

They are placed along the stretch of the river that was a border zone, a meeting place for friendly pow-wows or deadly combat between the Thlingit tribe of the coast and the Tahltans of the interior. Rarely, other Indians from farther afield, especially from the coast, are also known to have come here to trade or fight. The cairns are most abundant near the Scud, which is about the halfway point between the coast and the interior; and many of them command a view of the Little Canyon of the Stikine, which is somewhat of an obstruction to navigation.

HISTORY OF MINING AND PROSPECTING

In 1861 gold was discovered by Choquette a short distance below Telegraph Creek, and during the ensuing years bars were worked with moderate success between Buck's bar and Dutch Charlie's riffle. During the Cassiar rushes of 1873-5 prospecting, mainly for placer gold, was very active. With the Klondike

discoveries of 1896, and those at Atlin Lake in 1898, new prospecting rushes were started. One of the main routes to the new fields was up the Stikine to Telegraph Creek, thence overland to Teslin or Atlin Lake. Traffic on the river was very heavy in 1899 and 1900, so much so that it became necessary to maintain a watchman with a signal at Little Canyon, where the river is too narrow for boats to pass. At this time two railways were projected, the Yukon, by McKenzie and Mann, from Telegraph Creek or Glenora to Teslin Lake, and the Cassiar Central from Glenora to Dease Lake. Both companies brought supplies and equipment into the country and the latter actually started grading operations around Glenora. Sections of the grade may still be recognized.

A group of claims on a copper prospect about "10 miles below Glenora on the south side" is mentioned in the annual report of the Minister of Mines, British Columbia, for 1902, as are also placer and lode claims on Cave Creek, a tributary of Barrington River. Lewis Kirk discovered his August and Mountain Goat properties about this time, and prospecting on the Iskut resulted in the recording of nine claims for the Iskut Mining Company.

In 1903, hydraulic leases were recorded on Barrington River, and sometime prior to 1914 Dixon and Bodel staked claims on the Devil's Elbow properties, where the Stikine Mining Company did work for a couple of years. In the southern part of the area work was carried on intermittently on the property of the Iskut Mining Company. However, except for these small and desultory operations the area has been neglected.

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CHAPTER II

PHYSICAL FEATURES

INTRODUCTION

The area mapped lies almost entirely within the Coast Mountains; a small northeastern corner of the northern map-area (Map 309A) is within the Stikine Plateau. The boundary between the two physiographic provinces is well marked south of Stikine River by Mess Creek Valley, which is bordered on the southwest by a fault scarp. North of the Stikine the boundary follows, less definitely, along or near the wide, low valley of Dodjatin Creek.

The Coast Mountains parallel the coast throughout British Columbia and southeastern Alaska, and constitute a major physiographic sub-province within the Canadian Cordillera. Within the area mapped they have a width of 70 to 120 miles, and constitute a rugged, mountainous region carved from a great anticlinorium of sedimentary and volcanic rocks with a central composite core of batholithic intrusions.

The Stikine Plateau is a part of the Interior system, which in northern British Columbia occupies a wide belt between the Coast and Rocky Mountains. It lies mainly within the drainage basin of Stikine River. It has considerable relief, due to the presence of deeply cut valleys, monadnocks, and superimposed volcanic cones, and is mainly a great basin-shaped synclinorium of formations younger than those of surrounding areas, and with fewer intrusive bodies.

Stikine Valley presents a complete panorama of the Coast Mountains, from the subdued, rounded, and heavily wooded mountains near the coast to the rugged central axis of the range and thence to the lower and flatter topped ranges of the east that merge with the Stikine Plateau. The scenic beauty and grandeur are probably unsurpassed anywhere. Abrupt slopes, down which cascade foaming torrents, flank the river on either side. Great glaciers sweep down from the easily visible peaks of the axis, gathering in a multitude of tributaries from the cirques that flank the mountains on every side. Hundreds of smaller glaciers are visible, clinging to precipitous slopes, cascading in magnificent ice falls or projecting long, gently sloping tongues. Large streams from great glaciers bore their way through deep rock canyons to burst forth, some of them, well above the river, or to spread widely over the gravel flats of great valleys.

COAST MOUNTAINS

North and west of the Stikine, the main axis of the Coast Mountains rises to 10,000 feet at Kates Needle. The axial part is snow- and ice-bound for a width of 10 or more miles. Along the lower Stikine, great glaciers drop rapidly from this ice-field to river level, only slightly above the sea. Between the glaciers jagged, cirque-cut ridges extend from the axial peaks to rounded mountains 5,000 to 6,000 feet high, which drop abruptly to the wide, U-shaped river valleys. Cirques and hanging valleys are abundant. Because, in the north, Stikine Valley diverges east from the axis, glaciers there fail to reach the main

river. As far north as Patmore Creek the drainage is direct from the axis to the Stikine, but farther north the axial drainage is more northerly to the Chutine. Ridges between the large tributaries are unbroken by any low passes.

South of Stikine and Iskut Rivers, the summits along the main axial section average 5,000 to 6,000 feet in height, and are more rounded than the peaks to the north. The large tributaries cut deeply into the range, and the amount of ice is relatively limited.

The area between Iskut and Stikine Valleys is rugged, with many peaks rising to elevations of from 8,000 to 9,700 feet. In the southern part is found the second largest ice-field of the district, and glaciers are numerous throughout. The drainage systems in general flow east or west from the central part, but there are also some remarkable, low, large, northwest-trending valleys.

The area northeast of the junction of Stikine and Chutine Rivers, though here considered as part of the Coast Mountains, has a distinctive, apparently mature topography with rolling hills from 6,000 to 7,000 feet high, gentle slopes, and few peaks. It is intersected by steep-walled valleys. This topography is best developed south of Stikine River, between Mess and Yehiniko Creeks. A late Tertiary fault along Mess Creek separates it from the Stikine Plateau to the northeast. The fault is marked by a strong scarp, and the creek has cut a canyon 1,500 feet deep along it.

North of Stikine River the upland surface is more dissected, but seems to be represented by the relatively flat summits of the hills, which display a fairly continuous, gradual eastward slope. The sizes of these upland remnants show a pronounced decrease to the west and southwest, and were no longer found west of Chutine River. The writer believes that this old topographic surface was once continuous with that of the Interior Plateau to the east.

STIKINE VALLEY

Stikine Valley presents several interesting features. The river enters the area mapped, above Telegraph Creek, through the "Grand Canyon", which has a length within this area of about 10 miles. This section of the stream cuts through a deposit of late Tertiary lavas, and the channel is very narrow, and the walls vertical or nearly so.

Below Telegraph Creek the valley is wider and moderately mature, and is divisible into three sections: a northern, from Telegraph Creek to Jacksons Landing; a central section, from Jacksons Landing to Scud Portage; and a southern section, from Scud Portage to the mouth. Throughout this distance there may be recognized two physiographic features, namely, the present stream bed, and the "old valley" developed long before the present course of the stream, and into which the latter is in places deeply incised.

At Telegraph Creek the main upper walls of the "old valley", formed of truncated, clearly glaciated spurs, are 5 miles apart, but the distance between them increases to 8 miles at the Chutine. Between these walls the old floor falls about 1,000 feet as it approaches Glenora, maintains this elevation between Glenora and Yehiniko Creek, and then rises to a level nearly 1,000 feet above this at the Chutine. The present stream is deeply entrenched in this latter part of the old floor. The main tributary valleys along this stretch of the Stikine have a "reverse trend", as if they had been tributary to a stream flowing in the opposite direction. They also hang high above the valley base; the Yehiniko, the largest, is 1,500 feet above the valley floor and 2,500 feet above river level. Much of this is, of course, due to glacial scour.

From a little below Jacksons Landing to Scud Portage the bottom of the old valley maintains an average width of about half a mile, and receives no large tributaries. In this section the Little Canyon and Klootchman Canyon are the most informative features. The old channel passes a short distance to the east of these canyons, and the present stream has cut narrow, steep-walled channels through rock spurs of the walls of the old channel. The character of these canyons suggests that they were cut originally by a stream flowing alongside a glacier that once filled Stikine Valley; or, in the case of Little Canyon at least, Oksa Glacier at many stages may have filled the main channel, forcing the stream to one side. In either event, the main channel was obviously pre-glacial, and from its size and maturity must have been established a long time before the Glacial period.

Below Scud Portage the old channel is again very wide and mature, and the larger tributaries for the most part enter normally. It is also to be noted that Iskut Valley is as wide, and otherwise similar to it, although the Iskut is a much smaller stream.

To the writer these features suggest that the present stream is the result of piracy. The large valleys to the north and south appear to have belonged to older north-flowing and south-flowing streams respectively; whereas the narrower central part belongs, according to this view, to the tributary of the south-flowing stream that cuts across the divide between them and robbed the north-flowing stream of its headwaters. The course of the present stream around Yehiniko Creek, deeply incised in the bottom of the old valley, is probably due in part to the continuation of the piracy, and in part to post- or inter-glacial erosion.

As the canyons are inter-glacial or post-glacial, it is obvious that the narrow central part of the old valley, which is much more mature, must be considerably older. It would probably not be far wrong to date it as mid-Pliocene, possibly somewhat earlier. The much larger parts of the valley to the north and south must then be still older, early Tertiary at least. As the valley would appear to have maintained itself against the uplift of the Cordillera, the original valley must have antedated that uplift, which would make it late Cretaceous in age.

It is interesting to speculate on the possible effects of late Tertiary faulting and volcanism. Such faults are known to follow the west wall of the valley in many places, and appear to account for the steeper slopes on that side. They may also account for the unevenness of the valley bottom, which in places is pronounced. Again, the channel has in places an angular course that is likewise ascribed to faulting.

Attention has been called to the fact that the valley of the Iskut is comparable in size with that of the Stikine, although the Iskut is much the smaller. Iskut Valley must, therefore, have once been occupied by a stream much larger than at present, and it is within the bounds of possibility that that stream may have been the formerly north-flowing part of the Stikine, which then found a way across the Stikine Plateau to enter the present Iskut Valley. It also seems probable that the area now drained by Mess Creek was formerly tributary to the Iskut through the valley followed by the telegraph line, and that this water was turned toward the Stikine, in late Tertiary time, by the building of the Edidza group of volcanic cones.

On the Stikine Plateau, between the headwaters of Stikine and Iskut Rivers, a great mass of Tertiary and Recent volcanic rocks now rises more than 9,000 feet above sea-level. The outpouring of these lavas undoubtedly disrupted the earlier drainage, may have cut off the north-flowing part of the Stikine and helped to force it into its present course, and may also have turned other streams, such as Mess Creek, into the Stikine.

TERRACES

Terraces are abundant throughout the mapped area, and in many places well developed and continuous for long distances. Most of them are cut out of gravel and glacial drift; a few are parts of horizontal flows of lava; and some, usually poorly defined, are cut out of rock. They are due to many causes, most of them closely linked with glaciation. The more important formed: (1) by beach or delta deposition in temporary ice-dammed lakes; (2) by similar deposition in lakes or slack stretches of river that were maintained for considerable periods by dams of morainic or land-slide material, by alluvial fans from tributary valleys, or by lava dams; (3) by river action on unconsolidated obstructions such as moraines, land slides, or alluvial fans; (4) by the normal processes of streams that are overloaded at times, and not at others; (5) by action of streams flowing along the sides of glaciers; and (6) by changes of sea-level relative to the land.

Terraces that can be ascribed to one or other of these causes are very numerous in the area, particularly the northern half, and are found at all elevations up to 3,000 feet above the sea. Lack of space forbids their detailed enumeration. Mention may, however, be made of a number of isolated rock, drift, or gravel shelves about 300 feet above sea-level in the vicinity of Iskut and Kahtate Rivers. These appear to have been formed in glacial time when the land stood lower than at present, relative to sea-level. Buddington (7, p. 277)[1] found marine fossils in the bed of Tasakili or Goat Creek about half a mile from its mouth, at estimated elevations of 175 to 200 feet above sea-level; and also in the moraine of Great Glacier on the west bank of Stikine River above the mouth of Iskut River. The shells lay on top of the moraine where they had been washed out of the clay just in front of the ice.

CIRQUES

Cirques, horseshoe-shaped basins hollowed out of mountain sides by glacial action, are abundant in the area, and many glaciers, both large and small, head in them. In the central part of the Coast Mountains cirques have been formed on all sides of the mountains, but toward the east they become less numerous and are confined to the steep northern slopes where the snow is least subject to melting. Most of them are above timber-line, but a few that have been deeply cut are below this level. Though they were mainly developed in the early part of Quaternary time, some of the smaller are Recent.

Many cirques are now occupied by lakes that, with their marvellous blue, green, and grey colourings, nestle like magnificent gems in their picturesque settings of jagged rocks, ice, and scattered vegetation.

GLACIERS

At present the mapped area includes hundreds of small glaciers, many large ones, and three extensive ice-fields. These are the remnants of the Quaternary ice that formerly covered the whole region, except perhaps a few high peaks.

The largest ice-field lies north of Castle Mountain, where it occupies the central axial area of the Coast Mountains, with a width of about 10 miles. The surface, which is gently undulating, lies between 3,500 and 6,000 feet above

[1] References, in parentheses, are to bibliography at end of Chapter I.

sea-level. Steeper slopes are found where the ice extends up the slopes of higher peaks that project through it, and where the ice moves down to feed glaciers.

The axial part of the Coast Mountains south of the Iskut and southeast of the Stikine is relatively low, so that in this part the usual axial ice-field is not well developed. However, in the southernmost part of the district there is a second ice-field, part of a field smaller but similar to that north of Castle Mountain.

The third large ice-field is north of Iskut River. It has an area of more than 200 square miles, and lies 4,000 to 7,000 feet above sea-level. It feeds glaciers that supply Choquette and Porcupine Rivers, and four tributaries of the Iskut.

Most of the great glaciers originate from the above ice-fields. They have lengths up to 15 miles, and many average a mile or more in width. Their surface gradients are rarely as low as 50 feet to the mile, and are generally much more. Estimated thicknesses vary with the size of the glacier. The largest, Great Glacier, is estimated to be more than 2,000 feet thick at 8 or 9 miles from its lower end.

Besides these major glaciers, there are hundreds of others of all sizes down to those covering only a few hundred square feet (Plate IV A). Some are on cliffs so steep that it is difficult to understand why they do not slide off; others are on relatively flat surfaces; and still others are in cirques of their own fashioning. Some, cascading down precipitous slopes for thousands of feet, are so shattered with crevasses as to appear almost like a slide of broken blocks. In such, much movement is effected by the breaking away of masses that slide down the slope, come to rest, and are then annealed into a solid mass. On a hot summer day the noise of such ice falls, and of new crevasses opening, resembles a heavy barrage of many guns.

Glaciers become less abundant toward the east, and near Glenora are few, small, and found only on steep northern slopes. Nevertheless, almost every major stream heads in a glacier.

Great Glacier. This glacier was described, as early as 1863, by W. P. Blake, who accompanied the Russian expedition under Commander Bassarquine, who was commissioned to map the mouth of Stikine River and discover where the miners were getting their gold (2, 4, 5, 29). Other descriptions and data have been given by J. Hunter (13), W. H. Bell (3), John Muir (28), I. C. Russell (29), G. M. Dawson (10), E. R. Scidmore (30), Tarr and Martin (33), A. F. Buddington (7), and many others. The photographs taken by the International Boundary Survey of 1904-9 afford a splendid record of the state of the glacier at that time; and they, with the first descriptions by Blake, provide the only data sufficiently detailed and accurate for determining the changes that have since taken place.

The glacier rises in the first-described ice-field, and flows 15 to 18 miles to Stikine Valley, gathering in some important tributaries. In this distance the surface falls from 4,000 feet to less than 1,000 feet above sea-level. At the edge of the valley, where it is still some 700 feet thick, it debouches through a narrow canyon not much more than a mile wide to spread out as a beautiful fan 4½ miles wide (*See* Plate I). This fan is badly crevassed in lines concentric to the outer rim and also radially. Four or more important streams, filled with mud, emerge from under the ice. The northernmost carries a fine granitic flour. The front of the glacier is paralleled by two moraines 500 to 1,500 feet apart. The outer is clothed with a mature growth of hemlock and spruce, and impounds a

lake of considerable size; the inner is still mainly without vegetation. Small lakes have formed behind it, and are increasing in size and consolidating as the glacier retreats.

The history of the glacier is complex. At the close of the glacial period, when the land was 300 to 600 feet lower than now, there appears to have been a period of relatively mild climate when the ice retreated a long way up the mountains, if it did not disappear altogether. At this time the lower part of Stikine River was a fiord, in which were deposited the beds carrying the marine shells already mentioned (p. 15). Trees that attained ages of 100 to 200 years had time to grow in the valley now occupied by the glacier. The abraded fragments of their trunks can be found in the load of the present glacier.

At some time after the recent uplift of the land, the glacier again advanced, and the moraines beyond its present rim indicate it was recently more extensive than now. Indian legends, indeed, have it that at one time it bridged Stikine River completely to unite with Choquette Glacier to the east, so that the river flowed beneath it. The legend does not seem improbable, as according to Muir's account (28) Choquette Glacier in 1879 was readily seen from the river, and hence was probably not more than half a mile or so from Great Glacier.

The outer moraine, which borders the river, affords much information. One tree growing on it, and cut by the writer, showed 110 annual rings. Mr. Fowler, who lives there, reports counts as high as 150; and other trees, judging by their relative size, may be as much as 200 years old.

Vegetation is slow to take root on morainal material. Moraine that must have lain undisturbed for 20 years or more commonly shows little growth of any kind, and no evergreens. As a rule, the debris is first covered with alder and willow before evergreens begin to appear. The process probably requires a minimum of about 50 years. As a matter of fact, historical records of this glacier are available as far back as 1863, or 66 years before the present investigations were made. Blake's description (4) of the condition at that time indicates that the ice had not wholly melted away from the foot of the inner moraine, though melting had gone far enough to produce a narrow flat, floored with ice and boulders, between it and the true foot of the glacier. In this interval of 66 years almost no vegetation has appeared on the inner moraine, and undoubtedly many more years will elapse before evergreens begin to grow. It would probably be more accurate, therefore, to allow at least 100 years for the beginning of evergreen growth on the outer moraine, making it at least 300 years since the ice ceased building this moraine, a process that may have required at least 100 years, so that the ice-front probably stood at that position between 300 and 400 years ago, that is, about 1530 to 1630 A.D.

The ice-front then retreated rapidly some 500 to 1,500 feet, when there ensued another long period during which it maintained the position of its front and the inner moraine was built. This moraine is somewhat higher and wider than the outer, so that it may have required a somewhat longer time to build, possibly half as long again to twice as long. Allowing 50 years for the period of quick retreat, the ice may have stood at the inner moraine about 150 years, say from 100 to 250 years ago.

Since Blake's visit in 1863 there appears to have been some advance of the glacier, sending a tongue of ice across the inner moraine. Muir, in 1879 (28), describes it as discharging scores of bergs into the lake between the two moraines. Dawson reported in 1887 (10) that part of the front appeared to lie on moraine;

and the International Boundary pictures show the ice-front in approximately the same place. Since they were taken in 1906, ablation has been rapid and the front has receded 50 to 300 feet from the inner moraine (1929)[1].

Flood Glacier. Flood Glacier is about 15 miles long, and descends from about 4,000 feet above sea-level to less than 500 at the Stikine. It rises in a magnificent cirque into which tumble several small glaciers from the ice-field above. Though its main basin is about as large as that of Great Glacier, it has no important tributaries, and is, therefore, smaller. It carries both medial and lateral moraines, which merge in the last mile or more to cover the ice completely. Above this lower part the ice is relatively smooth.

About ¾ mile in front of and concentric with the end of the glacier is an extensive old moraine completely covered with mature vegetation. It may correspond to the outer moraine of Great Glacier. Within it is a flat outwash plain extending to a newer moraine, 10 to 25 feet high, that lies 50 to 300 feet from the glacier. It carries little vegetation, and on the north side encroaches on and partly buries a clump of trees 50 to 100 years old. Behind this moraine is ground moraine with a few little ponds.

Flood Glacier owes its name to the fact that almost annually, according to Dawson, there came from it, at the end of summer, great outpourings that raised Stikine River from a low stage to half flood. The last event of the sort is reported to have taken place in 1918. The cause of the floods, obviously, was the sudden discharge of the waters of Flood Lake, an ice-dammed body of water about 2 miles long, that occupies a tributary valley from which the tributary glacier has melted away. Such discharge would be most probable in late summer, when the accumulation of water, and the pressure it exerted, would be at a maximum. Lack of floods in recent years is probably due to the formation of a high-level outlet that keeps the pressure down. The strong stream that emerges from the south side of the glacier may be this outlet.

Mud Glacier. This is much like Flood Glacier, but smaller. It owes its name to the fact that the lower end is completely covered by debris. It has retreated well within its valley and has laid bare part of the rock base.

Porcupine Glaciers. Two glaciers come together in the upper part of Porcupine Valley. The north branch has two recessional moraines, the outer 1,000 feet from the ice-front and about 50 feet high, the inner 200 feet from the front and 20 feet high. The latter impounds a lake. Below these is a series of outwash plains. The outwash plain just outside of the outer moraine stands about 50 feet above present river level. To build the accumulations of outwash to such a height, the glacier must have stood a long time at the outer moraine.

Patmore Glacier. This glacier receded more than 14,000 feet between 1907 and 1928, as determined by comparing its position in the International Boundary Survey pictures with its present position (1928).

Choquette Glacier. This glacier rests directly on an outwash plain. There is no morainal material at the face, and the ice is remarkably clean. It is confined to a relatively narrow, steep-walled valley, and has no important tributaries. Its terminus in 1879 was probably fairly close to Stikine River.

[1] Plate I, taken in 1941, shows an appreciable retreat from the inner lake front as compared with the position shown on Map 311A.

Hoodoo Glacier. This glacier is really an ice lake. Its original valley has been dammed by outflows of lava, and new outlets have likewise been filled by lava. At present it escapes through a narrow, ice-cut canyon, in the base of which is a water-cut canyon into which the ice is sagging.

The glacier, supplied with abnormal amounts of slide material from Hoodoo Mountain, has built out great moraines of angular blocks, not only in its own valley but half a mile out from it into Iskut Valley. In places this moraine appears to have buried trees 50 to 100 years old, though they may have grown on an older morainal deposit and been destroyed later. When this moraine was forming, the ice at the mouth of the canyon must have stood about 600 feet higher than now.

Twin Glacier. Like Hoodoo, Twin Glacier has been dammed and obstructed by Hoodoo Volcano. This caused the formation of an ice lake, and an overflow into the valley to the east, creating, thereby, an extensive nunatak between the two distributaries, which joined again lower down. Owing to recent shrinkage, however, the overflow to the east has decreased and may have ceased. Drainage from the glacier is by a canyon, which, like that from Hoodoo Glacier, must have been cut under the ice. For some years, however, the ice has sagged into the canyon, and presumably somewhat enlarged it. The glacier carries very little debris.

Between 1909 and 1929 this glacier retreated about half a mile. Somewhat below this vacated belt, vegetation begins, first a heavy growth of alder, in which, about a mile from the 1929 ice-front, evergreens begin to appear. Another mile lower down the evergreen forest has become fairly mature. The retreat of the glacier in the last 200 to 300 years can be pretty well timed from these data. Apparently the glacier has been melted away repeatedly by lava flows, which it has successively overridden, so that a considerable thickness of these now underlies the ice.

Bronson Glacier. This glacier is mentioned because of its heavy covering of debris, which supports well established deciduous trees of several years' growth. In this way it is unlike any other glacier in the mapped area.

Kirk Creek Glacier. In contrast with the glaciers described, all of which have been rapidly wasting away of late years, Kirk Creek Glacier, in the northeastern part of the area examined, was observed to be advancing. When seen, it was pushing its moraine out over grassy slopes and disrupting trees. Some other small glaciers in the northeastern part of the area were also pushing forward their moraines.

HOT SPRINGS

On Stikine River opposite Great Glacier, and reached by a small slough slightly below and opposite Fowler's ranch, several hot springs issue from cracks in granitic rocks at the base of the valley wall, or from the mud just beyond. The outlets are scattered along the wall for 200 feet or more, with the strongest and hottest flow in the centre. The volume, which is said to be fairly constant, produces a slow stream about 4 feet wide and 3 inches deep. The water from the central spring is hotter than the hand can stand, and must be well over 100° F. It is odourless and colourless, and has no unusual taste. Gas issues from the main spring, but not from the others. It is detected only by the

presence of bubbles, and is probably carbon dioxide. The granite shows no appreciable alteration, and the springs appear to have made no deposits. The following is an analysis of the water by the Division of Chemistry, Mines Branch, Ottawa:

	Parts per million	
$CaCO_3$	30	
$CaSO_4$	202	
Na_2SO_4	154	(by calculation)
$NaCl$	423	
SiO_2	68	
Al_2O_3	2	
K_2O	Nil	
Fe	Trace	
Br	"	
I	"	
Li	Nil	
Mg	Nil	

Total solids by evaporation at 180° C. 880 parts per million

The water is presumably of magmatic origin, and associated in some way with recent igneous activity. Though low in solids, it ranks well above many famous mineral springs, and may have some therapeutic value. It has already been used to a limited extent. The springs and adjacent land are held under reserve by the Government.

CHAPTER III

GENERAL GEOLOGY

TABLE OF FORMATIONS

Sedimentary and Volcanic Rocks

Era	Period or epoch	Description
Cenozoic	Glacial and Recent	Moraines; river and lake deposits; marine beach and delta deposits.
		Hoodoo and other volcanic rocks; trachyte, ash, pisolitic mud, tuff, breccia, agglomerate, etc.; olivine basalt.
	Late Eocene	Basalt, andesite, latite, rhyolite, breccia, tuff, agglomerate, conglomerate, sandstone, shale.
Mesozoic	Upper Cretaceous	Helveker volcanics; trachy-andesite, andesite, basalt, tuff, breccia.
		Conglomerate, greywacke, arkose, sandstone, shale, rhyolitic to andesitic tuffs, lava.
	Lower Cretaceous and/or Jurassic	Andesite, shale, greywacke, tuff, breccia, jasper.
	Jurassic	Conglomerate, arkose, grit, greywacke, dacite and andesite tuffs; quartzite, argillite, limestone, shale, sandstone; andesite, dacite.
	Triassic	Argillite, shale, greywacke; andesite and dacite tuffs; limestone, conglomerate, and, probably, lavas.
		Andesite, basalt; tuffs, breccia, agglomerate; greywacke, limestone, shale, argillite, quartzite.
-------	?	Argillite, tuff, quartzite, shale, sandstone, schist, slate.
Palæozoic	Permian, probably some Pennsylvanian	Mainly white, crystalline limestone; minor amounts of chert, quartzite, argillite, slate, and schist.
	Pre-Permian	Grey and buff limestones, quartzite, slate, argillite, crystalline schists and gneisses, with some highly altered intrusive and extrusive rocks.

Intrusive Rocks

Mezozoic (mainly or entirely)	Lower Cretaceous ?	Quartz monzonite.
		Biotite-andesine granodiorite, some differentiated quartz monzonite.
		Quartz diorite, some granodiorite.
	Jurassic ?	Oligoclase granodiorite, rarely diorite and quartz diorite.
		Hornblende-andesine granodiorite, rarely quartz diorite, diorite, and quartz monzonite.
	Triassic ?	Orthoclase porphyry; pulaskite, nordmarkite, nepheline syenite, locally pyroxenite.
		Diorite.

SEDIMENTARY AND VOLCANIC ROCKS

Pre-Permian

The pre-Permian strata, along with the Permian, Triassic, and Jurassic beds, have been intensely folded and metamorphosed. In most places isoclinal folds are the rule, but overturned and recumbent folds are common. The structures become even more complex where the strata have been disturbed by intrusions, as for instance in the Kahtate Mountain region southeast of the confluence of Iskut and Stikine Rivers. There the structures can be seen in three dimensions on the steep mountain slopes, and their complexity appreciated.

In addition, more or less faulting took place during the folding, and faulting was intense in post-Eocene time, particularly in the northern part of the area mapped.

As a result of these disturbances, the recognition of the pre-Permian strata is in many places doubtful. Throughout much of the area mapped, the Permian beds, a thick accumulation of white limestone, is an excellent horizon marker, and the beds that lie below it can be ascribed with certainty to the pre-Permian. Where it is absent, however, no such certainty exists. The pre-Permian beds and the overlying Triassic sediments are much alike lithologically, so that it is highly probable that some Triassic has been mapped as pre-Permian, or vice versa, in such places.

As the oldest rock group of the region the pre-Permian naturally outcrops in the major anticlines. Except where destroyed by intrusions, it follows the axis of the Coast Range anticlinorium, and also appears in subordinate parallel anticlines, and in cross anticlines that run northeasterly, or roughly at right angles to the main structure. An exception to the general rule is represented in the large mass near Mess Creek, which is probably an upfaulted body.

The pre-Permian group is divisible into a lower part, made up mainly of fine-grained clastic rocks, and an upper part with much impure limestone. The upper part is not everywhere present, suggesting the possibility of considerable erosion before the Permian was deposited. The lower part, before metamorphism, was dominantly quartzose and fine grained. Impure quartzites, cherty quartzites, and quartzitic argillites are the most abundant types, with lesser amounts of ordinary argillites, and a little greenish or purplish rock that was probably basaltic or andesitic lava. Where these rocks are not too highly altered, as in the area south of Mess Creek, they display well-developed bedding, some of it very thin. Estimates of thickness in such highly folded and metamorphosed strata are little better than guesses, but it is believed that some 7,000 or 8,000 feet of these lower beds are present.

The upper part of the pre-Permian, before metamorphism, consisted chiefly of buff and dark grey, argillaceous and arenaceous limestones, interbedded with some argillite and dark grey quartzite. Pure limestones are rare. The change from the lower to the upper part of the group is gradational, with limestone beginning to appear and reaching a maximum proportion in a distance of about 500 feet. The maximum thickness of the upper, limestone-bearing part appears to be about 2,000 to 3,000 feet, but it is less in many places, and, as stated, entirely absent in others. Vestiges of fossils may be observed in it here and there, but they are commonly too much deformed to be of value for age determination.

Metamorphism

Both parts of the pre-Permian are now highly metamorphosed. The lower part is mostly transformed into slate and schist, but near igneous contacts, and over a considerable area extending from the International Boundary south of

Great Glacier southeast to the valley of Craig River, much of it has been converted into highly crystalline schists and gneisses. The schists of the less altered parts include biotite, sericite, chlorite, and hornblende schists, with a well-developed cleavage. The more highly crystalline schists in the areas mentioned above are dominantly knotty mica schists, with large crystals of hornblende, brown garnet, sillimanite, or staurolite at the centres of the knots. Other minerals noted in them, besides the ordinary mica, quartz, and feldspar that constitute the bulk of their volume, include cyanite, ottrelite, actinolite, tourmaline, apatite, andalusite, and a little dusty graphite.

The gneisses have somewhat the same composition as the crystalline schists, but carry less mica, and the quartz and feldspar are in larger grains. The mica, mainly biotite, is usually concentrated in streaks, giving the rock a banded structure. The feldspar is mostly plagioclase, though orthoclase may also be present. Quartz and feldspar are usually in equigranular aggregates, but the size of grain differs in different bands. Near an intrusive rock, however, these minerals begin to appear in larger aggregates with peculiar irregular shapes, some of them more or less botryoidal; and the number of such coarse aggregates increases as the intrusion is approached, with corresponding decrease of the finer equigranular material, until a true plutonic texture is reached. The composition of the intrusive rock at the contact may be almost identical with that of the gneiss, or may differ considerably from it.

Here and there rocks are found that are inferred to have been originally basaltic or andesitic in composition; but they are now, as a rule, so greatly mashed and sheared as to make it impossible to determine with certainty whether they were extrusive or intrusive types. Plagioclase and ilmenite are about the only supposedly original minerals remaining; the remainder is an aggregate of secondary minerals, such as chlorite, zoisite, epidote, calcite, and mica. Some of these greenstones may be Triassic bodies infolded in minor synclines.

The upper part of the pre-Permian has been metamorphosed to crystalline limestone or slate and schist, according to the percentage of impurities present in the limy beds. Near quartz monzonite contacts it becomes in places more coarsely crystalline and carries sheaves of wollastonite. It usually shows little change near contacts with hornblende granodiorite, except where mineralizing solutions have been active; and there it may be completely converted into a green aggregate of quartz, garnet, wollastonite, epidote, other silicates, and sulphides. Some of these altered limestones are very striking in appearance. South of Eagle Crag, for instance, and also in the western part of the central map-area (*See* Map 310A) they are now well banded, brightly coloured, green, grey, and purple silicate rocks.

Age

One collection of fossils (F32, p. 84)[1] was obtained from the limestone on Devils Elbow Mountain. Of it, G. H. Girty writes to E. M. Kindle, "The assignment of lot 32 is very difficult. . . . . All that I can say is that coral faunas of that type (large cup corals and Lithostrotions) are especially common in the Lisburne formation (Upper Mississippian)". E. M. Kindle states that he is in entire agreement with Dr. Girty in the above statements, and in placing lot 32 in the Mississippian. As the fossils were obtained from the upper strata of the pre-Permian, the rest of the strata is probably pre-Upper Mississippian; and it is quite possible that part of the group may be Devonian or even older.

[1] For identification and description of fossils, *See* Appendix at end of this report.

The pre-Permian beds are overlain directly by Permian strata, and in places there appears to be a considerable discordance between them, up to 30 degrees. Unfortunately, direct contacts are rarely seen, and on account of the intense metamorphism it is impossible to be certain that the apparent discordances are maintained up to the contacts. The fossil evidence, however, indicates an important time gap between them, so that it is not unlikely that such a discordance exists.

General Characteristics

The pre-Permian group is as a rule dark in colour, and almost everywhere the cleavage or bedding is sufficiently pronounced to produce, under erosion, minor topographical features peculiar to the formation. The prevailing dark colour, coupled with the fairly intense metamorphism, combine to render the rocks easily distinguishable from the other formations of the district, excepting some parts of the Triassic strata.

Permian

The Permian is represented essentially by a thick series of light grey limestones. In the field it was separated from the dark sedimentary beds below, and the volcanic rocks above, as a lithological unit; later, fossil determinations proved that it is a true stratigraphic unit.

The Permian strata, as in the case of the pre-Permian rocks, have been intensely folded, faulted, and metamorphosed by pressure and by heat from intrusions. They display the same isoclinal, overturned, and recumbent folds as the older group, and where such folding has occurred may appear to overlie beds actually younger. For this reason, too, estimates of thickness are difficult to make, and are commonly no more than approximations.

In position, the Permian is found on the flanks of the anticlines that expose pre-Permian rocks in their cores. Where such anticlines plunge so as to carry the pre-Permian below the present surface, the overlying Permian may be exposed over large areas. Synclines of pre-Permian strata may also have the central trough filled with Permian beds. In general, however, the Permian strata form bands that lie between the dark pre-Permian beds on one side and the Triassic volcanic rocks on the other. In places, however, no Permian is present in this position, and the Triassic rocks directly overlie the pre-Permian, suggesting that erosion may have removed the Permian beds before the Triassic measures were deposited.

A fairly detailed study was made of the Permian section on Missusjay Mountain, where the beds have an aggregate thickness of 1,500 to 2,500 feet. At the base is a conglomerate made up of well-rounded, water-worn pebbles in an argillitic matrix. The pebbles consist of chert and other hard materials from the underlying series, and are mostly less than an inch in diameter. Above the conglomerate lie some dark grey, thin-bedded, impure limestones, interbanded with a very few small beds of dark grey or green schist, and dark brown or grey slate. The limestone weathers to a corrugated surface. Above this, in turn, is a light buff, thick-bedded, impure limestone, with scattered shell lenses. In part it is silicified, and carries irregular masses of chert and quartz, some of them angular, and some cherty, white to bluish grey beds. This lower part of the series appears to thin to the south, possibly because it was laid down on an undulating erosion surface.

The upper, and main, part of the series is composed of light grey to white, crystalline limestone, much of it very pure. It is usually bedded, but in places is quite massive. It weathers to a smooth surface, and in places has developed

a pronounced sink-hole topography. A few beds are loaded with shells that have been silicified, and may owe their preservation to this circumstance. Some of the beds have been slightly silicified, but on the whole the amount of chert present is small.

The character of the Permian elsewhere in the area is practically identical, though the thickness varies considerably. The thickest section was found in the Chutine anticline, where the maximum is between 2,000 and 4,000 feet. This section, however, dsiplays at the top a thick group of limestones less pure than the normal white or light grey type, together with some light-coloured quartzite, chert, and a little argillite. These beds are absent on Missusjay Mountain.

Metamorphism

In the lower part of the Permian series the original quartzose or argillitic beds have been metamorphosed to schist or slate, and the limestones have been converted into crystalline limestones with some silicates and chert. The upper part of the series, in which the original limestone was purer, have mostly been just recrystallized. In a few places, as on Mount Helena, the product is a beautiful white marble with streaks of green; but mostly the grain is coarse to very coarse. Fossils, where found, are usually silicified; and it is believed that the chert found here and there, in nodules and thin beds, has been carried in by silica-bearing solutions, some of them perhaps emanating from the Triassic volcanoes.

Near igneous contacts there is usually evidence of contact metamorphism. Garnet, tourmaline, epidote, and other silicate minerals have been formed at the contacts with oligoclase and biotite granodiorite. For 100 feet or more from quartz monzonite contacts the limestone is altered in part to wollastonite, garnet, vesuvianite, and epidote. Even dykes of this rock cause some alteration. In Craig Valley, near the masses of hornblende granodiorite, the limestone is largely converted into wollastonite and silica.

Age

In the field, as already stated, unconformity between this series and the pre-Permian rocks was inferred because in places there seemed to be more or less pronounced differences in strike and dip near contacts, and also because the Permian beds lie first on one, then on another, member of the underlying group.

Seven fossil collections were made from different places where identifiable fossils appeared to be present. Because of the intensely faulted and folded nature of the rocks, it was not, of course, possible to know the horizon in the series whence they came, nor to relate one locality to another.

The first three lots obtained, numbered respectively F23, F24, and F25 (p. 83), contained only a half dozen very poorly preserved types. Of them E. M. Kindle states, "The collection warrants only the opinion that all of the lots are of Carboniferous age, and probably from horizons earlier than Permian." A fourth collection, numbered F35 (p. 85), contained some poorly preserved sponges and corals, and part of one brachiopod. Of it E. M. Kindle states, "While no positive statement can be made concerning the horizon of such poor material, it is very probable, in the writer's opinion, that a Carboniferous or Permian horizon is represented."

The other three lots, numbered F30, F31, and F33 (p. 84), fortunately contained a much larger number of better preserved fossils. They were examined not only by Dr. Kindle, but also by Dr. Geo. H. Girty, both of whom relate

them to the Alaskan Permian. Dr. Kindle states: "The Stikine fauna presents a facies different from either the Permian (Tahkondit) of the Yukon River (opposite Nation River) or that of southeastern Alaska, Saginaw Bay and other localities, yet it is obviously related to the latter. It may differ somewhat in geological age, but probably the difference in facies can be attributed to geographical conditions." As a matter of fact, the upper division of the Alaskan Permian, according to Buddington (7, pp. 118, 121), "is more uniform and consists of white limestone with intercalated layers of white chert." It thus appears to be a lithological replica of the Upper Permian of Stikine district, except that its thickness, about 1,000 feet, is much less than in Stikine district.

It may thus be concluded that the bulk of the formation is of Permian age, although some Pennsylvanian may possibly be represented, presumably in the lower horizons.

General Characteristics

The light grey colour and the bedding of the Permian limestones are very characteristic, and usually enable them to be separated from rocks above or below. There may be some difficulty, in places, in distinguishing them from the upper limestones of the pre-Permian, but the darker colour of the latter, and the greater amount of non-calcareous sediments interbedded with them, commonly enable the distinction to be made. Triassic limestones in Stikine area are generally less deformed, and, if pure at all, are usually associated with impure limestone or with other sediments that are clearly not the Palæozoic schists. Elsewhere in northern British Columbia, it may be noted, there are Triassic limestones lithologically almost identical with the Permian; but they are not known to occur to any extent in Stikine area.

Permian or Triassic

In several places throughout the mapped part of Chutine Valley, some sedimentary rocks overlie the ordinary Permian beds. It is believed that the contact is unconformable, but this was not definitely proved, and in places there appears to be a gradational change from the Permian into the overlying beds. However, in mapping, these beds have been included with the Triassic.

On Missusjay Mountain more than 100 feet, and possibly several hundred feet, of dark grey slate, schist, argillite, and quartzite appear abruptly above the Permian limestone, but owing to poor exposures and intense deformation the structural relationships between them and the limestone are not clear.

In Barrington Valley the uppermost Permian limestone beds are interstratified with bluish grey and white, cherty beds. These increase upwards in relative number to where thin beds of limestone and quartzite alternate. Still higher in the series the limestone beds disappear, and the rocks become a succession of well-bedded cherty quartzites with unusual colourings, light grey, pink, purple, green, black, and brown. Some dark brown and black sandstones, and a little argillite, are interbedded with them, together with some fine-grained, dense, green and grey tuffs. Definitely Triassic tuffs and breccias are found only a few hundred feet higher up, on Isolation Mountain.

On Cave Creek the Permian limestone is more abruptly capped by a dark-coloured succession of quartzitic, argillitic, and shaly rocks many hundreds and perhaps more than 1,000 feet thick.

On Mount Fizzle, and at a few other places in the southern map-area (*See* Map 311A), Triassic lavas are directly underlain by rusty, green and purple

limestones that carry *Pseudomonotis subcircularis*, which indicates an Upper Triassic age. These limestones appear to grade downward into the limestones classified as Permian, suggesting that perhaps part of the supposed Permian may be Triassic.

Triassic

VOLCANIC GROUP

The Triassic rocks, which are mainly of volcanic origin, occupy two general areas. The northern of these constitutes large parts of the north map-area (Map 309A) and extends southward a few miles in the eastern part of the central area (Map 310A). There follows a gap some 12 miles wide in which no Triassic has been mapped. The southern area of Triassic rocks occupies large parts of the southern map-area (Map 311A), whence it extends north nearly halfway across the central area.

In the northern map-area, the Triassic volcanic rocks are overlain by sedimentary rocks of considerable thickness, also of Triassic age, whose presence enables the geologist to distinguish the Triassic volcanic rocks beneath from the rather similar Jurassic volcanic rocks above. In the southern area no such Triassic sediments were recognized, and, consequently, it is very probable that the areas mapped as underlain by Triassic volcanic rocks may include considerable amounts of Jurassic volcanic rocks, as there was no good means of separating them.

As in the case of the older rocks, the Triassic strata are intensely folded and sheared, and are intricately faulted. Consequently, estimates of thickness are very rough, and the positions of fossil-bearing horizons cannot be accurately determined. Also, as with the older formations, the geological mapping is necessarily generalized, and areas mapped as Triassic may include many small infolded or infaulted masses of older or younger formations.

The bulk of the Triassic volcanic rocks is pyroclastic material—tuffs, breccias, and agglomerates—with minor amounts of lava. The true proportion of lava is difficult to estimate in the field, because pyroclastic types are not always easily separated from flows. The flows display pillow structures, amygdules, or other characteristic forms in only a few places; and the sediments, though they possess excellent bedding as a rule, show it only where water is actually flowing over a clean rock surface.

In the southern map-area, in many places the base of the series appears to be a dense lava, amygdaloidal near the lower contact. Upward, feldspar phenocrysts begin to appear, and become more abundant to where a medium-grained plutonic texture is attained. This change from volcanic to plutonic texture was observed on Geoffrion, Iskut, Surprise, Zippa, Raven, and other mountains. It suggests either that many bodies that from their textures have been classed as intrusions may be parts of thick lava flows; or that certain intrusions of the area may be merely parts of the volcanic flows that did not quite reach the surface.

Flows were found at the base of the series in other places also, as on Devils Elbow Mountain in the northern map-area. Rather more often, however, the base of the series is a coarse explosive breccia, containing blocks 2 and 3 feet thick of lava, pre-Permian sediments, and Permian limestone. Such breccias were observed in a small unmapped Triassic body on Butterfly Mountain (Map 310A) and on Choquette, Whipple, and Johnny Mountains in the southern area (Map 311A). A similar breccia, found south of the junction of Jekill and Craig Rivers, is so badly sheared that the limestone blocks are drawn into

lenses. In a few places, where breccia overlies Permian limestone, subsequent intense deformation has caused the limestone to flow and envelop the blocks of the breccia, so that it now resembles a conglomerate with a limestone matrix.

The volcanic rocks are commonly dark green, though red, purple, brown, and black colours are all abundant. Even greys or very light greens are to be found, and in places are so dominant that the rock looks like quartzite. The dark green colour is undoubtedly due to the prevailing chloritization, and the red colours to oxidation of the iron minerals. The latter conclusion is strengthened by the fact that red colour is greatly intensified along faults and other places where meteoric water has circulated freely.

The volcanic rocks are mainly albite andesites[1], oligoclase andesites, and basalts, with their fragmental equivalents. Dacites, trachy-andesites, and a little trachyte, are also present. The albite andesites usually carry phenocrysts of one or more of the following minerals: albite, diopside, aegirite, and, in a few instances, biotite. In the groundmass the feldspar is mainly albite, though some potash feldspar was also recognized in a few specimens. Dark constituents usually form a small to moderate percentage of the total; in only a few instances did they exceed 50 per cent. Magnetite is usually present, but never abundant.

The oligoclase andesites usually carry phenocrysts of augite or diopside, green or brown hornblende, biotite, andesine, oligoclase, or, rarely, labradorite. The groundmass is largely plagioclase. The total content of dark constituents is rarely high except in some of the hornblende-oligoclase types, where it probably exceeded 50 per cent.

The basalts usually have phenocrysts of labradorite and augite. It is believed that olivine was originally present in some. The dark constituents are not very abundant, and the composition in general tends toward the andesitic.

Most of these rocks, under the microscope, were found to be considerably altered, some even beyond identification. The alteration products are the usual ones, chlorite, calcite, zoisite, epidote, sericite, serpentine, quartz, albite, and hematite. Some rocks that in the field appeared to be wholly serpentine proved to contain little of it when placed under the microscope. Phenocrysts generally remain less altered than the matrix, and even where the latter has become soft and sheared can often be picked out as perfect crystals.

The pyroclastic rocks, as stated, constitute much if not most of the group, and range in composition from coarse explosive breccias with fragments 2 or 3 feet in diameter to fine-grained, well-bedded tuffs. Local, small lenses of sediments of more ordinary types are also found throughout the group. They are usually only some 50 feet or so in length, and may consist of conglomerate, greywacke, argillite, or limestone. In some localities limestone nodules are abundant in the volcanic rocks giving them a conglomeratic aspect. Many of the sedimentary beds are fossiliferous.

In the northern map-area, there appears to have been a time break in the succession, during which erosion and deep weathering occurred, and the rocks above the break contain a much larger proportion of ordinary sediments than those below. In the region extending from Mess Creek to Dokdaon Creek, and particularly in the Chutine-Yehiniko section, the volcanic rocks are deeply weathered to rather soft red materials, the rapid erosion of which is supposed to account, in part at least, for the wide depression there. Small amounts of similar material are found on the slopes of Helveker, Kirk, and Strata Mountains.

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[1] Note. On the published maps, and in his original manuscript, Kerr termed the albite andesites "keratophyres". As true keratophyre contains the soda-potash feldspar anorthoclase, and his descriptions do not indicate that any anorthoclase is present, it seems best to term the rocks simply albite andesites. Ed.

Above the weathered section there is a group of rocks, in places as much as 3,000 feet thick, that in the main are the products of active erosion coupled with some volcanic activity. Much of the group is made up of one to several beds of coarse conglomerate, carrying boulders of the underlying rocks up to a foot in diameter. Agglomerates, tuffs, and greywackes are interstratified with them and with one another. In some localities the conglomerate contains a little granitic material and is slightly arkosic. The matrix is either green, red, or mottled, but generally green despite the fact that it may overlie deeply weathered red rocks.

Much of the rock of this group is distinctly calcareous. Limestone nodules are present in some of the finer grained beds, and many of them have fossil nuclei. Limestone lenses and even fairly persistent beds of limestone also occur, and, locally, conglomerate may have a limestone matrix.

The thickest section of these rocks, perhaps as much as 3,000 feet, is exposed on Glenora Mountain, where the total thickness of the volcanic group may be double that figure. A small thickness of them also occurs on Conover Mountain.

In general aspect, the volcanic group is made up of massive dark rocks with little evidence of bedding. The rocks usually break into small blocks, and, owing to the lack of well-defined joints or bedding planes, they develop rugged, pointed peaks and a decided tendency toward a fairly regular dendritic system of gullies.

SEDIMENTARY GROUP

The Triassic sedimentary group overlies the volcanic group, possibly unconformably, and is represented by a number of small bodies in the northern map-area. Most of these are sharply folded synclines or synclinoria, and their mapping is much generalized and incomplete. Many small blocks, faulted out of their proper stratigraphic position, are present in the brecciated zone of Stikine Valley. Some were definitely recognized in the field, but probably others were not. A fairly large unmapped mass probably lies on Conover Mountain, west and southwest of the small intrusive body there. Others may occur in the low hill northeast of Dokdaon River.

In most localities this group lies on different members of the upper, more sedimentary part of the volcanic group, but in some places it lies on the lower part of the volcanic group. There is thus a suggestion that a period of erosion may have preceded its deposition.

In some places the basal or near-basal strata are greywackes derived largely from the underlying rocks, but with a small tuff content, and in places they are more or less calcareous. Near the base, also, a unique coarse tuff is commonly found, andesitic in composition, with large crystals of acid oligoclase, unusually dark green diopside, and, rarely, a crystal of biotite. It is well displayed on Brewery Creek mountains and in Pritchard Creek area.

The dominant rocks of the group are black and dark grey argillites, some of them limy. They are commonly fossiliferous. Limestone is present in many places, usually in local lenses but in a few instances in fairly continuous beds up to 100 feet thick. It ranges from dark grey, pure types to brown, arenaceous varieties, and some beds are petroliferous. Fossils are present in many places. Beds of brown sandstone are fairly generally distributed, and conglomerate was found in a few places, especially near Damnation Creek. The pebbles are well water-worn, and are derived both from the series itself and from the underlying volcanic group. Dacitic tuffs were found on Isolation Mountain and in the Damnation Creek area.

It is estimated that this group of rocks attains a thickness of 1,000 feet or more.

It is clear, in many places, that Triassic beds truncate the underlying Permian beds obliquely at low angles; and, as the mapping shows, in places they even lie directly on the pre-Permian. In the latter instances either the Permian has been completely removed there by erosion, or the Triassic rocks have overlapped the pre-Permian formations. In either case an unconformity is indicated. Further, in a few places bedding in the Triassic tuffs was determinable at the contacts, and indicates an angular unconformity.

Few fossils were obtained from the volcanic group. Three collections made on Mount Fizzle, in the southern map-area (F36, F37, F38, p. 85), were all too badly deformed for definite determination, though F37 may have contained a highly distorted specimen of the Upper Triassic form *Pseudomonotis subcircularis*. Two collections from the northern map-area, F11 and F15 (p. 82), were even more unsatisfactory.

Many collections were obtained from the upper, sedimentary Triassic group. These are numbered F1, F5, F6, F9, F10, F12, F13, F14, F19, F20, F21, F22, F26, and F27. Though most of these gave little information the definite recognition of *Stikinoceras kerri* in F13, F14, and F20, and of *Pseudomonotis subcircularis* in F27, established the age as Upper Triassic. Collection F26 from the east side of Helveker Creek Valley contains a brachiopod resembling an Upper Cretaceous form, suggesting that the mapping there may not be entirely correct, although the beds mapped as Triassic appeared to be on strike with other Triassic beds across the valley.

Jurassic

The Jurassic rocks underlie a number of small patches ranging from a few hundred feet to 3 miles in length in Stikine Valley in the northern map-area. One larger area is on the flanks of Kirk and Strata Mountains, where it forms a curving band that has been traced about 8 miles, and is 1,000 feet or more in width. It lies between Upper Triassic sediments below and Jura-Cretaceous volcanic rocks above; elsewhere the Jurassic rocks are synclinal remnants, most of which are fault blocks. Those of which the bases have been found overlie various Triassic sedimentary members, and in places even the older Triassic volcanic group. The relations are believed to indicate an unconformity. Dips wherever observed are nearly vertical, and close isoclinal folding is the rule so far as it has been possible to discover.

In the intensely faulted Stikine Valley section, there was naturally much uncertainty about what should or should not be included in the Jurassic, and more detailed work may alter the mapping considerably. Throughout the distance from Winter to Glomerate Creeks, on both sides of the river, there is much red arkose and slightly granitic conglomerate that may be Jurassic; or it may be that much of this red material is deeply weathered Triassic rock. The materials present in the Jurassic beds are on the whole well stratified, but exhibit rapid variation in character, both laterally and vertically. It is concluded, therefore, that the deposits are probably parts of an alluvial fan.

The long band on the flanks of Kirk and Strata Mountains was examined in detail only on Kirk Mountain. The base of the series is well fixed there by two fossil collections made only about 800 feet apart, one (F27) carrying Triassic fossils, the other (F28) Jurassic. Between these points, unfortunately, the section is not complete, for above the typical Triassic sediments there is a

short, drift-covered gap that is believed to conceal a conglomerate found a short distance to the south. The conglomerate carries pebbles up to 2 inches in length of granitic materials and of underlying rocks; and rests on green tuff and fine and coarse greywacke, thus suggesting an unconformity. Across the drift-filled gap there is a red and grey shale, followed by red, nodular, somewhat calcareous shale and a little conglomerate. Red sandy shale, red calcareous shale, and some grey limestone follow. These red beds have a total thickness of more than 100 feet. They are succeeded by a hard calcareous tuff interbedded with tuffaceous shales, overlain sharply by a considerable thickness of red arkose with some calcareous shale. The latter carry the Jurassic fossils (F28). Higher up there is a variety of tuffs, greywackes, and argillites; and to the south, in Kirk Creek Valley, a dacite flow forms part of the series. The thickness of this section is probably between 500 and 1,000 feet.

In the Glomerate Creek body a coarse conglomerate, which is considered to be the basal part, follows more or less continuously around the outer edge. The conglomerate, which in places appears to be in angular unconformity with underlying beds, carries large boulders, many of them 1 or 2 feet in diameter, in an arkosic and tuffaceous matrix. The boulders differ from those of the Triassic conglomerates in that they are never entirely of volcanic rocks. Some boulders of oligoclase granodiorite are always present, and in places nearly all the boulders may be of this material. Besides those mentioned, there are also some boulders of limestone and other sedimentary rocks from the underlying series, and some of materials resembling the Jurassic sediments themselves.

Chips from four granodiorite boulders in this area, and from one boulder in conglomerate just south of Shakes Creek, had approximately the following composition: quartz 16 per cent, oligoclase 53 per cent, orthoclase 24 per cent, and hornblende 7 per cent. They belong, therefore, to the oligoclase granodiorite of the region, and are in fact much fresher than the exposed mass of this rock some 4 miles to the east. Their freshness suggests rapid erosion, transportation, and deposition under cold climatic conditions.

Coarse gritty tuffs, dense hard tuffs, arkoses, and argillites are interbedded with this conglomerate and overlie it. Some of these beds are red, a feature more common in this group than in the older rocks. Two or more andesite flows, 5 to 15 feet thick, are intercalated with the lower members of the section.

Upstream, it is found that the nature of the conglomerate gradually changes. The size of the boulders decreases, to where, around Glenora, the average diameter is only about 2 inches. The proportion of boulders from the Triassic rocks decreases considerably, and also, to a less extent, the number of granodiorite boulders. Pebbles of chert and quartzite become fairly numerous, along with much material that may come from the Jurassic formation itself; and the matrix becomes so arkosic as to have in places the appearance of beds that lie on or near the disintegrated source rock. In other places the matrix appears very tuffaceous.

In the Glenora section many beds of this small-pebble conglomerate are found. Other rocks include tuffaceous grits, calcareous tuffs and grits, dense, hard tuffs, and arkoses. Some soft black to brown shales are present, and carry fossils. They are usually quite limy, and are accompanied by impure, petroliferous limestone with abundant fossil fragments. Fossil wood is present in the form of carbon, but no continuous coal horizons were noted. The tuffs are andesitic and dacitic. In the main the series is well bedded and hard, weathers light grey to rusty, and exhibits rapid lateral and vertical variations.

Age

The age of the series is fairly well fixed by fossil collection F3 (p. 81) from the Glenora section and F28 from Kirk Mountain, both of which display characteristic Jurassic marine fossils. F. H. McLearn expresses the opinion that F3 is probably basal upper Lias of the Lower Jurassic.

Conditions of Deposition

The presence of *Belemnites* and other marine fossils in many beds indicates a marine origin for a considerable part of the series. On the other hand, the presence of coaly beds would suggest that at times parts of the area were above the sea long enough for trees to grow, though possibly the woody material was rafted in. These considerations, combined with that of the rapid lateral variations of the sediments, which implies shoal water conditions, seem to demand the conception of a shallow estuary fed by streams. The very coarse conglomerate of the Glomerate Creek area would suggest that at least one of these streams was large, at least at flood time, and descended steeply enough to make possible the transport of boulders up to 2 feet in diameter.

The origin of the granodiorite boulders is an interesting matter for speculation. They could hardly have come from the Yehiniko Creek mass, because that appears to be sill-like and to have been folded with the surficial rocks in which it lies. Whether this is or is not correct, its upper horizons are now in Triassic rocks that underlie the Jurassic strata; hence, before the folding that produced the Stikine syncline, the Jurassic sediments were actually as high or higher than the present exposed top of the Yehiniko granodiorite. It, therefore, seems necessary to conclude that somewhat farther to the west or southwest there was recently uplifted mountainous country, in which a granodiorite mass was unroofed and undergoing rapid erosion.

Jurassic or Cretaceous

The Jura-Cretaceous rocks are a thick group of volcanic flows and tuffs, with some associated sediments, that overlie the Jurassic sediments of Kirk and Strata Mountains in the northern map-area. Their identity was established on stratigraphical and palæontological evidence; but as they have no features that would differentiate them with certainty from the Triassic lavas, it is obvious that they might also be present in other parts of the area that lack such evidence of identification. Where they are found, they are less deformed than the older rocks, and less altered in general appearance; and certainly no rocks with these characteristics were observed elsewhere in the map-areas; but the characteristics may be due to the local structure, which is that of a broad, open syncline.

The bedding is also much more distinct and easily observed than in the older volcanic rocks. It was possible, on Kirk and Helveker Creeks, to trace for some distance the individual beds in cliffs, and to distinguish fairly well the flows from the sedimentary beds. The flows are massive and display some columnar jointing, and the bedding of the sediments and tuffs is fairly well defined.

The base of the group, as seen on Kirk Mountain, consists of more than 500 feet of andesite, which ranges from dark grey where least altered, to dull red or green where more altered. Both the base and the top of this flow (or flows) are coarsely brecciated. In places the rock is amygdaloidal, and all of

it carries phenocrysts of andesine feldspar, with a few of basaltic hornblende, up to $\frac{1}{10}$ inch in length. Their relative abundance varies greatly from place to place.

Above this basal lava, throughout a thickness of at least 3,000 and perhaps as much as 5,000 feet, very thick and massive flows alternate with sediments, tuffs, and some thin flows. The flows seem to be mainly if not entirely andesites. The sedimentary beds include banded jasper and chert, some of which were traced laterally and found to grade into shaly or tuffaceous materials. Some conglomerate is present, the boulders consisting of volcanic materials only, with none of granodiorite. Red, grey, and green shales, greywackes, and argillites, in places cherty or quartzitic, are present, and few of them carry much lime. One zone, however, was high in lime and loaded with fossils, which broke out like nuts from their shells. Most of the shaly and tuffaceous rocks have a low silica content, are soft, and in places are very fissile. Tuffs are fairly abundant in the higher parts of the group, but much less so in the lower.

Age

A splendid collection of fossils, F29 (p. 83) was obtained from a locality on Kirk Mountain some 1,500 feet above the base of the group. Unfortunately, most of them were brachiopods that have not as yet been sufficiently well classified to be of much value for age determination. S. S. Buchman, who kindly examined them, reports as follows: "It is in my opinion a particularly difficult matter to say whether these specimens are Jurassic or Cretaceous without a prolonged investigation of characters, particularly internal. These are only partially known for Jurassic species, and are almost unknown in regard to Cretaceous. External likeness is no guide. However, I pronounce for the Cretaceous, possibly Lower Cretaceous . . . ." It, therefore, seems best for the time to classify the group as Jurassic or Cretaceous.

Upper Cretaceous

Upper Cretaceous rocks are found only in the northern map-area, where they constitute two groups, one between Glenora and Mess Creek, the other on Helveker, Kirk, and Strata Mountains.

The Glenora-Mess Creek group of occurrences comprises one large and several small masses, all of which are probably downfaulted blocks. At the base of the formation, on the southwest, is a coarse conglomerate, made up of well-rounded boulders up to a foot in diameter. The boulders comprise a great variety of materials. Volcanic rocks similar to those in the older Mesozoic formations are the most abundant, but others include sedimentary rocks similar to those of Palæozoic and Mesozoic age, granitic rocks similar to most of the near-by intrusive masses, including the quartz monzonite, and fragments not unlike the pyroclastic material of the Helveker volcanic group. Most of the boulders are highly fractured, as if considerably disintegrated before cementation. The matrix is composed of similar, though smaller, fragments, and ranges from red arkose to greenish greywacke, according to the relative abundance of the various constituents. Fragments of carbon are scattered through it. The rock is poorly cemented, and boulders break out readily. The size of the boulders decreases toward the northeast, and the softer seem to have been disintegrated by wear. On Mess Creek the pebbles range only to 4 inches in diameter, and are largely of hard materials such as chert and quartz, with some granitic material and slate, and the texture of the matrix is more sandy.

Above the basal conglomerate, the thickness of which was not determined, there are on Mess Creek 1,000 feet or more of sandstone and conglomerate, with a little shale and seamlets of coal. One bed of rhyolite or rhyolite tuff was found, and possibly tuffaceous materials may be mixed with the constituents of other beds. The beds are usually grey, more rarely pink, green, or even red. The conglomerates are similar in composition and pebble size to the basal conglomerate on Mess Creek. The sandstones carry scattered pebbles, and though the finer grained consist mainly of quartz, the coarser types contain much undecomposed mineral fragments from the volcanic and granitic rocks, so that they might better be called greywackes and arkoses. Bedding is rather poorly defined and irregular, and crossbedding was seen in a few places. Fossil leaves can be found in the fine sandstones and shales, and one fairly good collection, F2, was made on Kunishma Creek.

The upper parts of Helveker, Kirk, and Strata Mountains are occupied by the remnants of what was presumably a once continuous formation, which rests on various members of the folded and faulted Jura-Cretaceous and Triassic volcanic rocks. On Strata Mountain these older beds are decomposed and red to an observed depth of at least 10 feet, and the basal part of the overlying series appears in places to consist of broken, but not rounded, masses of this red material in a similar but somewhat more decomposed matrix. Where the underlying rock was conglomerate or breccia, it is difficult to establish the contact definitely. No rootlets, humus, or other products of vegetation were found to confirm the idea that the basal material is an old soil. A few water-worn pebbles and boulders are found in it here and there, and it generally grades upward to coarse conglomerate with well-rounded boulders up to a foot in diameter. On the western side of Strata Mountain, however, the basal rocks are red sandstone and arenaceous shale.

On Kirk and Helveker Mountains the basal beds are coarse conglomerates with well-rounded boulders up to 1 foot in diameter. They are red in colour, due to weathering; many boulders have a red crust over a green or grey core. The boulders comprise Jurassic sedimentary and volcanic rocks, altered Palæozoic sediments, and a great variety of intrusive rocks. Some of these are similar to known intrusions, such as sheared diorite, hornblende granodiorite, and biotite granodiorite. Others, such as one with high quartz and probably high orthoclase content, are only vaguely suggestive of some Coast Range types. As the constituents of the conglomerate were derived from rocks that lay thousands of feet above the present surface, exact matching is hardly to be expected. The conglomerate is fairly well cemented, but boulders weather out whole to form great talus slopes of gravel that conceal long sections of the strata below. For this reason, knowledge of the succession is as yet imperfect.

On the northwest slope of Kirk Mountain a hollow was found, possibly an old stream channel, below the supposedly basal conglomerate. This hollow, 100 feet or more in depth, is filled with green, grey, and red, bedded sandstone and shale containing fragments of carbon.

Above the basal beds, on all the mountains, occur coarse sandstones, green and grey arkoses, and sea-green and grey tuffs of rhyolitic and dacitic composition. These finer grained beds are interbanded with heavy conglomerates, 30 to 40 feet thick. The amount of finer materials, relative to that of conglomerate, is perhaps greatest on Strata Mountain, and least on Kirk Mountain, where conglomerates greatly predominate. An unusual bed, found on Strata Mountain near the base of the section, is a black sandstone with grey concretions. A similar bed was found on Dodjatin Creek.

In the upper horizons of the series, the conglomerates become coarser, to where, on Strata Mountain, well-rounded boulders range up to 3 feet in

diameter, and 1-foot boulders are very abundant. Finer grained beds are represented only by a very few beds of coarse sandstone and tuff; and tuff beds change in composition from rhyolitic to andesitic.

Somewhere above the middle of the succession, a sharp change takes place in the composition of the conglomerates. On Strata Mountain the pebbles in the lower beds are mainly of Palæozoic (?) schists, slates, and quartzites, with smaller amounts of volcanic rocks, whereas near the top of the section the pebbles are mainly of intrusive rocks, including hornblende granodiorite, quartz monzonite, and a dense rock with large quartz and feldspar phenocrysts. On Helveker Mountain the change also occurs well up in the series. There the lower of two coarse conglomerates, which are separated by some 50 feet of fine materials, carries mainly pebbles of volcanic rocks, and the upper, dominantly granitic rocks. These changes are taken to mark the successive removal of various types of rock, and the final unroofing of the batholithic intrusions, including the quartz monzonite.

No lavas were definitely recognized in the series, though the presence of tuffs suggests that they will be found somewhere if they were not destroyed by intraformational erosion. On the western side of Strata Mountain there are fairly large masses of rhyolite, but it is not known whether they are of extrusive or intrusive origin. Numerous dykes are present, apparently either feeders to the vents that gave rise to the pyroclastic beds, or to the overlying Helveker volcanic rocks. On Helveker Mountain, some dykes of trachy-andesite, carrying white feldspar phenocrysts, cut the lower conglomerates in such a manner as to suggest that they were still unconsolidated. The igneous material flows promiscuously around the boulders, and in places resembles a lava.

The full thickness of the series, 1,700 to 1,900 feet, is displayed on Helveker Mountain, where both the base and the top are found. On Strata Mountain (Plate IV B) where the upper volcanic rocks are not found, some 1,500 feet of strata are still present.

Structure

In the Glenora-Mess Creek area the base of the series was observed only on Mess Creek, where it is exposed on the face of a cliff. Though it cannot be studied at close range, the contact with the older Triassic volcanic rocks can be seen to be a sharp but irregular line, and judging by the nearby bedding in the older series, must represent a pronounced angular unconformity.

In most outcrops of this area the beds are tilted and have dips up to vertical. Many of the exposed parts are greatly shattered. Both effects seem due to faulting and the tilting of fault blocks, as there is slight evidence of folding. There is abundant evidence of major faulting along contacts on Winter, Dodjatin, Susie, and Kunishma Creeks. The southwest side of the mass in Mess Creek Valley is a 500-foot cliff of Triassic rocks, a nearly vertical fault scarp along which the displacement, taking into account the thickness of the Upper Cretaceous block, would seem to have been more than 1,500 feet. On the northeast side, also, there is a major fault that displaces the series, though it does not mark the contact, at least not along its entire length. Furthermore, the shattered condition of the outcrops, the scarps, and the structural relationships, make it seem highly probable that other important faults traverse this mass.

Outside of the disturbances along the borders, due to faulting, the structure is relatively simple. East of Buck Riffle the prevailing dip is 20 to 55 degrees southwest; west of it the dip is 20 degrees northwest to vertical. The difference in attitude suggests a fault between the two sections.

In the Helveker-Strata Mountains area the upper beds lie with great angular unconformity on the underlying formations, which are intensely folded

and in places have vertical attitudes. The Cretaceous rocks have a gentle monoclinal dip to the northeast, and are gently undulating with dips rarely as high as 30 degrees. There is some minor faulting, mainly on Helveker Mountain, but no major displacement. Some evidence suggests, however, that there may be important faults between the different bodies.

Age

A collection of leaf imprints, F2 (p. 81), in micaceous sandstones was obtained on Kunishma Creek, and examined by W. A. Bell. Several species were new, and others of no value for identification, but the presence of one, *Aspidiophyllum trilobatum,* so far only known from the Dakota group of Kansas and the Raritan of the Atlantic coastal plain, appears to fix the age as Upper Cretaceous, probably Cenomanian or Turonian rather than later.

No fossils were obtained from the Helveker-Strata group, but the general resemblance is so great that correlation can hardly be doubted.

Conditions of Deposition

The character of the sediments, the entire absence of marine fossils, and the presence of leaf imprints, fragments of carbon, and a little coal, all point to these beds as subaerial deposits.

The deep truncation of the steep folds of the older rocks, and their deeply rotted surfaces, combine to suggest a long period of erosion before the Upper Cretaceous rocks began to be deposited. The character of the basement, where it can be seen, makes it seem probable, or at least possible, that the topography was comparatively mature.

Uplift then began on one or both sides of the area, so that the products of erosion were carried into it, obviously, from the coarseness of the products, by very rapid streams. Seasonal changes, and variations of rainfall, probably account for the presence of the finer grained beds. Uplift must have proceeded faster than erosion could lower the surface, as the conglomerates become coarser and coarser in the higher horizons of the series. The series must record the erosion of many thousand feet of strata, as the batholithic covers were entirely removed, and the upper beds consist mainly of granitic debris.

The area may be considered, therefore, as part of a great intermontane valley of deposition, which probably occupied the whole area between the present Coast and Cassiar Ranges.

HELVEKER VOLCANIC ROCKS

The top of Mount Helveker is capped by some 500 feet of flows, tuffs, and breccias, here termed the Helveker volcanics. It will be recalled that the tuffs in the underlying series exhibited a progressive change in composition from rhyolitic near the base to andesitic at the top. The process is continued in the Helveker volcanics. At the base the flows are acidic andesites with phenocrysts of sodic andesine and hornblende, in a matrix largely of andesine with considerable orthoclase. Higher up, the andesine becomes less sodic, and finally, near the top, labradorite takes its place; the matrix becomes basaltic.

The lavas are light grey, green, or red, and the interbedded tuffs are mainly light green or brick-red. The lavas are relatively little altered, though in places brecciated. The upper flows, where well exposed in a cliff on the north side of the mountain, have well-developed columnar jointing. Dykes, probably feeders to the higher flows, are fairly numerous, but are difficult to distinguish from the lavas they cut.

Viewed from some distance to the southeast, the eastern limit of the exposure is a massive section of considerable thickness that pinches out westward in about one-quarter the length of the exposure. It may be a small volcanic cone. Some thin flows overlie it and conform in part to the slope of about 25 degrees, and in part to the flat beyond. What is probably a mass of ash rocks, but now largely obscured, overlies the flows and appears to fill all the lower levels to the top of the cone. Above it, in turn, several flows lie flat and generally parallel with the base of the series.

The sequence of increasing basicity that continues from the Upper Cretaceous rocks below into and through this succession of lavas suggests that there is no great break between them, and they are, accordingly, considered here to be of Upper Cretaceous age though they may be Paleocene.

Eocene

Six masses of rocks considered to be of Eocene age have been found in the valley of Stikine River between Brewery and Shakes Creeks. They are isolated from one another by drift, and are also believed to be fault blocks. The rocks are mainly lavas and their pyroclastic equivalents, with minor quantities of sediments. Basalt is the most common lava, but more acid types are also present. As the individual masses display considerable variation, they will be described separately.

The largest mass, at the mouth of Brewery Creek, has as its lowest exposed member a coarse conglomerate carrying well-rounded boulders up to 3 feet in diameter in a well-cemented greenish grey matrix. No bedding is visible in it. The matrix consists mainly of decomposed volcanic materials and quartz. The boulders display a great variety of fresh volcanic rocks, together with some of soft, greenish grey sandstone, and occasional specimens of pre-Upper Cretaceous volcanic and granitic rocks. Though some of the volcanic boulders resemble the Helveker volcanics, and others are like the Eocene lavas, most of them are of types not identified anywhere in the area. This, together with the fact that boulders of the nearby older formations are relatively few, suggest that rocks now completely removed by pre-Eocene and post-Eocene erosion must have been present when the conglomerate was forming, and, judging from the boulders in the conglomerate, that they must have been largely of volcanic origin. If any still remain, they must underlie the present areas of Eocene strata.

Above the conglomorate lie about 100 feet of shales, sandstones, and pyroclastic rocks, with some beds of conglomerate. Some beds are so friable as to suggest that they were never well consolidated, whereas others, particularly the finer grained, are dense and hard, and display unusual purple, green, and grey colours. There are some coarse explosive breccias, with bombs up to 6 inches in diameter. Some tuffs are made up largely of fragments of glass, whereas others contain lava and feldspar grains. All the clastic rocks display great variations laterally.

Fossil trees and other carbonaceous materials are abundant in some places, and collections of well-preserved leaves were obtained from some of the finer shales or tuffs.

The top of the section is a succession of lava flows, estimated to be nearly 500 feet thick. The lavas are mostly basalts, but some andesite and latite are also present. The basalts are usually dark and fine grained, but some have small phenocrysts of plagioclase or amphibole, and others display extraordinary light green shades. They are vesicular in many places, the vesicles filled with zeolites, agate, chalcedony, quartz, and other minerals. Some of those lined with silica weather out in nut-like masses, which when cracked open make a

pretty display of agate and drusy quartz. At one place lava stands in a vertical cliff more than 100 feet high, and shows well-developed but irregular columnar jointing. It appears to be all one flow.

Similar lavas continue up Brewery Creek beyond the second bend, where they outcrop in a cliff 200 to 300 feet high.

About 2 miles farther up Brewery Creek there is another small isolated mass of lava and breccia, through which the stream has cut a canyon. The lavas are all of the common basaltic and andesitic types.

In the mass at the mouth of Tsikhini Creek, the lowest beds are of rotten, earthy materials, grey to purplish grey and yellow in colour. They carry a few scattered boulders, most of which match fairly well with the Upper Cretaceous volcanic and sedimentary rocks, and with the granitic rocks to the east. In particular, pebbles were noted of an odd white volcanic rock, with biotite phenocrysts, that is associated with the Upper Cretaceous of Helveker Mountain. There are few pebbles of the unusual fresh volcanic rocks such as make up most of those in the Brewery Creek conglomerate.

The preceding beds are overlain by shales and tuffs, and then by basalts identical with those of the Brewery Creek mass, and containing similar amygdules. Three flows 15 to 20 feet thick are interbanded with heterogeneous pyroclastic and sedimentary materials, and the overlying member is a flow 75 to 100 feet thick. It is overlain, at the river near water level, by a hard, light grey rhyolite.

Nearly opposite, on the west bank of the Stikine, grey sandstone beds contain in places a peculiar, soft, yellow substance believed to be fragments of very fine-grained tuff. In one place the sandstone is so carbonaceous, and is interbedded with so many seamlets of coal, that the material is said to be suitable for use in a forge. Elsewhere the sandstone contains chunks of carbonized wood, or brown and black lignite that still retains its original woody texture. The sandstone has a vertical dip, and is so badly contorted and faulted as to suggest the nearby presence of a major fault.

West of the sandstone, a cliff exposes a peculiar breccia that resembles the less well exposed breccias in the Brewery Creek mass. It is mottled light grey, dark grey, and yellow, and contains bits of carbon, slate, quartz, feldspar, andesite, a soft yellow substance believed to be a glass tuff, and various other pyroclastic materials. Some large chunks of wood are also present, which look like driftwood but are heavier, dark brown, partly carbonized, and perhaps partly replaced by some mineral. The breccia as a whole resembles an explosive tuff that has been reworked by a stream and mixed with sedimentary materials.

The two masses north and south of Shakes Creek display a variety of rock types similar to those described, that is, basalts, pyroclastic and sedimentary materials, and a light grey rock that may be the rhyolite. Breccia similar to that just described is also present, but differs in containing fewer non-pyroclastic fragments. The main constituents are large fragments of glass, and andesite which, as that referred to in the preceding paragraph, carries large phenocrysts of oligoclase.

All the beds of the series are badly shattered by small faults, and tilted so that locally they lie even in vertical attitudes. Most of the blocks appear to be downfaulted into their present positions, with displacements of at least several hundred feet. The deformation is thus undoubtedly due to faulting rather than folding.

It is believed that these rocks are remnants of a considerably more extensive mass originally deposited in the ancient valley of Stikine River. The

arrangements suggest that flows were poured out, like those of Pleistocene or Recent age in the Grand Canyon of the Stikine; and that the river then cut into them, laying down deposits of mixed volcanic and sedimentary material.

Age

A collection of fossil leaves, F7 (p. 82), was made from the Brewery Creek mass, and examined by W. A. Bell, who assigns them to the Eocene and probably the late Eocene, comparable to the Kenai of Alaska.

QUATERNARY

VOLCANIC ROCKS

The Quaternary volcanic rocks fall into three distinct groups, the lavas of the upper Stikine Valley, mainly above Telegraph Creek, of Iskut Canyon, and of Hoodoo Mountain. The three have distinctive characteristics, and there is no evidence of any relationship between them.

Stikine Lavas

Isolated masses of lava perch on the sides of Stikine Valley from Shakes Creek to the northeastern limit of the northern map-area. They are obviously all parts of one flow, or succession of flows, that came down the valley and have since been removed in large part by river erosion. The lava is a dark grey, fine-grained, olivine basalt, carrying white, black, and yellowish green phenocrysts of labradorite, augite, and olivine, together with a few well-rounded vesicles. The flows display well-developed columnar jointing, and are fairly uniform throughout except at the base, which is somewhat softer and more scoriaceous for a thickness of about 6 inches.

The observed base of the lavas lies about 150 feet above the river south of Telegraph Creek, and 200 feet at Telegraph Creek. Six miles above Telegraph Creek the base is much more than 200 feet above the river on the west side, but in places on the east side, in the river canyon, it lies within 100 feet of water level. These irregularities are all due to the fact that the lava filled the bottom of the old valley; and for the same reason the observed thicknesses vary greatly, according as to whether parts near the middle of the old valley or its edges were measured.

In the upper parts of the canyon, as many as six flows have been observed, but around Telegraph Creek and below there seems to have been only one. Structures in the upper part indicate much channel cutting by the stream between flows, the channels, of course, being refilled by the next flow. This repeated filling of the old valley, which presumably was originally like the present wide valley below Telegraph Creek, has prevented a more normal development, and is the reason for the presence of the canyon in this section.

A small mass of the lava that crosses Telegraph Creek about 4,000 feet above its mouth outcrops as a wall-like mass some 75 feet in width and as much in depth, and some 300 feet long. Both the bottom and the ends are hidden by drift. It would seem that the lava here must have filled a small valley more or less parallel with the Stikine.

The lava rests either directly on fresh rock surfaces, evidently worn by either ice or water, or on gravels like the present river gravels, except that in places they are partly cemented. Here and there they seem to have the form of terraces, and they contain a surprisingly large proportion of granitic boulders.

As the lavas thicken upstream, and more flows are found in that direction, it must be presumed that the lava flowed down the valley; and the nearest possible source would seem to be the vast area of lavas up Klastline River to the southeast. If so, to reach Telegraph Creek the lava must have flowed some 52 miles at least, indicating great mobility.

The age of these lavas is believed to be partly late Pleistocene and partly Recent. The valley surface beneath the lavas shows evidence of glaciation, and the shape of the pre-lava valley suggests much glaciation; in fact, the changes wrought by glaciation after the lava was introduced seem to be relatively slight. Further, if the lava had been poured out in pre-glacial time, or during an early Pleistocene time, and channels then cut into it by the river, subsequent erosion by the southward-moving valley glacier would have been great. There is no evidence of any such erosion, either in the lava beds themselves or in the drift to the south.

One boulder of this rock was found, however, on the top of Conover Mountain some 15 miles southwest of the nearest outcrop at Shakes Creek. As no other source for the boulder is available, there seems no escape from the conclusion that it was carried to its present position by glacial ice. The general lack of such debris, however, leads to the inference that the lava must have filled the valley toward the end of the last interglacial period, so that the river had little chance to cut into the flow before glaciation, and hence the flow would have been protected by its massiveness. It is clear, from the distance it flowed, that it could not have been extruded during a glacial period, when it would have been forced to melt the valley ice ahead of it.

On the other hand, in the source area from which this lava is supposed to have come, undestroyed, well-formed craters, hot springs, and other evidences of recent vulcanism are reported to exist. It seems quite possible, therefore, that some of the later flows may be of Recent age.

Iskut River Lava

The Iskut River lava is found at the canyon of the Iskut, in the extreme eastern part of the southern map-area. It was traced upstream for 5 miles, and is said to be present throughout the whole 12 miles of the canyon. The lava appears as a thin deposit somewhat below the mouth of Snippaker Creek, and thickens fairly rapidly to a maximum of about 100 feet. The surface is fairly flat, but rough and clinkery. In places it is overlain by as much as 3 or 4 feet of pisolitic mud, and this in turn by about half an inch of fine, light grey sand or ash; in other places by soil that near the river contains an abundance of small river pebbles of non-lava materials. The surface suggests a very recent flow that has been subjected to little erosion.

In the lower parts of the canyon, which is mostly 100 to 200 feet wide and up to 100 feet deep, the river has cut completely through the lava or nearly so. In places the lava appears to represent a single flow, in other places two or more flows. At the highest point reached in the canyon, there appeared to be three flows, 40, 40, and 20 feet thick respectively. The lava displays well-developed columnar jointing, and, commonly, vertical walls.

Megascopically the lava is somewhat like the Hoodoo lava, but the microscope brings out important differences. The Iskut River lava is a dark grey, very fine-grained, olivine basalt, with phenocrysts of labradorite and olivine. The feldspar phenocrysts are large, up to an inch in length, and glassy, as the sanidine of the Hoodoo lavas. Plagioclase, titaniferous augite, olivine, and magnetite are the chief constituents of the groundmass.

It is believed that these flows were poured into Iskut Valley at some point in the upper part of the canyon section, probably from the north as no volcanic cone was visible immediately to the south, the only side observed. The character of the surface and the presence of the pyroclastic material suggest a very recent age.

Hoodoo Lavas

Hoodoo Mountain of the southern map-area is one of the most magnificent and interesting mountains in northern British Columbia (Plate V). It does not possess the rugged outline of its neighbours, but largely retains the shape characteristic of volcanoes. In general, it rises with gentle slopes of 10 to 20 degrees to a crater, now ice-filled, at an elevation of more than 6,500 feet. Except for minor irregularities caused by erosion, any contour line is practically a circle. About the middle of the south side two great vertical cliffs each rise for several hundred feet; over them streams drop in magnificent falls. The west side presents an irregular series of vertical cliffs of which the lower are as much as 700 feet in height. Hoodoos, needle-like pyramids up to 500 feet in height, and other odd monumental forms, give the mountain a weird appearance. The brilliant greens of forested sections alternate with variegated browns and yellows of long talus slopes that lie at the bases of the grim black cliffs. The old crater is filled with blue-white ice, from which irregular tongues protrude on all sides to supply a multitude of streams. On the west side these reach the glacier below over a series of beautiful falls and cascades.

The volcano erupted in the centre of an old valley that must have drained to the Iskut about 3 miles above the present Hoodoo River. Hoodoo and Twin Rivers appear to have been originally tributary to this main stream, and its damming has created two ice-lakes from which magnificent glaciers extend to encircle the northern base of the mountain. Successive outflows from the volcano repeatedly disrupted the drainage, so that the flanking streams and glaciers have had a difficult struggle to maintain their channels. The preponderance of Hoodoo volcanic rocks in the unusually extensive morainal deposits of Hoodoo Valley, almost to the entire exclusion of other material, and the angularity and size of the fragments, all indicate the removal of immense quantities of rock from the mountain. They must have fallen off in great slides such as that of 1919, and must have destroyed or created cliffs similar to those now visible. Many sections of the mountain are still in a very unstable state, and great slides with consequent stream damming and diversion are apt to occur from time to time.

The oldest Hoodoo lavas are no doubt now buried by later flows. Those now exposed fall into three main groups; an oldest *pahoehoe* series, with small phenocrysts or none, which is now mainly found on the west side of the mountain; a later *pahoehoe* series with large phenocrysts of sanidine, and now well exposed on the south and east sides; and the youngest series, of *aa* flows, which is confined to the top of the mountain, notably on the south side. Pyroclastic rocks, glacial drift, and some river and lake deposits are locally interbedded with the flows, and elsewhere may underlie them.

The oldest flows are dark grey, green, or black rocks, grading to lighter tints where the grain coarsens. They are generally fine grained, even glassy, but in thick flows the grain may become so coarse that the rock resembles an intrusive. In places they are vesicular, and the amygdules, many of them, are lined with analcite. The main constituent is sanidine, a transparent, glassy, potash or soda-potash feldspar; others are hornblende, chlorite, and magnetite.

The texture is commonly trachytic, and in many flows the feldspar laths have a sub-parallel arrangement. Phenocrysts begin to appear in the upper horizons, and become progressively larger upward.

A small patch, about 50 feet in diameter, of a still older lava, was found near the base of the mountain on the west side, where the slide of 1919 removed in places all of the old series described in the preceding paragraph. It is a greenish black, fine-grained, columnar lava, with a surface polished and striated by glacial abrasion.

Just south of this exposure, the slide of 1919 has removed the Hoodoo lavas from a patch 1,900 feet wide and the same distance high, of pre-Hoodoo granitic types, Triassic volcanic rocks, and Permian beds. This seems to have constituted one of the shoulders of the old valley now filled by the Hoodoo lavas. These are also glacially polished and striated.

Both patches, the small one of very old lava, and that of pre-Hoodoo rocks, are covered in spots with grey glacial drift, the type usual in the region, and which was undoubtedly deposited by ice coming from north of Hoodoo Mountain. Drift left by the action of glacial ice on the lavas themselves is brown. This grey drift was traced up the mountain slope for 1,500 feet, or to a height of more than 1,900 feet above sea-level, and may well have passed right over the top of Hoodoo Mountain as it was at that time. The grey drift is overlain by what has been termed the oldest exposed series of flows, and the base of the lowest flow is commonly a coarse breccia that contains glaciated boulders up to 3 feet in diameter, and other foreign materials. This makes a readily recogized horizon that was traced uphill, in the stream valley entering Hoodoo Valley near the foot of the glacier, from the glacier to an elevation of about 3,500 feet. In that section, the average dip slope is 30 to 40 degrees.

This set of flows displays some astounding variations in thickness down the dip. The lowest flow, just mentioned, is 300 to 400 feet thick at the top of the slide area, 1,500 feet above the valley, but farther uphill the thickness decreases considerably. Farther north, the same flow or another is less than 100 feet thick on the mountain slope, but near the glacier it thickens abruptly to tower above the glacier in a cliff 700 feet high. In several other places on the west side there are similar great cliffs, each of which appears to be cut out of a single flow. Again, in many places overlying flows have abnormal horizontal or near-horizontal attitudes, which can only be interpreted as indicating that lower flows had been thickened so as to create fairly flat platforms on which succeeding flows had poured out.

As both the composition of the lavas and the behaviour of the flows above the thick parts indicate that when molten they had considerable mobility, it can be inferred only that the thick parts are due to damming; and such damming can only have been caused by the presence of glacial ice. The molten lava, striking the top of the glacier filling the valley, was chilled sufficiently, before the ice could be melted and then vaporized, to build up great walls, behind which the molten rock was impounded.

Supporting this conclusion, attention may be drawn to the fact that all the flows of this early series show signs of more intense glaciation than any of the later series of flows. Such signs of glaciation have been observed up to an elevation of 3,500 feet, above which point the older series is concealed by the younger. Further, where younger lavas are poured out on the older, the younger include little talus material, even at the base of old cliffs, although at present talus in such positions is present in enormous amounts. All this evi-

dence would, therefore, seem to indicate the presence of glacial ice that closed in again directly an eruption was over, prevented atmospheric disintegration in large part, and swept away such products as did form.

The fantastic mountain topography thus developed has caused queer structural relationships. Islands of older flows are in places surrounded by a series of younger; a very old cliff may be flanked by later flows that either cascaded over its top or moved around it. In many ways the normal complexity of a volcanic cone has been further complicated. With the beginning of ejection of the second series of flows, the centre of ejection seems to have been shifted to the east, as they appear mainly on the south and east sides of the mountain. This series differs from the first only in having fairly abundant phenocrysts, usually large, and in places more than an inch long. Different flows can be distinguished by the number and size of their phenocrysts. The phenocrysts are mainly sanidine, though small crystals of pyroxene are also visible in thin sections.

One of the oldest of these flows forms much of the south face of the mountain, where it was traced from an elevation of more than 4,000 feet down to the base and out into Hoodoo Valley where it lies on gravel flats continuous with those below it. Its thickness near the lower edge ranges from 20 to 75 feet, and it has a brecciated and highly scoriaceous base of irregular thickness. Columnar jointing is not well developed. Its surface in most places is overlain by fine ash that makes excellent soil, and largely obscures the surface, which in places appears glaciated but elsewhere does not.

Higher members of this series are well displayed in Twin Valley and on the slopes above. The flows are 10 to 50 feet thick, and maintain their thicknesses fairly uniformly. They appear to have flowed out on glaciated surfaces, and to have been glaciated themselves to such an extent that some are represented by thin isolated remnants. Lava appears to have filled a canyon in the bottom of the valley where the present stream is; and probably there are other canyons, farther west, now filled and completely buried. Some thin ash beds are found between the flows. In general, these flows leave the impression that they were deposited under conditions much like the present.

The mountain is capped, particularly on the south side, by the *aa* flows. In contrast with the earlier, very fluid lavas that seem to have carried little gas, these appear to have been much less mobile and extremely gassy. They now consist of highly broken, very vesicular and pumiceous material that in the way it extends down the mountain suggests a very thick froth. The rock carries sanidine phenocrysts of about the same size and abundance as the lavas of the second series, and it may be of about the same chemical composition. It displays a variety of red and brown shades, and is largely responsible for the irregular top of the mountain and for many of the hoodoo forms. Because of its character, this rock is now mainly in small fragments that form great talus slopes flanking a few solid masses. Intermixed with the lava talus are pyroclastic fragments of various kinds.

On the south side of the mountain, a deep gully has been partly filled by a flow of *aa* that, in spite of the fact that it is so easily broken, still retains its flow characteristics. This, and the fact that it has not been removed by erosion, are taken to indicate a very recent origin. It is probably not more than a few hundred years old.

In addition to the various types of lava, pyroclastic rocks are found locally between the flows. Pisolitic mud, which is not uncommon, is a brown or yellowish, moderately hard, light rock composed mainly of very fine volcanic dust that would ordinarily be dissipated by wind but was brought down by heavy

showers accompanying explosive eruptions. It is either massive or bedded, and has a pisolitic texture. Possibly the glacial temperatures prevailing during extrusion may have caused more rain than is normal at times of volcanic eruption, so that the amount of this material is larger than in most volcanic deposits.

Volcanic tuffs are light yellow, grey, or brown in colour, light in weight, and apt to be earthy or chalky in appearance. Some are made up largely of glass fragments in a matrix that resembles the pisolitic mud. Some contain fragments of trachyte and sanidine, or incipient feldspar crystals.

Though most of the pyroclastic rocks are fine grained, on the top of the mountain and elsewhere some coarse explosive materials have been consolidated into agglomerates.

Some interesting unconsolidated sediments are found below the glacier in Hoodoo Valley, and extend well down toward the Iskut. Though poorly bedded, they have a crude deltaic structure, and are supposed to have been formed, early in the history of the mountain, in an ice-dammed lake formed by the melting of part of the glacier by a lava flow. On the west side of Hoodoo River, where the glaciated rock base of the river drops abruptly below gravel fill, there are between 200 and 250 feet of these deposits with deltaic bedding. In the lower parts most beds have an earthy matrix that may be, in part at least, pyroclastic material. These beds contain many large boulders, well faceted, striated, and polished, that seem to have been dropped by floating ice. Interspersed with these are beds of gravel and finer pyroclastic materials that have been worked over by water. The writer would suggest that the pyroclastic materials might have fallen on the surface of the glacier to drop down when the ice was melted. The percentage of coarse materials in the assemblage increases toward the top, and the upper 20 feet are mainly boulders and large pebbles. No fossils were noted. Overlying the delta deposits are 20 feet of glacial drift. Both the waterlain material and the glacial drift continue up the valley beyond the main body, in isolated patches or as a thin veneer, to a point 950 feet above Iskut River, or 1,100 feet above sea-level.

Similar deposits, partly obscured by slide material, are found on the east side of Hoodoo River. They constitute the gravels that, as mentioned (p. 43), are overlain by a flow of the second series of lavas that extends into Iskut Valley.

From the fact that the lowest flow of the earlier series contains clastic materials much like the upper parts of these sediments (p. 42), and the drift that overlies them seems to be the same as that underlying this flow, the writer considers that they were probably formed prior to its extrusion; and that their preservation is probably due to their being covered by this flow or a later one.

Hoodoos. On the west side of the mountain, at an elevation of about 3,500 feet, stands a magnificent needle, locally known as "the monument". Light grey in colour and more than 500 feet high, it stands out against the dark lavas as a most impressive spectacle. Efforts to reach it were frustrated by great cliffs, so that it could only be viewed from a distance. Slightly oval in cross-section, it rises like a needle with gradually decreasing diameter to a very sharp point. The rock appears to lie in plates parallel with the surface of the needle and these peel off like the layers of an onion. From the west, a band of uniform width can be seen running up the centre; it has horizontal jointing, like a dyke. The rock on either side of the central band appears to be of much the same type. In the writer's opinion, the mass is either part of a dyke or a volcanic neck from which extrusion probably took place.

Other neck-like masses were observed, some of which have somewhat similar shapes and stand out prominently. One, 2,300 feet north of "the monument", appears to be of much the same type of material and again shows horizontal jointing. It is, however, more elongated, and may be a dyke. One on the southwest slope is made up of light grey, granular rock similar to that which appears to compose "the monument." The surface was coated with small analcite crystals, and the rock has drawn-out, irregularly shaped vesicles. At another neck the lava beds, which are cut off abruptly, turn on one side from an outward to an inward dip, as if the vent had been formed by collapse. At least one "monument-like" outcrop was found to be a dyke.

Probably both dykes and necks were vents from which some lava escaped; but the amount supplied from these sources was probably small compared with that from the main vents now buried beneath the glacial cap.

In addition to those described, hoodoos formed by erosion of the ordinary flow rocks are numerous. Those produced near the summit by erosion of the *aa* flows have already been mentioned. A thick flow breccia on the southwest slope between elevations of 3,500 and 4,000 feet is responsible for many odd hoodoo forms. This flow appears to have picked up and included much talus material.

Age. It has been shown that the oldest lavas that are exposed in quantity flowed out on a glaciated surface that was traced to an elevation of 3,500 feet and may have gone higher. It has also been shown, from the peculiar shapes of the flows, that when these eruptions occurred the ice probably engulfed the mountain to elevations of 3,500 feet at least. At that time, however, a cone of the same height had been built up, so that the first eruptions must have taken place considerably earlier.

The second series of flows do not have the peculiar shapes of the first, but appear to have been ejected under climatic conditions much like the present. Apparently stream erosion had been active for a long time when eruption took place, as they fill a canyon of considerable depth. Also, they have been rather severely glaciated. All these facts suggest that this series of flows was extruded during an interglacial period, probably the last; and this determination would place the time of eruption of the older series in a preceding glacial epoch. It is quite possible, therefore, that volcanic activity may have been initiated either early in Glacial time or prior to the onset of glaciation. The evidence at hand seems to indicate that the volcano was active up to some time within the last few hundred years; and it may still be merely dormant rather than extinct.

Other Possibly Recent Igneous Rocks

On Mount Fizzle a large mass of black, fine-grained, vesicular rock may be a lava of Recent age. On the northeast slope of Iskut Mountain a few dark green, easily eroded dykes are jointed like those of fairly recent age, and on Bronson Creek dykes of light greenish grey, very fine-grained rock may also be of late age.

GLACIATION AND GLACIAL DEPOSITS

Quaternary glaciation appears to have begun with the accumulation of snow and ice in the high peaks of the Coast Mountains. As accumulation continued, the ice flowed away down the valleys from the axis of the range in both directions, southwest to the Pacific and northeast toward the interior. These movements seem to have continued a long time, and were brought to a close by the more general accumulation of ice over the whole Cordilleran region. As

this attained a maximum, outward flow began from the interior of the Cordillera rather than from the Coast Mountains, so that movement over Stikine district was reversed. The movement, however, seems to have affected mainly the upper levels of the ice-cap, whereas the lower levels remained more or less stagnant. With the disappearance of the general ice-cap, movement in the valleys away from the axis of the Coast Mountains appears to have begun once more and continued until the valley glaciers disappeared. This cycle would be repeated if more than one general ice-cap formed during the Glacial period, but no evidence for successive ice-caps has been obtained.

Evidence of alternate directions of ice movement in Stikine district must of course be sought in the northeastern part, as in the southwest movement was at all times toward the Pacific. In Stikine Valley itself, the centre from which ice flowed both southwest and northeast was the relatively narrow part extending roughly from Little Canyon in the central map-area to Klootchman Canyon in the northern map-area. All the evidence of alternating movements was, therefore, obtained in the northern map-area.

Evidence for early northeastern movement is found in the Telegraph Creek area, where, as already mentioned (p. 40), the Stikine lavas filled the bottom of a valley that, from its characteristic U-shape, had already been severely glaciated. The lavas were observed to lie on polished and striated rock surfaces, and on gravels; and the gravels consist largely of granitic materials such as are found in the Coast Range to the southwest, but not on the Stikine Plateau to the northeast.

Supporting evidence of northeastward movement, either earlier, later, or both, is found in the shape of the valley, which widens northward as far as Glenora; in the directions of the widening valleys of Chutine River and Shakes Creek; in the shape of numerous *roche mountonnée* surfaces in Stikine Valley and the tributary valleys; and in the existence of terminal moraines *northeast* of the mouth of Shakes Creek, which were almost certainly formed by a glacier coming down the valley of that creek. Also, practically all the materials in the drift from Chutine River to Telegraph Creek are of rock types found abundantly in the Coast Range but rarely, if at all, in the Stikine Plateau. No Quaternary volcanic rocks were observed in this drift, in spite of the fact that to the north, east, and southeast of Telegraph Creek there are hundreds of square miles of these lavas.

From Glenora upstream the Stikine Valley slope, instead of being downwards to the north as it was from Chutine River, reverses itself and slopes south. Also the valley commences to narrow. As the northward movement of the ice below this point is well established, it would seem that such movement must have become slower around Telegraph Creek, so that the ice lost much of its erosive power. In the last northward movement, this might be attributed to extensive wastage by melting as the glacier entered the dry region of the Stikine Plateau. In the first northward movement, it might have been due to stagnation as the Stikine glacier encountered the ice of the first inland ice-cap.

Proofs of the second, or southwestward, movement of ice are not numerous, but seem indubitable. A boulder of the unique Stikine lava was found on top of Conover Mountain (p. 40), and black obsidian of a type found associated with the placers of the Stikine Plateau, but not present in the Coast Mountains so far as known, was observed on Kirk Mountain. Boulders of granitic rocks of a type known only to the west occur on Helveker and Strata Mountains. There is no other evidence of any movement of ice from the west, but these boulders could have been carried northeast by the first ice-movement, and thence into their present position by the second.

Further evidence of southward movement is found on some of the higher peaks, such as Helveker Mountain, where it is indicated by striæ and *roche mountonnée* surfaces. Such rounding could not have been produced by valley glaciation, but only by that of a general ice-sheet.

Evidence of the final northeastward movement of ice in Stikine Valley is supplied by terrace and lake deposits that have been undisturbed, except by atmospheric erosion, since they were laid down. Drift, containing materials mainly from the Coast Range, overlies the Stikine lavas. On Dodjatin Mountain, in the northeast corner of the northern map-area, terraces that lie between 1,500 and 3,000 feet above sea-level slope downwards to the northeast. They seem to be the lateral moraines of a glacier filling the valley and moving northeast. Other similarly sloping terraces, composed of gravel, are interspersed with these and also found at lower levels. They may have been deposited by streams that followed the edge of the glacier. Northeast of Telegraph Creek horizontal terraces may be traced for several miles, and appear to have been the beaches of an old lake. The valley slopes below are covered with fine silts and clays that look like lake deposits. Dawson reports that similar deposits are found everywhere throughout the region from Telegraph Creek to Dease Lake. It may be presumed that while the Stikine glacier retired down river, the waters of the river were dammed by it and ponded into a large lake. These deposits overlie the Stikine lavas, as well as the drift deposits already mentioned.

INTRUSIVE ROCKS

Most of the area mapped falls within the region underlain by the "Coast Range batholith", a nearly continuous mass of intrusive rocks that extends more than 1,100 miles through the coastal areas of British Columbia, Yukon, and southeastern Alaska. The present study has proved that the "batholith" is composite, and made up of a wide variety of intrusions ranging in age from Triassic to Lower Cretaceous. Many of the masses are of batholithic shapes and proportions, but others range to bodies too small to be mapped. Most of the larger masses exhibit rather wide variations in composition, either through processes of differentiation, or through digestion of varying amounts of country rock. It has been possible to study the bodies not only laterally, but also through some 5,000 feet or more of vertical range; and it is believed that through this study, coupled with the examination of a great many thin sections, it has been possible to separate them into basically different types each with its own peculiar characteristics, to determine these characteristics, and to go on from that point to recognition of differentiated varieties and hybrid types as such. In the following pages these various intrusions are described, together with their relationships to other rocks so far as known. The attempt has also been made to evaluate the importance of each type as a carrier of ores.

On the published maps it was not possible to indicate all intrusive types by separate colours, and though the map thereby loses some of its value, on the whole the procedure followed is well suited to the map scale, the rather inaccurate geographic base, and the rapid exploratory nature of the geological work.

The types recognized are given in the following list, arranged in what is thought to be a chronological order, with the oldest at the bottom:

(9) Quartz monzonite
(8) Biotite granodiorite (with hornblende and andesine)
(7) Quartz diorite
(6) Younger oligoclase granodiorite (with biotite and hornblende)

(5) Younger hornblende granodiorite (with biotite and andesine)
(4) Older oligoclase granodiorite (with hornblende)
(3) Older hornblende granodiorite (with andesine)
(2) Orthoclase porphyry
(1) Diorite

Diorite

Under the term diorite is grouped a heterogeneous lot of rather basic rocks, mostly of dark colours and with a considerable variety of grain. Many resemble closely the coarser phases of basic lava flows, and where grain is the only feature on which to base a determination there is generally doubt as to whether the material is extrusive or intrusive. Diorite masses, so called, are very numerous in the region, but most of them are less than a mile across and, owing to the limited time available for study, have not been differentiated.

Bodies 1 to 3 miles in length are found in the southern map-area on The Knob, Surprise, and Zippa Mountains, and in Craig Valley. They are dark green rocks that vary in grain from fine to granitic. Where in contact with Palæozoic sedimentary beds their relations are definitely intrusive, and dykes of similar appearance and composition cut the sediments nearby. Where these rocks are in contact with Triassic volcanic rocks, the contacts appear to be gradational, and it may be that these intrusions are merely the hypabyssal equivalents of the lavas. On the other hand, they so resemble the lavas in composition that fine-grained phases are indistinguishable from them and chilled contacts would be very difficult to locate.

The diorites are usually altered to secondary products, but appear to have been made up largely of andesine and hornblende. On The Knob the diorite is cut by hornblende granodiorite, and on Zippa Mountain it is cut by pulaskite porphyry, which includes fragments of it.

The largest mass of diorite is in the central map-area north of Patmore Creek. This body, as mapped, consists of phases that seem definitely intrusive, but are inseparably mixed with included masses of various more or less altered country rocks, and with apophyses of what were taken to be later intrusions. Variation is so rapid, due to these causes, that in most places it is possible to gather several quite dissimilar specimens within a radius of a few feet.

The mass, in fact, particularly in its upper exposures, resembles a mixture of plastic materials that had been stirred vigorously. Some inclusions are angular, and appear to be enveloped by plastic material. Others are drawn out into various shapes as if they, too, had been plastic. In many places two or more types of rock are intermixed as in a marble cake. In other places stirring appears to have been so thorough that the various components constitute a completely new type. Much of the older material thus incorporated with the mixture closely resembles Triassic volcanic rocks; other parts of it resemble the schistose or gneissic equivalents of the Palæozoic sedimentary rocks.

This mass is exposed throughout a vertical range of nearly 4,000 feet, and the deeper parts near Stikine River seem to contain less included material. The more characteristically igneous part is dark grey or green, though lighter shades also occur, and in rare instances become as light as some of the acidic granodiorites. The grain ranges from fine to granitic, but most of the rock is medium grained. In places the textures are gneissic or even schistose. The rock usually contains up to 5 per cent quartz; biotite and hornblende constitute 30 to 40 per cent, the biotite itself ranging from about half of this amount to almost nil. The bulk of the remainder of the rock is basic andesine, with a little magnetite and apatite. All the minerals, except quartz, are rather badly altered.

As the mass was plastic rather than fluid, and shows no evidence of differentiation, it is not probable that any mineral deposits originated from it.

The age of the diorite, based on its similarity to the Triassic volcanic rocks and on its relations with surrounding formations, is considered to be probably Triassic.

Orthoclase Porphyry

Under the term orthoclase porphyry is grouped a variety of rocks—pulaskites, nordmarkites, nepheline syenites, and others—all of them high in potash and most of them notably porphyritic. One of the bodies affords clear evidence that its original magma carried unusual amounts of water and mineralizers, which had profound alterative effects both on the surrounding country rocks and on the primary products of consolidation of the magma itself. The other bodies lack this evidence, but as they display similar wide variations of phase, it is concluded that the original magmas were all of the same general character.

The orthoclase porphyry bodies include: one mass about 3 miles long in the northern map-area, on Rugged Mountain north of Shakes Creek; a small body, less than ½ mile in diameter in the central map-area north of Butterfly Creek; and several masses in the eastern part of the southern map-area, none more than 3 miles in length.

BRONSON CREEK MASS

The small mass in the southern map-area on the south side of Bronson Creek is the one that has caused the intense alterations mentioned above; it does not seem to have been much more than barely unroofed. The coarsest part carries phenocrysts up to ½ inch long, of grey, purple, and pink orthoclase, and some rounded grains of quartz, in a matrix of white mica, quartz, and indeterminate feldspars. The grains show peculiar chewed edges, evidencing attack by solutions. As the contacts are approached, the phenocrysts become fewer and smaller, and eventually disappear. The rock has been much sheared and altered, and is cut by quartz veins carrying pyrite with some chalcopyrite, molybdenite, and other sulphides; and from these fissures silica and iron sulphide have seeped out into the surrounding porphyry and impregnated parts of it.

On the hillside above the porphyry, the country rock is highly altered throughout a zone more than 2 miles long, and between 1,000 and 2,000 feet wide, corresponding to a vertical distance of at least 500 feet. Beyond this zone the alteration gradually fades, but some changes were noted as much as a mile from the contact and 2,000 feet or more above it. Alteration was also observed on the northeast side of Bronson Creek, but very little on the lower side of the porphyry mass.

It may reasonably be assumed that the most intense alteration would have been directly over the intrusive mass; certainly it should not have been less than where it can now be seen. Hence, it may be concluded that this small intrusion, which is little more than a mile long and about 2,000 feet wide in the widest part, must have altered intensely a block of roof rock at least 2 miles long, 2,000 feet or more wide, and 500 to 1,000 feet thick.

During alteration, the rock was converted into mixtures of quartz, sericite or paragonite, albite, carbonates, chlorite, and sulphides. Quartz is exceptionally abundant, and in many places constitutes the bulk of the rock. Albite is found in peculiar large masses in some of the rock. Chlorite and carbonates appear mainly toward the outside limits of the intensely altered parts. Pyrite is abundant everywhere; other sulphides occur in concentrations and scattered grains.

Not only were the amounts of the exhalations from this small mass of intrusive extraordinary, but it is also peculiar that the materials exhaled, chiefly silica, soda, and lime, are the very constituents in which the porphyry is deficient, as compared with the more common igneous rocks of the area.

ISKUT MASS

The large porphyry mass north of the Bronson Creek body, which appears to have been cut in two by Iskut Valley, is termed the Iskut mass. In the coarse varieties, pink and purplish feldspar phenocrysts up to 1 inch square in cross-section may constitute nearly half of the rock. They are mainly orthoclase, but some albite-oligoclase is also present, and rarely a crystal of quartz. In places the phenocrysts are bunched to form large aggregates. In the matrix, quartz, orthoclase, and albite-oligoclase are present in about equal amounts in the one thin section examined. Biotite, titanite, magnetite, white mica, calcite, and chlorite were also identified. In most places the rock has been more or less crushed or sheared, and somewhat altered. Pyrite is fairly common.

As most contacts are approached, the phenocrysts decrease in size and abundance, and finally disappear altogether, though in some instances the coarse grain is maintained up to the contact, presumably places into which the magma moved after the general period of intrusion, and after crystallization had become well advanced.

Sediments in contact with the porphyry are impregnated with much pyrite, but otherwise are not greatly altered, and contacts with the intrusion are generally sharp. The volcanic rocks northwest of the mass are rather completely metamorphosed, so much so that at many contacts the country rock has been converted into material much like the intrusive rock, thus making it appear as if the two were gradational. The intrusion contains angular and rounded inclusions that resemble altered volcanic rocks, and many of them, at their edges, show evidences of assimiliation.

CRAIG MASS

The Craig mass is a dark grey porphyry in which grey phenocrysts of orthoclase up to an inch in length constitute half or more of the rock. There are also a few albite-oligoclase phenocrysts, and some small grains of quartz. All constituents, except quartz, are badly altered, and the rock is much sheared; alteration products are mainly carbonates, white mica, chlorite, and zoisite. As in the other masses, the phenocrysts become smaller toward contacts, and eventually disappear.

Both the upper parts of the intrusive rock and the adjacent sedimentary rocks are much altered and pyritized. The porphyry is converted into a white, fine-grained mass filled with veinlets of quartz, chlorite, and pyrite, and with fairly abundant pyrite throughout. In it are numerous inclusions of the surrounding sedimentary rocks, similarly altered, and at contacts the sedimentary materials are so much altered as to be almost indistinguishable from the altered intrusive rock, and farther away are impregnated with abundant pyrite and have rusty outcrops. Dykes from the intrusion extend into the adjacent sedimentary rocks.

The Craig mass is intruded by apophyses from the hornblende granodiorite mass north of it, and appears, from its shearing and alteration, to be much older.

ZIPPA MASS

The mass on Zippa Mountain is nearly 3 miles long. The rock consists almost wholly of dark grey feldspar phenocrysts up to 2 inches long, held together by a minimum of matrix. Some phenocrysts are peculiarly banded, and may be anorthoclase; they display some microperthitic intergrowths of albite. Other phenocrysts have a grating structure, and are probably microcline. The matrix, now largely white mica, appears to have consisted mainly of orthoclase with a little albite. Titanite, biotite, and yellowish brown garnet were also identified.

In some places, however, the porphyritic texture is not pronounced, but the rock is nearly equigranular and somewhat gneissic. A thin section of this material showed orthoclase, with some admixed microperthite, 70 per cent; nephelite, 10 per cent; considerable amounts of biotite and brown garnet; and magnetite.

The Zippa mass surrounds some fairly large bodies of dark rocks that appear to be highly altered inclusions of volcanic or sedimentary origin. A green variety is made up almost wholly of greenish augite or diallage and biotite, with some 5 per cent of colourless to light brown garnet. A grey type is chiefly diallage with biotite and hypersthene. These rocks are fairly coarsely crystalline and equigranular. The Craig mass, it may be mentioned, contains inclusions of similar types.

Near its contacts, the porphyry, possibly through assimilation of some country rock, appears to pass into dark green contact phases very difficult to distinguish from the surrounding altered country rock. A thin section of one such contact phase showed it made up mainly of green augite or diallage with 10 to 20 per cent of interstitial orthoclase and some colourless garnet. Another, very coarse variety consists of augite crystals up to an inch long and about 10 per cent of titanite, also in large crystals, in a matrix of orthoclase that constitutes 20 to 50 per cent of the whole.

HOODOO MASS

The Hoodoo mass is exposed as a very small outcrop at the extreme southern edge of Hoodoo Mountain, and, presumably, most of it is covered by the lavas of the mountain. The rock is a coarse orthoclase porphyry similar to that of the Zippa mass. It is very badly sheared, mineralized, and rusty.

BUTTERFLY CREEK MASS

The Butterfly Creek mass is a small body, less than half a square mile in area, in the north part of the central map-area, at the headwaters of Butterfly Creek. Notwithstanding its size, it contains an extraordinary variety of rocks. Many porphyritic phases range from light greenish grey with pink and purple phenocrysts, to dark grey with dark phenocrysts. The phenocrysts are of all sizes up to an inch in length and half an inch in diameter, and in some varieties are so abundant that they make up most of the rock, and lie flat on one another to give an appearance of bedding. One rock composed almost entirely of large purplish and pink orthoclase crystals forms dykes to the east of the mass. The phenocrysts, as before, are orthoclase, with an occasional one of pyroxene or amphibole. The matrix carries orthoclase, some albite-oligoclase, aegirine-augite, colourless garnet, magnetite, apatite, and titanite.

Besides the above types, there are also equigranular varieties ranging from fine to medium grained, and from light to dark grey or green. Some dark green types carry large pyroxenes and large flakes of biotite.

SHAKES CREEK MASS

The Shakes Creek mass, in the northern map-area, is not only one of the largest but perhaps also the most variable in the region. It stands out on the north slope of Shakes Valley as a great, red-brown, jagged scar. From a distance the mass can be separated into two or three distinct parts. The southern part is pinkish. North of it is a grey band, which is in contact on the north with dark green rock. The latter looks like country rock, but closer observation indicates that part of it is altered intrusive material, and part is metamorphosed country rock. The dark green material does not form a band, but rather irregular patches. Both the light grey rock and the dark green patches are cut by pink dykes.

The pink and the light grey varieties are very similar in composition. Both are somewhat porphyritic, in places distinctly so, but on the whole far more equigranular or nearly equigranular material is present than in any of the masses previously described. Where present, the phenocrysts are of a peculiar banded orthoclase, which is probably anorthoclase. They range up to an inch in length, and in shape from long and thin to short and thick. Large phenocrysts occasionally have dark grey centres surrounded by a zone of pink, as if dark grey were the original colour and the pink had resulted from alteration. No quartz is present, and neither albite-oligoclase nor nepheline was identified, though the rock is so greatly altered that they might have been present and have disappeared. Orthoclase, of the type mentioned, usually constitutes 60 to 75 per cent of the rock. Brown garnet and biotite form much of the remainder, with some magnetite, apatite, and titanite. Some aegirine-augite and bronzite are usually present, but may be completely absent. In places the dark constituents tend to gather in masses that may be linked together in a more or less reticulate design. The red rock carries, locally at least, less dark minerals than the grey rock.

Dykes of the red or pink variety, as mentioned, cut the grey, and it is significant that although such dykes have a wide chilled edge where they cut country rock, the edges against the grey varieties are only slightly chilled. Also, the grey rock for distances up to 9 inches or more from dyke contacts is converted into red material. These facts seem to indicate: (1) that the grey porphyry was still hot when the red dykes were intruded; certainly it was far hotter than the surrounding country rock; and (2) that the dyke material included some mineralizer or other constituent with the power of reddening feldspar. If this conclusion is considered along with the fact that some large phenocrysts have grey centres with red rim, it suggests that all the feldspar was probably originally of the grey variety, and that the red colour is due to the development, or introduction, of the unknown reddening constituent.

All the rock has been greatly jointed, sheared, and altered to secondary minerals, so much so that many thin sections had to be examined before the original composition could be even approximately known. The chief alteration product is sericite, but chlorite and other secondary products are also present.

The green patches along the north edge appear to be partly metamorphosed volcanic rocks, and partly intrusive material that has assimilated much volcanic rock. A specimen, supposedly of the former, was very dark green with a few pink grains. The thin section was composed of 60 per cent or more of light

green augite in large crystals; much chlorite that seems to represent altered biotite, grains of magnetite, apatite, and titanite, and, the remainder, orthoclase almost completely altered to sericite, zoisite, epidote, and carbonates. A second specimen of supposedly altered volcanic rock was epidote-green in colour. Its thin section consisted mainly of orthoclase, altered as in the previous section, which surrounded numerous small grains of biotite and augite.

The dark types that are considered to be parts of the intrusion that has assimilated much volcanic rock are in places in sharp intrusive contact with altered volcanic rocks and throw off apophyses into them. They also include fragments similar to the altered volcanic rocks, and the edges of such fragments grade into the surrounding rock as if they were undergoing assimilation. These dark types range in grain from fine to medium. They are mostly dark green, but in places are mottled with red, or the dark green rock may carry grains of red feldspar. Their composition is quite variable. The peculiar banded orthoclase, which is probably anorthoclase, constitutes 50 per cent or less of these rocks, and the other chief minerals are brown garnet, aegirine-augite, and bronzite. Magnetite, titanite, olivine, colourless garnet, and apatite are important accessories. The relative proportions of all these minerals show a wide range.

The porphyry mass is cut by numerous pyritic stringers, and the volcanic rocks to the north are very rusty for a long distance from the contact.

The porphyry cuts the Triassic volcanic rocks, and pebbles of it are found in the basal part of the Upper Cretaceous conglomerates. The intense shearing and shattering it has undergone suggest that it is older than most of the other intrusions. Its age is, therefore, considered as probably Upper Triassic.

OTHER PORPHYRY MASSES

Small bodies of porphyry not unlike those described have been found on the north side of the granodiorite body on Devils Elbow Mountain; on the southwestern spur of Strata Mountain; in the large cirque northeast of Strata Mountain, on the mountain northeast of this cirque; on Kirk Mountain; north of the Yehiniko mass of granodiorite; and on Brewery Mountain. In the southern map-area there is a small mass on the west side of Craig River, about 2½ miles above its junction with the Iskut. Boulders carried by Dick and Simma Creeks, tributaries to Craig River, suggest that an undiscovered body or bodies exists in that area.

In precise classification, the varieties of these rocks that carry some quartz seem best referred to the group of nordmarkites, those that do not, to the pulaskites. Where nepheline has been recognized, they may be termed nepheline syenites.

HORNBLENDE GRANODIORITE

The rocks here included under the term "hornblende granodiorite" are of two different ages, and although these can generally be distinguished readily in many parts of the area by one grown accustomed to them, in other places subsequent alteration, differentiation, or assimilation of country rocks make the distinction doubtful or impossible. It was, therefore, thought best not to attempt it on the published maps.

The hornblende granodiorites are found mainly throughout a belt some 35 miles wide that lies east of the main axis of the Coast Range, the axial area itself being occupied largely by younger intrusions. Northeast of the belt there are some dykes and scattered masses of granodiorite and these, together with the metamorphism of the sedimentary or volcanic rocks, combine to suggest that granodiorite may not lie far below the surface.

The older granodiorite constitutes the Pereleshin mass, extending from Scud River in the central map-area south to Mount Robertson in the southern. Smaller masses believed to be of the same type are the one on Eagle Crag, which extends north, with one interruption, beyond the boundary of the southern map-area, and the northern and western parts of The Knob body. Most of the other bodies in the region are believed to be of the younger variety. The Cone Mountain area, north of Scud River, appears to be underlain by a mixture of the two.

Briefly, the major differences between the two hornblende granodiorites are as follows. The older is dark grey in colour, darker than most granodiorites. It carries a few dark grey phenocrysts of feldspar up to an inch long, and hornblende phenocrysts of the same size. No biotite is visible megascopically, and the rock has a general altered or sheared appearance. The younger granodiorite is light grey, not porphyritic, and has a fine to medium grain. The rock is generally fresh in appearance and unsheared. Its light grey to light rusty colour is fairly distinctive even at a distance.

OLDER HORNBLENDE GRANODIORITE

Ten specimens, considered as fairly representative of the older variety, were selected from widely different parts of the main Pereleshin mass for microscopic examination. Their average composition was: quartz, 17 per cent; orthoclase, 13 per cent; andesine, 60 per cent; and dark constituents, 10 per cent. The dark constituents are mainly hornblende, with a little biotite, though biotite may range from nil to almost 5 per cent, the latter very rarely. Magnetite, titanite, apatite, and zircon are accessory. Orthoclase constitutes most of the phenocrysts, which are dark grey, many with slightly purplish shades, though a few are distinctly pink. The plagioclase is zoned, and ranges from $Ab_{60}An_{40}$ in the centre to $Ab_{85}An_{15}$ on the rim; such a rim is usually narrow and may be missing. The hornblende, much of it in large phenocrysts, is generally more or less chloritized, and the crystals have a tendency toward parallelism. Much alteration to sericite, chlorite, epidote, and iron oxides, has given the rock, prevailingly, a dirty, unattractive appearance. Some alteration is universal, and parts of the rock have gone over completely to the secondary products, obviously the work of hot solutions circulating through the numerous minute fractures in the rock. These are now filled with chlorite and epidote, and are flanked by highly altered zones.

In places the rock is badly sheared and converted into finely granular material, and the hornblende phenocrysts are drawn out into smears of chlorite.

The contacts of the Pereleshin mass, so far as the rather limited observations show, dip outward, steeply in most places but flattening here and there. An exception is found in the section north of Porcupine Valley, where the eastern contact dips as much as 45 degrees west throughout a considerable length.

On the southern end of Pereleshin Mountain the presence of many small roof pendants seems to indicate that the present surface is near the original roof of the batholith. On the north end of Mount Robertson the intrusive passes beneath the roof of pre-Permian rocks. It seems reasonable to conclude, therefore, that the present outcrops display approximately the shape and size of the upper part of the original batholith.

The several thousand feet of vertical section observable show that the mass has not been much differentiated. In general, the usual rock type shows little change, except along gently dipping contacts. There some differentiation has occurred, and consists of somewhat increased proportions of oligoclase,

quartz, and orthoclase, with lesser amounts of andesine. The differentiates are lighter in colour than the average rock, and in places decidedly pink. Mostly they are so badly altered that the original constituents are difficult to determine.

Inclusions, though not numerous in the main body of granodiorite, have a fairly uniform distribution. Near steep contacts there are relatively few, but their number increases where the contacts flatten, and from Anook Creek to the top of Saddle Mountain they are extremely numerous. They include fragments of volcanic and sedimentary rocks, together with others that resemble quartz diorite and orthoclase porphyries. Some of them, of course, may be parts of the magma itself, consolidated during the primary stages of intrusion and afterwards broken up by further advances. The inclusions are generally well rounded, equigranular, fine to medium in grain, and mostly darker than the enclosing rock. Many of them show evidences of partial assimiliation.

A little mineralization appears to have followed intrusion of this mass. Roof pendants on Percleshin Mountain are very rusty, and rustiness is prevalent near contacts. Galena, sphalerite, and chalcopyrite were found in float from contact zones, and in a few places veins carrying hematite, pyrite, and chalcopyrite were noted. Some prospecting of the contact zones would seem justified.

The older hornblende granodiorite intrudes Palæozoic sedimentary rocks and the lower part of the Triassic volcanic group. It probably intrudes the diorite, though this has not been established conclusively. In turn it is cut by oligoclase granodiorite, biotite granodiorite, and quartz monzonite. Its relations to the supposedly younger hornblende granodiorite are not well established, as at the time the area was examined the relative importance of the two, compared with other rock types, was not recognized. The only data at hand are: (1) at the head of Darsmith Creek, southern map-area, some of the younger (?) granodiorite lies within an area of the older, and has a much fresher appearance; and (2) on Cone Mountain, central map-area, the younger rock again appears much fresher, and dykes thought to be of it are found cutting the older granodiorite.

YOUNGER HORNBLENDE GRANODIORITE

The younger hornblende granodiorite is a light grey rock with a medium- to fine-grained, equigranular texture. Tops of masses, and small masses, are apt to be somewhat darker than the normal rock, and finer in grain. Near contacts, in a few places, the rock becomes porphyritic, with phenocrysts of plagioclase. Gneissic textures are uncommon, and where present are never as pronounced as in the older granodiorite. Shearing is not pronounced, except in places along contacts. In general the rock is much less fractured, veined, and altered than the older granodiorite.

Twenty-six specimens considered as representative of the common rock type were picked from various masses throughout a vertical range of some 5,000 feet. They averaged: quartz, 21 per cent; orthoclase, 13 per cent; andesine, 56 per cent; and dark constituents, 10 per cent. It will be observed that this does not differ much from the composition of the older hornblende granodiorite. The plagioclase is zoned, and ranges from $Ab_{55}An_{45}$ to $Ab_{85}An_{15}$. In many crystals the zones are repetitive. The dark constituents are mainly hornblende and biotite, in average proportions of 7 to 3, though perhaps one-fifth of the specimens contained more biotite than hornblende, and an equal number about as much. Those with the larger proportions of biotite were almost all close to contacts, and in that position large and unusual crystals of the mineral are often visible. Magnetite, titanite, apatite, zircon, and rarely pyrite, are accessory.

Where the rock becomes darker, as near some contacts, the colour is due to relative decrease of biotite and increase of hornblende, and in some instances to an absolute increase of hornblende content. Otherwise the darker materials are not much different from those of the normal rock. Near most contacts biotite increases, and in many places exceeds hornblende.

Alteration is confined mainly to parts of the masses near the original roof. Elsewhere there may be local fracturing, and deposition of chlorite, epidote, and other minerals in hair-thick stringers with slightly altered walls; but near the roofs fractures are innumerable, and the rock is bleached and very rusty. Such alteration is confined largely to the upper 1,500 feet of the masses.

In places, particularly along fault zones, the rock takes on a pinkish to purplish tint and may be definitely red. Such a change is especially noticeable in the Conover mass, and it appears to be due to solutions of later age, unconnected with this particular magma.

Neither the contact nor the hydrothermal metamorphic effects of the granodiorite on the country rocks have been great. They are greatest in the roof sections, where a moderate amount of alteration and mineralization is noticeable; but along steep-dipping contacts the effects have been slight. Volcanic and sedimentary rocks of non-limy types are recrystallized, with considerable additions of biotite, and may become quite coarse grained so as to resemble closely the intrusive itself. Limestones are the rocks most affected. They have been partly silicified, with development of quartz, garnet, epidote, wollastonite, and other silicate minerals; and various sulphides and oxides, including galena, sphalerite, pyrite, pyrrhotite, chalcopyrite, magnetite, and hematite, have been added. The metamorphic effects of the deeper parts of the magma seem to have been greater than in the upper sections.

The original shapes of the intrusive masses appear to have been those of simple, rounded, nearly circular domes and elongated domes, with contacts that dipped outward at about 45 degrees. The individual masses thus tended to coalesce downward; and undoubtedly many of the larger masses are thus formed by the coalescence of smaller ones. The intrusion of later batholiths has destroyed much of the hornblende granodiorite, as shown by the presence of residuals such as those in the great area of quartz monzonite in the central and northern map-areas.

Contacts on the whole are fairly regular where dips are steep, but where dips become flatter, dykes and apophyses of the granodiorite in the country rock are fairly numerous, giving rise to much irregularity. The dykes are closely similar in composition and appearance to the general rock of the batholiths, but were evidently intruded at intervals as they cut one another with chilled edges.

The granodiorite is characterized by numerous inclusions, all of much the same size, namely, 3 inches or less in diameter. Many are well rounded, but some are angular and others very irregular. Their boundaries are as a rule well defined, though gradational. They are either grey or green, with grey predominating, and textures range from fine to medium grained and equigranular. Some are clearly of volcanic or sedimentary origin, but a few may be remnants of those parts of the batholith that consolidated early in its advance, and were broken up during later advances.

The granodiorite bodies exhibit almost no evidence of differentiation. On Devils Elbow Mountain the rock becomes slightly lighter in colour toward the roof, but this may have been due to alteration. In places, some rock seems to carry much orthoclase and albite-oligoclase, possibly with aegirine-augite instead of hornblende; but alteration is so extreme that the determinations were doubtful. Pegmatite dykes are entirely lacking, except for a few on Raven Mountain in the southern map-area.

The lack of differentiation, the fineness of grain throughout, and the presence of numerous inclusions at horizons originally deep within the masses, combine to indicate that the granodiorite magma was a relatively cold and inactive one, which solidified rapidly when the forces impelling it onward ceased to act. Further evidence to the same effect is afforded by the dykes, which rarely extend more than a few thousand feet from the contacts, whereas dykes of later intrusions extend for miles. The rapid solidification, which permitted little differentiation, probably accounts for the paucity of mineral deposits around its borders, although such evidence of mineralization as has been found shows that the magma actually carries a great variety of metals. Under more usual conditions of cooling and consolidation, this magma might have given rise to important mineral deposits.

The great numbers of inclusions seem to point to the conclusion that the magma advanced mainly by stoping. Some evidence suggests that the advance took place in a succession of movements, with considerable intervals between, during which at least the marginal parts of the intrusive mass became solid.

The younger hornblende granodiorite is cut in many places by the quartz monzonite, and is, therefore, older. Its relations to the biotite granodiorite and oligoclase granodiorite have not been established with certainty, owing to the doubt that attaches to the identification of some masses. Both these rocks, however, cut hornblende granodiorite masses that are believed to represent the younger type. Its relations to the older hornblende granodiorite have already been described, and it cuts the orthoclase porphyry. Tentatively, its intrusion is assigned to the Jurassic period.

Oligoclase Granodiorite

Three bodies classed as oligoclase granodiorite are found in the area under consideration, one in each of the three map-areas. That in the northern map-area is believed to be older than the other two, as indicated in the chronological sequence of intrusions on pages 47, 48.

YEHINIKO MASS

The Yehiniko mass, in the northern map-area, occupies some 50 square miles within the area, and extends far east of it.

The canyon of Yehiniko Creek cuts completely through a considerable part of this granodiorite, and reveals that its shape is that of a thick sill or laccolith, which dips southwest at a moderately low angle. Its thickness within this area is estimated at 1,500 to 2,000 feet. The average dip of the base of the sill is calculated to be between 5 and 15 degrees; but as direct observation in one or two places gave dips of 45 degrees or more, it is probable that much variation exists.

The granodiorite is a light grey, medium-grained rock of granitic texture. Alteration, however, has given it green or pink to red tints in a great many places. Gneissic textures are locally present, and schistosity, caused by movements following consolidation, is fairly common.

Seven out of eight specimens taken from various parts of this mass contain: oligoclase, 55 to 70 per cent; orthoclase, 5 to 20 per cent; quartz, 10 to 30 per cent; and hornblende, 5 to 15 per cent. The average composition of the seven was 62 per cent oligoclase, 11 per cent orthoclase, 17 per cent quartz, and about 10 per cent of dark minerals, which include a little magnetite, apatite, and pyrite, in addition to the hornblende. No biotite was seen. The eighth speci-

men, from south of Lingwell Creek, about 3 miles above its mouth, contained 54 per cent andesine instead of oligoclase, but was otherwise similar in composition. It appeared to be the freshest and coarsest material found.

For several hundred feet from its contacts the granodiorite is generally finer grained and highly gneissic. This is believed to be a secondary structure, as nearby dykes of the granodiorite in the country rock do not display it, not even those as thin as one-half inch. At contacts with the sedimentary rocks, *lit-par-lit* structures are well developed, and in places these mixtures have been sheared together, yielding peculiar gneisses. Similarly, on the west side of the mass, the volcanic rocks below the contact are altered to schistose or gneissic materials. The conclusion thus seems justified that the intrusion was involved in much if not most of the deformation that has affected the Triassic rocks.

Some pegmatites were found along the north side of the Yehiniko mass, as far as three-quarters mile south of the contact. They range from dykes consisting mainly of quartz to others carrying much pink orthoclase and some hornblende. Most of them are less than a foot wide. The more siliceous carry some bornite and chalcopyrite, chiefly in small fissures; and it is possible that mineralization reported to occur both north and south of the granodiorite mass may be genetically associated with this phase of it.

On page 31 it has been noted that boulders of oligoclase granodiorite petrographically identical with the rock here described are the chief constituents of the basal Jurassic conglomerate in the vicinity of Glomerate Creek and elsewhere. This fact, and those outlined in a preceding paragraph, fix its age very closely as late Triassic or very early Jurassic.

From the distribution of the Jurassic conglomerates, and of other Cretaceous conglomerates that likewise contain boulders of the oligoclase granodiorite, it seems unlikely that these boulders could have come from the Yehiniko mass. If not, they must have been derived from other masses now completely removed by erosion. This conclusion does not seem so far-fetched when it is considered: (1) that another 2,000 feet of erosion would remove, probably, all trace of the present mass, and (2) that the areas to the south have been uplifted more than the Yehiniko area. If the reasoning is correct, it follows that during Jurassic time the older oligoclase granodiorite was much more widely distributed than at present.

KAHTATE MASS

The Kahtate mass underlies Kahtate Mountain and part of Iskut Mountain in the southern map-area. The main body has an exposed area of perhaps 20 square miles, but as smaller exposures occur south of Kahtate River the rock probably underlies much of the river flats of Kahtate and Stikine Rivers.

The rock is a light grey, fairly massive granodiorite that differs from the Yehiniko mass in containing much biotite. It resembles rather strongly the supposedly younger biotite granodiorite, but differs in being more fractured, less fresh looking, and in displaying a greater variety of shades of colour, possibly because of greater alteration. However, although the rock is here considered as a separate intrusion, the writer must admit the possibility of its being a phase either of the biotite granodiorite or the younger hornblende granodiorite, as the time at his disposal was not sufficient for detailed examination of relationships.

The granodiorite has a granitic texture and a moderately coarse grain. Eight specimens collected from the mass throughout a vertical range of about 5,000 feet showed: oligoclase, 44 to 78 per cent; orthoclase, 1 to 20 per cent; quartz, 10 to 35 per cent; biotite, 1 to 11 per cent; and hornblende, 1 to 12 per

cent. The average of the eight specimens is: oligoclase, 63 per cent; orthoclase, 11 per cent; quartz, 19 per cent; and dark constituents, 7 per cent. Most specimens contain more biotite than hornblende, but in a fairly large number hornblende predominates. On Iskut Mountain the feldspars are altered to chalky white material and the dark constituents to green chlorites, whereas lower in the mass, near Kahtate River, the minerals are fairly fresh. Presumably this was due to a concentration of magmatic fluids in the upper parts of the mass.

On Iskut Mountain, near contacts with the older rocks, the granodiorite contains numerous inclusions of these rocks and throws off many dykes into them. Many of the inclusions are angular. At deeper levels, along Kahtate and Stikine Rivers, the magma appears to have been actively assimilating the surrounding country rocks. Fragments of these, mainly ancient schists and gneisses, were found far within the body of the intrusion, and in all stages of digestion.

As now exposed, the mass displays little evidence of differentiation, but it is so deeply truncated that such evidence may have been removed by erosion. Quartz veins, however, are fairly numerous in some places near it, and are sparsely mineralized. In general, the country rocks have been little affected by the intrusion, though some limestones have developed considerable reddish brown garnet and tourmaline.

The shape of the Kahtate mass appears to have been that of a dome, with contacts now exposed dipping outward at steep angles.

On Iskut Mountain the granodiorite definitely cuts Palæozoic sediments, Triassic volcanic rocks, and hornblende granodiorite. Its relations to the mass of biotite granodiorite to the east are more doubtful. The oligoclase granodiorite is cut by a few grey granite dykes that are possibly biotite granodiorite. Farther east a similar dyke carried rounded, boulder-like inclusions that megascopically and microscopically resemble the oligoclase granodiorite. The dyke was made up of a fairly acid andesine, much biotite, a little quartz, and no orthoclase. It may be a phase either of the quartz diorite or the biotite granodiorite.

STIKINE MASS

The Stikine mass underlies part of the flats of Stikine River in the southern part of the central map-area. It has a length of about 5 miles, a width of about 3 miles, and is correlated with the Kahtate mass because of a general similarity of appearance and composition.

The relations of the Stikine mass to the intrusive rocks of about the same age are clearer than in the case of the Kahtate mass. It cuts hornblende granodiorite, which is supposed to be the older phase, and is in turn definitely cut by the biotite granodiorite. At its contacts with the latter, the oligoclase granodiorite is considerably altered.

Quartz Diorite

According to Buddington, the central core of the Coast Mountains consists largely of quartz diorite. His descriptions (7, pp. 178-9, 207-8) are as follows.

"The western portion of the batholith throughout southeastern Alaska is known to be composed of quartz diorite for a width of 5 to 15 miles from the contact. The average composition of 20 specimens from this belt is as follows: andesine 54 per cent, potassic feldspar 2 per cent, quartz 20 per cent, hornblende 11 per cent, biotite 12 per cent, and accessories 1 per cent plus ..... In the Stikine River section the predominant rock of the west flank of the batholith

in a belt 5 to 10 miles wide is quartz diorite, and the average of five specimens is: andesine 61 per cent, potassic feldspar 2 per cent, quartz 18·5 per cent, hornblende 11 per cent, biotite 6·5 per cent, and accessories 1 per cent..... Quartz diorite occurs locally ..... within the predominantly more alkaline core of the batholith..... It is one of the predominant igneous rocks of the Wrangel-Revillagigedo belt adjacent to the batholith (core) on the west, and is the predominant intrusive rock of the Dall-Baranoff belt ..... Locally on the outer borders small masses of hornblendite are developed as marginal variants of it..... The quartz diorite is mottled in black and white with a generally predominant light-grey to white colour. In the hand specimens a well-defined gneissoid structure is usually evident. The hornblende occurs in black prismatic crystals without terminal faces, and the biotite in hexagonal flakes and chunky crystals. The hornblende and biotite may occur separate and oriented, or segregated in small patches or in short, indistinct narrow linear lenticles. Locally titanite crystals are common, though they are of erratic distribution. The rock is essentially of even grain with here and there a slight inconspicuous tendency toward a porphyritic texture. The plagioclase of first crystallization may appear in euhedral tabular crystals of very slightly larger diameter, many of which weather more easily in the centre ..... Andesine is the predominant mineral and ranges usually from 40 to 60 per cent. Hornblende and biotite together commonly form 15 to 23 per cent, but in a few specimens reach 35 per cent, and very rarely are as low as 6 per cent. Usually, where the amount of hornblende and biotite together is between 19 and 27 per cent, hornblende predominates slightly over biotite; if the combined percentage of both constituents is 18 per cent or less biotite usually predominates over hornblende, but there are exceptions to both generalizations. Quartz commonly forms about 20 per cent but ranges from 15 to 30 per cent. Potassic feldspar is absent in about half the specimens and where present may form as much as 7 per cent. The accessory minerals include titanite, magnetite, apatite, and zircon. Titanite is variable in distribution but is usually present and may form more than 1 per cent of the rock. Apatite and magnetite may likewise locally form more than 1 per cent. A few of the quartz grains include abundant needles that may be rutile."

Within the area mapped by the writer, very little quartz diorite is present. It enters the southern map-area on Elbow Mountain; and probably forms considerable parts of the areas of unsubdivided intrusive rocks (*See* maps) along the southwestern side of all three map-areas. Possibly the areas farther west, beyond the limits mapped, are underlain to a large extent by quartz diorite.

Two specimens taken from Elbow Mountain correspond in composition fairly closely with Buddington's descriptions. One contained quartz, orthoclase, and andesine, all very abundant, with quartz predominant. Biotite and hornblende were present in about equal proportions, and totalled about 15 per cent of the rock. A second contained 35 to 40 per cent andesine, about the same amount of quartz, 12 per cent hornblende, and 8 per cent biotite. However, the textures suggest crushing and possibly recrystallization. All the specimens showed large, rather ragged masses of the five chief constituents, separated by zones of finely granular material.

This magma exercised intense metamorphic, assimilative, and granitizing effects on the surrounding sedimentary rocks. All these, over a width of some 2 miles from the contact, are altered to highly crystalline schists and gneisses. As the contact is approached, the effects become more intense, to where in places a complete gradation may be observed from the igneous material on the west into the altered, but clearly sedimentary, rock on the east. Some beds

were apparently more readily assimilated than others, and this has given rise to *lit-par-lit* structures near the contacts. Within the intrusive rock inclusions are fairly abundant close to the contacts, but within a short distance from contacts they are first reduced to skeletons and then disappear entirely. The composition of the intrusion near the contacts varies rather rapidly, a peculiarity attributed to its assimilation of the country rocks. In particular, as the above petrographic descriptions show, the proportion of quartz present is large for typical quartz diorite.

A rather narrow zone of somewhat similar rock borders the biotite granodiorite to the top of Glacier Mountain. It is a coarse gneiss containing 47 per cent basic andesine, 33 per cent quartz, 10 per cent orthoclase, 6 per cent biotite, and 4 per cent hornblende. This rock is intruded by the biotite granodiorite; it is rather heterogeneous and seems to have assimilated much of the altered sediments to the south.

At the contact of the diorite on Elbow Mountain, just below timber-line, there is an area at least 200 feet square of hornblendite. A smaller mass occurs near the boundary monument. The texture of these rocks ranges from coarsely crystalline, with crystals up to 1½ inches long, to finely granular, the latter texture possibly due to crushing. In places the almost pure hornblendite grades into rock that is largely magnetite or ilmenite, or to other types that contain considerable feldspar. The latter is apt to cut the pure hornblendite as dykes. The relations of the hornblendites to the quartz diorite were hidden by drift. Against the sedimentary rocks the hornblendites appear to be in sharp intrusive contact. Dykes of hornblendite penetrate the sediments, and the latter are highly altered near the contacts.

Dykes identified as probably quartz diorite intrude the younger oligoclase granodiorite in places; and Buddington (7, p. 182) notes a similar relationship in the area west of the core. The quartz diorite is cut by dykes that are identified as biotite granodiorite, on Elbow Mountain; and biotite granodiorite also intrudes the gneiss on Glacier Mountain that is supposed to be a phase of the quartz diorite.

Biotite Granodiorite

Biotite granodiorite, as mapped, occurs throughout a belt some 30 miles wide that parallels the axis of the Coast Range and adjoins, on the east, the central belt of quartz diorite. The larger masses of it, however, lie within a belt 10 or 12 miles wide along the western edge of the wider belt.

This generalization, of course, rests on the assumption that the masses mapped by the writer as biotite granodiorite have been correctly identified, and it should be pointed out that this is not necessarily true. In this work, time was lacking for detailed tracing of contacts and corresponding study of contact relations; in large part, general petrographic and structural similarities were, therefore, the determining factors in deciding how an igneous body should be classified. More detailed work when eventually undertaken may change many classifications on these maps.

The biotite granodiorite is a uniformly light grey rock tinted light brown by rust on rounded upper slopes that have been exposed to continued weathering, especially those parts buried for long periods by snow. The clean, light colour and sharp contacts make recognition of masses possible at almost any distance, particularly when taken in conjunction with the rounded, unbroken, glaciated surfaces that characterize slopes up to 6,000 feet. Above that elevation, jointing, though much less pronounced than in other intrusive masses, controls the topography, so that the higher mountains rise by precipitous angular slopes

to blocky peaks and ridges. The growth of vegetation, too, is much poorer on the biotite granodiorite than on most other rocks, so that the rock is rarely sufficiently obscured to make its recognition difficult even at a distance.

The rock has a granitic texture, with a very coarse grain up to 4 millimetres. The minerals are fairly fresh, and the composition limited in range. Owing to the coarse grain, a true average composition is difficult to obtain, but nine thin sections from the main Stikine mass, taken from various positions throughout several thousand feet of vertical range, averaged 58 per cent plagioclase, 11 per cent orthoclase, 20 per cent quartz, 8 per cent biotite, and 3 per cent hornblende. The plagioclase is zoned, and ranges from An_{40} to An_{15}. Biotite and hornblende are commonly interlaminated, a peculiar feature, though some biotite forms hexagonal crystals up to 4 millimetres in cross-section. In some specimens orthoclase forms aggregates slightly suggestive of phenocrysts. Resin-coloured titanite is a rather striking accessory, and magnetite, apatite, and other less common accessories are also present.

Thirteen specimens taken from eight of the smaller masses of biotite granodiorite showed considerable similarity. They averaged 52 per cent plagioclase, 17 per cent orthoclase, 24 per cent quartz, 5 per cent biotite, and 2 per cent hornblende. As in the Stikine mass, biotite is dominant over hornblende in all specimens, though the total dark constituents range from 3 to 15 per cent.

The contacts of the granodiorite bodies are usually fairly sharp and straight. Dips are steep, generally more than 45 degrees, and in places nearly 90 degrees throughout vertical distances of 5,000 to 6,000 feet. In several places, where the roofs of the masses have not been completely eroded, it was noted that the steep slope of the sides changes rather abruptly, or through a curve of short radius, to a fairly flat top. Such relations were found south of Flood Glacier, on the Chutine mass, and on some of the smaller masses in the southern map-area.

In the main the common rock type is continuous to near the contacts with little change in composition or texture. The chilled edge is usually less than a foot wide, but in places fine-grained material with large biotite crystals may extend to widths of 20 feet. In general, the steeper the contact the narrower the chilled zone. Biotite streaks and segregations up to a foot in diameter, which are present here and there through the granodiorite, are more numerous near contacts. Contacts are apt to be more or less rusty due to the impregnation of the intrusive rock there by pyrite.

Inclusions are rather rare in the biotite granodiorite, except in the Chutine mass, which in this respect resembles the younger hornblende granodiorite, and should possibly be classed with it. Though a few inclusions are angular, most of them are well rounded, and appear to be mostly bits of the granodiorite itself, first consolidated and then broken by further advance of the magma.

Pegmatite and aplite dykes, though rather rare near steep contacts, are very numerous where the flat tops of the batholiths have been preserved. Their abundance is greatest at or close to the upper contacts themselves, and they die out fairly rapidly in either direction, so that few are found at distances greater than 500 feet above or below such a contact, measured at right angles to it. Observed dykes range up to 10 feet in width, but observations made from a distance, as on Kates Needle (central map-area) indicate that widths in places may be much greater.

The dykes range in composition from fine-grained aplites to coarse pegmatites with quartz and feldspar crystals 2 or 3 inches long. Many dykes are compound, with interbandings of the two types, some exhibiting hundreds of

thin bands within a width of 10 feet. The simplest form of compound dyke shows two outer bands of aplite, grading on their inner sides to bands of pegmatite, which are separated by a vuggy section. Such dykes may range from an inch to several feet in width. The pegmatites, usually, are coarser in the wider dykes. However, many dykes are composed of aplite bands only, without pegmatite. Such arrangements suggest that after consolidation of the aplite, but while the pegmatite was still fluid, there was a new injection driving out the pegmatitic fluid; and such pulsations may have continued until the fissure was completely filled with bands of aplite.

The pegmatites are made up of a slightly dark quartz, pink orthoclase, white plagioclase, and large thin flakes of biotite. The aplites are mainly albite-oligoclase with some biotite.

Except for the development of the aplites and pegmatites, there is little evidence of differentiation in the biotite granodiorites. The only places where any is found are the summits of batholiths that have been barely unroofed. Such places are on the little hill between Scud and Stikine Rivers, the eastern slope of Commander Mountain, on Alpha Mountain, on the slope north of Mud Glacier, and on the small mass north of Craig River. Throughout rather narrow and perhaps discontinuous zones, in these places, the rock approaches quartz monzonite in composition, with more oligoclase and less andesine than the normal biotite granodiorite, somewhat more quartz, and probably a greater excess of biotite over hornblende. The more acidic parts are pink, and in most respects greatly resemble the quartz monzonite. In places, particularly in the Scud mass, the feldspars are chalky and the dark minerals chloritized, as if magmatic solutions had been active. These end phases carry much more pyrite than the rest of the batholith, and weather very rusty.

As might perhaps be expected in a little differentiated mass, little mineralization appears to be associated with the biotite granodiorites. Mention has been made of small concentrations of pyrite in some border parts of the intrusions, and in places a little pyrite has been added to the country rocks near contacts. On the whole, however, the mineralizing effects have been very slight.

The age of the biotite granodiorite seems reasonably well established. It definitely cuts the Mesozoic volcanic rocks, believed to be Triassic, of the central and southern map-areas. It definitely cuts the oligoclase granodiorite of the Stikine mass in the central map-area; and also the rock identified as quartz diorite south of Great Glacier. There is evidence, presented later, to show that it is cut by quartz monzonite. It is, therefore, fairly definitely post-Triassic and pre-Upper Cretaceous in age; and is probably Upper Jurassic or Lower Cretaceous.

Quartz Monzonite

Quartz monzonite extends from the northern into the central map-area as one mass with an area of about 270 square miles. Two smaller masses lie in the central map-area, with areas of about 2 and 7 square miles respectively. The smaller of these, south of Patmore Creek, was not visited, but its presence is inferred from the existence of a strikingly yellow area amid the grey of the biotite granodiorite, and from the abundant pebbles of quartz monzonite brought down to Patmore Creek by the stream from this area.

Quartz monzonite masses also extend to the northwest as far as Taku River, a distance of 125 miles, and throughout maintain the same composition and similar shapes.

The quartz monzonite is distinguished by yellow or buff to pink colours, which enable it to be separated with fair certainty, at a distance, from all other rocks of the mapped areas except the orthoclase porphyry. Topographically it is distinguished, below an elevation of 5,000 feet, by its smooth, rounded surfaces supporting a rather scant vegetation, in which respect it resembles the biotite granodiorite. The slopes above 5,000 feet present in general a rugged, blocky appearance, due to the crudely rectangular jointing; and it is not uncommon to see nearly vertical cliffs of great height.

The composition of the rock is remarkably uniform. Twenty-seven specimens, gathered from various places throughout a range in elevation of 5,000 feet or more, averaged 32 per cent quartz, 30 per cent oligoclase, 35 per cent orthoclase, and 3 per cent biotite. Hornblende was found in a few contact phases. The quartz varies from dark grey to glassy and cloudy white. The plagioclase is white or grey, though where altered it may be pink. It averages Ab_{85} An_{15} in composition, and is not much zoned, though in some contact phases zoning is pronounced and composition ranges from An_{25} to An_5. Microperthite is generally present. Orthoclase (a name applied throughout this report to the potassic feldspars generally) is nearly always pink, and is responsible for the flesh tint of most hand specimens. In places it forms micrographic intergrowths with quartz. The biotite content ranges from nil to 9 per cent, but the average, as stated, is about 3 per cent. Titanite, ilmenite, magnetite, apatite, and zircon are accessory. The texture of the rock is granitic, and the grain very coarse, 4 to 6 millimetres.

One of the most interesting features of the quartz monzonite is the presence everywhere within it of irregularly shaped masses of coarse pegmatite, ranging from a few feet to more than 50 feet in diameter. Quartz usually dominates in these, in some to the exclusion of other minerals. Orthoclase, decidedly pink, usually exceeds plagioclase; and biotite is present in many. In places graphitic textures are beautifully developed. Well-formed crystals are common, and single crystals or crystal masses may attain diameters of a foot in the larger masses. The central part of each pegmatite mass is one or more vugs lined with quartz crystals. At their edges, the pegmatite bodies grade fairly rapidly into normal quartz monzonite.

It would appear that the consolidation of the quartz monzonite proceeded with so little disturbance that the more aqueous differentiates, which are usually expelled when an intrusive rock solidifies, could not escape. As a result, the pegmatitic constituents separated into centres, where the rock constituents crystallized leaving the water and other volatile materials to form the central vugs.

In places, usually near contacts, the quartz monzonite has a banded texture, represented by fine-grained, aplitic bands and alternating with coarse, pegmatitic bands. Streaks in which biotite, or even hornblende, are abundant, may be due in part to fracturing of the rock and escape of the residual liquors described in the preceding paragraphs.

Other variations also may be found near some contacts. Near Cinema Mountain, and on Mount Helena, the rock is dark coloured and contains feldspar phenocrysts up to ½ inch in length. The microscope shows that in this rock hornblende is present in abnormal amounts, more biotite is present than usual, and the plagioclase is more zoned and more basic than in the normal quartz monzonite. It is probable that these changes are caused by assimilation of the older intrusive rock with which the monzonite is in contact. Near other contacts the monzonite is fine grained, and appears to vary somewhat in composition. The writer considers that such types probably represent parts of the

magma that were consolidated during some pause in its advance, an idea that receives some support from the fact that contacts with the normal coarse monzonite are sharp.

As mentioned, the prevailing colour of the quartz monzonite is pale pink or flesh. In places, however, the rock is grey, and the grey colour grades into the pink, in places abruptly, in others more gradually. The microscope reveals no difference between the grey and pink parts. The pink colour is greatly intensified around vugs, pegmatite veins, and quartz veins, all of which are places where the more volatile constituents of the magma were concentrated in the closing stages of consolidation. These facts suggest that the pink colour is due to some change or alteration of the rock by these volatile constituents, and that those parts of the rock not reached by them have the natural original colour, grey. Aside from this change, the rock is very fresh, even the effects of weathering being small.

The contacts of quartz monzonite masses are unique in their steepness, so that in shape the bodies resemble inverted tumblers. Most of their dips are near-vertical, and only rarely was a dip as low as 45 degrees observed. In this region such dips can be observed, and followed, throughout vertical ranges of several thousand feet. Like inverted tumblers, also, the tops of the masses, wherever observed, seem to be almost flat though irregular in detail. Within the area mapped, such tops were observed on the east side of Missusjay Creek, on Mount Helena, and on Cinema Mountain. On Mount Helena a remnant of the roof remains, a mass of hornblende granodiorite. It is cut by innumerable reticulate dykes of the quartz monzonite; and a few angular blocks of the granodiorite, thus separated, were seen at least 100 feet within the quartz monzonite mass. Stoping was undoubtedly in progress here when crystallization commenced. In the other localities mentioned, similar relations obtain.

Along steep contacts the grain of the quartz monzonites is usually maintained to within about 3 inches of the contact, the remaining part being sharply chilled. In the flat roof parts the chilled edge is much thicker, reaching observed dimensions of as much as 20 feet. In such places the change from coarse to fine grained or dense material is much more gradual than along the steep contacts. In a few localities gneissic textures have been developed along contacts.

Inclusions in the quartz monzonite are remarkably rare, but were observed in a few places. As might be expected, they appear to represent various types of the older rocks, as well as phases of the quartz monzonite itself consolidated during pauses in its intrusion. Though some, like the granodiorite blocks on Mount Helena, are angular, most of them are rounded with resorbed borders. Their examination definitely left the impression that they were being rather rapidly assimilated by the quartz monzonite magma.

Dykes of quartz monzonite, as noted, are numerous above the flat roof sections observed, but elsewhere are not abundant, and over long sections of contact are entirely absent. Where they do occur, they are usually short, and trend upward away from the contacts at angles of 45 degrees or steeper. A very few dykes up to 100 feet in width were found on various sides of the main mass of quartz monzonite, and as far as several miles from it. They have irregular trends, and are broken by faults. Their texture is variable, and unlike that of the main masses. They usually have fairly large quartz crystals or masses; some have orthoclase phenocrysts up to ½ inch long; and the groundmass, or even the whole dyke, is usually much finer grained than that of the normal quartz monzonite, and may show much irregularity in grain size.

The metamorphic effects of the quartz monzonite on the rocks in contact with it have been slight. Even the limestones on the roof of the mass on

Missusjay and Helena Mountains are crystallized for only short distances from the contact, and are replaced locally across narrow widths by wollastonite with some garnet and epidote. Other rocks may have suffered slight recrystallization or alteration, or none.

Practically no mineralization is associated with the quartz monzonite intrusions. Some pyrite is found in the vugs of the pegmatite masses; small blebs of pyrite were found near one contact; and small veins of pyrite and quartz are possibly related to the rock.

The quartz monzonite has been somewhat deformed by faults that strike, in the main, a little west of north and dip 45 to 85 degrees west. Such faults are particularly numerous along Stikine River, and in the northeastern part of the main mass, and seem to be correlative with the faults that so thoroughly shattered the rocks of upper Stikine Valley. Joints parallel with the main system of faults are spaced at intervals of 20 to 50 feet throughout the whole mass; and other joint systems are locally developed, particularly at Klootchman Canyon.

The quartz monzonite cuts all the surficial formations of the region up to and including those of Triassic age. Boulders of it appear for the first time in the conglomerates of the late Upper Cretaceous, so that the intrusions could not have been unroofed until that time. Dykes believed to be quartz monzonite cut the biotite granodiorite between Patmore Creek and Flood Glacier. On these grounds the quartz monzonite is considered to be the latest of the Coast Range intrusions within the area mapped, and the writer suggests that its age is probably late Lower Cretaceous.

Minor Intrusions

Small intrusive masses, stocks, necks, and dykes, are very numerous in the area mapped. In the following pages are described those that have been studied microscopically; but many were seen that have not been so studied, and, of course, many must be present that were never seen.

Pyroxenite

Pyroxenite occurs commonly as a border phase of the orthoclase porphyries, but only one small independent mass was noted. It lies on the mountain between the two main tributaries of Missusjay Creek, about ½ mile from the quartz monzonite contact. It is a fresh, medium-grained, green rock, somewhat schistose, made up of pyroxenes with resorbed borders in a groundmass of finer hornblende, biotite, and a little plagioclase. It cuts Triassic volcanic rocks, to which its colour is so similar that other masses may have been passed unnoticed.

Hornblendite, Etc.

Many small masses of hornblendic rock were noted. Some are at or near the contacts of batholithic intrusive rocks and are cut by them, but others are not near any other intrusions.

On Devils Elbow Mountain (north map-area) at the quartz monzonite contact there is a small mass of coarsely crystalline, schistose, green rock. More than half of it consists of large masses of hornblende, with some smaller crystals, and the remainder is largely oligoclase.

On Butterfly Mountain (central map-area) some distance south of the small mass of alkali syenite, there is a considerable body of massive, medium-grained, green rock. It consists of more than 50 per cent biotite, augite, and hornblende, with some andesine.

At the contact of the biotite granodiorite on Eagle Crag Mountain (south map-area) a small body of coarse-grained, green rock consists mainly of large phenocrysts of hornblende streaked with biotite, in a groundmass of quartz and hornblende.

Opposite the mouth of Iskut River a mass exposed along the bank for 300 feet or more is about 75 per cent hornblende, mainly in large phenocrysts, with a matrix probably of labradorite. A somewhat similar rock is exposed for 50 feet along the shore, 4 miles up Iskut River. These are probably related to the quartz diorite.

Gabbro

Gabbros are relatively rare. One was found 2 miles up Johnson River (southern map-area). It is dark grey, fresh, and coarse grained, and is made up of plagioclase , An_{50}, and diallage, with a few grains of quartz. It cuts Triassic volcanic rocks.

A second body was found in the northern map-area, ½ mile north of the mouth of Pritchard Creek. It is a dark grey, medium-grained rock, made up of labradorite or basic andesine, and pyroxene, with a little biotite and quartz. It cuts Triassic and possibly Jurassic rocks.

West of Glenora, cutting Jurassic rocks, a small stock or large dyke of augite porphyrite carries large phenocrysts of augite in a groundmass consisting largely of labradorite with considerable quartz. It is rather dark greenish grey.

Trachydolerite

One mass of trachydolerite was found on the east side of Stikine River, 1½ miles below the mouth of Yehiniko Creek. The rock is hard, dense, grey, and relatively fresh. It is made up of biotite, orthoclase, labradorite, hypersthene, magnetite, and spinel, with phenocrysts of augite.

A second body lies ½ mile above the mouth of a small stream from the south side of Helveker Mountain, and is exposed over a width of a few hundred feet. It is a massive, fresh, fine-grained, dark greenish grey porphyry. Most of the phenocrysts are labradorite, but some are of augite or diopside. The groundmass contains plagioclase, orthoclase, and biotite. These rocks may be closely related to the Helveker volcanics.

Trachyte Dykes

A mile up Yehiniko Creek there is a dark grey dyke, fairly fresh, with very rusty weathering. It is made up almost entirely of sanidine laths about ⅓ inch long. Chlorite, magnetite, and some andesine are also present.

Along the base of Helveker Mountain porphyry dykes with phenocrysts up to an inch in length resemble the trachytes of Hoodoo Volcano, but are more altered.

Diorites

Most of the granodiorite masses appear to have dioritic border phases, but it was impossible in the limited time at the writer's disposal to determine whether these are true differentiates, or whether they are older and related to the volcanic rocks that they cut.

In the northern map-area, fine-grained dioritic intrusions are thought to be fairly numerous, but owing to their petrographic similarity to lavas could not be distinguished from them except where the fact of intrusion could be established. Thus ½ mile northeast of the mouth of Pritchard Creek an oligoclase diorite cuts Jurassic sedimentary beds. It closely resembles the lower flows of

the Jura-Cretaceous rocks to the southeast and may well be related to them. Another type cutting the Jurassic sediments carries hornblende, pyroxene, and probably oligoclase phenocrysts. Northwest of Winter Creek, on the mountain above the end of the trail, more than a square mile of coarse diorite is made up of about two parts of andesine to one of hornblende. It cuts Triassic lavas. Southeast of Alkali Lake diorites carrying oligoclase and pyroxene cut Triassic lavas.

In the southern map-area, along the south side of Iskut River within a mile below the mouth of the Inhini, one mass of diorite consists of plagioclase and biotite, a second of oligoclase, hornblende, and biotite. They are similar to the Triassic lavas of the district and may be related to them.

Albite Diorite

Albite diorite is fairly common in the northern map-area. Small masses of it were found both on Conover Mountain south of the granodiorite, and above Chutine River on both sides of Stikine Valley. Some resemble sills, but others clearly cut the bedding. The rock is medium grained, greenish grey, and highly altered. Albite and diopside are about the only primary minerals that can be identified.

At Glenora, similar rocks were found on both sides of the river. On the east side, at the end of the road to the ranch, a considerable body cuts the Triassic lavas. It is much altered to light grey, brown, and pink colours, and has albite phenocrysts. West of Glenora a much fresher, dark grey type cuts Jurassic strata. It has phenocrysts of albite with some diopside.

On the trail to the head of Tsikhini Creek, about a mile west of the base of the mountains, another body shows some potassium feldspar and quartz with amphibole. Some of the quartz may be secondary.

In the southern map-area a small stock has just been unroofed on the north side of Mount Fizzle, at the foot of the glacier. The mass is oval and about 1,000 feet long. It cuts Permian limestone and is badly sheared and altered. Albite was the only primary mineral identified.

Quartz Diorite Porphyries

Numerous small masses of these rocks were found in the northern map-area. They are very fine-grained porphyritic rocks that resemble dacites, and are probably closely related to them. At 1½ and 2 miles up Susie Creek dykes carrying hornblende are assigned to this class. The lowest of the Three Sisters Islands in Stikine River is probably a small stock. It carries some pyroxene. One and a half miles below Spence Creek, on the west side of Stikine River, a mass more than 500 feet in diameter of dense grey rock carries phenocrysts of quartz and andesine. On the northeast and east ends of Kirk Mountain, and the north slope of Strata Mountain, dykes and small masses display phenocrysts of hornblende and oligoclase or andesine. On Tsikhini Creek about 2 miles above its mouth there are abundant dykes of very fresh porphyry, carrying phenocrysts of quartz and plagioclase up to ¼ inch in diameter, with smaller hornblendes, in a fine, dark grey groundmass. These are so fresh that they may be of Tertiary age or even younger.

In the southern map-area, a small mass at the foot of Raven Mountain has phenocrysts of oligoclase or andesine, quartz, hornblende, and pyroxene. It may be a phase of one of the batholithic intrusives.

Granodiorite Porphyry

Two small masses, probably stocks or necks, of this rock were found in the northern map-area. One, about 1,000 feet long and 500 feet wide, is on the mountain between the branches of Brewery Creek. Another, about a mile long, lies in the Damnation Creek drainage basin. The rock consists of phenocrysts of andesine and augite in a fine-grained, grey groundmass containing quartz and orthoclase.

Rhyodacite

Two fairly large bodies of rhyodacite were found. One cuts Jurassic strata west of Glenora, the other Triassic rocks south of Three Sisters. They are light greenish grey, comparatively fresh rocks. The former has phenocrysts of andesine, orthoclase, and hornblende; the latter carries pyroxene as well as hornblende.

Granite Porphyry

In the general neighbourhood of quartz monzonite contacts are dykes carrying phenocrysts of orthoclase and quartz in a fine-grained, granitic groundmass. Though they do not resemble the quartz monzonite either in texture or appearance, the association suggests that they are probably related to it.

Two miles up Snipper Creek, a small intrusive mass carries quartz, orthoclase, acid plagioclase, hornblende, and pyroxene. It was not noted elsewhere.

On Dodjatin Creek, west of the Upper Cretaceous contact, there are dykes and possibly larger bodies of red granite porphyry. This rock is high in orthoclase and albite-oligoclase, and contains much quartz, and hornblende as a dark constituent. It may be related to the granodiorite of the Yehiniko mass.

Inclusion Dykes

Two extraordinary dykes were observed, one cutting the hornblende diorite of Pereleshin Mountain, the other the oligoclase granodiorite and Palæozoic strata of Iskut Mountain. They carry rounded, boulder-like masses of the rocks they cut, and more resemble arkosic conglomerates than anything else. Apparently the blocks have been plucked from the walls, and rounded, by spalling or friction during the rise of the dyke materials. The Pereleshin dyke is mainly orthoclase with much biotite and a little plagioclase and diopside; the Iskut dyke is composed of fairly acid andesine, with much biotite and possibly some quartz. Both are medium grained and of fairly uniform texture.

CHAPTER IV

ECONOMIC GEOLOGY

GENERAL STATEMENT

The greater part of the area mapped lies within what may be called the eastern contact zone of the Coast Range batholith. This zone has long been regarded as favourable for the occurrence of mineral deposits, and has already produced well-known mining camps such as Portland Canal, Alice Arm, and Atlin. On the basis of the general geology there is no apparent reason why Stikine River area should not contain commercially attractive deposits.

Though few discoveries have been made in the area, this is not surprising as very little prospecting has been done. In 1873 and following years the Cassiar gold rush attracted many prospectors to northern British Columbia via Stikine River Valley, but few paused to do any work within the present map-areas. The Stikine and its tributaries near Telegraph Creek were tested for placer deposits, and some of the bars of the main river were very productive for a short time. Following the Klondike discoveries of 1896-98, there was another rush of prospectors up the Stikine, but all had their eyes fixed on the distant Yukon.

The present work has yielded evidence of much mineralization throughout the area mapped, and several small deposits have been found either by the writer's parties or by earlier prospectors, suggesting the probability that more detailed search may discover others large enough to be worked profitably. Three or four general areas are suggested as good prospecting ground.

Orthoclase porphyries, as already mentioned on page 49, were good mineralizers. Deposits associated with them are of fair size, and take the form of both replacements and veins. They are made up of mixed sulphides, with pyrite usually dominant. Volcanic rocks were replaced more easily than non-calcareous sediments, and were altered to light grey aggregates of bleached chlorite, white mica, calcite, quartz, and albite.

Masses of the younger hornblende granodiorite also yielded much mineral, and dozens of small deposits were found around their contacts. They are mainly irregular replacements of limestones, but have also been found in various other rocks. Most of those seen are too small to be of value, but more significant deposits may be present in large fracture or shear zones. Such controlling channels can be recognized readily, if in limestone, by its alteration to green calcium silicates; or, if in volcanic rocks, by their alteration to light grey products.

The older oligoclase granodiorite of the Yehiniko mass seems to have given rise to pegmatites on the southeast side of the sill, in which some bornite and chalcopyrite occur. North of the mass some gold-bearing occurrences are reported. The rocks for a mile or so around these contacts may, therefore, repay prospecting.

In Alaska, Buddington (7) has mapped a long zone of injection gneisses and crystalline schists lying, in the main, west of the quartz diorite body forming the core of the Coast Mountains, but also forming large inclusions or roof

pendants within it. The gneisses and schists are the highly altered equivalents of Palæozoic and Mesozoic sedimentary and volcanic rocks. In the writer's opinion, this highly metamorphic core of the Coast Mountains was developed in early Mesozoic time, by the deforming forces that were causing the early Mesozoic uplifts; and much of it was destroyed later by the injection of the magmas forming the younger oligoclase granodiorites, the quartz diorites, the biotite granodiorites, and the quartz monzonites. Parts of it still remain, however, between these intrusive masses. The rocks of the highly metamorphic core themselves are too greatly altered to be favourable places for the occurrence of orebodies, but west of it, in Alaska, valuable deposits have been found. Within the area mapped, the northeastern boundary of the highly metamorphic core is, roughly, a line that extends from the terminus of Great Glacier to Craig River about half a mile above the mouth of Simma Creek. The areas of Palæozoic and Mesozoic rocks immediately northeast of this line should, therefore, be good prospecting ground for deposits formed under high-temperature metamorphic conditions.

DEPOSITS ASSOCIATED WITH ORTHOCLASE PORPHYRY

Mineralization is associated with all observed masses of orthoclase porphyry, but is extensive in the valley of Bronson Creek, and both above and below it in Iskut Valley. The description of these mineralized areas follows. They were staked by the Iskut Mining Company in 1906, and some work was done on them almost every year until 1930. During 1929 many claims were staked by the Consolidated Mining and Smelting Company in a belt practically surrounding those of the Iskut Mining Company.

The property of the Iskut Mining Company has been mentioned in various reports of the Minister of Mines for British Columbia from 1911 to 1933. The report for 1911 mentions that a ton of ore, presumably picked, was sent to the smelter and yielded $44.11. The report for 1919 states that a ton of chalcopyrite ore was sorted from one cut and yielded $1.20 in gold, 44·2 ounces of silver, and 12·45 per cent copper. It is not known whether this was the same ton mentioned in the report for 1911. Nothing observed by the writer seemed likely to yield such values, unless individual bits of ore were very carefully selected.

The geology of the Bronson Creek area is shown in generalized form on the map of the southern map-area. The creek itself lies within a syncline of Triassic volcanic rocks, which are intruded by a small mass of orthoclase porphyry (*See* page 49). To the south, on Johnny Mountain, the strata rise into a compound anticline, at the crest of which erosion has partly removed the volcanic rocks and exposed Palæozoic sedimentary strata beneath them. Actually, the minor folds are more numerous than indicated on the map; if work had been done on a larger scale and in detail, the results would look much more complex. The Palæozoic strata are mainly argillites, quartzites, and schists.

The orthoclase porphyry mass itself seems to have been barely unroofed, and contains numerous inclusions, variously altered, of non-intrusive materials. Near contacts the phenocrysts become fewer and smaller, and the groundmass is a dense green material. Eventually the phenocrysts disappear, and the rock is distinguishable with difficulty from the volcanic material. The dense green rock without phenocrysts forms many dykes and small masses. Both the upper parts of the porphyry itself, and the inclusions within it, are impregnated with sulphides that seem to have seeped into it from fissures now filled with quartz and sulphides.

Above the porphyry, throughout a zone more than 2 miles long and between 1,000 and 2,000 feet wide, corresponding to a vertical distance of at least 500 feet, the volcanic rocks are sheared and altered to light grey materials. These range from nearly pure quartz or albite to mixtures of these minerals with varying amounts of calcite, white mica, and chlorite. They are impregnated with pyrite and other sulphides, and weather to rusty brown or yellow tints.

Besides pyrite, which is by far the most abundant, the sulphides include arsenopyrite, pyrrhotite, chalcopyrite, galena, sphalerite, tetrahedrite, molybdenite, and possibly others. There are also some oxides such as hematite and magnetite. Massive pyrite may occur locally in parallel streaks, and highly mineralized rock also shows a banding. Both are believed to parallel the original shearing.

Although there are local, irregular pockets of high-grade ore present, which may be formed in part by fracture filling, most of them, so far as observation went, appear to be small; and it is probable that the deposit, if mined, will have to be treated as a single, large, low-grade body.

Mineralization farther up the mountain is confined to a zone 10 feet or less in width that follows the contact between the volcanic rocks and the underlying Palæozoic strata. The zone has been explored by many pits or open-cuts, in some of which the sulphide present is nearly all arsenopyrite, in others nearly all pyrite, in still others pyrrhotite. Chalcopyrite, sphalerite, and galena are commonly present, but not abundant.

On the east side of the peak of Johnny Mountain, and also north of Iskut River about 2 miles west of Bronson Creek, are extensive areas of light grey, highly mineralized rocks similar to those described. They warrant careful prospecting. The Bronson Creek glacier carries considerable float of chalcopyrite, galena, and pyrite; and similar float was seen several miles to the southwest. They thus suggest the presence of deposits in the drainage area of the Bronson glacier, and between it and Craig River.

DEPOSITS ASSOCIATED WITH THE YOUNGER HORNBLENDE GRANODIORITE

Much evidence of mineralization has been found along the contacts of masses of the younger hornblende granodiorite, but work to date has exposed only small patchy masses that lead to the expenditure of much time and money and yield no adequate returns. Only more widespread examination will prove whether or not large deposits will somewhere be found.

DEVILS ELBOW DEPOSITS

The deposits on Devils Elbow Mountain are the best known of this class. They were discovered prior to 1914, and have been restaked repeatedly since. At the time of the writer's visit, development consisted of numerous open-cuts, and three adits driven approximately north. The lowest adit at an elevation of 1,980 feet, was 300 feet long; the second, at 2,128 feet, was 60 feet long; and the third, at 2,205 feet, was 20 feet long.

The rocks include a small mass of the younger hornblende granodiorite, which has intruded Palæozoic limestones and other sedimentary beds. All the rocks, including those of the intrusive mass, have been intensely folded and much shattered by faults. It would require most detailed geological study to work out properly the structure of the area.

The mineral masses are confined to the limestones, which over a distance of about 100 feet from the granodiorite contact have been much silicified, with development of quartz, garnet, epidote, wollastonite, and other minerals. The other rocks of the area have been little affected by the intrusion, and carry no mineral. In places there seems to have been a tendency for the minerals to follow certain beds in the limestone rather than others. At most places where sulphides are found, the limestone has been converted into a green rock, the presence or absence of which has been utilized by prospectors for directing their operations.

Three types of deposits have been found. The first consists of lenses of solid magnetite and pyrrhotite, with small proportions of copper and lead minerals, and a little quartz, garnet, and other silicates. Some consist mostly of pyrrhotite, others mainly magnetite. These masses rest directly on the granodiorite, though some of them appear to be actually within the granodiorite mass. All, where exposed, are covered with an iron cap a few inches thick, composed largely of limonite and gangue materials. All the masses are small; the largest is not much more than 50 feet long and a few feet thick. Five or six of them are known. A sample from one assayed 0·09 per cent copper, 0·07 ounce silver a ton, and no zinc or lead.

Somewhat farther away from the contact, in places only a few feet, bodies of galena and sphalerite are found. All of them contain fairly large to very large amounts of quartz, garnet, and other gangue minerals, through which the sulphides are scattered. In size and shape, the bodies are mostly irregular lenses, ranging from a few inches to a few feet in any dimension. The largest body, seen in one of the adits, was 10 feet wide, but very low in grade, about 1 per cent combined lead and zinc.

The third type of deposit is represented by a single mass of chalcopyrite. It likewise is a small lens, a few feet in any dimension, and lies in the silicified limestones.

APEX CLAIMS

The Apex claims are at the summit of Devils Elbow Ridge, at an elevation of about 5,000 feet. The intrusive rock is not exposed on these claims, and is believed to lie at some depth below the exposures. The deposit appears as an irregular patchwork across the face of a large cliff of more or less altered limestone, as if the rock had been irregularly fractured, allowing the mineralizing solutions to enter and produce a net-like arrangement of silicified and mineralized materials. It is doubtful if the mass is rich enough to be mined as a whole, and certainly the richer parts cannot be mined selectively. However, as mineralization in other places increases toward the contact, possibly further investigation in that direction here may bring to light some body of value.

DRAPICH CLAIMS

The Drapich claims are situated opposite the mouth of Dokdaon Creek, on the northwest side of Stikine River. There a small mass of the younger hornblende granodiorite appears to have been barely unroofed, because some, presumably thin, masses of the surrounding Permian limestone overlie the granodiorite. Two such masses, long and narrow, which seem to occupy trough-like depressions in the roof of the intrusion, extend from the upper contact down over it; and these, for distances ranging from a few inches to 10 feet, are converted into marble, carry garnet and other lime-silicate minerals, and are locally enriched with chalcopyrite. The chalcopyrite occurs in small

pockets or lenses, mainly at the contact. The pockets are never more than a few feet thick, with very limited dimensions in other directions. Sphalerite, galena, hematite, magnetite, pyrite, and pyrrhotite are also present, together with secondary copper carbonates such as malachite and azurite.

OTHER OCCURRENCES

Slight evidence of mineralization was observed at granodiorite contacts on Conover and Phacops Mountains. To the east of the large intrusive body at the head of Dokdaon Creek are large rusty zones in the Permian limestones. On the west side of Cone Mountain there is magnetite float, apparently from the contact; and on the south side, at the contact with limestone, some chalcopyrite was observed. Ore minerals are also reported to have been seen on the face of The Knob in the granodiorite. In Craig Valley, near the junction of Jekill Creek, coarsely crystalline galena and chalcopyrite were found in the Permian limestone.

DEPOSITS ASSOCIATED WITH THE OLDER OLIGOCLASE GRANODIORITE

CALLBREATH CLAIM

On Nightout Mountain, in the area of oligoclase granodiorite, a prospect pit, when visited, was partly filled with snow. From the nature of the material on the dump, however, there appears to be a shattered zone in the granodiorite filled with pegmatite, the latter composed largely of quartz and orthoclase, with bornite and chalcopyrite locally filling fractures in the quartz. The thickness of the zone appears to range from a few inches to 1 foot, and possibly 5 per cent of the total is mainly bornite.

NIGHTOUT-TSIKHINI CREEKS DEPOSIT

It is rumoured that a gold deposit was discovered at the junction of Nightout and Tsikhini Creeks, and that some free gold was recovered by crushing and panning the rock. The writer was unable to find the deposit, though a mortar and other evidences of an outfit were observed up Tsikhini Creek.

OTHER DEPOSITS

WINTER CREEK

About 4 miles from Stikine River up Winter Creek Valley, at an elevation of about 5,000 feet, a discovery of copper ore was made as early as 1917. It has been staked and the claims abandoned several times since.

The rocks of the area are andesites and albite andesites of Triassic age, together with tuffs of the same compositions. About half a mile northwest of the workings there is a medium-grained body of andesine and hornblende that may be intrusive, and appears to be a mile or more in length. The rocks in this vicinity are much deformed and faulted, and display extensive zones of shearing.

A very rusty zone can be seen from a distance to extend from somewhat north of the workings for about 3 miles to the southwest. The rusty areas are irregular in dimensions, and not necessarily continuous. In places two or more parallel zones are present. In them the volcanic rocks are more or less altered

by mineralizing solutions to quartz, carbonates, white mica, and chlorite, and are impregnated by varying amounts of pyrrhotite and chalcopyrite with, locally, some pyrite. In places replacement has been sufficient to produce lenses of solid sulphide mixed with a little quartz and calcite; but such masses are usually small and grade outward into leaner material. A fairly representative sample of the massive sulphide assayed: gold, 0·12 ounce a ton; silver, 0·92 ounce a ton; and copper, 5·80 per cent.

The following description of the property was given by J. D. Mandy[1].

"The locality of the claims is cut by five cross-sectional gullies through the formation, which have assisted in naturally exposing some of the mineralization. The mineral occurrence consists of lenticular replacements mineralized with massive pyrrhotite carrying some chalcopyrite. These are very restricted in surface horizontal continuity and exhibit no definite zonal structure. The best exposure seen at the time of examination (June 14) was in the old discovery on the side of No. 2 gully. Here, across a width of 4 feet, some structure is evident and the zone strikes north 40 degrees east (mag.) and dips 80 degrees west. On the footwall is 6 inches of brecciated, calcareous gangue, then about 3 feet of massive pyrrhotite finely impregnated with chalcopyrite. An average sample of this exposed in a small cut assayed: gold, 0·32 ounce a ton; silver, 2·1 ounces a ton; copper, 9·7 per cent. At this spot there is a lens about 30 feet long of this type of material, but no continuity to the east could be located, and trenching proceeding at the time to the west did not show encouragement for continuity in that direction."

The claims staked in 1929 on this area were known as the Glenora and King groups.

LIMPOKE CLAIMS

The Limpoke claims were not visited. Mandy[2] states that they are situated on the west side of Barrington River 2 miles north of Limpoke Creek. The location as shown on the map (No. 309A) is that recorded in the staking, and does not appear to agree with Mandy's description. According to Mandy, mineralization occurs in altered andesitic lavas, which are cut by a pink feldspathic intrusion, possibly orthoclasite or syenite pegmatite. It may be a phase of the younger hornblende granodiorite. The deposit is reported to consist of chalcopyrite, bornite, and copper carbonates in a quartzose cross-fracture about 4 inches wide, and to be of no commercial importance.

AUGUST CLAIM

The August claim was located by Lewis Kirk about 1898, and was maintained in good standing by him up to the time of the writer's visit. It lies on the western slope of Kirk Mountain at an elevation of about 3,000 feet, and is reached by a splendid trail from the mouth of Kirk Creek.

The rocks there are Triassic volcanic types, andesite to albite andesite in composition. They are badly shattered by numerous faults, but not greatly altered by mineralizing solutions. In four such shatter zones, in which the rock fragments have been partly or wholly recemented by calcite, there are quartz veins bearing chalcopyrite and pyrite in scattered grains and irregular masses. The veins are generally small, ranging from ⅛ inch to 3 inches in width, but in places attaining 6 inches or more, and part of one vein was 2½

[1] Ann. Rept., Minister of Mines, B.C., 1930, p. A119.

[2] Ann. Rept., Minister of Mines, B.C., 1930, p. 118.

feet wide. The shattered zones in which they lie vary from 1 foot to 15 feet in width, and the quartz veins were estimated to make up less than 10 per cent of their volume.

Altogether, four such shattered zones have been found. The longest is 150 to 200 feet long, the others range from 25 to 100 feet. Three of them strike about north 50 degrees east, the fourth about east; and all dip steeply southeast to vertical. All end at shattered zones beyond which they could not be traced, and which are, therefore, presumed to be faults. The writer considers that in all probability these four sections were originally parts of one, or possibly two, mineralized zones that have been broken by cross faulting.

In 1917 the property was sampled carefully by the Alaska Treadwell Gold Mining Company. The 2½-foot vein mentioned above carried: gold, 1·86 ounces a ton; silver, 0·21 ounce a ton; and copper, 2·1 per cent. The average across 6 feet at this point was: gold, 0·41 ounce a ton; silver, 0·80 ounce a ton; and copper, 2·0 per cent. From these and numerous other assays, it appears that the quartz veins themselves carry high gold values, but, forming as they do less than 10 per cent of the shattered zones, the average for the zones is low. This fact, and the short lengths of the mineralized sections, appear to offer little encouragement to further development, but the presence of veins with high gold values should encourage further prospecting, as quite possibly, farther to the east or west, somewhat similar zones may be found that are less broken and more continuous.

MOUNTAIN GOAT CLAIM

The Mountain Goat claim is also owned by Lewis Kirk. It is 6 miles from Kirk's landing by trail, and 3,100 feet above Stikine River. The claim was not visited by the writer, but the following data were made available through the courtesy of the Alaska Treadwell Gold Mining Company, who examined this property in 1917.

The rock here is a reddish volcanic conglomerate carrying well-rounded boulders up to 18 inches in diameter. The beds strike north 10 degrees east, and dip 40 degrees east. They are cut by a dyke that strikes north 55 degrees west and dips 60 degrees northeast. The dyke is a very fine-grained felsite, which in places is altered to a soft greenish mass.

On either side of the dyke, and in places on both sides, are long, flat lenses of quartz with a maximum thickness of 3 feet. They were traced for about 1,000 feet along the outcrop, and are composed of granular white quartz carrying a little bornite and chalcopyrite. Assays of samples taken from the best mineralized parts of the veins ran 0·2 to 0·4 ounce in gold to the ton across widths of 1·5 to 2 feet.

JACKSON AND LADY JANE CLAIMS

On the mountain between Chutine River and Conover Creek, a discovery of copper, lead, and zinc sulphides was made in 1929 by Frank A. Jackson. Seventeen claims were staked by him along the mineralized zone, and subsequently the Lady Jane group of five claims was staked farther along the zone. Access is by a trail that begins about ¼ mile above the mouth of Chutine River and continues up Chutine Valley 4 or 5 miles to the northeastern end of the staked zone; thence it extends another 4 miles or so along the centre of the staked ground to end approximately in the centre of the Lady Jane group.

The rocks are Triassic flows, breccias, and tuffs of a general andesitic composition, striking a little north of east, with steep dips. From a point on the

ridge at an elevation of about 1,750 feet, a rusty zone can be traced southwesterly for about 3 miles, mainly just south of the crest of the ridge, but on the southwest end it falls considerably below the crest and is lost beneath the drift filling the wide valley of Conover Creek. Near the head of the creek, however, a zone of somewhat similar nature, with about the same strike, appears; so that the zone may be continuous for several miles beneath the valley, and, in fact, may have determined the position of the valley, as the most altered sections are highly fissile and more easily eroded than the adjacent rocks.

The width of the zone is not definitely known at any place, but appears to have a maximum width of 1,500 feet. The rock materials of the zone have been partly replaced by carbonates, quartz, white mica, and chlorite, and are locally impregnated with pyrite and other sulphides. In places replacement has been most intense near the centre of the zone, and becomes gradually less toward the edges. In other places intense alteration may be confined to bands of varying size, separated by bands or horses of relatively unaltered rock. The addition of pyrite is not dependent on the extent of alteration; the pyrite-rich parts may or may not be extensively altered.

Within this great zone there are irregular, quartzose masses carrying much chalcopyrite, galena, and sphalerite. These, by reason of their quartz content, are resistant to erosion and hence stand high. Many of them resemble boulders in a matrix of the fissile, rusty, volcanic rocks. Others, larger, are more or less lenticular. In places, similar material occurs as a cement for breccia, or in irregular veins that may extend beyond the zone into apparently unaltered rock. There is no apparent system to their distribution.

It would appear that the altered zone was formed first, and that at some later date it was broken by further movements that permitted access of the sulphide-bearing solutions. These movements, however, do not seem to have formed any well-defined channel in which a body of commercial size might be deposited.

The bodies formed have been explored by many small open-cuts, which, however, are large enough to demonstrate the small size, irregularity, and discontinuity of the masses of ore. By 1930 no single mass had been found that promised to be part of a commercial body. Nor are the masses numerous enough to suggest that any part of the zone can be mined as a whole. A fairly representative sample of the better material found in the small masses assayed: gold, 0·01 ounce a ton; silver, 1·74 ounces a ton; copper, 1·03 per cent; lead, 5·50 per cent; and zinc, 7·76 per cent. Other samples reported by J. D. Mandy in the Annual Report of the Minister of Mines for British Columbia, 1929, page 115, gave very similar results.

JOHNSON RIVER

On the north side of Iskut River 3 miles above the mouth of Johnson River there is a well-defined fracture zone along which a steep chimney has been eroded in the andesitic tuffs. It strikes north 40 degrees east and dips 60 degrees northwest. In this fracture zone is a vein mostly about 1 foot wide, though it widens locally to as much as 10 feet. Some subordinate, parallel veins were also observed. Vein material is chiefly quartz, with some galena, chalcopyrite, tetrahedrite, sphalerite, and pyrite. The vein is exposed for 200 feet, though only the lower 100 feet is accessible; and the highest outcrops examined show only a very narrow quartz-bearing zone with little or no sulphides. Present exposures may, therefore, represent the top of the deposit.

A representative sample of the better part of the main vein assayed: gold, trace; silver, 10·82 ounces a ton; copper, 3·43 per cent; lead, 5·04 per cent; and zinc, 1·47 per cent.

Mineral Occurrences

South of Helveker Mountain, and also just north of the high part of Strata Mountain, the volcanic rocks are impregnated with much pyrite. Other evidences of mineralization were seen in the valley of Helveker Creek. At the head of Kirk Creek, float carrying hematite, and other pieces carrying sulphides, did not seem to have travelled far. On Missusjay and Conover Mountains veins carrying quartz, calcite, and chalcopyrite were noted. Stringers of quartz, said to carry gold, were found on the eastern slope of Missusjay Mountain. From the contact of the older hornblende granodiorite and limestone east of Pereleshin Mountain comes float of calcite, pyrite, and sphalerite; and on the south end of the mountain veins bearing chalcopyrite, and some float were seen. Flood and Mud Glaciers carry large masses of quartz and pyrite, smaller fragments of chalcopyrite, pyrite, and pyrrhotite, and some of molybdenite. Interesting but valueless occurrences of amphibole asbestos lie south of Eagle Crag; and along the contact of the hornblende granodiorite on the ridge south of the same mountain there are heavy impregnations of pyrite and arsenopyrite. In Anook Valley and to the south there are chalcopyrite-bearing veins, and float of galena, sphalerite, and pyrite. On Elbow Mountain at the contact of the quartz diorite, there is much magnetite in the hornblendite. On Whipple Mountain and the mountains to the north there are veins of tetrahedrite, and others of quartz and chalcopyrite. The moraine of Twin Glacier shows considerable float of chalcopyrite, galena, and pyrite; similar float, probably from a different source, was seen several miles to the southwest. In the last locality veins up to a foot wide were observed, completely altered to gossan. Above Bronson Creek on the Iskut there are veins of chalcopyrite and other sulphides, and much malachite stain.

Placer Deposits

In an area such as that under consideration, which has been severely and repeatedly glaciated, it is clear that any placers formed in river beds prior to glaciation would be scoured off, carried away, and dissipated, except in valleys that lay at right angles, approximately, to ice-movement. Such valleys are relatively few, and of course not all of them will necessarily carry gold, as they may have contained no gold prior to glaciation. The only valley of this type in the area mapped in which placer deposits have been found is the lower section of Barrington River (north map-area).

A second mode of origin for present-day placers is the concentration of gold-bearing glacial drift by post-glacial streams. As the ice in scouring out old river valleys that contained placers mixed the gold particles with huge amounts of clay and sand, it is obvious that an immense volume of this drift must be worked over, the rock materials carried away, and the gold concentrated in the stream bottom, before a workable placer can result. The only agent capable of such an operation is a swift stream with a large volume of water. The only stream in the area answering such a description is Stikine River, and some gold has been found in its bars. The source of this gold is considered to be the drift from the Coast Mountains. As indicated in a preceding section (page 46), the ice-movement from the Coast Mountains was up Stikine Valley as far as Telegraph Creek, where it appears to have been halted. The oldest drift from the Coast Mountains should, therefore, have

been deposited in the Telegraph Creek area; and it is within a few miles below that the richest placers, and the coarsest gold, have been found. Some gold does occur in bars farther downstream, but it is very fine, flour gold, such as a rapid stream can move with relative ease. Above Telegraph Creek, little or no gold has been found in the Stikine.

BARRINGTON RIVER DEPOSITS

Barrington River flows in a canyon from Rowgeen Mountain to the point where it is shown on the map as entering an area of Quaternary alluvium. The most important known deposits are just below the mouth of the canyon. From several large pits on the east side it is reported that about $20,000 worth of gold has been extracted, mainly by Jim Jackson and associates, using hand methods, in about 20 years. Farther downstream, some gold has been recovered from old pits on the east side, just below the upper bridge; and every year some gold is obtained around big boulders in the stream bed, during low water. The latter fact would appear to indicate that gold is still being brought down by the stream out of the canyon.

At the end of the canyon a rock spur extends out from the east side, deflecting the stream to the west side of the valley, which it follows for some distance. The stream then turns eastward to where it strikes the rock wall of the valley on the east at a place that is known as the Goat Walk. Between the rock spur and the Goat Walk, on the northeast side, is a series of terraces deposited by the stream at higher stages. The base of each terrace, representing the position of part of an old river channel, is probably a paystreak. The main productive pit lies in one such position. A hole drilled to a depth of 100 feet in the bottom of this pit is said to have cut 94 feet of good pay. Other drilling, done by S. Barrington and associates in 1928 and 1929, showed poor ground below the Goat Walk, but above it increasingly rich pay to the highest hole put down.

In addition to the terraced section, it seems highly probable that important concentrations of gold are in the river bed itself, if this could be reached and worked. To do so, however, it would probably be necessary to divert the main stream to Shakes Creek, by way of Latimer Lake. The following considerations apply to the section between the mouth of the canyon and Chutine River.

Chutine Valley was deeply scoured by ice, probably particularly so near the mouth of Barrington River, as the glacier down Pendant Valley would have tended to push the ice to the north. The writer has estimated, from various data, that the valley was cut some 300 feet below the then level of Barrington River. When the glaciers withdrew at the end of each intense alpine stage, Barrington River would cascade down this steep slope, removing the glacial deposits and cutting into the rock below. No gold deposits could be expected under these conditions, but there were times, apparently prior to the last glacial advance, when Chutine Valley was filled by a lake to varying levels; and at these times deposition would occur. Evidence of this is seen in the west bank of the stream below the upper or pole bridge. There a series of gritless clay beds, with occasional sandy layers and stray pebbles, appears. The same horizon was cut in some of the drill holes farther upstream, at levels that indicate it to be approximately horizontal. When this bed was laid down, the lake must have been very deep, otherwise more coarse material from the mountains would have been present. This clay horizon constitutes a false bottom on and just above which considerable gold may be expected to have lodged.

Below the clay horizon there is a considerable, but unknown, thickness of gravels; and when the river was flowing over these, they would have caught and retained any gold washed down.

At the mouth of the canyon, a drill hole sunk to a depth of 100 feet did not reach rock. Estimates of the slope of the river bed, coupled with this figure, indicate that the stream must be flowing over gravel, rather than rock, in the lower 1,000 to 1,500 feet of its course within the canyon itself. Many of the rocks of the canyon are bedded, dip steeply, and trend across the valley, creating probably splendid riffles for the retention of gold. It seems quite likely, therefore, that this section of the stream may be richer than at any point below.

The final advance of the ice down Chutine Valley covered the lower end of Barrington Valley with a thick deposit of drift and alluvium. Since the ice retreated, Barrington River has cut through these deposits to expose, as described, earlier beds. In so doing it has removed great quantities of the finer drift, but the great boulders, too large to be moved by the stream, have been concentrated in its bed. The present appearance of the river bed is, therefore, in no way representative of what lies beneath. No boulders, it is reported, were encountered in the drilling operations.

The present canyon is worthy of detailed study and search for remnants of old, high-level channels in which placer deposits will probably be found. From one well-defined rock bench just within the mouth of the canyon, and about 15 feet above the present river level, some gold has already been recovered. Another well-preserved section, filled with gravels, is near Jimmie Creek, and should be a favourable piece of ground, though difficult of access. Other old channels may exist, and can be recognized readily as gravel or drift-filled depressions that enter and leave the rock wall of the present canyon.

The source of the gold in the placer deposits is also something that might engage the prospector's attention. The writer is inclined to believe that this source, or sources, lies around the intrusive mass of Limpoke and Spann Creeks; but further careful investigation will be required before a definite conclusion can be reached.

STIKINE RIVER PLACERS

Little record remains of the Stikine placers, as they were discovered and worked in the sixties. Most of the lower ones are known to have yielded mainly fine flour gold of the type readily transported by a swift stream. The coarsest gold, and the richest deposit, was that of Buck bar, some 4 miles below Telegraph Creek. This bar is known to have yielded $100 a day, per rocker, for a considerable period, though the total production is not known. At this bar a bedrock base a few feet above the river channel is composed of sandstone dipping downstream. It is evident that the gravel was completely removed from this, as over a considerable area the boulders are stacked. Most of the gold came from the bedrock surface.

Other bars below Buck bar have yielded gold, such as Miller's bar below Dodjatin Creek, Carpenter's bar above Winter Creek, and Fiddler's bar opposite the same creek. Other workings are known down to below Dutch Charlie riffle.

Stikine River formerly flowed along the terrace below Hyland Creek to the bend southwest of it, on a course approximately parallel with the contour line on the map. Buck bar lies on this course, and the writer suggests that other parts of this old channel may contain gold.

APPENDIX

FOSSIL COLLECTIONS FROM STIKINE AND ISKUT RIVER AREAS

All fossil collections referred to in this report are designated by the letter F. The localities from which fossils were collected are similarly indicated on the maps. All such points, which were productive of material with some diagnostic value, and the collections made are further designated by a number. The numbering begins with 1 in the northeastern part of the northern map-sheet and is continuous toward the south. Collections made in the area of the north sheet are F1 to F33; in the central map-area, none; and in the area of the south sheet, F34 to F38. Except as otherwise noted, the floras have been determined by W. A. Bell, the Mesozoic faunas by F. H. McLearn, and the Palæozoic faunas by E. M. Kindle, all of the Geological Survey.

F1. *Daonella* sp.
Age: Triassic

F2. "A small collection of leaf imprints in micaceous sandstone comprise the following species.
Sphenopteris (*Anemia*?) *stricta* Newberry
Conifer twig, too poor for identification
Aspidiophyllum trilobatum Lesquereux
Protophyllum stikinensis Bell
Platanus uniformis Bell
Populus kerri Bell
Myrica? sp.

"*Sphenopteris* (*Anemia?*) *stricta* is apt to be mistakenly assigned to *Asplenium dicksonianum* Heer. It occurs fairly commonly in the Dunvegan formation.

"*Aspidiophyllum trilobatum* has hitherto only been reported from the Dakota group of Kansas and from the Raritan of the Atlantic coastal plain. So far, therefore, as this meagre assemblage is concerned it would seem safe to infer an Upper Cretaceous age, and on the strength chiefly of the occurrence of *Aspidiophyllum trilobatum* and *Protophyllum* to favour a *Cenomanian* or *Turonian* rather than a later age."

A more complete description of this collection is given in Bulletin No. 49, "Contributions to Canadian Palæontology", Geological Survey, Canada.

"F3. *Porpoceras*" sp.
Belemnites sp.
Nautilus? sp.
Ostrea sp.
Age: Jurassic and probably of Lower Jurassic age

F4. Numerous small fragments of fossils in which fragments of bryozoa are rather common. The material permitted no definite statement regarding the horizon represented.

F5. Indeterminate brachiopods

F6. *Daonella* or *Halobia*
Age: Triassic

F7. "A small collection of carbonized leaves that are preserved mainly in a smooth, argillaceous, olive-grey shale. They comprise the following species:
Sequoia langsdorfi (Brongniart) Heer
Ginkgo adiantoides (Unger)
Trochodendroides arctica (Heer)
Alnus sp.
Corylites hebridica Seward and Holttum
Acer sp.
Cinnamonum sp.

"This assemblage includes species of widespread lateral distribution in Arctic lands, formerly assigned a lower Miocene age but regarded by Berry[1] and others as unquestionably Eocene or Paleocene. Berry records *Sequoia langsdorfi, Ginkgo andiantoides*, and *Corylus macquarrii* (=*Corylites hebridica*) from other Tertiary beds of British Columbia. The Tertiary floras containing them are assigned by him to late Eocene age and considered in a general way the same age as the Kenai of Alaska."

F8. Crinoid stems

F9. Flattened indeterminate brachiopods

F10. *Inoceramus*? sp.
Corals

"The coral has some of the appearance of a coral of subclass Hexacoralla. These rocks might be tentatively designated Triassic or Jurassic?"

F11. Worm tubes
Concretions?
Age: probably Mesozoic

F12. *Lima*? sp.
Ostrea? sp.
Age: probably Mesozoic

F13. *Stikinoceras* cf. *kerri*
Age: Upper Triassic

F14. *Stikinoceras* cf. *kerri*
Orthoceras? sp.
Age: Upper Triassic

F15. Coral, poor specimen
Age: Mesozoic?

F16. *Isastrea*? sp.
Age: Probably Mesozoic

F17. *Pecten* sp.
Astarte? sp.
Lima? sp.
"*Rhynchonella*" sp.
"*Plicatula*"? sp.
"*Myophoria*"? sp.
Age: Mesozoic

F18. *Pecten* sp.
Age: Mesozoic

F19. Corals, poor specimens
"*Terebratula*" sp.
Age: probably Mesozoic

F20. *Stikinoceras* cf. *kerri*
Pecten sp.

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[1]Berry, E. W.: Geol. Surv., Canada, Bull. No. 42, pp. 91-94 (1926).

F21. *Dielasma*? sp.
Spiriferina? sp.
Age: Triassic

F22. *Daonella* or *Halobia*
Age: Triassic

F23. *Campophyllum*? sp.

"The fossils are poorly preserved and the present collection warrants only the opinion that all of the lots F23, F24, F25, are of Carboniferous age and probably from horizons earlier than Permian."

F24. Crinoid columns abundant
Bryozoa
Spiriferina sp.
Age: *See* note for F23

F25. Crinoid stems
Bryozoa, several species in shale
Age: *See* note for F23

F26. Brachiopods

S.S. Buckman's comment on one of these brachiopods is as follows: "According to the shape and ribbing allied to *Cyclothyris latissima* Sowerby from the Greensand and to *C. vespertilio* Brocchi, which is from Upper Cretaceous."

F27. *Pseudomonotis subcircularis*
Age: Upper Triassic

F28. *Belemnites*
Age: Jurassic

F29. *Lima* sp.
Pleuromya? sp.
Modiola sp.
Pecten sp.
"Avicula" sp.

This collection included a large number of well-preserved brachiopods, which were very kindly examined by S. S. Buchman and reported on as follows:

"It is in my opinion a particularly difficult matter to say whether these specimens are Jurassic or Cretaceous without a prolonged investigation of characters particularly internal. These are only partially known for Jurassic species and are almost unknown in regard to Cretaceous. External likeness is no guide. However, I pronounce for the Cretaceous, possibly Lower Cretaceous, on the following grounds:

"Rhynchonellidae: The specimens which look like *Rhynchonelloidea* both externally and internally are of little value for determination of date; but the specimen of *Cyclothyris* aspect seems to mark Cretaceous."

"Terebratulidae: These may be judged as Cretaceous on the following grounds: capillation of test is a rare feature among Jurassic Terebratulids, but is common in Cretaceous. Punctation of test is easily seen in Jurassic species, the punctæ being small and very numerous; in Cretaceous species punctæ are observable with difficulty, they are few and widely spaced. Only with difficulty can I detect occasional punctæ in the specimens submitted. Long extended and sharp beak-ridges are rare among Jurassic species; they are a fairly common feature in Cretaceous species. The much incurved beak perforated by a small foramen is not known to me among Jurassic species; it is, however, a character of many Cretaceous species."

F30. "The identifications which follow are approximate or comparisons with Russian and other closely related species:

Batostomella? sp. may be *Rhombopora* or *Leioclema*
Polypora sp.
Cystodictya sp.
Spirorbis sp.
Marginifera aff. involuta Tsch.
Productus aff. koninckianus Vern.
Productus aff. aagardi Toula
Camarophoria aff. superstes Vern.
Camarophoria aff. margaritovi Tsch?
Pustula aff. juresanensis Tsch. also *aff. P. nebraskensis* Owen.
Pustula aff. orginae Stuck
Squamularia aff. rostrata Knt.
Spiriferella arctica Houghton?
Bellerophon sp.

"Age: Permian. Geo. H. Girty as well as E. M. Kindle correlate this collection as well as F31 and F33 with the Alaskan Permian. Kindle states: "The Stikine fauna presents a facies different from either the Permian (Tahkondit) of the Yukon river (opposite Nation river) or that of southeastern Alaska, Saginaw Bay, and other localities, yet it is obviously related to the latter. It may differ somewhat in geological age but probably the difference in facies can be attributed to geographical conditions."

F31. *Spirorbis* sp.
Batostomella? sp.
Fenestella sp.
Polypora sp.
Streptorhynchus n.sp.
Meekella sp.
Productus aff. boliviensis d'Orbigny
Productus aff. aagardi Toula
Marginifera aff. involuta Tsch.
Marginifera aff. juresanensis Tsch.
Squamularia aff. rostrata Knt.
Spiriferella arctica Houghton
Rhipidomella? sp.
Schizophoria aff. juresanensis Tsch.
Camarophoria aff. superstes Vern.
Rhynchopora aff. nikitini Tsch.
Dielasma aff. dubium Tsch.
Spirifer aff. texanus Meek
Pteria sp. (new as far as my knowledge goes)
Bellerophon sp.
Goniospira aff. lasallensis Worthen
Trachydomia aff. wheeleri Swallow
Age: *See* note for F30.

F32. Two or three genera of not well preserved corals
Age: Mississippian

F33. *Camarophoria aff. superstes* Vern.
Spiriferella arctica Houghton
Age: *See* note for F30

F34. This collection was examined by C. H. Crickmay, who reports as follows:

"The fauna is interesting to me in being different in its make-up from anything I have seen from the Pleistocene. All are living species. All are typically marine. All are cold water forms. They may have lived in any

depth between 10 and 100 fathoms. A few of the specimens seem to have been reworked from an older deposit. They are marked "X". The list follows:

ANTHOZOA

(X) *Caryophyllia* cf. *pedroensis* Vaughan—1 wave-worn specimen

PELECYPODA

Leda fossa var. *vaginata* Dall—1 broken shell, but 2 valves still together
Leda pernula Müller—1 broken shell
Nucala quirica Dall—2 good specimens
Nucula thraciaeformis Storer—several good fragments
Cardium sp.—2 fragments

(X) *Cardium* sp.—1 worn fragment
Macoma brota Dall—many good fragments
Macoma inquinata var. *arnheism* Dall—1 shell with both valves
Saxicava cf. *pholadis* Linné—fragment

GASTROPODA

(X) *Colus errones* Dall—one specimen
Chrysodomus liratus Martyn—several

(X) *Buccinum cf. fluctuatum* Dall—fragment

CIRRIPEDIA

(X) *Balanus* sp.—fragments of a small species
Balanus sp.—fragment of a single very large scutum"

F35. "Three of the specimens show structures with match-shaped cross-sections which may represent sponges. A fourth specimen shows a porous structure which may also be of sponge origin. Four specimens display cross-sections of corals. Two genera appear to be present but the representative of one is too poor to justify even a surmise as to its identity. Two of the corals show septa reminding one of *Zaphrentis*. A single brachiopod is present. This is a small coarsely plicated *Spirifer* of which only the median portion of the ventral valve is preserved.

"While no positive statement can be made concerning the horizon of such poor material, it is very probable, in the writer's opinion, that a Carboniferous or Permian horizon is represented by the fauna."

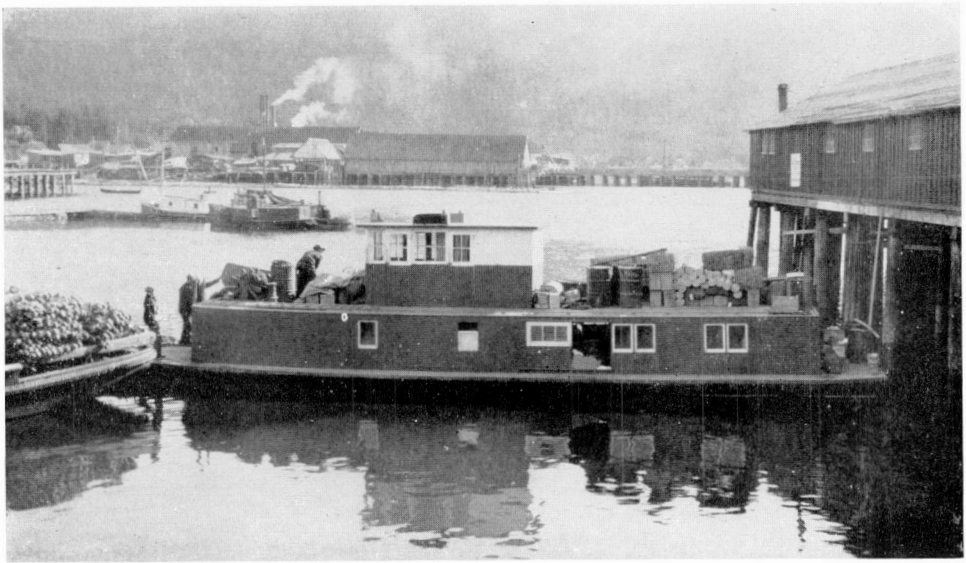
F36. "The character of the rocks, sometime schistose, and the poor state of preservation of the fossils, make it impossible to offer any definite opinion concerning the age of the sediments represented."

Crinoid stems in abundance
Pseudomonotis?
Berenicea?
Age: Jurassic? or Triassic?

F37. Material similar to that of F36

A highly distorted specimen could be *Pseudomonotis subcircularis*??, which if correct would date the beds as late Upper Triassic.

F38. Material similar to that of F36
Crinoid stems in abundance



68315

A. Barrington Transportation Company's steamboat *Hazel B. No. 3* at dock, Wrangell, Alaska, 1926. (Page 2.)



68306

B. Old settlement of Glenora, on Stikine River, 1926. (Page 5.)

PLATE III



79347

Telegraph Creek, on Stikine River, only village in the area and terminus of steamboat navigation from Wrangell, Alaska. Photo by George Hanson, Geological Survey, 1936. (Page 5.)



70495

A. Glacier at head of south fork of Dokdaon Creek, 1927. (Page 16.)



70479

B. Strata Mountain, southeast of the mouth of Chutine River. (Page 35.)

PLATE V



View southerly over Hoodoo Mountain (foreground) and Iskut River Valley to mountains west of Craig River. Photo by United States Army, 1941. (Page 41.)

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