MEMOIR 50

UPPER WHITE RIVER DISTRICT YUKON

BY

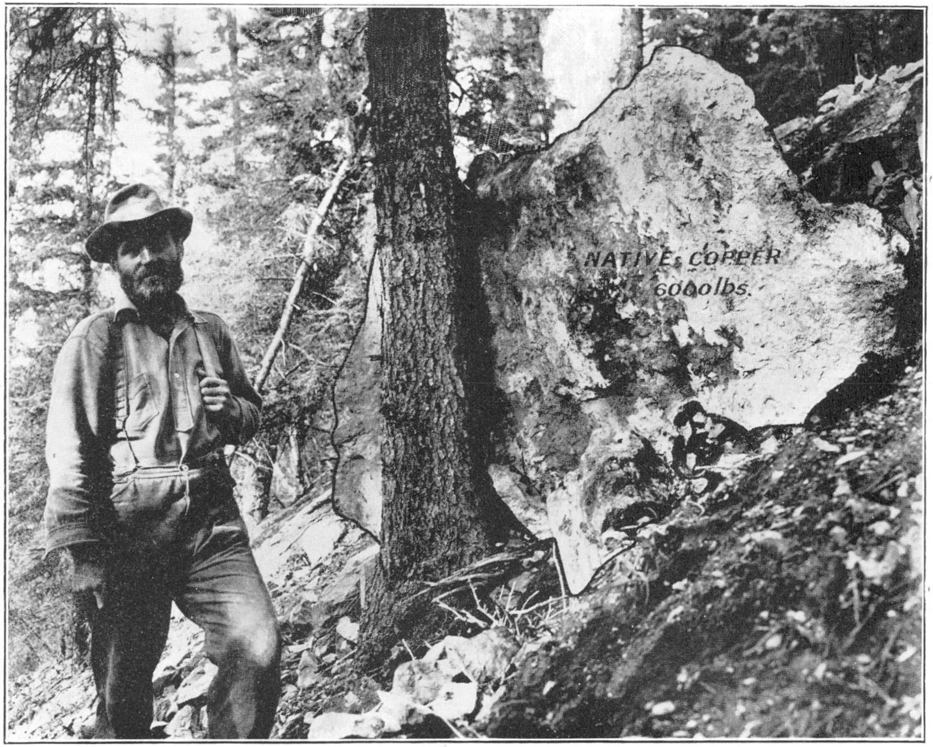
D. D. CAIRNES

GEOLOGICAL SURVEY

DEPARTMENT OF MINES

OTTAWA

1915


NATIVE COPPER
6000 lbs.

Explanation of Plate I.

A slab of native copper weighing about 6,000 pounds, found on Discovery copper grant near Canyon City, Yukon. Mr. Joseph Slaggard, one of the original owners of this property, is standing beside the copper slab.

CANADA
DEPARTMENT OF MINES
Hon. Louis Coderre, Minister; R. W. Brock, Deputy Minister.

GEOLOGICAL SURVEY

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No. 51, Geological Series

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CHAPTER I.

GENERAL AND INTRODUCTORY.

INTRODUCTION.

The probable occurrence of native copper along the upper portion of White river, Yukon, has long been surmised, and as early as 1891, when this district is believed to have been first penetrated by an exploring party of white men, fabulous accounts of the enormous quantities of native copper found in Upper White River district, were told to members of the expedition. From 1898 onward, prospectors in search of gold and copper have kept going into the region, induced so to do, partly or entirely as a result of Indian stories which had invested the Upper White River belt of both Yukon and Alaska with mineral wealth proportionate to its remoteness and inaccessibility.

Greatly exaggerated as were these early accounts concerning the mineral wealth of Upper White River district,[1] they nevertheless contained some truth. Native copper occurs at different points, individual masses of which have been found weighing several hundred pounds each, and one large slab was seen by the writer that is estimated to weigh approximately three tons (Frontispiece). Quartz veins also occur in several localities, some of which contain encouraging amounts of gold, and recently, placer gold has been discovered in economically promising amounts on some of the streams draining into Upper White river and its tributaries.

[1] The name Upper White River district as used in this memoir, refers, unless otherwise mentioned, to that portion of Yukon, only, which was mapped during the past summer, and does not include the adjoining area in Alaska which lies on either side of the extreme upper part of White iiver, and which might be considered as Upper White River district, Alaska.

This district lying along the landward edge of the St. Elias range, and including as it does, a portion of Nutzotin mountains (Figure 2), has been known, for some years, to be geologically and topographically favourably situated for the occurrence of mineral deposits, and would have been mapped and investigated by the Canadian Geological Survey at least two or three years ago, except for a series of unavoidable delays. The writer was, however, last spring (1913) instructed to geologically map and explore this area, and reached there several weeks before the stampede commenced to the neighbouring Chisana gold-field, across the International Boundary line, 30 miles to the west. Geological formations and conditions similar to those in Chisana district, occur in Upper White River district, Yukon, and this winter (1913-14) several hundred men are prospecting the gravels of this district, and gold is reported to have already been found in encouraging quantities on several of the streams within the area.

On account of the similarity, geologically, between the Chisana gold-fields and portions of Upper White River district, Yukon, a brief description of the general geology and gold-bearing gravels of the portions of Chisana district that have been found to contain valuable deposits of placer gold, is included in this memoir, in the chapter dealing with mineral resources. It is hoped that an understanding of the geological conditions prevailing in Chisana district, may be helpful in prospecting and developing the adjoining Canadian territory to the east.

The district examined was topographically mapped during the summer of 1913, by W. E. Lawson of the Topographical Division of the Geological Survey. This topographic map incorporates the work of the Alaska-Yukon Boundary Survey along the International Boundary, and topographical and geological editions of the map accompany this memoir. In the field, copies of the Boundary Survey map on a scale of 1 mile to 1 inch, and tracings of the topographic work by W. E. Lawson on a scale of approximately 3 miles to 1 inch, were used as bases on which to plot the geology.

Mr. F. J. Barlow acted as the writer's geological assistant. Mr. Barlow reached the mouth of Beaver creek on June 14, about three weeks before the writer arrived, and continued the field work until September 4. On August 8 the writer had to start for Vancouver to act as guide on excursions of the International Geological Congress, leaving Mr. Barlow to proceed with the geological work. Thus the writer was unable to

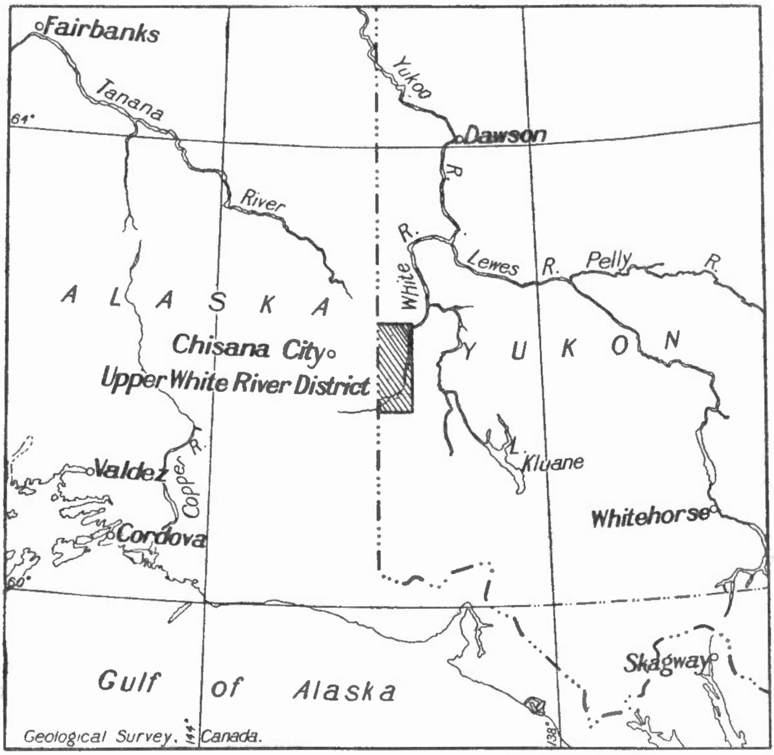

Figure 1. Index showing location of Upper White River district.

devote more than about one month to actual field work in Upper White River district.[1] Mr. Barlow performed all the duties assigned to him in a very willing and painstaking manner.

[1] During the season of 1914, after this memoir had gone to press, the writer was unexpectedly enabled to spend about a week in the early part of September in Upper White River district, and during this time completed the mapping of several hills or mountains in the northern part of the district between Beaver creek and Nutzotin mountains, which were not examined, due to lack of time, during the previous summer.

LOCATION AND AREA.

The portion of Yukon Territory, along White river, which was mapped and investigated during the past summer (1913), and which is here designated Upper White River district, is about 55 miles long, from north to south, and 12 to 23 miles wide. This area lies to the east of and adjoins the 141st meridian, the Yukon-Alaska International Boundary; extends to the north to about latitude 62° 30′ so as to include the mouth of Beaver creek; reaches to the south to about latitude 61° 42′, or to about 3 miles south of the crossing of White river by the Boundary line; and stretches to the east to include White river (Figure 1).

This particular area was selected for mapping and investigation, as it was considered to be, geologically, one of the most promising sections of that part of Yukon, for the occurrence of mineral deposits, and because a number of discoveries of ore material had been reported from that vicinity. The mapping was extended so as to include, in the one season, as much as possible of the better mineralized portions of the district.

HISTORY OF EXPLORATION.

White river was, in 1850, so-named on account of its milky colour, by Mr. Robert Campbell,[1] an officer of the Hudson's Bay Company. The first recorded exploration of White river, however, was made on the ice in 1872 by Mr. Arthur Harper, one of the pioneer traders of Yukon,[2] who ascended the river for about 50 miles. The lower part of this stream had been visited by several parties of prospectors, but until 1891 no attempt was made to reach its headwaters, and the larger part of the White River basin remained entirely unknown.[3] In 1891, Dr.

[1] Dawson, G. M., "Report on an exploration in the Yukon district, N.W. T., and adjacent northern portion of British Columbia": Geol. and Nat. Hist. Surv. of Can., Ann. Rep., Vol. III, Pt. 1, 1887-88, p. 138 B.

[2] Ogilvie, William, "Exploratory survey of part of the Lewes, Tatonduc, Porcupine, Bell, Trout, Pelly, and Mackenzie rivers": Report to the Minister of the Interior, Ottawa, 1890.

[3] Brooks, A. H., "A reconnaissance in the White and Tanana River basins, Alaska, in 1898": U.S. Geol. Surv., 20th Ann. Rep., Pt. VII, 1898-99, pp. 435-436.

C. W. Hayes of the United States Geological Survey, Lieutenant Frederick Schwatka, and a prospector named Mark Russell crossed overland from Fort Selkirk on Yukon river, to White river, reaching the valley of this latter stream near where it is crossed by the International Boundary. The party thence continued up the White to its source in Russell glacier, crossed over Skolai pass, and descended Chitina and Copper rivers to the coast. Dr. Hayes' report of this expedition[1] constitutes the first definite, published description concerning White River basin. This trip was made by back-packing, and consequently little time was available for more than casual observations along the route of travel. While at Fort Selkirk, the members of the expedition heard astonishing accounts of the enormous quantities of native copper in White River district, copper nuggets being reported to occur as large as a log cabin. These Indian stories concerning the mineral and particularly the copper discoveries in this region were, however, found to have been greatly exaggerated; but, nevertheless, it was definitely ascertained that placer copper occurred in the gravels of Kletsan creek, a stream which enters White river from the south, near the International Boundary.

In 1898, William J. Peters and Alfred H. Brooks of the United States Geological Survey, went up White river to the mouth of Beaver creek, thence continued up Beaver and Snag creeks, portaged over the divide to Mirror creek, and descended Mirror creek and Tanana river to the Yukon, the purpose of this expedition being to make a reconnaissance of Lower White river and as much of Tanana river as the limited time available would permit.[2]

In 1899, W. J. Peters and Alfred H. Brooks also made an expedition from Pyramid harbour to Yukon river, crossing White river to the west of the International Boundary, continuing along the base of the St. Elias range and Wrangell moun-

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[1] Hayes, C. Williard, "An expedition through the Yukon district:" Nat. Geog. Mag., Vol. IV, May, 15, 1892, pp. 117-162.

[2] Brooks, A. H., Op. cit. pp. 431-494.

tains to Nabesna river, and proceeding thence in a northerly direction across Tanana river to Eagle City.[1]

The information which these explorations have afforded concerning Upper White River district, Yukon, is very meagre indeed, but nevertheless, has constituted up to the present year the only known definite published descriptions of this area; and consequently has been and still is of great value. A number of surveys and investigations have, however, been conducted, on both sides of the International Boundary line, in sufficiently close proximity to Upper White River district to be of decided importance to this area and throw considerable light on the natural phenomena and conditions there found to occur. Among the more important of these investigations and those having a more direct bearing on the district here particularly being considered, should be mentioned those of Mr. R. G. McConnell of the Canadian Geological Survey, and of Messrs. F. H. Moffit and Adolph Knopf, of the United States Geological Survey. During the summer of 1905, Mr. McConnell explored the territory along certain of the headwater tributaries of White river,[2] and during 1908, Messrs. Moffit and Knopf made a topographic and geologic reconnaissance survey of an area including the northwestern slopes of the Wrangell mountains, and the adjacent Nutzotin mountains, Alaska.[3]

In 1911 and 1912 the writer mapped and investigated the geology along the Yukon-Alaska boundary line between Porcupine and Yukon rivers.[4]

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[1] Brooks, A. H., "A reconnaissance from Pyramid harbor to Eagle City, Alaska, including a description of the copper deposits of the Upper White and Tanana rivers": U.S. Geol. Surv., 21st Ann. Rep., Pt. II, 1899-1900, pp. 337-391.

[2] McConnell, R. G., "Headwaters of White river": Geol. Surv., Can., Sum. Rep. for 1905, pp. 19-26.

[3] Moffit, F. H., and Knopf, Adolph, "Mineral resources of the Nabesna-White River district": U.S. Geol. Surv., Bull. 417, 1910.

[4] Cairnes, D. D., "Geology along a portion of the Yukon-Alaska Boundary between Porcupine and Yukon rivers": Geol. Surv., Can., Sum. Rep. for 1911, pp. 17-33.

" Geology along a portion of the Yukon-Alaska Boundary between Porcupine and Yukon rivers" : Geol. Surv., Can., Sum. Rep. for 1912, pp. 9-12.

"The Yukon-Alaska International Boundary between Porcupine and Yukon rivers": Geol. Surv., Can., Memoir No. 67 (In press).

"Geological section along the Yukon-Alaska boundary line, between Yukon and Porcupine rivers": Bull. Geol. Soc. Amer. Vol. 25, pp. 179-204, 1914.

During the past summer, and particularly since the discovery of the gold-bearing gravels in Chisana, hundreds and, possibly, thousands of men have passed through or visited Upper White River district, and the public press has contained a great amount of more or less authentic information concerning this area.

ROUTES AND METHODS OF TRAVEL.

General Statement.

Upper White River district has, in the past, been considered to be one of the more difficultly accessible portions of Yukon, and very little authentic information has been available concerning the routes and methods of travel thereto. It was generally understood that White river was practically unnavigable for steam craft, and in fact for all ordinary types of power boats, although it was known that small, specially built gasoline launches could, with considerable difficulty, and during favourable stages of water, get a few miles up this stream. It was thus only possible to economically get freight and outfits into the district by sledding such in over the ice and snow during the winter months. The only alternative plan, was to pole up White river during the summer, which required considerable time and was very expensive; and further, for this work, thoroughly experienced polers and river men were necessary, and were not always available.

Since the discovery of placer gold in Chisana district, Alaska, within 30 miles of Upper White River district, the routes to this locality have become much better known. The Yukon government has also built good pack trails to the district, and White river has become much better understood than formerly. In fact, last autumn (1913), all manner of river craft, including canoes, row boats, poling boats, gasoline launches, and steam boats were to be seen working their way upstream at various points on the river. Some light-draft steamers reached the mouth of Donjek river, and others managed to get to within a few miles of this point, and one small especially designed gasoline boat managed to get to the mouth of the Beaver, and is reported to have accomplished the journey from the mouth of White river to the Beaver, in four days. This winter (1913-14) steam and gasoline boats are being built for use on White river next season (1914), which will take freight and passengers to Beaver creek, and undoubtedly freight will next summer be taken to White River district by boat, for a fraction of what it has formerly cost to take it over the ice or snow, in the winter. Thus, from now on, it will be possible to reach White River district or Chisana, with comparative ease and safety.

The majority of persons who have gone into Upper White River district, have followed one of three main routes which pass through Yukon, and may thus be considered as Yukon or Canadian routes. These three principal lines of travel may be designated as the White River, Coffee Creek Trail, and Kluane routes. Three more or less important Alaskan routes have also been followed to a considerable extent, mainly by persons going only to Chisana, but may also be used to reach Upper White River district. These may be termed the Tanana River, Russell Glacier (Skolai Pass) and Nizina-Chisana Glacier routes; of these the glacier routes are very dangerous and the Tanana River route is only available to persons commencing their journey from Fairbanks or some nearby point in central Alaska. In addition to these more important routes, others less available or convenient, or possibly less well known, have been followed by a few persons. Three of the most travelled of these less favoured routes may be termed the Chitina-Copper River, the Valdez-Copper River, and the Boundary routes.

In any case, irrespective as to which of these routes is intended to be followed, persons travelling to Upper White River or Chisana districts direct, from practically all points not actually within Yukon, Alaska, or adjoining districts, go via either Skagway or Cordova or possibly via Valdez, three ports situated on the southern coast of Alaska. Commodious steamers make regular and frequent trips from Vancouver or Seattle to these points, Skagway being distant about 870 and 1,000 miles from Vancouver and Seattle respectively, and Cordova and Valdez being about 1,615 and 1,705 miles respectively, from Seattle, measured along the inland Coast passage followed by the regular steamers. From Skagway and Cordova, short railway lines proceed toward the interior.

All the Canadian routes proceed from tidewater at Skagway over the White Pass and Yukon railway to Whitehorse, a distance of 110 miles. From Whitehorse, which is situated at the head of navigation on the Yukon and its principal tributary, Lewes river, the various Canadian routes diverge.

Canadian Routes.

Kluane Route.

The route from Whitehorse via Lake Kluane, to Upper White River district and thence to Chisana, is available during the entire year, but varies somewhat as to location, with the season—certain sled roads and stretches of stream and lake ice being utilized to advantage during the winter months (See Route Map in back of this memoir).

A wagon road has been constructed by the Yukon government, from Whitehorse westward to Kluane post-office situated near the upper (southern) end of Kluane lake, a distance of 150 miles. During the summer months, this road is followed from Whitehorse to Kluane whence it is possible either to go by boat to Jacquot's roadhouse, which is situated on the western side and near the foot of the lake, or to follow a trail to this point around the upper end and down the western side of the lake. Thence a trail has recently been blazed to Canyon City on White river, the distance from the post-office at Kluane to Canyon City being about 132 miles (Plate XVII). From Canyon City a good trail extends in a northwesterly direction to the International Boundary, near the point where the line crosses Beaver creek, a distance of about 15 miles. From the Boundary line westward into Alaska, although no trail has actually been constructed, the mark of the stampeders up Beaver creek to its head and over the divide to Chathenda creek and thence to Chisana City, a distance from the International Boundary of about 40 miles, has become quite well defined. A branch of the trail from Canyon City follows northward along Tchawsahmon lake and down Tchawsahmon creek[1] to Beaver creek, and connects with the government trail from the mouth of this latter stream. This branch trail thus crosses Bowen (Dominion), and Pan creeks which drain into Tchawsahmon creek, and in which gold in encouraging quantities is reported to have been discovered.

Since the freeze-up last autumn, the route followed from Whitehorse to Upper White River district and Chisana via Kluane lake, is somewhat different from the summer route just described. The wagon road from Whitehorse is followed to a point about midway to the lake, whence a sled road has been constructed to the north of the regular wagon road, which encounters Lake Kluane near the mouth of Cultus creek, midway down the eastern side of the lake and approximately 155 miles from Whitehorse. Thence the route crosses the lake ice to Jacquot's roadhouse situated near the lower end of the lake and about 22 miles from the mouth of Cultus creek. From Lake Kluane to Generc river, the winter route follows, in most places, the same general course as the summer trail, the Generc being encountered about 11 miles from its mouth. This stream is thence followed to the White, whence it is possible either to travel upstream on the ice to Canyon City or to go down the White about one mile to the mouth of Rabbit creek, proceed up this stream about 2 miles, thence turn to the northwest and follow up a small tributary of Rabbit creek, and continue along a chain of small lakes which lead into Tchawsahmon lake and thence down Tchawsahmon creek to near Beaver creek—river and lake ice being followed practically all the way from the point where the Generc is first encountered to within a mile or so of Beaver creek. The distance from Jacquot's on Lake Kluane to Rabbit creek is about 86 miles and thence to Pan creek, a tributary of Tchawsahmon creek, is 14 miles. If it is desired to continue to Chisana, the ice up Beaver creek is followed to the head of the stream, whence the route passes over the divide to Chathenda creek, and thence to Chisana City. The distances from the Pan creek to the crossing of Beaver creek by the International Boundary is just about 6 miles, and thence to Chisana City is 40 miles. Quite an amount of freight is being taken

[1] Also known as Lake creek and as Pond creek.

over this road during the present winter (1913-14) by the White Pass and Yukon Route Company and others, to White River and Chisana districts.

Coffee Creek Trail Route.

Coffee creek enters Yukon river on its left limit about 110 miles above Dawson and 350 miles below Whitehorse, measured along the river. Commodious steamers ply regularly between Whitehorse and Dawson during the summer months, it being possible to catch a boat going either up or down stream almost any day during the season. Coffee creek, during the summer, is thus readily accessible. From the mouth of this stream, the Yukon government has constructed a good pack trail to Canyon City, and a branch of this trail goes to the mouth of Beaver creek[1] on White river—Canyon City and the mouth of Beaver creek being distant by trail from Coffee creek, about 120 and 80 miles respectively (See Route Map in back of this memoir). From Canyon City, as mentioned in describing the Kluane route, trails extend to the different parts of Upper White River district, and one of these continues westward to Chisana City. From the mouth of Beaver creek, a good trail has been constructed which trends in a southwesterly direction for about 35 miles to a point where this stream is again encountered and thence continues up this creek to the Boundary line, a distance from the mouth of the Beaver, measured along the trail, of about 45 miles (Plate II). From the International Boundary, as before mentioned, a stampeders' trail runs up Beaver creek to its head, extends from there over the divide to Chathenda creek, and continues thence to Chisana City, an additional distance from the Boundary of 40 miles. The trip from Coffee creek to the mouth of Beaver creek or to Canyon City can be made with pack horses during the summer months

[1] This creek below the mouth of its main tributary, Snag creek, has been, in the past, by some people, also called Snag creek. The Geographic Board of Canada, however, has decided that this stream shall be called Beaver creek from its head to White river, and that only the northern tributary shall be called Snag creek.

in about 5 and 8 days respectively, without unduly exercising the pack animals, and from either of these points, the journey may be continued, if desired, to Chisana City, in about 5 and 3 days respectively.

The Coffee Creek trail thus constitutes a very good summer route to Upper White River district, but this trail is little used in winter by those visiting this locality, as it is much easier to travel and sled up White river on the ice than over the Coffee Creek trail, both routes leading to Beaver creek.

White River Route.

The White River route follows up White river from its mouth to Beaver creek, a distance which is generally considered by those making the trip, to be about 115 miles, but which, according to a survey of the river made by Mr. W. J. Peters[1] in 1898, is only 85 miles (See Route Map in back of this memoir). Ordinary light-draft steam and gasoline river boats were able last season (1913) to get about 60 to 70 miles up White river, or to about the mouth of Donjek river (Plate III); and one small, specially designed gasoline boat succeeded in reaching the mouth of Beaver creek, and is reported to have made the trip from the mouth of the White to Beaver creek in 4 days. Other boats particularly adapted to work on White river are this winter being constructed for use next season. Poling boats have in the past been mainly employed on this stream from the mouth up, and last season were used especially above the mouth of Donjek river, or above the different points at which the power boats stopped. It is claimed also, that it is quite possible to take poling boats a considerable distance up Beaver creek (Plate V).

A government trail has been constructed along the left limit of White river from opposite the mouth of the Donjek to Beaver creek, a distance of about 20 miles, which is intended to afford travelling facilities above the head of steamboat navigation. From

[1] Brooks, A. H., "A reconnaissance in the White and Tanana River basins, Alaska, in 1898": U.S. Geol. Surv., 20th Ann. Rep., Pt. VII, 1898-99, p. 443.

the mouth of the Beaver, as before mentioned in describing the Coffee Creek Trail route, a government trail has been constructed which trends in a southwesterly direction for about 35 miles to a point where Beaver creek is again encountered, and thence continues up this stream to the International Boundary, a distance from the mouth of the Beaver on White river, of about 45 miles. In case it is desired to continue westward beyond Upper White River district, a trail extends from the Boundary line up the Beaver to its head, strikes from there over the divide to Chathenda and continues thence to Chisana City which is distant about 40 miles measured along this route from the Yukon-Alaska Boundary. This trail to the west of the Boundary has not been regularly constructed, but is merely the more or less definite track of the Chisana stampeders.

After the freeze-up in the autumn, White river affords an excellent sled route to Beaver creek. From the mouth of the Beaver, all freighters and others follow, this winter, the regular trail which trends in a southwesterly direction for about 35 miles to where the Beaver is again encountered; thence they go up the ice on Beaver creek to Tchawsahmon creek and its tributaries, and other points where placer gold has been discovered. Some also follow up the ice toward the head of Beaver creek, pass over the divide between the head of Beaver and Chathenda creek, and continue to Chisana City.

A considerable amount of freight has gone over this White River route since the freeze-up last autumn; in fact the bulk of all the freight and outfits that has so far been taken into Upper White River district, and also into Chisana district, not only during the last few months but in the years past, has come up White river. Part of the freight that is being conveyed up White river this winter was boated to the mouth of the White, and some was even taken part way up this river before the freeze-up. Some freight, however, is being sledded all the way from Dawson. The route followed by those freighting to White river from Dawson in winter always depends largely on the condition of the ice on the Yukon. If the river freezes with a smooth surface, the traffic is most likely to go up Yukon river on the ice. This winter, the freight is mainly coming over the

Whitehorse-Dawson wagon road to a point about opposite Henderson creek. From there it is taken over a sled road to the head of Henderson creek, and thence down the Henderson Creek wagon road to the Yukon, from where it is sledded up the Yukon to the mouth of White river.

Boundary Route.

The Boundary route, or the Sixtymile River route as it has been called, has been followed by a number of stampeders starting from Dawson for Upper White River or Chisana districts. From Dawson the Miller Creek wagon road is followed to the International Boundary near the head of Sixtymile river. Thence a trail continues southward in the vicinity of the Boundary line, sometimes on one side and sometimes on the other. This is followed as far as Beaver creek, whence it is possible either to go upstream toward Chisana or downstream through Upper White River district. The distance from Dawson to the Boundary line along the wagon road, is about 60 miles, and the distance thence to Beaver creek, measured along the Boundary line, is 140 miles, and is at least 170 miles by the trail.

This route is only practicable to persons already at Dawson or in that vicinity, and should only be attempted by persons perfectly accustomed to such trips, and well acquainted with the country. The trail along the Boundary is very rough and is in places indefinite and hard to follow, being really nothing more than the line of travel of the International Boundary Survey parties when surveying and establishing the boundary line. It is not possible to follow the actual line itself, as this passes over some very high, rugged points, and furthermore, wherever any timber occurs, this has been slashed for a width of 50 feet in demarcating the Boundary, and the fallen trees and brush completely block all travel in many places.

ALASKAN ROUTES.

Tanana River Route.

As Chisana river is a tributary of the Tanana, it is possible to go to Chisana City all the way by water in summer and by ice in winter, by following up Tanana river and its tributaries (Figure 1). From Chisana City a trail leads up Chathenda creek, passes over the divide to the head of Beaver creek, and continues down this stream to Upper White River district. The distance from Fairbanks to Chisana City by the Tanana, is about 350 miles. Of this distance, it is claimed that during favourable stages of water in summer, small power boats will be able to reach within 50 to 75 miles of Chisana City, and for the remaining distance, poling boats may be employed. The distance from Chisana City eastward to the Yukon boundary is about 40 miles.

This route is very long, arduous, and difficult, and will be followed only by persons already at Fairbanks or some nearby portion of central Alaska, it being an altogether impracticable route for persons commencing their journey to Upper White River district, or Chisana, from points outside of Alaska.

Fairbanks is situated practically on Tanana river about 295 miles upstream from its point of confluence with the Yukon. To reach Fairbanks, it is customary to go one of two ways—either from Skagway over the White Pass and Yukon railway, and down Lewes and Yukon rivers to Tanana (Fort Gibbon) at the mouth of the Tanana, and thence up this stream; or up the Yukon from St. Michael or Nome to Tanana, and thence up Tanana river. Tanana is distant, 1,270 miles by river and railway from Skagway, and 900 and 1,000 miles, respectively, by river from St. Michael and Nome, both of which points are situated on Norton sound, near the mouth of Yukon river. Steamers ply during the summer months from Seattle, by the outside, open-sea route to Nome and St. Michael, which are distant from Seattle along this route about 2,310 and 2,360 miles respectively. Bering sea being frozen in winter, navigation does not open to these points until about June 1.

Russell Glacier (Skolai Pass) Route.

By the Russell Glacier route, the Copper River and Northwestern railway is followed from tidewater at Cordova to

McCarty, a point near the end of the railway line, 191 miles from Cordova. Thence a somewhat indefinite prospector's or stampeders' trail proceeds over Sourdough hill to the Nizina river and up this river to Chitistone creek where the trail forks, and whence either of two different routes may be followed to Russell glacier, which occupies Skolai pass. One branch of the trail continues up Chitistone creek and over a short divide to Russell glacier; the other trail continues up Nizina river past the mouth of Chitistone creek, to Nizina glacier, follows along the edge of the glacier about 2 miles to Skolai creek, and thence proceeds up Skolai creek to Russell glacier. The choice of these two trails to Russell glacier, depends largely upon the condition of the glacial ice, and also on the stage of the water in the streams. At times, it is considered easier to go up the Chitistone, and at other times, the Skolai trail is preferred. The trail thence proceeds over Russell glacier to the head of White river. The distance from McCarty to Russell glacier by either Chitistone or Skolai creek, is between 35 and 40 miles, and thence it is about 12 or 14 miles over the glacial ice and moraine, to the head of White river (Plate VI).

From the head of the White, the trail continues down the valley of this river for about 10 miles, where it again forks. One trail continues down White river to Canyon City in Upper White River district, Yukon, the other trail follows up Solo creek, and thence strikes in a northwesterly direction toward Chisana. Some persons going to Chisana district by this route, proceed toward the head of Beaver creek, while others go by Gehoenda creek direct to Chisana City. From Chisana City, a trail strikes up Chathenda creek, continues over the divide to the head of Beaver creek, and thence follows down this stream to the International Boundary and Upper White River district. The distance from the head of White river to the International Boundary via White river is between 35 and 40 miles and thence to Canyon City is approximately 10 miles. From the head of White river to Chisana City is about 40 miles, and from there down the Beaver to Upper White River district is approximately another 40 miles.

The Russell Glacier route is a comparatively short and direct route to Chisana and Upper White River districts, but it is both difficult and hazardous, and is available only during a few weeks in summer, when even then it is very dangerous in places for pack horses. Earlier or later than this short season, the pass between McCarty and White river is considered practically impassable, and should not be attempted. A number of persons have already lost their lives in attempting to cross this high, rugged, glacial pass, through the lofty, alpine Wrangell-Skolai Mountains barrier which separates the Coast from the Interior of Yukon and Alaska.

Nizina-Chisana Glaciers Route.

The Nizina-Chisana Glaciers route is the same as the Russell Glacier route, to Nizina river, i.e. the Copper River and Northwestern railway is followed from tidewater at Cordova to McCarty, a point near the end of the railway line, 191 miles from Cordova, thence a trail proceeds over Sourdough hill to the Nizina. The trail continues up Nizina river to its head at Nizina glacier, Homestead roadhouse at the head of Nizina river being about 29 miles from McCarty. Thence the trail crosses Nizina and Chisana glaciers to the head of Chisana river, and follows down Chisana river to near the mouth of Chathenda creek, whence it strikes direct for Chisana City on this creek. The distance from Nizina river over the glaciers to the head of Chisana river is about 40 miles, thence to Chisana City is an additional 7 or 8 miles. From Chisana City, as before mentioned, a trail strikes up Chathenda creek, passes over the divide to the head of Beaver creek and follows down this stream to the International Boundary which forms the western boundary of Upper White River district, Yukon—the distance from Chisana City to the Boundary line, by trail, being about 40 miles.

Very little information is available concerning this route as it was not used until very recently. Several hundred people have, however, crossed or attempted to cross Nizina and Chisana glaciers on their way to Chisana during the past winter (1913-14).

This is a short, direct route to Chisana City, but is generally reported to be very dangerous.

Chitina-Copper River Route.

By the Chitina-Copper River route, The Copper River and Northwestern railway is followed from tidewater at Cordova to Chitina, a distance of 131 miles. From Chitina, the United States government wagon road is followed up Copper river past Copper Center to Gulkana, a distance of 76 miles. From Gulkana a trail continues up Copper river past Chistochina to Batzulnetas at the mouth of Tanada creek, thence follows up this creek and strikes in a southeasterly direction to Sargents' camp on Nabesna river, whence the trail continues direct to Chisana river and Chisana City. From Chisana City a trail continues in an easterly direction to Upper White River district as before described. The distance from Gulkana to Batzulnetas is about 85 miles, thence to Sargent's camp is 40 miles, thence to Chisana City is 35 miles, and thence to the International Boundary is 40 miles.

This route has not been travelled to any great extent, as it is a long, roundabout way of reaching Chisana and Upper White River districts, and because the trail from Gulkana to Chisana City, a distance of about 160 miles, is rather indefinite and difficult to follow except by persons well acquainted with the district. Further, throughout the greater part of this distance, the travelling is in summer very heavy and arduous, and there are a considerable number of fairly large and in places treacherous streams to cross. In general, however, this route is much less hazardous than the glacier routes and for this reason is to be preferred, although it is considerably longer than either the Nizina-Chisana, or Russell Glacier routes.

Valdez-Copper River Route.

By the Valdez-Copper River route a United States Government wagon road is followed from the coast at Valdez, to Copper Center a distance of 102 miles. From Copper Center this route is the same as the Chitina-Copper River route. From Copper Center the wagon road continues up Copper river to Gulkana, a distance of 26 miles, whence a trail proceeds up Copper river past Chistochina to Batzulnetas, thence to Sargents' Camp on Nabesna river, thence to Chisana City, and thence to the International Boundary and Upper White River district. The distance from Gulkana to Chisana City is about 160 miles and thence to the Boundary line is 40 miles.

This route differs from the Chitina-Copper River route only in following a wagon road from the coast instead of taking advantage of the railway. It is possible by this route, therefore, to go from the coast to Chisana and Upper White River districts without having to pay any steamboat or railway fares or rates, this being practically the only route that is employed to reach these districts from the coast by which part of the journey is not by river or rail.

Distances.

Concerning the distances given in the following tables, those along railways and wagon roads represent actual measured mileage; those along steamer routes are from river or coast surveys; the distances along trails, however, are only approximately correct, but have been estimated making use of all the information, surveys, and maps available, and consequently have a very fair degree of accuracy.

General	Miles of 5280 feet
From Vancouver to Skagway, steamboat, inside passage............	870
" Seattle " " " " "	1000
" " " Cordova " " "	1615
" " " Valdez " " "	1705
" " " Nome " outside passage	2309
" " " St. Michael, " " "	2361
" Skagway " Whitehorse, W. P. and Y. Ry	110
" Whitehorse to the mouth of Coffee creek, by river............	350
" " " " " " White river, " "	380
" " " Dawson, by river	460
" the mouth of Coffee creek to Dawson, by river	110
" " " " White river " " " "	80
" Dawson to Tanana (Fort Gibbon) " "	700
" Tanana " Fairbanks by river	295
" " " St. Michael by river	900
" " " Nome by river	1000

Kluane route	Miles
(Summer route)	
From Whitehorse to Kluane (Near upper end Lake Kluane) by Yukon Government wagon road	150
" Kluane to Jacquot's roadhouse (Near lower end Lake Kluane) by trail	47
" Jacquot's roadhouse to Canyon City on White river, by trail	85
" Canyon City to Pan creek, by trail	17
" Canyon City to crossing of Beaver creek by International Boundary	15
" Pan creek to mouth of Beaver creek, by trail	42
(Winter route)	
" Whitehorse to Lake Kluane, mouth of Cultus creek, by wagon road and sled road	155
" Cultus creek to Jacquot's roadhouse, across lake on ice	22
" Jacquot's roadhouse to Rabbit creek, by trail and ice	86
" Mouth of Rabbit creek to Pan creek, over ice	14
" Pan creek to crossing of Beaver creek by International Boundary, by trail and creek ice	6
" Pan creek to mouth of Beaver creek, by trail and creek ice	42

Coffee Creek Trail route	Miles
From the mouth of Coffee creek to the mouth of Beaver creek, by Yukon Government pack trail	80
" the mouth of Coffee creek to Canyon City, by Yukon Government pack trail	120
" the mouth of Beaver creek to Pan creek, by Yukon Government pack trail	42
" the mouth of Beaver creek to the crossing of this stream by the International Boundary, by trail	45
" Canyon City to Pan creek, by trail	17
" Canyon City to the crossing of Beaver creek by the International Boundary, by trail	15
" International Boundary to Chisana City	40

White River route	Miles
From the mouth of White river to the mouth of Ladue creek by river	28
" " " " " " " " " " Katrina " " "	42
" " " " " " " " " Donjek river "	65
" " " " " " " " " " Beaver creek " "	85
" " " " Beaver creek to Pan creek, by Yukon Government pack trail	42
" the mouth of Beaver creek to the crossing of this stream by the International Boundary, by Yukon Government pack trail	45
" International Boundary to Chisana City, by trail	40

Boundary route	Miles
From Dawson to International Boundary by Miller Creek wagon road	60
" wagon road, to Beaver creek, by trail along Boundary line........	170±
" crossing of Beaver creek by International Boundary, to Pan creek, by Yukon Government pack trail................................	6
" crossing of Beaver creek by International Boundary to Canyon City, by Yukon Government pack trail...........................	15
" crossing of Beaver creek by International Boundary to Chisana City by trail...	40

Tanana River route	Miles
From Fairbanks to Chisana City by river..........................	350
" Chisana City to International Boundary line (western boundary of Upper White River district, Yukon, where it crosses Beaver creek, by trail...	40

Russell Glacier (Skolai Pass) route	Miles
From Cordova to McCarty, by C.R. and N. Ry....................	191
" McCarty to Russell glacier, by trail.........................	35 to 40
Across Russell glacier to head of White river.....................	12 to 14
From the head of White river to Canyon City, by trail down White river	45 to 50
From the head of White river to Chisana City by trail, via Solo creek	40
" Chisana City to International Boundary (western edge of Upper White River district, Yukon) where it crosses Beaver creek, by trail...	40

Nizina-Chisana glaciers route	Miles
From Cordova to McCarty by C. R. and N. Ry....................	191
" McCarty to head of Nizina river, at edge Nizina glacier, by trail...	29
Across Nizina and Chisana glaciers to head of Chisana river...........	40
From head of Chisana river to Chisana City.........................	7
From Chisana City to International Boundary (western edge of Upper White River district, Yukon) at point where it crosses Beaver creek, by trail...	40

Chitina-Copper River route	Miles
From Cordova to Chitina by C. R. and N. Ry.	131
" Chitina to Copper Center, by U. S. Government wagon road	50
" Copper Center to Gulkana " " " " " "	26
" Gulkana to Chistochina by trail	42
" Chistochina to Batzulnetas by trail	43
" Batzulnetas to Sargents' Camp on Nabesna river, by trail	40
" Sargent's Camp to Chisana City by trail	35
" Chisana City to International Boundary (western boundary of Upper White River district, Yukon) at point where it crosses Beaver creek, by trail	40

Valdez-Copper River route	Miles
From Valdez to Copper Center by U. S. Government wagon road	102
" Copper Center to Gulkana " " " " " "	26
" Gulkana to Chistochina by trail	42
" Chistochina to Batzulnetas by trail	43
" Batzulnetas to Sargent's Camp on Nabesna river	40
" Nabesna river to Chisana City	35
" Chisana City to International Boundary (western boundary of Upper White River district, Yukon) at crossing of Beaver creek, by trail	40

Expenses, Accommodation, and Development along Routes.

The following are some of the regular railway and steamboat fares which have been charged by the transportation companies operating along these routes. These rates are, of course, subject to change at any time.

From Vancouver or Seattle to Skagway, first class, including meals and berth	$30
From Vancouver or Seattle to Skagway, steerage, including meals and berth	20
From Seattle to Cordova or Valdez, first class, including meals and berth	45
From Seattle to Cordova or Valdez, steerage, including meals and berth	25
From Seattle to St. Michael or Nome, first class, including meals and berth	$70 to 100

From Seattle to St. Michael or Nome, steerage, including meals and berth	$35
From Skagway to Whitehorse, W. P. and Y. Ry.	20
From Whitehorse to Dawson (downstream), steamer, regular fare, including meals and berth	30
From Dawson to Whitehorse (upstream), steamer, regular fare, including meals and berth	50

Along the Whitehorse-Dawson wagon road, there are roadhouses at regular intervals of about 20 miles, and in places half-way houses occur, all of which keep open during the winter months (See Route Map in back of this memoir). Also, along the road from Whitehorse to Lake Kluane, roadhouses occur about every 20 or 25 miles. From Lake Kluane to Beaver creek, no regular roadhouses have been built, but freighters' winter camps have been in operation at different points. Also, cabins built some years ago, which are used by travellers, occur at different points along Burwash creek, at the mouth of Wade creek, and elsewhere. Roadhouses, in addition, occur along Yukon river between Dawson and White river, and have also been built at intervals of about 20 miles, up White river to Beaver creek and thence along the trail which strikes southwestward across Upper White River district. At least three good roadhouses have also been established between the Boundary line and Chisana City. As practically all of these roadhouses provide good and ample accommodation, travelling to Upper White River district and even to Chisana, along the main Canadian routes, is now attended with practically no danger, with little hardship, and with few privations.

Accommodations have also been provided along the Alaskan routes. Between McCarty and Chisana City, over the Nizina and Chisana glaciers, a distance of about 75 miles, 10 roadhouses and 2 relief stations are reported to have been established this winter (1913-14). This is, however, believed to be a very dangerous route at all times, and should never be attempted except under favourable stages of the glaciers. Also along the wagon road up Copper river, between Chitina and Gulkana, thence along the trail up this stream to Batzulnetas at the mouth of Tanada creek and thence southeasterly across Nabesna river to Chisana City, a distance from Chitina of about 235 miles, roadhouse or hotel accommodation is available at some 15 different points. These points are, however, not at all equally distributed, being in some places along the wagon road to Gulkana not more than 6 miles apart, and thence along the more difficult and uncertain trail being distant as much as 40 miles from one another. Between Chisana City and the western boundary of Upper White River district, a distance of 40 miles, three or four roadhouses have been built. There is no travel over the Russell Glacier (Skolai Pass) route during the winter months. There is, however, considerable activity along the Tanana River route between Fairbanks and Chisana City.

The price of meals at the greater number of roadhouses in Yukon is $1.50, but after the mouth of Beaver creek is passed, most places charge $2. The usual charge for sleeping accommodation is $1 to persons supplying their own blankets, as is customary, and $2 where bedding is furnished by the house. Along the Alaskan routes the price of meals in most places is from $1.50 to $2.50.

The White Pass and Yukon Route Company are taking freight this winter (1913-14) from Whitehorse to Chisana via Lake Kluane, in half ton lots at 30 cents, and over half ton lots at the rate of 25 cents per pound. The usual price for sledding freight up White river to Beaver creek is about 30 cents per pound. It is further expected that power boats will take freight up White river next season, to Beaver creek, for 10 cents or less per pound. These boats will also take passengers from Dawson up White river.

Previous to October 1, 1913, there were not a dozen men in Upper White River district and very few along the White River or Kluane routes; and the only buildings in Upper White River district were some half dozen cabins in Canyon City (Plate XVII) and two very small cabins on Beaver creek. Since then the numerous roadhouses just mentioned have been put in operation, and at several points small towns have sprung into existence. On December 1, 1913, there were about 50 cabins at the mouth of the Donjek, 250 at the mouth of Beaver creek, and a number of cabins have also been built on Pan creek, and elsewhere along the trails throughout the district. In Chisana district some 40 miles to the west several hundred buildings have been constructed since October 1, 1913.

An official wire from Mr. George Black, Commissioner of Yukon Territory, to Dr. Alfred Thompson, M.P., during the latter part of January, 1914, stated that 1,200 men were at that time distributed along the White River route between the mouth of White river and the Boundary line.

Three detachments of Royal Northwest Mounted Police have been established, respectively, near the mouth of Donjek river, at the mouth of Beaver creek, and on Beaver creek near the International Boundary, who will patrol the trails and routes and afford police protection to all persons within the district.

A mail service is in operation to Upper White River district, and the Yukon government is making application to have three post-offices established respectively at the mouths of White river, Donjek river, and Beaver creek.

CLIMATE.

The climate of Upper White River district is that of southern Yukon, as modified by the altitude and mountainous nature of the area. Being situated north of the 61st parallel of latitude, the district, as is to be expected, is during the winter months subjected to somewhat low temperatures; and separated as it is from the Pacific by a broad belt of mountains, the region does not come within the immediate influence of the ocean with the tendency to increase precipitation and minimize the variations in temperature. Nevertheless, the climate of southern Yukon in general has been, and by many still is thought to be much more severe than it really is. It is true that from 1895 to 1899 when the influx to the Klondike was at its height, great hardships were endured and many lives were lost, partly due to the somewhat severe climatic conditions prevailing in Yukon during the winter months. When, however, it is remembered that the majority of those rushing into this region were not accustomed to even the ordinary difficulties of travel in northern latitudes or in many cases, in any mountainous region; that many of the gold-seekers set out on their quest with only the vaguest notion as to the route to be traversed; that the route chosen, owing to lack of available information, was often one of the worst possible under the circumstances; and that a large proportion of the travellers made the trip during unfavourable seasons; it is perhaps surprising that so relatively few casualties occurred, rather than so many.

Since the White Pass and Yukon railway was constructed over White Pass summit, and steamers were placed on the navigable waters, erroneous impressions of the climate of southern Yukon have been largely corrected, and the district is becoming better known. Nevertheless, during a stampede such as occurred recently, when the news of the gold discovery at Chisana become known, many persons start for such a locality with insufficient outfits, with unsuitable clothing, and without having obtained any definite information as to their destination and the routes thereto. In such cases, unless the season happens to be very favourable, and game proves to be plentiful, great suffering results. However, of the hundreds who stampeded to or through Upper White River district before the freeze-up last autumn, relatively little suffering was endured, and probably not more than four or five lives were lost,[1] in spite of the fact that the majority of the stampeders were very poorly clothed, had in most cases no tents, little if any bedding, and insufficient provisions, and possessed very imperfect notions as to the whereabouts of their proposed destination, or the conditions of travel thereto. These men lived, ate, and slept in the open, and many subsisted for days or even weeks at a time mainly on ptarmigan and other game which was easily obtainable. Had the climate resembled, even to a remote degree, what it is sometimes depicted to be, the majority of these men must have perished.

The summer months in most parts of southern Yukon are particularly delightful, as on account of the somewhat northern latitude, there is almost continuous daylight during June and July, and for four months, typical, warm, summer weather is generally experienced. The winters, although cold, are not so

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[1] Quite a number of men are reported to have lost their lives, however, in attempting to cross the Alaskan glacier routes.

extreme as might be supposed. For instance, horses winter out safely, in Upper White River district, without artificial shelter and without being fed, provided they are in fairly good condition when turned out in the autumn, and provided also that they are placed on bars along White river, or elsewhere where feed is plentiful. For several years past, numbers of horses have so wintered in different parts of the district, and in most cases have been found in good condition in the spring.

The amount of precipitation in southern Yukon, varies considerably with the altitude and proximity to mountain ranges or groups. In Upper White River district, during most years, the amount of rain is moderate, and the snowfall is very light, snow rarely accumulating to a thickness of more than 12 inches on the level along the river flats or in other lower portions of the district. Good sledding also rarely commences, except on the river or lake ice, before December 1.

Ice commences to run thickly on the White about September 30, and the river freezes over, during most years, between November 10 and 15. The White generally opens in the spring, below Beaver creek, between May 25 and June 5, and above Beaver creek to Canyon City, it opens about June 12.

As concerns mining operations, due to the almost continuous daylight during part of the summer, work can be conducted by night almost as well as by day, without the aid of artificial light. Also, at least five months in each year are suitable for surface working and for the necessary outside operations contingent upon mining and similar industries. The ground is perpetually frozen to varying depths, but this does not interfere with mining operations, except while being conducted at or near the surface, and is of great value and assistance in placer mining in places, as, on account of their firm, frozen condition, the gravels where deep, can be worked by drifting without being timbered. Hydraulicing, sluicing, and all washing operations connected with placer mining can be commenced some time in May and conducted until well on in September.

VEGETATION.

Upper White River district, as a whole, is only sparsely forested, and nowhere do the dense growths of timber occur such as characterize portions of British Columbia and other localities to the south and southeast. Trees, nevertheless, grow on mostly all the valley floors up to an elevation ranging from 3500 to 4000 feet above sea-level, and on the mountain sides to practically the same height (Plate VII). Timber line is, however, characteristically lower at the lower ends of the valleys than at the upper ends, and in places does not reach above 3,000 feet (Plate VIII).

Four principal forest members occur that attain the dimensions of trees, and a number of varieties of shrubs were noted. The four main varieties of trees are white spruce (*Picea alba*), aspen poplar (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), and northern canoe birch (*Betula resinifera or B. alaskana*); and the more important shrubs include juniper, several species of willow (*Salix*), alder, dwarf birch (*Betula glandulosa*), wild rose (*Rosa acicularis* Lindl.), and "Soapollali" (*Shepherdia canadensis* Nutt).

Of these forest members, the spruce is the most useful tree, and is possibly the most widely distributed, growing at all elevations up to timber line. The best groves are generally found on the river flats and in depressions along the lower slopes of the ridges, where the trees occur straight and well grown. Individuals are not generally larger than 12 inches in diameter, 3 feet from the ground, but specimens with 24 inch stumps were noted. This tree furnishes a strong, easily worked timber, and is well suited to the usual needs of the miner, and to purposes of construction generally.

The birch occurs only rarely and is never of large size. The two varieties of poplar are very plentiful both on the valley floors and on the hillsides, but grow best along the alluvial flats of the main valleys. These are seen in all stages of growth from small shrubs to considerable forest trees 8 to 10 inches in diameter. Both varieties make good fuel, but are too soft and irregular in form to be of use for constructional purposes.

Willows and dwarf birch constitute the greater part of the shrub growth of the district. The willows are quite plentiful in the valleys, but do not extend far above the level of the larger streams. The dwarf birch occurs chiefly in the higher valleys and along the upper slopes above timber line. This shrub forms an undergrowth 2 to 4 feet high in many localities, so dense that to walk through it becomes extremely tiresome.

Several varieties of wild fruit were also noted in this district. Of these crow or heather berries (*Empetrum nigrum*), blueberries (bog bilberry, *Vaccinium uliginosum* L.), high-bush cranberries (*Viburnum pauciflorum* Pylaie), and northern cranberry or foxberry (*Vaccinium Vitis-Idaea* L.), were quite plentiful; and black currants (*Ribes Hudsonianum* Rich.), red currants (*Ribes rubrum* L.), gooseberries, strawberries, and raspberries occur in places.

Grass for horses is available in favourable localities throughout the entire year, and commencing in the latter part of May or early in June, becomes quite plentiful. From June until October, pack-horses, if well cared for and not worked too hard, will in most parts of the area, subsist on what natural fodder is available. As mentioned previously, also, in describing the climate of this area, horses will winter out safely in Upper White River district, if they are strong and in good condition when winter sets in, and if they are left in suitable localities.

All the botanical specimens which were collected have been examined by Mr. J. M. Macoun of this department, who reports as follows on certain specimens obtained:—

"The collection of plants made by Dr. D. D. Cairnes on or near the White river included several species not collected by him in previous years. Among these are three species that appear to be undescribed, and one other that is an addition to the Canadian flora. The following is a list of the species not collected in 1911-1912.[1]

[1] In 1911, Dr. Cairnes collected 110 species of flowering plants, and in 1912, obtained 20 species that were not found by him the previous season. See—

Cairnes, D. D., "Geology of a portion of the Yukon-Alaska Boundary between Porcupine and Yukon rivers": Geol. Surv., Can., Sum. Rept. for 1911, pp. 21-16.

Stellaria longipes Goldie, var. *Edwardsii* Wats.
Claytonia N. sp. A beautiful little plant apparently unrelated to any known species.
Saxifraga flagellaris Willd.
Potentilla biflora Lehm. New to Canada.
Oxytropis campestris DC., var. *melanocephala* Hook.
Polemonium humile Willd.
Eritrichium related to *E. Howardii* and the Siberian *E. rupestre*, but neither species. Apparently undescribed.
Pyrola. A species collected before in Yukon but as yet undescribed.

A small collection of mosses and lichens made near Canyon City included the following species:—

Musci.

Rhytidium rugosum (Ehrh.) Kindb.
Dicranum lævidens R. and W.
Thuidium abietinum (L.) Bry. Eur.
Polytrichum juniperinum Willd.

Lichens.

Cetraria nivalis Ach.
" *juniperina* (Linn.), var *terrestris* Schær.
" *furcata* (Huds.) Schrad.
" *sylvatica*, var. *sylvestris* Ord.
Thamnolia vermicularis (Sw.) Schær.
Stereocaulon tomentosum (Fr.) Th. Fr."

GAME.

Game is plentiful throughout most parts of Upper White River district, sheep, moose, and caribou being particularly numerous. In fact, were this locality only slightly more accessible and somewhat better known, few places on the continent would be more attractive to the sport-loving hunter.

The sheep are the white Alaskan variety (*Ovis Dalli*); these feed during the winter months in the main valleys, but with the approach of summer, they work farther and farther back into the higher mountains, and choose especially the lofty, rugged, craggy summits, and are frequently found in the vicinity of glaciers. They rarely return to the valleys during the summer except in crossing from one mountain to another. The writer one day in July of last season, counted over 400 sheep, all of which were plainly in sight at one time, on the hills to the south-west of Rabbit mountain (Plate XIII).

The moose are the large giant moose (*Alces gigas*); these magnificent animals range the lowlands in considerable numbers and are particularly plentiful in the flats bordering White river. Caribou are also somewhat numerous, and are frequently seen on the low open hills in different parts of the district. They are, when seen, the least difficult of any game to procure, as their curiosity is greater than their fear, and they will follow a horse or watch a man until scent gives them warning. Black and grizzly bear are sufficiently numerous to make it unsafe to leave a cache unprotected for more than a day or two, and they have been known to disturb provisions in the presence of the owner. Rabbits also abound throughout the district. Lynx, mink, martin, wolverine, and red fox are fairly numerous and cross, silver, and black foxes are occasionally found.

The chief game birds noted are rock ptarmigan (*Lagopus rupestris rupestris* Gmelin), willow ptarmigan (*Lagopus lagopus*), Alaska spruce partridge (*Canachites canadensis osgoodi* Bishop), fool hens or Franklin grouse (*Canachites franklinii*), willow grouse or Oregon ruffed grouse (*Bonasa umbellus sabini*), and several varieties of ducks and geese. The rock ptarmigan are found above timber line, and during the summer months live mainly on the highest, often snow-capped summits: the willow ptarmigan live during the summer season at above timber line. Both varieties are very plentiful in Upper White River district as well as in adjoining portions of Yukon and Alaska. These birds are very easily obtained and can often be secured with sticks or stones. Consequently many a stampeder to Chisana last autumn, depended on them partly or entirely for subsistence, and in some cases lived entirely on ptarmigan for days or even weeks at a time, after his other provisions became exhausted. The spruce partridge, fool hens, and ruffed grouse are much less plentiful than the ptarmigan, but still are quite frequently seen.

The streams and small lakes are generally well supplied with fish, chiefly greyling (*Thymallus signifer*).

CHAPTER II

TOPOGRAPHY.

REGIONAL.

GENERAL FEATURES.

The greater part of Yukon territory may be broadly divided into three main physiographic provinces which persist to the southeast through British Columbia, and to the westward through Alaska. Named in order from southwest to northeast, these provinces are: the Coastal system, the Interior system, and the Rocky Mountain system. These terranes constitute the Cordillera of northwestern North America, and follow in a general way the peculiar concave contour of the Pacific coast line. They thus all trend northwesterly through British Columbia, strike in a westerly to southwesterly direction through Alaska, and through Yukon, in between, they follow an intermediate, generally northwesterly, course. To the north, northeast, and east of the Rocky Mountain system, there occur a succession of plains, or lowland tracts—the Arctic Slope region, the Mackenzie Lowlands, and the Great Plains (Figure 2).

Upper White River district, Yukon, lies partly within the landward or northern side of the Coastal system and extends northward to include a portion of the southern edge of the Interior system.

ROCKY MOUNTAIN SYSTEM.

The Rocky Mountain system stretches northward from the western United States through Canada to near the Arctic, and south of Mackenzie bay, turns almost at right angles, crosses the International Boundary and continues in a direction slightly south of west, across Alaska to the ocean. South of Yukon, this system is notably complex and includes several high ranges whose axes are in general parallel. The Rocky Mountain system of Yukon has not been extensively explored and concerning it relatively little is known. This terrane, however, constitutes a mountainous belt which stretches northward toward the Arctic, and forms in general the watershed between Yukon river on the west and the Mackenzie on the east. After

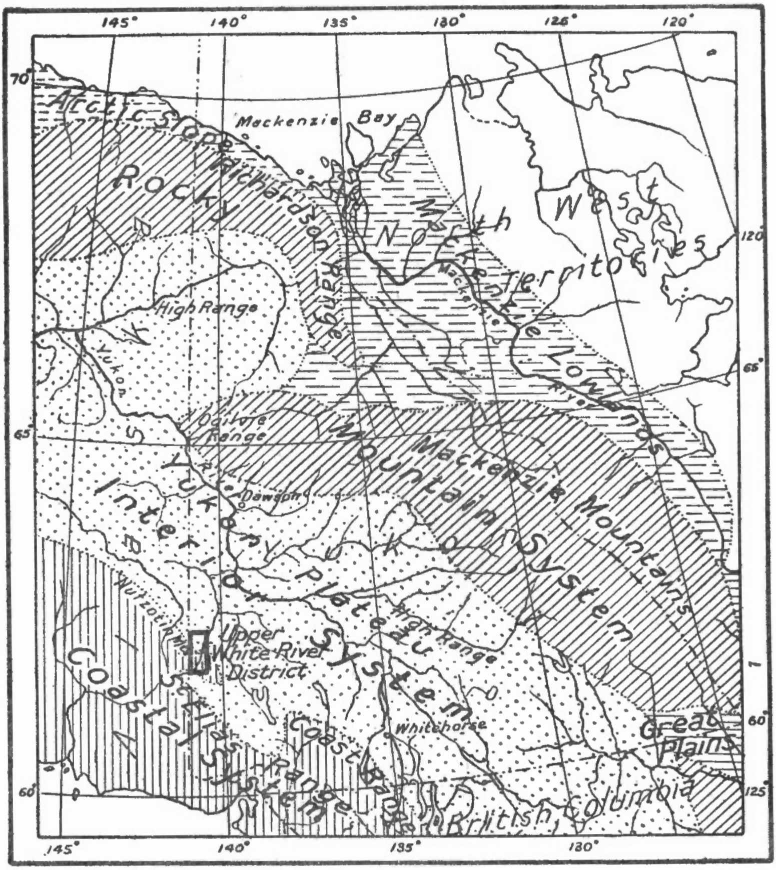

Figure 2. The physiographic provinces of Yukon.

bending to the southwest and entering Alaska this system is known to be a complex mass and is continued southwestward as a great trans-Alaskan chain to which the name Endicott mountains has been applied.[1]

[1] Brooks, A. H., "The geography and geology of Alaska": U.S. Geol. Surv., Prof. Paper, No. 45, 1906, pp. 42-46.

The limits of the Rocky Mountain system in Yukon, as elsewhere, are fairly sharply drawn, this terrane being bordered on the one side by the Yukon plateau, and on the other by various lowland tracts (Figure 2). Throughout Yukon the axes of the ranges comprising this mountain system, are en échelon, in character, the different ranges not persisting any great distance, but instead giving place in either direction to other parallel ranges. The Mackenzie mountains, which include the greater part of the Rocky Mountain system in Yukon, are described by Keele[1] as a complex of irregular mountain masses which are the result of deformation and uplift, include summits rising to heights of 7,000 to 8,000 feet above sea-level, and have a maximum width of about 300 miles.

INTERIOR SYSTEM.

The Interior system in Yukon and Alaska is comprised entirely of the most northerly of its larger divisions, the Yukon plateau.[2] This physiographic province extends from about latitude 58° in northern British Columbia, through Yukon and Alaska to Bering sea, and has a width of from 200 to 400 miles, stretching from the ranges of the Rocky Mountain system to the inner members of the Coastal system which fringes the Pacific ocean.

Into the upland surface of this plateau province in Yukon Territory, the main drainage courses have incised channels varying from 3,000 to 4,000 feet in depth, thus producing a very irregular topography. The summits of the unreduced hills and ridges, lying between the waterways, constitute remnants of what was once, apparently, a gently rolling plain sloping toward the northwest. The plateau seen from a summit having

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[1] Keele, Joseph, "A reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon and North West Territories": Geol. Surv., Can., 1910, pp. 16-18.

[2] Brooks, A. H., Op. cit., pp. 36-42.

Cairnes, D. D., "Wheaton district, Yukon Territory": Geol. Surv., Can., Memoir No. 31, 1912, pp. 9-25. " Portions of Atlin district, British Columbia, with special reference to lode mining": Geol. Surv., Can., Memoir No. 37, 1913, pp. 13-33.

an elevation corresponding to that of its surface, will impress the observer with its even sky line sweeping off to the horizon, and broken only here and there by isolated, residuary masses rising above the general level. This upland, however, bears no relation to rock structure, erosion having bevelled the upturned edges of the hard as well as the soft strata, with the result that its surface is entirely discordant to the structure of the highly contorted, metamorphic rocks that outcrop over it so extensively.

The Yukon plateau province has been studied by a number of geological observers, among whom there is a consensus of opinion that it represents a region which during a long period of crustal stability became almost completely base-levelled and was reduced to a state of old age. Accordingly this region must at one time have formed a portion of a plain, the edge of which was at or nearly at sea-level. This base-levelling process was followed by a widespread uplift and the nearly flat or gently undulating lowland became an upland tract. This uplift rejuvenated the streams which immediately commenced trenching their valleys in the upland surface and a new physiographic cycle was inaugurated. There is some difference of opinion as to the exact date of this planation and subsequent uplift, but the bulk of the evidence goes to show that this region was planated during either the Eocene or pre-Pliocene post-Eocene time, and that the planated tract was uplifted to nearly its present position during late Miocene, Pliocene, or nearly Pleistocene time.[1]

COASTAL SYSTEM.

The Coastal system from about the 50th to near the 60th parallel, embraces only the Coast range, unless the islands to the west be considered to form part of a separate range,[2] but

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[1] Cairnes, D. D., "Wheaton district, Yukon Territory": Geol. Surv., Can., Memoir No. 31; 1912, pp. 83-84.

[2] Dawson has separated the Vancouver range from the Coast range. See—

Dawson, G. M., "On the later physiographical geology of the Rocky Mountain region in Canada, with special reference to changes in elevation and the history of the glacial period": Trans. Royal Soc. of Can., Vol. VIII, Sec. IV, 1890, p. 4.

the simplicity of this province is interrupted near the head of Lynn canal, whence northward and northwestward the Coastal system embraces a number of ranges or mountain groups including the Coast, St. Elias, Aleutian, and Alaska ranges, which are in places separated by wide valleys.

The Coast range after following the coast line from southern British Columbia to near the head of Lynn canal, passes behind the St. Elias range, and thence northward, as far as it extends in this direction, constitutes the most easterly division of the Coastal system. North of Lynn canal, the Coast range, however, becomes gradually less prominent, until it merges into the Yukon plateau near Lake Kluane at latitude 61° and longitude 138° 35′, about 90 miles to the southeast of the southern end of Upper White River district.

The St. Elias range as the name is applied by Brooks,[1] with its broader significance, includes the Chugach, Kenai, and Skolai mountains which are orographically a western extension of the St. Elias range as this term is usually intended. "Thus defined, the St. Elias range extends northwesterly from Cross sound, bends westerly near the mouth of the Copper river, and near the head of Prince William sound, in longitude 147°, turns sharply southwest and merges into the highlands of Kenai peninsula."[2] The St. Elias range varies in width from 50 miles near Cross sound, to nearly 100 miles at Mount St. Elias, and then narrows down to less than 20 miles to the southwest in the Kenai peninsula. This "range is a rugged mountain mass parallel with and close to the Pacific coast from Cross sound as far as the entrance to Cook inlet, with one spur, the Skolai mountains, stretching to the southwest. On the seaward side, the range presents an abrupt escarpment, often rising directly from the water, while its northern slopes almost everywhere, fall off abruptly to the Central Plateau"[3] (Yukon plateau). The culminating points of St. Elias range are Mt. St. Elias and Mt. Logan which are situated due south of Upper White

[1] Brooks, A. H., "The geography and geology of Alaska": U.S Geol. Surv., Prof. paper, No. 45, 1906, pp. 29-32.

[2] Brooks, A. H., Op. cit., p. 29.

[3] Idem, p. 32.

River district, and rise to elevations above the sea of 18,024 and 19,500 feet respectively.

Skolai mountains, or more particularly the Skolai-Natazhat Mountain group, which are limited to the north for a distance of approximately 40 miles by White River valley, are rugged in character, with altitudes of 7,000 to 10,000 feet, and merge to the north or northwest with the Wrangell mountains. The most prominent break through the mountain barrier or watershed comprised of Wrangell and Skolai mountains, is known as Skolai pass, which lies between the heads of Nizina and White rivers.

Wrangell mountains owe their origin to the accumulation of volcanic material in times so recent that the forces of erosion have not yet removed it; and they thus differ from the other ranges of the Coastal system, which belong to that class of the earth's features that are the result of differential erosion in regions of deformation and uplift. The highlands of Wrangell mountains possess the irregular forms typical of volcanic mountains which are built up dominantly of lavas rather than ash deposits.

These mountains are, also, exceedingly rugged and occupy an intermediate position between Skolai and Chugach mountains in the south and east, and Nutzotin mountains on the northeast. Mount Wrangell, having an elevation of 14,005 feet, holds a central place in the group of mountains to which it gives its name, yet, though possibly the most imposing among them, it is not the highest. These mountains reach their culminating point in Mount Sanford which is 16,200 feet above the sea or 14,000 feet above Copper river; and at least five other peaks rise to elevations exceeding 12,000 feet. The higher portions of the Skolai-Wrangell ranges constitute a vast snow field from which scores of valley glaciers descend, and form the headwater sources of practically all the more important streams of the region, Russell glacier,[1] which occupies Skolai pass, being the starting point or head of White river.

Nutzotin mountains to the north, which are really an eastern

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[1] Named after I. C. Russell.

division of the Alaska range, are lower, but on the whole do not appear to be less rugged than the Wrangell-Skolai mountains. The greater number of the highest of the Nutzotin summits rise to elevations of from 6,000 to 9,000 feet, but this range reaches its loftiest point in Mt. Allen, which has an elevation of 10,420 feet. Nutzotin mountains, however, include no extensive snow fields and their few glaciers are small and unimportant.

PHYSIOGRAPHIC POSITION OF UPPER WHITE RIVER DISTRICT.

Upper White River district lies completely to the north of the Coast range, and includes a north-south section across the eastern or southeastern end of Nutzotin mountains. To the south, the district reaches part way across the broad valley separating the Nutzotin and Skolai-Natazhat mountains, and to the north extends slightly into the Yukon plateau region, but does not continue sufficiently far to embrace any of the typical plateau remnants which characterize this physiographic province.

Upper White River district is thus comprised for the greater part of an eastern portion of Nutzotin mountains, whose higher summits within the district rise to elevations of from 6,500 to 7,200 feet above sea-level. This mountain belt is bounded on the north by a broad, easterly trending flat some 30 miles or more in width, throughout which occasional knobs, hills, and mountainous masses rise rather abruptly. To the south of Nutzotin mountains, and separated from them by White River valley, the snow-capped mountains of the Skolai-Natazhat group rear their lofty summits skyward, and present an apparently impassable Alpine barrier.

LOCAL.

GENERAL FEATURES.

That portion of Yukon which is designated in this memoir, the Upper White River district, is drained entirely by the uppermost 60 miles of White river included in Yukon Territory, or that section of this river which extends from the mouth of Beaver creek, upstream to the International Boundary. This district is divisible into a northern and a southern portion, which are approximately equal in extent, but which possess very different and distinct topographic characteristics.

The southern division includes a north-south section across the eastern or southeastern end of Nutzotin mountains, and is consequently dominantly mountainous, being in places even decidedly rugged in character. The higher summits rise to elevations of from 6,500 to 7,200 feet above the sea, White river in the vicinity being about 2,500 feet above sea-level. The northern part of Upper White River district on the other hand, is dominantly a valley tract, which is interrupted occasionally, however, by knobs, hills, or small mountain masses that rise in places rather abruptly from the surrounding lowland. Between this low lying area and the mountain belt there is a rather well-defined topographic boundary, the northern slopes of Nutzotin mountains constituting a fairly regular wall extending along the southern edge of this depression to the north (Plate VII).

Nutzotin mountains constitute the innermost member of the Coastal system in the vicinity of the 141st meridian, and consequently adjoin the Yukon plateau along their landward edge. Thus in Upper White River district this dividing line between the northern and southern portions of this area, really marks the landward edge of the Coastal system as represented by its innermost member, the Nutzotin mountains.

CONTACT BETWEEN THE YUKON PLATEAU AND NUTZOTIN MOUNTAINS.

The line between the Yukon plateau and the Coastal system in northern British Columbia and southern Yukon, northward to the northern end of the Coast range, is in most places rather indefinitely marked. To the north of Lake Kluane through Yukon and in Alaska, however, the change from plateau to mountain province is in places quite sharply drawn. This feature is especially striking along the northern front of St. Elias range where, according to Brooks,[1] the smooth, grassy, flat-topped remnants of the plateau end abruptly against the steep slopes of the rugged snow-clad mountains. Similar relations have also been observed to prevail along the front of the Alaska range which in places drops off suddenly to the plateau on the north. So abrupt and persistent is this change from the smooth flat summits of the plateau upland to the rugged Coastal mountains, that it is suggestive at least of fault scarps. This sharp contact line has been noted by a number of geological workers in Yukon and Alaska, including McConnell,[2] Brooks,[3] Schrader[4], and Hayes.[5]

The northern portion of Nutzotin mountains, however, has not yet been at all closely studied, but from the information available it would appear that instead of a sharply drawn line between mountain and plateau province, there is in places a gradual transition from one of these terranes to the other. Brooks states, "A study of the topographic reconnaissance maps makes it appear at least, that here, as along the inland slope of the Coast range, there is a transition between the summit level of the Nutzotin mountains and that of the Yukon plateau."[6]

In Upper White River district, no satisfactory evidence could be obtained concerning the original or major cause for the somewhat abrupt approach to Nutzotin mountains, as the original surface of the Yukon plateau in that vicinity has been entirely destroyed. In fact the lowland tract here constituting the edge of the plateau province, is really a broad southeasterly trending erosion valley or trough extending from Tanana river to the White, and consequently whatever may have been

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[1] Brooks, A. H., Op. cit., p. 38.

[2] McConnell, R. G., "Headwaters of White River": Geol. Surv., Can., Summ. Rep. for 1906, p. 20.

[3] Brooks, A. H., Op. cit., pp. 38, 278.

[4] Schrader, F. C., "Reconnaissance along the Chandlar and Koyukuk rivers, Alaska": U.S Geol. Surv., 21st. Ann. Rep., Pt. 2, 1900, p. 463.

[5] Hayes, C. W., "An expedition through the Yukon district": Nat. Geog. Mag., Vol. 4, 1892, pp. 130, 131.

[6] Brooks, A. H., Op. cit., p. 287.

the original relation of the plateau upland to that of the mountains, this has now become entirely obliterated and all that remains to be observed is a broad erosion valley skirting the mountain range.

The contact between these two terranes may thus have originally been abrupt and have resembled that along the front of St. Elias range; or there may have existed a transition between these two physiographic terranes such as occurs between the Yukon plateau and the northern portion of the Coast range. The northern edge of Nutzotin mountains, however, although fairly well defined, does not present that regular, sharply drawn and persistent aspect such as would appear in the case of fault scarps and such as occurs along the eastern front of the Rockies in Alberta, and elsewhere along the faces of mountain ranges having this origin. Instead, however, the front of Nutzotin mountains in Upper White River district has much more the appearance of a somewhat irregular valley wall produced by long continued erosion, and accentuated by glacial action. Furthermore, if the boundary between Nutzotin mountains and the plateau province to the north was originally abrupt and due to fault scarps, and the mountains thus owed their relatively elevated position to being faulted above the adjoining portions of the Yukon plateau, it might be expected that older rocks in the mountains would have been brought up into contact with more recent geological formations in the plateau province. Instead, however, the oldest rocks known to occur in Nutzotin mountains are of Carboniferous age, and the formations outcropping on some of the hills or small mountain masses distributed throughout the valley depression immediately north of Nutzotin mountains in Upper White River district, are very much older and are thought to be of Pre-Cambrian age. Also the rocks exposed throughout the Yukon plateau province to the north of this depression, at least to near Yukon river, are dominantly of pre-Ordovician or Pre-Cambrian age. This geological relationship also appears to prevail for considerable distances both to the east and west of Upper

White River district,[1] along the edge of the Yukon plateau; which is quite contrary to what would naturally be expected to occur if the adjoining mountains to the south owed their higher elevation to faulting along the contact zone between these physiographic terranes.

Considering, therefore, the character of the northern front of the Nutzotin mountains in Upper White River district; the reported transition elsewhere between the uplands of the Nutzotin range and that of the Yukon plateau; the fact that within the plateau region to the north, hills occur comparable in height with the mountains of the Nutzotin ranges; and considering also the relative ages of the geological formations in these two terranes, it seems probable that at the beginning of the present topographic cycle, these two physiographic provinces merged one into the other, and that to valley erosion by streams and by ice is to be attributed the somewhat abrupt contact now in evidence.

RELIEF.

UPLANDS.

General Description.

All the more prominent uplands within Upper White River district constitute portions of Nutzotin mountains, although occasional smaller mountain masses are included in the wide depression to the north. Nutzotin mountains within the district are themselves divided by Lake Tchawsahmon valley into two groups or divisions, one lying to the northeast and the other to the southwest of this depression. The mountains of Upper White River district also embrace two geneti-

[1] Brooks, A. H., "A reconnaissance from Pyramid harbor to Eagle City, Alaska": U.S Geol. Surv., 21st. Ann. Rept., 1899-1900, Pt. II, See Plate XLVII.

Brooks, A. H., and Kindle, E. M., "Palæozoic and associated rocks of the Upper Yukon, Alaska": Bull. Geol. Soc. Amer., Vol. 19, 1908; See figure 2.

Prindle, L. M., "A geologic reconnaissance of the Circle quadrangle, Alaska": U. S. Geol. Surv., Bull. 538, 1913, see Plate II.

cally distinct types, those resulting from differential erosion, and those produced dominantly by accumulation; and it so happens that the genetic and topographic divisions correspond very closely, the mountains to the north and northeast of Lake Tchawsahmon valley being the result of differential erosion, while those to the south and southwest of this depression have been largely produced by accumulations of volcanic materials.

Mountains of Erosion.

The mountains of erosion embrace all the uplands to the north and northeast of Lake Tchawsahmon valley, and also include the eastern and northern portions of the group to the west and southwest of this depression. Farther west, however, the older rocks and former topography have become deeply buried under accumulations of lavas and accompanying fragmental rocks which now compose all the higher, more prominent portions of this mountain group to the west of Lake Tchawsahmon valley. Nutzotin mountains to the northeast of this valley are the direct extension of the main Nutzotin range to the northwest in Alaska, are of similar geological composition and structure, and have had with them a common origin. These are typical mountains of erosion and belong to that class of the earth's features which are the result of differential erosion in regions of deformation and uplift. These mountains have an average width of about 9 miles, and reach their culminating point in Mt. Taylor 7,203 feet above sea-level. They are also composed dominantly of a thick, rather uniform, much folded and contorted group of shales and related sediments which are much cut and invaded by basic intrusives. The intrusives being more resistant to erosive, destructive processes than the softer, less durable sediments, form in places the summits of certain of the peaks and ridges, but otherwise the geological formations have failed to give any marked or definite expression to the topographic features. Even these igneous members are very irregularly distributed and hence do not materially contribute to any persistent topographic type. Consequently, these mountains are notably irregular in form, being composed of geological formations which lack in most places any prominent recurring members, structures, or other features which might control and regulate the physiographic forms (Plates II, XI, XII).

The mountains to the west, across Lake Tchawsahmon valley, also, in places, closely resemble these typical Nutzotin mountains, and have had apparently a similar origin, but now all except their extreme eastern and southern edges have become deeply buried under accumulations of volcanic lavas and associated pyroclastic materials similar to those composing Wrangell mountains to the west and southwest.

To the north of Nutzotin mountains, occasional irregular knobs, hills, or small mountain masses are distributed throughout the lowland to the south of Snag creek and Beaver creek below their confluence. These hills or mountains range in elevation from 3,000 to over 5,000 feet, and are characteristically rounded and irregular in contour, due partly to glacial erosion, but more especially to the accumulation over them of heavy deposits of superficial and, dominantly, glacial deposits. These accumulations extend over the sides of these hills and mountain masses, and even reach well up to their summits, thus obscuring the bed-rock formation in most places.

Mountains of Accumulation.

The mountains to the southwest of Lake Tchawsahmon valley constitute a somewhat isolated group and owe their origin largely to the accumulation of volcanic lavas and pyroclastic materials in times so recent that the forces of erosion have not yet removed them. These mountains within Upper White River district have an average width of about 8 miles and reach their highest elevation in a rugged, lofty summit crossed by the International Boundary at a height above the sea of 6,774 feet. The volcanic rocks which mainly compose the mountain group, have been very slightly deformed, and particularly to the north and west, are still in practically the position in which they were originally deposited. The topography of the areas composed of these rocks is largely controlled by the attitude of the various lava flows and pyroclastic beds which there occur, and the mountains in these localities have, thus, not unusually a tabular appearance and mesa-like summits. The lavas and accompanying fragmental rocks have piled up as a series of superimposed sheets lying nearly horizontal in most places, the entire volcanic accumulation having the aspect of evenly stratified beds (Plate XIII). In these lava sheets columnar structure is common and a variety of colour is notable, the alternating grey, black, pink, and brick-red colours constituting a striking feature of the landscape.

The older rocks and former topography, which are obscured by these more recent volcanic accumulations, are exposed along the northern and eastern edges of this mountain group where, in places, the rocks consist largely of sediments and intruding volcanics similar to those composing the mountains to the north and northeast. This group of mountains to the west of Lake Tchawsahmon valley, thus constitutes a decided transition from the typical Nutzotin mountains of erosion, to the Wrangell mountains of accumulations to the west and southwest, and where according to Mendenhall,[1] floods of lava have obliterated an ancient topography whose relief in places exceeded 3,000 feet. Orographically, however, this group belongs to the Nutzotin mountains with which it merges and is thus considered as belonging to this terrane.

Origin of Nutzotin Mountains.

Different writers in describing the various members of the Coastal system of Yukon and Alaska, have made mention of the general uniformity of summit level observed in the Coast range, and the Chugach, Skolai, and even the Nutzotin mountains, and have considered this feature to indicate that these terranes are really dissected plateaus of the uplifted peneplain type. Brooks states, "The topographic surveys of recent date in the headwater region of the Copper

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[1] Mendenhall, Walter, C., "Geology of the Central Copper River region, Alaska": U.S. Geol. Surv., Prof. Paper, No. 41, 1905, p. 57.

and Tanana rivers, however, appear to indicate a transition between the Chugach-Nutzotin and the Yukon Plateau peneplains, and seem to lend support to Spencer's theory,[1] as do also the stratigraphic studies which point towards the conclusion of a synchronism of all the peneplains recognized in Alaska."[2]

In addition to this general accordance in the elevation of mountain summits, the evidence advanced to show that the Coastal system has been carved in whole or in part from an old planated and subsequently uplifted land surface, is found chiefly in the presence of antecedent streams flowing in constricted valleys through the mountain ranges, and also in the mergence in places of the upland of the landward members of the Coastal system with that of the Yukon plateau, for nowhere within the mountains themselves have any plateau remnants been discovered. That a number of antecedent streams do actually cross different members of the Coastal system is well known, and in the case of the Nutzotin mountains several streams including the Nabesna, Chisana, and White rivers entirely cross the range in narrow canyon-like valleys, showing that this mountain belt has been recently uplifted and that these streams have persisted in their courses during this upward movement of the land surface, the erosion in the bottoms of the stream channels keeping pace with the uplift.

In that portion, at least, of the Nutzotin mountains included within Upper White River district, no uniformity of summit level is apparent, and no evidence could be obtained indicating the former presence of a peneplanated surface. At a number of points, however, gently rolling stretches of upland occur, having elevations between 4,500 and 5,500 feet, but in each case these appear to be dominantly due to glacial action. The top of Tchawsahmon ridge is quite plain-like in contour and has an average elevation of between 4,500 and 4,900 feet. Also to the south of this ridge for a distance of 5 miles or more, small, nearly flat areas occur along the western

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[1] Spencer, Arthur, C., "Pacific Mountain system in British Columbia and Alaska": Bull. Geol. Soc. Amer, Vol. 14, 1903, pp. 121-125.

[2] Brooks, A. H., Op. cit., p. 288.

side of Tchawsahmon valley. These upland areas, however, are covered, in some places deeply, with waterworn gravels, and other detrital glaciofluvial materials, erratics as much as 12 feet in diameter being strewn over these surfaces up to an elevation of at least 5,300 feet. It is thus evident that vast bodies of ice at one time extended over these upland tracts, and not only reduced to a considerable extent all original inequalities of the surface but also resulted in the accumulation of morainal and other material in the existing depressions, giving to such stretches of upland, a decidedly plain-like appearance (Plates IX, XIV).

Therefore, although there seems to be no doubt as to the peneplanation and subsequent uplift of the Yukon plateau region, it appears somewhat improbable that the belt now occupied by Nutzotin mountains suffered at the same time like mature erosion.

The evidence contained in Upper White River district as to the exact date of the uplift of the Nutzotin mountains, is not very definite. However, certain loosely consolidated lignite-bearing sediments occur at different points throughout the district, that almost undoubtedly belong to the Kenai series which is considered to be dominantly at least of Eocene age.[1] These beds have been considerably deformed and eroded, and outcrop in places on the uplifted upland, showing that they were deposited and suffered erosion previous to the general upward movement of the region. The erosion and subsequent uplift of the mountain belt is thus later than the deposition of these sediments and earlier than the Pleistocene, as valleys eroded in the uplifted terrane contain Pleistocene deposits.

It would thus appear, that during the time the Yukon plateau region was being planated, which is thought to have

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[1] Collier, A. J., "The coal resources of the Yukon, Alaska": U. S. Geol. Surv., Bull. 218, 1903, pp. 17, 19.

Brooks, A. H., Op. cit., pp. 237-244.

Cairnes, D. D., "The Yukon Coal Fields": Trans. Can. Min. Inst., Vol. XV, 1912, pp. 365-366.

occurred in Eocene or post-Eocene pre-Pliocene times,[1] the adjoining Nutzotin Mountains belt to the south was also subjected to erosional processes, but that these did not succeed in reducing this mountain tract to the mature stage produced in the plateau province. Consequently, the Nutzotin mountains apparently remained as a region of considerable relief to the end of the cycle, and when the plateau province was uplifted in late Miocene, Pliocene, or early Pleistocene time,[2] this region was similarly affected. The vertical movement was also probably greater, however, along the margins of the upwarped tract than along its central axis as has been shown to occur elsewhere in this general region.[3] Accordingly, as the median line of the Yukon plateau province is marked approximately by the position of Yukon river from its headquarters to Bering sea, the belt now occupied by Nutzotin mountains occupies a marginal position in the upwarped tract and would have been uplifted higher than the adjoining portions of the Yukon plateau.

Thus at the beginning of the present erosion cycle, there was in all probability a decided difference in the general elevations as well as in the topographic characteristics of the Nutzotin mountains, and the adjoining portions of the Yukon plateau; and in Upper White River district, stream and glacial erosion have acted together to accentuate this distinction, and have impressed more and more deeply the line separating these two topographic terranes.

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[1] Cairnes, D. D., "Wheaton district, Yukon Territory": Geol. Surv., Can., Memoir No. 31, 1912, pp. 83-84.

"Portions of Atlin Mining district, British Columbia, with special reference to lode mining": Geol. Surv., Can., Memoir No. 37, 1913, pp. 45, 46.

[2] Cairnes, D. D., "Wheaton district, Yukon Territory": Geol. Surv., Can., Memoir No. 31, 1912, pp. 83, 84.

"Portions of Atlin Mining district, British Columbia, with special reference to lode mining": Geol. Surv., Can., Memoir No. 37, 1913, pp. 83, 89.

[3] Cairnes, D. D., "Wheaton district, Yukon Territory": Geol. Surv., Can., Memoir No. 31, 1912, p. 15.

Valleys.

General Description.

The proportion of valley to upland in Upper White River district is particularly great for a mountainous region, over one-half of the entire area being composed of lowland. In addition to the present valley of White river, other tributary master depressions occur in which at one time important rivers flowed, but in some of which, due to vast accumulations of glacial materials, the drainage is still very imperfectly integrated. These valleys are now occupied in most cases only by tributary creeks of lesser magnitude.

All the larger valleys have, typically, broad floors and somewhat steeply inclined walls, and in many places, pronounced topographic unconformities are in evidence at the contact of the walls with the upland surface. This phenomenon has been caused by the glacial erosion in the valleys having been relatively much more effective and conspicuous than on the adjoining uplands. All the pre-Glacial valleys have been both deepened and broadened, by the glacial ice by which they were formerly occupied, the widening being most pronounced near the valley floors. Thus, instead of the usual V-shaped, stream-cut valleys characteristic of rugged, youthful mountains, there occur everywhere in this district, valleys with broad, U-shaped cross sections. All the pre-Glacial depressions, in addition to having U-shaped cross sections, are also characterized in a general way by an absence of sharp angular surfaces or protrusions of bed-rock, these projections having been largely worn away on one or both sides of the valleys (Plate X).

The ice has also tended in each case to steepen the valley gradient toward the glacier head, and to reduce it toward the foot of the glacier, due to the excessive erosion in the vicinity of the ice, and to the deposition of the eroded material by the stream lower down in its course. Throughout the district both morainal and stream-laid deposits form important topographic features in the valleys, all of which are at present below the glaciers.

In a few places, however, and especially along some of the smaller tributary streams near their mouths, the present streams are flowing in post-Glacial channels which instead of being U-shaped are typical gorges (Plate XI). Even White river, itself, now flows for short distances through canyon-like incisions, 150 to 200 feet deep, in parts of its course in Upper White River district.

White River Valley.

The valley of White river has a total length of about 180 miles, from Russell glacier, the source of this stream, to its confluence with the Yukon. From the northern edge of Russell glacier, White River valley trends in a northeasterly direction for about 5 miles, thence it turns abruptly to the east, and for 30 miles or to about the head of the upper canyon in Upper White River district, extends along the northern edge of the Skolai-Natazhat mountains, in a direction almost due east. Thence the river valley follows a general northeasterly course to the Yukon.

In the upper part of its course, White river has a broad valley bottom from 2 to 5, or even in places nearer 10 miles in width, which is locally covered with timber, but for the greater part, consists of bare wastes of gravel. West of the International Boundary, remnants of terraces 30 to 50 feet or even higher extend in places along the northern side of the valley. These, where examined, consist of coarse, rudely-stratified gravels, glacial till, and related glaciofluvial accumulations. There may also be deposits of the same age on the opposite side of White river, but the present tributaries from the mountains to the south are so actively engaged in building alluvial fans that any remnants of higher terrace gravels that might have existed on that side of the valley, have probably been cut away or covered up by more recent deposits.

Commencing near the International Boundary, the valley gradually narrows, and about 3 miles below the Boundary line assumes a somewhat canyon-like form which continues down-stream for about 3½ miles; thence to Canyon City, a further distance of 3 to 4 miles, the stream flows through a gorge-like incision with abrupt walls rising almost vertically 150 to 200 feet on either side. This canyon is a recent, probably post-Glacial incision. The river, being forced from its former channel, on account of glacial damming by ice or morainal accumulations, became superimposed over its present position, and cut this gorge-like depression in obtaining grade.

Below Canyon City for 9 miles, White river has a flood-plain with an average width of about 1 mile, composed mainly of gravel, sand, and silt bars, over which the swift, detritus-laden stream continually shifts its course. On the north, this stretch of river is joined by Lake Tchawsahmon valley which has near the White a width of 7 to 9 miles. To the south, the broad valley of the Generc also joins that of the White. Thus, throughout this 9-mile stretch, White river really crosses a wide lowland depression, formed by the junction of these wide valleys.

Below this stretch again, for 8 miles, White river becomes confined to a single, narrow channel, and crosses through the main Nutzotin range, whose higher summits rise to elevations of between 4,000 and 5,000 feet above the stream. This portion, at least, of White River valley is apparently antecedent to the uplift of Nutzotin mountains, as it is evident that the stream must have persisted in its course through the mountains during the time of uplift, erosion by the river keeping pace with the upward movement of the land. This entire 8 miles of valley is sometimes spoken of as the Lower canyon, although, however, only the last mile of this stretch of valley is really a canyon, and the name should be restricted to this part, to which only it is appropriately applicable.

Below the Lower canyon, White river debouches on a broad valley lowland, which extends along the stream to some 10 miles below the mouth of Beaver creek or for a distance of about 45 miles, and throughout this distance the actual flood-plain of the river is in most places from 1 to 3 miles wide. This broad depression traversed by the White in this part of its course, embraces not only the actual valley of this river, but includes also the valleys of several of its tributaries including Koidern river and Beaver creek. This lowland extends to the west at least to the valley of the Tanana, and continues to the southeast to Donjek river.

About 10 miles below the mouth of Beaver creek, the flats end rather abruptly and the White again enters a narrower depression. In this part of its course the valley bottom is some 1,300 feet below the general level of the plateau surface. High gravel terraces occur on both sides of the river as far as the mouth of the Donjek, below which they are somewhat abruptly replaced by steep rock bluffs. The volume of the Donjek is approximately equal to that of the White above their confluence, and flows in a broad flat-bottomed valley. Between Donjek river and Katrina creek, the valley of the White is somewhat contracted and has abruptly rising walls. Below Katrina creek, however, it gradually widens out and so continues to the Yukon. Both Katrina and Ladue creeks are clear-water streams with broad, flat valleys. Everywhere below the mouth of Beaver creek, White river has a broad flood-plain from 1 to 5 miles in width, which consists mainly of broad bars of gravel and quicksand over and between which the river continually shifts its course, anastomosing streams being nearly everywhere in evidence. In fact, throughout this entire lower portion of its course, the river has the characteristic appearance of an overloaded stream. Great piles of driftwood, brought down in seasons of flood, are scattered plentifully over the valley floor, and constitute a characteristic feature of the landscape (Plate IV). In places, timber covers the broad river flats on either side of the flood-plain of the river as well as on certain of the bars within the actual flood zone itself, but in other places these areas are mere bare wastes of sand and gravel.

At the junction with White river, the Yukon makes a right-angled bend to the northeast, so that the axis of White River valley is extended by the Yukon below its mouth. On the Yukon opposite the mouth of the White, steep bluffs rise rather abruptly some 1,400 feet above the river.[1]

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[1] Brooks, A. H., "A reconnaissance from Pyramid harbor to Eagle City, Alaska": U.S. Geol. Surv., 21st. Ann. Rept., Pt. II, 1899-1900, p. 350.

Depression North of Nutzotin Mountains.

A broad depression having a general northwesterly trend, extends along the northern face of Nutzotin mountains, and persists to the northwest to the Tanana, and to the southeast to Donjek river. This depression is also possibly continued still farther in either direction by the valleys of these streams. In Upper White River district, as here considered, this lowland has a width of at least 30 miles, and thus extends to the north past the limits of this area (Plate VII).

This somewhat extensive lowland belt is traversed by a number of important streams which lie partly or wholly within its boundaries: these include, in addition to White river itself, Beaver creek, Snag creek, Dry creek, and Sanpete creek (Plate V). Occasional hills, or small mountain masses rise in places somewhat abruptly above the general level of the surrounding flat, but this depression is for the greater part, a typical lowland tract with an elevation ranging in most places between 1,900 and 2,500 feet above sea-level.

The surface of this lowland is minutely rough in most places, due to the widespread and irregular distribution of stream and glacial detritus. Kettle holes are of frequent occurrence, and these as well as other depressions between piles, heaps, mounds, or ridges of morainal materials contain lakes or ponds. These bodies of water exhibit a great variety of shape, size, and depth, corresponding to the erratic forms of the enclosing detrital accumulations. In fact, this broad lowland bears all the ear-marks of a typical glacial floor, and shows everywhere the effects of glacial deposition. The valley walls on the other hand are smoothed and steepened, and often have beautiful curved lines caused by the planing and eroding activities of the ice in moving down through the depressions or valleys it occupied.

This belt or tract is thus evidently one that after a long period of active stream erosion was invaded by glacial ice, which somewhat widened, and deepened the valley, planed and smoothed the faces of the enclosed walls, and also deposited vast amounts of detrital material along its course.

The streams at present traversing the lowland are employed in draining the belt through which they flow, and also in removing the accumulated glacial detritus. In most places, however, they have not as yet succeeded in trenching their channels to bed-rock, and have established no extensive or integrated system of drainage. Most portions of this general depression are, in fact, very imperfectly drained as is evidenced by the numerous small lakes and ponds, and by the generally wet, muskeg nature of the ground. Consequently the accumulated superficial materials deposited over the floor and along the walls of this valley tract, are yet dominantly where they were laid, the streams of the district not as yet having had time to transport them hence to any appreciable extent.

Lake Tchawsahmon Valley.

The somewhat broad, flat-floored depression in which Lake Tchawsahmon occurs, and which extends thence in a southeasterly direction to White river, is here termed Lake Tchawsahmon valley. This depression ranges in width in most places from 2 to 9 miles, and to the north of White river has a length of about 10 miles. At the southern end of Tchawsahmon ridge this valley forks, one branch continuing on either side of the ridge to Beaver creek. To the south of White river, Lake Tchawsahmon valley is in a general way continued by the valley of Generc river, a large stream having a flood-plain from 1 to 2 miles in width.

Lake Tchawsahmon valley resembles in its general characteristics the wide depression north of Nutzotin mountains. Its floor is deeply overlain with glacial as well as stream deposits, and through these accumulations the streams entering or traversing the valley, have as yet been unable to effect any organized or efficient system of drainage, and consequently small lakes, ponds, muskeg or tundra, and "nigger-heads" characterize the surface (Plate XII).

The walls rise in most places abruptly from the valley bottom, having been more or less steepened by glaciation; and along the western slope of the depression in particular, glacial erosion is strikingly in evidence, the mass of the ice having for some reason dominantly borne against this side of the valley. These vast bodies of ice have planated the valley slopes, reducing all projecting spurs, ridges, etc., and bringing them into general alignment to form for several miles a remarkably regular and in places a beautifully curved valley wall (Plate X). Since the abandonment of this depression by Glacial ice, the numerous small tributary streams from the upland have been cutting channels in these walls and have enlarged the pre-Glacial incisions in them. The result is that numerous V-shaped trenches are now cut in the steeply inclined valley slopes, and between them are left facetted forms, carved in the valley walls (Plate X). These facets and carved valley walls are to be seen elsewhere throughout the district, but are most typically and strikingly developed along the western side of this valley.

Tributary Valleys.

The more important tributary valleys in Upper White River district not already described, include those of the upper portions of Beaver and Sanpete creeks, as well as those of Miles, Boulder, Rabbit, McLellan, and Pan creeks. In addition, there are a great many small valleys or depressions containing rapid mountain creeks that rush and tumble down the mountain sides to the master depressions below.

Of the tributary or less prominent valleys of the district, that portion of Beaver Creek valley crossing the main range of Nutzotin mountains, alone represents apparently the work of an antecedent stream. The mountains on either side rise to elevations of between 3,000 and 4,000 feet above the valley floor, and the depression itself is constricted and narrow, but is typically U-shaped in contour due to glacial erosion, as are also all the older depressions in this region (Plate II).

Miles creek and the upper portion of Sanpete creek, which head together in the same depression, occupy a narrow, deep, trough-like, typically U-shaped valley whose walls are steeply inclined, planated, and regular, and the bottom of which is floored with gravels, boulder clay, and other glacial accumulations. Considerable masses of ice have thus at one time occupied and moved through this and other similar depressions in the vicinity, and have left behind them the dominant characteristic markings resulting from valley glaciation.

The numerous smaller creeks throughout the district, which rush in places in torrential fashion down the mountain sides to the master depressions below, dominantly occupy V-shaped incisions or even in places canyon-like cuttings, which vary in depth according to the size and age of the stream. These valleys, including those of Pan, Cash, and Bowen (Dominion) creeks as well as of many other similar streams, have been largely excavated in post-Glacial time, and hence have been slightly if at all modified by ice action (Plates II, XII). Rabbit and McLellan creeks as well as other streams draining into Lake Tchawsahmon valley from the west, flow through narrow canyons for some distance before debouching upon the alluvial flats below. These canyons, which open out into relatively broad valleys above, have been considered by some writers to "indicate that the range is still in the progress of uplift along its northeastern flank."[1]

This explanation for the occurrence of these canyons, however probable it may at first appear, calls for a very specialized type of uplift, as the streams in some other parts of the district, and even those adjoining Lake Tchawsahmon valley from the north and northeast, lack this canyon feature. Thus if these canyons are caused by an uplift of the land surface, only the extreme eastern edge of this particular small division, as well, possibly, as a few other similar sections of the Nutzotin mountains, have been effected, while the remaining adjoining portions must have remained steady, as there no canyons appear.

On the other hand it is a noticeable feature of these canyons, that they only occur incising those particular portions of the valley walls of the master depressions, such as the western slope of Lake Tchawsahmon valley, which have been most notably planated and eroded. The canyons thus occur on either side of facets carved in the walls of the parent depressions, as was previously mentioned in describing Lake Tchawsahmon valley, and

[1] Moffit, F. H., and Knopf, Adolph, "Mineral resources of the Nabesna-White Rivers districts, Alaska": U.S. Geol. Surv., Bull. 417, 1910, p. 50.

would thus appear to be a local development of similar origin to ordinary hanging valleys.

During the Glacial period, relatively much larger masses of ice occupied the master depressions than accumulated in the tributaries, and a correspondingly much greater amount of erosion occurred in the parent valleys. Accordingly as the floor of the master depression was deepened and widened, to the extent that the lower portions of the tributary depressions were entirely planed away, a hanging relationship was produced at the mouths of the tributaries. Upon the disappearance of the ice, the valleys of the tributary streams were thus left hanging above the floor of the parent valley, and consequently the tributaries in again establishing grade with the level of the surface of the main valley bottom, rapidly incised the canyons now in evidence. If the glacial accumulations overlying the floor of Lake Tchawsahmon valley were now suddenly removed, all the tributary streams at present debouching on this alluvial flat would be seen to have hanging valleys, and another period of canyon cutting would be inaugurated. Canyons are not so pronounced a feature of the streams entering this broad depression from the east, due to the valley wall on that side having not been so decidedly and strongly planated.

Boulder creek also probably drained into Lake Tchawsahmon valley in pre-Glacial time, and its valley resembles those of the other creeks joining the same depression from the east. However, due probably to glacial damming by ice or morainal accumulations, this stream was forced from its former channel. In the lower portion of its course Boulder creek became superimposed over its present bed, and in obtaining grade, excavated the gorge-like depression it at present occupies. Boulder creek, furthermore (Plate XI), joins White river at a point where this stream also has been forced to incise a new canyon-like channel on account of having been recently diverted from its former position.

DRAINAGE.

Present System.

Upper White River district is entirely drained by White river and its tributaries, of which the Generc is much the largest member, being comparable in size with the White above their confluence. A great part of the area is, however, drained by Beaver creek, which is a much smaller tributary than the Generc. This stream not only crosses the district, but with its various branches traverses the area longitudinally as well.

White river derives its water supply chiefly from the snow-fields of the Wrangell-Skolai group of mountains, and is throughout its course a turbid, swift-flowing shallow stream, with numerous channels traversing its wide flood-plain which is studded with constantly shifting bars and islands (Plate IV). Like all glacial streams White river also varies greatly as to the amount of water it carries, rising and falling rapidly not only with daily and seasonal variation, but also because of irregularities of precipitation, sunshine, and temperature. This stream is also particularly dangerous for those travelling in the district, due partly to its being so swift and subject to such rapid and high floods, partly because of the ice-cold nature of the water, and also on account of the treacherous quick sands, or glacial silts, that are everywhere strewn over its flood-plain. An acquaintance with the nature and general appearance of the quick sands, and a knowledge of the daily variation in the height of the water, coupled with a close observation as to the precipitation and sunshine, will, however, enable those fording or travelling on this stream to choose the most favourable times, and thus minimize the chance of loss and danger.

Generc river very closely resembles the White, being the same type of glacial stream, and is even considered by some to be more treacherous than White river, particularly above their confluence.

Beaver creek is also swift, but since it has not a glacial source it is normally a clear-water stream. It is like the White, however, subject to seasons of high flood during which as far west as the point last crossed by the International Boundary, it cannot be forded, even with horses. Each spring a great amount of driftwood comes down this creek and particularly down its main tributary, Snag creek. This driftwood later in the season remains as great piles and jams along the sides and even across or partly across these streams, Snag creek having obtained its name from this one of its most characteristic features (Plate V).

A great part of the broad depression through which Snag and lower Beaver creeks flow, as well as Lake Tchawsahmon valley, are very imperfectly drained and are dotted with small, often entirely unconnected, lakes or ponds. The whole surface of these lowlands is dominantly very wet and is characterized by muskeg and "nigger-heads." Everywhere little tricklets or brooks are in evidence, which, however, often run out or debouch on a lower level and are apparently lost, the drainage, such as exists, being continued only by a slow seepage system.

The uplands are much better drained than the valleys, as numerous torrential streams rush down over the mountain sides to the valleys below, many of which, however, debouch on the alluvial flats below and have no well-defined course to the main drainage ways of the district (Plate X).

Former System.

A number of important changes in drainage have occurred in Upper White River district and adjoining areas, as is evidenced by several old broad valleys whose former relationships are not well understood, and also by the rock-walled canyons along White river. These old depressions, such as Lake Tchawsahmon valley and the broad lowland north of Nutzotin mountains, must have been produced by streams of considerable size, but are now occupied by lakes and comparatively small creeks, their former waters having been in some way diverted to other channels. The recently incised Upper canyon on White river, which lies between sections of old valley, also indicates a diverted drainage. However, the information for a complete discussion of the former drainage system of this district is not at hand, and consequently only a few suggestions will be made and some references given which may help to throw light on this very intricate problem.

Brooks states that the upper waters of Tanana and White rivers drained in pre-Glacial time, to the Pacific ocean by a former White-Tanana river. He claims that this stream followed approximately along the valleys of Mirror, Snag, and Beaver creeks to the present White, thence turned up White River valley to Koidern river, continued up this stream, and crossing the Donjek found its way to Lake Kluane. From the southern end of this lake, he supposes the White-Tanana to have followed the valley of Creadon river probably by way of Schwack valley and thence continued to the ocean possibly by the Tatshenshini and Alsek valleys. The waters of Upper White river, he claims, followed a course to the south of that of the present stream, crossed the Generc, and joined the White-Tanana near the head of Koidern river.[1]

This theory, however, calls for a most remarkable reversion of drainage for which no adequate explanation has been assigned. It furthermore does not account for the old, antecedent channel of the White through the Nutzotin range below Canyon City, and in addition fails to explain the presence of Lake Tchawsahmon valley. Also, rock outcrops were found during the past summer near the summits of Kletsan hill, and Slaggart and Solomon ridges to the south of White river, and extend so far to the south toward the base of the Skolai-Natazhat mountains, that it seems very doubtful whether or not there can be any considerable old channel between these rock ridges and the mountains.

The evidence in Upper White River district would seem to indicate, however, that Upper White river in pre-Glacial time followed a course similar to that of the present stream as far as the International Boundary, but that below that point, this river swung to the north and continued down through Lake Tchawsahmon valley to the Beaver. The Generc river on the other hand apparently held practically its present course to White River valley, and thence persisted as now through the Nutzotin mountains, was joined by Koidern river and other streams, and was united with the Upper White which had possibly been joined by the waters of the Upper Tanana. These combined streams then may have flowed either down the Tanana and thence to the Yukon, or may have continued down the present val-

[1] Brooks, A. H., "A reconnaissance from Pyramid harbor to Eagle City, Alaska": U.S. Geol. Surv., 21st Ann. Rep., Pt. II, 1899-1900, pp. 354-355.

ley of the White to the Donjek. In any case some large stream flowed in the portion of White River valley between the present mouth of Beaver creek and the Donjek. Near the mouth of Donjek river, however, a decided change occurs. The valley of the White above this point is wide and contains on either side heavy banks and terraces of glaciofluvial accumulations. Below the Donjek these are suddenly replaced by high abrupt rock cliffs, and the valley instead of having an old appearance, exhibits considerable evidence of being a youthful depression. Thus in all probability, a former river drained through the present valley of the White to the mouth of the Donjek, but thence followed some other route to the pre-Glacial channel of the Yukon.

The Upper White, according to this system of drainage, came very close to the Generc in the southern portion of Upper White River district, and, due possibly to glacial accumulations, was eventually turned into it over the position of the present Upper canyon. A great amount of detailed study, however, will still be necessary before the drainage changes in this district are understood, and the former stream system is established.

SUMMARY.

Yukon Territory may be for the greater part divided into three broad physiographic provinces which persist to the southeast through British Columbia and to the westward through Alaska. Named in order from southwest to northeast these provinces are, the Coastal system, the Interior system, and the Rocky Mountain system. These terranes constitute the Cordillera of northwestern North America, and follow in a general way the peculiar concave contour of the Pacific coast line. In Yukon and Alaska the Interior system is comprised entirely of the most northerly of its larger divisions, the Yukon plateau, and in the vicinity of the 141st meridian—the Yukon-Alaska International Boundary—the Coastal system is composed of the St. Elias range and Nutzotin mountains, of which the latter are the more northerly and adjoin the Yukon plateau on the south, the St. Elias range extending from Nutzotin mountains to the Pacific ocean, Upper White River district includes a north-south section across the eastern or southeastern end of Nutzotin mountains, and extends to the south part way across the broad valley, separating these mountains from the Skolai-Natazhat group, a northern fork of the St. Elias range. To the north, this district reaches slightly into the Yukon Plateau region, but does not continue sufficiently far to embrace any of the typical plateau remnants which characterize this physiographic province.

Upper White River district is thus composed for the greater part of an eastern portion of Nutzotin mountains whose higher summits within the district rise to elevations of from 6,500 to 7,200 feet above sea-level. The mountain belt is bounded on the north by a broad, easterly trending flat some 30 miles or more in width, which really constitutes a southerly portion of the Yukon plateau, and throughout which occasional knobs, hills, and mountain masses rise, in places, rather abruptly. To the south of Nutzotin mountains, and separated from them by White River valley, the lofty snow-capped mountains of the Skolai-Natazhat group constitute in that direction an apparently impassable Alpine barrier.

All the more prominent uplands within Upper White River district thus constitute portions of Nutzotin mountains, although occasional smaller mountain masses are included in the wide depression to the north. Nutzotin mountains within the district themselves embrace two genetically distinct types—those resulting from differential erosion, and those produced dominantly by accumulation. The mountains of erosion belong to that class of the earth's features which are the result of differential erosions in regions of deformation and uplift. They embrace all the uplands to the north and northeast of Lake Tchawsahmon valley, and also include the eastern and northern portions of the group to the west and southwest of this depression. Farther west, however, the older rocks and former topography have become deeply buried under accumulations of lava and accompanying fragmental rocks which now compose all the higher, more prominent portions of this mountain group, to the west of Lake Tchawsahmon valley.

The typical Nutzotin mountains of erosion are notably irregular in form, being composed of geological formations which lack, in most places, any prominent members, structure, or other feature which might control and give a more marked or regular expression to the topographic features. The mountains of accumulation to the west and southwest are composed of lavas and accompanying fragmental rocks which have piled up as a series of superimposed sheets lying nearly horizontal in most places, the entire volcanic accumulation having the aspect of evenly stratified beds.

This group of mountains to the west of Lake Tchawsahmon valley, thus constitutes a decided transition from the typical Nutzotin mountains of erosion, to the Wrangell mountains of accumulation to the west and southwest, where floods of lava are claimed to have obliterated an ancient topography whose relief exceeded 3,000 feet.

The evidence contained in Upper White River district would indicate that during the time the Yukon Plateau region was being planated, which is thought to have occurred in Eocene or post-Eocene pre-Pliocene times, the adjoining tract to the south which is now occupied by Nutzotin mountains, was also subjected to erosional processes, but that these did not succeed in reducing the mountain belt to the mature stage produced in the plateau region. Consequently, the Nutzotin Mountains belt apparently remained as a region of considerable relief to the end of the cycle, and when the plateau province was uplifted in late Miocene, Pliocene, or early Pleistocene time, the mountain belt was similarly affected. The vertical movement, however, was probably greater within the mountains than in the plateau region, as the former occupy a marginal position within the upwarped tract, and the movement is believed to have been least along the central portion of the region which is approximately marked by the position of Yukon river, and was probably increasingly greater farther from this median line.

Thus at the beginning of the present erosion cycle, there was, in all probability, a decided difference in the general elevations as well as in the topographic characteristics of Nutzotin mountains and the adjoining portions of the Yukon plateau; and in Upper White River district, stream and glacial erosion have acted together to accentuate this distinction, and have impressed more and more deeply the line separating these two topographic terranes.

Upper White River district is drained by White river and its tributaries, of which the Generc is much the largest member, being comparable in size to the White above their confluence. A great part of the area is, however, drained by Beaver creek which is a much smaller tributary than the Generc.

The valley of White River from the source of this stream in the northern lobe of Russell glacier, to Yukon river, has a length of about 180 miles, and throughout its course White river is a turbid, swift flowing shallow stream with numerous channels traversing its wide flood-plain which is studded with constantly shifting bars and islands. Like all glacial streams, the White also varies greatly as to the amount of water it carries, rising and falling rapidly not only because of daily and seasonal variation, but also because of irregularities of precipitation, moisture, and temperature.

A great part of the lowlands, which comprise about one-half of the entire district, are very imperfectly drained, and are dotted with small, often entirely unconnected lakes or ponds. In fact, these lowlands or flats throughout Upper White River district are dominantly very wet, and with the exception of the flood-plains of the master streams are characterized by muskegs and "nigger-heads."

A number of important changes in drainage have occurred in this district and adjoining areas, as is evidenced by several old broad valleys whose former relationships are not now understood, and also by the rock-walled canyons along White river. A great amount of study will still be necessary, however, before the drainage changes in the district are understood, and this former stream system established.

CHAPTER III.

GENERAL GEOLOGY.

GENERAL STATEMENT

Upper White River district, as has been stated in the preceding chapter, occupies a position partly within the Yukon plateau, and partly within Nutzotin mountains which constitute the most northerly member of the Coastal system in the vicinity of the 141st meridian. Thus, the geological formations exposed within this district are those developed within these two topographic terranes.

In the Yukon plateau a great variety of rocks are developed. These include members ranging in age from Pre-Cambrian to Recent, and embrace sedimentary, igneous, and metamorphic types. In the adjoining Nutzotin mountains to the south, no geological formations older than Carboniferous have been identified, and the rocks range in age from Pennsylvanian to Recent. They include dominantly sedimentary and igneous members, although occasional small exposures of probably locally metamorphosed schistose or laminated rocks also occur.

The northern portion of Upper White River district, which extends into the Yukon plateau, is really an eroded valley tract in which the bed-rock formations are dominantly obscured by superficial deposits. Thus, little is known concerning the underlying rocks of this belt, but the formations that are exposed, are also dominantly those which characterize the Nutzotin mountains. Some older schistose rocks are also developed, however, within the northern portion of the district, which are thought to be of Pre-Cambrian age.

What appear to be the oldest rocks exposed in Upper White River district belong to the Yukon group and include mainly mica schists, quartz-mica schists, quartzite schists, and schistose amphibolites, which are believed to be of Pre-Cambrian age. More recent than the members of the Yukon group, but apparently older than all the other rocks of the district is a series of limestones, cherts, and shales which contain Carboniferous fossils. These rocks were identified at only a few points, and in each place the exposures are of small extent. Apparently more recent than these rocks, but also of Carboniferous age, is a thick series of shales, sandstones, conglomerates, and limestones, which contain Pennsylvanian or Gschelian fossils. Overlying conformably these Carboniferous beds, is a thick series of shales, greywackes, sandstones, and conglomerates which contain Mesozoic fossils. These Carboniferous and Mesozoic beds are extensively invaded and intimately associated with a group of volcanic rocks consisting mainly of andesites, diabases, basalts, and related pyroclastics. These volcanics appear to be the result of intermittent volcanism extending from Carboniferous to at least Cretaceous time. In late Jurassic or Cretaceous time the older rocks were invaded by a group of intrusive plutonic rocks of granitic habit, which range in character from granites to gabbros, or even in places to hornblendites. Overlying all these rocks, there occur in a few places, some loosely consolidated lignite-bearing conglomerates, sandstones, shales, and clays which are believed to be, dominantly at least, of Eocene age. Commencing about Eocene time, also, volcanisn again became active and in the Wrangell mountains to the west and southwest, has persisted to the present time. Basalts, diabases, andesites, and related rocks pierced the older formations, and lavas poured over the surface accompanied by showers of ashes and fragmental materials. These volcanic materials accumulated in places to a thickness of several thousand feet. In late Tertiary or early Pleistocene time, the district was also invaded by a group of latites, rhyolites, and related rocks which cut the older formations and in places flowed out over the land surface. Overlying all these rocks, are the unconsolidated Pleistocene and Recent accumulations which constitute a mantle of greatly varying thickness, obscuring the underlying bed-rock throughout a great part of the district. These materials consist of gravels, sands, silts, boulder clays, soils, peat, ground-ice, and volcanic ash, vast quantities of which have not only spread over the valley floors and have accumulated in the various depressions throughout the district, but extend as well over a great portion of the uplands. The volcanic ash is a very notable feature and apparently was showered over the district within the last few hundred years. This material ranges in thickness from a few inches or less north of White river, to 100 feet or more along the northern edge of the St. Elias mountains.

DESCRIPTION OF FORMATIONS.

YUKON GROUP.[1]

Distribution.

The members of the Yukon group have only a small areal development in Upper White River district, and were definitely identified only on Sanpete hill and Siwash ridge. In addition, however, Mr. Barlow collected specimens of schistose rocks from near Pan creek, from Horsecamp hill, and from the foot of Cottonwood hill, which may also belong to the Yukon group. Since, however, Mr. Barlow was not at all certain concerning the relationship of these schistose rocks, and as the writer through lack of time was unable to later visit these localities, it is uncertain whether the rocks belong to the Yukon group or are only metamorphosed phases of certain of the Carboniferous sediments. In any case, the exposures of these schistose rocks are too small to be shown on a map made to the scale of the geological sheet accompanying this memoir.

[1] As before mentioned in the "Introduction" section of Chapter I, the bulk of the field work for this memoir was performed during the summer of 1913, but at the close of the season a few hills or mountains in the northern part of the district were still geologically unexplored, due to the fact that the writer had to leave Yukon early in August to act as guide on excursions of the International Geological Congress. During the early part of September of the following year, however, the writer was unexpectedly enabled to again visit this locality and completed the mapping of the northern portion of the district. It was during these few days in 1914 that the members of the Yukon group were first identified in Upper White River district, and, accordingly, in the writer's summary report for 1913, and in this memoir as first sent to press, no mention was made of these rocks.

TABLE OF FORMATIONS.

Quaternary	Recent and Pleistocene	*Superficial deposits.* Gravels, sands, boulder-clays, silts, volcanic ash, peat, soil, and ground-ice. Dominantly glacial and glaciofluvial deposits which are still accumulating.
Tertiary	Post-Eocene	Rhyolites, latites, and related volcanics.
		Newer Volcanics. Mainly augite andesites and basalts, dominantly amygdaloidal or pumiceous, with related pyroclastic rocks. Not perceptibly disturbed.
	Eocene, possibly in part, Oligocene	Conglomerates, sandstones, and shales, loosely consolidated in most places. Contain seams of lignite.
Mesozoic	Cretaceous or Jurassic	*Granitic Intrusives.* Intrusive plutonic rocks ranging in character from granites to gabbros or even hornblendites, and possessing dominantly a granitic habit. Apparently represent outlying portions of the Coast Range batholith.
	Cretaceous, possibly in part older.	Shales, argillites, sandstones, conglomerates, and related sediments, considerably deformed and indurated. Only Cretaceous fossils were found, but Jurassic or even Triassic members may be present.
	Cretaceous, possibly in part older.	*Older Volcanics.* Andesites, diabases, basalts, and related rocks with their accompanying tuffs. These are intimately associated with the Mesozoic and Carboniferous sediments and are, in part, contemporaneous with them.
Palæozoic	Carboniferous (may include some Permian beds.)	Shales, sandstones, conglomerates, and occasional beds of limestone, considerably deformed, indurated, and, in places, metamorphosed.
		Massive limestone with some associated cherts, considerably metamorphosed.
Pre-Cambrian (?)		*Yukon group.* Mica schists, quartz-mica schists, quartzite schists, schistose quartzites, and schistose amphibolites.

Lithological Characters.

The members of the Yukon group occurring in Upper White River district are all decidedly schistose in character, and include, mainly, mica schists and quartz-mica schists, but quartzite schists or schistose quartzites, sericite schists, mica sillimanite schists, graphitic mica schists, and schistose amphibolites also occur.

The mica schists, quartz-mica schists, and quartzite schists are all closely related rocks which range in colour from grey to black, and in structure from mica schists possessing a high degree of schistosity to quartzite schists which cleave only imperfectly along the lamination planes. In places the mica schists contain a certain amount of graphitic carbon which gives them a black, lustrous appearance on cleavage surfaces. Sections broken across the lamination planes of these rocks, however, have a finely banded appearance, the layers being alternately light or nearly white and dark grey to black in colour. Certain of the mica schists also contain considerable sillimanite, and thus pass into mica-sillimanite schists. The mica schists are also in places minutely folded, contorted, and crinkled; at other points, however, the deformation is not so intense. The quartzite schists, or schistose quartzites, as in some cases appears to be the more appropriate name, are prevailingly dense, siliceous, light to dark green or greyish green rocks which consist mainly of quartz. These rocks cleave only imperfectly along the planes of schistosity, and break prevailingly into rough, somewhat platy or occasionally into prismatic fragments, the latter being due to more than one set of cleavage surfaces being nearly equally developed. The quartz-mica schists are characteristically, greyish, medium textured rocks which in places have a decided gneissoid appearance, and when viewed across the lamination planes, present a decidedly banded appearance, the alternate layers being nearly white and dark grey or greyish green in colour. The light bands consist mainly of quartz, and the darker layers are mainly composed of mica. Thus cleavage surfaces of these rocks have prevailingly a bright, glistening appearance, due to the abundance of mica present.

When examined under the microscope, the mica schists, quartz-mica schists, and quartzite schists are seen to be all composed dominantly of mica and quartz, there being every transition from a quartzite schist composed almost entirely of quartz, to a mica schist consisting for the greater part of mica. The quartz is dominantly in the form of irregular, interlocking and interfingered grains arranged as in a typical quartzite. The mica is generally biotite, but in some specimens sericite is more or less plentifully developed, and is in some rocks the dominant mica present. In addition to these minerals, sillimanite, graphitic carbon, feldspars, olivine, pyroxene, chlorite, calcite, and iron-ore minerals also occur. The sillimanite generally occurs as long fibrous shreds, associated with the quartz, feldspars, and micas. The graphitic carbon occurs as black, irregular streaks and bands, and also as fine disseminated particles, associated with the micas. These rocks are all typically composed of alternate light and dark bands. The light coloured layers consist mainly of quartz which in the schistose quartzites comprises the bulk of the rock mass. The darker bands are composed for the greater part of micas, but generally include considerable quartz, as well as one or more of the other minerals above mentioned. These rocks all appear to be altered sediments.

The schistose amphibolites are prevailingly dark green, finely textured, dense rocks with a decided schistose structure. These in most places, however, cleave only imperfectly along the planes of schistosity, and break prevailingly into rough, irregular, often somewhat prism-shaped fragments. When examined under the microscope, these rocks are found to be composed mainly of green hornblende, diopside, and carbonates, but contain also varying amounts of quartz, feldspar, sericite, sphene, and iron-ore.

Age and Correlation.

The name Yukon group was first used by the writer in 1912 in connexion with the schistose rocks along the Yukon-

Alaska International Boundary,[1] and is intended to include all the old, presumably Pre-Cambrian, schistose and gneissoid rocks in this general northwestern portion of the continent. The evidence obtained along the Boundary line would seem to indicate that these rocks are undoubtedly of Pre-Cambrian age. The rocks of Upper White River district that are referred to this group have been so classed entirely on lithological evidence. However, there would appear to be no doubt as to the correctness of the correlation, as these schistose rocks so closely resemble the members of the Yukon group, and are so unlike all the other rocks that occur in this general region.

CARBONIFEROUS SEDIMENTS.

General Statement.

More recent than the members of the Yukon group, but still apparently older than all the other rocks exposed in Upper White River district, is a series of sediments consisting mainly of limestones, but including also some cherts and shales, all of which are here for convenience referred to as the limestone-chert series. These beds were identified at only a few points, and in each case the exposures are small. They are overlain wherever noted by volcanic rocks, and nowhere were the lowermost beds of the series observed. Fossils collected from the limestone members at different points prove to be of Carboniferous and probably of Gschelian or Pennsylvanian age. In addition to these rocks, there also occurs within the district, a thick, extensively developed series comprised mainly of shales, sandstones, conglomerates, and limestones, which also contain Upper Carboniferous fossils. For various reasons, which will be discussed later, however, these beds are believed to be more recent than

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[1] Cairnes, D. D., "Geology of a portion of the Yukon-Alaska Boundary between Porcupine and Yukon rivers." Geol. Surv., Can., Summary Report for 1912, p. 11. "Geological section along the Yukon-Alaska Boundary line between Yukon and Pocrupine rivers." Bull. Geol. Soc. Amer., Vol. 25, pp. 184-187. "The Yukon-Alaska International Boundary between Porcupine and Yukon rivers." Geol. Surv., Can., Memoir No. 67 (in press). See section on Yukon group.

the limestone-chert sediments, and for the purpose of distinction will in this memoir be designated as members of the shale-limestone series.

Distribution.

As before mentioned, the limestone-chert rocks were identified at only a few points, and all the exposures are either in or within about a mile of the Upper canyon on White river. Two small outcrops occur on the northern end of Slaggart ridge, but possibly the largest exposure occurs along the lower portion of Boulder creek where these rocks are exposed to view along the sides of the canyon-like valley of this stream for a distance of about 2,000 feet, commencing about 1,500 feet from White river.

The members of the shale-limestone series on the other hand, are extensively developed, and with the Mesozoic sediments constitute the principal geological formation composing the main Nutzotin mountains, or the northwesterly trending mountain range which lies to the north and northeast of Lake Tchawsahmon valley and Tchawsahmon ridge. These rocks also occur on some of the smaller hills to the north of these mountains, and are developed as well along the northern and northeastern edges of the group of mountains to the south and southwest of Lake Tchawsahmon valley and Tchawsahmon ridge.

Lithological Characters.

The limestone-chert series consists dominantly of limestone with some associated cherts and shales. The limestones are grey in colour, massive, and dominantly crystalline in structure, and where exposed near the mouth of Boulder creek, have a thickness of at least 500 feet and possibly somewhat more than this amount. Underlying these limestones are some irregular, much altered, mashed, and distorted dark cherts and shales, which have an aggregate thickness of 100 feet or more. These break into irregular particles and are much weathered and decomposed on the surface. The peculiar, much weathered, dark, bedded rocks outcropping on the bank of White river, opposite Canyon City, are apparently closely related to these rocks, and probably represent the same period of sedimentation.

The members of the shale-limestone series have an aggregate thickness of at least 1,500 feet and probably of nearer twice this amount. However, due to the much folded and distorted condition of these beds in places, and owing also to the fact that nowhere were the lowermost beds of the series observed, the total thickness of these sediments remains rather uncertain.

This series consists dominantly of shales, but includes also some limestones, sandstones, conglomerates, and related rocks. The shales are for the greater part dark in colour—grey to nearly black, as well as reddish brown shales predominating. At a number of points these dark shales occur interbedded with limestones, and occasionally the two rocks are finely interlayed, the alternating members being not more than 1 to 2 inches thick. At other points limestone beds are intercalated in the shales at intervals of 10 to 15 feet, the limestone strata ranging up to about 4 feet in thickness. Individual limestone and dolomite members, having a thickness greater than 4 or 5 feet, are somewhat exceptional, but occasional bands occur, that are as much as 50 feet thick, and one particular limestone member which appears to be exceptionally persistent ranges in most places from 100 to 200 feet, and at one point is nearly 400 feet in thickness. The limestone and dolomite of this series range in colour from nearly white to dark grey, and are nearly everywhere decidedly crystalline in structure. At a number of points, the limestone also contains invertebrate remains. In addition, occasional reddish weathering beds were also noted which range in composition from a siliceous limestone to a calcareous sandstone, and thus constitute a transition between the limestones and sandstones.

Sandstones and finely textured conglomerates also occur, the sandstones being frequently more or less calcareous, but these members constitute only a very minor part of the shale-limestone series. Both sandstones and conglomerates occur dominantly in thin beds, and are in most places some shade of dark grey, green, or brown in colour.

Locally, the members of this series are considerably indurated in the vicinity of igneous intrusives, dominantly near their contract with the granitic plutonics. In such places the shales are hard and cherty, and have become characteristically bleached. They present frequently a decidedly banded or ribbon-like appearance, light grey to nearly white bands occurring interbedded with dark greenish-grey or even reddish or brownish layers. Such rocks break into irregular, sharply angular fragments rather than into shale-like slabs or plates.

Owing, largely to the complexity of the structure of these shale-limestone beds, no detailed sections of these rocks were measured and the relative positions of many of the strata were not determined. These rocks are also extensively invaded by volcanic rocks in most places, which adds considerably to the other difficulties in connexion with the study of this series.

Structural Relations.

The attitude of these rocks is extremely variable, but still in a general way they strike in a northwesterly direction parallel to the trend of the main Nutzotin range, and they dip prevailingly to the north. The structure is dominantly characterized by closed folds, the deformation being somewhat typically Appalachian. In places, these rocks are extremely and intricately folded, several closed or even reversed synclines and anticlines being often seen within a distance of 100 feet or even less.

Age and Correlation.

As was mentioned before, the members of the limestone-chert series may be of the same age as the members of the shale-limestone series, but for several reasons they are considered to be probably older. In the first place, the upper limestone member of the limestone-chert series is, wherever noted, considerably thicker than any of the limestone members of the shale-limestone series, and furthermore, these limestone-chert rocks are overlain by a great thickness of older volcanic rocks, and in their occurrence thus differ from the members of the shale-limestone beds as observed throughout the district. The limestone-chert beds are furthermore not more recent than the shale-limestone beds, as these are overlain by Mesozoic beds, and the limestone-chert beds contain Carboniferous fossils. The limestone-chert beds are thus contemporaneous with or older than the shale-limestone series, and the evidence obtainable would point to their being slightly older.

Fossils were collected from both of these series at a number of points, and have been examined by Dr. George H. Girty, of the United States Geological Survey, who refers them all to the Carboniferous. Dr. Girty, however, divides these remains provisionally into an upper and a lower group, both of which, he considers, belong to the Upper Carboniferous or Pennsylvanian. These fossil remains are found to correspond with Russian rather than with American facies and should thus probably be referred to the Artinskian and Gschelian or entirely to the Gschelian. The grouping of the fossils does not entirely correspond to the stratigraphic divisions as indicated in this report, but agrees in a general way, the apparent discrepancies being probably due to the uncertain and indefinite character of the invertebrate remains.

Dr. Girty reports on these fossils from Upper White River district as follows:—

"These collections are not very satisfactory, many of them being small and with poorly preserved specimens. There are possibly two distinct, though related, faunas in this material. Many of the faunas collected, however, are so meagre or so imperfectly identifiable that they cannot be grouped with certainty. They may belong with one faunal type or with the other or may represent one or more distinct faunal assemblages.

"I naturally turned to Dr. Cairnes' collections of last year (1912), assuming that the present ones belong to the same series of rocks. In my letter of April 3, 1913, I mentioned two faunal facies presented by his Alaskan Boundary collections. To one of these groups, that characterized by Lot XIi23, one of the present lots apparently belongs (1098). With the other fauna (the group of collections beginning with XIIi25) the second of the faunal facies of the present series of collections may in many respects be compared.

"List of species identified in Dr. Cairnes' collections.

Lot 1087

Zaphrentis sp.

Lot 1088

Zaphrentis sp.
Syringopora sp.
Favosites sp.
Crinoid stems
Fenestella sp.
Cystodictya sp.
Dichotrypa ? sp.
Batostomella sp.
Schizophoria aff. *resupinoides*
Productus aff. *aagardi*
" *semireticulatus*
" *cora* ?
" aff. *fasciatus*
" sp.
Spirifer cameratus Tsch. non Morton ?
Spiriferina aff. *ornata*
Cleiothyridina ? sp.
Plagioglypta ? sp.

Lot 1089

Spirifer sp.

Lot 1090

Stenopora sp.

Lot 1092

Zaphrentis sp.
Polypora sp.
Spirifer cameratus Tsch. non Morton ?
Spirifer sp.
Cleiothyridina ? sp.

Lot 1094

Fenestella sp.
Polypora sp.
Leioclema ? sp.
Cystodictya sp.

Lot 1095

Syringopora sp.
Lithostrotion ? sp.

Lot 1097

Syringopora sp.
Spirifer sp.
Orthoceras sp.

Lot 1098

Fenestella 2 sp.
Chonetes aff. *geinitzianus*
   " sp.
Productus aff. *humboldti*
   " " *aagardi*
   " sp.
   " aff. *schrenki*
Rhynchopora aff. *nikitini*
Spiriferina sp.
Cleiothyridina sp.

Aviculipecten sp.
" ? sp.
Bucanopsis aff. *meekana*
Naticopsis sp.

Lot 1099 (VIIk12)

Polypora sp.
Batostomella sp.
Rhombopora sp.
Schizophoria aff. *resupinoides*
Productus aff. *wallacianus*
" " *fasciatus*
Marginifera aff. *typicalis*
Camarotoechia ? sp.
Camarophoria ? sp.
Dielasma ? sp.
Squamularia aff. *perplexa?*
Spiriferina sp.
Cleiothyridina ? sp.
Enchostoma sp.

Lot 1099 (IIIw28)

Fenestella sev. sp.
Thamniscus ? sp.
Schizophoria aff. *resupinoides*
Aviculipecten sp.

Lot 1099 (VIIk12)

Campophyllum sp.

Lot 1099 (VIIk12)

Stenopora sp.
Batostomella ? sp.

Derbya ? sp.
Girtyella ? sp.
Reticularia ? sp.
Spiriferina sp.
Composita ? sp.
Aviculopecten ? sp.

Lot 1101

Crinoid stems
Batostomella ? sp.
Leioclema ? sp.
Schizophoria ? sp.

The following is a list of fossils collected by Mr. E. W. Nesham, D.L.S., of the International Boundary Survey, from along the 141st meridian near the summit of Mt. Natazhat, about 18 miles to the south of White river. The finding of these remains by Mr. Nesham, helps to show the great extent of these Carboniferous beds in this region.

Lot 1395

Crinoid stems (abundant)
Fenestella sev. sp.
Polypora sp.
Septopora sp.
Stenopora ? sp.
Cystodictya sp.
Chonetes aff. *verneuilianus*
Productus semireticulatus
Schizophoria aff. *resupinoides*
Camarotoechia ? sp.
Spirifer cameratus Tsch. non Morton ?
Platyceras ?

Dr. Girty further refers to Bulletin number 417, published by the United States Geological Survey[1] and states:—

[1] Moffit, F. H., and Knopf, Adolph, "Mineral resources of the Nabesna-White Rivers district, Alaska": U.S. Geol. Surv., Bull. 417, 1910, pp. 20-25

"Possibly here again we have the same two faunal facies, that of lots 7099 and 7099a (U.S. collections) answering to 1395, etc., of Dr. Cairnes' last collection, and 7102h et al (U.S. collection) answering to 1098, but the two sets of faunas present not a few differences."

In Dr. Girty's letter of April 3, 1913, referred to, he states: "The Alaskan Boundary fossils themselves fall more or less distinctly into two groups, beside which there are a number of nondescript lots too limited or too imperfectly preserved to declare their true affinities. They have been provisionally assigned to one or the other of the two main faunas, but may belong to neither. To one group I would refer lots XIi23 .... To the second group may be referred lots XIIi25 ....

"Of these collections lots XIIi25 .... are the most doubtful, not because of contradictory evidence, but because of the insufficiency of confirmatory evidence. Both these groups of collections contain types so similar to Russian species described by Tschernyschew in his monograph on Gschelian brachiopoda that it seems almost inevitable to correlate them at least provisionally with the Gschelian stage which occurs just below the lower Permian (Artinskian) of the Russian section. This is true of both groups of collections, though they show fairly distinct facies from one another, for both are about equally related to the Gschelian, yet herein enters an element of doubt, owing to the singular fact that among Tschernyschew's Gschelian brachiopoda, and indeed in the associated fauna, are numerous species which not only lack corresponding types in our own Pennsylvanian but are closely related to types which seem to be restricted to the Mississippian. The first group of collections contains few, if any, of these types, whereas the second contains a considerable number of them, and the question is immediately raised whether we are to rely upon the one set of affinities and call the horizon Gschelian, or on the other and call the horizon Mississippian. Since, however, we have in Alaska a Lower Carboniferous horizon equivalent to the *Productus giganteus* zone of Europe, to which the present fauna does not appear to be closely related, it seems more probable that the second group of collections as well as the first should be correlated with the Gschelian.

"I should perhaps add that in the case of all these identifications and correlations I have met not only the usual difficulty that many of the fossils are poorly preserved so that their identification, and consequently their significance, is doubtful, but also the additional one that I have been entirely without specimens of the Gschelian fauna with which to make comparison, and have had to rely solely upon descriptions and figures, chiefly the latter, as the text is mostly in Russian."

In a later letter, Dr. Girty also writes: "It may interest you to know in this connexion that I have recently had a visit from Dr. Olaf Holtedahl of Christiana, Norway. Among other things he wanted to see some of the Alaskan collections and I showed him your collections together with Mr. Maddren's. Holtedahl has been working on the Carboniferous of Spitzbergen and also studying the Gschelian, Artinskian, and Permian fossils collected by Tschernyschew and others, so that I thought his opinion would be of service to us. The Alaskan faunas seemed familiar to him and yet as might be expected, with a difference. He corroborated my conclusions in some respects, but not in all. For instance, he agreed with me that the fauna which I wrote you was like the Nation River fauna was younger than the other, while the typical Calico Bluffs fauna which I showed him was still different and older. On the other hand, the Nation River fauna appeared to him to be Artinskian rather than Gschelian as I had designated it, but he would not class the Artinskian with the Permian as many Russians and Americans are doing. He regards it as still in the Upper Carboniferous or Pennsylvanian, because so many of the Gschelian species run over into it." In this letter, in referring to the Nation River fauna, Dr. Girty means the fauna of the limestones at the mouth of Nation river. These limestones are supposed to overlie the members of the Nation River formation.[1]

Dr. E. M. Kindle of this Department, also reports on one

[1] Brooks, A. H., and Kindle, E. M., "Palæozoic and associated rocks of the Upper Yukon, Alaska." Bull. Geol. Soc., Amer., Vol. 19, 1908, pp. 262, 294, 295.

lot of fossils from these beds as follows : "This lot comprises numerous small fragments of plant stems embedded in grey sandstone. These fragments are too poor to permit any precise determination, but I am inclined to refer this material, largely on empirical grounds, to the Nation River formation which has been considered to be of late Carboniferous age."

As most of the fossils collected from the shale-limestone series were obtained from the included limestone members, and since these fossils have been by Dr. Girty identified with those from the limestones that occur at the mouth of Nation river, it would seem evident that these limestones at the mouth of the Nation river, correspond with certain of the limestones of the shale-limestone series in Upper White River district, probably with the main, most persistent limestone horizon which is described above. Also as these limestones at the mouth of Nation river are thought to overlie the members of the Nation River formation, and as the argillaceous and arenaceous members of the shale-limestone series in Upper White River district lithologically very closely resemble the members of the Nation River formation, it would seem to be altogether probable that certain at least of these argillaceous and arenaceous members in Upper White River district, particularly those below the main limestone horizon, correspond with the beds of the Nation River formation. The shales, sandstones, and related members of the shale-limestone series which overlie the main limestone horizon would thus appear to be slightly more recent than the Nation River beds. Furthermore, since there is some doubt as to whether the fossils of these limestones are of Artinskian or Gschelian age, and since a number of geological writers both on this and the Asiatic continent refer the Artinskian to the Permian, it is possible that certain of the shale-limestone members may be of Permian age. However, as Dr. Girty does not think this at all probable, these rocks are in this memoir all referred, tentatively at least, to the Carboniferous. This is considered particularly permissible at this time, as certain authoritative geological writers now include the Permian in the Carboniferous.[1]

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[1] Schuchert, Charles, and Barrell, Joseph, "A revised geologic time-table for North America." Amer. Jour. of Sci., Vol. XXXVIII, 1914, p. 25.

The limestone-chert beds may possibly correspond with the main limestone horizon in the shale-limestone series, but it would seem much more probable that they represent a horizon below the Nation River formation, and corresponding to the lower Pennsylvanian.

Carboniferous sediments similar to those included in the shale-limestone and limestone-chert series have been described by other writers as occurring in localities not far from Upper White River district. Brooks includes these beds in his Nutzotin series[1] which, however, embraces Mesozoic beds as well. Moffit and Knopf have also described similar rocks in the nearby Nabesna-White Rivers district, under the general term "Carboniferous rocks."[2]

MESOZOIC SEDIMENTS.

Distribution.

The Mesozoic sediments have a somewhat extensive development in Upper White River district, and with the Carboniferous beds compose the greater part of the main Nutzotin range. Being very similar lithologically to certain of the arenaceous and argillaceous members of the Carboniferous shale-limestone series, it was not always possible to distinguish these two formations; however, the Mesozoic beds were identified at numerous points not only throughout the Nutzotin mountains to the north of Lake Tchawsahmon valley, but also along the northern and northeastern portions of the mountain group immediately to the south of Tchawsahmon ridge and Lake Tchawsahmon valley.

Lithological Characters.

The Mesozoic sediments consist dominantly of shales, argillites, greywackes, sandstones, and conglomerates, and have an aggregate thickness of apparently about 1,000 feet. However,

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[1] Brooks, A. H., "A reconnaissance from Pyramid harbor to Eagle City, Alaska": U.S. Geol. Surv., 21st. Ann. Rept., Pt. II, 1899-1900, pp. 359-360.

[2] Moffit, F. H., and Knopf, Adolph, Op. cit., pp. 17-27.

neither the uppermost nor lowest beds of this formation have been identified. More recent Tertiary sediments occur within the district, but nowhere were these seen overlying the Mesozoic beds, and in any case the latter were deformed and eroded before the Tertiary period of sedimentation commenced. Thus, it is quite possible that the original uppermost beds nowhere remain, and even if remnants are still preserved, due to closed folds or faulting, such were not recognized. Furthermore, the members of this Mesozoic group or series very closely resemble the underlying arenaceous and argillaceous Carboniferous beds. In fact, the beds throughout appear to be conformable and the entire Mesozoic-Carboniferous sedimentary terrane represents apparently a continuous uninterrupted period of sedimentation. Thus, except where fossils were obtainable, it was in many places impossible to determine whether the sediments were Mesozoic or Carboniferous. All the limestone members, however, appear to be Carboniferous, as most of these beds contain fossils, and all of these remains that were obtained have proved to be of this age. There are also a number of other points of distinction between the sedimentary terranes of these two periods, but nevertheless so intimately associated are these rocks in places and so barren are they of fossil remains in most localities, that it was nowhere possible to determine absolutely where the beds cease to be Mesozoic and commence, instead, to represent Carboniferous sedimentation. Thus the thickness of these Mesozoic beds remains rather uncertain.

In addition, since the members of this entire Mesozoic-Carboniferous sedimentary terrane are now so folded, tilted, distorted, and closely related, it has been found advisable on the map accompanying this memoir, to group the two formations under a single colour, as even where the members of the different periods are distinguishable, the scale of the map is not such as to satisfactorily show them separately.

These Mesozoic sediments are to a great extent dark or banded shales and argillites with which are interbedded a large proportion of greywacke and smaller amounts of conglomerate and sandstone, the entire series being notably more siliceous than the underlying Carboniferous beds. Dark grey and slate-coloured shales and argillites are most conspicuous in some places, but in other localities considerable thicknesses of banded, or ribbon-like beds occur. These banded shales on weathered surfaces have a general alternately light and dark layered appearance. On fresh fractures, the colours are seen to be mainly dark grey to nearly black and dark greenish or reddish. In places, however, the banding is due largely to varying texture and composition rather than to alternating colours. Fine-grained, thinly bedded greywackes, interstratified with shales, upon weathering present a decidedly banded appearance, due to the unequal resistance of the different layers to subaërial destructive processes. In the vicinity of intrusive igneous rocks and particularly near their contact with the granitic plutonics, the shales and argillites have in places become bleached and indurated and thus transformed into hard, cherty rocks with alternating white or greyish and dark grey to black bands. Although these rocks have been thus considerably indurated in places, nowhere was any secondarily induced slaty cleavage observed. The different layers or strata in the banded shales range in thickness from 1 inch or less to more than 2 feet, but they are typically from one-quarter to 2 inches thick. The argillites break prevailingly into sharply angular pieces, and do not as a rule cleave readily along their bedding-planes, so as to produce slab or plate-like fragments.

The sandstones and greywackes are much less extensively developed than the shales and argillites, and are dominantly greyish, or greenish in colour. They are also in most places finely textured, although coarsely grained rocks of this type occur.

Conglomerates were noted at only a few points and are prevailingly finely textured and in thin beds. Along the main Nutzotin range the greater number of exposures of these rocks are also characterized by an abundance of dark argillite and chert pebbles. Possibly the greatest development, particularly of coarsely textured conglomerates, however, occurs along Boulder creek about midway between its mouth and head. There sandstone and conglomerate are well exposed for a few hundred feet in the bottom of the gorge through which the stream flows. The conglomerate greatly exceeds the sandstone in amount and contains large, well rounded pebbles and boulders dominantly from 1 to 4 inches in diameter, which consist mainly of granitic rocks and various volcanics. The sandstone is coarsely textured, and yellowish, greyish to greyish-green in colour, and like the conglomerate is quite firm and perfectly consolidated, but is not indurated. At one point a lens of coal-like carbonaceous material about 12 inches long and 1 inch thick was noted in the sandstone beds.

Structural Relations.

These Mesozoic beds are in places quite regular with gentle dips and fairly persistent strikes, but at other points they are greatly distorted, tilted, and disturbed. Closed and reversed folds characterize certain localities, as along the south side of Beaver creek near the International Boundary line where several sets of closed anticlines and synclines occur within a distance of 100 feet or less. In fact, due to this closed folding and also owing to the fact that these beds have been extensively invaded by volcanic and plutonic rocks, they have become extremely irregular, and to measure or estimate sections of them becomes consequently very difficult and somewhat uncertain.

Age and Correlation.

Fossils were collected from these beds at a number of points, but in each case only a single species was obtained. These have been examined by Dr. T. W. Stanton of the United States Geological Survey who states: "These fossils are also *Aucella* and.......... are believed to represent a variety of *Aucella crassicollis* and to be of Lower Cretaceous age." Similar fossils were also collected from these Mesozoic shales near the head of Bonanza creek, Chisana district, Alaska, concerning which Dr. Stanton also reports: "This lot consists entirely of *Aucella crassicollis* Keyserling, as I interpret that species, and indicates the Lower Cretaceous age of the beds from which it comes."

Similar appearing Mesozoic beds occurring in the Nabesna-White River district, Alaska, a few miles to the west of Upper White River district, Yukon, have been described by Moffit and Knopf.[1] From these rocks fossils have been collected representing both the Jurassic and Triassic periods, and some remains were found which are thought to be possibly of Cretaceous age. Therefore, as these rocks resemble lithologically the Mesozoic beds in Upper White River district, and in both areas constitute a correspondingly prominent part of the Nutzotin mountains, and since in Upper White River district these beds overlie Upper Carboniferous sediments, it would seem altogether probable that in Upper White River district these Mesozoic beds include not only Cretaceous but also Jurassic and even possibly Triassic members, but that unfortunately fossil remains were obtained from only the Cretaceous horizons.

These Mesozoic beds in Upper White River district, also appear to correspond very closely with the Laberge series[2] of other portions of southern Yukon and of northern British Columbia, which have been considered to be of Jura-Cretaceous age.

Older Volcanics.

General Statement.

Associated with the Carboniferous and Mesozoic sediments of Upper White River district, is an extensively developed group of basic to semi-basic volcanic rocks which appear to represent a long but intermittent period of volcanism. Copper bearing andesites, basalts, and related rocks almost undoubtedly corresponding to these volcanics, occur in adjoining portions of Alaska and have there been considered to be in part at least of Upper Carboniferous age. Certain of the members of this volcanic group occurring in Upper White River district, however, are more recent than the Mesozoic sediments of this area. Thus

[1] Moffit, F. H., and Knopf, Adolph, Op. cit., pp. 27-32.

[2] Cairnes, D. D., "Preliminary memoir on the Lewes and Nordenskiöld Rivers Coal district, Yukon Territory": Geol. Surv., Can., Memoir No. 5, 1910, pp. 30-35.

"Wheaton district, Yukon Territory": Geol. Surv., Can., Memoir No. 31, 1912, pp. 53-57.

"Portions of Atlin Mining district, British Columbia, with special reference to lode mining": Geol. Surv., Can., Memoir No. 37, 1913, pp. 59-63.

until more evidence is obtained these volcanics will be considered as of Carboniferous-Cretaceous age and are in this memoir designated, for convenience in description, as the "older volcanics."

Distribution.

These older volcanic rocks are extensively developed throughout Upper White River district, and occur either alone or associated with the Carboniferous-Mesozoic sediments in most localities, except along the central or southwestern portions of the mountain group to the west and southwest of Lake Tchawsahmon valley, where all the pre-Tertiary formations are overlain by the newer volcanics. In fact not only do these older volcanics occur in the form of numerous irregular igneous masses, but throughout the district the Carboniferous and Mesozoic beds are everywhere minutely and persistently invaded, intruded, and overlain by these rocks. Thus, in many places, the geological formation is really a complex composed of the older volcanics and the Cretaceous-Carboniferous beds. Also, as the volcanic rocks are more resistant to ordinary subaërial destructive agencies than the adjoining sediments, they in many places form the summits of hills or mountains, the axes of ridges, and other prominent points, whereas the sediments are in most places covered with products of decomposition. Thus, even where the sedimentary rocks are much the more extensive, the volcanics are often considerably the more prominent.

Lithological Characters.

These older volcanics include, mainly, augite andesites, hornblende andesites, mica andesites, augite diorite porphyrites, basalts, and diabases, as well as their accompanying and related tuffs and breccias. These rocks vary considerably in general appearance due to their possessing a somewhat wide range of colour, texture, structure, and mineralogical composition. They are dominantly fresh appearing rocks, but in places are considerably distorted, fractured, and veined with calcite and quartz.

At a few points also, these volcanics have become locally metamorphosed and given a laminated or even a schistose structure.

These volcanics are characteristically some dull subdued colour, of which dark shades of green prevail, but browns and even reds also occur. In texture, they range from homogeneous appearing rocks, in which none of the component minerals are discernible with the naked eye, to much more coarsely grained members containing large well-defined phenocrysts embedded in a groundmass which, in some cases, may also be seen to be crystalline without the aid of a lens. The phenocrysts are dominantly plagioclase, hornblende, and pyroxene, of which the hornblende and pyroxene are black or nearly so, and the plagioclase ranges from light grey to pale greenish in colour. In places, also, these rocks are notably amygdaloidal; the amygdules range in size from microscopic to an inch or more, but are dominantly, however, less than one-quarter inch in diameter. These amygdaloidal cavities, which during the time the lavas were cooling were occupied by gases or vapours, are now for the greater part filled with secondary minerals, mainly zeolites, calcite, chlorite, epidote, and chalcedonic quartz, the zeolites and calcite predominating in most places. It is in certain of these reddish amygdaloidal flows that the native copper of White River district of both Yukon and Alaska occurs. In Upper White River district, native copper has only been found in these rocks in the vicinity of the Upper canyon on White river, but similar reddish amygdaloidal volcanics are typically and somewhat extensively developed on Cottonwood mountain, Miles ridge, and elsewhere throughout the district.

Thus, many of these rocks have quite a mottled appearance due either to large, light coloured feldspar phenocrysts distributed throughout a finely textured, dark groundmass, or owing to the white zeolites, calcite, or quartz amygdule fillings being scattered throughout an otherwise dark greenish reddish or brownish rock. Such types are thus quite contrasted in appearance with other dull, dark, dense rocks in which none of the mineral constituents are discernible without artificial means.

The tuffs and breccias that occur occasionally associated with these various volcanic types, range from dense, finely-textured ash rocks to massive, coarse breccias having somewhat the appearance of conglomerates. These breccias differ from conglomerates, however, in that they are composed mainly or entirely of igneous material, and the cemented rock fragments in addition exhibit little if any eroding action.

As these older volcanics are prevailingly massive in form, and are nearly all of about equal hardness, they present a very uniform resistance to ordinary subaërial destructive agencies. Consequently, hills or mountains composed mainly of these rocks exhibit a characteristically irregular type of topography, owing to a lack of any persistent bed-rock structures or exceptional recurring formational members which might tend to control and give expression to the physiography (Plate XII).

When examined under the microscope, these older volcanics are all seen to be mainly plagioclase-pyroxene-hornblende aggregates. They also include rocks having both decidedly porphyritic and ophitic structures. The ophitic structure is diagnostic of diabases, which rocks are composed of minerals all of which appear to belong to one generation; the porphyritic rocks on the other hand exhibit two distinct periods of crystallization. In the porphyritic members of these older volcanics, the percentage of phenocrysts to groundmass varies considerably, but the phenocrysts are generally fairly abundant and the fabric may thus be described as predominantly dopatic to sempatic.[1] The groundmass also varies considerably and ranges from hypohyaline or partly glassy to holocrystalline, but is rarely coarser than microcrystalline. Pilotaxitic structures are very characteristic of the groundmass of many of the rocks, and in such cases the feldspars have somewhat the appearance of a number of small shoe-pegs irregularly distributed and filled with chiefly augite prismoids and iron-ore grains. At times, a certain amount of brownish glass also occurs when the structure is designated as hyalopilitic.

In addition to plagioclase, augite, diopside, and hornblende, which are the dominant minerals in these rocks, biotite also occurs, and some alkali feldspar and even quartz is present in some of the more acidic andesites.

Plagioclase is much the most plentiful and persistent single component of these volcanics; and is generally present in both generations, although in some of the basalts only augite occurs as phenocrysts. The plagioclase ranges from andesine tc bytownite according to the basicity of the rock, and the phenocrysts of this mineral generally occur in large, well formed crystals that are twinned according to the albite and frequently according to the

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[1] Cross, W., Iddings, J. P., Pirsson, L. V., Washington, H. S., "The texture of igneous rocks": Jour. of Geol., Vol. XIV, No. 8. Nov.—Dec., 1906.

Carlsbad and pericline laws as well. Zonal structures also characterize many of the plagioclase individuals.

The pyroxene present in these rocks is dominantly a colourless, or nearly colourless diopside, but pale green augite also occurs. Both common green hornblende and brown basaltic hornblende occur in the andesitic members, but of these two minerals, the green variety is much the more often encountered.

As accessories, magnetite is always present and in some of the basalts, constitutes quite a percentage of the entire rock mass. Zircon and apatite are also of rather common occurrence. The most abundant secondary alteration minerals are calcite and chlorite which always occur. In addition, some specimens exhibit considerable secondary epidote, and in certain of the tuffs in particular, a great amount of finely distributed biotite also occurs, distributed throughout the rock mass. The tuffs and breccias occasionally contain a considerable amount of foreign material which in places is of sedimentary origin.

At a few points, these older volcanics have been locally mashed, sheared, and transformed into laminated or even decidedly schistose rocks which are generally much altered to calcite. Only occasional small developments of these metamorphosed types were noted.

Origin.

These older volcanics in Upper White River district at least, are dominantly of local origin. In the main Nutzotin range to the north and northeast of Lake Tchawsahmon valley, they are extensively developed, but are prevailingly intrusive into the surrounding rocks and occur still included in them in the form of dykes and irregular masses in the position in which they originally cooled below the former land surface. Along the eastern edge of the mountain group to the southwest of Lake Tchawsahmon, as well in places on the hills on the northeast side of this broad depression, these volcanics, however, occur in the form of flows associated with occasional tuffs and breccias, the flow structure being in places still quite apparent. The lavas appear to have come to the surface along certain fractures in the older rocks, and to have poured out over these from long incision-like vents. Due to the considerable degree of basicity possessed by these volcanics, they would readily become quite fluid and pour naturally over the surface unaccompanied by the terrific explosions and cone building processes characteristically accompanying the more viscous acidic eruptions. Along Boulder creek and elsewhere, these lava flows overlie sedimentary rocks, and numerous dykes of the same volcanics cut these sediments. The dykes thus probably represent the vents through which the overlying rocks came to the surface. Everywhere throughout the district where there are flows of these rocks, dykes or other intrusive masses of the same material occur in the near vicinity, showing the source of the extrusive lavas.

Across the 141st meridian in Alaska, where these volcanics are much more extensively developed than in Upper White River district, they are claimed to be contemporaneous with the Carboniferous sediments, and in this connexion Moffit and Knopf state: "The fragmental volcanic material was laid down in water, for the tuffs and breccias are interstratified with shales and limestone beds and at many localities contain fossils. It is known that the lavas also, or at least a part of them, were poured out and cooled under water."[1] In Upper White River district no such evidence was obtained, but the conditions are possibly somewhat different in the two areas. Furthermore, on account of the much greater development of the volcanics to the west, the opportunities for studying them are much better there than to the east in Yukon.

Age and Correlation.

The only direct available evidence concerning the age of these volcanics, is that obtained by a study of the relation of these rocks to sediments of known age. In Upper White River district wherever these volcanics were observed in contact with the Cretaceous-Carboniferous sediments they cut or overlie them. It is thus evident that some of these volcanics are more recent than the Cretaceous beds, and in the short time available in the field, it was not possible to subdivide them into age groups, even if some of these rocks are older than Cretaceous. On Boulder creek, volcanic rocks lithological and otherwise

[1] Moffit, F. H., and Knopf, Adolph, Op. cit., p. 17.

apparently corresponding to the copper bearing amygdaloids, cut and overlie conglomerate beds which contain large granitic boulders evidently of Mesozoic age. These volcanics thus cooled at least as late as Cretaceous time. In fact, all the evidence available in Upper White River district indicates a late Mesozoic age for these volcanics, as they appear to be all more recent than the Mesozoic sediments and are older than the Tertiary rocks.

However, in the Nabesna-White Rivers district, Alaska, to the west, considerable evidence has been obtained indicating that the copper-bearing volcanics there, which appear to be the same as those in Upper White River district, are of Upper Carboniferous age. Thus either these volcanics on the Yukon side of the Boundary line include rocks of both Carboniferous and Mesozoic age, or these volcanics are of different age from those described in Alaska, or the Alaskan geologists have come to wrong conclusions concerning the volcanics in the Nabesna-White Rivers district. From the evidence cited by Moffit and Knopf[1], it would hardly seem possible that they could be mistaken. Furthermore the writer investigated these volcanics on both sides of the line and they appear to be, almost undoubtedly, the same. It would thus seem probable that in Upper White River district, these older volcanics include members ranging in age from Pennsylvanian to Cretaceous, and thus represent a long intermittent period of volcanism similar to that giving rise to the newer volcanics,[2] which commenced about Eocene time and is still in progress.

GRANITIC INTRUSIVES.

Distribution.

At a number of points in Upper White River district, intrusive plutonic rocks occur which have characteristically a granitic habit, and are here for convenience in description, designated as the granitic intrusives. These rocks constitute a

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[1] Moffit, F. H., and Knopf, Adolph, Op. cit., pp. 17-27.

[2] See pages 97 to 101 of this memoir.

number of isolated, irregularly shaped bodies that occur as stocks or batholithic masses of no great size. The larger developments of these rocks within the district, range from 1 to 8 miles in their greatest dimensions, and in all, only a few areas occur in which the exposures of these intrusives exceed 1 mile in diameter. The largest area of these granitic intrusives embraces the greater part of Gates ridge. Another important development extends over most of Tchawsahmon ridge, and reaches across the Beaver to include some of the hills to the north. These rocks also occupy both ends of Horsecamp hill, and are exposed over the southeasterly portion of the Nutzotin range immediately overlooking White river on its right limit. A number of other smaller exposures of these rocks occur on Sanpete mountain, on Siwash ridge, in the vicinity of Cottonwood mountain, on Niggerhead hill, and near the crossing of Snag creek by the International Boundary.

Lithological Characters.

These intrusives vary in composition from that of an acid granite to a basic gabbro or even a hornblendite; and in general are some shade of grey, but possess quite a wide range of colour. The more acid varieties are almost white or light grey, but with increasing basicity the colour becomes darker, the hornblendites being quite black. The granites and granodiorities have in places a pink or reddish hue, due to the colour of the prevailing alkali feldspar which they contain; while greenish tints characterize some of the more basic rocks due to the development of chlorite, epidote, or related minerals. These intrusives are also remarkably uniform in texture, being dominantly coarse-grained rocks. Medium textured facies, however, are developed, and in places these intrusives are decidedly porphyritic. They are characterized nearly everywhere by having a typical granitic appearance, and are thus commonly spoken of as granites, which term, however, is, strictly speaking, applicable to only a small percentage of these rocks.

When examined microscopically these rocks are seen to have a wide range of composition, but include mainly alkali feldspar, lime-alkali feldspar, quartz, hornblende biotite, diopside, augite, hypersthene, and certain common accessories such as apatite, zircon, and iron-ore, as well as various secondary alteration minerals, mainly, muscovite, calcite, chlorite, and epidote. The most common rock types examined prove to be diorites—augite diorites, and quartz hornblende diorites, especially, having been identified. In addition, granodiorites, quartz granodiorites, granitites, gabbros, and even hornblendites were examined.

Age and Correlation.

Certain of the early Mesozoic conglomerates of this district contain granitic pebbles apparently derived from these intrusives, and at the same time the granitic rocks cut the early Mesozoic sediments at different points. This evidence corresponds exactly with that found to obtain for the Coast Range intrusives in southern Yukon and northern British Columbia[1], where the early Jura-Cretaceous beds contain granitic pebbles and boulders evidently derived from these intrusives, but the intrusives themselves cut these same beds which are in part derived from them. Thus, it is seen that these Coast Range intrusives represent a long, intermittent period of igneous activity extending possibly from early Jurassic to well into Cretaceous time. After portions of the granitic batholith had cooled and been eroded, giving rise to various sediments, igneous activity continued or again broke forth, and granitic intrusives lithologically almost identical with the earlier members, invaded the sediments produced from them. The granitic intrusives in Upper White River district correspond lithologically with these Coast Range intrusives and appear to be undoubtedly closely connected, genetically, with the great Coast Range batholith, and possibly represent outlying portions of this vast geological terrane.

Tertiary Sediments.

Distribution.

Tertiary strata were noted at only three points in Upper White River district, all of which are within 3 miles of the

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[1] Cairnes, D. D., "Portions of Atlin district, British Columbia, with special reference to lode mining": Geol. Surv., Can., Memoir No. 37, 1913, pp. 57-59.

International Boundary and are less than 2 miles apart. The most northerly development of these beds occurs along the upper part of McLellan creek[1] where these rocks are more or less continuous for about a mile. The other developments occur near the heads of two small creeks about 1½ and 3 miles respectively to the north of McLellan creek, where the exposures within the district are in each case between one-half and 1 mile in length. At the most northerly locality, these sediments extend to the west some distance into Alaska.

Lithological Characters.

These beds comprise mainly loosely or only partly consolidated sandstones, shales, and clays. The sandstones are prevailingly greyish to yellowish and brown in colour, and the shales and clays are dominantly some light shade of grey, green, or blue, but some quite black strata also occur. All the beds are soft and decrepitate readily to form sand and clay beds. Some thin seams of lignite and a considerable amount of fossil wood were also found associated with these sediments in places.

These rocks are prevailingly nearly flat lying, and in most places have been only slightly disturbed by earth movements. They have, however, been extensively invaded by more recent volcanics including members of both the rhyolite-latite group and the newer volcanics, which pierce or overlie them wherever they are exposed.

Age and Correlation.

These Tertiary beds appear to correspond to the members of the Kenai series[2] which includes the oldest known Tertiary sediments in Yukon and Alaska, and which is generally referred

[1] Locally known to some as Coal creek.

[2] Collier, A. J., "The coal resources of the Yukon, Alaska": U.S. Geol. Surv., Bull. No. 218, 1903, pp. 17-19.

Brooks, A. H., "The geography and geology of Alaska": U.S. Geol. Surv., Prof. paper, No. 45, 1906, pp. 237-244.

Cairnes, D. D., "The Yukon coal fields": Trans. Can. Min. Inst., Vol. XV, 1912, pp. 365-367.

to the upper Eocene. Since, however, Kenai beds in some districts rest conformably upon the Upper Cretaceous, and form with it a continuous series without any perceptible stratigraphical break, it is possible that the Kenai series includes some lower Eocene. Since, also, the Kenai beds contain seams of lignite, it is customary to include in that formation all Tertiary beds containing coal. It would thus seem possible that rocks more recent than Eocene have been in places included in the Kenai, just as has happened at times in connexion with certain lignite-bearing Cretaceous beds.

The Kenai sediments in most places, at least, where they have been studied, represent deposits laid down in separate basins of deposition, and the plant remains which they contain show that most of them at least are of fresh-water origin. The lignite seams in the Kenai series are also not confined to any particular horizon, but occur in all positions from top to bottom of the series. This is just what might be expected, considering that the Kenai beds are believed to have been deposited in unconnected basins, in which case, the coal seams would not be formed in all the basins simultaneously, nor would they occupy similar positions in the series in different localities.

The Tertiary beds in Upper White River district are thought to correspond to the members of the Kenai series because they lithologically closely resemble the rocks of this formation seen in other localities, and because they contain fossil wood and lignite, of which the wood is somewhat indefinite but indicates at least a Tertiary period of deposition.

NEWER VOLCANICS.

Distribution.

An important group of volcanic rocks which are dominantly at least of post-Eocene age and are extensively developed in Upper White River district, is here for convenience designated as the "newer volcanics." These are confined practically entirely to the southwestern corner of the area, and are exposed mainly along the higher or southwestern portion of the mountain group which lies to the west and southwest of Lake Tchawsahmon valley. These volcanics thus extend along the International Boundary line from about 5 miles south of Beaver creek, to past the southern edge of the district, and continue westward and southwestward to the Wrangell mountains, where they are most typically and extensively developed.

Lithological Characters.

These newer volcanics consist mainly of lavas, but include as well, numerous intercalated ash and breccia beds. These rocks present, characteristically, a bright, fresh appearance and are contrasted in this respect with the dominantly dull appearing older volcanics of the district. Black and grey tones predominate, but lavender, and dark bluish slate colours occur, as well as various shades of pink and red which are very striking, the reds ranging from a dull brick colour to a bright vermilion hue. The tuffs and breccias, which are prevailingly lighter in appearance than the lavas with which they are interbedded, are generally ash coloured or some shade of grey, or yellow. These lavas and accompanying fragmental rocks have a maximum thickness in Upper White River district of about 3,000 feet, and are piled up as a series of superimposed sheets lying in most places, nearly horizontal. They, however, dip gently away from the extrusive vents, and the lower beds and flows naturally conform to the topographic features over which they have accumulated. Particularly where considerable sections of these rocks are exposed, as on the eastern face of Centre mountain and in the vicinity (Plate XIII), the entire volcanic group or series has a general stratified aspect, and the alternating grey, green, black, yellow, and red shales present a bright, vari-coloured appearance which constitutes one of the most striking pictorial features of the district. The lavas have also a characteristically well-marked columnar structure, and the tuffs and breccias weather in many places to form tall, irregular, craggy pillars or "hoodoos" which are as much as 50 feet in height, corresponding to the thickness of the beds from which they were derived.

These extrusive lavas are for the greater part porphyritic rocks of medium coarseness, containing phenocrysts of the intermediate feldspars, basaltic hornblende, pyroxene, biotite, or olivine. The feldspars are generally present and in many specimens, two or three of the bisilicates occur together. These volcanics are mainly augite andesites, diabases, or basalts, although there appears to be a practically complete series of transitional forms from fairly acidic andesites to olivine basalts. In texture, these rocks range from glassy to holocrystalline, and from extremely pumiceous to quite dense. They are, in addition, dominantly amygdaloidal, the amygdules being in most cases empty, although in some of the older members, they are partly or entirely filled mainly with calcite, zeolites, epidote, or chlorite. These newer volcanics thus differ from the amygdaloids of the older volcanic group, in which the amygdules are prevailingly occupied by secondary minerals.

In addition to these extrusive facies, dykes and other intrusive forms pierce not only the rocks older than the lavas themselves, but in addition cut the earlier members of this group. These intrusives are dominantly dense, dark, greyish green to nearly black rocks having a marked basaltic habit.

When examined under the microscope these volcanics are seen to possess mainly a porphyritic structure, the groundmasses ranging from partly glassy or hypohyaline to holocrystalline, but being rarely coarser than microcrystalline. Pilotaxitic structures characterize the groundmass of many of the holocrystalline porphyritic types, but when a certain amount of brownish glass occurs in the groundmass, the structure is designated as hyalopilitic. Some specimens also possess a typical ophitic structure which is diagnostic of the diabases.

The dominant minerals comprising these volcanics are lime-alkali feldspar, ranging from oligoclase to basic labradorite, some alkali feldspar, augite, hypersthene, diopside, basaltic hornblende, biotite, and olivine. Iron ore is also abundant in the more basic members; in addition other accessories occur, as well as a number of secondary alteration minerals including, mainly, calcite, chlorite, and epidote.

Equivalent volcanics under the name, Wrangell lavas, have been described in considerable detail by Mendenhall[1] and

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[1] Mendenhall, W. C., "Geology of the Central Copper River region, Alaska": U.S. Geol. Surv., Prof. paper, No. 41, 1905, pp. 54-62.

also by Moffit and Knopf,[1] so no repeated lengthy technical descriptions will be here included.

It might be expected that a series of lavas which have been outpoured throughout such a long period of time, might exhibit considerable lithological, mineralogical, and chemical differences between the earlier and later members, and such distinctions might even be supposed to gradually and persistently accumulate. From the investigations that have been conducted, however, the main differences seem to be mainly that the more recent flows are fresher in appearance and have more tendency to be glassy than those first extruded. In fact, throughout the district only the very recent rocks are glassy in appearance; the older lavas never are. This would indicate that the glassiness tends to disappear with age.

Origin.

It is somewhat doubtful whether or not these lavas were erupted from the volcanic vents in the Wrangell mountains, although the lavas persist thence to Upper White River district, and throughout are apparently of the same age and possess the same characteristics. It would seem, however, that the lavas in this district are in part, at least, of local origin, as numerous large related dykes occur which cut the underlying rocks, and even in some cases pierce the older members of this group. From these conduits thus the lavas were probably extruded.

Age and Correlation.

These lavas in Upper White River district, cut and overlie the Tertiary sediments (Kenai (?)) and are thus at least post-Eocene in age. No evidence was obtained, however, indicating that any of these rocks have been extruded in Recent times, as in the Wrangell mountains. These lavas, also, as mentioned before, correspond with similar volcanics to the west and southwest where they have been studied in detail by Mendenhall, who named them the Wrangell lavas, and who considers them

[1] Moffit, F. H. and Knopf, Adolph, Op. cit., pp. 32-36.

to range in age from about Eocene time to the present. He states: "These flows, therefore, instead of preceding the deformation of the early Tertiary plain, are later than the dissection which followed its uplift, and are to be regarded as very recent indeed."[1]

Rhyolite-Latite Volcanics.

Distribution.

Certain rhyolites, latites, and related rocks which occur in Upper White River district, are in this memoir, for convenience in description, designated as the rhyolite-latite volcanics. These rocks are restricted in their occurrence practically entirely to the mountainous area lying north of White river and southwest of Lake Tchawsahmon valley, and even there, they have only a relatively slight areal development. Throughout this area, narrow dykes of these rocks are somewhat plentifully distributed, and at a few points, surface flows or larger intrusive bodies occur. These volcanics are most extensively developed along the eastern portions of Rabbit and Canyon mountains, but also comprise a small mountain lying about 2 miles to the north of the summit of Rabbit mountain. These larger developments range from 1 to 3 miles in their greatest dimensions, but in width nowhere do they exceed a mile and in most places, they are not more than one-quarter to one-half mile wide.

Lithological Characters.

The members of this rhyolite-latite group consist of certain light coloured porphyritic rocks ranging from nearly white, light grey, or yellowish, to pale lavender or darker greenish grey shades. The groundmass is invariably cryptocrystalline or too finely textured for the component minerals to be discernible with the unaided eye, and the phenocrysts include mainly feldspars, hornblende, and biotite.

Volcanics representing possibly the most extensively developed facies of this group, have a pale lavender or greenish

[1] Mendenhall, W. C., Op. cit., p. 57.

grey groundmass which includes numerous fine, needle-like hornblende phenocrysts. These rocks are well exposed along Rabbit creek where they have a marked and very perfect vertical prismatic jointing, the columns being in places 50 feet or more in height (Plate XIV). Members of another characteristic and more acidic rhyolitic type consist of a white to light grey groundmass which is in places stained yellow with iron, and in this groundmass are embedded occasional quartz and feldspar phenocrysts, the quartz being prevailingly in four or six-sided, often corroded forms. Rocks of both of these types break characteristically into irregular, thin plates or slabs which exhibit a roughly conchoidal fracture, and give a clear ringing sound when struck with a hammer. In places, these volcanics assume a somewhat more coarsely grained appearance, due to phenocrysts of feldspar, biotite, and hornblende becoming more abundant—such rocks apparently represent somewhat deeper seated phases of the types just described, there being all transitional forms between the different facies.

These rocks are in places pumiceous or amygdaloidal, and are all notably rough to the touch, the lighter coloured varieties in particular having often somewhat the appearance of brick on a fresh fracture.

Under the microscope, these rocks are seen to consist dominantly of quartz, alkali feldspar, lime-alkali feldspar, hornblende, and biotite, with accessory apatite, zircon, and iron ore. The groundmass is dominantly micropegmatitic or granophyric, consisting mainly of quartz and feldspars, or feldspars mainly, with which are associated some of the ferromagnesian minerals.

The rocks range in mineralogical composition, from typical rhyolites to types midway in composition between andesites and the rhyolite-trachyte group, and thus include latites and even certain holocrystalline porphyritic types, corresponding to quartz dioriteporphyrites. In the rhyolites, the phenocrysts include mainly quartz, orthoclase, and an acid plagioclase, but in the latites, plagioclase, hornblende, and biotite are prominent.

Age and Correlation.

These volcanics cut the newer volcanics wherever members of the two groups come in contact, showing that the rhyolite-latite volcanics are at least of late Tertiary and possibly early Pleistocene age. In places even, as on the eastern face of Rabbit mountain, they have flowed over the present land surface since it has become uplifted and eroded to nearly its present form, the topographic features having since been modified only by glacial action and recent erosion.

Superficial Deposits.

General Statement.

The superficial deposits of Upper White River district include mainly gravels, sands, silts, boulder clays, muck, soil, ground-ice, and volcanic ash, some of which are of glacial origin, some are the result of volcanism, and other members again have been produced by ordinary subaërial destructive agencies. The great mass of all these Quaternary accumulations is, however, due either directly or indirectly to ice action, but ordinary eroding and disintegrating processes have produced a certain minor amount of recent detrital materials which constitute a thin mantle covering the land surface nearly everywhere. The volcanic ash is a very notable feature of the district, but occurs mainly to the south of White river. The ground-ice, as in most parts of this northern region, remains in most places throughout the entire year, and occurs just below the surface vegetation.

On the geological map of Upper White River district accompanying this memoir, the colour representing Quaternary superficial deposits is employed mainly to indicate the occurrence of the main heavy valley accumulations where the nature of the underlying bed-rock is very uncertain or totally unknown; but it does not include the thin irregular mantle of dominantly recent materials which extend over the uplands and through which the bed-rock is frequently exposed and is thus fairly well known. This geological colour thus really represents, for the greater part, the main deposits of glacial origin, and serves the double purpose of affording information concerning the position and extent of these deposits, and also depicts in somewhat striking fashion, the valley systems of the district.

Glacial Deposits and Glaciation.

Since a study of the deposits which are the result of glacial action necessarily involves a consideration of the glaciers which produced them, a brief description of the glaciation of this district will be here included with that of the accumulations resulting therefrom. Also, although there is at present no glacial ice actually within Upper White River district there is abundant evidence to show that at no very distant geologic time it occupied the greater part of the area. The glaciers have now, however, retreated to the higher Skolai-Natazhat mountains to the south where extensive ice fields still remain. Thus a study of these present day glaciers and their activities, although outside of the district here particularly under consideration, will help to elucidate and exemplify the operations and processes formerly so active within this area, and some of which are still there in evidence far beyond the edges of the ice itself.

The St. Elias range, or that particular division of this topographic terrane, the Skolai-Natazhat mountains, which extend along the southern edge of Upper White River district, is capped by glacial ice which, as seen from White river, appears to include all the range above an elevation of about 7,500 feet. This glacial feeding ground, although only slightly explored, except along the International Boundary, is known to be one of the most important distributing centres in the entire Coastal system, and all the larger valleys that head back in these mountains contain valley glaciers. White river, which heads in the northern lobe of Russell glacier, is possibly the main glacial outlet for these mountains along their landward slope, although the Generc which heads in Klutlan glacier, is a very important tributary.

This great St. Elias ice cap formerly extended down the valley of the White to about the mouth of Donjek river, and included all of Upper White River district except some of the higher peaks and ridges which projected above the glaciers, the total areal extent of the projecting points being small. This is evidenced by glacial groovings and markings, as well as by the presence of morainal and other glacial materials deposited by the ice, considerable accumulations of which occur at elevations of between 5,000 amd 5,300 feet above sea-level. Large erratics were also noted at altitudes exceeding 5,000 feet, and one individual 12 feet in diameter was discovered at a height of 5,200 feet above the sea, or about 2,200 feet above the level of Lake Tchawsahmon valley opposite (Plate IX).

The existing glaciers along the northern face of the Elias mountains are exerting to-day a profound influence in shaping their containing valleys, and the same effects are plentifully in evidence in Upper White River district, as a result there of the former ice invasion. These valley glaciers are scouring, rasping, plucking, and undermining the rock, and this quarried and more or less ground and comminuted material is transported by the ice and deposited along its sides, ends, and underneath it, and eventually is largely transported by the streams flowing from the terminus of the melting ice. The result is that, due to their former ice occupation, the valleys of Upper White River district have been deepened and widened, particularly near their floors, and have been changed from normal V-shaped to typical U-shaped depressions. Projecting spurs and other obtruding or angular surfaces have been removed in places, giving the valley walls a planated surface, all portions of which tend to be brought into alignment as is well shown along the western edge of Lake Tchawsahmon valley (Plate X). The ice also by its efficient eroding and quarrying processes, tends to steepen the valley gradients near the head of the glacier, and by the deposition of detritus reduces the gradient lower down.

The glaciers have thus acted in a two-fold capacity, as in addition to the destructive processes just described, they have also contributed vast quantities of detrital deposits to the main valleys of the district, and have thus been constructive in their operations. All materials transported by the ice, either included in it, carried on its surface, or moved along under it, are eventually deposited at its terminus or along its sides, and when the ice retreats, these remain as morainal accumulations in the valley bottoms. Such deposits consist of a heterogeneous mixture of angular or only partly rounded rock particles of all sizes, the included boulders being possibly striated or scratched. Vast amounts of such morainal accumulations are now distributed over the bottoms of the larger valleys in Upper White River district, particularly of Lake Tchawsahmon valley and the depression north of the Nutzotin mountains. During the ice occupation, transporting waters also occasionally flow through or under the ice, and after the retreat of the glaciers, streams bring down enormous amounts of material of all sizes, the fine being naturally carried farther from its source than the coarser. During seasons of rapid melting when the glacial streams are in flood, they are in addition able to transport vastly more and coarser material than at other times. Thus, the outwash deposits become very extensive, and great quantities have accumulated over the flood-plains of all the glacier-fed drainage ways of Upper White River district, due to these waters having been overloaded for so long a period of time. In fact, both the moraines and water-laid accumulations of glacial origin constitute in this area very important topographic features. The outwash deposits along the valleys of White and Generc rivers in particular, are very extensive and constitute wide gravel and silt bars over and around which the streams constantly shift their channels, anastomosing streams being nearly everywhere in evidence. It is these glacial silts that apparently give to White river its muddy colour, and it is these also when deposited, that constitute the treacherous quick sands which characterize the valley flood-plain. Thus, deposits of glacial origin have been accumulating in portions of Upper White River district from the beginning of the Glacial period to the present.

The glacial materials produced include mainly gravels, sands, silts, and boulder clay, vast quantities of which not only floor the main valleys of the district, but extend in places well up into the uplands. Along the main streams, the unsorted morainal accumulations have been partly or largely removed and replaced by outwash stream-laid deposits. The various glacial materials are as much as one hundred and in places probably several hundred feet in thickness. Moffit and Knopf have estimated that in the vicinity of the 141st meridian, these accumulations in White River valley have a thickness of at least 400 feet and possibly greatly exceed this amount.[1]

Boulder clay was noted at a number of points, but is particularly conspicuous along the left limit of White River between Miles ridge and Horsecamp hill where it forms a bed about 30 feet thick, which is exposed in the scarped river bank for a distance of about 3 miles. Another noticeable exposure occurs along the eastern end of Miles ridge.

These various materials as well as the glacial ice itself have had a profound effect also on the drainage systems of the district, and many of the changes in stream courses are attributed originally to glacial damming. Even master streams have been turned from their valleys, and these wide depressions are now occupied only by small tributaries or lakes, the latter being due to reversed slopes having been produced by the accumulation of glacial materials. In some cases, also, as discussed in the topographic chapter of this report, these drainage changes have involved the main river systems of the region, and are even thought by some writers to have diverted the waters of considerable areas from the Pacific ocean to Bering sea.

Volcanic Ash.

One of the most interesting of the Recent deposits is a layer of volcanic ash or pumiceous sand which extends over the greater part of Upper White River district and is particularly prominent to the south of White river. Wherever observed within the district, this ash bed has a thickness of from 1 to 3 inches where not concentrated by wind or water since being deposited. One of the best exposures noted, occurs about one-third mile up Kletsan creek from White river, where a well defined layer about 3 inches in thickness is exhibited in a scarped bank.

This ash lies at or near the surface, the vegetation, where any occurs, being rooted in it. It is also of very recent occurrence and has fallen since the present waterways cut their courses to approximately their present depths. In general appearance

[1] Moffit, F. H., and Knopf, Adolph, Op. cit., p. 41.

it resembles a white to light yellow, coarse sand, the grains of which are dominantly pumiceous and light enough to float on water. The individual particles noted in Upper White River district range in size in most cases, from about 1 mm to 5 mm in diameter, although occasional pieces occur that are twice or three times the size, and on the other hand, much finer material was also observed in places. In some of the larger pieces, minute biotite plates, as well as prisms of hornblende, occur. Farther south, this volcanic ash becomes rapidly thicker, and along the edge of the St. Elias mountains it has, as seen from a distance of a mile or so, much the appearance of snow drifts. There individual particles are as much as 5 inches in diameter. Thus, the source of this material can be at no great distance, and is probably situated somewhere along the northern portion of these mountains south of Upper White River district.

This ash bed appears to correspond to and constitute a portion of a layer of volcanic ash that covers an extensive area farther east in Yukon, reaching from Lake Bennett northward to below Selkirk on Yukon river.[1] This ash also extends to the west of Upper White River district into Alaska where it has been described by Moffit and Knopf as occurring in the Nabesna-White Rivers districts. These authors also mention that a similar layer of volcanic ash was found on the Yukon at a point about halfway between Circle and Fortymile.[2]

Since Schwatka's trip down the Yukon in 1883,[3] it has been known that a layer of volcanic ash covers a considerable area in southern Yukon. Dawson[4] has also given a somewhat detailed account of this occurrence, but Hayes[5] is believed to have

[1] Cairnes, D. D., "Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district": Geol. Surv., Can., Memoir No. 5, 1910, p. 47. "Wheaton district, Yukon Territory": Geol. Surv., Can., Memoir No. 31, 1912, pp. 73-74.

[2] Moffit, F. H., and Knopf, Adolph, Op. cit., pp. 42-44.

[3] Schwatka, Frederick, "Along Alaska's great river": 1885, p. 196.

[4] Dawson, G. M., "Report on an exploration in the Yukon, N. W. T., and adjacent northern portions of British Columbia": Ann. Rept., Geol. and Nat. Hist. Surv. of Can., Vol. III, Pt. 1, 1887-88, pp. 43 B-46 B.

[5] Hayes, C. W., "An expedition through the Yukon district": Nat. Geog. Mag., Vol. IV, 1892, pp. 146-150.

first described this ash from Upper White River district. He found that this material rapidly increases to the south of White river, and that along the face of the St. Elias mountains it is from 75 to 100 feet in thickness. He also states, "Taking the approximate limits of the deposit, as observed on the Yukon by McConnell, on the Pelly and Lewes by Dawson, and on the Teslin and at Skolai pass by the writer, it will be seen to cover an oval area, with the maximum thickness near the western extremity. The oval area is about 370 miles from east to west, and 220 from north to south, or about 52,280 square miles. Assuming the deposit to be in the form of a flat cone with the above base and a vertical height of but 50 feet, its volume amounts to 165 cubic miles of material."[1]

Both Hayes and Dawson have collected considerable data bearing on the age of this material and both agree that it must be at least several hundred, but is probably less than 1,000 years old.

Probably the most notable features concerning this ash, are its remarkably even and wide distribution, and the fact that as originally deposited, it occurs practically everywhere as a single bed undivided by any intercalated layers of foreign material. At a few points, however, two layers have been found separated by several inches of peat or other material, but in each of such places it is uncertain whether the upper layer was washed or drifted to its present position after being ejected, or whether these two beds represent two distinct eruptions. This ash would thus appear for the greater part at least to have fallen very tranquilly, somewhat like snow, and to have come all at one time which must have been of short duration, possibly not exceeding a few days or even hours.

Hayes also attributes the colour of White river largely to this ash deposit and states: "This turbidity has been attributed to the glacial source of the river, but glaciers could scarcely supply such an enormous quantity of mud unless acting under peculiar conditions. The presence of this great deposit of unconsolidated material, which is being ground up by the ice and

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[1] Idem, p. 148.

removed by the subglacial streams, affords a ready explanation of the turbidity of the water. The highly vesicular character of the tufa permits a much larger amount of it to be held in suspension than of sediments derived from compact rocks."[1]

Other Recent Accumulations.

In addition to the volcanic ash and certain of the glacio-fluvial deposits, other superficial materials have accumulated throughout the district during Recent times, which are due to ordinary eroding and disintegrating processes as well as to the sub-Arctic temperature conditions. These materials include dominantly fluvial and littoral sands and gravels, muck, peat, soil, and ground-ice, and constitute a thin mantle covering the district nearly everywhere except on steep slopes and escarpments where they have no opportunity to accumulate.

The sands and gravels occur mainly along the lakes and smaller tributary streams which are not fed by glaciers. The peat and muck, which are in places several feet or even yards in thickness, occur mainly around the lakes, as these occupy imperfectly drained portions of the valleys, favourable for such accumulations. In addition to the muck and related deposits of the valleys, a thin layer of other soils and decomposition products in the process of becoming soil, form the uppermost geological deposit not only in the valleys, but also on some of the more level portions of the uplands.

Below the immediate vegetation of the surface, the ground is in most places frozen. The ground-ice occasionally is clear, resembling glacial ice, and in such cases represents small lakes which have congealed. In origin, however, the ground-ice differs little from that of frozen soil, and remains throughout the entire year, except along stream cuttings and in places where the overlying vegetation and muck have become removed. These materials act as insulating non-conductors of heat, and when stripped from the surface, the ice below is readily melted by the heat of the sun during the summer months.

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[1] Idem, p. 150.

Due to the sub-Arctic temperature conditions also, normal stream erosion is greatly augmented by various agencies which are in this region abnormally effective. These include, primarily, frost action, expansion and contraction due to rapid and considerable temperature changes, and nivation. These processes have been investigated and described by the writer[1] for neighbouring portions of Yukon and Alaska and have been shown to be extremely important eroding and disintegrating agencies.

GENERAL GEOLOGICAL SUMMARY.

All the more important points concerning the general geology of Upper White River district, so far as they are known, will now be briefly reviewed, and will be considered as nearly as possible in the order in which they occurred. This presentation of the succession of geological events will thus really constitute the geological history of the area. The information available is of necessity somewhat fragmentary, and the records of certain periods have been almost or entirely destroyed; still a systematic treatment of all the known data may help to a better understanding of the many vicissitudes through which the district has passed.

The oldest rocks known to occur in Upper White River district are included in the Yukon group, and consist mainly of mica schists, quartz-mica schists, quartzite schists, and schistose amphibolites, which are considered to be of Pre-Cambrian age. These rocks have only a slight areal development within the district, and are so highly metamorphosed that they afford very little information concerning this early period in the geological history of the area. They only show that great thicknesses of arenaceous and argillaceous sediments were deposited in a Pre-Cambrian (?) sea which occupied this region at that time, that these sediments have been invaded by various igneous rocks, and that all have since become so metamorphosed as to be dominantly schistose or gneissoid in character. These rocks, however, constitute a portion of a group of rocks which have an extensive development to the north and west in Alaska and

[1] Cairnes, D. D., "Differential erosion and equiplanation in portions of Yukon and Alaska": Bull. Geol. Surv., Amer., Vol. 23, 1912, pp. 333-348.

Yukon, and are of great economic interest, as it is from the schistose members of the Yukon group that the gold of the Klondike and of most of the other more important placer camps of Alaska and Yukon has been derived.

Much more recent than these schists, but still apparently older than all the other rocks of the district, are the Carboniferous sediments. These beds include mainly shales, sandstones, conglomerates, and limestones, having an aggregate thickness of at least 2,000 feet and of possibly twice this amount; and in the limestone members in particular, fossil remains are fairly plentiful. These remains, so far as they have been examined, are dominantly Upper Carboniferous, but a few specimens collected both in Upper White River district and in the neighbouring Nabesna-White Rivers district, according to Dr. Girty, who examined them, suggest a Lower Carboniferous age for the beds in which they were found.

The records of these Carboniferous beds thus show that the sea reigned over this region during the latter part of Carboniferous time and probably throughout this entire period, and that its waters contained an abundance of animal life. Arenaceous, argillaceous, and calcareous sediments accumulated over this sea floor until they were in places possibly 3,000 to 4,000 feet in thickness. The normal course of sedimentation was, however, repeatedly interrupted in certain localities by volcanic activity, as a result of which andesitic and basaltic lavas were extruded, and tuffs and breccias were ejected. In adjoining portions of Alaska, these volcanics are claimed to occur interbedded with the sediments, and in Upper White River district it seems probable that certain members of these older volcanics are contemporaneous with the Carboniferous sediments, but of this no direct proof was obtained.

Marine occupation with its accompanying sedimentation apparently continued from Carboniferous until well into Cretaceous time, and during the Mesozoic epoch, arenaceous and argillaceous sediments were deposited which have now become altered into shales, argillites, sandstones, greywackes, and conglomerates. These beds are extensively developed within the district, and have an aggregate thickness of at least 1,000 feet.

They are, however, only sparsely fossiliferous, the only fossil remains that were found being of Cretaceous age. To the west in Alaska, however, apparently corresponding sediments contain Jurassic and even Triassic fossils as well Thus in all probability Jurassic and possibly Triassic members also occur in Yukon, but the beds there are either unfossiliferous, or if present the fossil remains were unfortunately not collected.

Throughout the western portions of British Columbia and southern Yukon, a widespread crustal movement occurred in Jurassic and possibly late Jurassic time, which was possibly the greatest in the history of this region, and was accompanied by the intrusion of vast amounts of igneous materials including a great part, at least, of the rocks composing the Coast Range batholith. This geological terrane is composed dominantly of plutonic rocks which range in composition from that of an acid granite to a basic gabbro; but are for the greater part, apparently diorites and granodiorites. These intrusives exhibit throughout a characteristically granitic habit, are prevailingly fresh and unaltered in appearance, and have a dominantly greyish colour, although pinkish, reddish, and greenish shades occur. At the close of the Jurassic disturbance a considerable area was above the sea, and what was probably a short period of erosion ensued.

This earth movement, with its accompanying igneous intrusion, did not apparently extend sufficiently far north to directly affect Upper White River district, the Coast Range batholith being not exposed north of about latitude 61° in the vicinity of Lake Kluane. Some of the Jurassic or Cretaceous conglomerates of the district, nevertheless, contain an abundance of granitic pebbles and boulders that are evidently a result of the subsequent brief erosion period which followed to the south.

The Jura-Cretaceous sediments of Upper White River district have, however, been invaded by granitic intrusives which lithologically very closely resemble the rocks of the Coast Range batholith and also are indistinguishable from the granitic pebbles in these same Jura-Cretaceous sediments themselves. These intrusives occur in Upper White River district in the form of isolated bosses or batholithic masses of no great extent, but are almost undoubtedly closely related to, or constitute outlying portions of the Coast Range batholith to the south. There, also, the Jura-Cretaceous sediments have been extensively invaded by the Coast Range intrusives which are, in the field, indistinguishable in character from the granitic pebbles and boulders that constitute, to a considerable extent, the lower conglomerate beds of the Laberge (Jura-Cretaceous) series. It is evident therefore, that granitic intrusions, apparently all derived from the same parent magma, have invaded this same general belt at different and, in some places, widely separated periods ranging from some time in the Jurassic until at least towards the close of the Cretaceous.

The Mesozoic epoch, and particularly the later part of it, was also characterized by volcanic activity as a result of which the Mesozoic and Carboniferous sediments became extensively invaded by andesites, diabases, basalts, and related rocks. These constitute the later members of the older volcanic group of the district and are lithologically very similar to the Carboniferous members in Alaska to the west. They are also indistinguishable from corresponding members on Upper White River district, provided any of these rocks are really of Carboniferous age. These older volcanics, wherever observed in this district, either cut or overlie the Cretaceous-Carboniferous sediments and would thus appear to be all of late Mesozoic age. However, considerable evidence has been obtained in the Nabesna-White Rivers district to the west, indicating that some of these members are of Carboniferous age. It is thus considered possible that these older volcanics represent a long intermittent period of volcanism extending from Carboniferous until late Cretaceous time. These volcanics, along the main Nutzotin range in Upper White River district, are dominantly intrusive into the surrounding formations, and are very intimately associated with the Cretaceous-Carboniferous sediments, so much so in fact, that in many places the geological formation really consists of a complex of the sedimentary rocks and intrusive volcanics. These volcanics, however, occur both as extrusives and intrusives, and to the south and southwest of Lake Tchawsahmon valley, andesitic and basaltic flows, with occasional accompanying tuffs and breccias, are somewhat extensively developed, and are also apparently of local origin.

The Mesozoic period of sedimentation was terminated at about the close of Cretaceous time, by a widespread deformation, at the close of which a considerable area, including apparently all of Upper White River district and the greater part at least of southern Yukon, was above the sea. Degradation became active, and no evidence has been obtained to show that from then to present time, any portion of this region has been subjected to marine conditions.

During early Tertiary time fresh-water sediments were deposited throughout considerable portions of Yukon and Alaska. These beds were apparently for the greater part at least, deposited in isolated basins, and now consist mainly of friable, partly consolidated sandstones, shales, and clays, which in places contain seams of lignite. In Upper White River district these beds, which are considered to belong to the Kenai series, have only a slight development but occur throughout three small areas. They are nearly flat-lying wherever exposed, and are thus contrasted with the Mesozoic sediments which are extensively and in places even minutely deformed, closed folding being characteristic of the structures in many localities. It is thus evident that previous to the deposition of the Eocene beds, and after the deposition of the Cretaceous sediments, an extensive and far reaching period of deformation ensued corresponding apparently to the Laramide revolution elsewhere.

After the deposition of the Kenai beds, a gradual uplift occurred which, though of orographic character, was in places accompanied by volcanic activity and by a considerable local disturbance of the Eocene sediments. This movement affected apparently all of the Yukon plateau province, as well as the Nutzotin mountains and other members of the Coastal system. The exact date of this orogenic disturbance is somewhat in doubt, but Brooks[1] has produced considerable evidence to show

[1] Brooks, A. H., "The geography and geology of Alaska": U.S. Geol. Surv., Prof. paper, No. 45, 1906, pp. 292, 293.

that it occurred during late Eocene or early Miocene time. A long period of crustal stability ensued during which, what is now the Yukon plateau was reduced to a nearly featureless plain which was subsequently elevated. Spencer,[1] Brooks,[2] and other writers, also, maintain that during the time the Yukon plateau was being peneplanated, extensive tracts in the adjoining Rocky Mountain and Coastal systems, including the Nutzotin mountains, were also reduced to a like condition. The writer considers the available evidence to indicate that during the period the Yukon plateau was being planated, the adjoining portion at least of the Nutzotin mountains included in Upper White River district, was subjected to extensive erosion, as discussed in the topographic chapter of this memoir. There appears, however, to be no satisfactory reason for supposing that this terrane was ever reduced to a plain-like condition. It would appear rather that at the close of the erosion cycle this mountain tract still possessed considerable relief.

The planation of the Interior plateau province according to Dawson,[3] was accomplished during the Eocene; he further maintains however, that after a period of volcanism, accumulation, deposition, and local slight folding during the Miocene, denudation again reduced the region nearly to the base-level of erosion in late Miocene or post-Miocene time. Brooks[4] claims that the Yukon plateau as well as other adjoining tracts, were planated after the late Eocene or early Miocene uplift, and agrees with Dawson in considering that the upwarp subsequent to this planation period occurred in Pliocene or early Pleistocene time. Spurr, however, shows that the erosion of the Yukon plateau was contemporaneous with the deposition of the Miocene strata in the lower valley of Yukon river, and therefore, urges that the Yukon plateau was planated in Miocene

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[1] Spencer, A. C., "Pacific Mountain systems in British Columbia and Alaska": Bull. Geol. Soc. Amer., vol. 14, 1903, pp. 117-132.

[2] Brooks, A. H., Op. cit., pp. 286-290, 293.

[3] Dawson, G. M., "On the later physiographical geology of the Rocky Mountain region in Canada, with special reference to changes in elevation and the history of the glacial period": Trans. Royal Soc., Can., Vol. III, Sec. IV, 1890, pp. 11-17.

[4] Brooks, A. H., Op. cit., 290, 292, 293.

time, and was subsequently uplifted in late Miocene or early Pliocene time.[1]

In Upper White River district, the available evidence indicates that the planation period was at least subsequent to the deposition of the Kenai beds. These sediments, occurring as they do in the Nutzotin mountains, do not constitute a portion of the planated surface, but elsewhere in Yukon and Alaska Kenai beds are exposed within the Yukon plateau, and constitute portions of the planated plateau surface. In Upper White River district, however, these beds were at least uplifted after their deposition and before the Glacial period. This district was thus apparently eroded and in part peneplanated during late Eocene or post-Eocene pre-Pliocene time, and was subsequently uplifted to practically its present position during late Miocene, Pliocene, or early Pleistocene time.

Also, as discussed more fully in the topographic chapter of this memoir, the writer considers the bulk of the available evidence to indicate that both the northern or Yukon plateau portion, and the southern or Nutzotin Mountains section of Upper White River district, were synchronously uplifted. The abrupt contact between the portions of these two provinces is believed to be due to several causes. In the first place, the Nutzotin mountains just previous to being uplifted are thought to have possessed considerable relief as compared to the plain-like contour of the adjoining Yukon plateau province; and, further, being situated nearer the edge they would be uplifted higher than the more northerly areas which lie nearer the central axes of the upwarped tract. This initial difference in altitude at the commencement of the present cycle would also naturally tend to be rapidly accentuated by erosive processes, and a fairly sharply drawn contact would soon be produced. Some writers, however, maintain that since the general uplift of the region, the mountain tract has been faulted above the plateau province to the east and that the somewhat abrupt contact between mountain and plateau provinces represents a fault scarp.

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[1] Spurr, J. E., "Geology of the Yukon Gold district, Alaska": U.S. Geol. Surv., 18th. Ann. Rept., Pt. III, 1898, pp. 260, 262, 263.

The Tertiary period, particularly after Eocene time, was also one of persistent volcanic activity. Successive lava flows, with intercalated pyroclastic beds, attain in places in Upper White River district a thickness of 3,000 feet, and have deeply buried the older formations throughout the greater portion of the mountain group which occupies the southwest corner of the area. These rocks are dominantly of an andesitic or basaltic nature and are brightly coloured, fresh looking, and prevailingly glassy, pumiceous, or amygdaloidal in structure. They are thus contrasted in appearance with the more dense, dull appearing members of the older volcanic group. These lavas are also in most places nearly flat lying, and have a general stratified aspect. In the Wrangell mountains, they have been extruded from about the close of Eocene time until the present, but in Upper White River district, there is no evidence of any volcanic activity since the commencement of the Glacial period. It is uncertain whether or not these lavas came from the Wrangell mountains, but since numerous related large dykes occur within Upper White River district it seems more probable that these indicate the vents through which the lavas have been extruded.

Mendenhall, who has studied these Wrangell lavas in considerable detail, states that they "flowed out not over a plain but over a region of considerable topographic diversity, one steep ridge of older rocks, at least 3,000 feet high, having been buried by the successive eruptions. These flows, therefore, instead of preceding the deformation of the early Tertiary plain, are later than the dissection which followed its uplift, and are to be regarded as very recent indeed."[1] Moffit and Knopf, however, state in this connexion: "These observations prove that the beginning of volcanic activity put an end to sedimentation, and that the lavas do not everywhere rest upon a surface of erosion as assumed by Schrader and Spencer."[2]

In pre-Glacial time, but after the extrusion of at least most of the Wrangell lavas, a series of volcanics, comprising mainly latites, rhyolites, and related rocks, invaded Upper

[1] Mendenhall, W. C., "Geology of the Central Copper River region, Alaska": U.S. Geol. Surv., Prof. Paper, No. 41, 1905, p. 57.

[2] Moffit, F. H., and Knopf, Adolph, Op. cit., p. 35.

White River district. These occur both as intrusives and extrusives, and apparently all originated from local vents. They are, however, of only relatively slight areal extent, but are interesting as being so recent.

After the last great uplift of the district, the streams began rapidly trenching their valleys in the upwarped surface, and soon deep V-shaped incisions resulted, and the waterways and valley systems became established. At a later date the St. Elias mountains to the south became the gathering ground for glaciers, and huge tongues of ice came down White River valley and its tributaries, extending to about the mouth of Donjek river and including all of Upper White River district except occasional projecting high summits and ridges. The main valleys of the district were deepened and widened and given typical U-shaped cross-sections, and their walls were scoured and planated by ice action. Vast amounts of morainal and other glacial accumulations were also deposited on the valley floors, as well, in places, as along portions of the valley walls, and on the uplands to an elevation exceeding 5,000 feet above sea-level. These deposits greatly disorganized the drainage system of the district, diverting streams from their channels and necessitating their cutting new ones, and in some cases even master streams were forced to follow other valleys, leaving their former containing depressions occupied only by lakes or small tributaries. The accumulation of morainal material also in places dammed the lower portions of valleys, and thus produced reversed slopes, giving rise to lakes of various sizes, such as Lake Tchawsahmon.

In addition to the glacial deposits which have been accumulating from Pleistocene time to the present, and are thus of both Recent and Pleistocene age, a thin layer of other Recent accumulations mantles the district nearly everywhere, even in most places overlying the glacial deposits. These Recent accumulations have been produced dominantly by ordinary eroding and disintegrating processes, but include materials due to volcanism and also to the sub-Arctic temperature conditions there prevailing. These deposits include fluvial and littoral sands and gravels, peat, muck, soil, ground-ice, and volcanic ash.

CHAPTER IV.

MINERAL RESOURCES.

GENERAL STATEMENT.

The mineral resources of Upper White River district include deposits of gold-bearing quartz, gravels containing placer gold, copper deposits, and lignite. These will be described in regular order, the gold-bearing deposits being first considered, then the copper deposits, and finally the lignite seams. In connexion with the placer gold deposits, those of Upper White River district, itself, will be first considered, and then a brief account of the recently discovered Chisana gold fields, Alaska, will be given; as owing to the proximity of these two districts to one another, and also on account of their geological similarity, it is hoped that an understanding of the conditions prevailing in Chisana district may be helpful in prospecting and developing the adjoining Canadian territory to the east.

GOLD.

UPPER WHITE RIVER DISTRICT.

LODE DEPOSITS.

Occurrences.

Gold-bearing lode deposits occur in Upper White River district, mainly on Baultoff mountain and vicinity, and along Beaver and Rabbit creeks. A considerable number of mineral claims have been staked on these various deposits at different times, the greater number of the locations having been made since the spring of 1905. Quite a number of claims have also been located at various points throughout the district, on which there is no evidence of a deposit of economic or ore minerals of any description.

On the greater number of the gold-bearing, or presumably gold-bearing quartz locations throughout the district, no development of any kind has been performed, and consequently these claims have lapsed. On a few, there is evidence of a slight amount of work, possibly amounting to about one year's assessment.[1] But so far as could be learned, on only three properties on the Canadian side of the Boundary line, has more than this small amount of development been performed; on these in addition to some surface cuts and shallow pits, adits have been commenced and have been run from 10 to 30 feet respectively. One of these properties is situated on Beaver creek and the other two are located on Rabbit creek.

Baultoff Mountain and Vicinity.[2]

On Baultoff mountain a number of quartz deposits form prominent outcrops, and, as the quartz is somewhat iron-stained and in places occurs along the summits of the higher ridges, the reddish or yellowish exposures can be distinguished for a long distance. The quartz also occurs dominantly in the shales and related sediments, but in places has been deposited along the contacts between these rocks and the intrusive volcanics which have so extensively invaded the older sedimentary formations in this vicinity.

Near the summit of the mountain and along the top of a sharp ridge, a mass of quartz is exposed which is about 150 feet in width. This deposit, however, appears to be lenticular in form, and could not be traced for more than 50 to 100 feet on either side of the summit of the ridge. The greater number of the other quartz deposits in this vicinity range from about 4 to 12 feet in thickness, but were rarely traceable for any considerable distance, and appear in the majority of cases to narrow rapidly

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[1] According to the mining laws of Yukon Territory, one hundred dollars worth of work must be expended on each mineral claim each year to hold the same, until it is crown granted, or in lieu of this work, one hundred dollars in cash may be paid to the mining recorder of the district in which the claim is situated.

[2] Moffit, F. H., and Knopf, Adolph, "Mineral resources of the Nabesna-White Rivers district, Alaska": U.S. Geol. Surv., Bull. 417, 1910, pp. 59, 60.

in either direction along their strike. An occasional vein is, however, more persistent, and as an example, on the south of the mountain near the head of a small creek draining toward the east into Beaver creek, a vein of solid quartz is exposed for several hundred feet, which strikes in a northerly direction cross-cutting the stratification of the country rock, and is throughout from 6 to 12 feet in thickness. A number of smaller fissure veins were also noted which appear to be quite persistent but are dominantly less than 12 inches in thickness.

The quartz of these deposits is all very sparsely mineralized and in most places exhibits only a slight iron coloration. Copper stains (malachite and azurite) also occur, and occasional rare particles of pyrite and chalcopyrite were noted.

Although none of these deposits on Baultoff mountain, particularly under existing conditions, would appear to warrant development, it would seem quite possible that in a mineralized district, where quartz is so abundant, deposits may occur which have not yet been discovered, that contain sufficient gold, copper, or other minerals to pay for mining. With this possibility in view, therefore, further prospecting in this vicinity is recommended.

In addition to the quartz deposits, claims have also been staked along certain iron-stained, sheared zones traversing the volcanic rocks of this mountain. One such band or zone is about 200 feet wide and has the appearance of a greenish to reddish, somewhat schistose rock. A typical specimen examined under the microscope proves to be much altered, mashed, and somewhat sheared, and appears to have originally been an andesitic tuff. It consists mainly of plagioclase rapidly altering to calcite, and also contains some quartz and occasional particles of iron-ore minerals. As an ore deposit this does not appear to possess any economic value.

Beaver Creek.

No gold-bearing lode deposits of importance are known to have been found as yet along Beaver creek in Upper White River district, Yukon, although quite a number of claims have been staked and several have been developed to some extent in Alaska within a few miles of the Boundary line.[1]

An adit, however, has been driven about 30 feet, at a point on the right bank of Beaver creek 1 mile above the mouth of Tchawsahmon creek or approximately 3½ miles below the Boundary line. This adit is entirely in greyish granitic rock in the vicinity of black hornblendite which outcrops just below the workings. There is no evidence of an ore deposit of any kind in or near the adit, but the persons who performed this work, claim that the granitic rock itself contained near the surface promising amounts of gold. If so, this gold must have been merely a surface concentration such as is liable to occur almost anywhere, particularly in a district where the stream gravels frequently contain more or less placer gold.

Rabbit Creek.

At two points on Rabbit creek claims are located, on both of which a certain amount of development work has been performed. One of these properties is located a short distance above and the other is a similar distance below the falls on this stream. The dominant bed-rock in each case is a dark green, hard, dense, volcanic rock, which in the field can only be designated as a greenstone. When examined under the microscope, however, it is seen to be an augite andesite or in places a finely textured andesitic tuff. Overlying and piercing these rocks are some more recent volcanics which have a dense, cryptocrystalline, pale lavender to greenish groundmass through which are distributed fine, black, needle-like phenocrysts of hornblende. This rock has a composition ranging from that of a rhyolite to an andesite, but in most places appears to be a latite.

At the upper property on Rabbit creek, which is between 3½ miles and 4 miles east of the Boundary line, measured as the crow flies, a fault zone is well exposed in the greenstones on the north side of the creek and within about 100 feet of their uppermost exposure on this stream. Above this point, the more recent

[1] Moffit, F. H., and Knopf, Adolph, Op. cit., pp. 59, 60.

volcanics commence and also extend over the greenstones for a distance to the east.

This fault zone strikes N. 4°E. (Magnetic), and dips to the east at an angle of about 40 degrees. At least three major movements are evidenced in this zone which is well exposed in the creek bank to an elevation of about 100 feet above the stream bed. This zone also has an average thickness of from 2 to 3½ feet, and consists dominantly of quartz, but contains also some calcite and ankerite (ferriferous dolomite), as well as more or less altered greenstone. These gangue materials are only sparingly mineralized, but contain some disseminated pyrite and chalcopyrite, and are also in places stained with malachite (green copper stain).

Two adits have been commenced on this deposit, but have only been driven 6 and 10 feet respectively. Another adit has been driven about 8 feet on the south side of the creek, but has not as yet encountered the ore deposit which is only exposed on the north side of the stream.

An average sample was taken across the deposit in the face of one of the adits, where it is well developed and about 3½ feet in thickness. This sample was assayed in the laboratory of the Department of Mines, Ottawa, and proved to contain: gold, a trace; copper, 0·85 per cent.

Below the canyon on Rabbit creek, an adit has been driven about 16 feet in the south bank of the stream at a point where a fracture zone about 40 feet wide traverses the greenstones. This zone is composed mainly of iron-stained greenstones, which exhibit more or less disseminated pyrite, and include numerous irregular bunches and stringers of quartz having a maximum thickness of about 6 inches. These trend in various directions and contain slight amounts of pyrite and malachite (green copper stain).

Placer Deposits.

Very little definite information is as yet available concerning the placer gold deposits of Upper White River district. For a number of years it has been known that small quantities of gold occur associated with the gravels of some of the streams, but the district, as a whole, has been very slightly prospected until the last few months.

During the winter of 1912-1913, however, Pan creek was somewhat carefully and extensively prospected by Messrs. William E. James, Peter Nelson, and Frederick Best, who claim to have found gold there in important quantities, but state that they were forced to stop work as water came in so rapidly in each case when bed-rock was reached, that the pits or shafts had to be abandoned. In the spring, Messrs. James and Nelson went farther west into Alaska and became the original locators in Chisana district (Plate XV).

Since the finding of placer gold in Chisana, a considerable amount of prospecting has taken place in Upper White River district from where very encouraging reports are received. Gold is not only now known to occur on Pan creek, but is claimed to have been found in encouraging amounts on Bowen (Dominion) and Hidden creeks, which lie to the south of Pan creek and also drain into Tchawsahmon creek. Placer gold is also reported to have been found in paying quantities up Koidern river[1] which joins White river on its right limit about 18 miles below the mouth of Generc river.

Practically all the streams on which gold is known to have been found, both in Chisana and Upper White River districts, except Koidern river, head in the Nutzotin mountains, and are situated on the southern flank of this range. Since also the same geological formations persist throughout this portion of the Nutzotin mountains, the conditions prevailing in and between these areas are very similar. Therefore, as some of the Chisana creeks are known to contain valuable deposits of gold-bearing gravels, and as very little information is as yet available concerning this district, a brief description will be given in the following section of this memoir, in the hopes that such may prove helpful in future prospecting and mining operations on the Yukon side of the Boundary line.

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[1] Koidern river as well as Tchawsahmon creek, are both locally known to certain of the prospectors in the district, as Lake creek. Tchawsahmon creek is also known as Pond creek.

CHISANA DISTRICT, ALASKA.

Topography.

The portion of Chisana district that has been found to contain valuable deposits of placer gold is situated on the southern flank of Nutzotin mountains, the original discovery being about 30 miles west of the Yukon-Alaska International Boundary. This area is thus generally mountainous, but immediately adjoining the gold-bearing creeks, the topography is characteristically undulating in character (Plate XVI). Nutzotin mountains, however, which lie immediately to the north, and in which these creeks head, are quite rugged, and rise to elevations of 9,000 to 10,000 feet above sea-level—Discovery claim on Little Eldorado creek, originally owned by James and partners, being about 5,000 feet above the sea. All the higher elevations, including the main gold-bearing creeks, are above timber line (Plate XVI), the closest timber being along the valley bottom of Chathenda creek, distant 3 or 4 miles from the mouth of Little Eldorado creek.

Practically all the streams in the district have steep walled valleys and many of them flow in places through deep gorge-like canyons. It is thus apparent that the present stream valleys are to a great extent, at least, very youthful in age, and that in comparatively recent times the drainage system of the district became greatly disturbed and altered, the streams being forced to make new valleys for themselves. Such a change may have been produced by a somewhat sudden uplift of the district, or by glacial damming of portions of the stream valleys, due to great accumulations of morainal material coming down from the mountains to the north. The former stream valleys, now dry and filled with gravels, are still well preserved in places and constitute quite marked and very noticeable topographic features.

General Geology.

The rocks of Chisana district are dominantly of sedimentary origin, and consist mainly of dark grey to black shales with occasional intercalated sandstone and conglomerate beds, all of which are extensively invaded by volcanics, prevailingly of andesitic and basaltic character, that occur mainly as dykes less than 100 feet in thickness. These sediments and invading volcanics are the same, for the greater part at least, as compose the adjoining Nutzotin mountains to the north, in which head the principal creeks of Chisana district that have been found to contain gold-bearing gravels. The sedimentary rocks are highly mineralized, as a result, probably, of the igneous invasion, and contain a great amount of secondarily introduced quartz and calcite, mainly in the form of narrow veinlets, and are also highly impregnated with pyrite. In addition, they have characteristically a general bright red coloration on weathered surfaces, due to oxidation of the iron-containing minerals. From these mineralized sediments of the Nutzotin mountains, with their included quartz veins and stringers, the gold of the Chisana placers has almost undoubtedly been derived.

The sediments appear to be dominantly at least of Mesozoic age, but may include also some Carboniferous beds. The writer collected some fossil remains from the shales along Bonanza creek, which are highly impregnated with, and partly replaced by pyrite. These fossils were examined by Dr. T. W. Stanton of the United States Geological Survey, who has reported as follows: "This lot consists entirely of *Aucella crassicollis*, Keyserling, as I interpret that species and indicates the Lower Cretaceous age of the beds from which it comes." Other fossils from this district have been examined by Dr. E. M. Kindle of the Geological Survey, Canada, who states that they are of Mesozoic age and provisionally refers them to the Cretaceous. The geological formations in this vicinity are thus practically the same as compose the greater part at least of the main Nutzotin range in Upper White River district, Yukon.

Discovery and Resulting Stampede.

Placer gold in Chisana district is claimed to have been first discovered about May 3, 1913, by William E. James, and Peter Nelson of Dawson, both of whom with a third partner, Frederick Best, had spent the greater part of the previous winter prospecting in Upper White River district, Yukon. All three of these partners are old-time (Sourdough) prospectors, well known in both Yukon and Alaska. A White River Indian named "Joe," however, claims that he first found the gold and told Mr. James of his discovery; and in substantiation of this story, he actually exhibited to a number of persons, a small amount of placer gold very similar, at least, to that obtained in the Chisana creeks, at about the time Messrs. James and Nelson made their discovery. A number of persons also claim to have been shown this gold by the Indian several months before the first claim was staked in Chisana. Joe further states that this is the gold he originally showed Mr. James whom, he claims, he afterwards told or showed the exact point from which it was obtained. Mr. James in conversation with the writer, denied that the Indian had told or showed him where to find the placer gold, and declared that all "Joe" showed him was a quartz vein on Chathenda creek, which exhibits native gold. Mr. James further stated that prospecting in the vicinity of the vein shown him by the Indian, he found the placer gold himself. The Indian claimed an interest in Mr. James' property in Chisana, and stated that Mr. James ("James Billy") promised him one or more claims for himself.

Whether, therefore, Indian Joe is or is not the real discoverer of Chisana, he contributed towards its discovery; but it remained for Messrs. James and Nelson to actually unearth the wealth contained in the gravels and bring it to the notice of the public; in doing which they have not only very materially benefitted all those who have pecuniarily profited or will profit thereby, but in addition, they have rendered a considerable service to the country in general, as this discovery is almost certain to result in a considerable development in adjoining portions of both Alaska and Yukon.

The original discovery of Messrs. James and Nelson was made on Bonanza creek, but when shortly afterwards Mr. James found some rich ground near the mouth of Little Eldorado creek, a tributary of Bonanza creek, actual mining was first there commenced, as this ground was considered to be of a more easily and readily workable nature. Accordingly, Messrs. James and Nelson commenced sluicing on this claim (Discovery claim) on Little Eldorado creek on July 4, 1913, and by August 2, when visited by the writer, they had obtained about $9,000 from this claim, an average of about $300 per man, for each 8 hours of work performed (Plate XV). It had been impossible up to that time to hire men in the district, and the work had been practically all performed by the owners, who, in addition to sluicing, had to devote a considerable portion of their time to looking after their other extensive interests in the vicinity.

The news of this discovery soon reached the "outside," and a stampede commenced which was widely disproportionate to the nature and extent of the discoveries that had been made, and which was and will be the greatest since the memorable early rush to the Klondike during 1897–98.

Several thousand men and a few women stampeded into Chisana before the freeze-up, coming from all directions, and over all the available known routes, a large number of them travelling via Upper White River district. With rare exception these early stampeders were all poorly and inefficiently outfitted, and in many cases they had only very vague notions concerning the geographical whereabouts of Chisana, or the routes they were to travel. Consequently, those who finally reached the gold fields at all, were unable to remain more than a few days and departed, so that there were possibly not more than 300 or 400 persons in the vicinity at any one time. Hundreds of men lived for days at a time, or even in some cases for one or two weeks, mainly or entirely on ptarmigan roasted with or without salt, these birds being fortunately very plentiful and easily killed with sticks or stones. All provisions were valued at from $1 to $2 per pound, but as very few persons had sufficient for themselves, provisions were practically unprocurable even at these high prices. Rough clothing, especially boots, overalls, and shirts, were almost priceless treasures.

By August 1, when the greater number of stampeders began to arrive, practically all the available ground in the vicinity of the strike had been staked—even the hilltops being located in places. The majority of those arriving after this date either returned at once, staked "wildcats," jumped someone else's claim, or in case they had any provisions left, prospected the creeks in the neighbouring districts. Most prospectors who were so fortunate as to obtain any promising ground, returned later to the district with sufficient outfits to enable them to do their assessments, and many men took in large outfits after the freeze-up and prepared to spend the winter prospecting and getting in shape for work in the spring.

Commencing early in August, the writer published repeated warnings, cautioning prospectors and others against going into Chisana during the autumn or winter (1913-14) unless properly outfitted and otherwise fully prepared to remain in the district until spring, if necessary. All the known valuable ground had been located, and there was no possibility of being able to rush into the district, stake quickly, and return. It was sheer folly to go into Chisana particularly after August 1, without being prepared to do bona fide prospecting or to enter into business of some kind. Quite a number of persons who went in properly prepared, however, have made promising discoveries. The others in most cases not only obtained no ground, but suffered great hardships and privations. It is estimated that 50 or more men lost their lives during the stampede previous to November 1. Some were drowned in the dangerous glacial streams of that northern country, some met with fatal accidents crossing the Skolai pass between McCarty and the head of White river, and still others became lost and starved to death. Many of these fatalities would have been averted if those starting for Chisana had been properly outfitted.

Gravels.

The gold-bearing creek gravels of Chisana district consist mainly of dark grey to black shale and slate fragments which, although somewhat waterworn and rounded, nevertheless retain their characteristic slab-like shape. Intermixed with the shale and slate boulders and pebbles, are also some of various basic volcanics. The bench or old channel gravels are more worn than the creek gravels, and contain relatively more quartz, showing that they have been subjected to stream action with its wearing, disintegrating, dissolving, and transporting tendencies for a longer period than the creek gravels.

The creek gravels are not frozen in summer, as they are not covered by insulating muck or moss, but the bench gravels, being in most places covered with moss or other vegetation, with also more or less muck, are frozen throughout the entire year.

The gold-bearing creek gravels are very easily workable, being in most places less than 6 feet in thickness, and not over 100 feet in width (Plate XV). They thus constitute typical prospector's diggings, as a minimum of equipment, time, and labour are required to obtain the gold from them. The bottoms of the old channels are in places above and in places below those of the present creeks which they cross, thus the older gravels now occur both as bench deposits above those of the present stream gravels, and as buried gravels below the level of the present stream bottoms. These old channel gravel deposits are much thicker and wider than the creek gravels contiguous to them, but how thick or wide they are, is not yet known. It would appear, however, that they must be in places as much as 100 feet thick and possibly over 1,000 feet wide.

It seems quite possible from what is now known of the different gravels in Chisana district, that the bulk of the placer gold in the district was or is in the old channels, and will be obtained, either from the gravels of the old channels directly, or from the gravels of the present streams below where these cut the older gravels. In such places, the gold originally in the older gravels is now concentrated in the gravels of the present intersecting streams. The richness of Discovery claim, on Little Eldorado creek, and of the claims below it on Bonanza creek, for example, is believed to be due largely to the fact that Discovery claim on Little Eldorado is situated just below the intersection by Little Eldorado creek of an old channel in which at one time flowed the waters of a former Chathenda creek.

Gold.

The gold from Chisana that has been assayed is worth about \$16·40 per ounce, and is dark in colour, having a peculiar almost bronze like cast, due possibly to a slight coating of iron oxide. All that has so far been found is also quite coarse, practically no dust having been obtained. The greater amount of the gold is in particles ranging in value from 1 to 10 cents, but nuggets worth from \$1 to \$2 are common, and some have been found worth from \$18 to \$20; one nugget weighing 8 ounces and valued at about \$131 being shown the writer. In shape, the gold particles are dominantly flat, some being decidedly thin and flake-like, indicating apparently that the gold was prevailingly deposited originally either in narrow seams in the enclosing slate rock, or along the contact between quartz veinlets and the enclosing rock formations.

Extent of Gold-bearing Gravels.

In Chisana district, itself, a small area not exceeding 12 square miles has been proved to contain important deposits of gold-bearing gravels, and within this area quite a number of both creek and bench claims have been found to contain gold in sufficient quantities to pay for working, and even in some cases, to be considered rich. This area is situated, as before mentioned, along the southern flank of the Nutzotin range; and apparently similar geological conditions persist to the east along these mountains for about 40 miles at least or to well within Canadian territory.

Horsfall creek, which drains into Beaver creek and is situated midway between Bonanza creek and the International Boundary line, was worked to a limited extent, mainly by one man, a number of years ago, under conditions much more adverse than exist at present. This creek has been all staked since last July, and a number of claims, upon being prospected, are stated to have given very satisfactory results.

In addition to this creek, other similar streams containing valuable gravels will in all probability yet be found, not only between Horsfall creek and the creeks to the west draining into

Chisana river, but also still farther to the east toward the Boundary line.

COPPER.

General Occurrences.

Native copper has long been known to occur in White River basin, and the reported occurrence of this metal in vast quantities was the incentive that originally drew the prospector into this region. The first definite information, however, concerning its exact whereabouts or quantities is contained in Hayes' report of a trip he made from Selkirk to Skolai pass in 1891 in company with Lieutenant Schwatka and a prospector named Mark Russell.[1] The Indians previous to this time, had carried on quite a traffic in native copper which was used for arrow heads, knives, cooking utensils, and also for bullets where lead could not be obtained. While at Selkirk, the members of the Hayes' expedition were told of masses of native copper as large as houses, and Indians were secured who promised to guide the party to these fabulous deposits. As the locality was approached, however, the copper masses grew gradually smaller and when their source on Kletsan creek was finally reached what were shown "consisted of small nuggets, the largest only a few ounces in weight."[2] Hayes further states—"Some time was spent in searching for the source of the copper in Kletsan creek, but without success, as we soon reached the snow line, beyond which of course, further search was impracticable. It appears to have been brought by glaciers from the region toward the south which is still covered by snow and ice."[3]

Kletsan creek is a small stream which heads in Natazhat glacier in the vicinity of the International Boundary line, about 14 miles south of White river. It flows in a northeasterly direction until about 2¼ miles east of the Boundary, when it

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[1] Hayes, C. W., "An expedition through Yukon district": Nat. Geog. Mag., Vol. IV, 1892, pp. 143-145.

[2] Idem, p. 143.

[3] Idem, p. 144.

changes its course and follows a northwesterly trend, crossing the Boundary about 5½ miles south of the White, whence it continues to the north joining this river at a point about one-half mile within Alaskan territory. Thus, the greater portion of this stream, including all its upper course, which is below Natazhat glacier, and in which the placer copper has been mainly discovered, is within Canadian territory, but some miles to the south of the district mapped during the past summer (1913).

In 1899, the placer copper deposits on this stream were visited by Brooks in the course of his trip from Pyramid harbour to Eagle City, and as this locality is within Yukon Territory, and as his report[1] contains the most recent known published account of this occurrence that is of a reliable nature, a couple of paragraphs from his descriptions will be here quoted. These deposits, whether of economic importance or not, are of particular interest as they constitute possibly the first known occurrence of copper in White River basin of either Yukon or Alaska. Brooks states: "The placer copper deposits (all native) are contained in stream benches that owe their existence to rock barriers through which the streams have now cut their courses. The placer copper, as far as observed, is confined to a distance of about half a mile above the point where the creek leaves its rocky canyon. The placer copper is irregularly distributed on the bed-rock in the crevices and also among the large boulders. The nuggets found by the Indians who accompanied me seldom exceeded a few ounces in weight, although one was found which weighed 5 or 6 pounds, and another which I saw from the same region weighed 8 or 10 pounds. The Indians dig the copper with caribou horns, and by this primitive method of mining must confine their efforts to the recent stream cuttings.

"As far as the limited time would permit a careful search was made for evidence as to the source of this native copper. An examination of the greenstones showed them to be traversed by an irregular system of joints, and calcite veins were observed which followed these joints. A careful examination showed

[1] Brooks, A. H., "A reconnaissance from Pyramid harbor to Eagle City, Alaska": U.S. Geol. Surv., 21st. Ann. Rept., Pt. II, 1899-1900, pp. 379-381.

that some of these veins carried native copper. These copper-bearing veins were found close to the contact with the limestones. Calcite veins were also found in the white crystalline limestone near the contact with the greenstones. A superficial examination of the greenstones showed that they are of a dioritic character and are cut by a series of aphanitic dykes, which are provisionally classed as diabases. The presence of amygdaloidal greenstones (probably andesites) and some tufas among the stream gravels suggest that these basic intrusives may be the feeders of apophyses of outpourings of volcanic rocks. No other copper minerals, except secondary malachite, were found during the day spent in investigating the deposits. In the western extension of the copper belt amygdaloidal greenstones carrying amygdules of copper pyrite and various gangue minerals are not uncommon. To the east the Kletsan copper belt was traced only to the vicinity of the International Boundary. Its eastern extension beyond this point, if it exists, is to be sought north of our route of travel. To the west the same zone seems to extend to the Upper White river."[1]

Moffit and Knopf also state concerning these Kletsan Creek deposits: "In 1902, a number of years after this examination, which was necessarily of a hasty character, some attempt was made by Mr. James Lindsay to test the placer copper possibilities of the locality. On account of the glacial ice and snow on the high ranges at the head of the creek and a number of other adverse conditions, unfavourable conclusions were reached."[2]

Since 1898 prospectors, largely due to Indian reports, have been coming into White River district in search of gold and copper, the natives having invested the region with richness proportionate to its remoteness and inaccessibility. Prospecting in search of copper has shown that this metal is widely distributed in the portion of the White River basin lying to the west of the International Boundary and that native copper also occurs there as nuggets in the gravels of many of the streams. Deposits of native copper and associated minerals also occur on

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[1] Idem, p. 381.

[2] Moffit, F. H., and Knopf, Adolph, Op. cit., p. 57.

the Canadian side of the Boundary line, in Upper White River district, but by far the greater number of discoveries have been made in Alaska; and as the deposits there are in places much better exposed, and are in some cases also, more extensively developed, and are consequently better understood, a few facts concerning these Alaskan deposits will be here included, in the hopes that a knowledge of such may be of value to persons interested in or exploiting the adjoining portions of Yukon across the Boundary line.

During the summer of 1908 Moffit and Knopf investigated the mineral resources of the Alaskan portion of the White River basin and have contributed the most recent and comprehensive description of the copper deposits of that region. The writer can, therefore, not do better than quote from these authors, who state with reference to the White-Nabesna region: "Copper in its bed-rock sources is widely distributed in the form of sulphides (chalcocite, bornite, and chalcopyrite), and on the basis of the facts revealed by the little development work that has been done it may be stated that most of the native copper found in the region is an oxidation product of those sulphides. Some primary native copper, however, has undoubtedly been discovered. In mode of occurrence the copper ore shows two different habits, geologically distinct. In one, so far the better known, it occurs associated with the Carboniferous basaltic amygdaloids; in the other it is found in limestone at or near the contact with the dioritic intrusives.

"Native copper occurs as nuggets in the gravels of many of the streams, and green-coated lumps of metal, up to 5 pounds or more in weight, are occasionally found in the wash of creeks draining areas of amygdaloid bed-rock....................

"Metallic copper occurs also in the surface croppings of sulphide deposits in the amygdaloids, where it is undoubtedly an oxidation product of the sulphides that appear in depth. In such places it is directly associated with the dark-red oxide (cuprite) and more or less green carbonate.................

"At a few localities native copper is associated with certain highly amygdaloidal portions of the Carboniferous basalts and intergrown with the white minerals that fill the former steam cavities in the ancient lava flows. Slaggy-looking portions produced by the weathering and removal of the amygdules from the lava, and amygdaloid that is cut by small irregular veinlets filled with the same minerals as those forming the amygdules appear to be the most favourable places for metallic copper. The copper in the vesicles and stringers is associated with calcite and delicately spherulitic prehnite, but in some of the veinlets calcite, prehnite, quartz, a black lacquer-like mineral, partly combustible, and chalcocite, instead of metallic copper, are associated together.

"At a number of places throughout the region narrow stringers of chalcocite cutting the ancient basalts are encountered, but so far as known they have no great persistence..........
"At other localities some irregularly disseminated sulphides, in some places chalcocite, in others bornite, occur in the basalts, but these do not appear to be connected with definite vein or lode systems and are consequently of an unencouraging character. Oxidation of these sulphides and disintegration of the containing rock give rise to the nuggets of cuprite and native copper that are found in the talus slopes at several localities in the region.

"In contrast to these occurrences, which, as shown by the foregoing discussion, are limited to the ancient basalt flows, copper is found as bornite and as chalcopyrite intergrown with contact-metamorphic rock in limestone adjoining diorite intrusives. In deposits of this type the ore mineral is associated with garnet, coarsely crystalline calcite, epidote, specular hematite, and scattered flakes of molybdenite................

....

Only two deposits of this character were seen in place, but evidence of energetic contact metamorphism was detected at a number of other localities."[1]

In conclusion these writers further state: "The main interest of the White-Nabesna region has centred in the occurrences of native copper. No phenomenal ore bodies have yet been discovered, but it has been shown that some primary native copper occurs in the amygdules of zeolitic amygdaloids......

....

[1] Moffit, F. H., and Knopf, Adolph, "Mineral resources of the Nabesna-White Rivers district, Alaska": U.S. Geol. Surv., Bull. 417, 1910, pp. 52-54.

This discovery is sufficiently encouraging to warrant further development, and it is to be hoped that the nature and extent of the deposit will soon be demonstrated.

"From the descriptions given in the preceding pages it will be apparent that a lode-quartz region of some promise has been discovered in the Nutzotin mountains near the International Boundary and that as yet it has been but imperfectly explored by the prospector."[1]

The volcanic rocks which are the chief copper carriers in the White-Nabesna district, are also somewhat extensively developed across the International Boundary in Upper White River district. Unfortunately, however, in Yukon the particular amygdaloidal lava flows which have proved to be the main source of the copper, appear in part at least to underlie the superficial deposits of the White River valley and are thus very difficult to discover. Native copper is, however, also apparently extensively developed along the edge of the St. Elias mountains to the south as evidenced by the Kletsan Creek placer deposits, but there the bed-rock occurrences appear to be too high in the mountains for economic working.

Thus, up to the present, so far as is known, copper deposits associated with these old lavas that are of economic importance have been found on only one property on the Canadian side of the line. This property, which is situated on the south side of White river near Canyon City, is known as Discovery copper grant. Native copper and copper minerals are, however, also reported to have been found on Generc river to the east, and at several points in the vicinity of the Upper canyon on White river, copper stain and occasional particles of native copper have been found in reddish amygdaloidal lavas. Near the mouth of Boulder creek, for instance, several claims have been located, but although some native copper is claimed to have been discovered there, the only copper minerals the writer could find consisted of occasional patches of copper stain in the amygdaloids. As before mentioned, also, old reddish amygdaloidal lava flows of the same age, apparently, as the copper-bearing flows of Alaska,

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[1] Idem, pp. 61-62.

are developed at a number of points in Upper White River district, as described in the section of this memoir dealing with general geology, and all such lavas are liable to contain copper. Further prospecting in this district is thus recommended, as it would appear to be possible that copper deposits may yet be found to be quite extensively developed on the Yukon side of the Boundary line.

Discovery Copper Grant.[1]

Discovery Copper grant is located on the right or southeast side of the White about 1½ miles upstream from Canyon City, the workings on this property being mostly situated on the steep valley wall from 100 to 200 feet above the river. Copper is believed to have been first discovered here by Solomon Albert in May, 1905, when three copper grants were staked by the discoverer and his two partners, Joseph R. Slaggard and M. C. Harris, who still hold this ground. Practically all the development work has been performed on the first located grant which is known as "Discovery" and on which the greater part of all the copper occurs that has as yet been found in this vicinity.

The geological formation on this property, where exposed, consists dominantly of greenish to reddish andesitic volcanics similar to those which are so extensively exposed to the west in Alaska, and with which are there associated most of the copper deposits of the White-Nabesna district. At Discovery, the copper occurs mainly in a finely textured, massive, reddish amygdaloid, the amygdules of which are for the greater part filled with a dark green secondary mineral aggregate which is composed mainly of chlorite. Bed-rock is here, however, for the greater part covered with superficial deposits, which adds much to the difficulties and uncertainties of prospecting. The geological conditions are consequently somewhat obscure, and no definite flows could be detected such as occur farther west in Alaska where in many places extensive sections of the copper-containing lavas are exposed.

[1] Moffit, F. H., and Knopf, Adolph, Op. cit., p. 53.

On Discovery property three adits have been driven distances respectively of 30, 20, and 20 feet; in addition a certain amount of surface work has been performed, mainly in the shape of open-cuts and trenches. This development has shown that the volcanic country rock is traversed by numerous irregular fractures, some of which exhibit pronounced slickensiding. These seams in places contain native copper, a number of slabs of which have either weathered out or have been dug up that weigh as much as several hundred pounds each, and one particularly large tabular mass was measured by the writer that is about 8 feet long, 3 feet 6 inches wide, and 4½ inches thick, and is estimated to weigh about 6,000 pounds (Frontispiece).

Narrow calcite veins, containing chalcocite (copper glance) as well as stringers of cuprite and disseminated native copper, also traverse these rocks in places. In addition, in one of the adits the dark green volcanic country rock contains occasional veinlets of chalcocite, which mineral is also disseminated through the rock in places. In the bottoms of the cuts, chalcocite also begins to appear, and in places specimens were obtained showing the chalcocite partly oxidized to the native state. It is thus perfectly evident that the native copper is a surface oxidation product and is derived directly from the chalcocite. Further, as occasional particles of chalcopyrite (copper pyrites) occur in places disseminated through the amygdaloids, it would seem probable that with greater depth this will prove to be the primary copper mineral.

The native copper cannot, therefore, be expected to continue more than a few feet below the surface, except possibly along well-defined fissures where there is a ready circulation. Thus, although there appears to be a considerable aggregate amount of copper in this vicinity, it is problematical whether or not, except very near the surface, it is anywhere sufficiently concentrated to constitute workable ore bodies. Such will have to be determined by future mining operations. There is, however, enough copper in sight to warrant further development, and as bed-rock is in most places covered with superficial deposits, there is no reason to suppose that the best deposits have first been discovered. On the other hand it is quite possible that underlying this mantle of detrital material, copper deposits much more valuable than those so far uncovered, may yet be found in this vicinity. However, unless the primary sulphides themselves, when reached, are sufficiently concentrated to pay for exploitation, the marketable ore will comprise for the greater part at least only the occasional bunches, slabs, and masses of native copper at the surface, which would not seem to be sufficient in amount to afford more than a limited and very uncertain output. In any case, until a railway is constructed into the district, the shipping facilities will not permit of the mining of copper properties in this vicinity.

COAL.

Along the upper portion of McLellan creek[1] and also along the upper part of a small stream about 3 miles to the north, which drains to the west into Ptarmiga creek, Tertiary beds occur which contain a considerable amount of fossil wood and also include occasional thin seams of lignite, none of which, however, were noted to exceed 2 inches in thickness. As these sediments in other parts of Yukon and Alaska contain valuable deposits of lignitic fuel, it is possible that such may occur in Upper White River district. However, in addition to their having only a slight areal development, these beds are here also extensively invaded by more recent volcanic rocks. Thus, the chances of finding workable deposits of coal in this vicinity, are considered to be somewhat slight.

SUMMARY AND CONCLUSIONS.

Upper White River district constitutes a portion of a well mineralized region, and possesses itself a considerable degree of mineralization. The more promising of the mineral deposits that have been discovered, are those containing copper and gold, both of which metals in this district as well as in adjoining portions of Yukon, are found not only in their bed-rock sources,

[1] Known locally to some, as Coal creek.

but occur as well in the form of placer deposits. The district as a whole, however, has been only slightly explored, and although promising prospects have been located, it has not yet been demonstrated, except possibly in the case of the gold-bearing gravels, that a single mineral deposit can be profitably exploited.

A considerable portion of this district is not only mountainous, but is somewhat rugged in character, and can be more easily prospected than many portions of western Canada, due to the relative abundance of bed-rock exposures and also owing to the fact that little or no timber occurs in most places, the country being prevailingly quite open. Extensive valley or lowland tracts, however, also occur, throughout which superficial detrital accumulations, dominantly of glacial origin, have deeply buried whatever minerals the underlying bed-rock includes.

The placer gold deposits had only been slightly prospected until the past winter, when as a result of the Chisana discovery, a considerable number of men are reported to have been investigating the gravels of this district. As yet, however, the writer has been unable to obtain any definite and reliable information concerning these recent developments, other than to the effect that placer gold in encouraging amounts has been discovered on several creeks. Since the general geological conditions in portions of this area are very similar to those in Chisana district, Alaska, it is hoped that valuable deposits of placer gold will yet also be found across the line in Upper White River district.

Vein quartz has been developed to a slight extent in portions of this area, and in places contains gold as well, occasionally, as copper. The individual quartz veins and masses that have been discovered, although in places quite large and persistent, are nevertheless only very sparsely mineralized. It is quite possible, however, that deposits of similar extent and size may yet be discovered containing gold, either alone or associated with minerals, in sufficient amount to allow of their being worked at a profit.

Native copper has long been known to occur in White River basin, and it was the greatly exaggerated reports concerning the abundance of this metal that originally drew prospectors into White River district. This metal, however, so far as is known, has been found in Upper White River district in economically important quantities on only one property, which is known as Discovery Copper grant. This property is situated in White River valley, near Canyon City, and the bed-rock in the vicinity is consequently nearly everywhere deeply covered with superficial accumulations. Prospecting is thus rendered very difficult and any discovery that is made is more or less accidental. Consequently, there is no reason to suppose that the best has been discovered first, but, on the contrary, since the volcanics which contain the copper are extensively developed and are the same apparently as those which are the chief carriers of this mineral across the Boundary line in Alaska, there is no reason to suppose that copper deposits are not as extensively developed to the east as to the west of the line.

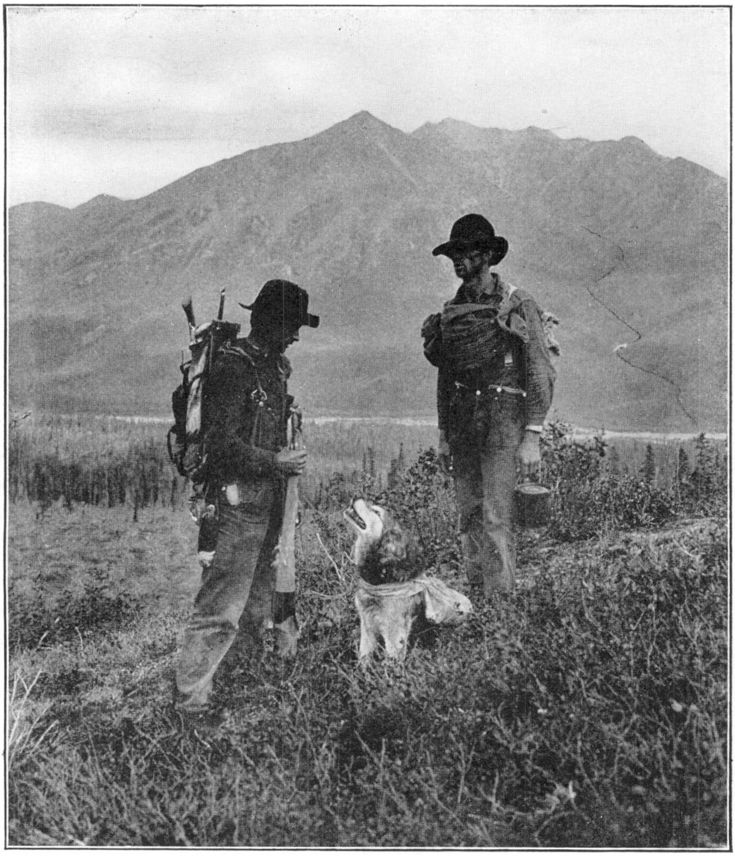
The native copper at Discovery is, however, an oxidation product of chalcocite which in turn may with depth give place to chalcopyrite. Thus, the native metal cannot be expected to extend far below the surface, and it is to the primary sulphides that we must look for any extensive or persistent ore bodies. Sufficient development has, however, not yet been performed to determine whether or not these sulphides are sufficiently concentrated to constitute economically valuable ore-bodies.

Further prospecting and development are thus recommended, in the hopes of finding other deposits of economic minerals, and to determine the importance of those already discovered, very little being as yet really known concerning the mineral possibilities of this district. Important finds and developments are expected to result from the discovery of gold at Chisana, as hundreds of keen prospectors have since been scouring Upper White River district and adjoining areas as never before. It is thus possible or even probable that this prospecting, which is really an outcome of the Chisana discovery, will result in finds being made in other nearby portions of Yukon and Alaska, which will greatly exceed in importance the placer deposits of the original Chisana area.

Explanation of Plate II.

Stampeders in the valley of Beaver creek, nearly opposite the mouth of Pan creek, Upper White River district, Yukon Territory. This view is typical of the topography of Beaver Creek valley. The mountains are composed dominantly of sediments from which the placer gold of the district is supposed to be derived. (See pages 11, 45, 56, 57.)

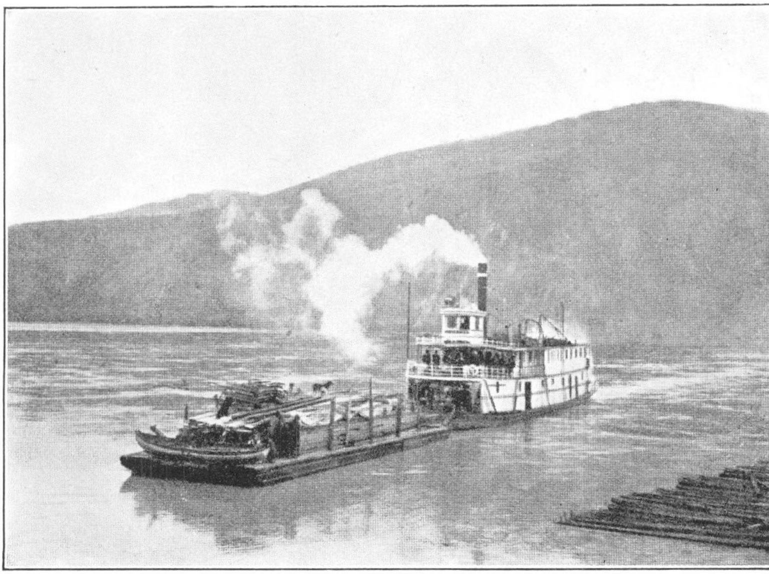
Plate II.



EXPLANATION OF PLATE III.

Steamer *Vidette* on her second trip up White river in August, 1913, with passengers, freight, and outfits for Upper White River and Chisana districts. This is one of the largest boats to go up the White. Steamers of this type are able to go up White river, under favourable conditions, to about the mouth of the Donjek. Photograph by J. Doody. (See pages 7, 12.)

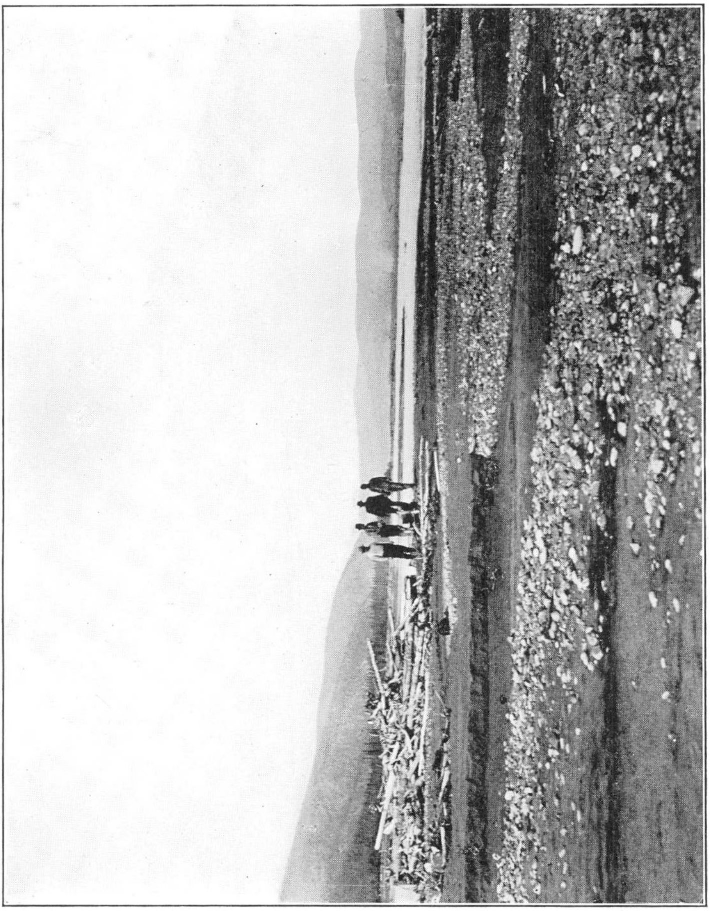
PLATE III.



Explanation of Plate IV.

A typical view on White river, 60 miles from its mouth, showing the wide river flat with its characteristic sand and silt bars which are plentifully strewn with snag piles. (See pages 53, 59.)

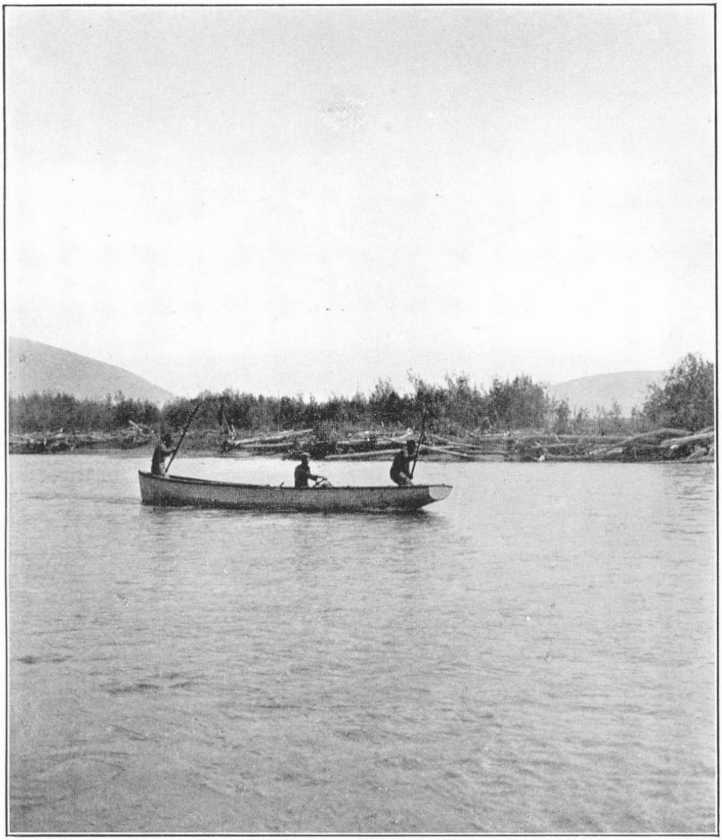
PLATE IV.



Explanation of Plate V.

Poling on Beaver creek near the mouth of this stream. This is the model of poling boat with "shovel nose," found to be best adapted to poling on these swift streams. Note the characteristic piles of driftwood on the bank, which are brought down during seasons of flood. (See pages 12, 54, 60.)

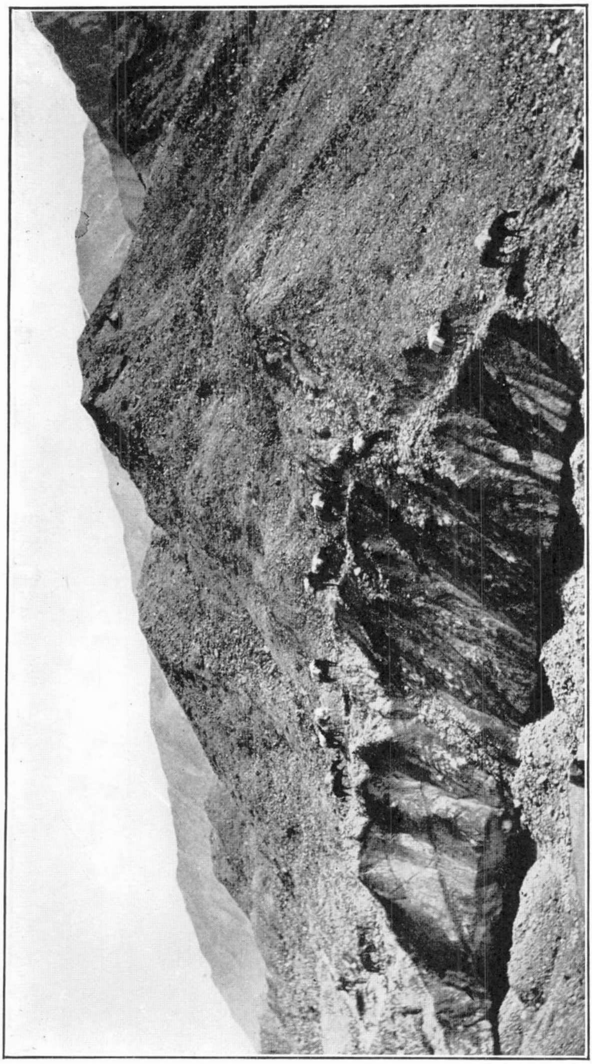
PLATE V.



Explanation of Plate VI.

Trail over Russell glacier moraine, Alaskan route to Upper White River district. The morainal material is shown overlying an ice cliff, over which the horses are passing. Photograph by J. D. Craig. (See page 16.)

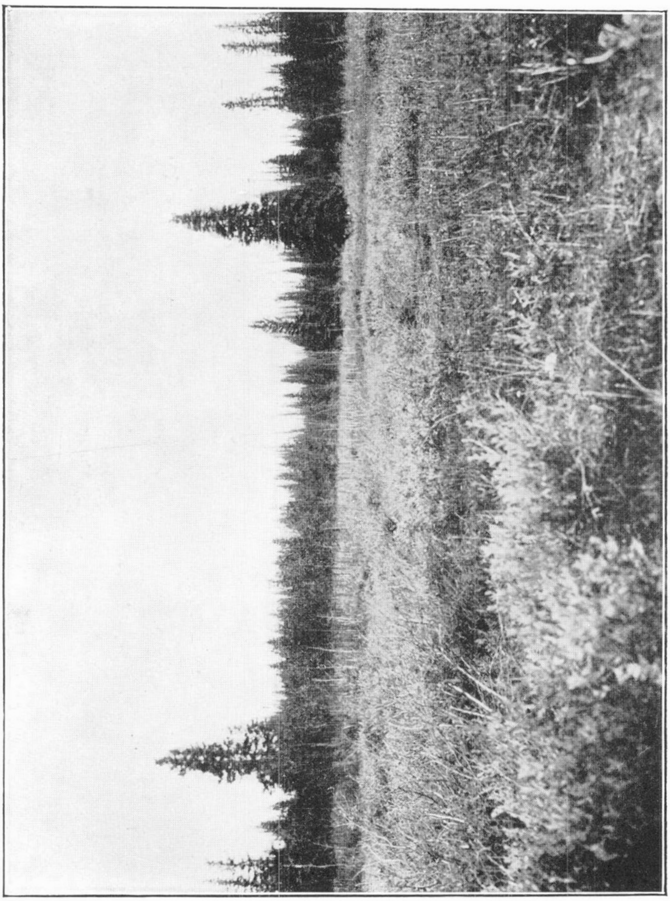
PLATE VI.



Explanation of Plate VII.

A typical view in the flats bordering Beaver creek, showing the character of the forest growth and general vegetation prevailing in the lower portions of Upper White River district. (See pages 28, 40, 54.)

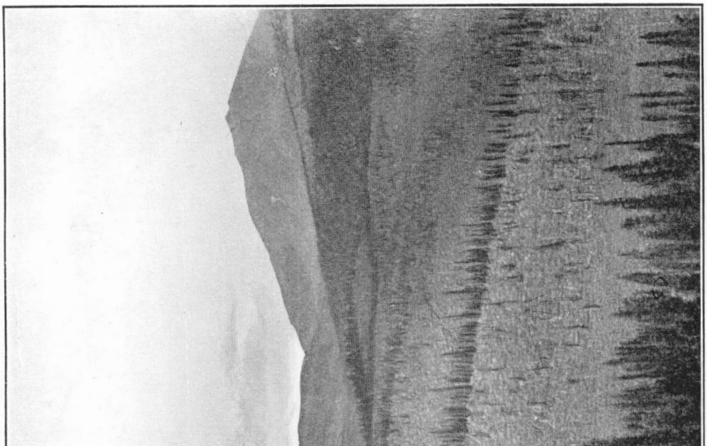
PLATE VII.



Explanation of Plate VIII.

Looking in a southwesterly direction across the valley of Boulder creek. The character of the forest in the higher timbered valleys is shown, timber line here being between 3,500 and 4,000 feet above sea-level. (See page 28.)

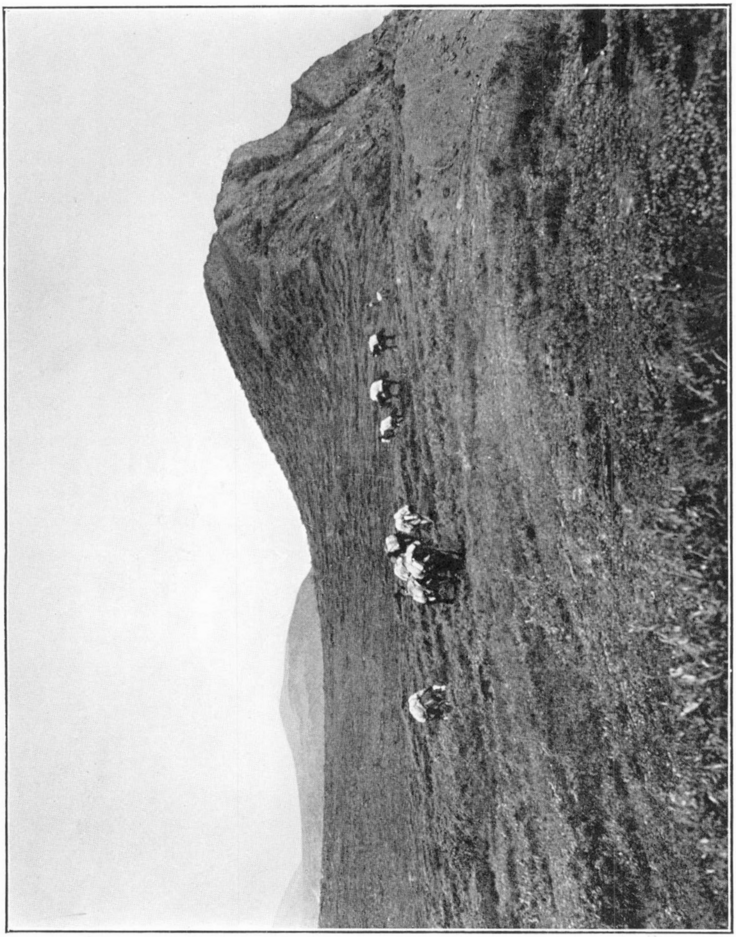
PLATE VIII.



Explanation of Plate IX.

View showing the gently rolling character of the upland between McLellan and Rabbit creeks, over 1,500 feet above the level of Tchawsahmon Lake valley to the east, or between 4,500 and 5,000 feet above sea-level. The pack horses shown are used to move camp and transport supplies and outfits. (See pages 48, 105.)

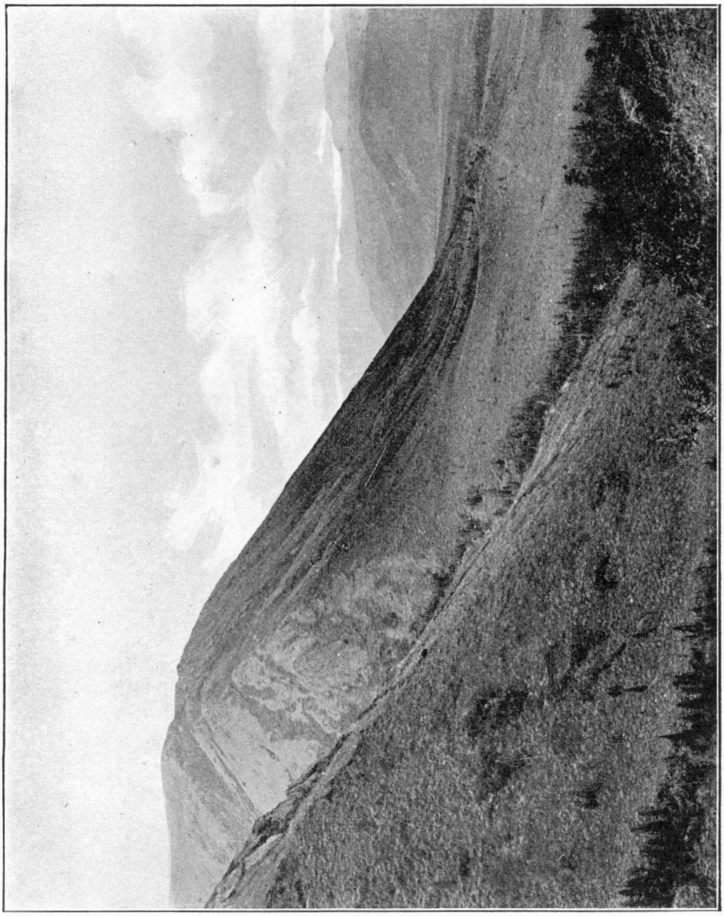
PLATE IX.



Explanation of Plate X.

Looking across McLellan Creek gorge, where this stream enters Lake Tchaw-sahmon valley. The beautifully curved western wall of this valley is here well shown, this broad depression being typically U-shaped, due to glacial erosion. (See pages 50. 56, 60, 105.)

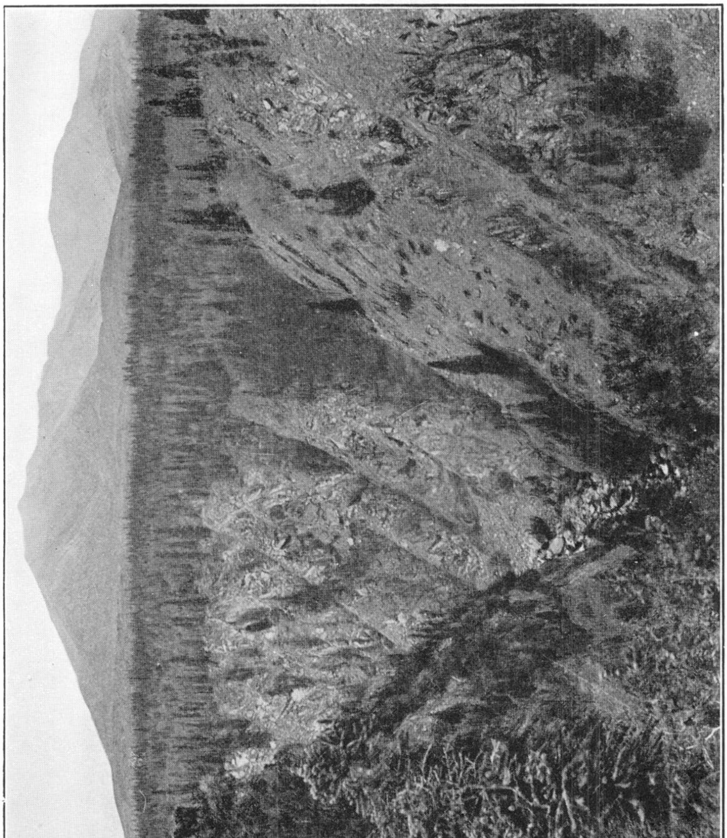
PLATE X.



EXPLANATION OF PLATE XI.

Looking toward Flat Top mountain, across the recent gorge or canyon-like valley of the lower portion of Boulder creek. This type of valley is characteristic of a number of streams in the district. (See pages 45, 51, 58.)

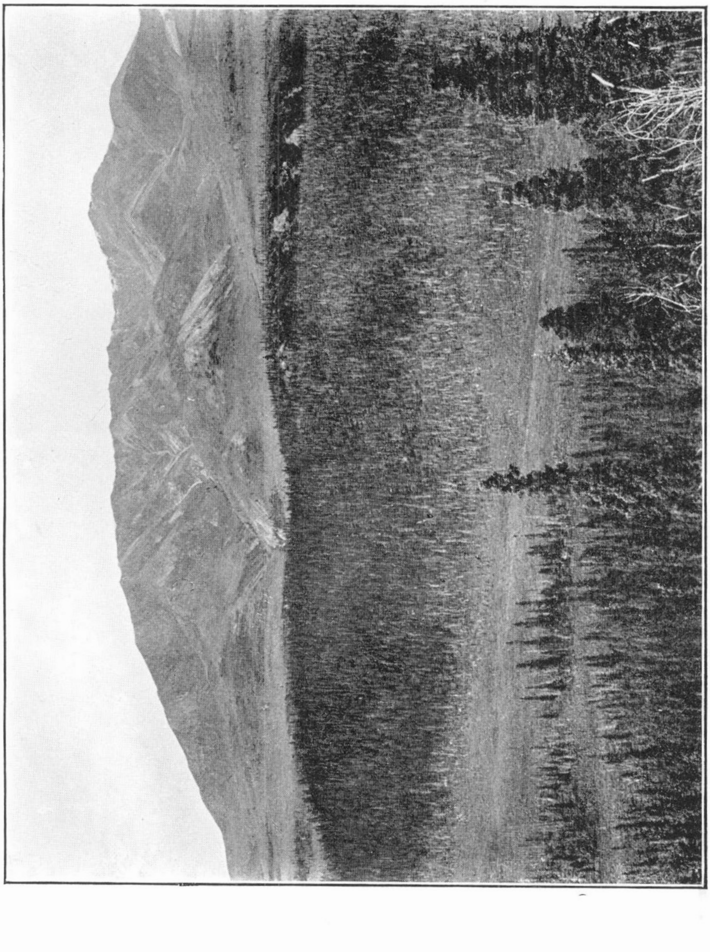
PLATE XI.



Explanation of Plate XII.

Looking in a southwesterly direction toward Flat Top mountain, which is composed dominantly of the older volcanics—andesites, basalts, diabases, and related rocks, showing the characteristically irregular type of topography resulting from the erosion of these rocks. (See pages 45, 55, 57, 90.)

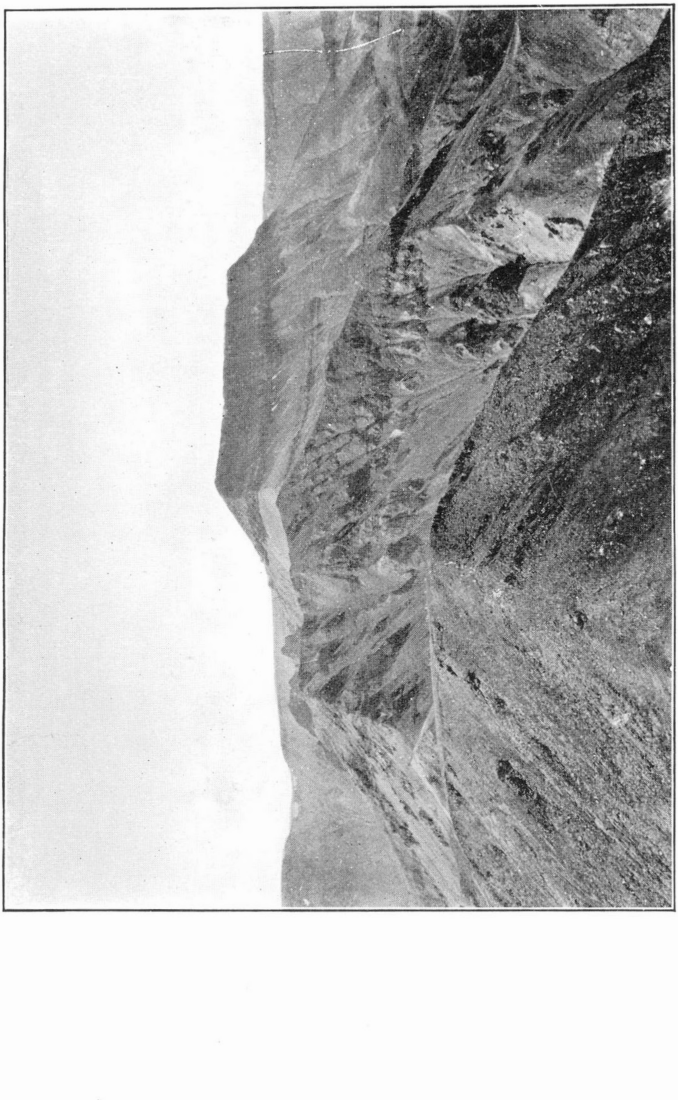
Plate XII.



Explanation of Plate XIII.

Looking in a southwesterly direction toward Centre mountain, the summit of which is crossed by the International Boundary line. This mountain is composed dominantly of the newer volcanics—basalts, andesites, and related rocks. The nearly horizontal lava flows and intercalated tuff beds are here well shown. (See pages 31, 46, 98.)

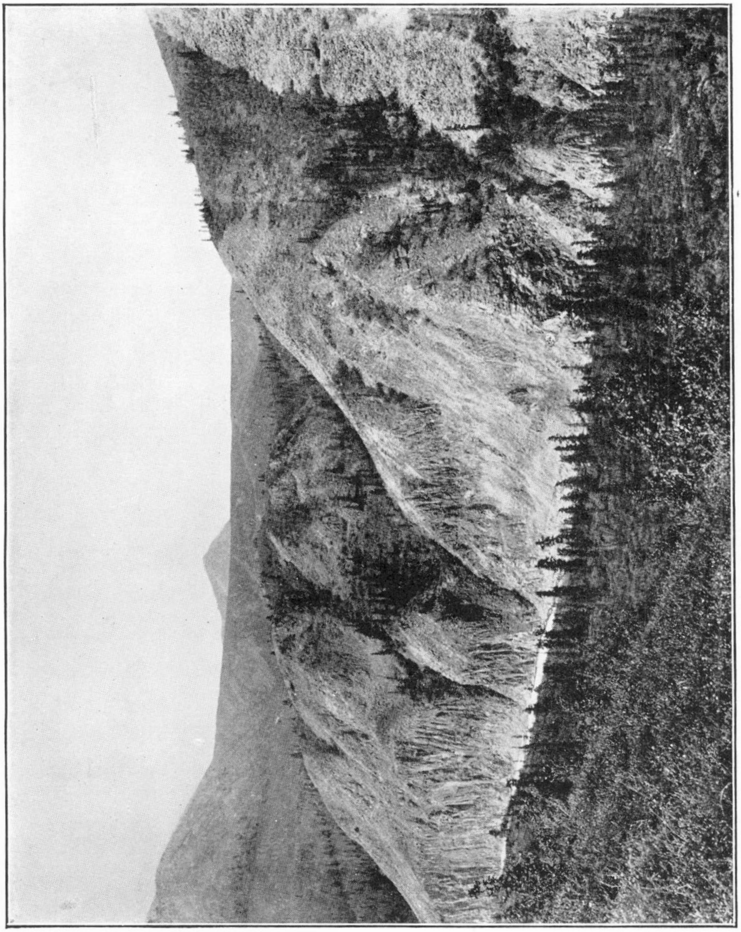
PLATE XIII.



Explanation of Plate XIV.

Looking across Rabbit creek from the south. The typical prismatic jointing of the rhyolite-latite volcanics is well shown. (See pages 48, 102.)

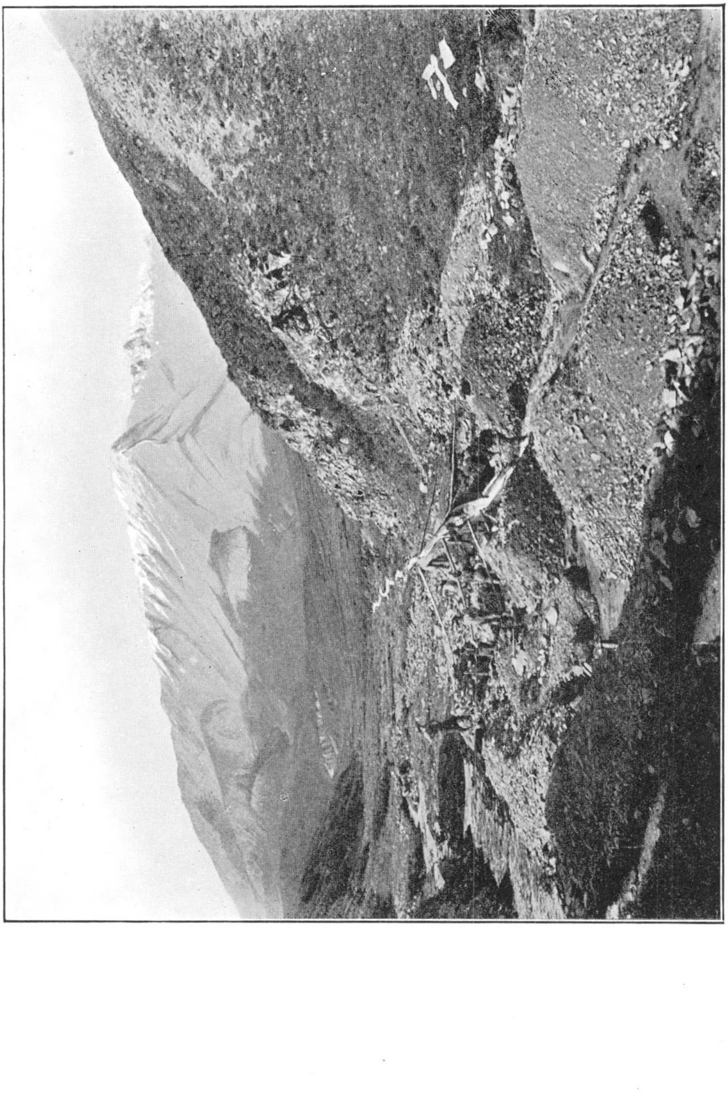
PLATE XIV.



Explanation of Plate XV.

Sluicing on James' Discovery, Little Eldorado creek, Chisana district, Alaska, August, 1913, gold being obtained at the rate of $300 per day per man. (See pages 125, 129, 131.)

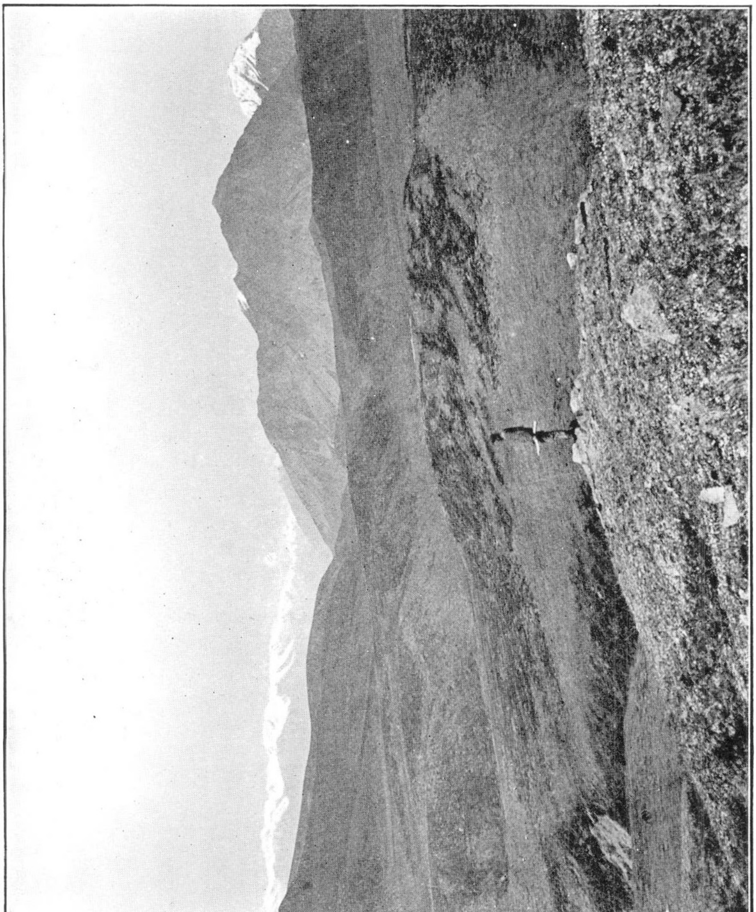
PLATE XV.



Explanation of Plate XVI.

General view, looking westward across the central portion of Chisana gold fields, Alaska, lying to the north of and adjacent to Bonanza creek. (See page 126.)

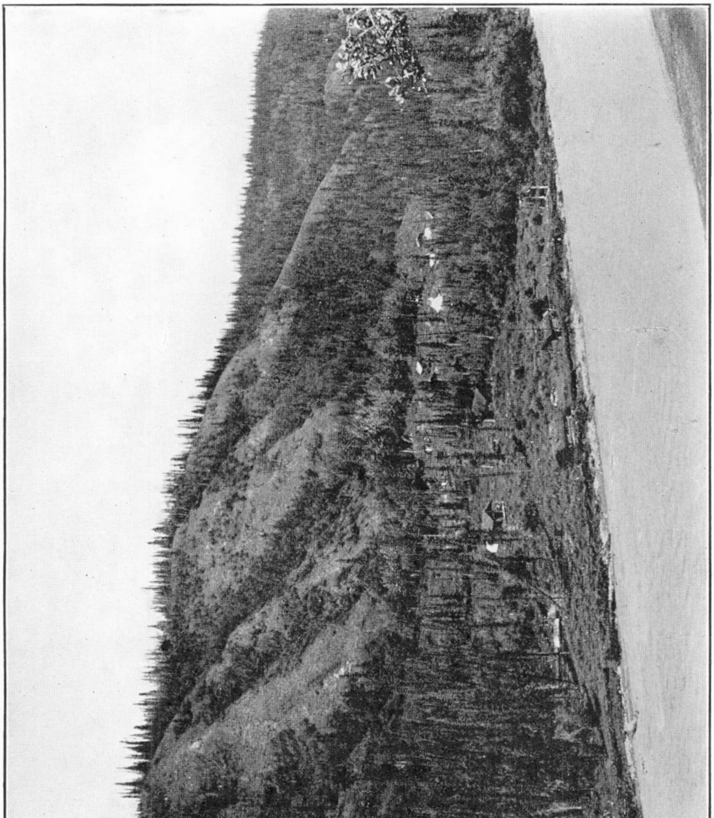
Plate XVI.



Explanation of Plate XVII.

Canyon City on White river, Yukon. (See pages 9, 24, 139.)

PLATE XVII.



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LIST OF RECENT REPORTS OF GEOLOGICAL SURVEY.

Since 1910, reports issued by the Geological Survey have been called memoirs and have been numbered Memoir 1, Memoir 2, etc. Owing to delays incidental to the publishing of reports and their accompanying maps, not all of the reports have been called memoirs, and the memoirs have not been issued in the order of their assigned numbers and, therefore, the following list has been prepared to prevent any misconceptions arising on this account. The titles of all other important publications of the Geological Survey are incorporated in this list.

Memoirs and Reports Published During 1910.

REPORTS.

Report on a geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont.—by W. H. Collins. No. 1059.

Report on the geological position and characteristics of the oil-shale deposits of Canada—by R. W. Ells. No. 1107.

A reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon and North West Territories—by Joseph Keele. No. 1097.

Summary Report for the calendar year 1909. No. 1120.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 1. *No. 1, Geological Series.* Geology of the Nipigon basin, Ontario —by Alfred W. G. Wilson.

MEMOIR 2. *No. 2, Geological Series.* Geology and ore deposits of Hedley mining district, British Columbia—by Charles Camsell.

MEMOIR 3. *No. 3, Geological Series.* Palæoniscid fishes from the Albert shales of New Brunswick—by Lawrence M. Lambe.

MEMOIR 5. *No. 4, Geological Series.* Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district, Yukon Territory—by D. D. Cairnes.

MEMOIR 6. *No. 5, Geological Series.* Geology of the Haliburton and Bancroft areas, Province of Ontario—by Frank D. Adams and Alfred E. Barlow.

MEMOIR 7. *No. 6, Geological Series.* Geology of St. Bruno mountain, province of Quebec—by John A. Dresser.

MEMOIRS—TOPOGRAPHICAL SERIES.

MEMOIR 11. *No. 1, Topographical Series.* Triangulation and spirit levelling of Vancouver island, B.C., 1909—by R. H. Chapman.

Memoirs and Reports Published During 1911.

REPORTS.

Report on a traverse through the southern part of the North West Territories, from Lac Seul to Cat lake, in 1902—by Alfred W. G. Wilson. No. 1006.

Report on a part of the North West Territories drained by the Winisk and Upper Attawapiskat rivers—by W. McInnes. No. 1080.

Report on the geology of an area adjoining the east side of Lake Timiskaming—by Morley E. Wilson. No. 1064.

Summary Report for the calendar year 1910. No. 1170.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 4. *No. 7, Geological Series.* Geological reconnaissance along the line of the National Transcontinental railway in western Quebec—by W. J. Wilson.

MEMOIR 8. *No. 8, Geological Series.* The Edmonton coal field, Alberta—by D. B. Dowling.

MEMOIR 9. *No. 9, Geological Series.* Bighorn coal basin, Alberta—by G. S. Malloch.

MEMOIR 10. *No. 10, Geological Series.* An instrumental survey of the shore-lines of the extinct lakes Algonquin and Nipissing in southwestern Ontario—by J. W. Goldthwait.

MEMOIR 12. *No. 11, Geological Series.* Insects from the Tertiary lake deposits of the southern interior of British Columbia, collected by Mr. Lawrence M. Lambe, in 1906—by Anton Handlirsch.

MEMOIR 15. *No. 12, Geological Series.* On a Trenton Echinoderm fauna at Kirkfield, Ontario—by Frank Springer.

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